Achieving a mass-scale transition to clean cooking in India to improve public health

Thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy (D.Phil) Geography and the Environment

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Woman cooking on traditional stove in West Bengal (picture taken by the author during field work, 2010)

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DPhil Abstract

This research provides policy-relevant insights into how a mass-scale, equitable transition to the use of Advanced Biomass (cook) Stoves (ABSs) can be achieved in India, with the aim of improving public health, especially for women and children. The research uses socio-technical systems to provide a characterisation of transition processes, and governance to explain issues of power influencing transition. A review of previous government cook-stove programmes in India and China highlights governance shortcomings in the former, in particular a lack of functional links between layers of administration and poor engagement with community institutions and cooks. Primary data from West Bengal and Karnataka highlighted sophisticated, skilful, flexible and culturally context specific cooking practices. Reasons for apparent low demand for improved stoves, characterised as *lock-in*, are found to include a combination of risk aversion and habits, lack of affordability, low awareness of the health consequences, as well as a mis-match between the normative priorities of policy makers – currently health- and those of cooks. It is found that the majority of polluting emissions within households - as well as greenhouse gases - from cooking derive from poorer households. A sectoral carbon offset strategy is proposed as a means of funding subsidies for ABSs and programme support measures. Several large corporations have invested significant sums in technology development, community outreach and dissemination, resulting in sales of over 600,000 ABSs. Reasons for their involvement appear mixed. Their market-based activities have generally not reached poor households and there are questions about their ability to build viable businesses in this highly dispersed and heterogeneous sector. A fundamental dichotomy is highlighted between large, centralised cooking programmes and the diverse, complex and changing reality of cooking activities, beliefs and behaviours on the ground. The research concludes that functional multi-level and multi-actor governance structures would be required to achieve a mass-scale transition to clean cooking using ABSs, with a lead role for the public sector. A key component of future success will involve building structures that ensure the agency of cooks and account for their socio-cultural cooking practices in the processes of technology and programme design and implementation.

Word count: 99,600

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Acronym	Definition
ABS	Advanced Biomass Stove
ALRI	Acute Lower Respiratory Infection
ARTI	Appropriate Rural Technology Institute
B/S/H	Bosch und Siemens Hausgeräte GmbH
BBS	Baseline Biomass Stove
BEPE	(Chinese) Bureau of Environmental Protection and Energy
BOP	Bottom Of the Pyramid
BPL	Below Poverty Line
C0	Carbon monoxide
$C0_2$	Carbon dioxide
$C0_{2e}$	Carbon dioxide equivalent
CCD	Covenant Centre for Development
CCRERT	China Center of Rural Energy Research and Training
CCT	Controlled Cooking Test
CDM	Clean Development Mechanism
CEO	Chief Executive Officer
CFC	Chlorofluorocarbon
CH_4	Methane
CNISP	Chinese National Improved Stove Program
COPD	Chronic Obstructive Pulmonary Disease
CSR	Corporate Social Responsibility
CWE	Chief Wage Earner
DALYs	Disability Adjusted Life Years
DFID	Department for International Development
DOE	Department of Energy
EC	European Commission
ECM	Emerging Consumer Markets (BP)
ESMAP	Energy Sector Management Assistance Programme (World Bank)

Acronym	Definition
ESRC	Economic and Social Research Council
FAO	Food and Agriculture Organisation
FG	Focus Group
GACC	Global Alliance for Clean Cookstoves
GCI	Galvanised Corrugated Iron
GERES	Groupe Energies Renouvelables, Environnement et Solidarités
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GVEP	Global Village Energy Partnership
GWP	Global Warming Potential
HDI	Human Development Index
HPI	Human Poverty Index
HSC	Higher School Certificate (India)
HSSE	health, safety, security and environment
IAP	Indoor Air Pollution
IBEF	India Brand Equity Foundation
ICS	Improved Cook-stove
IEA	International Energy Agency
IFAD	International Fund for Agricultural Development
IIT	Indian Institute of Technology
IPCC	Intergovernmental Panel on Climate Change
IRs.	Indian Rupees
ITDG	Intermediate Technology Development Group (now Practical Action)
KPT	Kitchen Performance Test
LPG	Liquid Petroleum Gas
M&E	Monitoring and Evaluation
MDG	Millennium Development Goal
MFI	Micro-finance Institution
MIT	Massachusetts Institute of Technology

Acronym	Definition
MJ	Mega Joule
MNRE	Ministry of New and Renewable Energy (India)
MOA	Ministry of Agriculture (China)
MPI	Multidimensional Poverty Index
MRSI	Market Research Society of India
N_20	Nitrous Oxide
NAMAs	Nationally Appropriate Mitigation Actions
NBCI	National Biomass Cook-stove Initiative
NCAER	National Council of Applied Economic Research (India)
NCBI	National Biomass Cook-stove Initiative (India)
NERC	Natural Environment Research Council
NGO	Non-governmental organisation
NMHC	Non Methane Hydro Carbon
MNRE	Ministry of New and Renewable Energy (India)
MSPI	Ministry of Statistics and Programme Implementation (India)
NMVOC	Non Methane Volatile Organic Compound
NPIC	National Programme on Improved Chullahs (India)
NRB	Non-renewable biomass
NSS	National Sample Survey (India)
NSSO	National Sample Survey Organisation (India)
OBC	Other Backward Class
OECD	Organisation for Economic Cooperation and Development
OED	Oxford English Dictionary
OM	Organic Matter
PCIA	Partnership for Clean Indoor Air
PIC	Product of Incomplete Combustion
PM	Particulate Matter
PM_{10}	Particulate Matter less than 10 microns
PM_4	Particulate Matter less than 4 microns

Acronym	Definition
PoA	(CDM) Programme of Activities
R&D	Research and Development
RBC	Reinforced Brick Concrete
RCC	Reinforced Cement Concrete
RE	Renewable Energy
SC	Scheduled Castes
SEC	Socio Economic Classification
SEW	Self Employed Worker
SNM	Strategic Niche Management
SPSS	Statistical Package for the Social Sciences
SSC	Secondary School Certificate (India)
SSP	Swayam Shikshan Prayog
ST	Scheduled Tribes
STS	Socio Technical System
TBU	Technical Back-up Unit
TERI	Tata Energy Research Institute (India)
UCB	University of California-Berkeley
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VLE	Village Level Entrepreneur
W/m^2	Watts per square metre
WBT	Water Boiling Test
WHO	World Health Organisation

Currency converter (used throughout thesis) (source: www.xe.com accessed 22/9/12)

	US Dollar ($)	Euro (€)	Pound (£)	Indian Rupee (IRs.)
US Dollar $	1	0.77	0.62	0.019
Euro (€)	1.30	1	0.80	0.014
Pound (£)	1.62	1.25	1	0.012
Indian Rupee (IRs.)	53.25	69.1	86.4	1

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Much of the primary data for this research would have been impossible to obtain without the patient participation of many women in India. Thank you for your time and for answering my – probably strange seeming – questions. If the findings from this research contribute to even one Indian house having better indoor air quality, your time and mine will have been well spent. I was also lucky to encounter numerous people in India who gave generously of their time. Special thanks to Mehebub Anam and Faruk Abdulla from the Women's Studies Research Centre at the University of Calcutta and Benoy Hazra from the University of Burdhaman who facilitated the focus groups for me in West Bengal, and to Kiran Kumar, of the NGO SKG Sangha who did the same in Karnataka. I must also give thanks to the very humane and wise D. Vidya Sagar of the same organisation, who taught me much about India and cooking.

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Philip Mann

"A virtuous circle in action, thanks to technology; environmental protection, improved safety for women, access to clean energy for the poor, enhanced climate security." Quote from UN Secretary General, Ban Ki-moon, with reference to improved cook-stoves, Copenhagen, December 2010

1 Chapter 1: Introduction and research context

1.1 Objective of the thesis

The objective of this research is to contribute insights into how to achieve an equitable transition to the mass-scale adoption and use of improved biomass and solid fuel cook-stoves in India. The thesis takes the stance that the primary purpose of promoting such improved cook-stoves is to reduce exposure to household air pollution, and hence improve public health, and reduce drudgery for women, while recognising synergistic and beneficial secondary outcomes of reduced greenhouse gas emissions, biomass use and hence forest degradation.

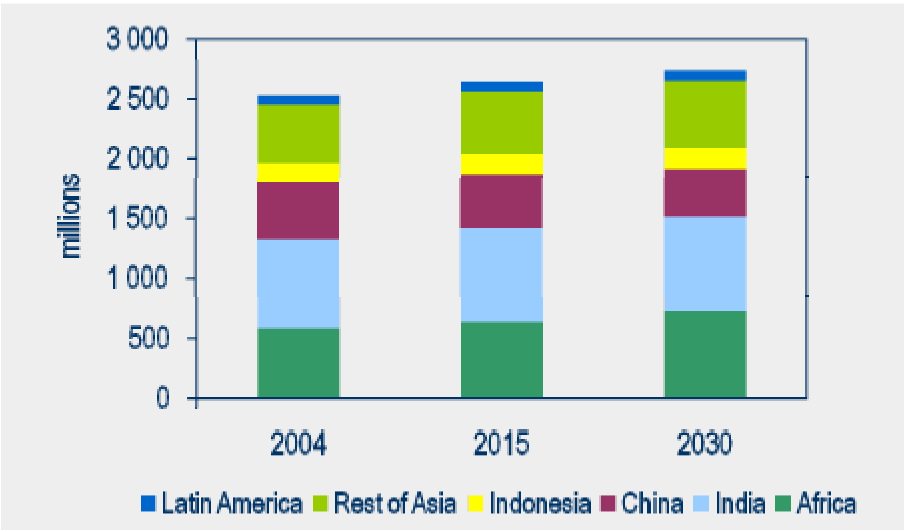
Cooking is a ubiquitous human activity. Indeed evolutionary analysis of human physiology suggests that *"...cooking may be obligatory for humans..."* and that a diet of only raw food would not provide enough calories to have supported a hunter-gatherer livelihood and thus "...*cooking appears to have been a key feature of the environment of human evolutionary adaptedness*..."(Wrangham et al 2003, p35).

However the way cooking is currently undertaken in the developing world, with 2.5 billion people relying on traditional fuels (IEA 2008), results in serious, adverse social consequences, principally in the form of major public health problems for women and children (Wilkinson et al 2009). Recent analysis has shown that of environmental factors responsible for disease burden, indoor air pollution from solid cooking fuels is associated with 1.6 million deaths annually, compared with 1.7 million deaths from dirty water and poor sanitation, 1.2 million from malaria, 800,000 from urban outdoor air pollution and 150,000 from climate change impacts such as adverse effects on production of agriculture, changed disease and extreme weather event patterns (WHO 2011).

In Europe cooking methods underwent a rapid transition from the 18th century onwards migrating from traditional wood stoves, to those using ceramic and metal, and thenceforth to the mass use of modern fossil fuels and electricity (Westhoff 1995). The drivers of this change were both shortages of wood and technological and economic development. By contrast the developing world remains reliant on 'traditional' cooking practices, with 2.5 billion people relying on biomass and other solid fuels to supply the heat required to cook meals. The majority of these people use primitive, so-called *traditional stoves* on which to burn the fuel, resulting in inefficient combustion and high levels of indoor air pollution.

Despite considerable efforts in the past decades the number of people relying on biomass and other solid fuels, burned in traditional stoves, for cooking is set to increase from 2.5 billion to 2.7 billion by 2030 without new measures being undertaken (Figure 1). Action is underway on both international and national levels to support a transition to clean cooking. Insights from this research are intended to support these ongoing efforts, and contribute to development of knowledge on specific debates at the intersection between poverty alleviation, public health and low carbon development strategies in developing countries (Simon et al 2012).

Figure 1: Outlook for number of people relying on traditional biomass for cooking



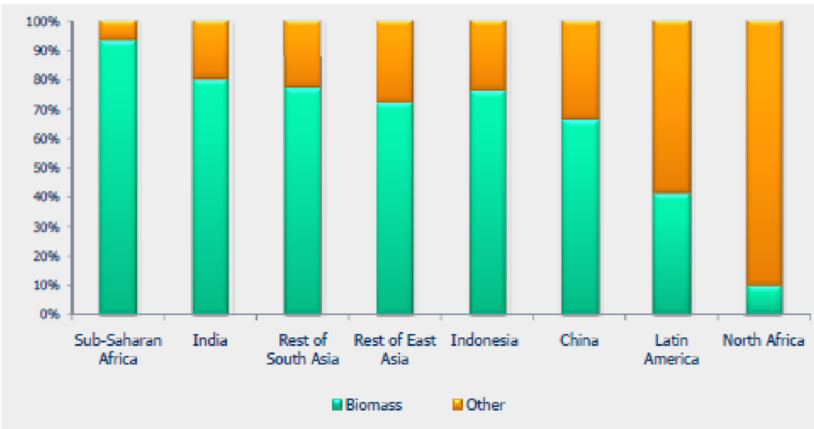
Source: (IEA 2008)

1.1.1 India as a case study

India is one of the oldest civilisations on earth, and today represents a vast, diverse and vibrant country. With a population of 1.24 billion people, India is the second most populous country in the world. Rapidly developing in some sectors and segments of society, India has a Gross National Income of US$1,410 per capita, with 29.8% of the population below the country's poverty line (World Bank 2012b). Indian ranks 134 out of 187 countries using the Human Development Index (HDI) – an index combining length of life, health, standard of living and other factors (UNDP 2012).

In 2009 42% of total primary energy consumption in India was from coal and peat, while 24% was supplied by oil (IEA 2011). The growing use of fossil fuels has resulted in India becoming a major emitter of greenhouse gases, although per capita emissions, at 1.5 tonnes CO_2 in 2008, remain low in global terms (World Bank 2012b). A further 24.5% of total primary energy supply was from biomass and waste, much of which was used for cooking food (IEA 2011). The use of traditional biomass fuels makes up over 80% of residential energy consumption in India, a globally high proportion (Figure 2). The majority of this biomass is used for cooking, while some is for space-heating purposes, particularly in the high Indian states around the Himalaya. Of the 2.5 billion people globally relying on traditional fuels for cooking, some 800 million are in India (IEA 2008). This figure highlights the importance of India as a case study for research on cook-stoves.

Figure 2: Share of Traditional Biomass in residential energy consumption, 2005

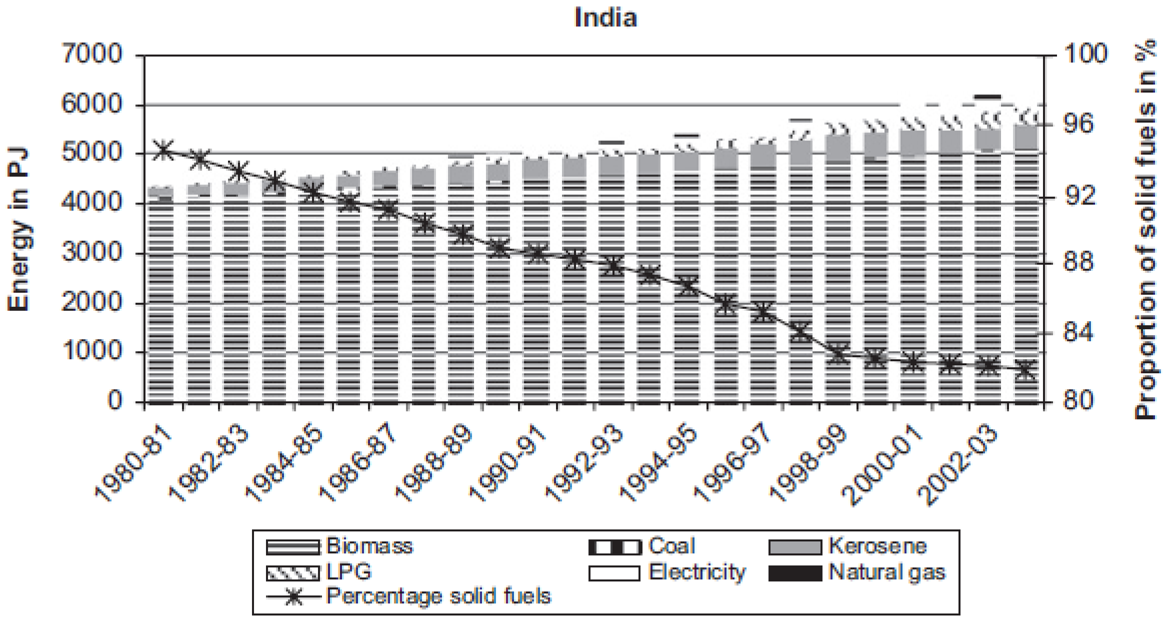


Source: (IEA 2008)

1.2 Summary of current cooking energy in India

Figure 3 shows the evolution of residential energy use in India from the early 1980s to 2002/03, highlighting that while solid fuel (biomass and coal) use as a proportion of residential energy use is decreasing, the absolute quantity of residential solid fuel use is increasing (Pachauri et al 2008).

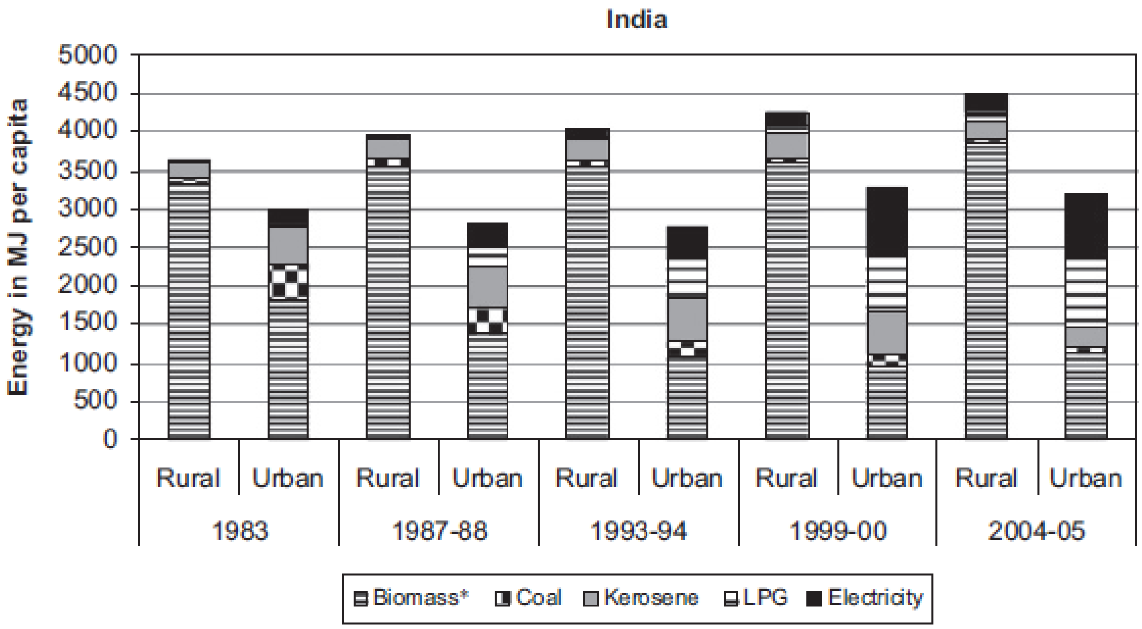
Figure 3: Residential energy consumption in India



Source: (Pachauri et al 2008)

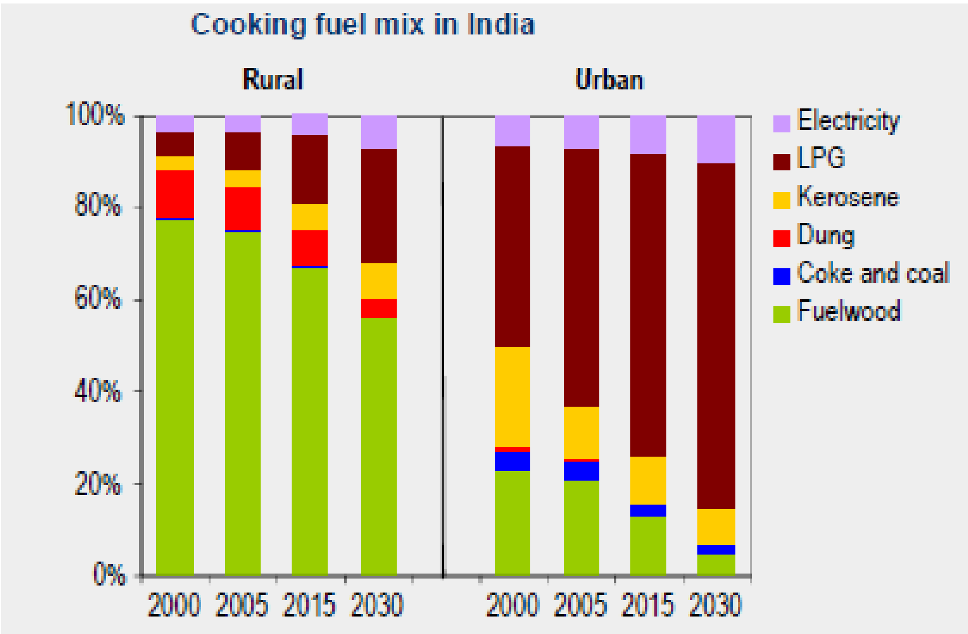
The principal reasons for the increase in absolute consumption of solid fuels is an increase in the per capita consumption of these fuels in rural areas (Figure 4) and population increase within India as a whole. Figure 4 also highlights a decrease in urban per capita consumption of solid fuels between 1983 and 1999/00, although this trend appears to have reversed between 1999/00 and 2003/4. Nevertheless the broad trend in India is for a shift in urban residential energy use towards modern fuels (LPG, kerosene and electricity), while the dominance of solid fuels in rural areas is set to persist, albeit with the consumption of biomass projected to fall to 60% of rural household use by 2030 (Figure 5).

Figure 4: Per capita energy consumption patterns in urban and rural households in India



Source: (Pachauri et al 2008)

Figure 5: Projected trends in cooking fuel mix in rural and urban India



Source: (IEA 2008)

The past and projected trends in fuel use (Figure 4 and Figure 5) are instructive, and highlight the likely continued importance of solid fuels, in particular in rural areas. However in terms of a transition to the use of clean solid fuel cook-stoves, it is useful to analyse one further variable: the numbers of households using different fuels.

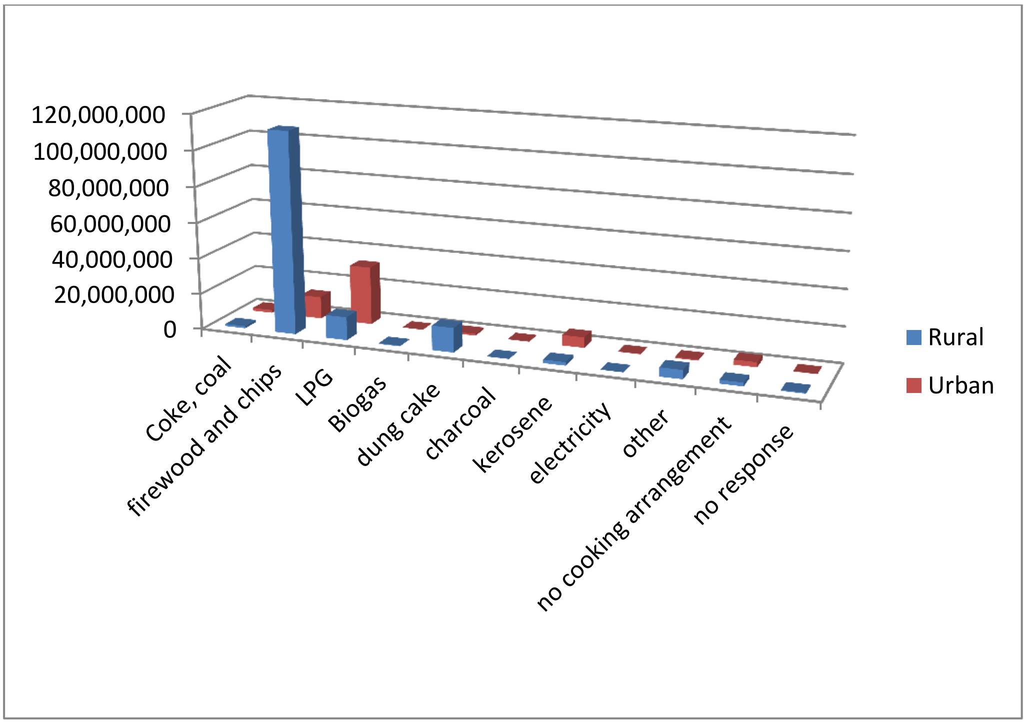
The Indian National Sample Survey (NSS), undertaken under the auspices of Ministry of Statistics and Programme Implementation, is a large-scale, nationwide, survey conducted in a series of rounds. The NSS produced a special report on residential cooking and lighting use, covering the period 2004-05 (MSPI 2005). This report asked respondents about their primary source of energy used for cooking; the results are summarised in Table 1 and Figure 6.

Table 1: Numbers of households (x 1000) in India using different fuels as their primary source of cooking

	Coke, coal	firewood and chips	LPG	Biogas	dung cake	charcoal	kerosene	electricity	other	no cooking arrangement	no response	Total
Rural	1,184	112,629	12,896	367	13,622	41	1,884	51	4,981	2,009	497	150,161
Urban	1,586	12,354	32,507	10	984	24	5,817	118	634	2,774	146	56,954

Source: (MSPI 2005). *Note: 'Chips' are categorised by the Indian Government as any biomass that is not fire-wood, dung, or charcoal. Chips include small twigs and agricultural wastes.*

Figure 6: Numbers of households in India using different fuels as their primary source of cooking



Source: (MSPI 2005)

The clear conclusion is that a significant majority of all Indian households is constituted of rural households using solid fuel (mainly biomass) as their primary cooking source. Nearly 128 million rural households use either wood, coal or dung as their primary cooking fuel, that is 85% of rural households, and nearly 62% of all Indian households (207 million[1]). Combining rural and urban, over 142 million households use solid fuel (including coal) as their primary cooking source, 69% of all Indian households. However these data do not present the complete picture. It is known that the use of multiple fuels (and stoves) within the same kitchen is common; the secondary and tertiary stoves/fuels are not represented in Table 1. In order to develop a complete picture of actual cooking practices, national data collection processes would need to develop new metrics, such as the hours of use for each fuel/stove combination.

The degree to which biomass is purchased or freely collected is of interest with respect to cook-stove adoption. It has been recognised for some time that those households paying for fuel have, understandably, a higher degree of interest in adopting measures to reduce fuel use (Barnes et al 1994). It has been reported that of those households using fuel wood and chips as their primary cooking source only 27% pay for the fuel (Bairiganjan et al 2010). Since it can be assumed that no dung users pay for their fuel, at least 105 million households using solid fuel as their primary cooking source do not pay for it. Note that dung is an essential product for fertilising soil; the fact that much is burned in stoves and thus not placed on fields, has adverse economic and environmental impacts.

1.2.1 A brief history of cook-stove activities in India

In recent decades there can be considered to have been three broad phases during which different forms of cook-stove promotional activity have taken place within India. Firstly from the mid-1980s, a centrally managed government programme, the National Programme on Improved Chullahs[2] (NPIC), developed and disseminated large numbers of improved stoves; while the local public administrations engaged with private sector and civil society in the development and distribution of

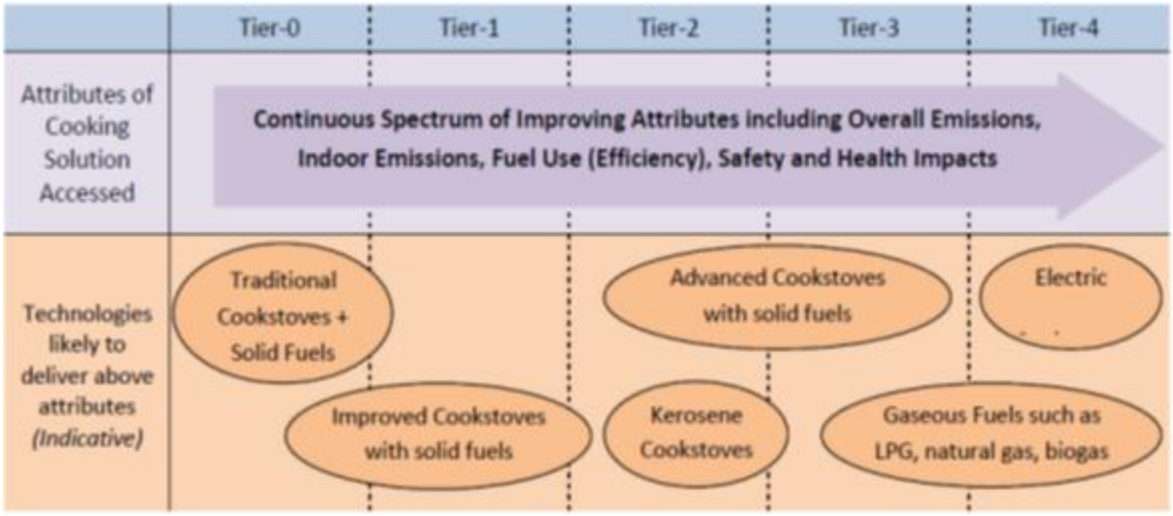
[1] In 2004/5 there were 207 million households in India (National Sample Survey Organisation).
[2] 'Chullah' is a term denoting a cooking stove in India

improved stoves, the NPIC was clearly a government-led programme. The NPIC and analogous government programmes from other countries are analysed in Chapter 3. During the second phase, following the end of the NPIC in 2002, local private sector and civil society activity in the cook-stove field continued, but at a lower level. In addition four large corporations – Shell (through a charitable foundation), BP, Bosch Siemens and Philips - initiated cook-stove activities, independently of government and without public support, including research into advanced stoves and testing and implementation of different dissemination and business models; the activities of these corporations are analysed in Chapter 6. While the activities of these private sector entities, as well as a number of NGOs, continues, a third phase in cook-stove promotion in Indian can be considered to have started in recent years, with the Indian Government announcing a new national programme, the National Biomass Cook-stove Initiative (NBCI) in December 2009.

The NBCI has the ambitious objective of providing high performance solid fuel cook-stoves to poor households (MNRE 2009). The NBCI has the "*...primary aim to enhance the availability of clean and efficient energy for the energy deficient and poorer sections of the country...*" (MNRE 2011b, website). The MNRE has established high standards for the NBCI in terms of polluting emissions, with the programme being "... *uniquely framed among all stove programs in the world, today or historically, by explicitly aiming to provide every household in the country with combustion comparable to LPG in cleanliness and efficiency, whether from modern fuels or biomass*..." (Smith 2010, p252). This relates to Tier 3 of a classification of cooking options, developed recently as part of the UN Secretary General's Sustainable Energy for All Initiative. Figure 7 identifies Advanced Biomass Stoves – ABSs – as the target technology in terms of biomass stoves with performance akin to LPG; such ABS stoves generally employ fan-assisted combustion and are mass-manufactured by the four large corporations studied in detail in Chapter 6 (apart from Bosch Siemens which developed a liquid biofuel stove). Further descriptions of stoves and their performance are provided in Sections 1.3.1 and 1.3.2.

While there is a clear focus on social development within the NBCI, it is recognised that climate benefits would provide "…*icing on the cake*…" (Smith 2010, p252). The development of this programme recognises that biomass cook-stove technology development has significantly progressed since the NPIC (Venkataraman et al 2010), and that lessons on the difficulty of dissemination and achieving broader transition goals need to be drawn from that programme.

Figure 7: Spectrum of cooking solutions, illustrating technologies, emissions and costs



Further technology description	3-stone fire or 'traditional chullah'	Basic (slightly) improved stoves (eg mud surround with/without chimney	Rocket stoves with well-designed combustion chambers, insulation etc	**Advanced Biomass Stoves (ABS),** often with fan to assist combustion. Mass manufactured	As above
Emissions of household air pollutants	High emissions	Lower emissions but not low enough to achieve health outcomes desired	Lower emissions than Tier 1 but still not low enough to achieve desired health outcomes	In laboratory tests emissions can be as low as LPG stoves	Low/negligible
Indicative cost (author's estimates)	Low/zero purchase cost Running cost dependent on fuel (monetized or not)	Less than US$5 purchase cost Running cost less (20-30%) than traditional stove when using traditional monetized fuel	US$ 5 to US$ 30 purchase cost Running cost up to 50% less than traditional stove when using traditional monetized fuel	US$ 20 to US$ 80+ purchase cost Running cost around 75% less when using traditional monetized fuel, and similar to kerosene/LPG for manufactured biomass pellets	Variable capital costs (high for biogas). Running costs: zero/low for biogas, high for LPG and electricity

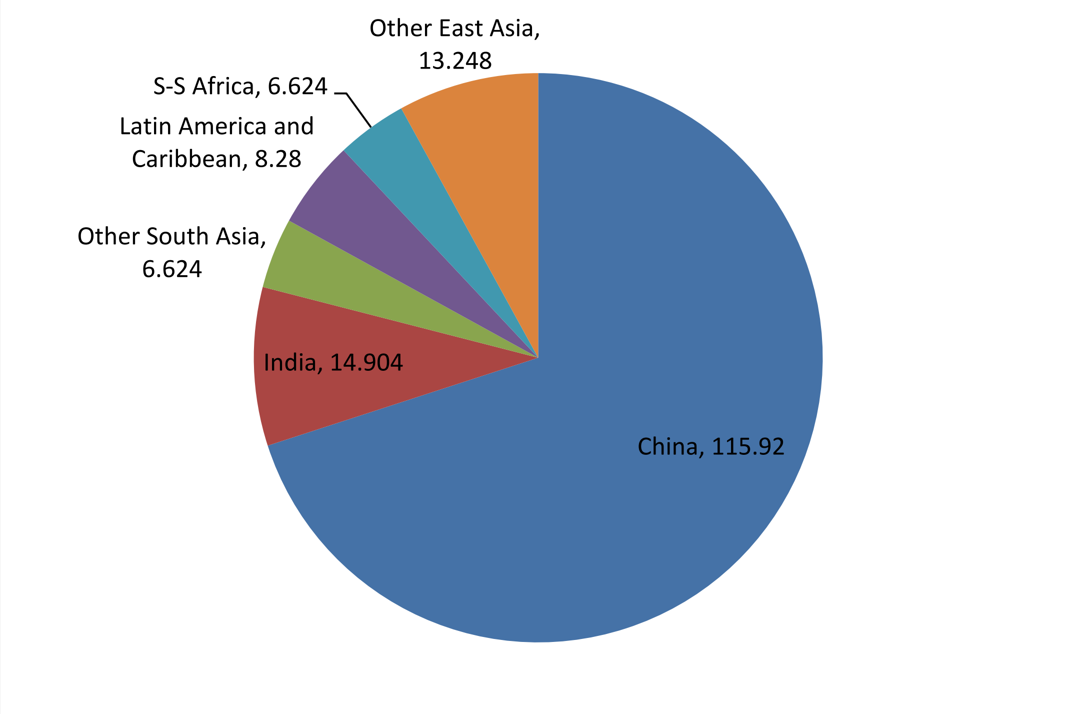
Source: (ESMAP et al. 2012) with additions by the author

The NBCI is currently at the early stages of development, including technical testing, pilot programmes and programme design, the results of which are intended to inform full scale roll-out during the Indian 12th Five Year Plan (2012-2017) (MNRE 2011a). Current thinking is that the NCBI will focus on a market-based approach, while recognising that particular measures (ie subsidies) are required to reach the poorest populations (Smith 2010); consideration is being given to using carbon markets as a means of providing subsidies (The World Bank 2011). This focus on a government programme working along market principles, providing public support where needed, marks a new departure and represents largely untested waters. This broad approach under the NBCI is mirrored in the international community, through the recently developed Global Alliance for Clean Cookstoves (GACC) supported by the UN Foundation (Smith 2010). The GACC is a "…*public-private initiative to save lives, improve livelihoods, empower women, and combat climate change by creating a thriving global market for clean and efficient household cooking solutions*…" with the goal of fostering "…*the adoption of clean cookstoves and fuels in 100 million households by 2020*…" (GACC 2011).

1.2.2 Use of "improved" cookstoves

Data on end-use devices (cook-stoves) in India is not covered by the NSS. However a recent global report on the use of improved cook-stoves, (WHO 2009), reports the use of 14.9 million improved cook-stoves in India, with "improved cook-stove" being defined as any stove with an enclosed fire box and chimney. Thus it can be concluded that there are around 127 million households (142 less 14.9) in India using solid fuel without the use of an improved stove. In addition it is very likely – although solid data do not exist – that the vast majority of the 14.9 million '*improved cook-stoves'* reported to be in use are using relatively old designs, with very poor technical performance compared with modern, advanced, improved stoves.

Figure 8: Numbers of improved stoves* distributed (millions)



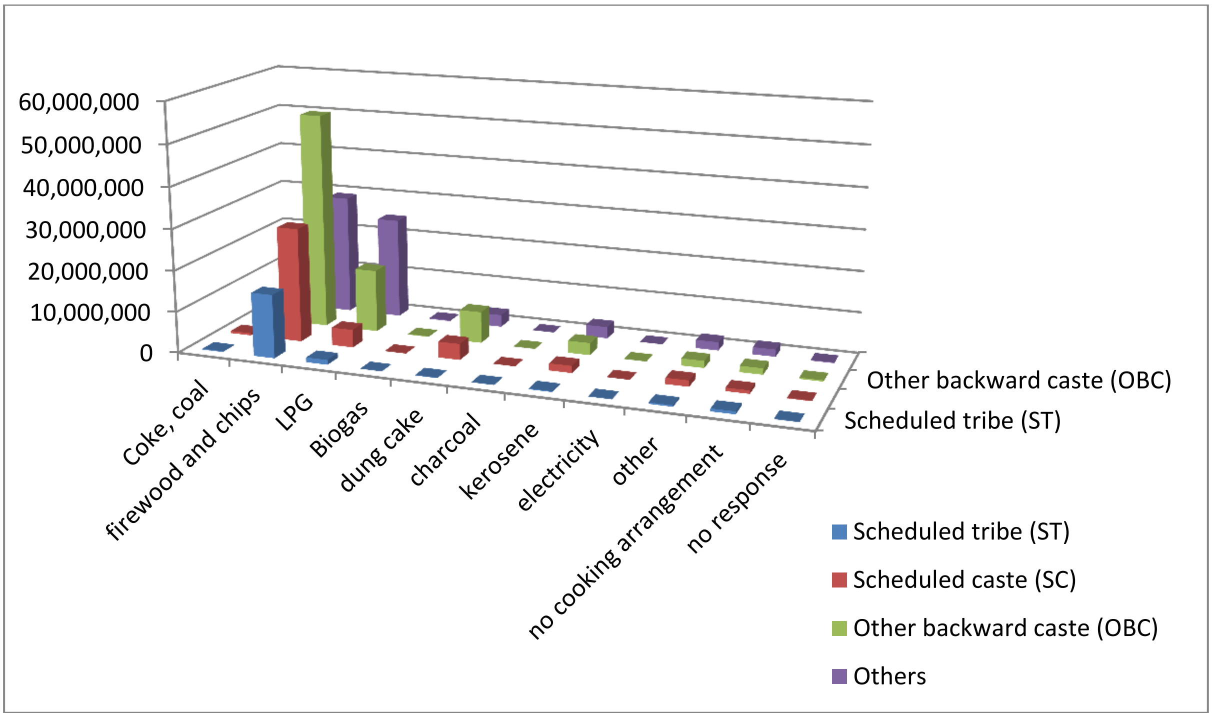
Source: Adapted from (WHO 2009) *as quoted in* (The World Bank 2011).
**Improved cook-stoves are defined here as any stoves with enclosed fire boxes and chimneys. Data from household surveys.*

From Figure 8 it can be seen that around 165 million improved stoves are thought to have been distributed around the world, representing around 30% of households globally using solid fuels for cooking, although as noted above the majority of these "improved" cook-stoves are likely to perform poorly compared with modern stoves. Almost 75% of these improved stoves were distributed in China, where more than 70% of households using solid fuel for cooking have adopted an improved stove, compared with only 8% in India (Legros et al 2009) as quoted in (Bailis et al 2011).

1.2.3 Variations in cooking fuels between socio-economic groups

The distribution of different primary cooking fuels amongst social and economic groups in India is of interest with respect to a transition to the use of clean cook-stoves. The NSS data (MSPI 2005) breaks down the use of primary cooking fuels into 4 social groups: *Scheduled tribes* (ST), *scheduled castes* (SC), *other backward class* (OBC) and *others,* or so-called *forward* classes. Scheduled castes and scheduled tribes are historic groupings of disadvantaged individuals, the former sometimes also known as *dalits*. There are certain obligations under the Constitution of India to support disadvantaged castes. The NSS 1999-2000 highlights the proportion of the Indian population in different social groups: 36% OBC, 28.3% ST and SC, and 35.7% others. Combining urban and rural households Figure 9 presents the number of households from different social groups using various primary cooking fuels. No clear relationship can be observed between the social group and the primary fuel used.

Figure 9: Numbers of households in India (urban and rural combined) using different primary cooking fuels for different social groups



Note: Calculations by the author based on (MSPI 2005).

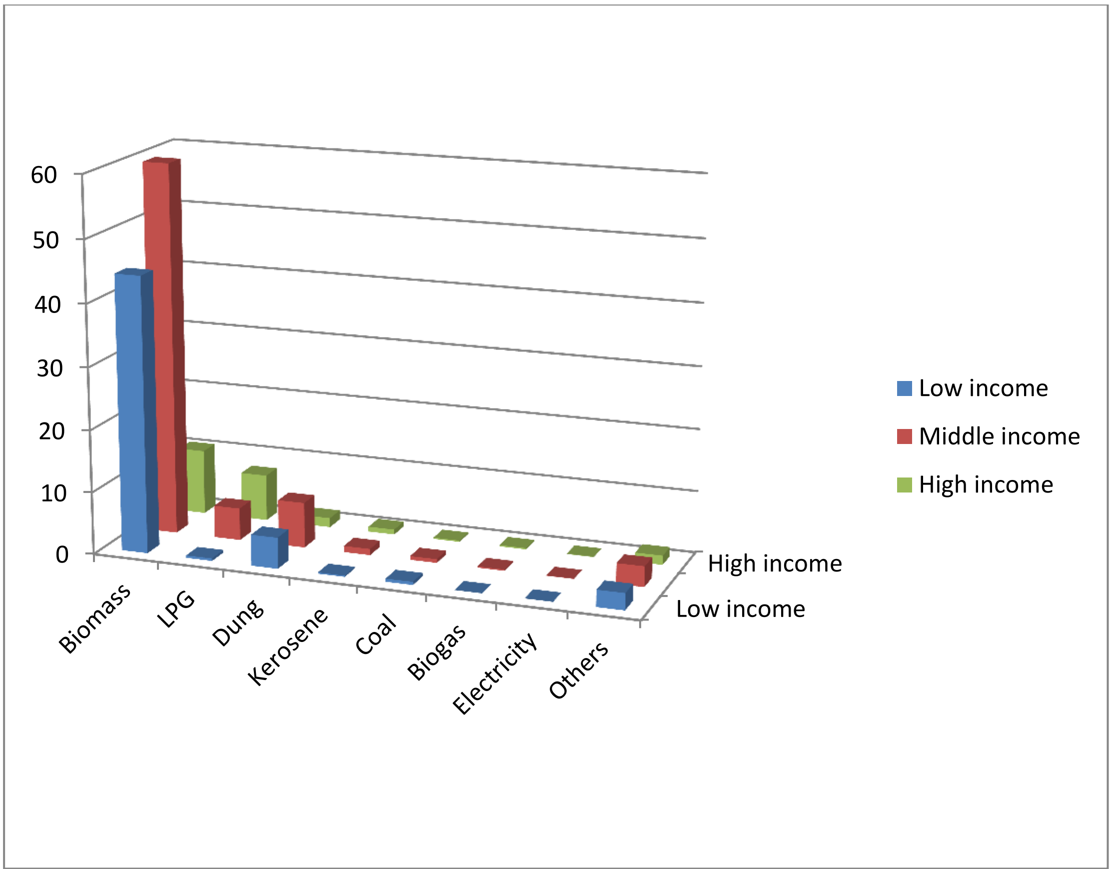
Of more interest concerning a transition to the use of clean cook-stoves, perhaps, are the income breakdowns of households, especially those in rural areas where the majority of the biomass-using population resides. The data presented in Table 2 and Figure 10 shows the estimated numbers of rural households using different primary cooking fuels, broken down by income classes ((Patil 2010) using the NSSO 2007 data round)[3]. It is interesting to note that a significant number of middle income rural households use biomass.

Table 2: Projected numbers of rural households (million) using different primary cooking fuels, broken down by income groups

	Biomass	LPG	Dung	Kerosene	Coal	Biogas	Electr.	Other	Total
Low income	44.3	0.4	5	0.2	0.5	0	0	2.7	53.1
Middle income	59.7	5.2	7.3	1	0.6	0.2	0.03	3.3	77.3
High income	10.5	7.5	1.5	0.8	0.2	0.2	0.04	1.5	22.2
									152.6[4]

Source: (Patil 2010)

Figure 10: Projected numbers of rural households (million) using different primary cooking fuels, broken down by income groups



Source: (Patil 2010)

[3] (Patil 2010) employs the monthly per capita expenditure (MPCE) classes used by the National Sample Survey Organization (NSSO) as proxies for household income. Definitions of each rural group (from (Reddy et al 2009) are taken to be: Low income – less than IRs. 410; middle income - IRs. 410 to IRs. 890; and high income – more than IRs. 890.

[4] Note that the number of rural households has been estimated "*...using the rural population estimate of United Nations Population Division and the projected family size of 5.03...*" (Patil 2010) and hence is different from the number of rural households provided in (MSPI 2005).

For the purposes of this research the key conclusion is that biomass use (including dung) in low and middle income households in rural areas (49.3 and 67 million households respectively), combined, make up over 75% of all Indian rural households and 52% of all Indian households. Low income biomass using households represent around 33% of all rural Indian households and 22% of all Indian households[5]. Thus actions leading to a transition to clean cooking in India can be framed as largely involving the bottom and middle of the pyramid in rural areas.

Given the high proportion of poor households in India, affordability of improved cook-stoves is a central issue. Affordability can be perceived of as both an objective fact and a subjective judgment on the part of those concerned. Both capital and running costs are relevant in the case of cook-stoves. In the case of those households buying fuel – mainly urban dwellers - (for example monetized wood) purchase and use of an improved stove can save on ongoing expenditure for fuel, in addition to saving time, although the value of the time saved for fuel collection is not generally taken into account; it has been found that on average almost 50 minutes a day is spent collecting biomass fuel in rural Indian households, although it is noted that this time is generally not monetized (Barnes et al 2012). Assuming an urban slum household uses 640kg per year of fuel-wood (Pandey 2002) and that the cost of this wood is IRs. 2/kg (author's estimate, in reality market prices are highly variable), annual fuel expenditure of nearly IRs. 1,300 (US$ 24) could be reduced by IRs 385 (US$7) per year through the adoption of basic improved stove assuming reduced fuel consumption of 30%, yielding a payback of less than a year for a basic improved stove (US$5 stove, see Figure 7). However an ABS reducing consumption by 75% would yield savings of around IRs. 975 (US$ 18) per year, producing a longer payback (nearly three years for a US$50 stove), probably unattractive for many poorer households. In the case of rural households fuel savings resulting from the adoption of an improved stove will not generally yield financial benefits, since traditional fuel is generally gathered freely and not paid for in rural India.

[5] Assuming total household number in India of 222 million (NSSO 2007)

Concerning capital costs of improved stoves, it can be considered an objective fact that households in the low income group (monthly per capita income of less than IRs. 410 (US$7)) would not be able to afford an ABS given the large up-front cost (see Figure 7). However Barnes et al (2012) estimate that even families living below the official poverty line (monthly per capita income of less than IRs. 254 (US$4.8)) could afford US$5 for a stove, bringing basic improved stoves within their reach. Issues of affordability and willingness to pay for improved stoves are addressed further in Chapter 5.

1.3 Cooking choices and technologies

The choice of cooking fuel and stove depends on a multiplicity of socio-economic, cultural and local environmental issues. Much past analysis (ESMAP 2004, ESMAP 2003) has emphasised the primacy of affordability as a key determinant of cooking choices. While it is certainly true that both capital costs of stoves, as well as running costs (for fuel), are likely to be key determinants of cooking choices, there is a paucity of analysis of other influencing factors, such as cultural applicability, convenience and ease and flexibility of use.

In simple terms changes to domestic cooking technology can follow one of four technology routes to reduce exposure to polluting emissions within the household:

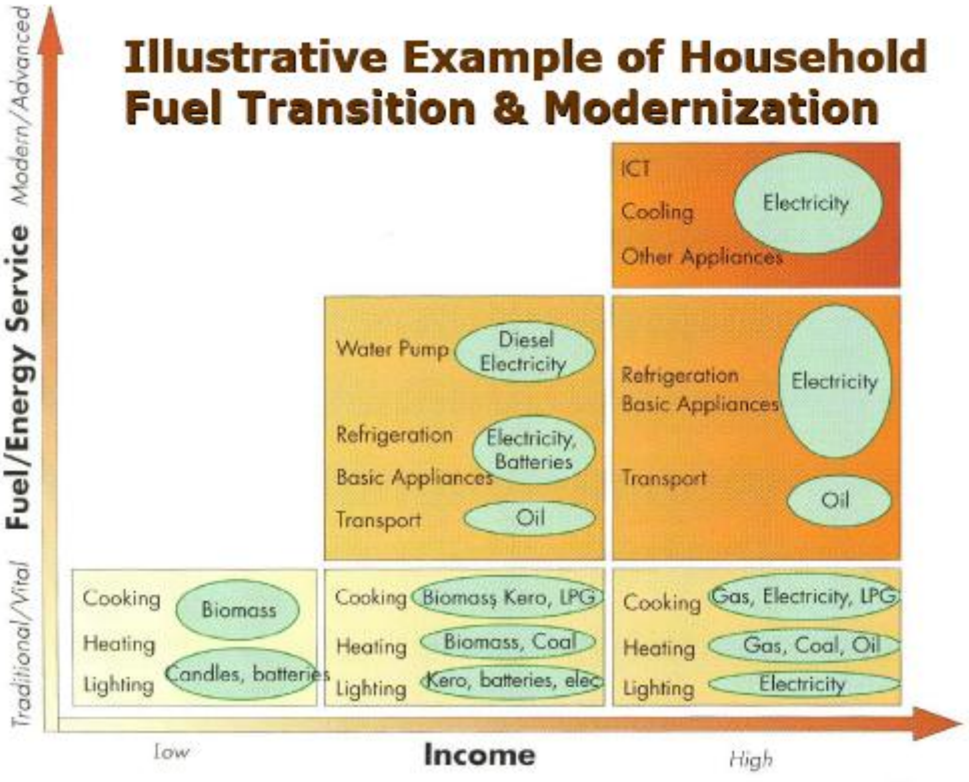
1. Switch to a clean fossil fuel, such as LPG, or electricity. While this is a viable option- especially LPG - for many of those in the growing middle classes in urban areas in India, it is not affordable for the majority of poor households, and is not available in many rural areas;
2. Switch to a clean renewable, non-solid-biomass fuel. The use of biogas is growing in parts of India and other developing countries, albeit from a low base. Table 1 shows that in 2004/5 there were nearly 367,000 biogas users in rural parts of India, and 10,000 in urban ones. Biogas requires considerable capital outlay, as well as sufficient land and cattle to feed the system. The use of solar cookers of different forms has yet to take hold, and is a fringe technology currently. There are a variety of reasons for this, chief amongst them being

cultural resistance to their use and the lack of available cooking heat in mornings and evenings (and no suitable storage technologies currently);

3. Switch to processed solid biomass fuel, for example pellets made from agricultural waste such as nut shells. This approach has the advantage of producing a fuel which is consistent in physical form, calorific value and moisture content and can thus be optimised for efficient and clean combustion; in addition it does not result in degradation of forest resources. Such processed solid biomass fuels are in some cases sold in combination with high performance stoves designed specifically for the purpose (for example see Figure 14);
4. Switch to a modern, clean burning, biomass cook-stove using the same fuel as before. A wide range of 'improved' biomass stoves has been developed in the past 3 decades, ranging from models designed to be built in the home, or by local artisans, to those designed for very high performance which are mass-manufactured in factories (see Sections 1.3.1 and 1.3.2).

The concept of an *energy ladder* has been promoted in the past to describe the transition of fuel choice changes as incomes increase - for example from animal waste or wood, to charcoal and then to LPG or electricity (Figure 11). Recently however the energy ladder concept has been refined to the more realistic concept of *energy stacking,* whereby users gaining access to new cooking sources, continue to use the old fuel sources on some occasions (Masera et al 2000). The *energy ladder model* provides a conceptual description of developments, placing modern fuels such as LPG, kerosene and electricity at the top of the ladder. This does not however necessarily predict a desirable, or even likely, future scenario for cooking in India, as explained below.

Figure 11: Energy ladder model



Source: (IEA 2002)

There are some, for example Goldemberg et al (2004), advocating a mass transition to fossil fuels for cooking in the developing world (eg liquid kerosene and LPG [6]), which could be seen as taking a *modernisation* perspective to development. This thesis takes a different perspective, assuming that for large parts of the population a more likely path involves the continued use of existing solid (biomass or coal) fuels; as such it is argued that the focus required – for a large proportion of the population - is on improving use of traditional fuels rather than fuel-switching. The reasoning is three-fold.

Firstly the cost of switching to liquid or gaseous fossil fuels is likely to remain too costly for a large proportion of the Indian population currently relying on traditional biomass. Research has shown that while increasing income is associated with an increase in use of modern fuels such as LPG, a doubling of average national incomes results in only a 16% reduction in the number of people

[6] For example the UNDP has been promoting LPG within its *LP Gas Rural Energy Challenge* programme

relying on biomass (WHO 2009, IEA 2009); hence it can be concluded that biomass will be a major source of cooking fuel in India for decades to come, at least.

Secondly a mass switch to fossil fuels for cooking would have significant adverse energy security and balance of payments implications, especially for those developing countries reliant on fossil fuel imports (Venkataraman et al 2010).

Finally it is considered likely that improved biomass cook-stove technology will soon be developed to the point where household polluting emissions can be reduced to safe levels; this assumption, discussed in the following section, runs through this thesis and the issue of biomass stove technology and its performance - while a valid field of research – is not pursued in detail, other than the summary of biomass stove technologies presented below. The issue of advanced biomass stove development is however a highly topical one and it is certainly true that further development is necessary. As noted during a speech by the director of a foundation working on cooking and development "...*the balance between price, performance and durability of improved cook-stoves is very challenging. We are not yet at the point where we have a $10 stove, which can achieve 90% emissions reductions and last for a long enough period; but we are getting there*..." (West 2011). It is noted that an international competition is currently under consideration, as part of the X-Prize Foundation, to incentivise the development of a high performance, affordable solid fuel cook-stove (Smith 2010).

While improvements in public health are not the only determining factor in policy terms, it has been shown that to improve public health, improved stoves are more cost effective than switching to LPG or kerosene. It is reported that the cost of different cooking strategies, in south Asia, in terms of cost per healthy year gained is US$314 for switching to LPG, US$36 for kerosene and US$13 for improved stoves (Bruce et al 2006). Intervention costs and benefits of different cooking programme strategies: 1) switching to LPG, 2) switching to kerosene or 3) shifting to improved stoves, are reported on a global basis in (Hutton et al 2007). This analyses the costs and benefits for interventions which "...*reduce indoor air pollution by halving the global population currently lacking access to (1) cleaner fuels (liquefied petroleum gas (LPG)) and (2) cleaner-burning and more efficient stoves*...", finding that "...*Globally, annual economic benefits of halving the population without access to LPG amount to (US)$91 billion at a net cost of $13 billion. The improved stove intervention generates $105 billion in economic benefits at a negative net cost of $34 billion*..." (Hutton et al 2007, p34). [7]

A starting point for this research is that a pre-requisite for a mass-scale transition to clean cooking appears to be the availability of high-performance stoves, designed to use biomass and other solid fuels, which are acceptable to cooks in terms of their usability and their capacity to cook food to the standard required. The next section provides a brief overview of historical and recent stove technical developments to place this in context.

1.3.1 Biomass stove technology developments past and present

Biomass stove technology development is a complex area which is the subject of wide-ranging debate amongst many international scientists. This section provides a brief overview only. The issue of measuring stove performance is discussed in the next section.

There is a spectrum of different forms of biomass cook-stoves, with overlaps between them making simple categorisation difficult. For the purposes of this summary four categories are described: 1) traditional biomass stoves; 2) early, slightly improved stoves, or simply *improved stoves*; 3) rocket stoves; and 4) advanced biomass stoves (ABSs); the focus of this thesis is on a transition to the mass use of ABSs, although it is recognised that this is likely to entail many households adopting other stoves, such as rocket stoves, on the way to this goal.

[7] (Hutton et al 2007). "Costs include fuel, stove, and programme costs, from which monetary fuel cost savings are subtracted to estimate net costs. Economic benefits include less expenditure on health care, health-related productivity gains, fuel collection and cooking time savings, and environmental impacts."

Traditional and early improved stoves

Traditional biomass stoves take a variety of forms, from the classic 3-stone fire, to traditional Indian chullahs surrounded with mud. Early improved biomass stoves employed a combination of a surrounded combustion chamber designed to improve heat transfer to the pot and/or a chimney. A huge variety of designs based on these principles were developed between the 1960s and the present day, and the distinction between what is termed a *traditional stove* and an *early, slightly improved stove* is somewhat blurred. The thinking behind the early *improved* designs was three-fold: firstly surrounding the combustion chamber would reduce heat loss to the environment compared with a traditional open fire, thus allowing more heat for cooking. Secondly the design of the combustion chamber could be optimised to allow for more complete combustion, which would not only use less fuel, but also reduce polluting emissions. Thirdly, the use of a chimney would remove those polluting emissions which could not be avoided to outside the kitchen where they would be less harmful. Some *improved stoves* are manufactured on site from locally available materials, while others are made by artisans at various levels of mass-production; some of these stoves use fired ceramics which can yield improved performance. Many of the simplest improved stoves are available for US$5 or less (The World Bank 2011). Figure 12 presents photographs of some of the many versions of traditional and *early improved* stoves. It is now well documented that early designs of *improved* biomass stoves did not perform sufficiently well to reduce household air pollution to safe levels from a health perspective (Bailis et al 2007).

Figure 12: Examples of traditional and improved stoves (various sources)

Traditional open fire in use in Nepal (photograph by the author)

Traditional mud chullah, Karnataka, India (*source:* (Westhoff et al 1995)

Improved chullah (Astra Ole) made by trained masons, Karnataka, India (*source:* (Westhoff et al 1995)

Improved chullah with metal chimney, India (*source:* (Westhoff et al 1995)

Metal improved stove made by trained craftsmen (Nada Chullah), Haryana, India (*source:* (Westhoff et al 1995)

Improved 'Laxmi' Chullah, Western India. (*source:* (Westhoff et al 1995)

Rocket stoves

So-called *Rocket* stoves are produced in a variety of materials and at a range of scales from artisanal to mass-production (see Figure 13). The design idea for rocket stoves was developed by an NGO based in the USA, Aprovecho, in the 1980s. Their use in many developing countries has shown that more efficiency and cleaner combustion can be achieved as shown in Figure 16.

The principals of rocket stove design are outlined in (Winiarski 2002), see Table 3.

Table 3: Rocket stove design principles

1.)	Insulate, particularly the combustion chamber, with low mass, heat resistant materials in order to keep the fire as hot as possible and not to heat the mass of the stove body;
2.)	Within the stove body, above the combustion chamber, use an insulated, upright chimney of a height that is about two or three times the diameter before extracting heat to any surface (griddle, pots, etc.);
3.)	Heat only the part of the fuel that is burning (and not too much). Burn the tips of sticks as they enter the combustion chamber, for example;
4.)	Maintain a good air velocity through the fuel. The primary Rocket stove principle and feature is using a hot, insulated, vertical chimney within the stove body that increases draft;
5.)	Do not allow too much or too little air to enter the combustion chamber. Strive to have stoichiometric (chemically ideal) combustion: in practice there should be the minimum excess of air supporting clean burning;
6.)	The cross sectional area (perpendicular to the flow) of the combustion chamber should be sized within the range of power level of the stove.
7.)	Elevate the fuel and distribute airflow around the fuel surfaces;
8.)	Arrange the fuel so that air largely flows through the glowing coals;
9.)	Transfer the heat efficiently by making the gaps as narrow as possible between the insulation covering the stove body and surfaces to be heated but do this without choking the fire.

Source: adapted from (Winiarski 2002)

Figure 13: Examples of rocket stoves

StoveTec rocket stove, mass-produced in China (source: http://www.stovetec.net)

Home-made cement and mud rocket stove in production (source: bioenergylists.org)

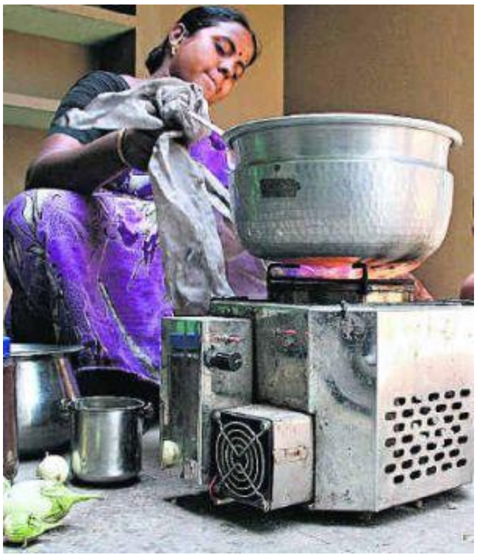
Institutional rocket stove made of bricks (source: bioenergylists.org)

Envirofit, mass-produced rocket stove G-3300 (source: www.envirofit.org)

Advanced biomass stoves

Advanced biomass stoves (ABSs) have emerged in the past decade as a result of scientific research combined with production by large private sector organisations. In general these include a fan to improve combustion efficiency; these fans are either powered by rechargeable batteries or by a thermo-electric device powered from the heat of the fire itself. Such so-called *blower semi-gasifier* *stoves* can achieve very low pollution emissions in the laboratory, with particle emissions less than 10% of those from a traditional fire (Smith 2010).

Figure 14: Examples of advanced biomass stoves



Oorja stove, with built in fan, designed to use biomass pellets made from agricultural waste (originally marketed by BP India, now by First Energy Private Ltd, India) (sources: http://biopact.com/2007/07/revolution-in-kitchen-5000-indian-rural.html and http://firstenergy.in)

Philips fan driven efficient wood-stove (source: http://www.research.philips.com/newscenter/archive/2006/060227-woodstove.html)

The BioLite HomeStove, incorporating fan powered by thermoelectric generator (source: www.biolitestove.com)

Advanced biomass cook-stoves employ sophisticated materials, such as advanced ceramics for combustion chamber insulation, and require manufacturing to tight specifications. Thus they need to be mass-produced. The great advantage of these stoves is that they achieve high combustion efficiency and produce low emissions; hence indoor smoke does not need to be removed to the outside using a chimney (Smith 2010). Some can also burn a variety of biomass from wood to dung, although fuel specifications are more restricted if high performance is to be achieved. Other advantages cited are that ABSs can cook quickly and be presented as sleek, modern, aspirational, consumer devices (Smith et al 2011). However prices are higher than those for rocket stoves, which restricts the markets open to them, in the absence of other forms of financing.

As part of the wider trend towards commercialisation of the cooking sector (Bailis et al 2009), a number of large corporations have engaged in the sector within India, to varying extents and using different technologies and business models. Each of these corporations has developed an ABS model which has the potential to perform to the standard required of the Indian Government (performance matching LPG stoves).

This engagement is relatively recent (within the past 5-10 years). The academic literature has had little to say about emergence of these large corporations in this sector, with the exception of one study published during the development of this thesis (Shrimali et al 2011). This thesis complements this study and contributes to further understanding of this subject.

1.3.2 Performance of cook-stoves

The international cook-stove community is currently discussing development of an agreed standard for improved cook-stoves. Qualitatively it is recognised that high emissions reductions are required from improved cook-stoves (Mehta et al 2012); for example experts have said that reductions of household polluting emissions of at least 90% (compared with a traditional stove) will be necessary (U.S. DOE 2011).

An 'ISO International Workshop on Cookstoves' was convened in the Netherlands in February 2012, with a view to developing an international standard for cook-stoves. One proposal was to rate cooking arrangements on four parameters: fuel use/efficiency, total emissions, indoor emissions, and safety (explosions, burns etc.); total emissions and indoor emissions relate to carbon monoxide (CO) and particle matter ($PM_{2.5}$) which are generally used as proxies for the overall health impact of cooking. The ISO standard for cook-stoves has yet to be finalised, and details contained within the draft standard are highly technical and subject to further change. Nevertheless, tiers of performance have been defined, ranging from Tier 0 (poorly performing traditional stoves) to Tier 4 (aspirational performance levels). According to one possible testing methodology, indoor emissions of CO would need to be reduced by more than 50% to shift from Tier 0 to Tier 4, while indoor emissions of $PM_{2.5}$ would need to be reduced by more than 90% (PCIA 2012).

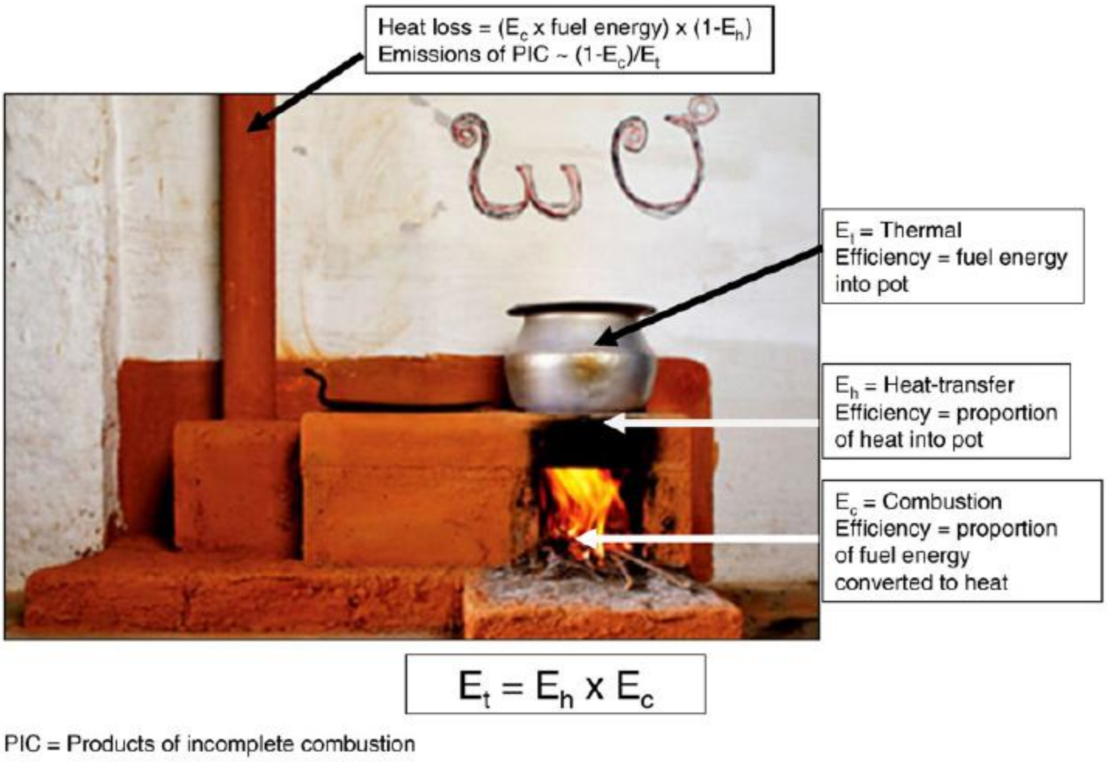
Measuring the performance of cook-stoves is a complex and technical issue. The following provides a summary of the topic, necessary to define, for the purposes of this thesis, what an acceptable improved cook-stove might be. A key complexity is the variation between performance measurements made in laboratory conditions, and performance in real-life situations which is subject to multiple factors in addition to the design of the stove, including behaviour of the cook, fuel composition (eg moisture content) and ambient conditions. Studies in India and elsewhere have shown considerable variation between the performance of stoves in laboratories and in households (Smith et al 2007).

In addition stove use within households is known to decay in performance over time. Technical performance reductions are known to occur due to degradation of materials or distortions in key dimensions, for example the combustion chamber. One study in Orissa found "...*a meaningful reduction in smoke inhalation in the first year*..." but "...*no effect over longer time horizons*..." due to technical degradation and mis-use (Hanna et al 2012, p1); the paper concludes that stoves need to be developed and monitored in real-world settings. The development of one or possibly several "Indian Cooking Cycles", for measuring in-house stove performance, is under consideration as part of the NBCI (Venkataraman et al 2010). Nevertheless, in the absence of a widely agreed protocol for field testing, the most appropriate current method of comparing stove performance is through the use of a laboratory-based protocol, the most common of which is the Water Boiling Test[8]; this specifies testing of stoves using a measured amount of water, with tests being undertaken bringing this water to boil and simmering for a set period (more detail can be found at (PCIA 2011)). A final complexity is whether the improved stove, once adopted is subject to general use, or whether it is only employed for some cooking tasks; the development of low-cost remote stove-use monitoring devices is currently being explored with a view to monitoring actual stove use in households (Ruiz-Mercado et al 2011).

Figure 15 illustrates the relationship between overall (thermal) efficiency of a stove (E_t), the heat transfer efficiency (E_h) and the combustion efficiency (E_c). While improving overall thermal efficiency (E_t) requires improvements in both E_h and E_c, reductions in polluting emissions (Products of Incomplete Combustion – PICs) are strongly affected by improvements in E_c but only weakly affected by improvements in heat transfer efficiency[9]. While improvements in heat transfer efficiency are often associated with enhancement of combustion efficiency, this is not always the case; some early 'improved' stoves actually increased emissions of pollutants by reducing combustion efficiency (Smith 1989).

[8] The laboratory-based Water Boiling Test (WBT) is widely used in conjunction with tests in the field using the Controlled Cooking Test (CCT) and a Kitchen Performance Test (KPT) to measure stove performance.
[9] According to (Venkataraman et al 2010, p66) *"... A 5% increase in combustion efficiency, from 90% to ~95%, for example, would decrease total emissions of products of incomplete combustion by about 50% while increasing overall stove energy efficiency by only about 5%..."*.

Figure 15: Relationship between overall (thermal) efficiency of a stove (E_t), the heat transfer efficiency (E_h) and the combustion efficiency (E_c)



Source: (Venkataraman et al 2010)

Table 4 provides emissions factors for various health damaging pollutants and greenhouse gases for different cooking fuels; it should be noted that these figures do not relate directly to emissions per meal, and consequently to exposure of cooks to different pollutants, due to wide variations in calorific values of different fuels and efficiencies of stoves.

Table 4: Emissions factors for different fuels (g / kg fuel)

	CO	NMVOC	PM	Black carbon (BC)	Organic matter (OM)	CO_2	CH_4	N_2O
LPG	14.9	18.8	0.32	0.01	0.08	3085	0.05	0.15
Kerosene (2)	39.9		0.51			2985	0.7	0.4
Coal	275.1	10.5	17.9	5.42	8.78	2411	7.9	0.24
Kacha koyla	275.1	10.5	17.9	5.42	8.78	2411	7.9	0.24
Fire wood	69	7	3.2	0.6	2.8	1358	5.0	0.09
Cow dung cakes	39.9	24.2	3	0.12	2.5	1046	4.5	0.3
Dust coal	275.1	10.5	17.9	5.42	8.78	2411	7.9	0.24
Saw dust	69	7	3.2	0.6	2.8	1358	5.0	0.09
Jute / agricultural waste	65.6	8.5	6.3	0.6	4.6	1302	7.6	0.05

Source: (Venkataraman et al 2010) except (2) which is from (Venkataraman et al 2010, Smith, Uma et al 2000)

Notes: 1) NMVOC (non-methane volatile organic compounds); PM (particulate matter), 2) as no emissions factors were available for different forms of the coal used for cooking in India, the emissions factor for Chinese coal was used for all three forms of coal fuel

Different fuel/stove combinations are known to result in a range of emissions of health damaging pollutants. Table 5 provides calculated data for emissions of two health-damaging pollutants CO and particulate matter (PM) (Venkataraman et al 2010). While these are only two of many health damaging pollutants released from biomass combustion, they provide convenient metrics for comparison between fuel/stove combinations.

Use of coal with a traditional chullah emits the highest levels of both CO and PM, two orders of magnitude more than the emissions from an LPG stove. Although all are highly polluting (for both CO and PM) in comparison with LPG, there is a range of emissions from different biomass fuels burned using traditional chullahs; from least polluting to most polluting, the ranking is as follows: wood, dung, agricultural residues, coal.

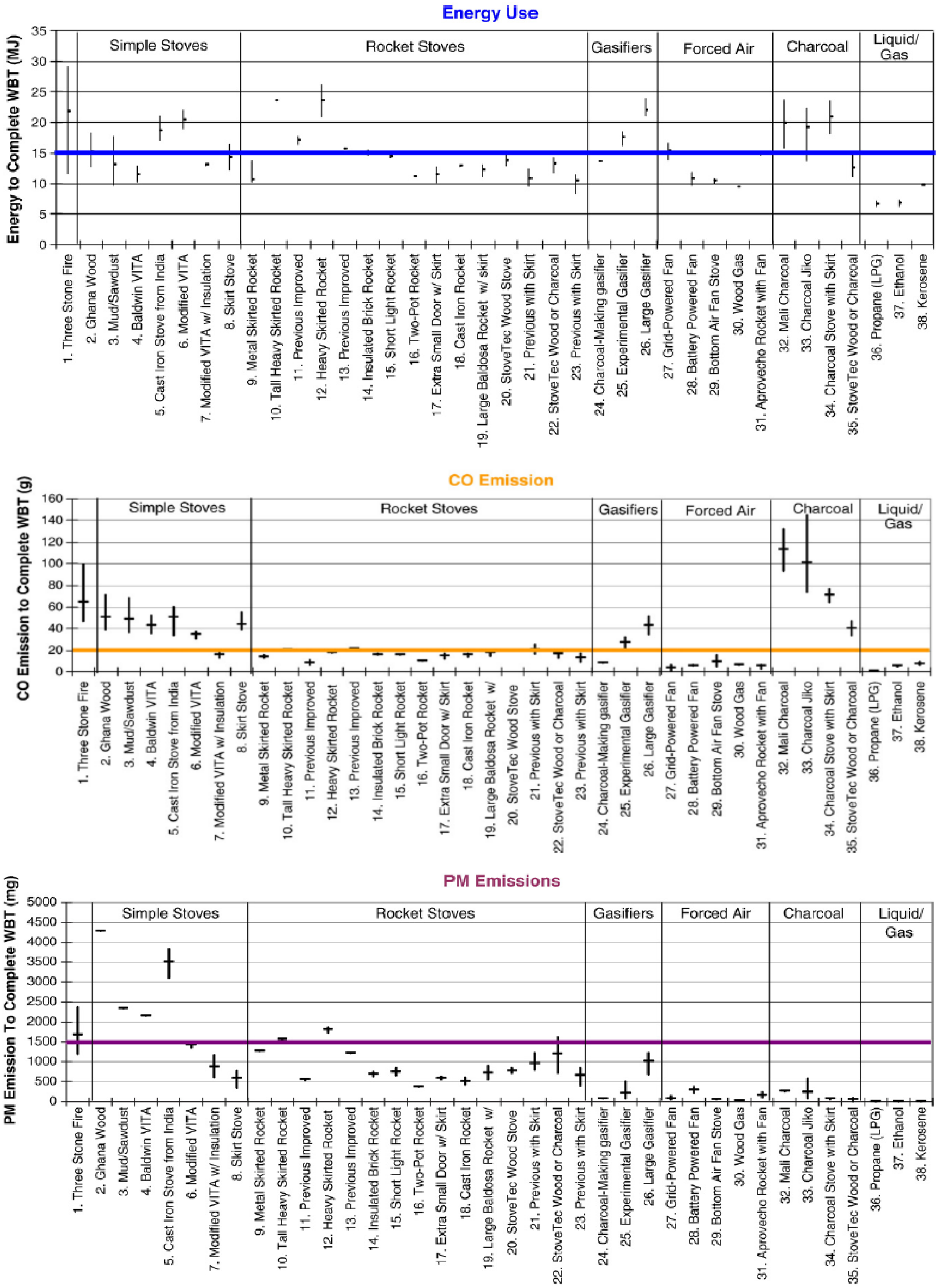
Table 5: Emissions per day for major stove/fuel combinations, assuming 11 MJ/day delivered to the cooking vessel and taking into account stove efficiencies

		Emissions (g/stove-day)			
	Thermal efficiency (%)	CO		PM	
Traditional chullah / wood	18	264	±57	12	±8
Traditional chullah / agro residues	11	410		39	±18
Traditional chullah / dung	10.5	348		27	±17
Traditional chullah /coal	14.3	784		51	
LPG	57	6.3		0.13	

Source: (Venkataraman et al 2010)

Data has been published providing the results of laboratory tests, using the Water Boiling Test (WBT), of the performance of 50 different types of stove (MacCarty et al 2010); note that the tests involved burning wood only unless otherwise mentioned. The summary of results in terms of a) energy use, b) emissions of carbon monoxide and c) particulate emissions is presented in Figure 16. Note that the horizontal coloured lines represent acceptable benchmarks of performance suggested by the authors. The stoves under the *forced air* heading in this figure represent those described above as advanced biomass stoves, while those under the *simple stove* heading are those termed *early, slightly improved cook-stoves*.

Figure 16: Results of testing 50 different stoves



Notes:Tests used the 2003 University of California-Berkeley (UCB) revised Water Boiling Test (WBT) Version 3.0.

Source: (MacCarty et al 2010).

From these results it is clear that it is only the *forced air* (ABS) stoves that perform at or close to the performance of LPG in terms of particulate and CO emissions. In comparison with a three-stone fire, forced air stoves tested reduced polluting emissions (CO and PM) by an average of 90% and fuel use by 40%, while rocket stoves reduced CO emissions by 75%, and PM emissions by 46%, and fuel use by 33% on average (MacCarty et al 2010). While a number of the *simple stoves (early improved stoves)* reduced fuel use compared with a three-stone fire, not all reduced CO and particulate emissions, and some actually increased emissions of these.

1.3.3 Stoves and climate forcing agents

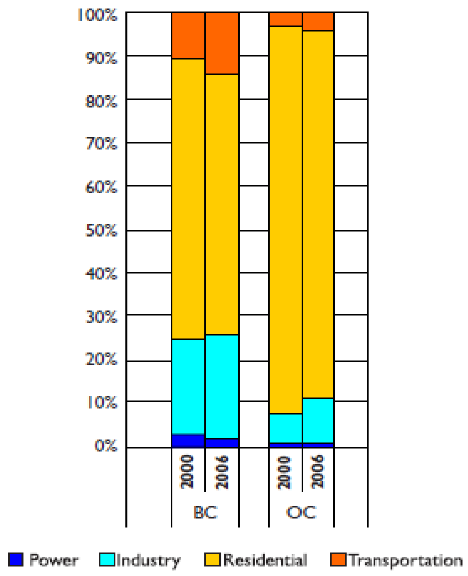
The performance of different stoves has also been reported in terms of greenhouse gas emissions (MacCarty et al 2008, Smith, Uma et al 2000). The quantification of climate forcing emissions from cook-stoves is broadly made up of two components:

1) ***CO_2*** is released when biomass is burned. The net climate forcing effect of CO_2 from cook-stoves depends on the degree to which the biomass is renewable. If wood is gathered from a forest which is maintaining or increasing its quantity of biomass, then the CO_2 released when wood is burned can be assumed to be absorbed by the forest re-growth, and hence net CO_2 emissions to the atmosphere are zero.
2) ***Products of incomplete combustion (PICs)*** are released when combustion in a cook-stove is incomplete. As well as many of the PICs being health damaging pollutants, many are also greenhouse gases. Those PICs which also have a climate forcing effect can be divided further into two groups:

   - Gases such as CH_4, CO and non-methane hydro-carbons (NMHC). These have 100-year global warming potentials (GWP) of 25, 1.9 and 12 respectively (MacCarty et al 2008); nitrous oxide is also present in biomass combustion emissions;

   - particulate matter, made up of soot, so-called *black carbon* or *elemental carbon*, and organic matter. The climate forcing mechanisms of these species are highly complex and there continues to be scientific uncertainty concerning the global warming potentials of these particulate emissions (USAID 2010, Ramanathan 2008). One study reports that "...*Emission inventories suggest that household emissions account for about two-thirds each of Asia's anthropogenic black and organic carbon emissions*..." (USAID 2010, p13). Black carbon has a positive climate forcing effect by both absorbing radiation in the atmosphere, and reducing the albedo of glaciers when it deposits on them. It has been estimated that "...*emissions of black carbon are the second strongest contribution to current global warming, after carbon dioxide emissions*..." and that 25-35% of atmospheric black carbon derives from India and China (Ramanathan 2008, p221). Figure 17 shows that the majority of Asian black carbon emissions are from residential sources (ie cooking and heating). Due to the short residence time in the atmosphere, reducing black carbon emissions has been proposed as a potential quick win in terms of climate mitigation (USAID 2010). Despite the scientific uncertainty, for the purposes of this research the Global Warming Potential (GWP) values quoted in (MacCarty et al 2008) are used: 100-year GWP of black carbon is 680, while the 100-year GWP of organic matter is -50 (a cooling effect). Thus the overall climate forcing impact of particle emissions from any specific source depends on the ratio of black carbon to organic matter.

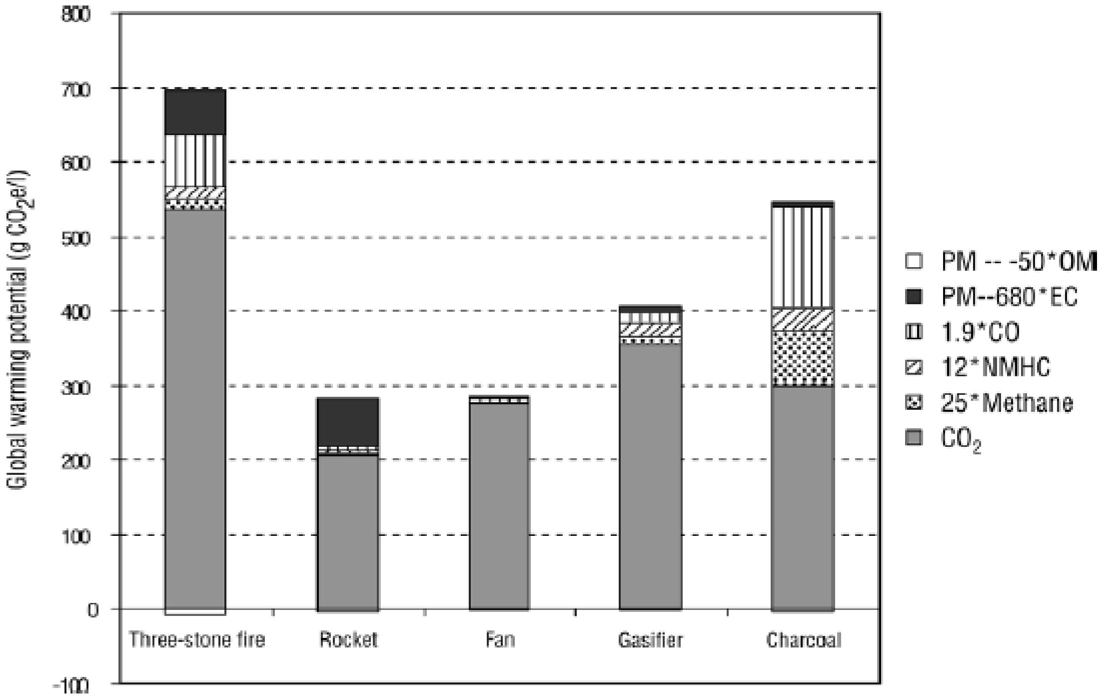
Figure 17: Share of emissions of black and organic carbon from contained combustion in Asia by major sector in 2000 and 2006



Source: (Zhang et al 2009)

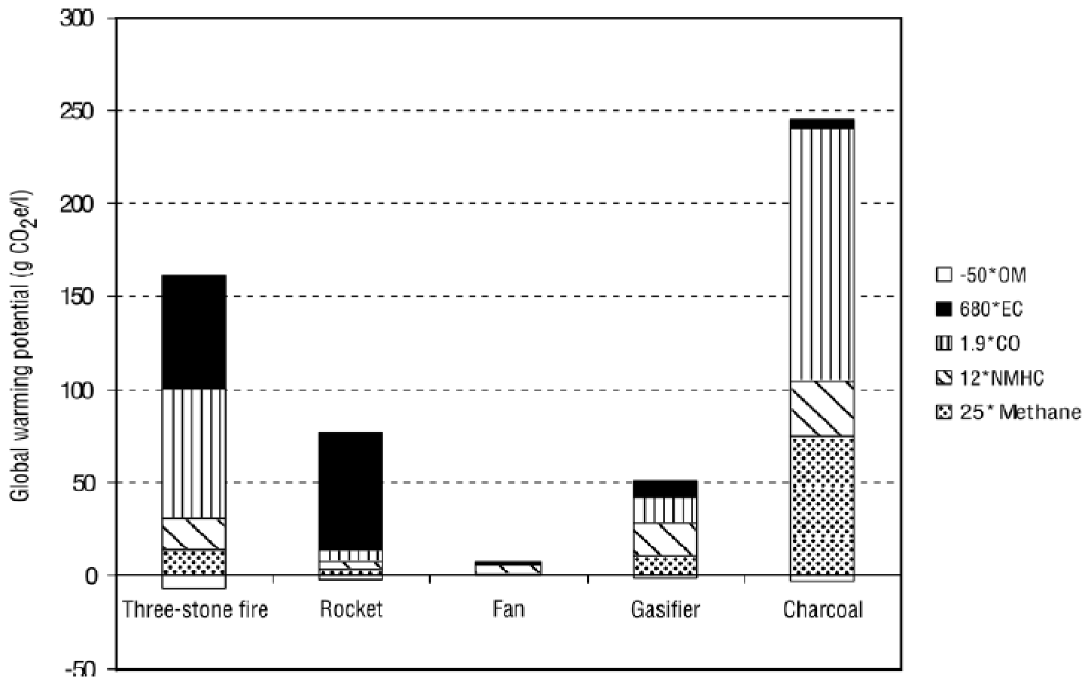
Using the modified University of California at Berkeley (UCB) 2003 water boiling test (WBT) (Bailis et al 2007) four wood-burning and one charcoal burning stove were tested for climate forcing emissions (MacCarty et al 2008). The wood stoves tested included a traditional three-stone fire, a rocket stove, a fan stove (advanced biomass stove) which in the case of these tests was a prototype stove designed by Philips, and a gasifier stove. The summary of results – showing the relative climate forcing effect of the different stoves in grammes CO_{2e} per litre of water boiled and simmered for 30 minutes - are summarised in Figure 18 and Figure 19. The former shows total climate forcing emissions, including CO_2 and assumes that none of the CO_2 emitted is reabsorbed (ie the wood source is totally *non-renewable*). The latter shows only the emissions of PICs, assuming that all the CO_2 emitted is reabsorbed (ie the wood source is totally *renewable*).

Figure 18: Total global warming impact of different stoves



Notes: 1) Results in grammes CO_2 equivalent on a 100-year time-frame, per litre of water boiled and simmered for 30 minutes, normalized for starting temperature and fuel moisture content. Inclusive of CO_2 and all PICs. 2) OM = Organic Matter, PM = Particulate Matter, EC = Elemental Carbon. 3) Numbers in right hand key are Global warming potential as 100-year CO_2 equivalent. (source: (MacCarty et al 2008)*)*

Figure 19: Global warming impact of different stoves (products of incomplete combustion only)

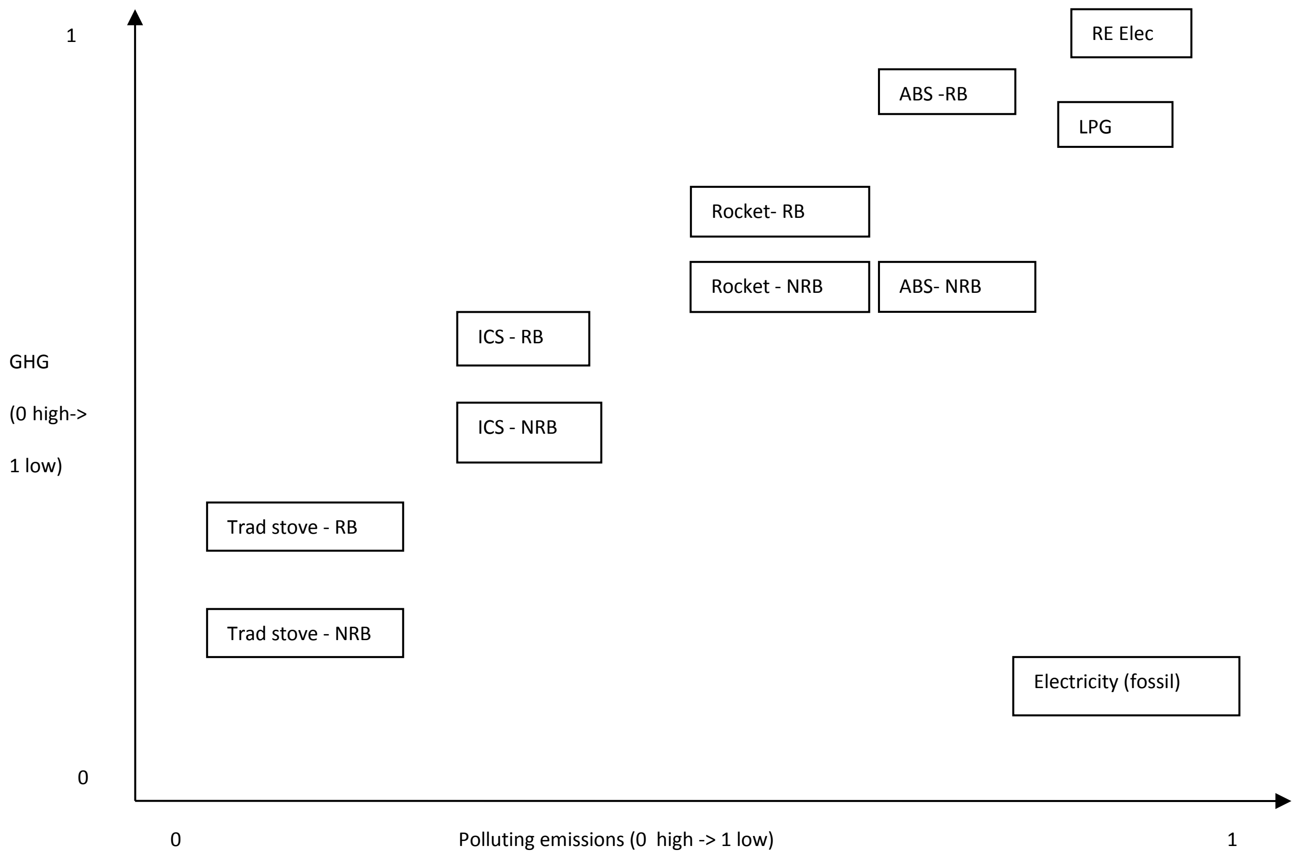


Notes: Results in grammes CO_2 equivalent on a 100-year time-frame, per litre of water boiled and simmered for 30 minutes, normalized for starting temperature and fuel moisture content (source: (MacCarty et al 2008)*)*

The laboratory results showed that in situations of unsustainable harvesting of wood (ie 100% non-renewable wood), the rocket stove and fan stove (ABS) produce roughly the same climate forcing effect, with reductions of roughly 60% compared with a traditional three-stone fire. In situations where the wood is sustainably harvested (ie 100% renewable wood) the rocket stove reduces climate forcing by approximately 50% while the fan stove achieved reductions of around 95%. The degree to which wood harvesting is renewable or not clearly varies geographically, and no generalisation can be made.

Figure 20 shows conceptually the performance of different cooking arrangements in terms of household polluting emissions and greenhouse gas emissions. Overall the conclusion from the tests of health-damaging pollutants and climate forcing emissions is that while rocket and ABS stoves can achieve reductions of both in the laboratory, the ABS stoves are the only ones that achieve reductions in polluting emissions to levels close to those of LPG stoves. In addition in situations of sustainable harvesting of wood, the ABSs produce much larger relative reductions in climate forcing emissions. As discussed above, it is important to stress that these tests, produced in the laboratory under controlled conditions, do not necessarily represent the reality in household kitchens (Hanna et al 2012); currently there is insufficient experience with ABSs in practice to determine their actual performance over time.

Figure 20: Conceptual characterisation of the indoor air pollution and greenhouse gas emissions from different solid fuel stoves



Notes: NRB = non-renewable biomass; RB = renewable biomass; ICS = improved Cook-stove; ABS = advanced biomass stove; RE = renewable energy.
Source: the author

1.4 Socio-economic and environment impacts of cooking

1.4.1 Cooking – a major public health issue

There is current no internationally agreed standard defining safe levels of exposure to indoor air pollution. However very detailed technical guidelines have been produced by the international community, with a view to working towards an agreed standard (WHO et al 2010). Emission levels from traditional cook-stoves are known to exceed WHO guidelines by orders of magnitude (WHO 2005).

The human consequences of traditional cooking practices in the developing world have been heavily researched and documented in the past decade. In particular the public health consequences of indoor air pollution from solid fuel cooking have been presented inter-alia by (Wilkinson et al 2009, Smith et al 2007, Dherani at al 2008, Smith et al 2003). However, the precise nature of the *dose-response* relationship between levels of exposure to indoor air pollution and health impacts still requires further research, and is the subject of current longitudinal studies, including in Guatemala (RESPIRE, a Randomized Intervention Trial). Despite this uncertainty, evidence is increasing that the safe level of exposure to indoor air pollution is very low, and the "...*drop off in health impacts is significant even down to low levels of exposure*..." (Venkataraman et al 2010, p64); in other words the safe level of indoor air pollution is thought to occur at a very low level of emissions.

WHO has estimated that 1.6 million premature deaths resulted, in 2000, from exposure to indoor air pollution from solid fuel combustion from cook-stoves, 2.7% of the global burden of disease (WHO 2006a). In addition to deaths, WHO reports that around 33 million *disability adjusted life years (DALYs)* result from exposure to indoor air pollution in low income countries, highlighting the significant contribution to morbidity as well as mortality. It has been reported that the cost of this disease burden globally ranged between US$212 billion to US$1.1 trillion (Sovacool 2012, United Nations 2010).

The main health impacts of exposure to indoor air pollution include acute lower respiratory tract infections such as pneumonia, ischaemic heart disease and chronic obstructive respiratory problems (Wilkinson et al 2009, Smith et al 2007, Dherani et al 2008, Smith et al 2003, Haines et al 2009). In addition adverse pregnancy outcomes and poor foetal development in utero, including under-weight babies, have been reported as associated with exposure to air pollution from cooking (Sram et al 2005). While medical correlations are hard to determine, it is reported that one "...*study, done in Ahmedabad, found an excess risk of 50% of stillbirth among women using biomass fuels during pregnancy*..." (reported in (Smith 2000, p13290)).

Much of the burden of disease is carried by women and children who are the most exposed to fumes from biomass cookers. It has been reported that annually indoor air pollution is associated with nearly 900,000 deaths among children under five as a result of pneumonia (WHO 2006a). Highlighting the gender inequity in terms of exposure to health hazards, it is reported that women over 30 years old have a relative risk of contracting chronic obstructive pulmonary disease (COPD) from exposure to household air pollution of 3.2, while the comparable figure for men is 1.8 (WHO 2011).

Of total annual deaths attributable to indoor air pollution globally it has been estimated that 407,000 occurred in India in 2002 (Gopal Raj 2007). Analysis by the WHO shows that indoor air pollution is associated with 8 DALYs/1000 population/year, which compares with a figure for diarrhoea from poor water, sanitation and hygiene of 14 DALYs/1000 population/year, and with disease from outdoor air pollution of 1 DALYs/1000 population/year (WHO 2009). Table 6 provides further detail on the burden of disease in India from indoor air pollution.

Table 6: Burden of disease in India due to indoor air pollution from solid fuel use for the year 2002

Percentage of population using solid fuels	ALRI deaths attributable to solid fuel use (<5 years)	COPD deaths attributable to solid fuel use (≥ 30 years)	Lung cancer deaths attributable to coal use (≥ 30 years)	Total deaths attributable to solid fuel use*	Total DALYs attributable to solid fuel use	Percentage of national burden of disease attributable to solid fuel use
82	251,560	155,250	340	407,100	10,646,500	3.5

Notes: ALRI = Acute Lower Respiratory Infection; COPD = Chronic Obstructive Pulmonary Disease
Source: (Winiarski 2002) *and* (WHO 2007)

In addition to the health impacts resulting from exposure to household air pollution from traditional stoves, there are a number of other impacts on the health of women and children. The daily drudgery associated with the carrying of heavy fuel-wood loads can result in physical injury (Bryceson et al 1993). Given the fact that traditional fires are open and often in the main living space, burns from contact with traditional fires are frequent, in particular for small children; the author has witnessed the resulting injuries within several Nepali villages. The collection of wood also exposes the gatherer to natural hazards, including attack by snakes and wild cats. Finally in certain areas, for example around refugee camps in areas of conflict such as Darfur, collection of fuel wood exposes women to sexual attack (Gaye 2007).

A thought experiment has been developed in which a 10-year programme in India (2010-2020) introduces 150 million advanced biomass cook-stoves (Wilkinson et al 2009). By 2020 the health benefits resulting are projected to be "…*averted premature deaths from acute lower respiratory infections will have reached about 240,000 children aged younger than 5 years, and more than 1.8 million premature adult deaths from ischaemic heart disease and chronic obstructive pulmonary disease (COPD)*…" (Wilkinson et al 2009, page 1925).

Increasingly it is understood that deep emissions reductions are necessary to achieve significant health benefits and meet the levels of indoor air pollution suggested in the WHO guidelines (Venkataraman et al 2010). The Global Alliance recently reported that the *"…(e)xisting body of evidence suggests that to achieve powerful reductions in child pneumonia…stoves and fuels must have very low indoor emissions*…" (Mehta et al 2012). In lieu of a decision regarding a recognised stove standard, discussed above, it is assumed within this thesis that, for cooks using solid fuels, ABSs are required to achieve necessary health improvements.

1.4.2 Other social and local environmental impacts of cooking

Despite the fact that energy was not represented by one of the Millennium Development Goals (MDGs), access to energy is generally understood to be one of the necessary conditions for achieving the MDGs (Modi et al 2006, Bardouille 2004). This importance has been emphasised recently through the launch of the UN Secretary General's *Sustainable Energy for all* Initiative in 2011. More specifically the links between cooking and achievement of the MDGs has been recognised within the international community. In addition to the health impacts on women and children, one report highlights the need to improve cooking in developing countries in order to achieve MDGs on gender equality and universal education (WHO 2006b). Linking MDGs on universal education and gender equality with cooking, the report recognises that children, together with women, spend much time collecting cooking fuels, time that could otherwise be spent going to school or in other productive activities.

Gathering of fuel is a source of daily drudgery heaped upon billions of people, especially women and children. The amount of time spent each day collecting fuel varies depending on local geography; it has been estimated that the average time spent per day collecting fuel in India is one hour (ESMAP 2002), although is known to vary from between zero (for those buying fuel, delivered to their door) to four hours or more per day. Use of improved stoves can reduce the burden of time both by reducing the amount of fuel needed and by reducing cooking time. Economic valuations, used to assess the value of time savings achieved by switching to improved biomass stoves or from biomass to LPG, have shown economic benefits of around US$30 per household per year (The World Bank 2011). While this is a useful indicative value, being of the same order as the cost of some advanced biomass stoves, it is generally the case that women's time is not valued as an economic asset by policy makers in developing countries.

In the 1970s and to some extent the 1980s, many cook-stove programmes were driven by the key objective of reducing wood-fuel use to reduce deforestation. However more nuanced analysis has shown that in many cases cooking is only one source of forest degradation, and probably only a minor one in comparison with expanding agriculture, human settlements and timber production (Arnold et al 1999). The wide-spread acceptance of the so-called *gap theory* (gap between biomass use and re-growth) in the 1980s assumed that biomass was the principle cause of deforestation; however this theory has since been discredited as overly simplistic and resulting in mis-informed policy prescriptions (Mearns et al 1989). This *gap theory* was supported by analysis that attempted to measure consumption of fuel wood and compare this with the standing stock and annual growth of trees. This in turn led to the conclusion that the difference between supply and demand for wood-fuels would rapidly result in the total destruction of the forests in Africa and South Asia. However such analysis has since been shown to represent reality poorly. This is due to its overly geographical aggregation of data and lack of understanding of the actual fuels being used by the rural poor in particular, which include dung and dead twigs, neither of which contribute to deforestation; for a further discussion of this complex issue see (Leach 1987). While it is certainly true that the collection of biomass for cooking fuel causes pressure on forest resources in some areas – for example in charcoal producing areas supplying urban centres – the actual extent of forest degradation due to cooking fuel collection is highly context specific.

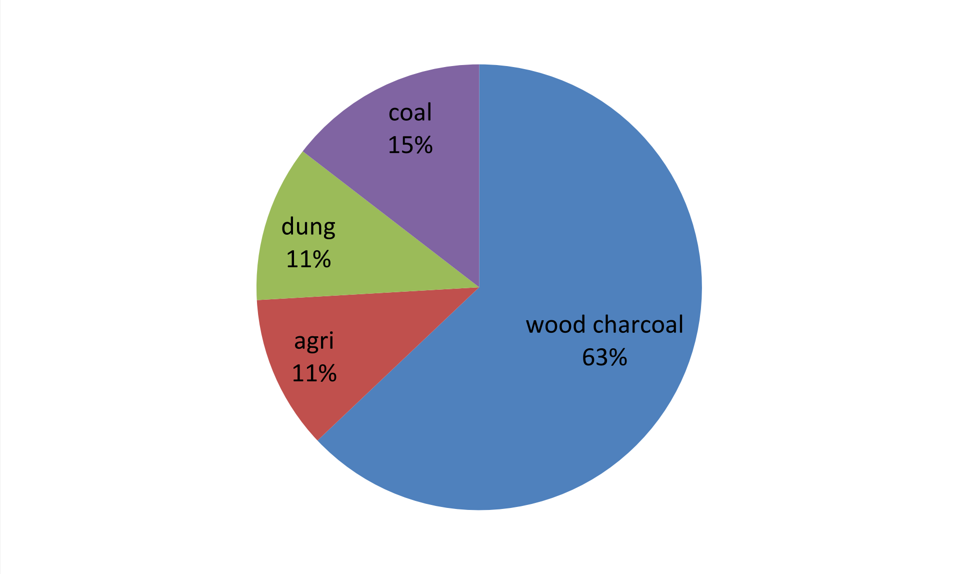
The emission of particles and other pollution has environmental impacts beyond the household. The Asian Brown Cloud is made up of black carbon and other particles from a variety of sources. One source reports that cooking is the dominant source of the Asian Brown Cloud (Biello 2007) which has local environmental and health impacts as well as acting as a climate forcing agent as discussed above.

1.4.3 Cooking and climate change

At the other end of the geographical spectrum, cooking produces environmental impacts at the global level, contributing to climate change through the emission of greenhouse gases as well as particles including 'black carbon'. The complex mechanisms by which cooking contributes to climate forcing are outline in section 1.3.3 above. Variations in this climate forcing due to the geographical and socio-economic context make an estimate of global climate forcing from cooking difficult to ascertain. One of the most complex issues is the degree to which biomass is harvested sustainably. Making the assumption that 10% of the cooking biomass fuel in India is non-renewable, (Venkataraman et al 2010) estimates that the emissions from solid fuel cooking annually in India are around 80 million tonnes CO_{2e}[10] or around 4% of national greenhouse gas emissions.

[10] Note that these figures are derived from (Venkataraman et al 2010) Table 4, page 69.

Figure 21: Breakdown of total greenhouse gas emissions from solid fuel cooking in India (CO_2, CH_4 and N_2O only, assuming 10% non-renewable biomass)



Source: Figures derived from (Venkataraman et al 2010) *Table 4, page 69*

Note that if it were assumed that 40% of biomass cooking fuel was non-renewable, the emissions from solid fuel cooking in India would leap to 175 million tonnes CO_{2e} annually, or nearly 9% of India's emissions of Kyoto greenhouse gases, highlighting the importance of the biomass renewability variable, for which estimates are highly uncertain. These estimates include only those greenhouse gases within the Kyoto Protocol (CO_2, methane and N_2O) and not black carbon, carbon monoxide and non-methane organic compounds. The estimates are thus likely to significantly under-represent the climate forcing impact of cooking.

1.5 Cooking and carbon offsets

1.5.1 Cook-stove carbon offsets and development

The range of scales of the impacts of traditional cooking – spanning from the level of individuals to the global atmosphere – represents a challenging theoretical and practical problem for analysts and researchers. At the same time a convenient synergy presents itself; most activities to improve cooking practices from a human development perspective, also reduce emissions of greenhouse gases, thus presenting the possibility for improving public health while generating 'carbon offsets', a win-win scenario (Simon et al 2012). The emergence of carbon offsets suggests an increasingly complex set of governance processes, whereby states and corporations are joined by an array of actors at different levels, including international organisations, donors, financial institutions, cities and other civil society players, in a complex web of governance relationships (Bulkeley et al 2010).

The introduction of carbon finance into the cook-stove sector brings about interactions between two very different sectors – climate mitigation and development – with objectives which sometimes offer each other *mutually supported benefits*, that is striving towards the objectives of one will support achievement of objectives in the other. However a number of *mutually supported impediments* have also been identified in a paper to which the author contributed (Simon et al 2012); both are summarised in Table 7.

Minimising *mutually supported impediments* while maximising *mutually supported benefits* will require a nuanced analysis of carbon offset cooking projects, avoiding the assumption of automatic *win-win* scenarios in all cases. In order to achieve this there is recognised to be a need for *"...further scholarly and practical engagement to tackle the many outstanding challenges and uncertainties.... Firstly, the connection of Southern communities to carbon finance, financiers and, ultimately, carbon emitters buying carbon credits, opens up important possibilities for scholars to examine stoves by engaging scholarship on the scalar politics of climate mitigation (Betsill & Bulkeley 2005), capital flows for 'clean development' (Newell et al 2009; Bumpus 2011), and long standing debates on market based development intervention (Bailis et al 2009; Simon 2010*)..." (Simon et al 2012, pp275-285).

Table 7: Mutually supported benefits and impediments for carbon financed cook-stoves

	Development	Climate
Mutually supported benefits	1. GHGs emission reductions from improved stoves coincide with decreases in harmful indoor air pollutants. 2. Emissions accounting through monitoring and ex-post verification can double as follow-up maintenance visits. Routine up-keep extends stove use longevity. Consistent stove use increases scope of development benefits. 3. Carbon financing can provide partial stove cost offsets for households and/or commercialization of local stove production, thus lowering stove purchase price and providing market access to poorer households. Affordable technologies are required to increase distribution of household benefits.	1. Through technology design attributes, smoke abatement and curtailment of other pollutants occurs together with GHG emissions reductions. 2. Dedicated and long-lasting stove use is required to optimize size and duration of GHG emissions reductions. Carbon financiers and monitoring agencies will view dependable emission reduction favourably. 3. Increased use of efficient stoves reduces overall GHG emissions and also consumption of non-renewable biomass (decreases deforestation – thus increasing levels of forest carbon sequestration).
Mutually supported impediments	1. Distribution scale-up under carbon financing is pursued in order to generate sufficient GHG reductions and implement straightforward emissions accounting procedures – both of which are required to attract investors. Distribution economies of scale and technology standardization may be ill equipped to satisfy diverse household requirements, leading to the allocation of inappropriate stoves and to continued levels of indoor air pollution.	1. Development objectives requiring nimble stove distribution and household sensitive technology applications may be impeded under distribution scale-up. Consequently, the distribution of stoves that are incompatible with household level practices can decrease the rate and longevity of household stove use, thus dampening overall levels of GHG emissions reductions.

Source: (Simon et al 2012)

Secondly the need for additional grounded analysis of carbon offset projects is required to "...*further explicate specific programmatic, institutional and intra-partnership conditions that hinder and enable acceptable carbon financing and scale up outcomes for individual households and investors alike...*" (Simon et al 2012, p285). It seems clear that, as a minimum, those involved in monetising carbon offsets require a thorough understanding of the practices, attitudes and beliefs of the cooks themselves, as well as ensuring the development of processes whereby those cooks can exert sufficient influence and agency within the governance of offsets.

It has been argued that "...*if significant resources are to be devoted to mitigating climate change, then why not spend them first on projects where significant co-benefits accrue, particularly to the* *poor?..."* (Smith 2010, p252). While fully valid, it is further argued within this thesis that the raison d'être of cook-stove programmes should remain clearly focussed on human welfare, in particular public health, and not on climate mitigation per se. In addition to a moral argument for focusing on improving public health as the primary objective, there is a practical purpose to having a clear, single, policy focus. To paraphrase Professor Paul Collier (speaking about the Tinbergen's Rule[11] during Oxford University Social Science Lecture Series, 18th November 2010): almost always when people think they can tackle two policy objectives with one policy instrument they are being ideological, and policies adopted will fail to meet either objective properly. Within this research carbon offsets are thus seen as a potential means to an end, presenting the possibility of providing an additional funding stream to increase the uptake of improved cook-stoves, in order to improve public health.

1.5.2 Cook-stove carbon offsets in practice

Section 1.3.3 indicated the emissions of greenhouse gas emissions from various stoves, highlighting the potential for creation of a carbon offset revenue stream through the adoption of improved stoves. It has been estimated that if all of the greenhouse gas emissions from cooking in India – 80 million tonnes CO_{2e}, including CO_2, methane and N_2O only, not particles or other greenhouse gases – were eliminated the savings would be worth around US$1 billion/year (£620 million per year) on the international carbon market (Venkataraman et al 2010)[12].

It is reported that CDM cook-stove projects in the pipeline are claiming between 1 and 3 tonnes of CO_{2e} per stove per year (Bailis et al 2011). Assuming a price of carbon offsets of €5 per tonne CO_{2e} and the more conservative and realistic savings quoted by (MacCarty et al 2008) of 0.5 to 1.5 tonnes CO_{2e} per stove per year, the potential financial benefits are worth between €2.5 and €7.5 per stove per year, or between €17.5 and over €50 over the 7-year crediting period common for offset

[11] Named after Jan Tinbergen (1903–1994,Nobel Prize 1969), Tinbergen's Rule sets out that policy makers need exactly the same number of instruments as the targets in (economic) policy they wish to attain. (Source: An Eponymous Dictionary of Economics)

[12] Note that at current prices of around £2.4/tonne CO_{2e} the value would be more like £200 million per year (US$300 million per year) (www.pointcarbon.com, July 2012)

projects. These figures are of the same magnitude as the costs of advanced biomass stoves, highlighting a potentially significant financing resource for the sector. A number of organisations have developed cooking carbon offset activities in both the voluntary and compliance markets, as discussed in (Simon et al 2012).

While still nascent in nature, carbon finance for cook-stove projects and programmes thus presents the potential for considerably increased financial flows, potentially filling the gap between what users are able/willing to pay for improved stoves and what advanced, modern stoves cost. However the scale of cook-stove carbon offset projects and programmes is not yet at a level to compare with the magnitude of the challenge in India, and significant barriers remain to exploiting the carbon value of improved cook-stove projects. One key issue remains the degree to which cooking carbon offset activities achieve equitable results, by reaching poor households. To support understanding regarding equity in this sector, Chapter 4 explores the distribution of greenhouse gas emissions from houses in different socio-economic groups. Attempts at applying carbon offsets to cook-stove projects by corporate entities are discussed in Chapter 6 and recommendations for the future of cooking carbon offsets are presented in the final chapter of the thesis.

1.6 Defining and quantifying a transition to clean cooking in India

For the purposes of this research a *transition* to clean cooking is defined as a transformative change within the cooking system such that high performance technologies are being adopted. Furthermore, for a transition to have been achieved:

1) Once adopted the new stoves are continually used, maintained and replaced with those of similar or higher performance at the end of their working lives. The ways cook-stoves are employed in practice is critical to long-term success; it has been identified that improved cook-stoves often do not perform as well in the field as they do in the laboratory (Venkataraman et al 2010), or are not used to the extent previously thought once adopted (Hanna et al 2012);

2) More generally the rate of adoption of these technologies continues to expand such that - given reasonable assumptions about turn-over – the new technology is near universal within a specified period.

This definition begs the question: what is defined as *high performance?* This research takes the stance that the key metric of interest is the level of reduction in indoor air pollution to improve public health. It is assumed that the standard required by the Indian Government, under the nascent upcoming National Biomass Cook-stove Initiative (NBCI), will be for solid fuel cook-stoves to match the performance of LPG stoves in terms of emissions of health damaging pollutants (MNRE 2009, Venkataraman et al 2010). As discussed above, this implies reductions in emissions of indoor air pollution of the order of 90% compared to traditional stoves. In practice, from the current state of knowledge reviewed above, it is assumed within this thesis that those using solid, traditional fuels will need to switch to the use of ABSs.

However, assuming that these stoves involve centralised and sophisticated manufacture, this stance is controversial and runs counter to the thinking of some important mainstream practitioners in the sector. For example, the German development agency GIZ runs the largest donor cook-stove programme in the world (GIZ 2011), basing its programme model predominantly on stoves (eg rockets stoves) made locally by artisans or in small manufacturing units, on the premise that they are affordable to poor users without end-user subsidies and that their manufacture adds value to the local economy (Pers. Comm, Dr Marlis Kees, 2012). This approach is considered fully valid, and the assumption taken for the purposes of this research is that while ABSs are the desired end-point, the route to their adoption for many individual households may well be through an intermediate solution, for example rocket stoves. In addition the assumption that ABS stoves will perform well in the field could legitimately be challenged, as unrealistic. However the assumption made here is that, if not already achieved, the considerable research and technology development activities underway will soon result in ABSs which perform in the field.

In terms of transition paths and end-points, (Venkataraman et al 2010) assumes 160 million improved stoves will be required for universal adoption of clean biomass cooking in India by 2020. This differs from the figure quoted above (142 million households using solid fuel) chiefly because it includes all those households using solid fuels, not only as their primary fuel, and also makes assumptions about replacements of ABSs during the period. As highlighted above, low and middle income rural households will make up a large proportion of the population requiring shift to improved cooking - 49.3 and 67 million households respectively, including dung users.

The period over which universal access to clean cooking should be achieved has not been defined by the Indian Government. However the UN Secretary-General's Sustainable Energy for All Initiative has promoted the target of achieving universal access to modern energy services (including cooking) by 2030, as one element of the UN International Year for Sustainable Energy for All in 2012. Thus the period of transition to clean cooking in India to 2030 seems appropriate.

The path between the current, baseline situation, and the desired transition end-point, can take a variety of different trajectories. From a technology adoption perspective, the transition for individual households could involve a switch from the current traditional or early improved stove, to a rocket stove, and later to an advanced biomass stove (ABS) over a period of, say, 10 years; alternatively with appropriate policy measures leap-frogging straight to ABS might be achieved.

From a policy and programme design perspective, two broad paths are possible. The first involves following a purely market-driven route, implying that only the middle and high income groups will adopt the more expensive ABSs in the early stages, while poorer households proceed via an intermediate solution; under this model it might be assumed that mass adoption of ABSs by the richer households would subsequently lead to price reductions, allowing adoption by the poorer households. However given the extreme price sensitivity known to exist within Indian households, it is thought unlikely that this model would lead to mass adoption of ABSs in the time period required. The second route, by which targeted subsidies are provided to support adoption of ABSs by poorer households, might be the only way to achieve universal adoption of ABSs by 2030 and thus achieve an equitable transition.

1.7 Scope, assumptions, research questions, research design and methodology

1.7.1 Scope and assumptions

The primary focus of the research, in terms of target population, are those households currently using solid fuels in poorly performing stoves, the majority of which are low and middle income rural households. Households using solid fuel as both a primary and secondary source of cooking are included. The research assumes that the required transition involves a switch for these solid fuel users to ABSs by 2030.

The research focuses on domestic cook-stoves only and not those used within commercial kitchens. Neither are other, equally valid, approaches to reducing domestic household air pollution analysed, such as fuel management practices (eg splitting wood into small sticks and ensuring it is dry), house design as a strategy to reduce exposure to pollutants, and changes to everyday activities such as keeping children away from cooking areas where possible, using pressure cookers and thermos flasks (GIZ 2010).

The cooking sector now involves a multiplicity of actors, operating at a wide range of geographical scales, with an array of interests and objectives, and with very different levels of access to financial, institutional and intellectual resources. The cooking system includes inter-alia: cooks and households; communities and local civil society actors; local private sector operators and administrators; national administrations; international donors; and – recently – international actors in the form of large corporations, carbon prospectors and various international partnerships. A wide range of issues could legitimately be studied in order to achieve the research objective, from technology development, policy design, financing schemes (including carbon offsets), governance, private sector and civil society engagement, technology adoption and user practices.

This research takes as a starting assumption that ABS stoves, meeting the performance requirements, are currently available or soon will be. As discussed above, this point is debatable and depends on verification of currently available ABS performance in the field see (Venkataraman et al 2010, Hanna et al 2012). The research does not investigate technical design considerations of ABSs, although this is recognised as an essential avenue for future research. However the processes involved in technology design are included within the scope, in particular the extent to which cooks are involved in these processes, as are issues concerning acceptability of ABSs to cooks.

1.7.2 Research question

In order to achieve the objective of the research - to contribute insights into how to achieve an equitable transition to mass-scale adoption and use of improved biomass and solid fuel cook-stoves in India, for the primary purpose of reducing exposure to household air pollution - the following central research question is posed:

"*What insights can be drawn from analysis of past cook-stove programmes, the practices of cooks and the recent activities of large corporations in the sector, and how can these insights be used to enhance policies, institutions and governance to improve prospects of a future equitable transition to clean cooking?"*

1.7.3 Research design, methodology and methods

The research question posed is broad and normative in nature, specifying a desired future; this stance reflects the researcher's background in development policy and as a practitioner. However in attempting to answer questions about the future, this research can rely only on data from the past and present. At the start of the research some consideration was given to building a model which would be capable of *predictive* power, developing scenarios concerning possible cooking futures in India using different assumptions. However while many past efforts at economic modelling of cooking in India have provided valuable insights(for example see van Ruijven et al 2011, Kavi et al 2007, Kumar 2007, Gupta et al 2006), the economic frame was considered too limited to answer the broad research question posed. Consideration of *agent-based modelling* was also considered but rejected as being unrealistic given the complexity of the issue, poorly parameterised processes, and lack of suitable data.

It was concluded that attempts at modelling and prediction would not be possible given the high degree of complexity, multiple actors and influences involved, and consequently the impossibility of fully representing the complex web of causal relationships. Instead it was decided that analysis of key variables, actors and linkages between them, would represent a more realistic research approach. Thus a mixed methodology was developed, in order to improve understanding of some of the actors and the relationships within the overall cooking system. This approach was developed within an inter-disciplinary frame for the research, with the aim of employing natural science, social science and economic approaches for the question in hand; this approach reflected the nature of the problem, as well as the financial support provided for the research by UK Economic and Social Research Council (ESRC) and Natural Environment Research Council (NERC)[13].

The choice of research elements needed to reflect a balance between the ideal - a wide and deep coverage (of issues, geographical scales and actors) - and the pragmatic, in particular what was feasible in terms of data collection and analysis. In principle the final choice was guided by a number of criteria including: a) the relative importance (weight) of issues and actors with respect to the research question posed; b) gaps in existing research and knowledge and c) the availability and accessibility of data. The first criterion is acknowledged to be subjective in nature, and its assessment was based on the accumulated knowledge of the author. It is also acknowledged that the choice of research elements, in practice, evolved, and was iterated, over the period of the research guided by the over-riding issue of data availability. An early decision to have a central focus on carbon offsets, was reversed, due to the subsequent publication of a number of research articles on the topic, including one co-authored by the writer of this thesis (Simon et al 2012), the ongoing

[13] The research was funded through a joint ESRC/NERC Studentship.

interregnum with the carbon markets, and the recognition that other more fundamental issues within the cooking sector could more usefully be researched; carbon offsets are included however within some of the empirical chapters, as well as the concluding chapter. The result was a decision to focus on two sets of actors, namely cooks and large corporations engaging in the cooking sector in India, while acknowledging that this did not represent complete coverage of the key elements of the cooking system.

The study of cooks at the household level was chosen, given their self-evident centrality to the research question at hand and strong evidence from multiple researchers and practitioners that analysis of their activities, needs and desires has been too limited in the past and that this has limited the success of previous endeavours (Barnes et al 1994, Venkataraman et al 2010, Ruiz-Mercado et al 2011, GIZ 2011, Pohekar et al 2005, Khrishna et al 2004).

The reason for the inclusion of large corporate entities as an element of the research was due firstly to the fact that these are currently the predominant players involved in research, manufacture and distribution of ABSs. Additionally their involvement has received very limited attention by academic researchers to date[14]. Finally, the researcher already had established links through which data could be gathered effectively.

In addressing the research question the following types of research perspectives and designs were considered:

- *Analysis of historical policy approaches* including cooking programmes in India and other countries, comparing findings with analogous sectors;
- *Broad but shallow analysis of users*, employing existing national level data (eg NSSO). This was rejected, as much previous analysis of this data exists, and it is not considered

[14] Note that while there was no academic literature relating to large corporations at the start of this research, one article of relevance was published during the writing of the thesis and was used to supplement the findings (Shrimali et al 2011).

sufficiently rich from social and cultural perspectives to respond to the research agenda established;

- *Narrow but deep study of users*. The option of performing an intense study of current users of ABSs was rejected as this would have skewed the population with respect to the research which is based on a mass-scale transition. In addition data problems were anticipated. Instead it was decided to undertake a deeper study of cooking activities, associated beliefs and socio-cultural settings of users of traditional stoves;
- *Case studies of specific actors* within the system such as manufacturers and distributors of stoves, civil society actors working on local advocacy or supply chains.

In order to maximise coverage of issues a combined approach was chosen, with three main empirical elements, each with their own research aims and questions, employing a mix of research methods (summarised here and described in more detail within the relevant chapters):

1) **Historical, comparative review of past experiences with government improved cook-stove programmes and an analogous sector (Chapter 3)**

   Aim: To analyse and distil past experience with stove programmes in India and China, and within the sanitation sector in Bangladesh, regarding *what* happened and *why*.

   Research questions: What can be learned regarding transition success or failure from analysis of past public programmes and the comparison between them? How can these insights be employed to improve prospects of achieving a future transition to clean cooking in India?

   A historical meta-analysis of two cooking programmes from India and China was undertaken using a literature review, to uncover features of past success and failure. In addition a programme in an analogous sector (sanitation) was analysed. In this way some triangulation was achieved, both within the cooking sector, and between sectors.

2) ***Users: Cooking practices, attitudes, social and cultural context (Chapters 4 and 5)***

Aim: To advance knowledge of the practices of cooks using traditional stoves, in particular those in low and middle income households, and analyse what factors can be used to *explain* the findings.

Research questions: *what* are current cooking practices and attitudes to these? What are the material impacts of cooking in terms of polluting emissions and greenhouse gases? How are these distributed across socio-economic groups? What socio-cultural and behavioural factors need to be accounted for in achieving an equitable transition to clean cooking?

Given the large, heterogeneous nature of the population under study, ideally data analysed would have been both thick (ie highly detailed) and wide, that is covering a high proportion of the Indian population. In order to achieve a pragmatic balance between thickness and coverage, the data collection approach firstly involved a market survey of 3,000 households, providing data in a quantitative and discrete choice format, which was readily susceptible to quantitative analysis; this is provided in chapter 4. Secondly qualitative data was collected from a smaller sample of cooks, using focus groups (Chapter 5). This allowed for a more nuanced, qualitative analysis of cooking practices in their socio-economic and cultural contexts, as well as some triangulation with the quantitative data, given over-lapping research areas. As data was collected in only two states of India, some caution was necessary when extrapolating findings to the whole of the country.

3) ***The role of large multi-national private sector (Chapter 6)***

Aim: To analyse the activities of four corporations in the cooking sector in India to date – Shell (through a charitable foundation), BP, Philips and Bosch Siemens - with a view to increasing understanding of their potential future role in supporting a transition to clean cooking.

Research questions: Why are these entities involved in the cooking/development sector? What business approaches and strategies have they employed (including carbon finance) and what has been the material contribution to date? What are the likely distributional impacts of their engagement? What does their involvement imply about governance in the sector and the achievement of equitable outcomes?

The research involved a literature review (mainly grey literature), personal observation from working within one of the corporate entities and an internet survey and key-informant interviews.

The final chapter attempts to bring the different elements together in order to look to the future and draw conclusions about the cooking system as a whole, and thereby draw policy recommendations.

1.7.4 Thesis structure

The following chapter (Chapter 2) provides the conceptual and theoretical framing of the research, first providing a conceptual framing of the issue at hand, and then introducing the key theoretical and analytical lenses of socio-technical systems (STS), governance and practice theory.

The thesis proceeds in the following three chapters following the empirical elements described above. Chapter 3 analyses successes and failures of past government cooking programmes in India and China and a sanitation programme in Bangladesh. Chapter 4 provides results from an extensive market survey of traditional stove users in West Bengal. Chapter 5 present results of focus groups with users of traditional stoves in West Bengal and Karnataka. Chapter 6 investigates the activities of large international private sector organisations engaged in the cooking sector in India.

The findings from the empirical elements of the research are drawn together and analysed in the final Chapter 7, in order to draw empirical and theoretical conclusions and sketch a policy prescription for the future.

1.8 Contribution

The thesis contributes both empirically and theoretically, as well as suggesting policy avenues that might be explored to accelerate a transition to clean cooking in the future. The last of these contributions reflects the author's previous experience and interests as a practitioner and advocate in the clean cooking field.

Empirically the thesis involves the collection and analysis of three sets of primary data. This includes a survey of cooking practices and preferences, and focus groups analysing the same issues in their socio-economic and cultural context. Primary data is also collected and analysed from large corporate entities engaged in the cooking sector.

The conclusions drawn have policy relevance, filling gaps in current understanding. They discuss the extent to which the findings of this research are generalisable to the wider context of India and other countries and regions, and conversely where context and local idiosyncrasies imply that they are specific to the areas of study. More generally consideration is given to the feasibility and limitations of inter-disciplinary research in producing generalised conclusions about the cooking system. In this way pointers are given to areas where future research might prove valuable.

"...it might be said that a theory is primarily a form of insight, i.e. a way of looking at the world, and not a form of knowledge of how the world is..." (Bohm 1980, p4)

2 Conceptual and theoretical framework

2.1 Introduction

This chapter outlines the conceptual and theoretical frameworks used as the basis for this thesis. Drawing on the roots of the word, *theory* (theatre – stage (Bohm 1980)) helps to provide a frame of reference for use in improving understanding of the research problem at hand. Theory is employed as a tool to support both *descriptive* and *explanatory* analysis with a view to answering the normative research question which this research seeks to answer. While the thesis employs a new conceptual and theoretical framing of the Indian cooking issue, it does not aim to achieve theoretical assimilation, focusing instead on building on and contributing to existing theoretical positions with respect to the issue of clean cooking.

Given the scale and importance of the issue, and the fact that considerable development funds have been expended in the sector, it is surprising that there is a dearth of academic literature framing cooking in terms of existing theories of social science. In the past cooking has generally been framed as a technology adoption issue (Gupta et al 2006, Lambe et al 2009), as well as one which can be modelled using economic tools and assumptions (van Ruijven et al 2011, Kavi et al 2007, Kumar 2007, Gupta et al 2006). However neither of these approaches seems capable of fully capturing the rich web of inter-connected influences involved. Thus the theories underpinning the thesis have been chosen to provide a more complete and holistic view.

The first part of the chapter introduces some over-arching conceptual elements, including development/environment nexus, gender and development. These are introduced to frame the cooking issue as a whole, both in a geographical sense, and with respect to its relationship with key issues, namely gender, socio-economic development and climate change.

The second part of this chapter introduces a Socio-technical Systems (STS)[15] approach, which has been widely applied to transitions problems, mostly in developed countries, (Verbong et al 2007) but only very recently in developing Asian economies (Berkhout et al 2010a); it has not before been employed with respect to the cooking sector. The inclusion of socio-technical systems as a conceptual building block of this research was introduced based on the author's experience of the shortcomings of existing approaches, which generally focus on individual elements of the cooking system, not giving sufficient consideration to interactions between them. The use of STS, it was hoped, would support a more holistic description of the cooking sector, including a broader range of actors and issues and the linkages between them.

The third section of this chapter relates to governance and political economy of cooking. This is presented with the aim of supplementing the descriptive power of STS with explanations of the power relationships that have resulted in current and past cooking systems, and resulting questions concerning the achievement (or not) of equitable results. Building on this approach practice theory is finally explored as an over-arching conceptual approach to framing cooks and cooking within the research.

In general cooking and development has in the past been the remit of development professionals, whether in government, civil society or international development institutions, working on the basis of what have been called 'learning-based development approaches' (Romijn et al 2010); the author himself is from this tradition. Consequently the field has been largely un-theorised, a gap which this chapter attempts to, at least partially, address. While this chapter provides a broad conceptual and theoretical palate as a conceptual grounding for the research, further theoretical insights are provided within the context of each of the empirical chapters of the thesis. Table 8 provides an overview of the links between the core research aims and questions addressed within each of the empirical chapters, and the methodological and theoretical approaches applied.

[15] Note that the use of STS to denote *Science and Technology Studies* and *Science, Technology and Society* is also common. However throughout this thesis STS is employed as an abbreviation of *Socio-technical Systems*.

Table 8: Summary of theoretical approaches to core research aims and questions

Chapter	Research aim	Research questions	Main methodological and theoretical approaches
Chapter 3	Analyse and distil past experience with stove programmes	1) What happened in the past? 2) Why did past programmes succeed or fail?	- Literature review - Socio-technical system transitions (to characterise multi-level transition processes) - Governance – highlighting key issues of structure and agency - Development theory – participation, gender
Chapter 4	Advance knowledge of the activities and impacts of cooks using traditional stoves	1) What are current cooking activities within the research areas and how are these distributed across socio-economic groups? 2) What attitudes to these activities are reported? 3) What are the material impacts of theses cooking practices?	- Quantitative analysis of market research survey data
Chapter 5	Analyse and explain the practices of cooks using traditional stoves	1) How do socio-economic, cultural and behavioural factors shape practices? 2) What implications do the findings have with regard to achieving an equitable transition to clean cooking?	- Qualitative analysis of focus group data - Practice theory to analyse social context of cooking - Governance – analyse where agency lies
Chapter 6	Analyse the activities of corporations in the cooking sector to date, to assess their potential role in a future transition to clean cooking	1) Why are these entities involved? 2) What strategies have they employed (including carbon finance)? 3) What has been the material contribution? 4) What are the distributional consequences? 5) What are the governance implications, including agency of cooks?	- Qualitative analysis of key informant interviews, personal observation and literature review - Governance – structure and agency and CSR - Socio-technical transitions - Practice theory

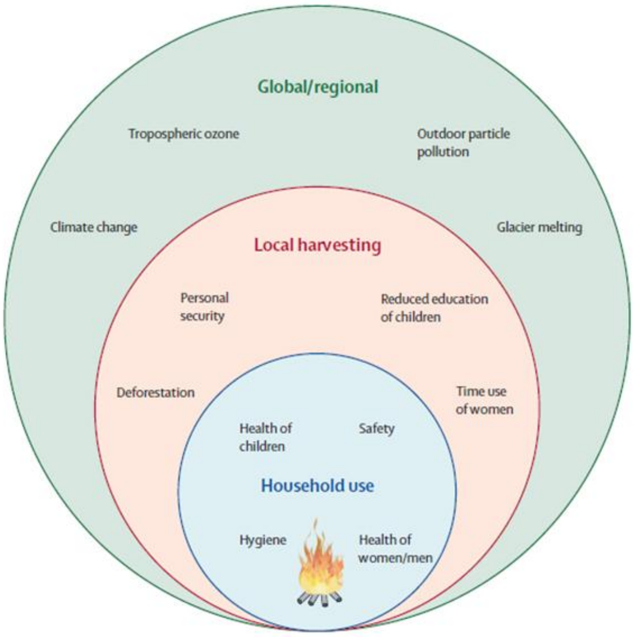
2.2 Framing the cooking problem

This section applies a range of theoretical frameworks to situate the main subject matter of the thesis – domestic cooking in India. The analysis first frames cooking as a multi-scalar and geographical issue, operating at multiple levels across a range of issues, from individuals at one end to global environment and multi-national institutions at the other. Secondly the section introduces elements of several development theories, highlighting the impacts of the sector on socio-economic development, and the gender-specific nature of cooking.

2.2.1 Multi-scalar nature of cooking

Domestic cooking impacts, and is impacted by, a surprisingly wide range of issues, some of which are highlighted in Figure 22. On an individual level, domestic cooking within households in developing countries has a profound impact on the health of those exposed to resulting indoor air pollution, mainly women and children. The collection of fuel involves substantial work, resulting in reduced time for alternative activities (economic or educational), and in certain situations - for example in areas surrounding refugee camps – a major security risk for fuel gatherers. At the same time, while deforestation from cooking fuel collection has been over-emphasised in the past (Mearns, Leach 1989), in certain areas the collection of fuel-wood does result in forest degradation (Van der Plas et al 2002). More widely the emission of black carbon from cook-stoves has been associated with regional impacts, including the Asian Brown Cloud (MacCarty et al 2008, Gustafsson 2009). These emissions of black carbon have been related to melting glaciers, due to a reduction in albedo of the ice (Ming et al 2009). Finally at the global scale emissions of greenhouse gases from cook-stoves in developing countries are now well documented, see for example (Smith et al 2000, Venkataraman et al 2005, TERI 2000); although significant uncertainty exists as to the quantification of emissions (Edwards et al 2011) assuming emissions of 1.5 tonnes $CO2_e$ per stove per year (author's estimate based on (Bailis et al 2011, MacCarty et al 2008)) from 500 million stoves globally would result in greenhouse gas emissions of 750 million tonnes $CO2_e$ per year from cooking, which is around 1.5% of total anthropogenic greenhouse gas emissions - (IPCC 2007) reports total emissions of 49 billion tonnes of $CO2_e$ in 2004.

Figure 22: Diagram showing the range of scales of impacts of traditional cooking fuel use



Source: (Wilkinson et al 2009)

In geography a useful distinction is made between *phenomenon scale*, or the size at which human and environmental processes actually occur, and *analysis scale*, that is the scale of analysis of a particular problem (Montello 2001). The temporal scale is also apparent throughout this research, with chapter 3 looking to past experiences, chapters 4, 5 and 6 analysing the present, and the final chapter dealing with normative questions about the future. As pointed out by Montello (2001, p 13503) "...*The world can never be studied, modeled, or represented in all of its full detail and complexity. Scale is important in part because of its consequences for the degree to which geographic information is generalized*...". This insight is considered throughout this research, mostly implicitly, for example in the generalised conclusions that stem from primary data in chapters 4 and 5. Analysis of the cooking system would be possible at a variety of scales, and ideally all of them to come to a full understanding of the system as a whole. However pragmatism dictates that a limited number of *analytical scales* are possible within this thesis. Two units of analysis are studied empirically, that is individual cooks and large corporations, for reasons already outlined. These analyses, combined with material from the literature on other scales – spatial and thematic - (eg deforestation, national policy and global climate change) are then used to consider a scaling-up of the findings. However the limitations of this approach are acknowledged, given the lack of detailed understanding of the different scales, and links and interactions between them.

In addition the cooking system is also influenced by a number of different types of actors and institutions. These range from individuals and families, through local civil society and government, national political institutions, and institutions operating at the global level. While still at a nascent stage of development, multi-level governance is discussed below with reference to this variety of actors and institutions, the influence and agency they have on the cooking system.

2.2.2 Cooking at the nexus of development and climate

Cooking is at the nexus of development and climate change. From a development perspective cooking directly relates to all of the *livelihoods assets* outlined in the *sustainable livelihoods* approach (*human capital* – health, education issues; *social capital* – gender issues; *natural capital* – biomass use, pollution; *physical capital* – stoves used; and *financial capital* – cost of fuel and end-use devices (DFID 1999)). At the same time cooking is responsible for appreciable quantities of greenhouse gas emissions, as shown above, and is susceptible to climate impacts, principally from diminishing biomass yields in a climate-changed world.

Until recently climate change and development were separate issues from policy and practitioner perspectives. However a number of efforts have been made in academic and policy circles to mainstream climate thinking within development discourses (EC et al 2003). Work to ensure that development is resilient to climate impacts is extensive (Huq et al 2006) and while a complex area to plan for and implement, is generally politically uncontentious from a north-south perspective. The issue of reducing the greenhouse gas emissions from developing countries on the other hand is politically trouble-some, as there are some areas where trade-offs exist between development and climate mitigation objectives (Mann 2010) and (Huq et al 2006).

An interesting review of international climate policy in 2010, named the Hartwell Paper, concluded that one of the principal reasons for the failure of international climate mitigation processes to date is the fact that reductions of greenhouse gas emissions has been the all-encompassing goal (Various authors 2010). The paper concludes the need for "...*a radical reframing - an inverting - of approach: accepting that decarbonisation will only be achieved successfully as a benefit contingent upon other goals which are politically attractive and relentlessly pragmatic*..." (Various authors 2010, page 5). It further advocates that the "...*organising principle of our effort should be the raising up of human dignity via three overarching objectives: ensuring energy access for all; ensuring that we develop in a manner that does not undermine the essential functioning of the Earth system; ensuring that our societies are adequately equipped to withstand the risks and dangers that come from all the vagaries of climate, whatever their cause may be*..." (Various authors 2010, page 5). This re-framing of the climate problem is directly relevant to the cooking sector, and is in accordance to the normative stance taken in this thesis, that the over-riding objective should be based on development imperatives, principally public health.

While human development objectives form the primary drivers for clean cooking programmes, designed in the right way such programmes can also yield climate mitigation benefits. In addition by reducing the quantity of biomass required by households, cooking programmes can limit vulnerability to climate change in areas where biomass productivity will be reduced due to climate change. In this way interventions to promote clean cooking can be said to create win-win scenarios, and to be following the *development first approach,* whereby development strategies with ancillary climate benefits are pursued (Davidson et al 2003). Such an approach is expected to overcome some of the resistance of developing countries to action in the climate mitigation realm, and recalls the oft forgotten Article 4.7 of the UNFCCC which states that "…*The extent to which developing country Parties will effectively implement their commitments under the Convention ...will take fully into account that economic and social development and poverty eradication are the first and overriding priorities of the developing country Parties*…" (UNFCCC 1992).

2.2.3 Cooking, gender and capabilities

Since the early 1970s the central role of women in development has been increasingly acknowledged. Recognising the critical role that women make to social and economic development, including to agriculture and industry, one seminal text by Ester Boserup highlighted how development processes and policies had historically been biased against women, and argued for the essential need to educate women in order to optimise their role in development (Boserup 1970). This work catalysed the international Decade for Women (1976-1986), providing impetus for increased attempts by development agencies to mainstream gender into their programmes. Today high-profile development publications emphasis the issue, with the latest World Development Report focusing on gender equality and development, emphasising the need for gender equality in order to achieve productivity gains, more representative decision-making and improved outcomes for the next generation (World Bank 2012a). While some progress towards gender equality is reported, inequities persist, with girls having lower primary and secondary school enrolment rates, women having lower access to economic opportunities and frequently having a lesser voice within households and society (World Bank 2012a).

In the context of South Asia, it has been argued that a central factor contributing to women's role is the extent of gender inequality in terms of power over property (Agarwal 1994); it is further argued that gender balance in the control over property is one important factor influencing the degree of intra-household bargaining power held by women, playing a role in the power that women have within households alongside social norms and perceptions (Agarwal 1997). A recent report analyses in detail gender equality issues in India, finding wide variations between different Indian states but a general continuation of inequity between the sexes (Iversen et al 2011). The study found that a significant number of states have poorer educational indictors for girls than boys, larger than the number of states in which girls fared better. Furthermore the study finds that women continue to suffer domestic violence in many parts of India. Female mortality of children between the ages of 1 and 5 was found to be higher than that of male children (Iversen et al 2011).

The gender and international development literature points to discrimination against, and exclusion of, women in terms of health outcomes (Nussbaum 2000), and suffering from the impacts of environmental degradation (Agarwal 1997). However the gender and health literature, surprisingly, does not routinely highlight indoor air pollution from cooking as one of the causes of ill-health.

The cooking sector can draw on the *capabilities approach*, the theoretical construct which can be used to conceptualise the needs of women in development (Nussbaum 2000). The *capabilities approach* is based on the idea that analysing human capabilities (what people are capable of doing) is the best way of considering human development, focusing on the principle of each person's capabilities as *ends* rather than *means*, and thus over-coming the situation in which women are seen as supporters of the ends of others (ie men). A *threshold level of each capability* is proposed, with the aim being to ensure that each citizen exceeds these thresholds (Nussbaum 2000). Amartya Sen, Martha Nussbaum and others have been instrumental in applying the capabilities approach, resulting in various metrics of human development, including the Human Development Index (HDI), and the Human Poverty Index (HPI), introduced in the 1997 Human Development Report of UNDP; both of these go beyond simple measures of economic status to measure poverty. The latest incarnation, introduced in the 2010 Human Development Report is the *Multidimensional Poverty Index* (MPI), which "... *directly measures the combination of deprivations that each household experiences. The MPI uses microeconomic data to reflect the percentage of households that experience overlapping deprivations in three dimensions—education, health and living conditions..*." (Oxford Poverty & Human Development Initiative website, accessed 8th September 2010). The MPI, for the first time, helpfully includes aspects of energy use in measuring human development in terms of depravations ("Electricity: If household does not have electricity" and "Cooking Fuel: If they cook with wood, charcoal, or dung") (Alkire et al 2010). While the inclusion of cooking is important in raising the profile of this important development issue, it is argued here that the formulation of cooking depravation within the MPI is mis-conceived, since it is not the use of wood, charcoal or dung per se that results in depravation but rather the exposure to indoor air pollution and the effort and drudgery involved – especially for women - in fuel collection and cooking. Use of improved cook-stoves (especially ABSs) can reduce both indoor air pollution and fuel use – and hence drudgery – significantly, and consequently reduce depravation and increase capabilities.

In addition to the general literature on gender and development, there is a specific one on gender and energy. One recent report highlights that "…*energy interventions can have significant gender benefits, which can be realized via careful design and targeting of interventions based on a context-specific understanding of energy scarcity and household decision-making, in particular how women's preferences, opportunity cost of time, and welfare are reflected in household energy decisions*…" (Köhlin et al 2011). Furthermore a growing literature on cooking and gender highlights the specific issues outlined in Chapter 1 including drudgery, injury, personal safety and household decision making (Clancy 2002).

2.3 Cooking as a socio-technical system

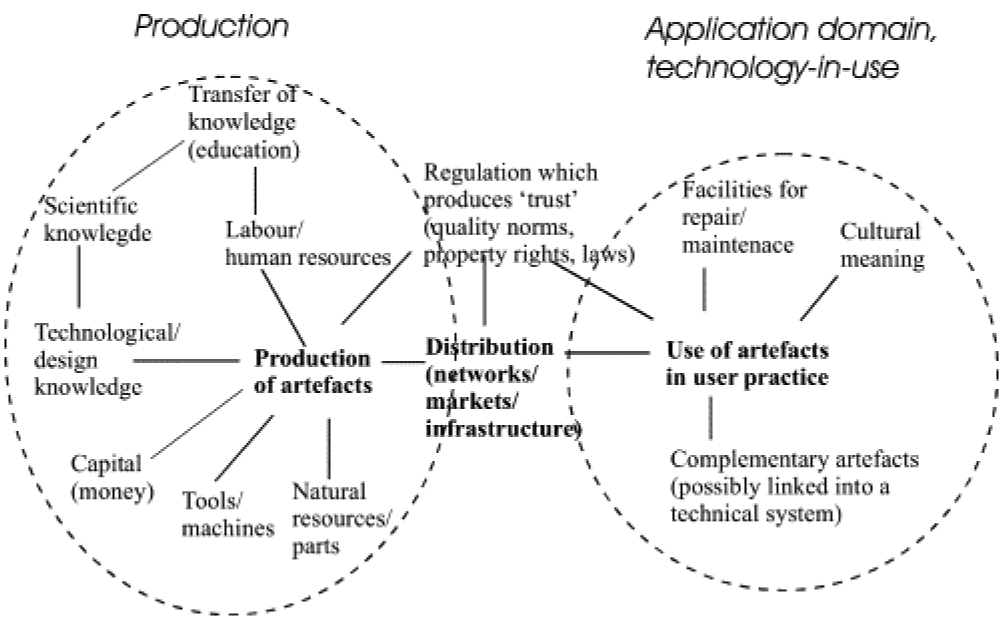
This section outlines current thinking on a socio-technical systems (STS) perspective to transitions. It is used to develop a more complete description of the cooking system in India.

2.3.1 Socio-technical systems, transitions and cooking

Socio-technical systems (STS) [16] takes a perspective whereby both social and technical aspects are viewed as essential and interacting elements within a system. The definition of the term *socio-technical systems* is generally provided "…*in a somewhat abstract, functional sense as the linkages between elements necessary to fulfil societal functions (e.g. transport, communication, nutrition). As technology is a crucial element in modern societies to fulfil those functions, it makes sense to distinguish the production, distribution and use of technologies as sub-functions. To fulfil these sub-functions, the necessary elements can be characterised as resources. STS thus consist of artefacts, knowledge, capital, labour, cultural meaning, etc*…" (Geels 2004, page 900) (see Figure 23).

[16] STS is used here as an abbreviation for Socio-technical systems. Note that in other literature STS is used to denote Science and Technology Studies, of which Socio-technical Systems can be seen to be a sub-set.

Figure 23: The basic elements and resources of socio-technical systems



Source: (Geels 2004)

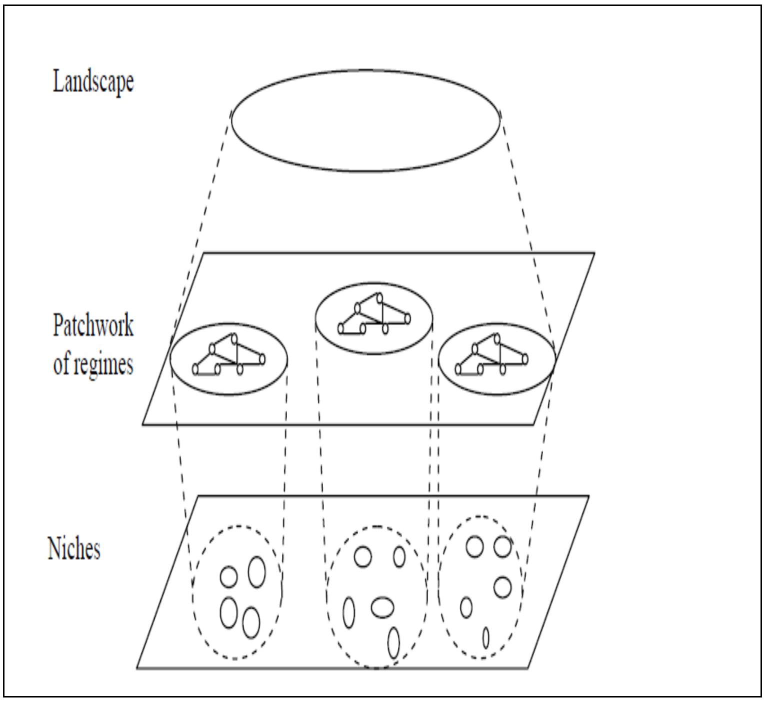
STS can be used to describe the characteristics of different social groups as actors within the system - industrial firms, users, societal groups, public authorities and research institutes (Geels 2004).

The *multi-level perspective* is commonly applied in a transitions perspective to differentiate aspects of the socio-technical system under scrutiny. This multi-level perspective has generally been taken to include three levels, namely:

- ***Socio-technical regimes*** which fulfil societal functions (eg transport, water, or in this case cooking), and comprise not only commonly applied technologies but also the different actors involved in shaping their use, including those developing, distributing and using the technologies as well institutions making policy, undertaking regulation and representing communities (eg civil society groups) (Geels et al 2007). Inclusion of actors within the regime concept results in a holistic analysis, encompassing issues such as technical and social norms, cognitive patterns, rules, regulations and skills, in addition to particular characteristics of technology (Bai et al 2009). Given difficulties of defining regimes in practice in empirical analysis – discussed below - the term has been taken to include a

"...*series of complex, nested, real-world phenomena*..." (Smith et al 2005, p5) thus softening the delineation of regime boundaries. Regimes are generally characterised as stable and subject to path dependence and lock-in (Berkhout et al 2010b). Firstly vested interests of those incumbent actors involved in the regime, including social networks, represent 'organisational capital' which has an inhibiting effect on new regimes taking hold. Secondly *cognitive routines* limit the imagination of those with the potential to envisage alternatives, and regulations and standards tend to support incumbent regimes. Thirdly the existing infrastructure has a tendency to provide a stabilising effect through "...*sunk investments and technical complementarities between components...*" (Berkhout et al 2010b, p 264).

Figure 24: Multi-level perspective on socio-technical systems



Source: (Raven 2010)

- ***Niches*** are conceptualised as the spaces in socio-technical systems where innovation happens under conditions of protection from market selection (Bai et al 2009). Such protection is said to be required as many innovations are either expensive or not yet fully optimised, and hence cannot compete with the existing competition. Thus niches are characterised as occurring in *incubation rooms* (Berkhout et al 2010b) where technological and social learning can occur; in practice the protection provided to regimes can be through public policies to subsidise a new technology, or some form of patient capital investment by private sector organisations (Berkhout et al 2010b). Niches do not necessarily include only novel technologies, but may also involve innovative institutional arrangements or patterns of behaviour. The delineation of *niche* boundaries is also somewhat fuzzy in practice, with niches being "...*nested within and outside socio-technical regimes*..." (Bai et al 2009, p 258); indeed niches can be conceptualised as overlapping the boundaries of regimes, indicating a two-way interaction between them (Berkhout et al 2010b).

- ***Socio-technical landscapes*** involve those slow moving aspects of socio-technical systems which have a "... *deep structuring influence on niches and regimes*..." (Berkhout et al 2010b, p 264) but are generally beyond the direct influence of regime actors. Landscapes may be said to include issues such as national or international policies, demographic changes, broad institutional frameworks and "...*power relationships between important societal groups, cultural values, and shared understandings about societal problems and visions of the future*..." (Bai et al 2009, page 258).

The term ***energy transitions*** features in both the academic literature (Berkhout et al 2010b, Elias 2005) and policy literature (Pachauri et al 2008, Gan et al 2008, Leach 1992). For the former the concept of transitions is grounded in the STS literature. Much of this literature relates to sustainability transitions in developed countries, and while the definition of sustainability in its broadest sense relates to social, economic and environmental issues, the focus of much of this literature is on environmental sustainability (Smith et al 2005, Berkhout et al 2010b, Kern et al 2008). STS has been widely used to research energy transitions in developed countries (Genus et al 2008), in particular with respect to a desired shift to a low carbon future, but has not before been associated with domestic cooking in developing countries. The focus of STS to date on environmental sustainability marks a distinction with the subject matter of this research, cooking in

India, which, while it is at the nexus of socio economic development and environment, takes as its raison d'être the development aspects (public health) of the problem. However STS is considered an appropriate frame for cooking, given that STS transitions do not appear to be tightly bound to the type of normative goals of the transitions under study.

In the STS context a *transition* refers to a major shift in the dominant *socio-technical regime* (Raven 2010), in this case the adoption and use of advanced biomass stoves. Transitions from existing regimes to new ones are said to occur through a process of co-evolution between and within the different layers, where there is an appropriate interaction between the levels: where the *regime* is sufficiently open or adaptable, where suitable innovations have been developed within the *niche*, and where there is pressure from the *landscape* for change, or at least a lack of over-whelming resistance to change. Transitions are frequently long-term (often over decades) and complex process, and follow *transition experiments* within which different technological, social and institutional solutions are tested in niches or innovation experiments (Raven 2010). Frequently ST regimes are resistant to change due to behavioural, socio-cultural, or technological *lock-in* (Barnes et al 2004) and (Raven 2010).

A number of different descriptions of the ways in which STS transitions occur exist in the literature. For the purposes of this chapter, a heuristic model is used as a primary source, given its attempt to account more for context and provide a greater degree of analysis of agency than other more structural models (Smith et al 2005). This model proposes a *quasi-evolutionary* model of regime change, which is a function of three factors: firstly the degree of articulation of *selection pressures* on existing regimes; secondly the extent to which resources required for transition (including capabilities and knowledge) are available within (or beyond) the existing regime; thirdly the degree of coordination of responses to pressures on the regime (Smith et al 2005). It is the latter two factors, jointly termed *adaptive capacity*, which appear to make this model of STS transitions more applicable to cooking in India, given the relation to agency of actors within existing regimes.

The term *selection pressure* refers to a range of factors, either from the level of niche innovations or from the ST landscape or within the regime, which provide impetus for a change in the incumbent regime. In the case of cooking in India, this might relate to shortages, or increasing costs, of existing biomass fuels, resulting in development of alternative stoves and fuels which use less fuel or different fuels. This is the case in some parts of India. Selection pressures may also be exerted from outside the regime, as appears to be happening in the case of national and global cooking programmes, the latter focusing on public health as a goal.

Referring to the heuristic model proposed by Smith et al (2005), one interesting question is the degree to which members of the existing cooking regime in India (cooks) were involved in the articulation of the normative goal of public health, and the extent to which they agree with it. This can be helpfully framed in the context of STS, namely that selection pressures from outside the regime (by policy makers) are not necessarily on the same axes as those pressures from within the regime (from users).

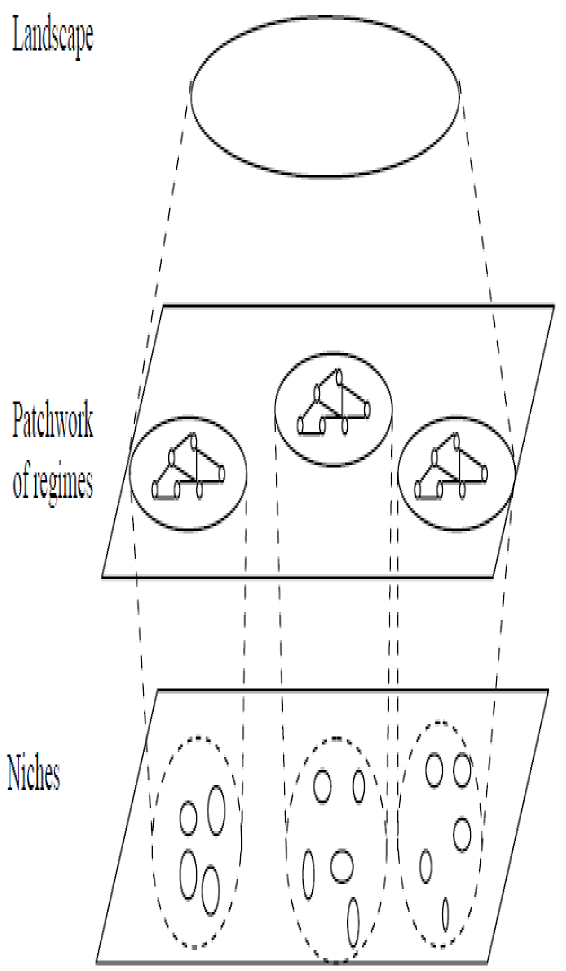
2.3.2 Application of socio-technical systems to cooking in India

In order to apply the STS transitions approach to cooking in India, it is necessary to provide an explanation of what is included within the different levels. In discussing niches, regimes and landscapes Raven (2010) explains that distinguishing between these levels can be difficult and depends on the stance of the person or institution defining the levels; "…*the distinction between the levels is therefore analytical and not ontological*…" (Raven 2010, page 6). One response to this criticism of the multi-level approach to STS – that it is difficult to apply in practice – is to suggest that systems can be seen as *nested levels* (Geels et al 2007), in which for example, biomass-based cooking using traditional stoves is a nested regime within the wider cooking regime which includes those cooking on LPG, kerosene and other fuels, and the cooking regime in turn is a nested part of the wider energy system.

Some guidance on system delineation is provided by referring to transitions in socio-technical regimes as occurring at "...*the level of organisational fields*..." (Geels et al 2007, p 402); these are in turn defined as "...*those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products.*.." (DiMaggio et al 1983, page 148). However it is recognised that ultimately the empirical choice concerning boundaries of regimes, niches and landscapes within STSs remains somewhat arbitrary.

For the purposes of this research two nested systems could be assumed to exist: firstly the cooking system as a whole, including those cooking using all stove/fuel combinations, and secondly a system including only those cooking using traditional stoves. However given the fact that users frequently switch between different fuel/stove combinations, the main heuristic model employed for this research is of an overall cooking system. Cooks themselves are clearly part of the existing regime, as are the processes and actors involved in shaping social and cultural practices, making policy and providing fuel and stoves. Thus institutions included within the regime include NGOs, local government and regulatory agencies, and national government. International processes and actors are assumed to be operating within the landscape. Given the limited use of advanced biomass stoves in India, they are considered still to reside at the level of niches, as are the niche experiments being employed by some large corporations involved in developing, manufacturing and distributing them. This, admittedly still loose, definition is used to define what is taken here to be included within the different levels of the existing cooking system in India, as illustrated in Figure 25.

Figure 25: Multi-level perspective on socio-technical systems, indicating delineations assumed for the different levels of the cooking STS in India



Overall STS heuristic model employed

Landscape

-demographic changes
- gradual shifts in economic approach (eg towards neo-liberalism)
- Societal attitudes (eg within caste system)
- Pressure from international community (eg health and gender MDGs)

Regime

- cooks (patchwork using different fuels and stoves)
- associated social and cultural norms
- federal and state policy processes
- manufacturers and distributors of improved stoves (eg rocket stoves)
- civil society representing users

Niches
-Corporations developing new technologies (eg ABSs)
- novel business models
-carbon financing approaches for cooking projects

Source: (Raven 2010, adapted by the author)

Socio-technical systems is used within this research to ask the following types of question:

- Is the current *regime* sufficiently open or adaptable, or subject to lock-in? Does it have the capabilities (knowledge, resources etc.) to enable a mass-scale transition to ABSs? Is there demand for change from cooks?
- Have appropriate innovations been developed through successful *niche experiments?* In other words, have technologies acceptable to cooks been proven to work, and do workable business and delivery models exist?

- Is there positive pressure from the *landscape* to encourage transition, for example in the form of policies, changes to societal expectations, or from the international community through expectations surrounding the health and gender MDGs?
- Are there pressures from the landscape inhibiting transition (eg perverse subsidies)?
- Is there sufficient interaction and coordination of responses to pressure on the regime between the levels, including institutional arrangements to ensure communication between levels?

2.3.3 Managing and governing socio-technical system transitions

In addition to conceptualising different aspects of STSs within the context of the multi-layer perspective, there is an expanding literature on the means by which transitions can be actively managed and governed. It is to be noted that there is a fundamental debate within this literature regarding the distinction between selection of specific transition end-points on the one hand, and *"... managing critical processes of selection and variation within a broader dynamic of sociotechnical evolution*..." on the other (Shove et al 2007, page 2). If it is assumed that the former approach is desirable and feasible, a core question is raised about the processes by which transition end-points are defined and their legitimacy (Shove et al 2007).

While recognising the importance of such core governance issues, leaving them aside for the time being and assuming that actively managed transitions are desired, the following provides a brief overview of approaches set out in the transitions management literature. One, for example, differentiates processes on the strategic and tactical levels, recognising also the importance of operational matters, especially transition experiments and reflexive monitoring and evaluation (Loorbach 2009). In the process of managing a transition, the importance of incumbent actors is recognised, with the emphasis placed on structuring and coordinating their activities for maximum impact. At the strategic level, the importance of the process of envisioning is stressed, through the development of agreed visions of the future, involving a variety of actors associated with the issue at hand, representing a sufficiently broad set of interests and perspectives. At the tactical level emphasis is placed on analysis of barriers to the transition sought (eg technological, economic, socio-cultural) within the incumbent regime. At the operational level a range of risky, diverse, and sometimes competing, experiments are essential to test approaches. However the value of such experiments must be complemented with ongoing monitoring and evaluation, undertaken in a reflexive manner to ensure learning (Loorbach 2009).

This research also draws on aspects of innovation systems approaches, outlined in Jones et al (2009), and *Strategic Niche Management* (Raven 2010) which view successful innovations more broadly than simply the development of good technology or knowledge, focusing more on the structures and institutions through which innovations find their way into use. Innovation systems approaches inter alia emphasise the roles of both codified and tacit knowledge, a distinction of relevance to the cooking sector in which much codified technical knowledge exists within stove developers, while this group generally lack an understanding of the deep tacit knowledge of cooking possessed by the cooks themselves. The approach stresses the importance of balancing 'demand pull' and 'supply push' by promoting two-way communication, through networks, between producers and users of innovation. The innovation systems approach also stresses the need to understand agency of different actors and the power dynamics between these actors in the system, and to strengthen the power of the demand side, in this case the cooks.

The limitations of Strategic Niche Management (SNM) with respect to adding insight into household energy activities in a developing country household setting is outlined in (Romijn et al 2010). An analysis based on SNM principles is applied to various household energy programmes in developing countries, and this analysis is compared with what are termed *learning-based development approaches* which are considered to be the usual ways in which rural development projects are undertaken, involving strong engagement with local institutions, capacity building and ongoing revision of working modalities based on changing contexts. While SNM is found to have the benefit of providing an "...*endogenous treatment of the larger context*..." (Romijn et al 2010, page 326), it is seen to have weaknesses when compared to learning based development approaches; in particular learning based development approaches identify and engage with complexities of local context and stakeholder organisation, and highlight the importance of power and agency differences within and between local institutions (Romijn et al 2010), which SNM based approaches tend not to do.

2.4 Governance and political economy of domestic cooking

2.4.1 Key concepts in governance and political economy

Governance is defined simply as the "…*The action or manner of governing*…" (OED 2012). While a socio-technical systems (STS) perspective provides a useful framework within which to *describe* different elements of systems such as cooking, and the generic ways in which these interact, it does not *explain* the decision-making processes involved in producing observed outcomes, nor the role of power, or agency*,* of different actors, the interplay between them within *structures* (institutions) and related underlying processes of political economy. In addition STS does not provide insights into why different distributional outcomes (equitable or not) result from various processes and the ways they are managed and governed. These can be addressed through consideration of the governance of the cooking system, and underlying political economies. Here *agency* "…*refers not to the intentions people have in doing things but to their capacity of doing those things in the first place (which is why agency implies power: cf. the Oxford English Dictionary definition of an agent, as 'one who exerts power or produces an effect')*…" (Giddens 1984). S*tructure* can be seen as being formed of the processes, institutions and norms which "…*facilitate or constrain agents' attempts to make changes*…" depending on the position of the actor within the structure in question (Smith et al 2005). Long-running debates exist on the primacy of *agency* or *structure* in determining changes in society including at the interface of society and nature (Chowdhury et al 2006). Within this research the philosophical approach taken follows that of *structuration*, whereby primacy is given to neither structure nor agency (Giddens 1984). In terms of understanding of processes of change within the cooking system in India, this implies a requirement for analysis of institutions, processes, norms and actors at multiple levels, acknowledging that structural factors have influence (power over) who cooks with what, and how change is catalysed or constrained; for example incumbent political and economic structures, as well as socio-cultural norms can constrain change, explaining the path dependence outlined in section 2.3.1. Conversely actors constantly re-work structures (exert agency over them) at a range of levels creating – in the language of socio-technical systems - niches and innovations.

There is no literature addressing the governance of domestic cooking per se. The general framework developed under the banner of *governance of clean development* (Newell et al 2009) provides a useful starting point however. While much of the governance of clean development literature relates principally to the CDM as a key policy tool – which is not the main focus of this research – the ultimate objectives (development in an environmentally sustainable manner) are congruent with this aims of the thesis.

For the purposes of this research, governance and political economy frames of reference can be employed to respond to the following over-arching questions, following Newell et al (2009):

1) Which actors are involved in the governance of the domestic cooking sector, or "Who Governs?" (Newell et al 2009) in the public and private spheres as well as in civil society, whether through individual institutions or networks?
2) What forms of governance do different actors involved in cooking undertake, or "How do they govern?" (Newell et al 2009)?
3) What are the processes by which decisions are made about "What is and is not to be governed" (Newell et al 2009)? This question includes both questions concerning whether cooking is subject to intervention at all, and if so, what the focus of resulting activities is;
4) What are the social consequences of different governance regimes, or "On whose behalf" does governance take place (Newell et al 2009)? The answer to this question addresses the

degree to which changes within the cooking system resulting from specific policies and investments are equitable or not.

The involvement of a range of new actors, including (western) consumers, corporations, and NGOs has been shown, in the context of global environmental governance, to highlight the need for "...*expanding the focus on institutions of government (such as parliaments, bureaucracies, and law) to broader conceptions of environmental governance, where diverse groups in society wield power and authority*..." (Liverman 2004, page 735). The range of potential scales of influence within the cooking system is truly vast, varying from the very local (individual households), to global actors in the public sector (eg UNFCCC, and the Global Coalition for Clean Cookstoves) and private sector actors in the form of global corporations. In between are a number of layers of public sector administrations, as well as private sector and civil society actors. The processes by which the cooking system is governed are thus complex; understanding these complexities will help broaden appreciation of how equitable results can be achieved, or what constrains their achievement.

In the context of environmental governance, it has been argued that conventional governance debates – whereby either states or market-actors take leading governance roles – are inadequate to represent the complex and multiple-scale, multi-actor, governance processes at play (Lemos et al 2006). Emergent hybrid models of governance are identified, including co-management between state, market and communities (Lemos et al 2006). These emerging forms of multi-scale, multi-actor governance are potentially of relevance to the cooking sector, and are explored further in Chapters 6 and 7.

Political economy has been defined as "...*the processes by which ideas, power and resources are conceptualised, negotiated and implemented by different groups at different scales*..." (Tanner et al 2011, page 2). To support the policy focussed aspects of this thesis it is important to include elements of the political economy of cooking with a view to analysing "...*the broad logics of production and the distributive consequences of these logics*..." (Castree 2002, p 361). More specifically a view of the different forms of power at play is taken to include "...*material (control of production, technology and finance), institutional (access to and representation within key decision-making bodies) and discursive (ability to generate dominant framings in policy discourse and the media)...*" (Newell et al 2011, page 90).

A number of political forces might be expected to shape processes (or not) within the cooking system. These can be conceived of as being within the socio-technical *landscape.* The starting point however is simple, namely that promoting clean cooking – like malaria vaccines – is principally focussed on the poor and so is unlikely to receive the same level of attention as issues affecting wealthy populations. Thus as a starting point, it might be assumed that cooking, in relative terms at least, is a governance 'blind spot' (Newell et al 2009). Contentions that, firstly, cooking in general does not receive the attention and resources befitting its importance, and secondly that the poorest households in particular are a blind spot within the cooking sector, are both tested within this thesis.

The remainder of this section briefly reviews how the literature on governance and political economy relates to governance by the state, by international institutions, by multi-national corporations and by civil society in the context of domestic cooking in India. Highlighting these specific elements does not negate the importance of the governance links between these actors, nor the array of other actors which it does not cover (eg local private sector). Indeed the degree of coordination and coherence between different governance actors has been highlighted as one of the critical factors in achieving equitable and clean development outcomes (Newell et al 2009).

2.4.2 Governance in the context of cooking in India

2.4.2.1 Governance by the state in the public sphere

Chapter 1 clearly shows that a mass-scale transition to clean cooking in India would necessarily involve a large number of poor households. The concepts of a mass-scale and an equitable transition to clean cooking are therefore equivalent in practice. The current cooking situation that pertains in India is highly heterogeneous, with rich urban families using modern clean fuels such as

LPG for cooking, while poor rural families use a variety of unrefined biomass fuels in rudimentary stoves.

The theory of *uneven development* originated by Leon Trotsky and adopted more recently by Marxist theoreticians (Harvey 2006) has it that societies do not develop at the same rates; this uneven development is a function of a number of factors including history, culture, and relative levels of power and agency between actors operating at different levels. In turn it is possible for development trajectories to be accelerated, by leap-frogging technologies (for example the case of mobile phones becoming the norm in many developing countries in which use of fixed line phones is limited), thus reducing unevenness in a manner following the metaphor of punctuated equilibriums (which has been used as a model to describe evolutionary change within energy systems generally (Koh et al 2008)) as opposed to linear progression along a development path.

For the purposes of this research, the concept of uneven development can provide insights at a number of scales, both spatial and temporal. The fact that many Indian households cook in ways analogous to European practice some 500 years ago, is of historical interest, but is not central to this thesis. Of more interest for this research is the uneven cooking development that exists between and within communities in India currently and the reasons for this. As outlined in Chapter 1, there are marked differences between urban and rural communities, and within these between different socio-economic groups in terms of both the quality and quantity of fuels used (Pachauri et al 2008). The reasons for these differences have been identified as a combination of economic (income, energy prices) and geographical (availability of fuels) issues (Pachauri et al 2008). In addition to these factors it has been argued that the design of certain policies, such as the subsidised distribution of kerosene, also tends to favour rich households and hence support uneven development (Viswanathan et al 2005).

It is generally recognised that most poor people in India, especially those in rural areas, will not be in a position to switch to fossil fuels (LPG or kerosene) in the foreseeable future. Therefore cooking energy for the poor does not suffer, to the same extent, from political vested interests that plague other parts of the energy system, namely pressure from the fossil fuel lobby to increase use of its own offering. However political forces are at play in determining the degree of public financial resources provided to different elements of the cooking population. This is most visible in the form of subsidies provided for fossil fuels for cooking.

In India in 2010-11, the subsidy for LPG was estimated to be nearly Indian Rupees (IRs.) 22,000 crore[17] or around £2.6 billion, while the subsidy for kerosene was around IRs.19,500 crore (£2.3 billion) (TERI et al 2012). Ostensibly the reason for these subsidies is to reduce prices for domestic fuels for the poor (ESMAP 2003). However data shows that only around 1% of the rural Indian population used LPG as a primary cooking fuel in 2007–2008, while over 60% of the urban population did so (Government of India 2010). Similarly in 2007-08 only 6% of rural households used kerosene as a primary fuel for cooking while the corresponding figure for urban areas was 8% (Government of India 2010). This, combined with the fact that much subsidised kerosene and LPG is diverted to purposes not intended (including for automotive fuels), has led most commentators to conclude that these subsidies are both inefficient and regressive (Rao 2012). However the considerable lobbying power of those benefitting from the subsidies – principally the middle classes - has made it impossible for reform of the subsidy system to take place, until very recently: reports in the Indian press in May 2012 show that the Government of India is in the process of reforming subsidies, starting with the withdrawal of LPG cylinder subsidies to members of Parliament and other officials, followed by removal of subsidies to families earning at least IRs50,000 a month (Sahu 2012).

Such reforms are sensible from an equity perspective, especially the fact that they are means tested since those, few, poor households using kerosene and LPG will generally be spending a much larger share of their income on fuels than rich families. However the broader question relates to why

[17] A 'crore' is a unit used in India and other parts of South Asian meaning ten million (10,000,000), or 100 lakhs (one lakh is 100,000).

these subsidies were initiated, and why such large sums of public money are used to subsidise LPG and kerosene (over £2 billion per year each) compared with the small amounts provided for the whole period of the National Programme on Improved Chulhas (NPIC) (1985 to 2002), during which time IRs. 15,000 crore of public funds were invested (Barnes et al 2012), equivalent to around £17 million or £1 million per year (3 orders of magnitude less than the fossil fuel subsidies)[18]. The burden of disease from cooking with traditional stoves, highlighted in Chapter 1, is vast but is not monetised within the policy structure, perhaps reflecting a relative lack of focus by national politicians given the lack of a voice by the mainly poor, rural households concerned. The reason for such high spending on fossil fuel subsidies compared with cook-stove programmes, one suspects, lies deeply rooted in Indian politics, with the status quo maintained by those who benefit, principally the middle classes, as well as the political lobby power of the fossil fuel industry.

However, the decentralised nature of the Indian public administration, and the established democratic tradition there, should in principle result in the poor having sufficient power within the system to ensure that their needs are expressed. Some have pondered whether the broad shift towards neoliberal policies (eg privatisation, deregulation and budget cuts) has weakened the state (Liverman 2004). Within this chapter it is not possible to unpack the myriad complexities of Indian democracy; nevertheless it is considered that the state still plays a powerful role, with the generation of influential Five Year Plans for example and conception of specific programmes such as those on cooking. It has been noted that "...*the Indian economy remains highly regulated despite the neoliberal reforms introduced from 1991*..." (Newell et al 2011, p91). In this context it is useful to outline the three main layers of public institutions involved in managing state affairs.

At federal level the Ministry of New and Renewable Energy (MNRE) has responsibility for matters relating to domestic cooking. Its role in the government run cooking programmes of the past is explored in the following chapter, and more recently it has taken the lead in the new national stove

[18] Note it is considered by the author that the figure quoted by (Barnes et al 2012) is an under-estimate, and it is not clear what aspects of the programme it covers (management, subsidies or both).

programme the *National Biomass Cookstoves Initiative* (NBCI). As part of this, in 2010, MNRE was tasked with trialling different stove models and developing design components for this major new programme, with a view to results being written into the twelfth Five Year Plan (2012-2017), compiled by the Indian Planning Commission chaired by the Prime Minister of India; at the time of writing this plan was not available. In practice it is considered that capacity constraints within MNRE, specifically lack of skills related to clean cooking, will be an inhibiting factor in the design of the new Indian cooking programme. This is perhaps illustrated by the fact that two Indian institutes were tasked with developing the design of the programme on behalf of MNRE (IIT Delhi et al 2010); however as yet (as of July 2012) no details were available from MNRE on the design of the programme. In addition to capacity constraints, the fact that this new programme is afforded only one page on the MNRE website (MNRE 2011a), might be interpreted as indicating the low priority afforded to cooking when compared to MNRE's main remit which is electricity generated through renewable energy.

At the level of inter-ministerial politics, it is likely that over-lapping interests, different political agendas and varying levels of political power between Indian federal ministries (for example MNRE, The Planning Commission, Ministry of Environment and Forests) might result in policy conflicts at federal level. The Planning Commission, for example, has a powerful agenda-setting mandate, and may not view clean cooking for the rural poor as a key policy priority. The Ministry of Health and Family Welfare should have an important role to play but has been notably absent in cooking activities in the past. While the complexities of inter-ministerial politics are not explored within this research, the author has personal experience of the type of conflict that might arise. In trying to establish a baseline for a biomass carbon offset project, one project developer (pers comm., anonymous, 2008) was required to assess the degree of *non-renewable biomass* within the project baseline; however despite support in principle from MNRE, and the fact that data demonstrated that a proportion of the biomass was non-renewable, a Ministry of Environment and Forests official refused to acknowledge this fact, stating – for political purposes apparently associated with international climate change negotiations - that non-renewable biomass did not exist in India.

State level institutions play an important role within India, including on energy matters, with federal bodies delegating responsibilities downwards. Their involvement on specific issues, in practice, varies from state-to-state (for example see an analysis of varying state level support for renewable energy and involvement in CDM projects (Newell et al 2011)). The reasons for this variation between states "...*appear[s] to be correlated with state income level and factors such as resources, industrial growth and governance type*..." (Newell et al 2011, page 93). State level involvement in previous Indian Government cooking programmes is assessed in detail in (Barnes et al 2012) and summarised in the next chapter. In the cook-stove programmes of the past, each state had considerable autonomy in how it ran its own stove programme and analysis (Barnes et al 2012) uncovers considerable variations in the degree to which different states were successful, both during the period of active support by federal government and afterwards. The reasons for such variations are diverse, and include the degree of interagency coordination at state level, the strength of local NGOs, including involvement of women's self-help groups, previous legacies of making stoves, and the degree of congruence with existing state policies on, for example, integrated rural development (Barnes et al 2012).

At local level, the system of **Panchayat raj** provides local administration at three levels (village, block and district). While the panchayat system has its roots in history, in the modern Indian context it is the means by which the Indian government decentralises a number of administrative tasks to the local level. In principle the Panchayat system provides space for participation of the local level in decision making. The degree of participation and agency within the political process which the Panchayat system affords to citizens is the subject of considerable study (Corbridge et al 2005). While detailed study of the Panchayat system is beyond the scope of this thesis, it is interesting to note the conclusions of others with regard to governance of clean development: "…*In practice, when* *resources and bargaining with powerful actors are at stake, there are also dangers of corruption, buying-off of local leaders and capture of revenues by Panchayat leaders*..." (Newell et al 2011, page 93). The degree to which local level participation was achieved in past Indian Government cooking programmes, or was captured by policy elites, is examined as far as possible in the following chapter.

2.4.2.2 Governance by international institutions

Several international institutions and coalitions are engaged either directly or peripherally in the cooking sector. These are conceived of as providing g*overnance from above* (Newell et al 2009), that is international governance directed at national institutions, and operate within the *socio-technical landscape* of the Indian cooking system; that is, while they may have some over-arching impact on the regime actors, it is assumed that these actors probably have little influence in shaping the international organisations in turn.

Firstly the World Health Organisation (WHO) has some influence through its research into the health impacts of indoor air pollution (WHO 2011). The results of this research could be expected to exert some influence on politicians in India, as well as providing evidence for NGOs in support of particular campaigns. Specifically the WHO is engaged in establishing international guidelines for air quality (WHO et al 2010) which are likely to have some influence on national regulations. Assuming that the Government of India adopts the recommendations of the WHO, then this UN organisation could be said to be exerting some form of agency over the Indian cooking system, which would have to radically adapt were it to meet the international standards.

Another UN organisation, the UN Framework Convention on Climate Change (UNFCCC) is also involved peripherally in the Indian cooking sector, through the development of rules for the Clean Development Mechanism (CDM) to which some cook-stove projects are eligible. In practice however the complexity of cooking CDM projects has resulted in very limited flows of finance into the cooking sector in India to date. This, combined with the fact that the topic has been treated extensively in other publications (Simon et al 2012, Bulkeley et al 2010, Bumpus 2009, Mann 2007) means that it is not dealt with here in any detail. One issue relating to governance of the rules associated with cooking CDM projects is addressed, however. Appropriate CDM methodologies for cooking were absent for a number of years after they became available for more 'mainstream' CDM sectors, which can be seen as a governance blind spot. The author in the past has directly observed the relevant bodies within the UNFCCC, and witnessed that the appropriate bodies within the CDM (Executive Board and Methodology Panel) lacked both the technical capacity to deal with the issue and, in the early stages, apparently the motivation to do so. While the issue of CDM methodologies was finally resolved following a UNFCCC expert workshop, attended by the author, in 2009 ("UNFCCC workshop - Enhancing the usability of CDM methodologies for household cooking energy supply"), the delay of more than four years has resulted in a limited number of cooking CDM projects to date. The underlying reasons for this particular governance blind spot are certainly partly due to the complexity of the sector with regard to achieving and certifying emissions reductions. However it might also be considered that the high level of agency of those actors associated with emissions reductions from industrial plants (eg HCFCs, large power plants) compared with those interested in cook-stoves, resulted in rapid progress in the former case and slow progress in the latter.

The Global Alliance for Clean Cookstoves (GACC), established by the UN Foundation in 2010, is a coalition of bodies from the public and private sectors and civil society. It has set itself the ambitious goal of fostering the adoption of clean cook-stoves in 100 million households by 2020. The main current roles of the GACC are lobbying to increase awareness of the issue, engagement in international research and work on the setting of standards, building markets and mobilising finance (GACC 2011). In addition there are plans for country level activities although details are not currently available and it is thought that India will not play an active role in the GACC[19]. Despite the fact that the direct influence of GACC on India is thus likely to be peripheral, it is expected to play a role in setting the agenda for global cook-stove activities and thus its convening and agenda-setting

[19] Information received during a meeting of the GACC in Eschborn, Germany 2012.

(discursive) role in the governance of the sector may be significant. In this context it is interesting to note that the representation on GACC's Advisory Board is composed of members from the Governments of the USA and Germany, two members from Shell, one from the host institution (UN Foundation), and the Executive Director of GACC. The lack of representation by politicians from developing countries, or of civil society organisations representing users, could be due to the recent creation of the organisation. However it certainly highlights a legitimacy issue, with the funders of GACC represented but not the users of its outputs.

2.4.2.3 Governance by multi-national corporations

There is an increasing emphasis on market-based approaches to energy in developing countries (including cooking), which has been criticised by some for under-estimating the continued importance of public sector support (Bailis et al 2009). The activities of those large corporate entities engaging in the development and commercialisation of ABSs in India is explored further in chapter 6, to address questions including which driving forces are at play (pure profit, corporate social responsibility - CSR, philanthropic). This domain is what has been termed *private governance of private finance* (Newell et al 2009).

The concept of uneven development has been applied to the phenomenon of neo-liberalism and market-based cultures, with prominent academics arguing that capitalism and neo-liberal approaches have been associated with inequity in the distribution of development benefits in recent decades (Harvey 2006) due to uneven power relationships. Others argue that this is because of the relationships between actors at different levels, and specifically differential levels of power between communities and large corporations. The greater power of the corporations results in the inability of communities to hold them to account, one of the key factors in determining whether equitable development results from the actions of corporate entities (Garvey et al 2005).

Corporate social responsibility (CSR) can be seen as an attempt, by global corporations in particular, to gain legitimacy. It has been argued that insufficient scrutiny has been applied to assessing the development outcomes resulting from CSR activities, for example with regard to their distributional consequences (Newell 2008). The level of community engagement in shaping CSR activities is seen as an important determinant of their success in achieving equitable development, and lack of such engagement by corporations is regarded as an area which has received insufficient attention (Newell 2005).

More emphasis needs to be placed on the accountability of corporates with regard to their CSR activities, in particular accountability to the communities within which they operate, which are likely to have considerably less power than the corporations (Newell 2005). More generally it has been argued that in the absence of external pressures, corporate involvement in the developing world, driven by CSR, will not result in equitable distribution of development benefits. A case is made for a more people-centred approach to research into the development impact of CSR initiatives, focussing on the degree of participation of communities and development impacts, more than the business case (Prieto-Carron et al 2006). It has been suggested that a combination of regulation and pressure from civil society is necessary to ensure that corporate activity results in development and poverty alleviation (Graham et al 2006). However others question the effectiveness of regulation, in particular in a developing country context, where state capacity is often limited, placing more emphasis on approaches which increase accountability, and thus pressure, on corporations involved (Newell 2008).

In the case of cook-stoves, it may be that there is little or no profit to be made at the very bottom of the pyramid. Nevertheless the simple fact of their engagement in this sector implies that these corporations are bringing some fresh resources and skills. Analysing the reasons for their engagement and the internal governance processes involved, based on their ultimate constituency – shareholders - resulting in this engagement will shed some light on the likely development impacts of their activities. Ultimately the question is whether the activities of those corporations engaging in the cook-stove sector will have lasting beneficial, and equitable, development impacts, or will wither with time, leaving no legacy of value.

2.4.2.4 Governance by civil society

Many NGOs have been active in the promotion of cook-stoves for decades. The international NGO Practical Action[20] has been active for many years, both in the implementation of cook-stove programmes, as well as actively and effectively lobbying at an international level for an increase in attention to the subject amongst donor organisations (Warwick et al 2004).

In India, a number of NGOs are involved in the development and dissemination of improved cooking technologies. Amongst these, the NGO SKG Sangha has been active in both cook-stoves (over 200,000 installed) and biogas digesters (over 100,000 installed), winning a prestigious Ashden Award for Sustainable Energy for its work in 2007 (SKG Sangha 2011).

The role of NGOs in the previous Indian Government cook-stove programme is explored in the following chapter. In governance terms, NGOs have the potential to provide resources (expertise, technologies and money) at ground level, often with more focus on the needs of the poor given their specific local knowledge. In addition, NGOs can act as an effective conduit for the voices of poor people within public administrations and international organisations, giving agency to cooks that would otherwise not be possible. While the targeting of development activities on the poor might be considered to be better for NGOs than for public donor organisations, one study finds that the actual targeting of development NGO activities on the poor depends partly on the source of the organisation's funding (Nunnenkamp et al 2009).

To summarise, governance occurs within the cooking system over a broad range of geographical scales and between a spectrum of actors. The degree of connection and coherence between the different actors at different levels, and in particular how well the needs of the poor are represented, is key to achieving lasting, equitable, results.

[20] Practical Action was previously called the Intermediate Technology Development Group (ITDG).

Governance is a useful starting point from which to ask questions such as who has power and agency over decision-making regarding allocation and distribution of resources, how do these actors exercise their power and what are the distributional consequences? Of primary importance for cooking is whether there are *blind spots* (Newell et al 2009) resulting either in the neglect of the sector relative to its importance, or in activities producing inequitable outcomes by not serving the poor.

2.5 Behaviour and conceptualising cooks and cooking practice

Cooks and the cooking process can be conceptualised in different ways, with the manner chosen influencing the findings in subtle but sometimes profound ways.

2.5.1 Behaviour and choice

Behaviour, defined in its broadest sense, includes attitudes and beliefs - the antecedents of behaviour – and actions which are its ultimate expression. The choices people make – or do not make – is influenced by behaviour in its broadest sense, encompassing processes, whether conscious or subconscious, learned or innate, voluntary or involuntary. Theories of consumer behaviour related to energy use have typically focussed on those behaviours resulting in reduced environmental impact. A comprehensive review of consumer behaviour and behaviour change has been compiled, focusing on issues relating to motivating sustainable consumption in western economies (Jackson 2005). While some of the thinking may be transferable from rich market economies to the topic in hand (cooking behaviour in India), it is considered that some important differences between the two contexts limit the degree of transferability. Firstly literature related to energy use in developed economies typically refers to consumers in the market economy switching to an alternative technology, or reducing consumption through behaviour change of some sort. In the case of domestic cooking by contrast, many of the users are currently employing stoves and/or fuels outside the market economy; that is stoves and fuels are often either not paid for, or acquired within informal, local, economies. Thus the behaviour change in question (acquisition and use of improved biomass stove) involves both the adoption and use of a new technology and also – in many cases – new involvement in formal markets. Another key difference between experiences in Europe and the subject matter of this research is that the former generally focuses on using less energy, while for the latter the issue of polluting emissions is of more primary importance from the perspective of this research.

Providing a useful framework within which to understand behaviour with regard to technology adoption, innovation theory has it that "*…the main characteristics which determine an innovation's rate of adoption are: (a) relative advantage, (b) compatibility (c) complexity, (d) trialability, and (e) observability…*" (Rogers 2001a, page 7541). *Relative advantage* is that perceived by the user concerning the innovation, in comparison with the technology currently in use (traditional stoves and fuels). *Compatibility* refers to the norms and values of the individuals and societies in which the innovation is to be adopted, while *complexity* is the degree to which the innovation is perceived to be difficult to implement. *Trialability* refers to the extent to which users can adopt the innovation for a limited initial period to assess its merits and shortcomings; in the case of cook-stoves users are generally not given trial options, which may inhibit adoption. Finally *observability* refers to the extent to which the benefits of the innovation are visible to others; the more observable the benefits the more likely a good innovation will be disseminated quickly. In the case of stoves, the tight social networks amongst cooks (women) especially in rural areas means that levels of observability should be high.

This framework provides a useful counter to a historical strand of thinking regarding consumer behaviour, based on classical economic theory, which takes as its starting point the concept of *economic man, a*lso known as *homo economicus.* This model of human behaviour assumes that people are driven by the pursuit of selfish interests, based on knowledge of the options and assessment of the pros and cons of each, to maximise their own utility (Economist 2011). However, increasingly the limits of this approach have become apparent both in terms of its ability to describe current behaviour, as well as to design policies to change behaviour in the direction of specific policy goals. Behavioural economics has been developed to extend the economists model of human behaviour, drawing on insights from psychology (Economist 2011). Thus there has been a shift in thinking towards more nuanced models, recognising that human beings do not always respond in ways that seem rational (to classical economists).

Some economics techniques have been applied recently in Bangladesh to understand both the social and economic factors influencing cooking practices, specifically switching to improved stoves (Miller et al 2010); this work, marks an interesting departure, using experimental designs that yield revealed preferences of users, with results capable of analysis using quantitative techniques.

Generally researchers and practitioners are faced with formidable data challenges when trying to represent and analyse cooking behaviour. The sheer numbers of people involved and the diversity of their everyday activities is generally represented by large, highly aggregated data sets. For example much research and practical work in India is based on nationally produced statistics, generated as part of the census or National Sample Survey Organisation (NSSO). State sponsored surveys, such as a recent national analysis of energy used for cooking and lighting (MSPI 2005), certainly provide valuable information for researchers on which to base broad characterisations of the cooking sector, such as presented in Chapter 1. Indeed researchers have used NSSO data to develop energy-economic models of cooking in rural areas in India, thereby analysing broad associations between factors such as energy use, income, and indoor air pollution eg (Kavi Kumar et al 2007), sometimes resulting in generalised conclusions about, for example, the relative cost-effectiveness of different cooking options (Kanagawa et al 2007).

Some researchers, realising the problems of highly aggregated data-sets go further, attempting to build *bottom-up* models to analyse current, and predict future, cooking choices (van Ruijven et al 2011); however such attempts are also reliant on highly aggregated data from NSSO to calibrate the models. The NSSO data does not itself represent the multiple fuel use strategies employed by single households, thus limiting the value of models using data resulting from it. Thus while useful, analyses based on aggregated data can never represent cooking behaviour as it actually happens.

2.5.2 Cooks and cooking practice

Representing cooks as data points, resulting from census processes or market surveys, can result in cooks themselves being conceived of as one-dimensional passive actors. While implicit in much research, this stance has been shown to be an incomplete and inappropriate representation of cooks. Key commentators have for some time called for *putting people* back into equation (Mearns, Leach 1989) and taking a more *actor oriented* approach to the cooking issue, highlighting that "...*development interventions should include actor-oriented tools in energy planning, implementation, monitoring and evaluation*..." (Reddy et al 2009, page 1002).

The way in which cooks have been conceptualised in much past analysis, it is suggested, has resulted in cooks being seen as passive actors with little agency, following simple rules and logics, on which new policy initiatives and technologies can be imposed from above. A fundamentally different framing of the issue, placing cooks and cooking within the psychological, social, cultural and historical context in which they exist, might overcome some of the shortcomings associated with analyses of the sector to date. One element of such a new perspective would be the recognition of the agency of the cooks themselves.

Practice theory has its recent roots in theorists such as Anthony Giddens, outlining his theory of *structuration* (Giddens 1984). As part of this theoretical exploration, Giddens argues that individuals cannot and should not be separated from their everyday contexts, which they in turn have a role in shaping. He thus places special emphasis on the power or agency of individual human actions with regard to societal change, while recognising that social context can both stimulate and inhibit such change. While interpretations of practice theory vary between theorists, interest in its application to cooking in India within this thesis was "…*tied to an interest in the 'everyday' and 'life-world…"* of cooking (Reckwitz 2002, p 244) with a focus on "…*emphasizing routines, shared habits, technique* *and competence…"* (Shove et al 2005, p 44). Proponents of a practice approach have emphasised the collective nature of practices, with individuals conceptualised as the *carriers of practices* (Reckwitz 2002, p 249-250, as quoted in Bartiaux et al (2011), p 68). In this sense the usage of practice theory within this thesis departs from what can be regarded as its conventional meaning, in that within this research there is an attempt to show how an understanding of actual everyday cooking practices could be employed actively to encourage user-centred design of improved stoves. Additionally, whereas practice theory is generally applied empirically as a means of analysing societal changes underway, such as the adoption of Nordic Walking (Shove et al 2005) and eco-renovation of houses (Bartiaux et al 2011), within this research more emphasis is placed on existing cooking practice (ie use of traditional stoves). The reasons for this are two-fold: firstly few households have adopted ABSs and hence there is little practice to be studied. Secondly, it is conjectured that the habits and states of mind (ref. *habitus* following Bourdieu (1977)) associated with the practice is using of traditional stoves needs to be better understood as part of a future transition to clean cooking.

In a different context (eco renovation of houses in Europe), Bartiaux et al (2011) use a four-legged approach for the empirical study of practice. These are outlined briefly below with respect to their relation (or not) to this research, following the characterisation of Bartiaux et al (2011):

1. *Technologies and material structure* – the practice of cooking, and specifically the stove used, is closely related to the material characteristics of the cooked food required, and the fuel available, as well as the technologies to be found in the locality;
2. *Know-how and embodied habits* – know-how relates principally to knowledge and skills acquired for cooking on a stove and producing food to the standard required, and in the context of this research the prevalence of ingrained habits associated with cooking;

3. *Institutionalised knowledge and explicit rules* – Institutional knowledge is that acquired through formal training, or in the case of this research held by specialist researchers. Explicit rules relate to formal standards (eg technical standards for stoves), rules for subsidy provision etc.
4. *Teleo-affective structures* – loosely refers to the underlying reasons why individuals might change their practices. In the case of cooking, it is important to understand key drivers of individual cooks, whether these be - for example - cooking food to a certain standard, maintaining a clean home, improving the health of family members etc.

Relating a practice perspective to the topic at hand (adoption and use of improved stoves) helpfully supplements the traditional, object or artefact-orientated, approach with consideration of how the artefact (stove) is embedded in daily routines, which are in turn embedded within a socio-cultural context (Orlikowski 2000).

In commenting on the shortcomings of an STS transitions approach it has been noted that "...*for all the talk of sociotechnical coevolution, there is almost no reference to the ways of living or to the patterns of demand implied in what remain largely technological templates for the future...*" (Shove et al 2007, p 768). A practice perspective helps to address such over-emphasis on *technological determinism*, implicitly present in many past cook-stove debates, whereby stove manufacturers are effectively seen as being in control of the process of transition to clean cooking. Such a conceptualisation is inappropriate. Firstly it does not recognise the core social and cultural aspects associated with cooks (ways of living). Secondly, and more profoundly (although departing from traditional uses of practice theory), it does not recognise the processes by which cooks shape (or should shape) the processes of transition. While the opposite perspective, a *social constructivist* view - in which cooks and their social networks are totally in control of progress towards a cooking transition – is also inappropriate, since some important parts of the design, manufacture and distribution of stoves will necessarily happen outside this realm, a practice perspective helps to address past imbalances in perspective and bring the cooks back to the rightful place, at the core of the issue. One practical consequence, for example, might be an increased recognition, on the part of stove designers, of the need to deeply involve cooks in the design of new stove models.

For this research practice is employed in what might seem to be a simplistic manner - although this is not to trivialise its importance - to describe practices of cooking including the daily activities, routines and habits, their cultural roots, and the feelings of the person involved (usually women), their wider social environment, situating cooking within social and cultural context of family (with an interest in the food resulting from cooking), community and the state. Using a practice perspective helps to expand the field of vision, relating cooks and cooking to factors such as the household context, in which complex family dynamics exist, as well as shifting social norms and gender roles, and broader political changes taking place. In other sectors a similar stance has been adopted; for examples with regard to improving building energy efficiency where "...*users play a critical but poorly understood and often overlooked role in the built environment*..." recognising that "…*Buildings don't use energy: people do…*" (Janda 2011, page 1 and 20). Taking a practice stance, one study of changing household electricity consumption in India, highlights the importance of time-saving for women as a key factor influencing purchase of home appliances (Wilhite 2012). The study also finds that shifting social norms and expectations are driving increases in electricity consumption. Taking a practice approach, this thesis aims to tease out similar, hitherto largely unexplored, influences on cooks and the choices they make regarding cook-stoves.

2.6 Conclusions

This chapter has highlighted the conceptual and theoretical frameworks employed within this thesis. A novel combination of three conceptual and theoretical perspectives with respect to cooking is proposed, to enhance descriptive and explanatory understanding of the domestic cooking sector in India: Socio-technical systems; governance and political economy and practice theory. In summary it can be considered that for an equitable transition to clean cooking to occur, socio-technical niches need to reach the mainstream cooking regime, necessarily involving effective governance processes – providing agency to all relevant actors – while recognising the need for a practice perspective to represent the full socio-cultural context of domestic cooking.

Insights gained from employing these perspectives are provided in the following four empirical research chapters, while the concluding chapter outlines some broader findings regarding the value of the theories used and the need for further theoretical development.

"Those who cannot remember the past are condemned to repeat it" (Spanish philosopher George Santayana, 1905)

3 Review of experience with past government cook-stove programmes and a sanitation programme

3.1 Introduction

This chapter analyses experiences from the past government stove programme in India, the National Programme on Improved Chullahs (NPIC), and compares these with experiences from a government cook-stove programme in China, and with a sanitation programme in Bangladesh. The objective is to use the lessons learned from this analysis to develop insights about previous successes and failures with respect to cooking STS transitions, which can be used to improve prospects of achieving a future transition to clean cooking in India.

The NPIC represents the first of the three phases of cook-stove activity, characterised by the author to have occurred in India in recent decades (see section 1.2.1), and started in the mid-1980s. The second phase, which might be characterised by programmes led by corporations, is analysed in Chapter 6. These two chapters together aim to provide insights in support of the third, current phase, represented by the new National Biomass Cookstove Initiative (NBCI).

Using a review of the literature the chapter highlights reasons for the success or failure of past government public programmes with regard to their ability to achieve equitable socio-technical transitions. Following the definition of 'transition' provided in Chapter 1, success is defined as a mass-scale adoption of clean improved cook-stoves (capable of reducing emissions to safe levels), followed by sustained use of this new technology, and thenceforth either re-adoption following the need for replacement, or replacement with a technology with even greater performance.

The comparison of previous cook-stove programmes in Indian and China, and a sanitation programme allowed analysis across geographies and sectors, and is considered analytically appropriate for the following reasons. Firstly all three programmes were initiated by governments, and aimed at large scale change of a sector operating at the domestic level. The comparison between India and China is appropriate given that each country has a similar population and started off with comparable numbers of households using solid fuels for cooking with unimproved stoves; in addition the two countries both had extensive government improved cook-stove programmes, distributing comparable numbers of stoves. However, as illustrated in Figure 8, China's success is not matched by India's efforts. There is thus potential to draw insights from the relative success in China compared with relative failure in India.

To enable cross learning between sectors, an analysis of successes and failures in an analogous sector - sanitation – is provided; this sector is considered valid for comparison with the cooking sector given its relation to social development (health), the impact on every-day household practices of changes in the sector, and the history of intervention in the sector.

While the comparison between the three programmes studied yielded some valuable insights, there are there are some core, relevant, differences in political structure and cultural context between the countries, in particular between India and China; in India multi-party democracy exits, while in China the one-party political system exerts a very different sort of influence on its citizens. These political, and other cultural factors, would have had exerted relevant influence on the relative success of the programmes implemented in the different countries. However they are highly complex and not addressed within the literature relating to the cook-stove programmes studied, and hence do not feature in the analysis provided within this chapter.

3.1.1 The National Biomass Cookstove Initiative (NBCI)

The findings are intended to inform the nascent NBCI, the current status of which is outlined briefly here. The NBCI is currently undertaking pilot projects, expected to report in 2013, monitoring around 100,000 (1 lakh) domestic improved stoves to determine social and economic benefits. These pilot projects are being implemented through State Nodal Agencies, experienced NGOs, Self Help Group, manufacturers and entrepreneurs. Subsidies of up to 50% of stove cost are being provided (MNRE 2011a); subsidies of IRs.500-800 for approved stoves (those achieving government standards) have also been reported (Pursnani 2011). The results of these pilot projects will be used to determine the technical approach for the broader programme.

The MNRE is consulting on deployment models for this broader programme (IIT Delhi et al 2010), and there is currently little clarity about the future modalities to be employed by the programme. Current investigations involve analysis of appropriate delivery mechanisms, as well as possibilities for inclusion of activities on biomass fuel processing and delivery (IIT Delhi et al 2010); this latter aspect would mark a new departure for Indian government programmes, which have previously focused on end-use devices (ie stoves) only.

3.2 India – the National Programme on Improved Chulhas (NPIC)

The Indian Government has a long track record of promoting improved stoves on a large scale, through the National Programme on Improved Chulhas (NPIC) which ran from 1985 to 2002, funded by the then Ministry of Non-Conventional Energy Sources (MNRE [21]).

3.2.1 NPIC objectives

The broad objectives of the NPIC were to develop efficient biomass stoves and promote their deployment. The key initial aims of the NPIC in 1985 were to reduce wood-fuel use to minimise deforestation and forest degradation; two lesser initial objectives were to reduce drudgery for rural women and create income generating opportunities in rural areas through the local manufacture and sale of improved stoves (Hanbar et al 2002). The initial aims resulted in a focus on fuel efficiency, and can be attributed not only to a positive policy focus on forests, but also to a context in which the health benefits of clean combustion were not yet broadly understood (Venkataraman et al 2010). However the objectives of the programme shifted during its implementation, largely due to new findings on the importance of indoor air pollution with respect to health (Smith et al

[21] Note this paper uses the abbreviation MNRE to represent the appropriate ministry. The current name of this is Ministry of New and Renewable Energy (hence MNRE), adopted in 2006. This name replaced the Ministry of Non-conventional Energy Sources, abbreviated by some of the literature as “MNES”.

2000) and the realisation that biomass fuel use for cooking was only one source of forest degradation, and probably only a minor one in comparison with expanding agriculture, human settlements and timber production, as discussed in Chapter 1. Of relevance is the fact that highly aggregated data analysis, by respected international organisations such as the Food and Agriculture Organisation (FAO), resulted in mis-leading conclusions and interventions not necessarily appropriate to local priorities, in a manner akin to the mis-use of aggregated data reported by (Leach 1987). Inappropriate interventions recommended included the development of wood-lots where they were not required or were uneconomic to run, and the promotion of improved stoves focussed on improved efficiency for fuel reduction, where this was frequently not the primary priority for cooks.

While not explicitly stated as an aim of the NPIC, there was a general expectation that the activities of the programme would result in a general shift in behaviour towards use of improved stoves, involving a change in attitude and culture that would make their use common-place; this implicit aim would have been equivalent to a *transition* in the sense defined in this research, although in practice this was not achieved.

Changing programme objectives over time (Hanbar et al 2002), are likely to have resulted in a lack of clarity regarding programme implementation. The gradual shift in focus from fuel efficiency (ie reducing deforestation) towards indoor air pollution (ie health), while appropriate, reflected a lack of clarity by those driving the programme and in particular poor analysis underlying the programme objectives. Additional driving forces such as the desire to achieve income generation amongst stove makers and installers would have complemented programme implementation had appropriate mechanisms been in place.

3.2.2 Programme strategy

The NPIC employed the *subsidy and welfare* approach, allowing the purchase of one improved stove, at a subsidised price, per household (Hanbar et al 2002). Overall national targets were devolved to the state level. The cost of improved stoves deployed through the NPIC was between IRs 100-300 and 50-100% of this cost was met with subsidy, depending on the state and (in some cases) the socio-economic status of the household (Kishore et al 2002).

The NPIC resulted in the distribution of around 35 million stoves. However there is evidence that the use of subsidy resulted in unintended and unwanted outcomes; in some households the subsidised stove was purchased purely for the stove pipes which were subsequently used for irrigation, latrines or simply sold (national survey 1992/3 quoted in Sinha (2002)). It is now widely recognised that while use of subsidies may increase technology adoption, this is not necessarily translated into sustained use of the adopted technology, and careful subsidy design is required (Barnes et al 1994).

During its lifetime the NPIC attempted to undergo a transition from a pure subsidy approach towards one adopting more commercial principles, with the adoption of entrepreneur training programmes (Hanbar et al 2002). There was a shift in the late 1990s from artisanal small-scale stove production to mass production at village or district level (Hanbar et al 2002). The previous approach of training individual *Self-employed Workers (SEWs)* resulted in high drop-out rates of the SEWs due to the low earning potential, despite the availability of a subsidy. There is little evidence in the literature of the success of this commercialisation approach, although anecdotal evidence suggests that few of the commercial chullah production centres established by the NPIC are still operating. The foundations for a fully-fledged commercialised approach were not well developed in most states; indeed the presence of public subsidies is reported to have actively discouraged private entrepreneurs, who could not compete with heavily subsidised stoves (Barnes et al 2012, Sinha 2002).

The NPIC does not appear to have targeted its efforts at those for whom fuel collection is difficult, involving long journeys, and those paying for fuel, as suggested in the literature (Barnes et al 1994). Many Indian families gather fuel freely, and for such families reduction in fuel use is likely to be less of a priority compared to families paying for fuel or gathering it from far away (Sinha 2002). In addition in most states there was no means, under the NPIC, for distinguishing between very poor, poor and relatively well-off families. The latter group is likely to have the financial means to replace an improved chullah once it has been demonstrated that it is useful; however very poor families are unlikely to be able to purchase a replacement and hence would require on-going support.

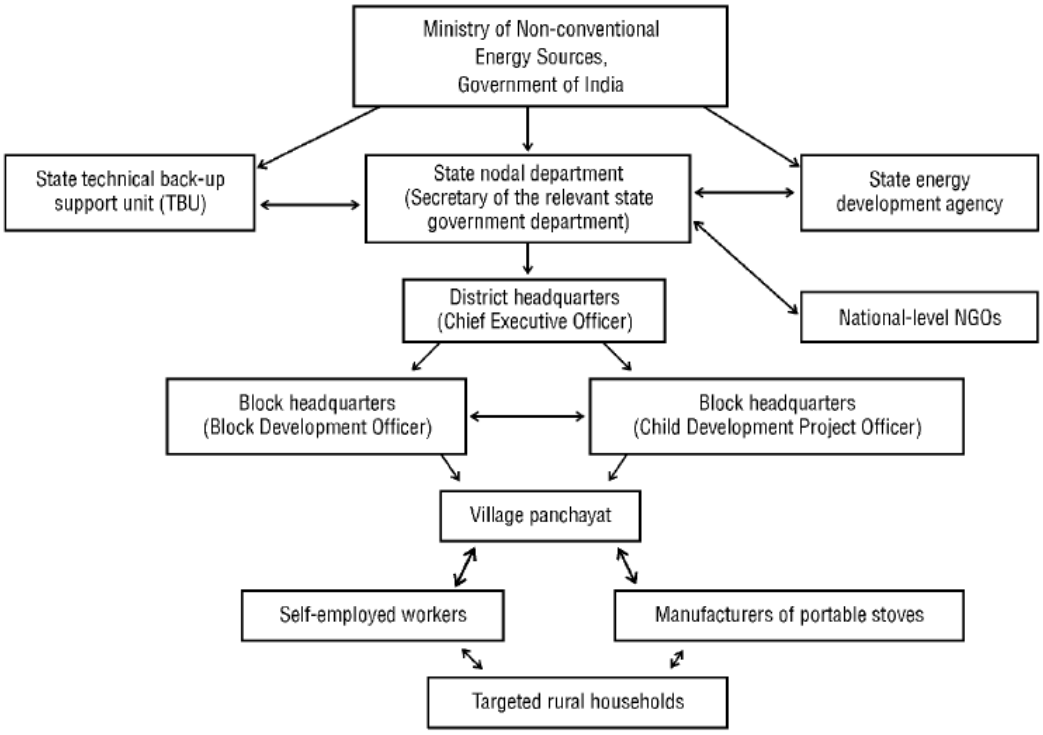
The programme was fundamentally designed to achieve its specific objectives (stove installations) with insufficient programme funds available for monitoring and assessment (Sinha 2002). This resulted in an incomplete record of achievement and problems experienced during programme implementation, and consequently faults in programme design were not recognised in time for corrective action to be taken, despite the long-running nature of the programme. At household level, the programme focus on numbers of stoves installed, rather than numbers of stoves in peak working condition and being used, led to insufficient funds being available for both maintenance and repair services (Kishore et al 2002) and monitoring of the actual use and performance of individual stoves which was lacking (Parikh et al 1999). Consequently mechanisms to enable technology adjustments, based on user preferences or technical performance, were sub-optimal.

There is evidence that the driving force of the programme - based on annual targets developed at national level and devolved to state level and then through multiple layers of state administration - resulted in what might be called ‘target chasing’ (Hanbar et al 2002). It is reported that the majority of stoves under the NPIC were installed in the last quarter of each year (Kishore et al 2002). While specific evidence has not been found, it might be expected that in such a situation, quality of installation might be of lower priority than quantity.

3.2.3 NPIC programme structure

The MNRE devolved responsibility for operations through a number of layers of administration, starting with departments in individual states, and then to districts, blocks and village Panchayats (see Figure 26). The programme ran in 23 states and 5 Union Territories (out of 28 states and 7 Union Territories).

Figure 26: Administrative structure of NPIC



Source: (Hanbar et al 2002)

The programme involved two components, one for research and development and one for the dissemination of improved stoves. The dissemination component was driven by a national target devolved through multiple layers of government bureaucracy to the ultimate suppliers, the Self-employed Workers (SEWs), composed of non-state actors including private sector and civil society bodies (see Figure 26). The state ministry responsible for execution of NPIC (termed the 'Nodal Department') varied depending on the state concerned, initially involving departments responsible for rural affairs in most cases, although some states chose forestry or social welfare departments. Nodal departments were provided annually, by MNRE, with a target for stove installations in the state; this target was then devolved through a number of layers of the state machinery. Initially the target provided by MNRE to each state was defined in terms of numbers of stoves distributed, although from 2000/01 the target definition changed to the number of villages covered by the programme (Hanbar et al 2002); there is however no evidence of the MNRE judging success of its activities according to the number of stoves actually in use.

The second component of the NPIC involved research, development and testing of the new stove models. This component was managed by an appropriate state body (Technical Back-up Unit – TBU), in some cases universities, and in other cases engineering colleges or state research institutes. There are indications that too much emphasis within this component was placed upon meeting centrally defined stove technical performance criteria[22], as measured in the laboratory, at the expense of developing a knowledge base of the actual needs of users and the performance of stoves in real household conditions (Sinha 2002). However, in one case at least - in Maharashtra state - a relatively high level of satisfaction was reported by women at the close of the programme; this has been attributed to the sustained engagement with communities and users by the state Technical Back-up Unit (Appropriate Rural Technology Institute (ARTI)) which worked to understand user needs and train women in the use of improved stoves (Barnes et al 2012). ARTI worked with local artisans to produce improved stoves, and undertook extensive monitoring, managing to raise the awareness of users with respect to the benefits of improved stoves (The World Bank 2011).

3.2.4 Results obtained by NPIC

The programme resulted in over 60 domestic improved stove designs all of natural draft (ie not fan assisted) both in fixed and portable designs. The fixed designs were initially mostly made using traditional materials (mud and clay) while the portable designs were fashioned from metal. Latterly attempts were made to make fixed improved chullahs using cement, although transport problems were apparent due to the weight of the resulting stoves.

[22] Mandated standards had to be achieved for stoves to be eligible for subsidies: 20% efficiency in fixed mud stoves and 25% in portable metal stoves (Barnes et al 2012).

Figure 27: Examples of a traditional chullah, and portable and fixed stoves disseminated under the NPIC

Traditional chullah (photo: Esther Duflo, MIT and J-PAL, 2007)

Metallic portable stove being demonstrated outside house, Maharashtra state (photo: ITDG)

Government-approved fixed chimney stove, Maharashtra state (photo: ITDG)

Statistics presented by the MNRE state that the NPIC provided improved stoves to 35 million households (MNRE 2004), or around 25% of all Indian households (Hanbar et al 2002) during the lifetime of the programme.

While these figures may appear impressive, research has questioned the claims reported by MNRE in its series of annual reports (Kishore et al 2002). While the figures for the number of stoves installed are unproblematic – providing that the programme monitoring was rigorously undertaken, which cannot be verified – the conclusions drawn concerning programme outcomes are highly misleading.

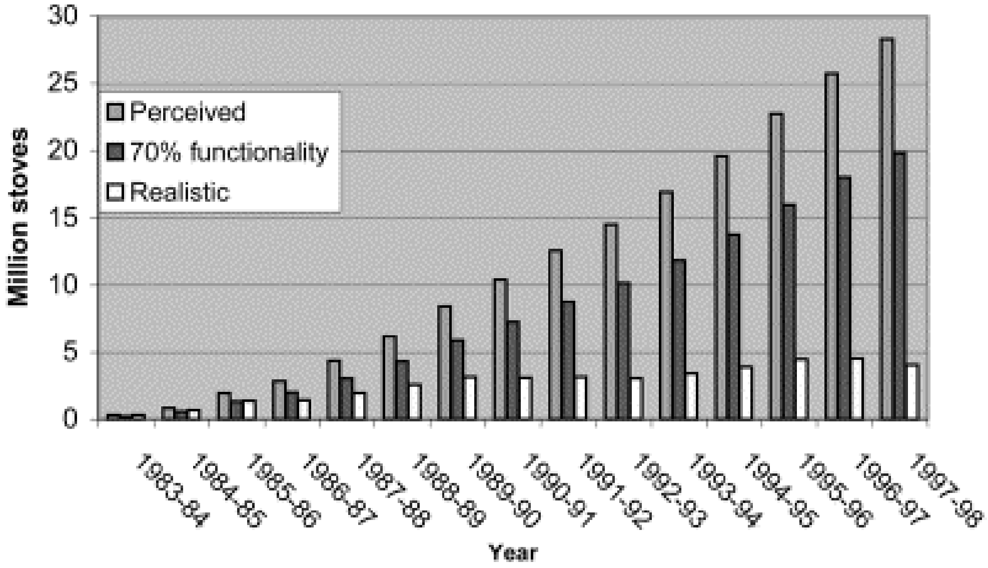
In particular MNRE assumed that 1) stove lifetime is indefinite (where in reality stoves installed lasted for 30 months on average (Kishore et al 2002)); 2) improved chullahs saved an average of 700kg of wood per year; 3) biomass has a value of IRs.400/tonne (Kishore et al 2002). Between 1983-4 and 1997-8 MNRE reported that 29.3 million stoves had been installed, and assumed that this implied that there the same number were in use in 1997-8. However for improved stoves made of mud, constant repairs would be necessary, and certain of such repairs would need to have been made by a skilled technician if the stove were to maintain its performance[23]. While women are very skilled at repairing traditional mud stoves – usually an ongoing task for minor cracks, with a complete re-build every year or so – there is evidence that few received sufficient training to repair improved chullahs, and that trained technicians generally did not undertake repairs on an ongoing basis (Kishore et al 2002). With portable metal stoves corrosion occurs and the life of these stoves can be expected to be 1-2 years (Kishore et al 2002).

Using statistical techniques, it has thus been calculated that in 1997-8 only 4 million of the NPIC chullahs were in operation, compared to the figure of 29.3 million cited by MNRE (Figure 28) (Kishore et al 2002) [24]. A survey undertaken in Indian in the mid-1990s showed that of all rural households only 5% had an improved stove (Zhang et al 2006) quoted in Barnes et al (2012).

[23] Note that the internal dimensions of the improved stoves (in particular the combustion chamber) are critical to its efficient functioning, especially combustion efficiency.

[24] Note that Figure 7 indicates that nearly 15 million improved stoves were in use in India around 2007/8, which appears to contradict this finding; note however that the definition of improved stove used to compile this figure was broad and consequently is likely to have included many stoves not considered improved under the NPIC.

Figure 28: Improved stove numbers in use in India showing 'perceived' number, 'cumulative' number and 'realistic' number



Notes: 1) 'perceived' number – means numbers cited by NPIC, assuming indefinite life of chullahs; 2) 'cumulative' number - based on 70% of functionality of installations, and 3) 'realistic' number based on statistical analysis by (Kishore et al 2002)*. Source:* (Kishore et al 2002)*.*

The consequences of the gross analysis undertaken by MNRE, of the number of stoves in effective operation, are large subsequent over-estimations of the benefits in terms of wood-fuel and monetary savings. Analysis shows that, making realistic assumptions, the fuel-wood savings per year in 1997/8, as a result of NPIC chullahs was around 0.75 million tonnes/year; this is around 26 times less than figures presented by MNRE (Kishore et al 2002). Monetary savings were seen to have been over-estimated by a similar amount, indicating that far from achieving a high cost/benefit ratio the programme cost more than the benefits it achieved (programme cost in 1997/8 IRs.4.6 billion versus calculated fuel-wood saving benefits of IRs. 128 million) (Kishore et al 2002).

No figures could be found concerning the rate of installation of improved chullahs following the termination of the NPIC in 2002. However anecdotal evidence suggests that this gradually reduced to a low level following the ending of the provision of subsidies. Hence it can be assumed that the current impact of the NPIC, in terms of stoves installed, is also low.

There is evidence that the national R&D infrastructure for cooking was enhanced as a result of the NPIC, with national laboratories such as the Indian Institute of Science continuing to take an active role in developing new stove designs (BP 2007b). With regard to the effect of the NPIC on the manufacturing and distribution parts of the cooking regime at local level, evidence is hard to find, although anecdotally it seems that there was little lasting impact; while there was no on-going monitoring after the end of the NPIC, of the use of NPIC improved chullahs, it is widely understood that the rate of replacement of chullahs was very low (Hanbar et al 2002).

Thus the end result of the NPIC was the dissemination of large numbers of improved chullahs, driven by the incentive of a one-off subsidy, but very little replacement and new uptake following the end of the subsidy regime, and thus – importantly for this research - a lack of transition. Hence while learning on a large scale was achieved, and an R&D infrastructure was developed, the NPIC can be considered a failure overall.

3.2.5 Stove design issues

The initial programme emphasis on reduced deforestation resulted in stoves being designed to maximise heat transfer efficiency of the stove design, which was expected to result in a reduction in fuel use. One strategy employed was to install chimneys on improved stoves, with the aim of removing pollutants from within the house. The physical removal of these pollutants is known to have been only partially successful, and had the unintended consequence of increasing outdoor air pollution. There is conflicting evidence of the success of NPIC stoves in reducing indoor air pollution. While evidence provided by MNRE (NPIC 1998) showed that air pollution levels inside houses were reduced, independent research indicates that no significant improvement was achieved with chimney stoves (Smith 1987), and that some NPIC 'improved' stoves had higher polluting emissions than traditional stoves (Smith 1989), due to reduction in combustion efficiency (Smith et al 2007, Smith 1989), see Figure 15. In addition the provision of a chimney tends to increase air supply to the combustion chamber which increases fuel use, acting counter to the main initial objective of the programme. One study found that 25% of fixed ‘improved’ chullahs tested had an efficiency of less than a traditional chullah, while 12% were more than twice as efficient; averaged over all tests, fixed improved chullahs were found to be 38% more efficient than traditional closed chullahs (NCAER 1993). While the technical issues surrounding stove performance are highly complex and beyond the scope of this research, a broader point of relevance is that technical monitoring of stove performance on the ground (both fuel efficiency and levels of polluting emissions) was largely absent, with the result that the impact of stoves on levels of indoor air pollution (and thus health) was not known; this compares with the Chinese programme which was relatively well monitored (Sinha 2002).

Clearly there was a great deal of variability in manufacturing and installation quality; the low performance and durability of the majority of stoves disseminated during the NPIC is widely reported, and is thought to be one of the main reason for the overall failure of the programme (Venkataraman et al 2010, Sinha 2002). It has been claimed that a key reason for poor manufacturing quality was the structure of the programme, based on top-down targets, motivating stove producers to satisfy the needs of government (numbers of stoves installed) over those of users (quality, durable stoves) (Barnes et al 1994, Sinha 2002).

One legacy of the NPIC is likely to be suspicion at household level with regard to newly introduced cooking technologies. The short life-span of many NPIC stoves, together with the low level of support under the programme for maintenance (Venkataraman et al 2010) could be expected to have resulted in widespread negative perceptions amongst Indian families. Successful cook-stove programmes require not only good technology but also a positive perception of that technology on the part of the cooks. Significantly there are reports noting that even where women were trained in maintaining their own stoves, they were generally not motivated to do so, indicating that they did not value the use of the stove highly enough (Sinha 2002).

3.2.6 User engagement

Important elements of successful cook-stove programmes are achieving awareness amongst the target groups, women, of the core problems (especially health) as well as the solutions; together these should result in demand for change. Under the NPIC ten-day *demonstration* camps were undertaken to encourage engagement of users, as well as local government officials and other stakeholders (Sinha 2002). Nevertheless there is no systematic research in the literature reporting surveys of the socio-cultural acceptance of NPIC improved stoves by users, and little on the general levels of awareness and demand.

It is likely that the general lack of engagement between stove technicians and cooks resulted in difficulty in developing chullah designs that would simultaneously meet the different programme objectives (in particular reduced fuel use, and latterly indoor air pollution reduction) while achieving ease of production and use (Barnes et al 1994). Many Indian families employ multiple fuel use strategies for cooking, depending on price and availability of different fuels (wood logs, twigs, dung and agricultural waste). The development of a stove performing well using all of these fuels presents a significant technical challenge, one that has was probably not met under the NPIC, although data to support or refute this conclusion has not been found.

There are suggestions in the literature that in some areas the NPIC resulted in a certain degree of increased bottom-up demand for improved cooking systems, with "...*women raising their voices in various fora to demand improved cook-stoves*..." and "...*some states promoting improved cook-stoves through people's programmes*..." (Sinha 2002, p26). Despite these successes it is found that the overall level of engagement of users in the process of change was not given sufficiently high priority (Barnes et al 1994, Sinha 2002). This is probably a result of the overall top-down target-driven approach of the programme, with too little attention given to bottom-up socio/cultural/attitudinal issues associated with the real practices of users.

While increased knowledge and awareness was probably achieved at the time of the programme, fundamentally there is little evidence that users were at the centre of programme and technology design considerations. Neither does there appear to have been any recognition that creating sustained user demand was any more complex than providing a new technology at a subsidised price. Stove designers were motivated more by the demands of their 'customer' – the government - than by the real customer – the cooks - resulting in examples of stoves being installed which did not match the cooking pots used by the family concerned (Sinha 2002).

The NPIC seems to have made simplistic assumptions about users (cooks), apparently framing them as rational economic agents, or *homo economicus* (see section 2.5.1). Under this framing it seems to have been assumed that design technicians could provide an appropriate technology with limited user engagement, and that uptake of this technology would be strong providing public subsidy was available. This latter assumption is apparently true, given the fact that 35 million stoves were distributed; however the lack of attention to user practices and demands seems to have resulted in little attitudinal change, given the – anecdotal – evidence that there was a low level of replacement of stoves following removal of subsidy schemes.

More broadly there was an apparent failure to connect the top-down approach of the NPIC with the complex and diverse reality of cooking practices on the ground (bottom-up). While some efforts were undertaken to 'educate' users, there was no evidence that this resulted in real user demand (bottom-up) for improved stoves following the end of the NPIC. The challenge for future efforts is to manage the linkages between these top-down and bottom-up elements of the cooking system, and fundamentally to catalyse demand from the bottom up; without such demand, future efforts are doomed to fail.

3.2.7 State-to-state variations in approach

There was a general attempt within the NPIC to promote links between public administrations and different types of non-state actors in the cooking sector. Such engagement by, and support from, public authorities has been identified as essential for the success of stove programmes, including the need to build capacity in research, manufacturing and distribution (Barnes et al 1994, Bailis et al 2009). However the result of these attempts was mixed under the NPIC. While some NGOs and Gram Panchayats (self-governments at village level) reportedly worked with government to support raised awareness of women as to the benefits of improved stoves, in many states lack of co-ordination between levels of state administration was apparent, and cumbersome procedures hindered effective working with non-state actors (Sinha 2002). Key lessons have been drawn together from states considered to have been most successful under the NPIC, with success defined as high rates of initial adoption followed by reinvestment or refurbishment by the family. Some of these reported lessons, good and bad, are summarised in Table 9; it is noted that evidence of success is taken from limited areas within these states, and does not imply general state-wide attainment of objectives which was generally not achieved (Barnes et al 2012).

This analysis highlights some generic factors associated with areas where success was achieved under the NPIC. Firstly the development of a coherent programme strategy, appropriately devolved through layers of administration appears to be a pre-requisite for success. Secondly the development of strong, functional links with existing non-state institutions operating on the ground, is necessary to provide a means of translating centrally-devised objectives into activity relevant for cooks. Thirdly programme structures must provide sufficient incentives at all levels, for production, distribution and maintenance of stoves. Finally the need for strong engagement with users is important at early stages within a programme, as well as during the post-adoption phase, when adaptation of technologies based on feedback is necessary. The converse of these lessons also holds, and applies to the majority of areas within India, where success was not achieved.

Table 9: Summary of lessons learned from areas within India considered to have achieved some success under NPIC

	Strong points	Weak points
Andhra Pradesh	- Strong coordination between agencies and Technical Backup Unit (TBU) -Extensive rural outreach resulting in TBU adapting stoves according to research of user feedback - Whole village approach	- Large subsidies did not support market development - After sales support and maintenance was poor - Lack of gathering of user feedback by nodal agency during monitoring of stove numbers
Gujarat	- Good coordination with existing housing schemes - Integrated rural development approach - Working with local NGOs (although high NGO failure rate was noted)	- Over reliance on subsidies did not result in stove maintenance or market development - Stove design and construction problems - Entrepreneurs not incentivised to produce and maintain stoves in absence of subsidies - Lack of awareness-raising of cooking health issues
Haryana	- After sales surveys were undertaken and after sales service provided - Well defined institutional structure for programme - Strong role for women's self-help groups supported women's understanding and ownership of the problem	- Large subsidies failed to incentivise Self Employed Workers (SEWs) to become entrepreneurs (although did reach poor households) - Poor quality stoves produced by some SEWs, due to target/subsidy chasing and lack of sufficient engagement with users
Karnataka	- Latter emphasis on SEWs and NGOs for distribution (shifted from earlier target-driven approach) - Strong research and development, including field testing resulted in framework for technical innovation	- Poor supply chains for spare parts and after-sales service - Absence of ownership amongst poor households provided with 100% subsidy
Maharashtra	- Involvement of existing traditional potters in production and sales, following commercial approaches - Technical adaptation of stoves by TBU to meet user needs, in coordination with traditional potters	- Absence of ownership amongst poor households provided with 100% subsidy
West Bengal	- Nodal agencies worked closely with extensive network of NGOs (150) - Some competition achieved between NGOs and good marketing - NGOs formed good links with Panchayats, helping to motivate villagers - After-sales service provided freely for one year	- Lack of stove field testing and adaptation of stoves by TBU - Some NGOs and SEWs assessed that the means of providing funds by the state did not provide sufficient incentive - Market perceived of as not sufficiently profitable by some SEWs and NGOs

Source: adapted from (Barnes et al 2012)

3.3 Review of Chinese cook-stove and Bangladesh sanitation programmes

3.3.1 Chinese National Improved Stove Program (CNISP)

The Chinese National Improved Stove Program (CNISP) started in 1982 and is generally considered to have been much more successful than the NPIC (Barnes et al 1994, The World Bank 2011). Improved stoves disseminated were mainly for biomass use, although some coal stoves were also distributed. In some areas stoves were designed to provide space heating as well as cooking. Surveys have shown that despite problems with product quality in the early stages of the programme, over two-thirds of stoves distributed were still in use after the programme (Smith et al 1993). A high level of support was provided for R&D, including an innovation system promoting competition between stove designers.

Institutional reorganisation within China in the early 1980s lead to separate ministries having responsibility for cooking in urban and rural areas. In urban areas the focus was mainly on fuel switching to fossil fuels, while activities in the rural areas focussed on improved cook-stoves. The renewed interest in improved stoves in the 1980s – there had been government activity in this area pre-Cultural Revolution – was largely due to growing concern about fuel shortages in rural areas, as well as forest and agricultural soil degradation (Smith et al 1993), although additional objectives included reducing drudgery for rural women and reducing polluting emissions (Sinton et al 2004). The last of these objectives was pursued later by the Ministry of Health which initiated a programme to promote improved stoves in poor regions of China in the mid-1990s (Sinton et al 2004).

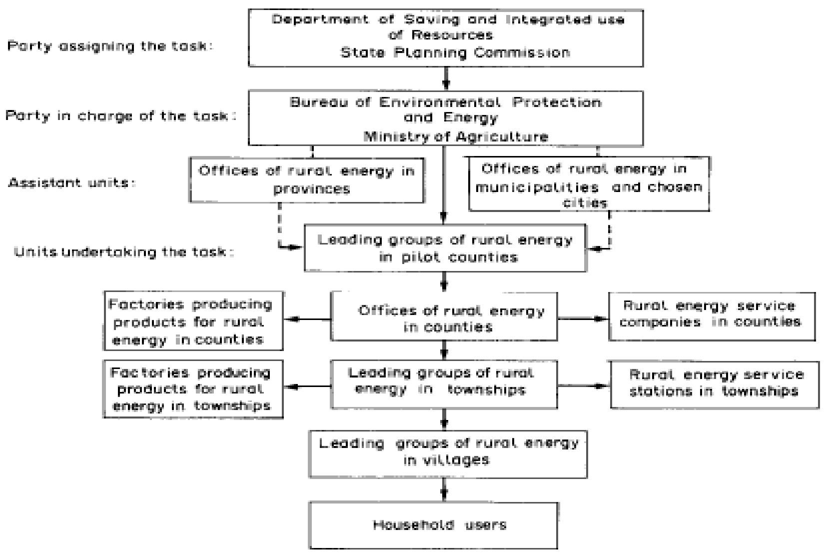
The CNISP broadly followed three overlapping stages (Sinton et al 2004):

1) 1983-1992 – focus on dissemination using subsidies to counties (and some households), and support to technical institutions;
2) 1990-1995 - subsidies to households were rapidly reduced, while financial incentives (tax benefits and cheap loans) were given to rural energy companies to advance the objective of commercialising the cook-stove sector. Training and administrative support continued;

3) After 1995 – government emphasis placed on support in the areas of advice and demonstration of stoves, as well as the administration of standards and certificates. The focus shifted away from an emphasis on stoves alone to more general integrated rural energy activities, including biogas and solar.

The centralised administrative organisation responsible for stoves (Bureau of Environmental Protection and Energy (BEPE) within the Ministry of Agriculture) organised a rural infrastructure for stoves, for research, programme administration, manufacture and rural extension. This included coverage of all Chinese provinces and municipal regions, including more than 1,500 Rural Energy Offices (Smith et al 1993). This infrastructure operated at all levels from national ministries, through to provincial, district and village levels. No doubt the high degree of experience within the Chinese administration of working between administrative levels contributed to the overall success of the programme (Sinton et al 2004).

Figure 29: Organization of the Chinese National Improved Stove Program



(Smith et al 1993)

The overall programme strategy was an annual selection - by the national body responsible for the programme (BEPE) - of pilot counties with which contracts would subsequently be drawn up. These contracts typically included obligations on the county, such as 90% penetration of improved stoves within three years and certain stove technical standards (eg pre-determined thermal efficiency). Later, further contractual obligations were added relating to the level of commercialisation and the numbers of stoves still in actual use after three years of installation. BEPE committed to provide a certain level of finance to the county, although it has been noted that this was not substantial, typically US$3,000 per year from BEPE to one county. This compares with financial transactions under the Indian NPIC of typically between US$250,000 and US$ 1 million between central government and state nodal agencies (Smith et al 1993); note that the geographical coverage of Chinese counties and Indian states are not comparable – the latter cover a much wider population – but the interesting point is that the lower level of individual financial transfers might be expected to have reduced graft and increased efficiency.

The 'leading groups' at county level (see Figure 29) were appointed by county chiefs and had a key role in administration and coordination of the programmes. The provincial Offices of Rural Energy played an essential role with regard to monitoring and evaluation, not only of the numbers of stoves installed but also their technical performance.

The County Rural Energy Offices were principally responsible for the extensive promotion and awareness-raising activities undertaken. The limited available funding meant that marketing had to be highly efficient and involved the use of demonstration visits to villages and households by teams from the Rural Energy Offices (ESMAP 2010).

Some counties adopted incentive policies, including the provision of preferential wood-cutting prices for stove-adopting households (for example in Wuhua County, Guangdong Province (Smith et al 1993)). In addition financial rewards and penalties were applied to village level administrations depending on adherence to certain programme criteria. Finally, in some counties local crafts-people were both incentivised and penalised, with financial rewards for the making of improved stoves and penalties for the making of traditional stoves (Smith et al 1993). A government end-user subsidy was applied to improved stoves in some cases, although it is interesting to note that this was at a much lower level than the Indian programme (stove cost 45 yuan - approximately €5.50 - with government subsidy of 4.2 yuan) (Barnes et al 1994). Poor households were allowed to obtain spare parts at no cost in a number of counties.

Sustained government support was provided for the institutional infrastructure behind the development and production of stoves until the early 1990s. This included rural energy companies and rural energy service units, of which there were 1,000 and 2,200 respectively in 1988, employing around 30,000 people (Smith et al 1993). The government provided low cost loans to help establish rural energy companies, with the overall aim of moving towards commercialisation in the sector. The sustained support by the government, coordinated between levels of administration, is documented as helping to expand the provision of improved stoves, while maintaining technical quality in production (Smith et al 1993), highlighting a marked difference with the Indian programme. However differences in stove effectiveness have been noted between those made in large centralised manufacturing units (with sophisticated combustion chambers) and those made on site, and it is clear that although the latter presented an improvement over traditional stoves, they did not perform sufficiently well to achieve the indoor air quality standards of the Chinese Government (Sinton et al 2004).

Following the winding down of the programme in the early 1990s, the focus shifted towards government support for manufacturers and energy service companies, with the government developing certification systems. The majority of effort on both development and dissemination was henceforth left to the market, with some technical oversight by government authorities (Sinton et al 2004).

3.3.1.1 Results obtained by CNISP

Between 1982 and 1990 improved stoves were distributed to 120 million households in rural areas under the CNISP (Barnes et al 1994) (note Sinton et al (2004) quotes 130 million by the early 1990s). Figure 8 illustrates the global significance of improved cook-stove efforts in China, with around two thirds of all improved stoves installed globally being in China (WHO 2009). The fact that around 115 million improved stoves are in use in China today (WHO 2009) is testament to the fact that the programme not only achieved the *adoption* but also the *sustained use* of improved stoves.

It is interesting to note that while sustained and coordinated involvement by the Chinese administration at all levels was a key reason for success, the overall financial commitment by public authorities was relatively modest given the scale of the programme, with most of the costs being borne by householders purchasing stoves at full (or near full) cost. It has been estimated that as of 1989 the Chinese Government had invested around US$200 million, while the investment by householders in new stoves had been about US$1 billion (Smith et al 1993); the ratio of public to household investment is much lower than under the NPIC.

Surveys have estimated that nearly two-thirds of respondents stated that they would replace their existing improved biomass stove if it broke, with only 6% saying that they would revert to their traditional stove (Sinton et al 2004). While this is a very positive result it does not tell the whole story of how the stoves were used, and what the impact of their use was. Firstly there is evidence that many of the early generations of stoves, installed in the 1980s, were not well maintained and subsequently became inefficient and ineffective; the need for a commercial mechanism to promote the upkeep of older stoves was identified (Sinton et al 2004). Secondly it would be simplistic to assume that the adoption of an improved stove in a house completely replaces the old cooking technologies, or that a certain percentage improvement in stove efficiency necessarily results in the same percentage reduction in overall biomass use. Indeed evidence was found that in a large proportion of houses that had adopted improved biomass stoves, an old, dirty coal stove remained in use for heating water, probably due to the ability of these stoves to work for long periods without being refuelled (survey reported in Smith et al (1993)).

While a survey in the early 1990s found that 95% of biomass stoves had chimneys, only 38 % of the coal stoves surveyed were found to have flues (Sinton et al 2004) indicating that further effort is required in the development and dissemination of improved coal stoves, since coal is a relatively common cooking fuel in China. The use of multiple stoves (and fuels) in most houses - both on a day-to-day basis depending on fuel availability and items being cooked, and seasonally - implies that the introduction of a single technology is unlikely to achieve predictable results in terms of fuel use (type and quantity) and wider impacts on health and deforestation.

A survey was undertaken to analyse the impacts on indoor air pollution of the Chinese stove programme (Sinton et al 2004); however the results of this were difficult to interpret given the wide variation in fuel/stove use, as well as confounding factors such as the presence of environmental tobacco smoke. Nevertheless some significant improvements were observed, including reductions in PM_4 concentrations for those using improved biomass stoves, when compared with other means of burning biomass fuels. However reductions in indoor air pollution were found to be insufficient to achieve national guidelines on air quality, and in "...*nearly all household groupings, PM_4 levels were higher than -- and sometimes more than twice as high as -- the national standard for indoor air measured in PM_{10} of 150 µg/m³...*" (Sinton et al 2004, p33). The fact that the Ministry of Health was not a major player in the main stove programme – even though this ministry did later have its own programme – may explain why health impacts of the programme were not given a higher priority.

The initial Chinese programme followed a targeted approach, supporting 860 of the country's 2,126 counties. In many of these counties there is evidence of transformative change and one survey found that "...*in many regions, stove programs appear to have successfully turned 'improved' stoves into 'conventional'' stoves*..." (Sinton et al 2004, p49). More broadly there is also some evidence of spreading beyond the areas of government intervention, which if true, is an important indication of a real *transition.* Information presented by the Chinese Ministry of Agriculture (MOA) highlights that "...*through provincial programs, independent efforts by counties not involved in the CNISP, commercial activity, and word of mouth, improved stoves spread to counties beyond those supported* *by the CNISP, until, according to MOA, most of China's rural households had at least one*..." (Sinton et al 2004, page 34).

Under the first phase of the programme a large number of stove designs were developed, with R&D undertaken at the national, provincial, and county levels. The China Center of Rural Energy Research and Training (CCRERT) carried out training, as well as promoting competitions under which stove designers presented their designs, which were independently tested at CCRERT and compared with others. This competitive innovation system is likely to have had a significant and positive impact on the quality of stoves disseminated through the Chinese programme, although it is to be noted that the actual performance of the improved stoves disseminated under the programme is lower than their performance measured in the laboratory (Sinton et al 2004); it is also significantly less than the performance of current state-of-the-art improved stoves. During the third phase of the programme public support for stove R&D was stopped, with development efforts being left to the market. There are indications that this has resulted in under investment in R&D, in particular due to poor protection of intellectual property – fake versions of branded stoves are apparently common – reducing incentives for the private sector to invest in research (Sinton et al 2004). Nevertheless many private sector companies in China are still producing stove parts, and several of the most modern improved biomass stoves (eg StoveTec) are produced in China (The World Bank 2011), many of which are exported, indicating that a by-product of the CNISP has been the development of an export industry.

3.3.1.2 Review of reasons for success/failure

In general terms the relative success of the CNISP can be attributed to the sustained and coordinated support of the Chinese administration, and a programme strategy designed to provide appropriate incentives at different levels. The transition from subsidy-driven approaches to commercialisation appears to have followed a more coherent strategy than in India, and is likely to have been boosted by the general shift to commercial and entrepreneurial approaches within China during the period.

The programme undoubtedly benefitted from the extensive experience of managing similar programmes involving multiple levels (from state administration, through to the provincial, county and village levels). Indeed it has been noted that *"...The improved biomass stove program design...benefited from the experience of widespread rural energy infrastructure that had been created largely in promoting biogas and micro-hydro ...."* (Smith et al 1993, p942). This experience meant that many previous failures associated with the running of similar programmes were not repeated.

The impressive institutional architecture appears to have been a major factor behind the results achieved, without having adding significantly to unnecessary bureaucracy, and having been achieved at relatively low levels of public spending. This includes demonstrated pragmatism regarding links between different levels of administration, with direct links between central government and counties in many cases, bypassing the provincial level where it was not felt to be useful. Systems of financial incentives and penalties at a number of levels (county, village and crafts-people) increased motivations to achieve results (Barnes et al 1994). While the institutional structure of the programme provides important lessons for other countries, it may not be directly comparable given the unique context of Chinese governance: a long experience of centralised one-party government, with a past history of working with a sophisticated network of regional and local administrations.

The fact that the CNISP concentrated initially on pilot areas where biomass was in short supply or fuel costs were high, and where institutional capacity was sufficient is likely to have been a key determinant of the high level of uptake and use of improved stoves. The criteria for choosing counties in which to work included the presence of fuel shortages; strong managerial, institutional and financial capacity and ownership of the programme within the county administration; and adequate supply of the materials necessary to make improved stoves (Smith et al 1993). The strategy encouraged competition between counties to become the next pilot areas, hence increasing local ownership of the programme (Sinton et al 2004). It is also apparent that areas and users targeted by the programme, at least in the 1980s, were those most able to pay for stoves, hence the low level of subsidy provided. The strategy employed by the Chinese programme was thus to work first in areas and with people where positive results were most likely to be achieved. This compares with the Indian NPIC approach which did not target certain regions, and which worked across nearly all of India.

There appears to have been more focus on user needs and desires during the stove design process (compared with NPIC), perhaps due to the strong local management and ownership of the programme. This, combined with the drive towards commercialised approaches through the rural energy companies established under the programme, is more likely to have resulted in products that households wanted to buy and use, compared with the more centrally governed approach in India.

The relative failure to meet indoor air quality standards can be at least partially attributed to the fact that this was not a key objective of the programme from the outset. Indeed, the fact that the Ministry of Health did not play a major part in the main programme, instead running its own, implies that health considerations were not to the fore. However as noted before, the performance of stove technology today is far advanced compared with the knowledge existing when the CNISP started.

The sustained engagement of government in technical follow-up was in marked contrast to the NPIC. Training and M&E efforts by government are some of the key factors behind the relatively high performance of the majority of the Chinese improved stoves (compared with the Indian NPIC) (Sinton et al 2004). This included comprehensive post-purchase technical monitoring of stoves in situ (ie in houses) using the Water Boiling Test[25]. The shift from artisanal to centralised production is

[25] Note the WBT uses a measured volume of water and tests the amount of wood required to bring this to the boil and simmer for a certain period; the actual WBT used was adapted to the Chinese situation. Although there are many technical arguments surrounding the ability of the WBT to represent real cooking situations, being standardised it has the advantage that it allows for comparison between houses and regions.

likely to be another factor behind the relatively high technical performance of stoves disseminated through the programme.

The low level of end-user subsidy offered under the Chinese programme (less than 10% [26] compared to 50-100% under NPIC), is likely to have increased user involvement in the new technology and promoted sustainable markets for stoves. The majority of the input of public finance was for programme level activities related to coordination and administration, monitoring, training, promotion and research, rather than end-user subsidies.

The fact that unimproved coal stoves continued to be used by many households should be viewed as a failure. While the characteristics of the improved biomass stoves were appreciated by the majority of users, as evidenced by the large uptake of these devices, insufficient thought was given to stove uses other than cooking, in particular space and water heating; for these tasks stoves are used for long periods, and users tend towards use of (generally unimproved) coal stoves, even though they are highly polluting, since the stoves do not need to be recharged with fuel as often as biomass stoves (Sinton et al 2004). Such everyday user practices and preferences clearly need to be fully understood for success in this arena.

3.3.2 Sanitation programme in Bangladesh

This section presents a brief analysis of activities in the sanitation sector, highlighting achievements and lessons for the cook-stove sector. The reasons for this analysis are firstly that the sector is analogous in many ways to the household energy sector, involving the need for mass-scale technology and behaviour change, and thus requiring careful programme design taking into account strategies and institutional architectures that can achieve scale while accounting for the cultural sensitivities involved. Secondly, while the achievements of public programmes on cook-stoves in India have been patchy at best, progress in the sanitation sector has been relatively strong in some countries. The analysis draws on experiences with the sanitation sector in Bangladesh, where there

[26] Although note that the evidence of subsidy levels is not consistent, with (Sinton et al 2004) citing average subsidies of 26%.

has been considerable success with the so-called *Total Sanitation Campaign* initiated around 2002, and outlined in (ESMAP 2010) on which the brief analysis below draws.

Driven by public health objectives, including the MDG for infant mortality, around 2001 the Government of Bangladesh committed itself to eradicate open defecation by 2010. The focus was on creating changes in attitudes and behaviour with respect to sanitation, and hence creating genuine demand for lasting change, rather than encouraging users to merely chase subsidised latrines, an approach which had previously failed. The result was that over a 5-year period in the 1990s, 90 million people gained access to (and used) latrines in Bangladesh increasing coverage from 20% to 80% (ESMAP 2010).

Prior to the Total Sanitation Programme the practice of open defection and use of poor quality latrines was common in Bangladesh, presenting a major public health hazard. Despite a number of programmes by both government and NGOs during the 1980s and 1990s little was achieved with respect to sanitation, with growth in coverage of only 1% per year. Some of the key reasons for this lack of success have been identified as being an over-emphasis on technology, and over representation of engineers with respect to the design of programmes, with too little engagement of communities and end-users (ESMAP 2010). In addition the centralised nature of the previous programmes resulted in a limited number of latrine designs being presented to users, while geographical and cultural variation called for a much wider range of options.

The new Total Sanitation Programme followed a different rationale, placing a much greater emphasis on engaging communities to achieve genuine bottom-up demand for improved sanitation, as well as encouraging local entrepreneurial activity to develop, produce and market locally appropriate technologies. Programme objectives shifted from numbers of latrines installed nationally – an approach that had previously been driven by the use of subsidies - towards the creation of a real demand from communities for a cleaner local environment. This demand was catalysed through sanitation awareness campaigns acting through a variety of local bodies including government, civil society and private sector, and targeting a range of stakeholders including households, community groups, students and teachers.

Key differences between the pre and post Total Sanitation Programme approaches are outlined in Table 10.

Table 10: Key differences in approach to sanitation programmes in Bangladesh before and after introduction of Total Sanitation Campaign

Elements of campaign	Past Target-driven approach	Present/future Community-led (Total Sanitation Programme)
Core activity	Constructing latrines	Igniting and facilitating process
Latrines designed by	Engineers	Community innovators
Number of designs	One or a few	At least 32 so far
Indicators	Latrines constructed	Open defecation ended
Motivation	Subsidy	Self-respect

Source: adapted from (ESMAP 2010) *p65*

While the programme relied on community level engagement, strong and sustained support and commitment from government has been identified as a critical factor in its success, in particular the consensus achieved between national and local government. This helped transform the programme from the previous technocratic approach into a *participatory social movement;* incentives were provided for communities that had achieved 100% improved sanitation giving an impetus for ongoing engagement by local government (ESMAP 2010). In general the buy-in from local government was seen to have resulted in more efficient administration and management of the programme, as well as a greater motivation for it to achieve results in their communities, whether by awareness-raising or regulating.

While subsidies were employed for the poorest households, they were not a universal feature of the programme, with the main focus being on local entrepreneurs working to commercial principles.

These entrepreneurs recognized the need for product differentiation, including low-cost solutions for the poorest households. Community level participation in programme monitoring was also an important feature of the programme (ESMAP 2010).

This brief analysis indicates that there are some important lessons to be gained by the cook-stove sector from the sanitation sector. Overall the key change in programme design that resulted in success was from a top-down, supply-driven model, towards one centred on community and user engagement, with demand being met following largely commercial principles but still involving strong support from both local and national government. The effective links between, and well-defined roles of, different levels of administration were key factors in programme success (ESMAP 2010). Achieving demand for change through community engagement and awareness-raising at a number of levels was central, as was the resulting application of peer pressure within communities, due to the community level benefit gained by individual households improving their sanitation practices. However it is important to note too that there are important differences between the sanitation and cook-stove sectors. While there is a strong community health benefit achieved by the ceasing of open defecation, the benefit of reducing smoke relates more directly to individual households. Thus the aspects of the Total Sanitation Programme that centred on community involvement based on communal level benefits may not apply as strongly in the case of cook-stove programmes.

3.4 Analysis of chapter findings

This section presents common programme features associated with success and failure across the programmes analysed. It has been shown that under both the Indian and Chinese Government programmes large numbers of improved stoves were disseminated. However in the case of the Indian programme, there appears to have been little on-going demand for new improved stoves following the end of the subsidy regime, and the programme can consequently be considered a failure in terms of achieving transition. In China by contrast, there is good evidence that uptake of improved stoves has spread beyond the government supported programme, both temporally and into new geographical areas, while in Bangladesh the evidence points to a transition to cleaner sanitation.

3.4.1 Common features of programme success and failure

3.4.1.1 Programme design features

Four core programme design features are found to be associated with success: 1) widely shared, coherent and clear programme objectives; 2) coherent long-term programme strategies providing appropriate incentives for the different programme actors; 3) effective monitoring of programme impacts, combined with modalities to enable adaptations to programme design and 4) targeting considerations.

The cooking programmes in India and China suffered from seeking simultaneously to achieve multiple objectives. To a degree one positive aspect of the cooking sector – that actions within it can simultaneously result in benefits for local development (eg health and gender equality), as well as local and global environment – is also disadvantageous, as it results in a lack of focus. The sanitation example did not suffer from a similar multitude of objectives, with a clean local environment supporting the health of inhabitants being the clear driver of activities in the sector. Indeed one subtle but important factor attributed to the success of the sanitation programme in Bangladesh is the shift from the previous programme objectives, based on numbers of latrines installed, to the ending of open defecation, an objective which achieved buy-in from local communities.

More fundamentally the process whereby programme objectives were articulated in the case of the cook-stove programmes appears to have been captured by a small sub-set of experts, with little engagement at programme design stages with those affected (cooks); the discursive power appears to have remained at a high level. While in Indian an energy ministry was responsible for programme design, it would seem appropriate for a greater role to have been played by those ministries more closely associated with the key issues of gender and public health.

It has been pointed out in the transition management literature that 'guiding visions' play an important role in the envisioning and framing of transitions, as well as motivating the different actors involved (Smith et al 2005). In this sense it is encouraging that the new cooking programme by the Indian Government appears to have a very clear – and ambitious - over-riding objective (public health) with the other possible objectives representing desired but non-essential outcomes. However it is not clear that this government vision is universally shared amongst users, and the warning regarding a lack of legitimacy in setting transition objectives, outlined by Shove et al (2007) (see Chapter 2), needs to be heeded. While it seems (at least to the author) that the current focus of the majority of the cook-stove community on public health is appropriate, a central question remains whether cooks should simply be educated to understand the importance of cooking with respect to public health – that is to agree with the 'experts' – or a more thorough process of defining objectives from the bottom up should be instigated, representing a sharing of discursive power.

The second design feature associated with success is the development of long-term coherent overall programme strategies. These have been found to be important in clearly delineating initial programme stages, where - in the language of socio-technical system transitions - niches are created (both technology and distribution models) and latter stages where the focus of state support is to encourage those niches to enter the mainstream regime. There is a need for a long-term strategy providing incentives (and skills) to those involved in delivering the change required, which promotes expansion of that change (adoption and use of more cook-stoves) beyond the initial catalytic subsidies. The use of subsidies is discussed in Chapter 7, and experience has shown that, while required in order to serve poor households and thus achieve equitable outcomes, careful design of subsidy mechanisms is required in order to avoid destroying nascent markets (The World Bank 2011, Barnes et al 2012). Lessons might be learned from Market Transformation processes in the west, whereby once certain levels of market penetration are achieved, it has been demonstrated that subsidies can be gradually withdrawn (Boardman et al 1997).

The Chinese cook-stove programme took an approach to subsidies that apparently resulted in successful commercialisation, shifting the focus of public funding from end-user subsidies gradually towards enterprise support measures, building rural energy institutions capable of manufacturing and delivering cooking technologies, as well as the development and policing of standards; this strategy resulted in conditions supporting technical innovation in response to user needs. In Bangladesh the role of community level innovators and entrepreneurs was emphasised. In India by contrast large end-user subsidies appear to have dis-incentivised entrepreneurial activity, as well as inhibiting innovation; in addition they often resulted in a lack of ownership of the stoves by the cooks. It is apparent that the entrepreneurs involved in India focused more on serving the needs of their perceived *customers* in government - those providing subsidies - rather innovating to meet the needs of cooks; commercialisation in India largely failed as a result. Recognising the need for enhanced incentives for innovation, the new Indian cook-stove programme is supporting an international prize (X-Prize) for the development of the next generation of advanced biomass cook-stoves (IIT Delhi, TERI 2010, X Prize 2010).

The ability to deliver coherent long term planning within the CNISP in China may be partly attributable to the political, one-party structure within the country, and the tradition of centralised planning devolved through layers of administration. In India, where politicians are required to appeal to their electorates at regular intervals, long-term plans might be expected to be more difficult to deliver.

Monitoring and evaluation (M&E) were core features of programme design success for both the Bangladesh sanitation programme and Chinese cook-stove programme. Built in at the start, the roles of the responsible organisations were defined more clearly than within the Indian cook-stove programme. The result is that in India, failures in programme design and operation in India were not recognised and acted upon.

The programmes in China and India followed different strategies in terms of populations targeted. While in China criteria were used to select pilot counties in which to operate, including management expertise and buy-in, and likelihood of success– in general areas with higher proportions of people able and willing to pay, and where fuel supply problems were highlighted - in India states were not targeted, and nearly all were provided with targets from national government. Thus is it perhaps unsurprising that there appears to have been a greater level of initial acceptance of improved stoves in China, since administrations chosen were better equipped and the users targeted had a greater need for them. It appears rational to target users where need for improved stoves is greatest, due for example to fuel supply shortages, and where affordability is assured (Barnes et al 1994). However there is a need to balance the rationale of targeting with the need for achieving equitable outcomes, by ensuring that poor households are served.

3.4.1.2 Programme structure and governance

Both Indian and Chinese stove programmes represented top-down approaches, involving significant government input, operating through a number of layers of bureaucracy. The importance of sustained government involvement in cooking programmes is broadly acknowledged (Barnes et al 1994, Venkataraman et al 2010, Bailis et al 2009); however the nature of this role is still the subject of debate. A general conclusion from this chapter is that successful programmes in sectors involving processes of change within multiple households (eg cooking or sanitation) require strong central government leadership. From a socio-technical multi-layer perspective, the state can be seen as being both part of, and influencing, the regime and providing landscape pressure for transition from outside the regime. However there appears to be a dichotomy between the dispersed, complex and heterogeneous nature of cooking practices on the ground and the nature of centrally-directed, top-down cook-stove programmes.

The analysis undertaken points to one means of overcoming this dichotomy, through the development of effective, well-functioning links between layers of public administration, combined with the formation of appropriate partnerships with non-state actors close to the ground. A conclusion of a major review of cook-stove programmes points to the necessity of active communication between different parts of the system: "...*Ultimately, however, dissemination programmes are most effective when they allow for interaction and feedback between stove designers, producers and users*..." (Barnes et al 1994, pvii). The literature highlighting the need for multi-level, multi-actor governance with regard to solving environmental problems is likely to be of relevance to the cooking sector (Lemos et al 2006).

Compared with India, programmes in China and Bangladesh appear to have achieved better delineation of roles between levels of administration, and better coordination between state bodies and non-state actors. It appears that while both Indian and Chinese programmes involved multiple layers of administration, the latter was more adept at producing an efficient structure, taking pragmatic decisions about which layers to include – and importantly which to exclude – and setting in place structures to ensure ownership of the programme by local administrations, and incentives for them to achieve desired results.

Long-term and sustained support from government generally results in large programmes and the challenge is to avoid top-down, supply-driven approaches, which are unlikely to address the complex and heterogeneous reality of cooking practices on the ground; the Indian programme appears to have fallen into this trap with too much power– material, discursive and institutional - maintained within high-level institutions, except in the few cases highlighted where specific, well-functioning, partnerships with non-state actors were created. Within the Chinese programme a greater degree of transfer of power to lower level institutions appears to have been achieved, at least institutional and material power through appropriate transfer of responsibility and resources to the local level. The example of the sanitation programme in Bangladesh demonstrates an alternative approach; this programme emphasised developing genuine community engagement first, thereby providing agency to, and creating demand for change within, communities; only once this was achieved were activities initiated to enable this change to happen.

3.4.1.3 User engagement

The programmes studied highlight the core need for user engagement and bottom-up demand for the technologies being promoted in order for transition to be achieved. In terms of transitions, without such demand the adaptation pressure within the regime is lacking. In the case of Bangladesh such demand was achieved through active community participation in all stages of the programme. In China the evidence points to the creation of demand through spreading of early success achieved within motivated communities.

The literature relating to NPIC highlights that one reason for the poor cook-stoves promoted was lack of user engagement. The technology development process did not generally take sufficient account of user needs and preferences in India, with the exception of some states where effective partnerships with non-state actors were created. Too much centralised control was exerted over stove designs through the Technical Back-up units. The result in general was the production of cook-stoves apparently not highly valued by the majority of cooks. The Indian programme was designed with the primary aim of achieving targets, set by administrators far removed from the field, and with stoves designed largely by technicians with insufficient knowledge of the needs and desires of cooks on the ground. In Bangladesh by contrast, the role of central government was largely to support local administrations and communities to engage with users, and raise awareness and hence catalyse bottom-up demand.

The analysis of the programmes studied in this chapter has clearly identified the need for user engagement at all stages of stove programme implementation. Emphasis needs to be placed on active engagement, giving genuine agency to cooks, in particular in terms of their discursive power to influence the future. Such engagement necessarily needs to focus on women, and is informed by practitioner debates on gender and energy (UNDP 2000, Cecelski 2003), as well as the broader discourses on the need for appropriately gender-balanced participation in development, with a view to giving a louder voice to women, often marginalised in development discussions (Cornwall 2003). Nevertheless, it is recognised that while participation is attractive in principle, its practice is complicated by hidden power relationships, cultural subtleties and the possibility of capture by special interests both within communities and by those defining development programmes (Rogers 2003). The need in the case of cook-stove programmes is for real participation, by women in particular, at all stages of programme development, from articulation of programme objectives, through the design process for technologies to ensure they meet real needs, and during programme implementation, to gain an active process of feedback from those most closely involved (cooks).

3.5 Conclusions

This chapter has analysed three different, government-led, programmes, involving cook-stoves in India and China and sanitation in Bangladesh. This has allowed some generic lessons to be learned. While acknowledging that the influence of differences in cultural and political contexts between the countries is important, detailed analysis of these factors has not been possible.

In conclusion, it has been demonstrated that the India cook-stove programme (NPIC) failed to achieve a transition to clean cooking, in the sense that niches developed did not achieve widespread acceptance and thus did not manage to reach the majority regime. In China however use of improved cook-stoves appears to have become main-stream, representing a socio-technical transition, whereby niche experiments, facilitated by the government programme, were elevated up to the regime. Similar success was achieved with sanitation, although via a different programme approach.

The chapter findings point to the central need for active user engagement and participation, creating agency - especially for women - during all stages of cook-stove programme implementation. This finding is in accord with another study which found that "…*In developing countries, many [cooking]* *programmes that had potential for alleviating indoor air pollution and reducing women's labour met with limited success because of the lack of consideration for women's needs and preferences*…" (Sinha 2002, page 24). Institutional and governance arrangements - involving effective working between multiple levels of administration and associated with functional partnerships with a range of state and non-state actors to ensure engagement of cooks - appear to be key criteria for success. The appropriate distribution of power (material, discursive and institutional) needs to be achieved to ensure the design of suitable interventions and provide the appropriate incentives to build momentum for transition. Indeed it has been noted that cooking programmes "... *succeed or fail for certain groups depending on the organizational structure, interrelationships and distribution of decision-making control embedded within development partnerships*..." (Simon 2010, p2011). The role of central government is shown to be important in providing landscape pressure, as well as financial resources required for transition. As pointed out by The World Bank (2011, pxi) "...*It will be necessary to clearly understand and designate the respective roles of governments, nongovernmental organizations, microfinance organizations, and the private sector in programs to promote advanced biomass and effective improved cookstoves*...".

The presence of bottom-up demand for change appears to be critical for successful transition processes. In Bangladesh this was achieved through community level involvement being built in to the programme design. In India, fleeting demand was created through the subsidy scheme employed; however, this did not result in long-term demand for the cook-stoves on offer. It is concluded that sustained public education, in particular focussing on public health for women and children, will be necessary, but perhaps not sufficient, for creating genuine demand for cook-stoves. Given that much of the target population resides in poor households, the provision of end-user subsidies, in some form is also expected to be required. The following chapter investigates inter alia, the degree of demand for change amongst cooks in one research area, as well as the technical potential for producing carbon offsets, a potential revenue source for subsidy schemes, within different socio-economic groups.

In India too much emphasis was placed on cooking as a technology development problem, with insufficient attention given to the needs of cooks and the actual *use* of this technology (practices). A broader understanding of cooking practices in everyday life and associated social, cultural and other factors influencing demand for change appears necessary; this will help shift the balance from the approach taken under the NPIC, representing technological determinism, towards a better representation of the role of social factors in shaping technology (Kline 2001, Williams et al 1996). To achieve a broad-based, equitable, transition to clean cooking, poor households need to be served, and for this there is a need for more nuanced analysis of user practices, differentiated between different socio-economic groupings. The following two chapters aim to increase knowledge in this regard. The next chapter presents an analysis of a large survey of end-user practices, attitudes and beliefs with regard to existing cooking practices and possible futures, disaggregated into various socio-economic classifications. Chapter 5 – based on focus groups - provides a more nuanced analysis of cooking practices, related to their cultural and socio-economic settings.

"The starting point of the current exercise is the user". Quote from the Indian Ministry of New and Renewable Energy in the press release, late 2009, announcing the new National Biomass Cook-stoves Initiative

4 Cooking behaviour, attitudes and emissions of household air pollution and greenhouse gases – market research in West Bengal

4.1 Introduction

This chapter reports and analyses household survey data with a view to advancing knowledge of the practices and impacts of cooks using traditional stoves, in particular those in low and middle income households. Specifically the analysis aims to address three questions:

1) What types of stoves and fuels are used and how does this vary between socio-economic groups of households?
2) What likes/dislikes, opinions and beliefs do cooks have regarding their existing stoves and fuels, and what are their beliefs and expectations regarding changing to improved stoves or fuels?
3) What levels of household air pollutants and greenhouse gases are emitted, and how do these vary between socio-economic groups? This data is calculated using quantitative data on fuel use, gathered as part of the survey.

Individual cooks are at the heart of this research. As shown in Chapter 3, insufficient attention has been given to cooking practices, and the needs and desires of cooks. It is recognised that "…*the main paradigm for successful improved cook stove (ICS) programmes has always been and will always remain understanding users' needs. Lack of appreciation of this paradigm amongst field workers is still faltering many ICS programmes*…" (Hulscher 1998, page 1). Improving understanding of factors influencing the stoves and fuels that people use and what predisposes them to switch (or not) to 'improved' methods is a necessary – but not sufficient – pre-condition to unlocking a transition to clean cooking, and is the subject of this chapter. One of the factors that might be expected to influence stove and fuel choice is the socio-economic status of the household; this is tested as part of the analysis.

The theoretical approach adopted for this research holds that individuals are at the centre of the existing cooking *regime* within the *socio-technical system* currently in place, and that without some adaptation pressure the existing regime will prevail. It is hypothesised that the core aspect of this adaptation pressure needs to derive from cooks themselves; in the absence of demand for change from them, and without access to resources (eg knowledge, skills and money) a transition to clean cooking will not occur. The second part of the chapter provides new insights, reporting opinions of cooks regarding their current cooking practices, including issues considered both positive and negative, as well as expectations of changing to improved stoves.

The final section of this chapter presents results of calculations performed, based on the quantitative survey results of fuel use, to determine quantities of greenhouse gas emissions and health damaging pollutants. Results are differentiated between households in different socio-economic groups. The aim is firstly to uncover any relationships between the degree of exposure to health risks from stove emissions between different socio-economic groups, which would provide insights into key target groups for stove programmes whose primary aim was to improve public health. Secondly, by differentiating greenhouse gas emissions from cooking by socio-economic group, it is possible to evaluate both the total contribution to climate forcing of each group, and – more importantly for this research - the technical potential for production of carbon offsets within each group through the adoption of improved cook-stoves. A novel aspect of the research presented in this chapter is its analysis differentiated by socio-economic classifications (SECs), which has been lacking in much previous research.

The populations analysed were predominantly those using traditional stoves, since this group makes up the majority of Indian households. Analysis of the attitudes of some of those, relatively few, Indian households using ABSs is included within Chapter 6.

4.2 Household survey in West Bengal India – scope, design and methodology

4.2.1 Introduction to the research area

This data presented in this chapter was gathered during a survey of 3,000 households undertaken in West Bengal, a state in the north-east of India. According to the West Bengal government website, the state has the following characteristics (West Bengal Government 2012): it is the fourth most populous state in India with a population of around 80 million in 2001, nearly 8% of the Indian population, made up of 28% urban and 72% rural households. The regional capital is Kolkata. The religious make-up of the population is dominated by Hindus (72%) and Muslims (25%). The state is densely populated, with slightly over 900 people per km^2, compared with the average for India of 324 people per km^2. Literacy rates are slightly higher than national averages at 69% overall, 77% for men and 60% for women. The Human Development Index (HDI) of West Bengal was 0.492 in 2007/08, ranking the state 13th out of 28 Indian states, the same as its ranking in 1999/2000; its growth in HDI during the period 1999/2000-2007/08 has been slightly less than the average for all Indian states of around 20% (Government of India 2011).

West Bengal is a significant state in terms of agricultural production, with 65% of total land area cultivable (West Bengal Government 2012). Other important economic sectors include service industries, mining and manufacturing (IBEF 2011).

The survey was undertaken within Bardhaman and Midnapore districts, located in the southern part of West Bengal (see Figure 31), in the Gangetic plain, a largely flat area, contrasting with the north of the state which rises to the Himalayas. The economy of the area is broadly based on agriculture, while some large-scale heavy industry is also present, for example in Durgapur (Bardhaman District), due to the presence of coal. The survey was undertaken within all six sub-divisions of the Bardhaman District (also spelled as Burdhman) and in one sub-district of Midnapore District

(Midnapore Sadar sub-district)[27] (see Figure 31). The total population of the areas surveyed is approximately 8 million people, 68% rural and 32% urban, residing in around 1.5 million households[28].

This part of India was chosen for study since national surveys (NSS) indicated high use of coal as a cooking fuel (MSPI 2005). Coal is known to emit higher levels of health damaging pollutants than other solid fuels, as shown in Table 4 and Table 5, implying high potential for improvement in health outcomes resulting from the use of improved cook-stoves. In addition, given the high carbon content of coal, reducing use of coal in cooking – through the use of an improved cook-stove – has the potential to yield relatively high CO_2 savings, and hence produce substantial quantities of carbon offsets which might be used as a revenue source.

4.2.2 Survey design

The survey was undertaken in August 2008, being commissioned and specified by the author, working as a consultant on behalf of BP Energy India Pvt. Ltd[29], and undertaken by a local contractor TNS India Pvt. Ltd. The data and analysis is divided into two parts:

1) Reported fuel and stove types used: enabling assessment of how different socio-economic variables influence *revealed preferences* associated with cooking, and presenting quantitative data on fuel use;
2) Reported attitudes and beliefs with respect to the current fuel/stoves in use, and the potential alternatives available.

The final results of the survey were presented in the form of a report "Understanding Fuel Consumption Practices" dated 15th October 2008 (TNS India Pvt Ltd et al 2008). The analysis presented below is based on the underlying data held in an Excel spreadsheet (TNS Pvt Ltd 2008).

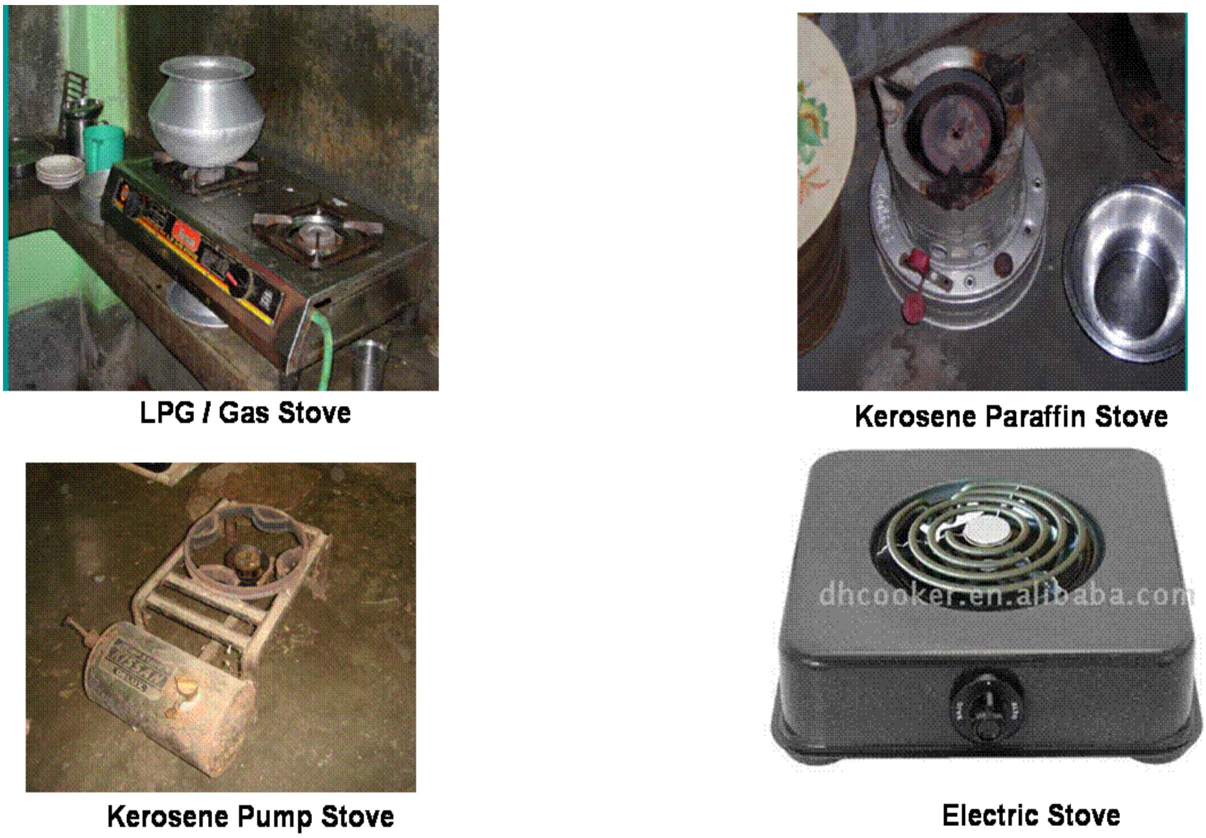
[27] Midnapore (also spelled Medinipur) Sadar sub-district is a subdivision of the Paschim Medinipur district in the state of West Bengal, India. It consists of Midnapore municipality and six community development blocks: Medinipur Sadar, Garhbeta–I, Garhbeta–II, Garhbeta–III, Keshpur and Shalboni

[28] Note that in all cases where 'Midnapore' is referred to, this relates to Midnapore Sadar sub-district.

[29] Business now operated by First Energy

The main objective of the survey was to support BP's understanding of cooking practices in West Bengal in general, and specifically to allow a baseline to be established (both energy and carbon), with a view to possible expansion of BP's cook-stove activities in the future to this region. The author over-saw the process of questionnaire design, data collection and report preparation, and supplemented the questions required by BP, by adding new ones to the survey questionnaire. Key additions to the questionnaire involved questions on household attitudes to the current cooking systems used, problems and benefits reported and the attractiveness of switching to alternative stoves and/or fuels.

Figure 30: Typical fossil fuel and electric stoves used in India



Notes: Photographs used as prompts during household survey (Source: (TNS India Pvt Ltd et al 2008)*)*

The data collection was divided into two modules:

1) **Consumer household survey** – the main element of the data collection exercise, households within the survey sub-districts were selected by stratified random sampling in three different zone types (urban, rural and peri-urban). Within areas surveyed, skipping instructions were followed to randomise household selection; after every successful interview, a certain number of households were skipped (5 in urban and 3 in rural) and the next one interviewed. The survey instrument, a detailed structured questionnaire, was used by TNS staff to collect data from 3,146 households (see Table 11 and Table 12).
2) **Supplier survey** – suppliers of fuel in the sub-regions were surveyed to validate the responses from the consumer survey, in particular to improve understanding of the seasonal variations[30] in fuel usage, since the household survey only provided a snapshot over a short period in August. The survey instrument used was a semi–structured questionnaire. Data was collected from 104 suppliers (Table 13).

[30] West Bengal has four main seasons: summer (beginning March to mid-June), rainy season (June to end September), a short autumn (October-November), and winter (November-January), followed by a short spring in some areas (source: Wikipedia accessed 4th February 2010).

Figure 31: Map showing location of West Bengal in India and Bardhaman and Midnapore districts within West Bengal

Source: www.splendidasia.com

Indian States showing location of West Bengal

Source: http://www.wb.nic.in/westbg/dis.html

West Bengal state

Source: http://www.wb.nic.in/westbg/dis.html

Bardhaman District showing sub-divisions

Source: www.splendidasia.com

Midnapore District showing sub-districts

Midnapore Sadar sub-district

Table 11: Sample sizes per sub-district for the consumer survey

Sub districts	Urban	Peri – Urban	Rural	Total
Bardhaman Sadar North	147	150	152	449
Bardhaman Sadar South	138	164	150	452
Asansol	149	151	150	450
Durgapur	150	150	149	449
Katwa	145	159	139	443
Kalna	160	151	144	455
One sub district from Midnapore (Paschim Midnipur – Midnapore, Salbani & jahargram)	160	148	140	448
Total	1049	1073	1024	3146

Table 12: Actual sample (unweighted base) per socio-economic group (SEC) in urban and rural areas, and *weighted base (see explanation below)*

URBAN	SEC A	SEC B	SEC C	SEC D	SEC E
Unweighted Base	*206*	*408*	*450*	*476*	*582*
Weighted base	160	300	341	551	770
% of urban group (weighted basis)	7.5%	14.1%	16.1%	26.0%	36.3%
RURAL	**SEC R1**	**SEC R2**	**SEC R3**	**SEC R4**	
Unweighted Base	*39*	*80*	*332*	*573*	
Weighted Base	*34*	*70*	*495*	*419*	
% of rural group (weighted basis)	*3.3%*	*6.9%*	*48.6%*	*41.2%*	

Note that the SEC classification system employed, outlined in Annex 1, is a commonly used composite index developed by the Market Research Society of India[31]; it uses a combination of employment status and education level for urban areas; and type of house and education level for rural areas. The rows labelled *unweighted base* represents the actual number of households sampled, while the *weighted base* rows show these figures weighted for the actual proportions of households in each SEC in the survey areas. The Indian Readership Survey (2007) was used as the source of universe populations for each SEC, with the figures used representing the state of West

[31] In urban areas, SEC A denotes higher socio-economic status, while SEC E is for low socio-economic status. In rural areas the scale is from R1 (high socio-economic status) to R4.

Bengal (excluding Kolkata), as universe proportions were not available for the individual districts studied.

Table 13: Sample sizes per sub-district for supplier survey

Sub districts	Sample Size
Bardhaman Sadar North	11
Bardhaman Sadar South	24
Asansol	15
Durgapur	15
Katwa	10
Kalna	15
One sub district from Midnapore	14
Total	104

4.2.3 A cautionary note

The methodology employed for data collection introduces several potential sources of bias or error. Firstly the design of the survey (eg sampling, questioning approach) has a central influence on the resulting data. This source of bias/error was minimised by testing the initial survey design in a small number of households and iterating the questions based on the findings.

There is another, less tractable, factor that could have influenced the results of the survey, namely the fact that the survey was undertaken by a market research company on behalf of a large multi-national organisation. Respondents were made aware that the commissioning organisation was an international company. This fact might potentially have exerted subtle influence on respondents, and certainly would have established a hierarchy of power, with economically poor, often uneducated respondents on one side and a powerful multi-national on the other. This might perhaps have encouraged respondents to provide the answers they imagined the company was seeking, or maybe motivated an attempted *gaming* of the response, such that respondents replied in ways which they anticipated would result in personal gain for themselves (for example encouraging the company to work in their area, or provide them with a free product).

More specifically it is likely that there would have been a mis-match in social and economic status between questioners and respondents, with the former likely to have been wealthier, more highly educated and possibly from a higher caste. These factors too can be expected to have influenced the data resulting from this survey, although the fact that data gatherers were inhabitants of West Bengal, operating in the local language (Bengali), would have mitigated this effect to some extent.

While important to highlight, these factors are prevalent in all similar market research in India, and were reduced to the extent possible. However it is important to acknowledge the possibility that practices and beliefs reported do not necessarily directly correspond with the actual behaviours and attitudes of respondents. While the possible influence of BP as the commissioning organisation has to be acknowledged, the fact that the author was able to introduce questions without resistance from BP, and that the organisation had no influence on the analysis and interpretation of the data presented in this thesis will have limited this effect. Overall, while noting the need to be aware of these possible sources of error, it is considered that given the careful process of survey design, they have been minimised to the extent possible.

4.3 Survey results

Survey results are presented in three main sections: 1) reported stove and fuel use, 2) reported attitudes to, and satisfaction with, existing stoves and fuel, and attitudes to switching to alternatives, 3) calculated emissions of household air pollutants and greenhouse gases.

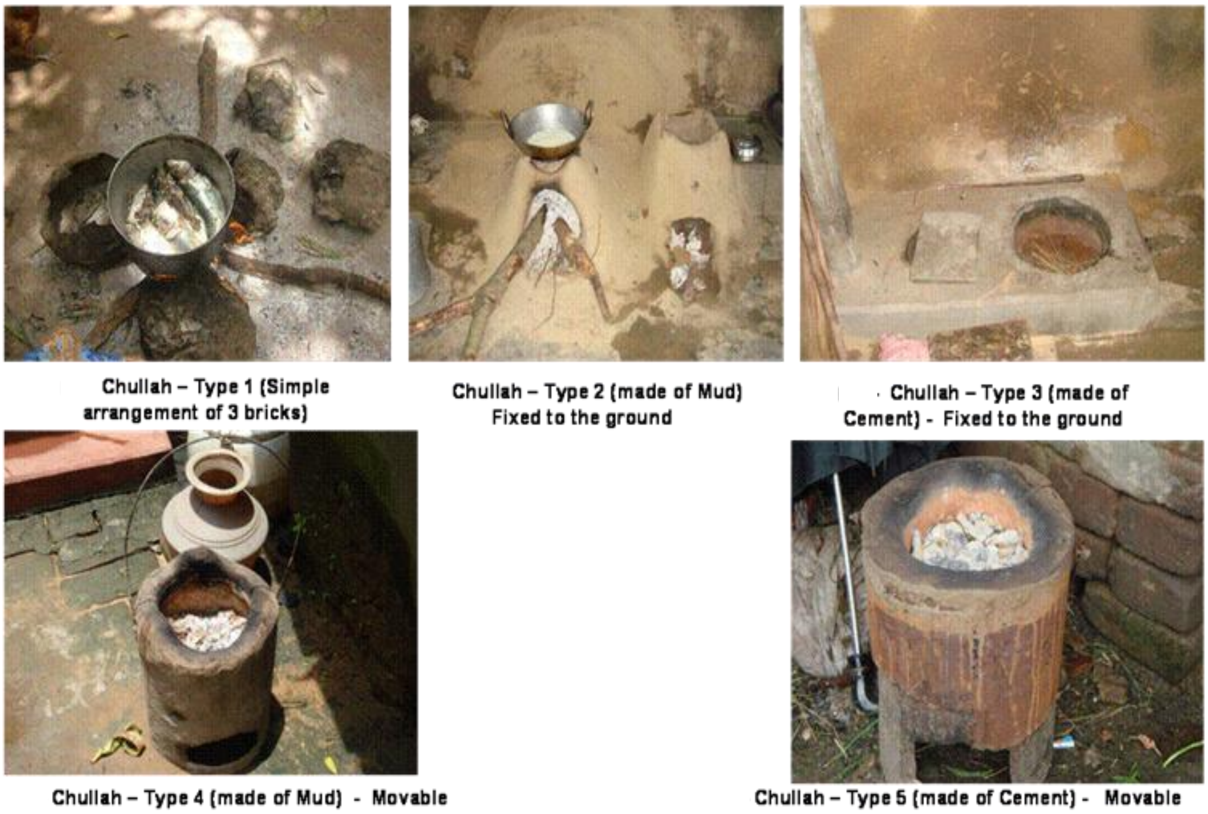
4.3.1 Reported stove and fuel types used

The survey collected data on primary and secondary stove and fuel use. Gathering data on secondary devices and fuels is a novel aspect of this research, one not covered by national data gathering exercises (eg NSSO, census), although as noted below, analysis of secondary stoves and fuels proved highly complex. The resulting data is disaggregated between rural and urban populations and socio-economic groups, allowing for further analysis.

4.3.1.1 Reported stove use

Figure 33 shows that for all areas (urban and rural combined[32]) surveyed fixed and moveable mud chullahs (Type 2 and 4 respectively, Figure 32) together represent 72% of the primary stoves used, with LPG making up the majority of the remainder.

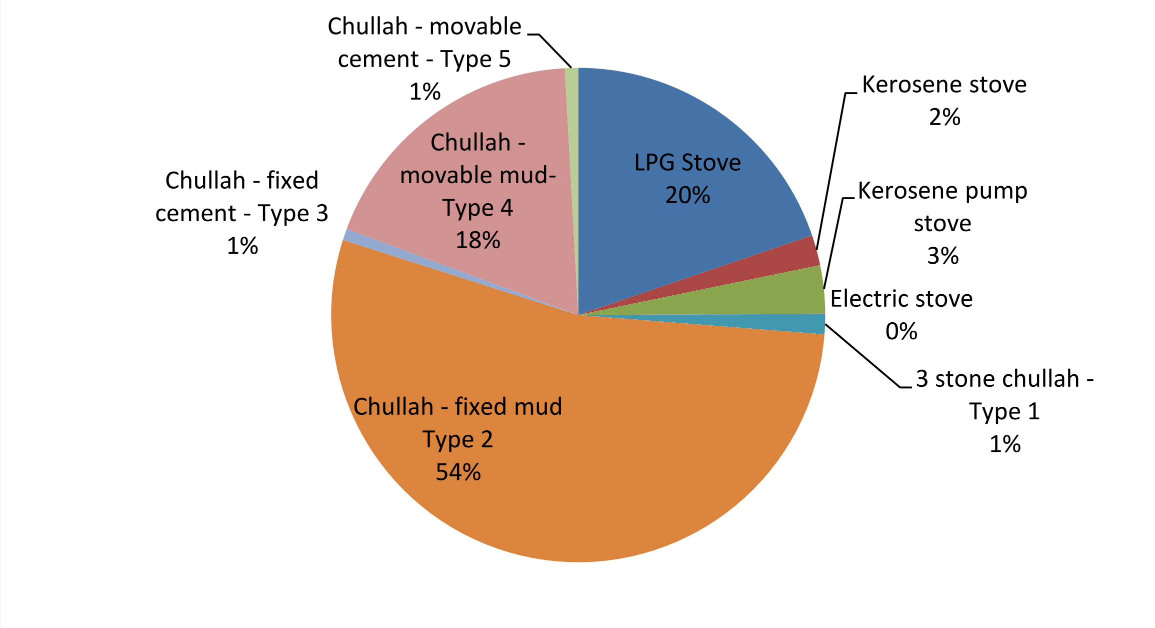
Figure 32: Typical traditional stoves used in West Bengal. Photographs used as prompts during household survey



(Source: (TNS India Pvt Ltd et al 2008))

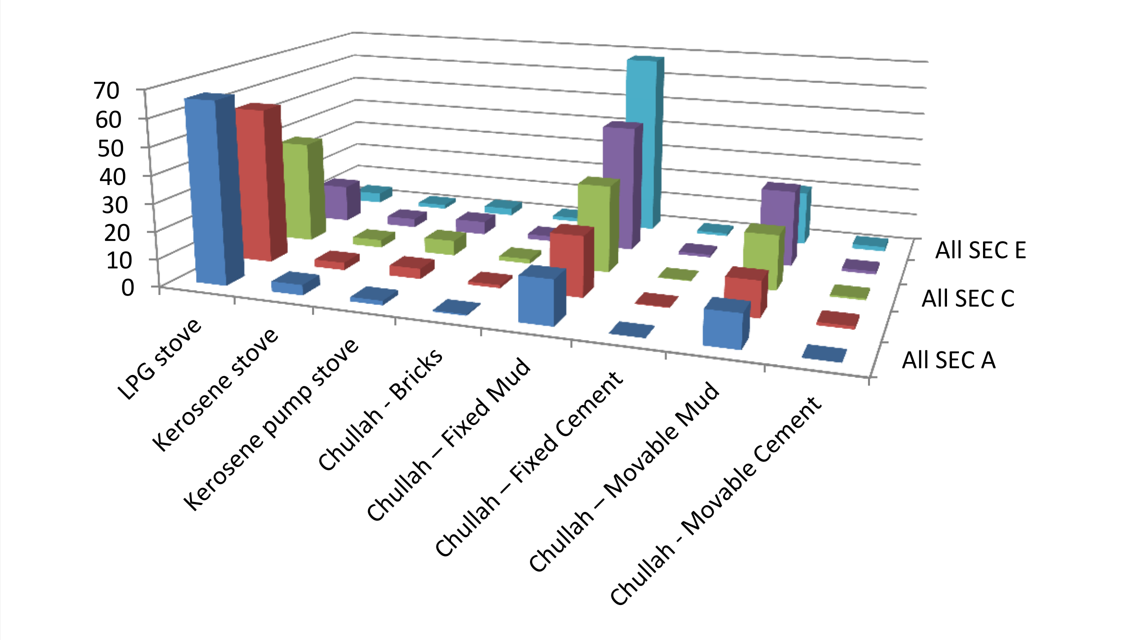
[32] Note that peri-urban and urban responses were amalgamated into one 'urban' group for all analysis in this chapter.

Figure 33: Stove most used (%) over all cooking occasions (primary stove), urban and rural combined, survey areas, West Bengal, 2008



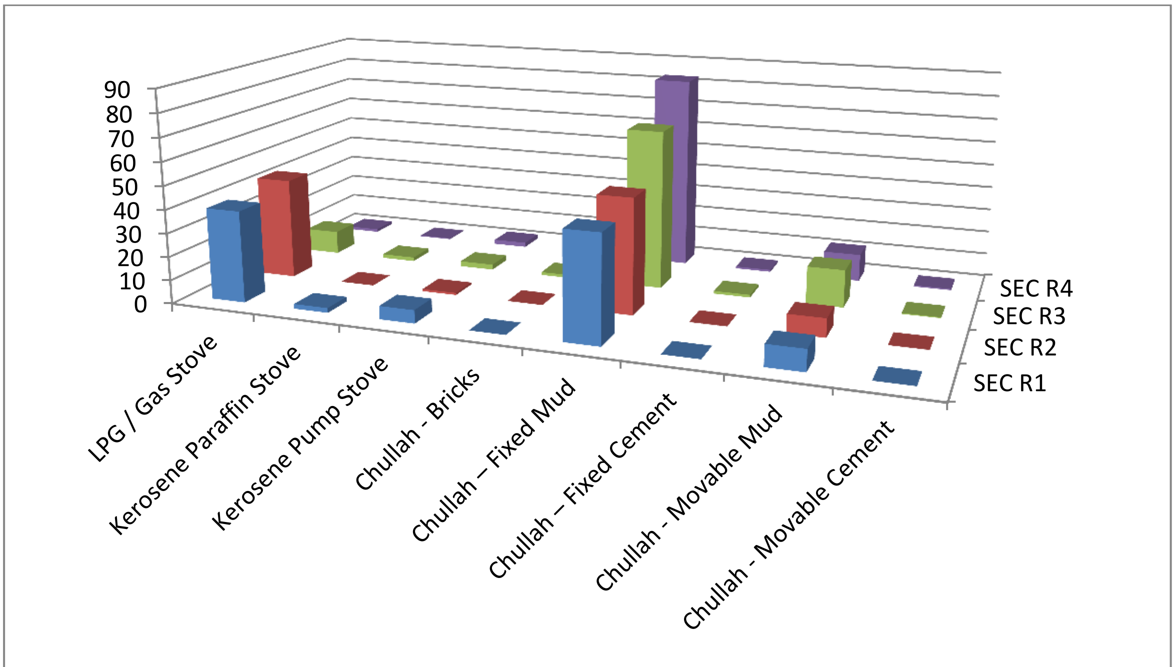
Data for stove use in urban and rural areas, broken down by socio-economic classification (SEC) is presented in tabular form in Annex 2 (Table 38 and Table 39) and graphically in Figure 34 and Figure 35 respectively below. Figure 34 shows that for urban areas there is a clear relationship between the main type of stove used and socio-economic status of respondents. A high proportion of SEC A group respondents use LPG as their primary stove (66%), while only 4% of SEC E does so, and there is a clear reduction in LPG use from SEC A to SEC E. The opposite is true for fixed mud chullahs with a steady increase in use from richer (SEC A) to poorer respondents (SEC E). A similar pattern, although less clear, is found for movable mud chullahs. While it is not surprising that the poorer a population is, the more likely it is to use traditional chullahs, it is interesting to note the relatively high prevalence of fixed and moveable mud chullahs used as main stoves amongst the higher SEC groups (combined use of these chullahs is 28% for SEC A and 35% for SEC B), indicating that even those who might be expected to afford LPG chose to use traditional chullahs.

Figure 34: Main stove used in urban areas (% households in each socio-economic group), survey areas, West Bengal, 2008



For rural areas Figure 35 shows that proportional use of LPG is much lower in rural than urban areas, probably a result of the problem of gaining access to this fuel given the distance from urban centres. Use of traditional chullahs as a primary stove is high in rural areas, with use of fixed mud chullahs increasing with decreasing SEC status (83% of households in R4).

Figure 35: Primary stove used in rural areas (% households in each socio-economic group), survey areas, West Bengal, 2008



Combining the profile of the survey area (Table 43 and Table 44 in Annex 2) with the findings presented in Figure 34 and Figure 35, calculations show that of all households in the survey area (urban and rural combined) 54% of households are in the lower rural SEC groups (R3 and R4) and are using either fixed or moveable mud chullahs as their primary stove. These findings have important consequences for any stove programme seeking the replacement of traditional stoves, highlighting the significance of those households in lower SEC groups in rural areas.

Key conclusions from this analysis of primary stove use are that firstly, there is a high prevalence of traditional chullah use as the primary stove amongst both urban and rural populations. Secondly, use of LPG is significant in urban areas amongst the higher SEC groups, while around 30% of this group continue to use traditional chullahs despite the likelihood that they could afford a more advanced stove. Thirdly, many households that could probably afford to use LPG continue to employ traditional chullahs. Finally, the lower SEC groups are by far the most significant users of traditional chullahs in urban and rural areas, especially the latter.

4.3.1.2 Reported fuel types used

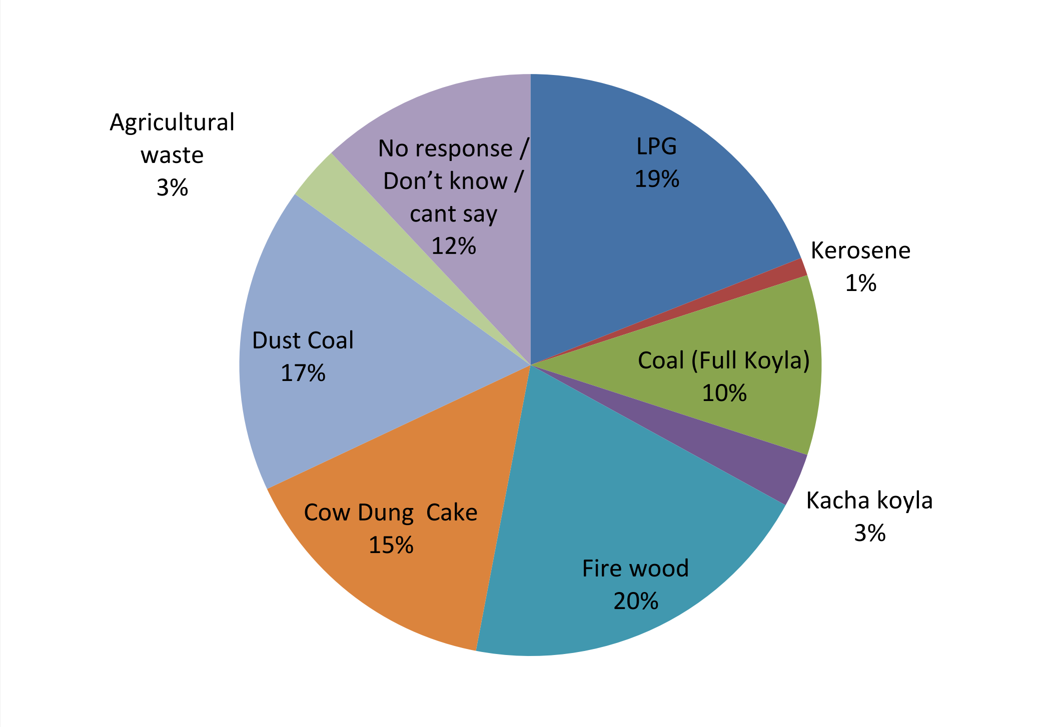
While the fuel used in LPG stoves and kerosene stoves is self-evident, a wide range of fuels is known to be burned in traditional stoves. Table 14 describes fuels reported as used in the study areas.

Table 14: Brief description of main fuels used with traditional chullahs

Fuel type	Comment
Fire wood	Including large wood pieces and sticks
Cow dung cakes	Dung is formed into flat cakes and dried on the ground or on the side of houses, and is sometimes mixed with coal dust
Agricultural wastes	Includes a wide range of materials such as straw from paddy fields, jute sticks, as well as inferior fuels such as leaves, roots etc.
Saw dust	Collected or bought from saw mills
Full Koyla	Koyla translates as coal in Bengali. Full koyla represents processed coal (processing involves separating the coal from rock and dirt, and sorting into different sizes using floatation or mechanical techniques)
Kacha Koyla	Loosely translates as 'raw coal'. This is the unprocessed, raw version of the ore, from the mines. Kacha Koyla is known to emit more smoke when burned, compared with full Koyla, and is generally cheaper
Dust coal	Small, powder or granular coal, usually a by-product of coal mining or processing. It is cheaper than solid coal, and is mixed with water, moulded into pellets, which are then dried outside ready for use as fuel.

The pattern of fuel use within individual houses is known to follow complex patterns, with the fuel used on specific occasions dependant on a wide range of factors including physical availability, price, season and cooking needs of particular food. It is now generally recognised that even in those households adopting modern fuels such as LPG or kerosene, the use of traditional stoves and fuels continues to some extent. This conceptualisation of the transition to modern fuels is termed *energy stacking* and replaces the previous model known as the *energy ladder* (Masera et al 2000); it reflects the reality that adoption of a *modern* stove and/or fuel is not generally a one-way process in which the traditional stove/fuel is left behind. For those using traditional stoves as their main cooking device, the use of multiple fuels provides a significant data challenge for policy makers and researchers. The data presented below provides information on reported use of *primary fuels*, that is those fuels used most often. While this is helpful in understanding the main activity of those households being studied, it does not present the full complexity of fuel use, which is explored further in section 4.4.1 and in the following chapter.

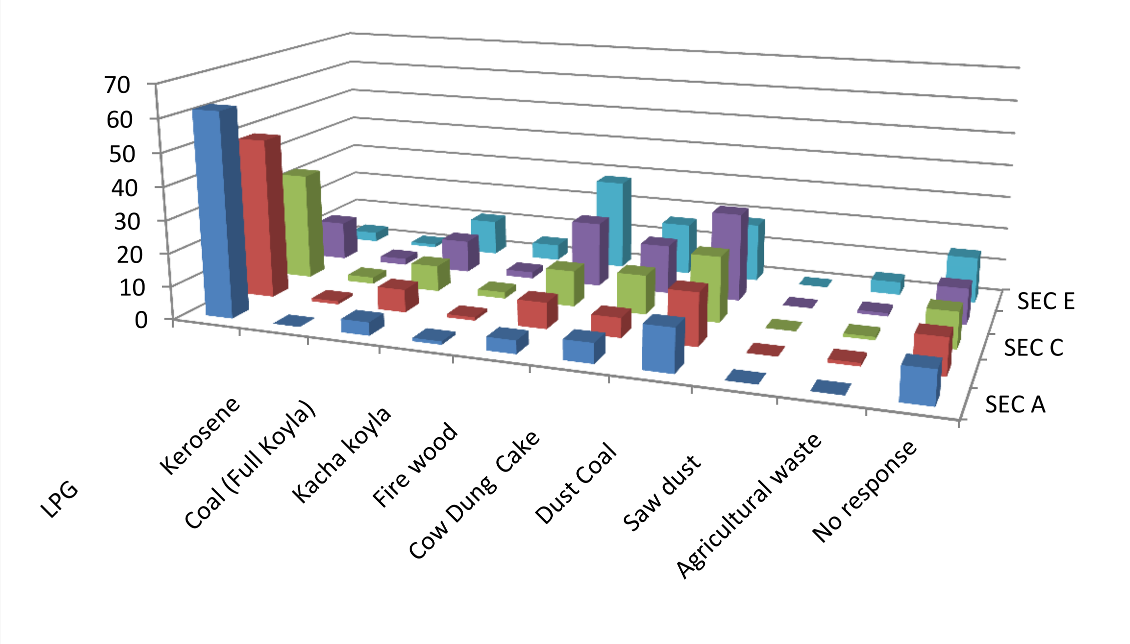
Figure 36: Fuel reported as used most often (% of households) urban and rural combined (n=3,146), survey areas, West Bengal, 2008



Amongst the total survey sample the use of primary fuels in traditional stoves is relatively evenly spread between different forms of coal, wood and cow dung. The probable reason that 12% of respondents were unable to state the primary fuel used is that within their fuel mix no single fuel predominates. It should be noted that the use of different forms of coal revealed by this survey is specific to the area which is coal rich, and is not typical of other parts of India, as shown in Figure 6.

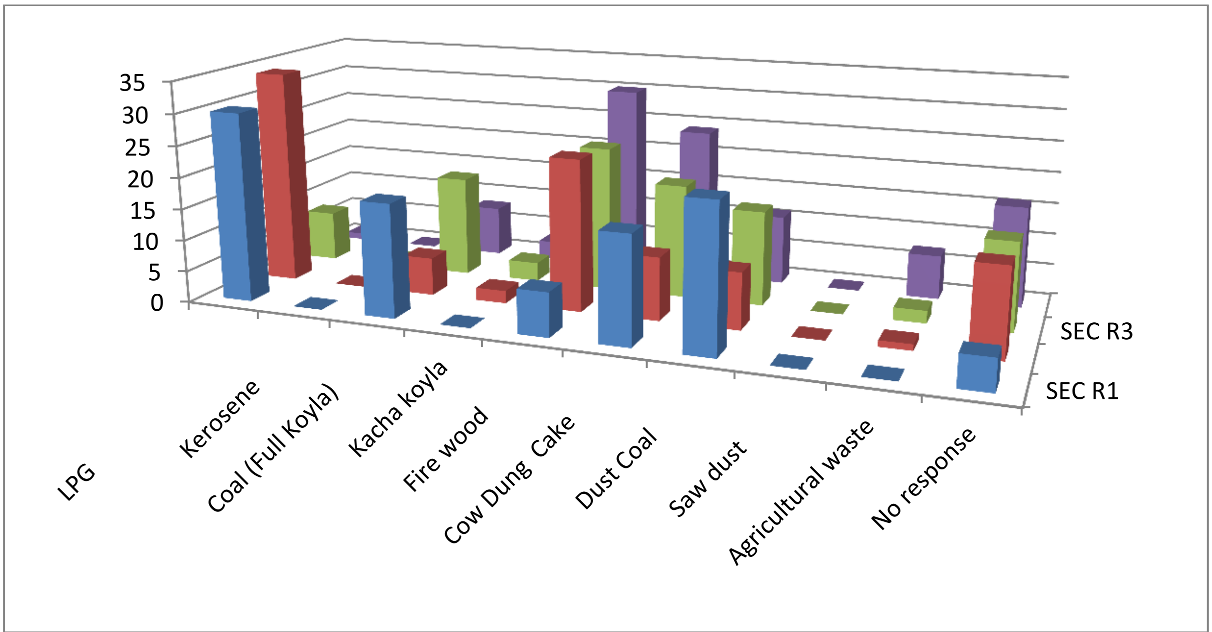
Primary fuel use in urban and rural areas, broken down by SEC group, is presented in tabular form in Annex 2 (Table 40 and Table 41 respectively) and graphically below (Figure 37 and Figure 38 respectively). For urban areas, comparing Figure 37 with the use of primary stoves in urban areas (Figure 34), there is no clear pattern of main fuels used with traditional chullahs.

Figure 37: Fuel used most often (% households in each SEC group) in urban areas (n=2,122), survey areas, West Bengal, 2008



The arrangement of primary fuels used in traditional stoves in rural areas similarly shows a complex pattern (Table 41 and Figure 38) although it can be seen that firewood and cow dung are more prevalent as primary fuels amongst the lower SEC groups, explained by the fact that these fuels are available at low or zero cost in rural areas.

Figure 38: Fuel used most often (% households in each SEC group) in rural areas (n=1,024), survey areas, West Bengal, 2008



Qualitatively Table 15 provides an indication of some of the combinations of fuel use reported, providing an indication of the diversified fuel use strategies adopted by individual households:

Table 15: Examples of common fuel-use combinations reported in the survey areas, West Bengal, 2008

Urban areas	Rural areas
Cow dung cake or coal used for main cooking, supplemented with kerosene for heating water for tea due to the faster set-up time for kerosene compared with a chullah	Fire wood used as main cooking fuel, substituted with agricultural residues when available and kerosene when dry fuel cannot be obtained (only for richer households)
Fire wood used for main cooking, with kerosene for very occasional cooking tasks and fire-lighting in poorer households	Twigs, leaves, paper and roots used by the poorer segments, supplemented by kerosene when it can be afforded
Cow dung cake mixed with rice husk or coal dust used for main cooking, with kerosene as a frequent supplementary fuel source for the richer households	As above but with cow dung cake replacing twigs
Dust coal pellets and cow dung cake for main cooking with kerosene for fire lighting	Cow dung cake with paper and sometimes plastic waste
LPG stove used for most cooking in richer households, supplemented with fire-wood on occasions	Dust coal (hand-made pellets) supplemented by twigs and leaves
Kerosene stove used backed up with traditional chullah burning dust coal pellets	

The use of traditional fuels (coal, wood, dung) together with fossil fuels (kerosene and LPG) can be explained in two ways: firstly, where traditional fuels are the predominant energy source, cost is frequently the factor limiting the use of kerosene or LPG, although limited use of these latter fuels may be affordable amongst wealthier households, and they are used when time is too short to set a fire on a traditional chullah. Secondly, where kerosene and LPG are the primary fuels used for cooking, traditional fuels may be used when they are easily available (for example when a tree is cut in the garden) to save money, or on special occasions, or simply as a recourse to the *traditional* way of doing things.

The fuel-use data presented above provides information about the proportion of households using each primary fuel, broken down into SEC groups. However, it does not indicate the total number of households, and hence the relative importance in terms of a transition to clean cooking. Since the population is not spread evenly between different SEC groups, analysis was undertaken to project the total number of households in Bardhaman District within each SEC group using different primary fuels. This was achieved by using figures above for the proportion of households in each SEC group using each primary fuel, as well as the proportion of the total population for each SEC group (obtained from the Indian Readership Survey, IRS, 2007) and the total population (obtained from the Indian Census).

The results are shown in Figure 39 and Figure 40 below (urban and rural respectively) from which the following conclusions can be drawn. Firstly, the lower two SEC groups are the most important in terms of the number of households using traditional fuels, especially in rural areas, with the highest being firewood, cow dung and dust coal. However, there are still significant numbers of households in the higher SEC groups using traditional fuels as their primary cooking energy source; this might indicate an attachment to the traditional fuels; indeed one study finds that "…*lack of willingness to give up biomass usage due to its ease of access and the non-continuous supply of other fuels, were key factors driving continual usage of biomass even in households having other cooking fuel options...*" (TERI 2008, page 10). Rural areas are more significant in terms of the number of households using traditional fuels, consistent with the rural/urban population split in Bardhaman which is 63% / 37% (MOHA 2001).

Figure 39: Projected number of urban households using different primary fuels broken down by SEC group for Bardhaman District, 2008

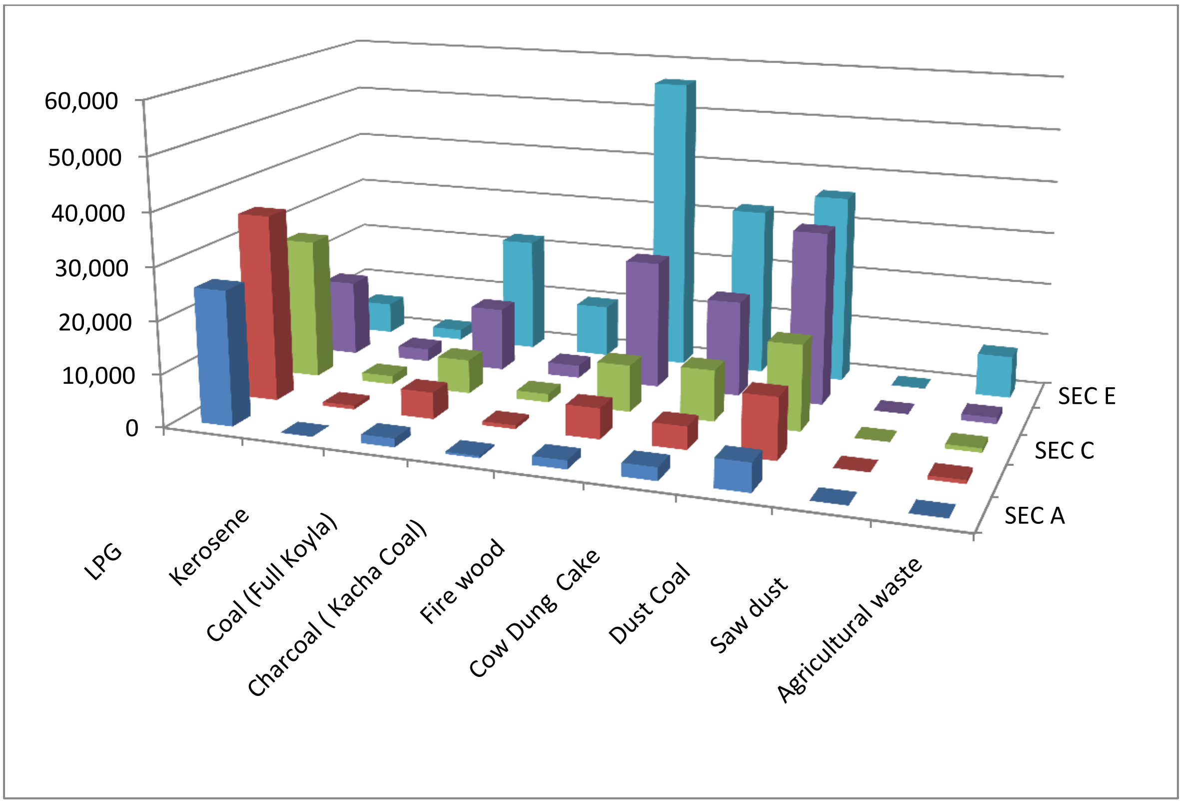
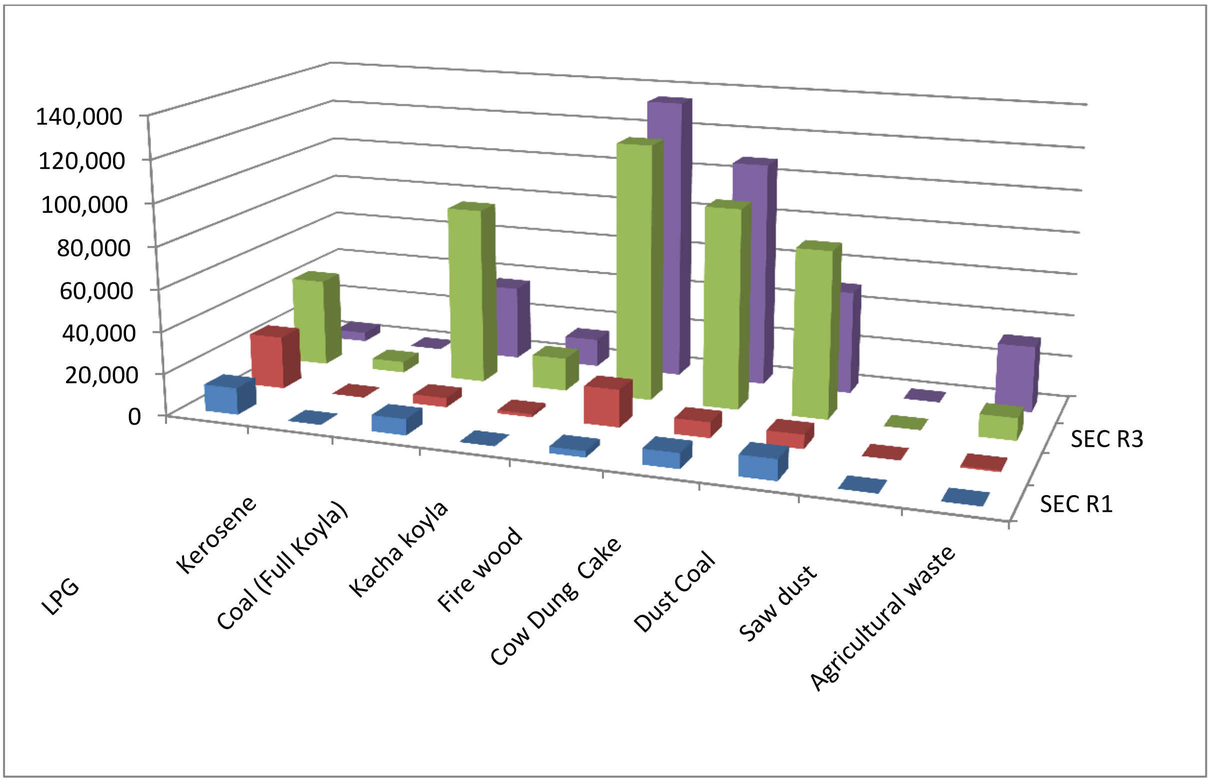


Figure 40: Projected number of rural households for different primary fuels broken down by SEC group for Bardhaman District, 2008



This section has clearly highlighted that the primary target groups in relation to a transition to cleaner cooking - those using traditional chullahs and fuels – are those within the lower SEC groupings; these could be expected to be the households with the least ability to pay for improved stoves and fuels. The findings are in line with, and complement, published literature for India as a whole, although as noted previously high use of coal is specific to the research area (Reddy et al 2009).

The significance of the poor, in particular in rural areas, for a transition to clean cooking has important policy implications, especially in the current context in which efforts to improve cooking are increasingly focussed on market-driven initiatives (Bailis et al 2009).

It is important to note that the results yielded by analysis of the survey data have the general tendency to average across populations, and thus lose much of the individual nuance of behaviour. While such averaged results are useful, it should not be forgotten that they do not fully represent the complex reality for individual households.

4.3.2 Attitudes and beliefs with respect to existing stoves/fuels

This section presents the survey results yielded from a series of attitudinal questions asked of survey respondents concerning current cooking practices and the possibility of change.

4.3.2.1 Satisfaction levels reported

All respondents were asked about their level of satisfaction with the current primary fuel used. Specifically the question asked was: "*On a scale of 1 to 5, where 1 means Extremely Satisfied and 5 means Extremely Dissatisfied, Can you please tell me how satisfied you are with the main fuel you are currently using*?". The resulting data allowed for further investigation of the levels of satisfaction reported for different fuels and per socio-economic group (Table 16).

Table 16: Reported satisfaction levels reported (% of households), for all fuels combined urban and rural, per socio-economic classification (output from SPSS), survey areas, West Bengal, 2008[33]

SEC group		Reported satisfaction level						Total
		0 (no response)	1	2	3	4	5	
All SEC A + All R1 (counts)	Count	10	81	50	65	17	0	223
	% within SEC group	4.5%	36.3%	22.4%	29.1%	7.6%	.0%	100.0%
All SEC B + All R2 (counts)	Count	20	113	117	144	34	1	429
	% within SEC group	4.7%	26.3%	27.3%	33.6%	7.9%	.2%	100.0%
All SEC C + All R3 (counts)	Count	35	153	163	282	39	1	673
	% within SEC group	5.2%	22.7%	24.2%	41.9%	5.8%	.1%	100.0%
All SEC D + half R4 (counts)	Count	46	125	145	276	44	5	641
	% within SEC group	7.2%	19.5%	22.6%	43.1%	6.9%	.8%	100.0%
All SEC E + half R4 (counts)	Count	49	106	150	343	32	1	681
	% within SEC group	7.2%	15.6%	22.0%	50.4%	4.7%	.1%	100.0%
Total	Count	160	578	625	1110	166	8	2647
	% within SEC group	6.0%	21.8%	23.6%	41.9%	6.3%	.3%	100.0%

In order to test any statistical association between two variables - levels of satisfaction (for all fuels combined) and socio-economic group - SPSS software was employed to undertake a Pearson chi-square test. In statistics "…*There is said to be association between two variables if the distribution of the response variable changes in some way as the value of the explanatory variable changes*…" (Agresti, Finlay 1997). The Pearson chi-square test is used to provide evidence to reject (or not) the *null hypothesis (Ho)*, which – if true - would imply in this case that the same proportion of people in each SEC group report each level of satisfaction with their current fuel. If the null hypothesis is rejected however, the test does not have anything to say about the nature of the relationship between the variables, which is best assessed through graphical representation of the data.

In order to undertake this analysis, the categories for urban and rural socio-economic classifications have been merged, as indicated in the table. The *null hypothesis* was taken to be that '*there is no association between level of satisfaction reported and socio-economic group*'. The results are shown in Table 17 which indicates a P value approaching zero. Generally in social science a chi-square probability of 0.05 or less is interpreted as a evidence that the null hypothesis can be rejected; the lower the p-value the higher the confidence that the null hypothesis can be rejected.

[33] Note that as there are 5 SEC groups for urban populations but only 4 for rural, the same method as previously employed in this chapter has been used to combine results from urban and rural populations: the R4 group has been divided into two equal parts, one combined with SEC D and the other with SEC E.

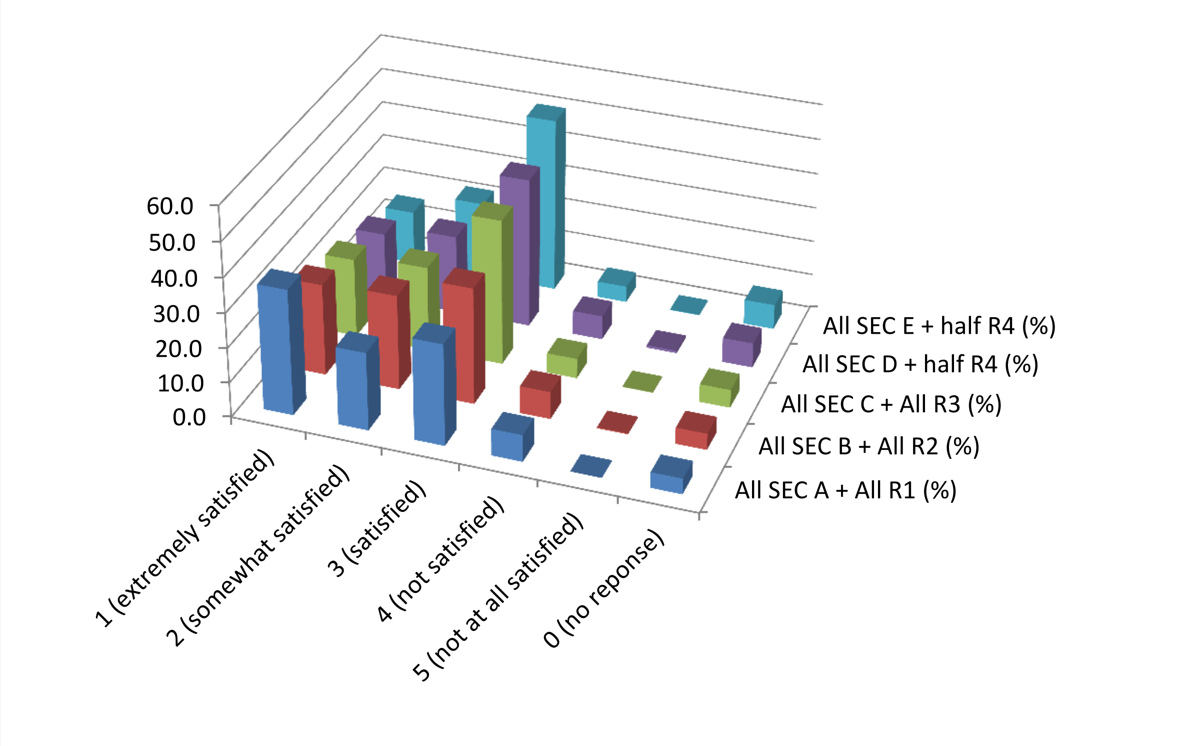
Table 17: Chi-square tests for satisfaction levels reported (all fuels combined) per socio-economic group

	Value	Degrees of freedom	Asymp. Sig. (2-sided) Otherwise known as 'p' value
Pearson Chi-Square	89.157 [a]	20	0.001
Likelihood Ratio	87.109	20	0.001
N of Valid Cases	2647		

a. 5 cells (16.7%) have expected count less than 5.

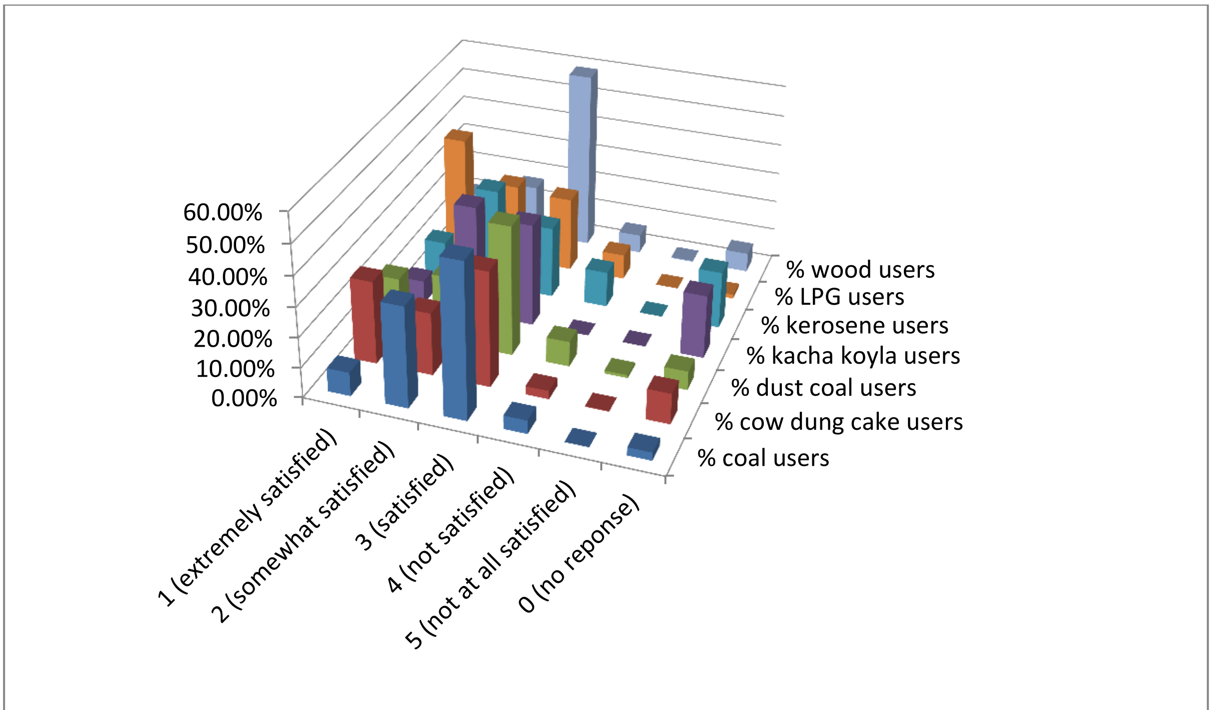
In order to observe the nature of the association Figure 41 shows graphically the levels of reported satisfaction with the main fuel used, for all fuels combined, per socio-economic group. Key observations that can be made include the fact that few people from any of the socio-economic groups indicate that they are either *not satisfied* or *not at all satisfied* with their current main fuel. The overall skeweness of the results towards higher satisfaction levels may be a result of the questionnaire process (respondents unwilling to express dissatisfaction with living conditions to a stranger). The majority of respondents are either satisfied or better. Secondly, a higher proportion of the higher socio-economic groups are very satisfied compared with the lower groups, probably explained by the fact that many use LPG; conversely a higher proportion of the lower socio-economic groups indicate only moderate satisfaction (score 3) than the higher groups.

Figure 41: Satisfaction level reported per socio-economic group for all fuels (% of households), survey areas, West Bengal, 2008



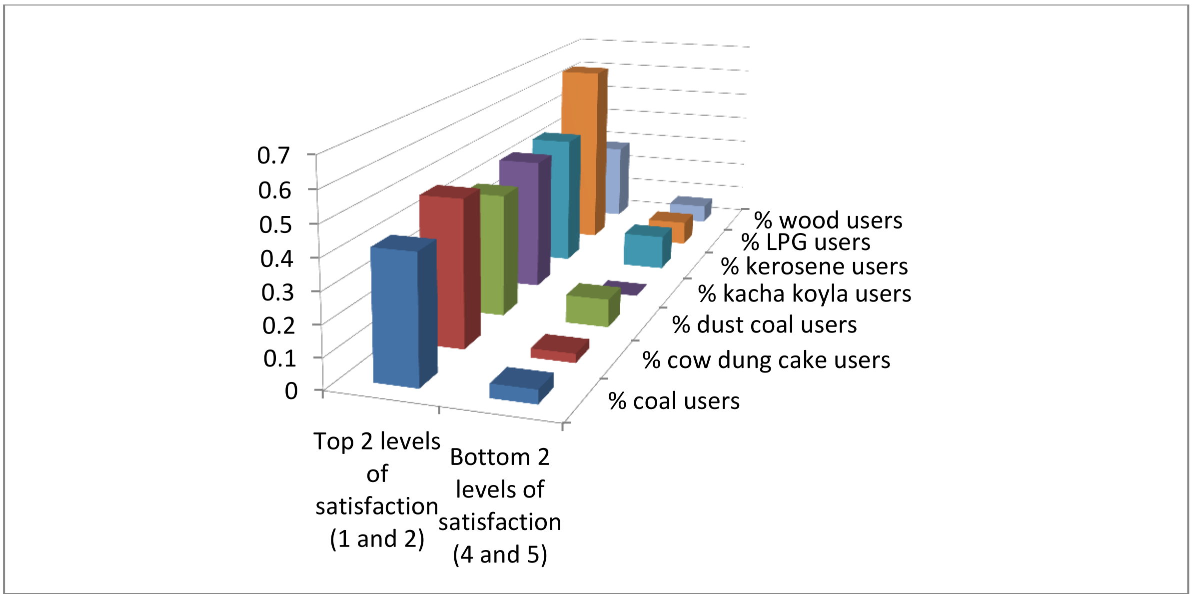
Further statistical tests were performed to analyse the association, if any, between the level of satisfaction reported and the main fuel used (Annex 2, Table 46 and Figure 42 below).

Figure 42: Satisfaction level reported per main fuel used, survey areas, West Bengal, 2008



Patterns emerging from this figure are hard to interpret but include a repeat of the finding that a low proportion of people indicate low satisfaction levels (4 or 5) for any of the main fuels used. Users in the LPG group report the highest proportions of satisfaction level 1 (*extremely satisfied*) at nearly 40%, although a significant number of LPG users reported to be either only *satisfied* or *not satisfied*. Interestingly the next highest group reporting satisfaction level 1 is the cow dung cake using group. High proportions (nearly 60% and around 50% respectively) of the wood and coal using groups report average levels of satisfaction (level 3).

Figure 43: Reported levels of satisfaction per main fuel used, with top two and bottom two levels amalgamated and the middle satisfaction level (3) omitted, survey areas, West Bengal, 2008



In a further attempt to uncover patterns within the data for level of satisfaction reported per main fuel used, Figure 42 excludes the middle satisfaction level (3 – *satisfied*) and merges the top two and bottom two satisfaction levels. LPG remains the group with the highest proportion of users reporting satisfaction levels 1 or 2, while wood users are the lowest group reporting the highest two satisfaction levels.

4.3.2.2 Problems and benefits reported with existing primary fuel

In order to shed light on the levels of satisfaction reported for each primary fuel, survey respondents were asked to speak about problems and benefits experienced with their primary fuel.

Respondents were asked "*There are some statements mentioned on this card. Please tell me with the help of this card if there are any problems you have faced with the current main fuel you are using in your household*". An initial list of problems was developed and tested during a pre-survey trial, after which it was further developed, resulting in the 24 questions shown in Table 18, which shows the proportion of households reporting each problem. Each household answered only for the primary fuel they used, and were free to signal as many problems as they wished. Note that the interpretation of these results do not enable a ranking of the problems by importance for the householder; they do however shed some light on the most commonly perceived problems for the main fuels used, as summarised below.

LPG – key problems reported focussed on cost and availability of LPG. Very few reported problems in using LPG (eg time taken to cook, problems of smoke), although the danger of explosion was reported by many (52% in rural areas);

Kerosene – The proportion of people using kerosene as the primary fuel is relatively small, and for those in this group the problem of availability at an affordable price was the main issue, especially in rural areas; the quantity available at subsidised price[34] is known to be insufficient to cover all cooking needs, and the black market price is significantly higher. Many reported having to queue to obtain kerosene. Other problems frequently reported included having to clean stove wicks frequently and the time taken to cook. 31% of rural kerosene users complained that food smelt of this fuel, higher than for any other fuel. While concerns about spillage, fire, burns and poisoning of children through drinking kerosene are known to exist in many parts of the world, the questions asked in the survey did not relate to these risks; the only question about risk of fire concerned Kuchha houses[35], and only a small part of the sample lived in such properties;

[34] The government run kerosene subsidy varies from state to state, with urban bias in many states (discussed further in (ESMAP 2004, ESMAP 2003).

[35] Houses are categorised into three types: Kuchha, Semi-Pucca or Pucca, see Annex 1 (section 8.1) for descriptions of each.

Coal – Problems reported focussed on the time spent cooking, especially time taken to start the fire, and problems with smoke causing dirty utensils and breathing problems. The problem of obtaining dry coal during the monsoon also featured strongly. Availability and price were not cited as major problems, presumably because those using coal are close to the fuel source and it is available cheaply or for nothing;

Dust coal – A large number of people using dust coal expressed problems with time spent cooking and smoke (dirt and health issues) in similar proportions to those for full coal users, and less than for kacha koyla users;

Kacha koyla – The pattern of problems reported closely resembles those for coal, although significantly higher proportions of households raised problems with time taken in cooking (time to set the fire and for cooking itself) and associated problems with smoke, compared with coal. For example 81% of rural respondents cited problems with blackening of cooking vessels, while 82% of urban respondents said that smoke causes irritation. These results are to be expected given the inferior quality of kacha koyla;

Wood – Problems with the large numbers of households using wood as a primary fuel source focussed on time taken in cooking and problems with smoke. For example, compared with coal, larger proportions of households complained of smoke causing irritation and breathing problems, and making clothes and houses dirty, although the proportions were roughly equivalent to kacha koyla. 68% of respondents complained of difficulty in obtaining dry wood during monsoon;

Cow dung – Problems cited followed a very similar pattern to those of wood users, with issues associated with smoke (dirt and health issues) and time spent cooking predominating. 58% stated that it was difficult to dry dung cakes in monsoon.

Overall the findings confirm the problems known to exist with fuels used on traditional stoves, principally problems with convenience (eg obtaining dry wood) and smoke making houses and cooking utensils dirty, and causing health issues (irritation and breathing problems). It is apparent from the results in Table 18 that kacha koyla users report the most complaints about smoke problems, followed by wood and then cow dung users, with coal and dust coal users reporting them in roughly similar proportions. Time spent in the overall cooking process (setting fire and cooking on it) was also raised frequently as an issue with traditional fuels; note that the question of time spent gathering fuel was not asked by the survey team. Issues reported with the modern fuels LPG and kerosene focussed on issues of availability and affordability, with few citing issues associated with smoke. The findings are in line with other research which finds that issues of convenience, speed and flexibility of cooking are often more important to cooks than reducing levels of household air pollution for the purpose of health improvement (Miller et al 2010). Reduction of smoke as a means of achieving a cleaner home is reported to be valued by cooks (Troncoso et al 2007), although it has been noted that rich households are prepared to pay more for this than poor ones (Lambe et al 2009).

Table 18: Problems reported per primary fuel used (% of households reporting each problem), survey areas, West Bengal, 2008

	LPG			Kerosene			Coal			Kacha koyla			Wood			Cow dung			Dust coal		
	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)
Unweighted base	641	78	563	42	4	38	292	115	177	76	30	46	614	268	346	471	212	259	511	115	396
Weighted base	518	76	442	41	4	37	318	125	193	83	26	56	649	260	388	479	203	276	560	135	425
Any Problem faced	87	84	88	78	83	77	97	96	98	93	88	95	95	95	95	89	88	90	95	91	96
1 Non availability / Irregular supply	57	62	56	30		34	9	11	7	6	11	4	10	6	12	7	4	10	10	4	11
2 Availability in black market at higher price	34	48	31	56	83	52	2	1	4	4	8	2	11	7	14	4	2	5	8	3	10
3 Takes long time to get delivered	55	65	53	8	0	9	4	3	5				5	5	4	5	4	6	9	3	11
4 Expensive both initially and subsequently	41	39	42	14	31	11	1	0	2	0	0	0	3	3	3	2	1	3	5	3	5
5 Danger of bursting	34	52	31	12	0	14															
6 Food smells of the fuel used to cook	2	0	2	11	31	9	5	6	4	4	0	6	16	18	14	12	18	8	7	3	8
7 The amount available in ration shops is not sufficient for the entire household	1	5	0	20	31	18	1	0	1	1	3	0	1	0	2	3	4	2	4	0	5
8 Have to wait in long queues to get it	21	15	23	32	44	31	1	1	0				2	1	3	2	1	3	3	0	3
9 Cleaning the wicks of the stove				34	52	31															
10 Takes time and effort to start the fire	1	0	2	13	0	15	35	21	44	63	56	65	44	39	47	41	37	44	37	35	38
11 Takes time to cook	2	12	1	18	31	16	21	25	19	47	47	47	30	29	30	32	29	34	29	31	29
12 Vessels become black at the bottom	2	4	2	17	0	19	47	52	43	60	81	50	71	73	70	59	53	63	46	41	47

	LPG			Kerosene			Coal			Kacha koyla			Wood			Cow dung			Dust coal		
	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)
13 Smoke and dust causes irritation	2	0	2	14	0	16	51	51	51	76	61	82	65	62	68	60	56	63	53	47	54
14 Smoke leads to breathing problems	0	1	0	15	0	17	29	32	27	51	37	57	64	59	68	62	53	69	41	39	41
15 Expensive initially	37	42	36	16	31	14	6	1	9	6	3	7	12	11	13	9	7	11	9	7	10
16 Difficult to use in Monsoon if its wet	1	2	0				41	40	42	61	42	69	68	69	68	63	57	68	47	54	45
17 Risk of fire in the Kuchha houses	3	9	2	6	0	7	3	2	4	4	3	4	36	33	37	25	28	23	6	6	6
18 Cleaning the stove (dirt particles get in the eye)	0	0	0	12	0	13	1	0	1				13	15	11	11	6	14	5	2	6
19 Breaking the twigs into pieces is painful							4	1	5				38	37	40	10	7	13	3	2	4
20 Hands get dirty and messy	1	2	0	6	0	7	26	25	26	37	25	42	38	41	36	57	51	61	48	42	50
21 House gets dirty and messy with black stains	0	0	0	6	0	7	14	9	17	30	35	27	43	46	40	42	36	46	32	26	34
22 Dirty in terms of personal hygiene	0	0	1	6	0	7	3	3	3	6	0	8	26	25	27	36	25	43	17	7	20
23 Difficult to dry cow dung cakes in monsoon																58	58	58			
24 Making the cow dung cakes																32	24	37			
No Resp	13	16	12	22	17	23	3	4	2	7	12	5	5	5	5	11	12	10	5	9	4

Benefits reported with existing primary fuels are presented in Table 19, in response to the question: "*Some people we were speaking to mentioned benefits to the use of these kinds of fuel; can you please look at this card and tell me the benefits/reasons for you / anyone in your household to use this fuel*." An initial list of benefits was developed and tested during a pre-survey trial, after which it was iterated. Each household answered only for the primary fuel they used, and reported as many benefits as they wished to. As for the *problems* section above, these results do not enable a ranking of the benefits by importance to the householder.

LPG – The key benefits cited by respondents related to convenience; 94% said that they liked LPG because of its fast cooking characteristics; 62% liked the fact that fuel could be delivered to the home. Lack of smoke was raised as a benefit, with 74% saying that the utensils do not become blackened; in comparison only 15% cited the benefit that LPG was considered less injurious to health. The other main benefits highlighted were that flame regulation is easy (80%) and the stove can be used during any season (65%);

Kerosene – Responses followed a similar pattern to LPG, although fewer respondents cited benefits with kerosene use compared to those using LPG as primary fuel. Those responding highlighted key benefits as being easy flame regulation (55%), the ability to use kerosene during any season (50%), fast cooking (38%) and the appropriateness of kerosene for small families (43%);

Coal – Key benefits related to the cheap cost of fuel (41%), easy availability (31%) and the fact that ash residues are useful for cleaning utensils or for agriculture (30%). Overall the proportion of households citing benefits from coal use was considerably less than for LPG or kerosene;

Kacha koyla – Users of kacha koyla were the group in which the lowest proportion of households reported speed of cooking as being a benefit; it is interesting to note that appreciable proportions within all fuel groups reported speed of cooking as a benefit, and it is unexplained with which fuel the comparison was being made. The most frequently reported benefit of kacha koyla was easy availability in local shops (57%, higher than for coal), while use in any season was also frequently reported (36%). Use of ash residues was cited by 31% of households;

Wood – Of all the groups except LPG wood users reported speed of cooking in the highest frequency (51%). The fuel was also thought to be inexpensive (55%), and easily available (38%). 28% of households said that the smoke from wood fires was useful to reduce pests within the house, while 41% stated that the ash was useful as a by-product;

Cow dung – The most frequently reported benefit of cow dung was that the fuel is inexpensive (65%). Smoke to reduce indoor pests was raised by 38% of households, the highest proportion of all groups, while 58% of households said that ash from the fire was a useful by-product;

Dust coal – The most frequently raised benefit of dust coal was its low cost, with 61% of dust coal using households highlighting this benefit, higher than any other fuel apart from cow dung. Easy availability was also frequently reported (50%).

In summary the findings divide roughly between higher quality fuels such as LPG, for which convenience and speed can be characterised as the main benefits, and lower quality fuels for which price and easy availability were the key benefits reported. However more than half of wood users cite speed of cooking as a benefit, perhaps reflecting the fact that the long tradition of using wood with traditional stoves has resulted in a high degree of skill of cooks using this combination. The proportion of people reporting health benefits for LPG was approximately the same as those reporting benefits of smoke for pest removal (solid fuel users). It is important to note that the priorities of (richer) LPG users may be different from (poorer) solid fuel users; the former more frequently live in pucca housing, often with fly-screens on windows and doors, with insects being a relatively smaller problem than the poorer that live in less-well insect-proofed accommodation. The value of ash (for example as a soil additive or for use as a cleaning agent for pots) from the fire was raised as a benefit by significant proportions of all solid fuel using groups.

Table 19: Benefits reported per primary fuel used (% of households reporting each problem), survey areas, West Bengal, 2008

	LPG			Kerosene			Coal			Kacha koyla			Wood			Cow dung			Dust coal		
	All	Rural	Urban (urban & peri	All	Rural *	Urban (urban & peri	All	Rural	Urban (urban & peri	All	Rural	Urban (urban & peri	All	Rural	Urban (urban & peri	All	Rural	Urban (urban & peri	All	Rural	Urban (urban & peri
Unweighted base	641	78	563	42	4*	38	292	115	177	76	30	46	614	268	346	471	212	259	511	115	396
Weighted base	518	76	442	41	4	37	318	125	193	83	26	56	649	260	388	479	203	276	560	135	425
Any Benefits	99	97	99	80	83	80	97	97	97	93	89	95	96	95	97	90	88	92	96	95	96
1 Cooks fast because of more heat	94	94	94	38	83	33	26	21	29	15	17	15	51	49	53	29	26	32	29	28	29
2 Fuel is delivered at home	62	53	64	9	0	10	16	19	14	5	8	4	17	15	18	15	12	17	22	20	23
3 Utensils does not become black	74	72	75	28	44	26	4	2	5	1	0	2	6	8	4	12	11	12	16	12	17
4 Easy flame regulation	80	83	80	55	44	56	8	4	11	4	4	5	15	17	13	17	12	20	19	13	21
5 Does not take much storage space	35	39	35	35	13	38	5	3	6	1	0	1	13	17	10	11	13	11	14	4	18
6 Useful for smaller families	48	39	49	43	31	45	11	9	12	6	13	2	34	41	30	17	20	15	28	23	30
7 Inexpensive fuel	3	0	3	23	31	23	41	37	43	26	11	33	55	56	55	65	60	69	61	63	61
8 Can use it in any season	65	67	65	50	52	50	11	7	15	36	40	34	27	32	23	20	16	23	19	26	17
9 Available in own garden / neighbourhood - need not buy				2	0	2	16	16	16	12	9	13	38	40	37	23	20	25	8	10	7
10 Available in nearby shop / someone delivers it	23	7	25	16	0	18	31	29	33	57	66	53	30	24	33	26	24	27	50	48	50
11 Control cooking by adding more fuel	3	0	4	9	39	5	15	15	15	3	3	3	21	23	19	21	17	23	20	14	22
12 Ash residue can be used in cleaning vessels / agriculture							30	31	29	31	25	34	41	44	39	58	49	64	37	39	37

	LPG			Kerosene			Coal			Kacha koyla			Wood			Cow dung			Dust coal		
	All	Rural	Urban (urban & peri urban)	All	Rural *	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)	All	Rural	Urban (urban & peri urban)
13 Smoke is useful to reduce pests in house		0	0	2	0	3	11	12	11	4	0	6	28	27	29	38	31	43	19	6	23
14 Make it at home, need not buy							2	2	2				6	7	5	36	36	35	3	6	3
15 Considered less injurious to health	15	16	15	10	52	4	1	1	1	2	0	2	15	23	10	17	10	23	6	7	6
16 Available all the time	7	11	6	12	31	9	15	17	13	31	5	43	35	39	32	26	20	32	19	24	17
No Resp	1	3	0	20	17	20	3	3	3	7	11	5	4	5	3	10	12	8	4	5	4

*low sample implies that these findings are not significant

4.3.2.3 Expectation of shifting to another fuel and/or stove

Two questions were asked to determine the degree of expectation that households would shift to a different stove/fuel in the following 12 months. The logical progression of the questioning was first to show a photo-card of widely known alternatives and ask respondents if they expected to shift. A follow up question was asked of those expressing low expectation of shifting; this question highlighted some lesser known alternatives (solar cookers and small LPG stoves, see Figure 44) and sought to determine if prompting with these options improved the expectation of shifting amongst the *unlikely shifters.* The options presented were chosen in an attempt to differentiate two financial barriers: 1) high up-front capital cost, and low (zero) running-costs (solar) and 2) low capital cost but on-going cost for fuel (LPG). Unfortunately it was not possible to present an example of an advanced biomass stove as one of the alternatives. BP did not wish to present their Oorja stove for fear that this might raise expectations associated with future BP activity in the area. For the purposes of this research this omission was unfortunate. Responses to the second question did not provide additional insights and the data are thus not presented.

Table 20: Questions asked regarding expectations of shifting cooking stove in the following 12 months

Question	Scoring		Photo cards
First question: *"There are various types of stoves available in the market these days. Can you please take a look at this card (*Figure 30*) and tell me how likely you are to shift to another kind of stove in the next 1 year?"*	I will definitely not shift to any other stove I will probably not shift to any other stove I may or may not shift to any other stove I will probably shift to any other stove I will definitely shift to any other stove	1 2 3 4 5	Photo-cards shown with commonly known stoves and fuels (Figure 30 – modern alternatives). Figure 32 – traditional chullahs – used to identify current stove.
Second question (asked only of those responding "1", "2" or "3" to first question. "*Kindly take a look at this card (*Figure 44*). Please go through the description carefully and tell me whether you are likely to change your stove. Please note that there is no right or wrong answer, we are only interested in knowing your frank opinion."*	Yes I expect to shift No I still do not expect to shift	1 2	Photo-cards shown with solar cookers and small LPG stoves (Figure 44)

The questions asked of respondents were – in hindsight – ambiguous, focussing as they did on expectations of change and not distinguishing between desire to change and expected ability to do so. In other words, a low reported expectation of change could either indicate that a shift is not a priority or that it is considered to be impossible (for example for financial reasons); it is likely that the reasons vary between users and fuels used.

Figure 44: Photo-card used to further prompt those expressing low expectation of shifting

Table 21: Intention to shift to another fuel (% of households) by main fuel currently used, survey areas, West Bengal, 2008

	LPG	Kerosene	Coal (full koyla)	Kacha koyla	Wood	Cow dung	Dust coal
Unweighted base	641	42	292	76	614	471	511
Weighted base	518	41	318	83	649	479	560
I will definitely shift to any other stove	1	2	5		2	2	1
I will probably shift to any other stove	13	14	7	7	11	18	18
I may or may not shift to any other stove	16	14	13	13	27	22	18
I will probably not shift to any other stove	7	8	9	16	10	9	4
I will definitely not shift to any other stove	61	63	65	64	48	47	57
No Resp	1		2	1	1	2	2

This data-set is summarised in Figure 45 and broken down by primary fuel in Figure 46. The former highlights the overall low expectation of changing across all fuels, with nearly 65% of respondents saying that they either definitely or probably will not shift. Only 16% stated that they would definitely or probably shift; unfortunately the results of the survey do not provide further information about the households within this group. The reasons for this low expectation of change, which vary across fuel types, are explored further in the next chapter.

It is noticeable from Figure 46 however that for the fuels identified as the most significant within the survey area in terms of absolute number of households (Figure 39 and Figure 40), namely wood, cow dung and dust coal there is a lower expectation of not shifting and a consequent higher expectation of change, compared with the other fuels. This might be due to the inferior nature of these fuels, as indicated by the high proportion of users complaining about smoke with reference to these fuels.

Figure 45: Proportion of households expressing different expectations of changing cooking stove/fuel in next 12 months (all fuels), survey areas, West Bengal, 2008

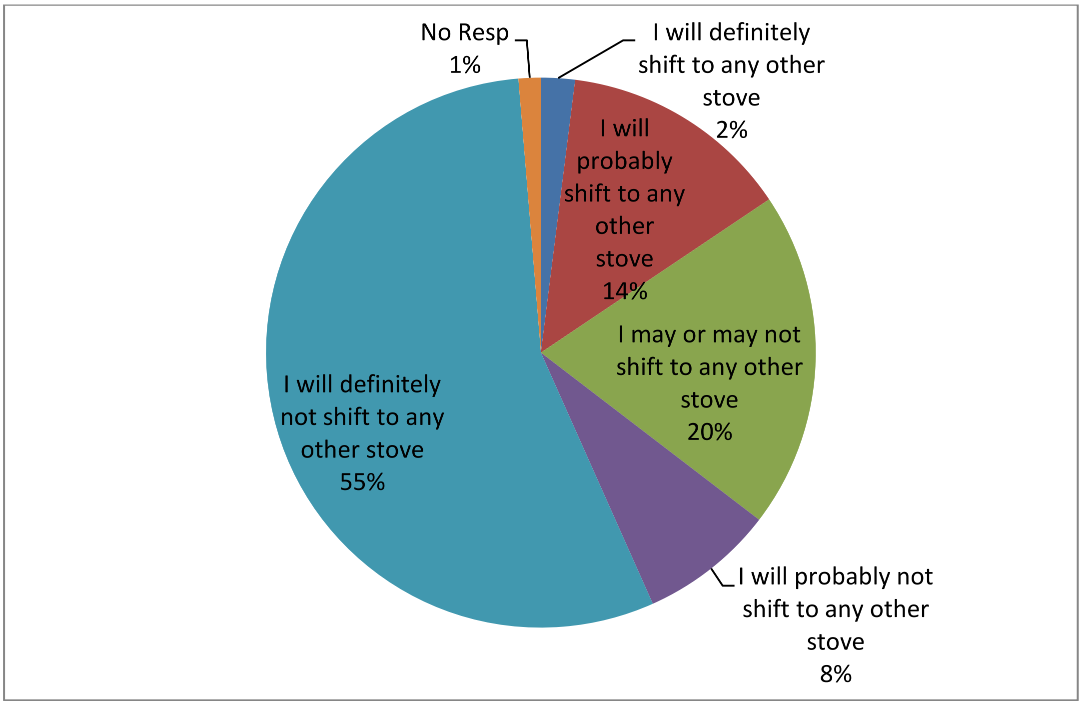
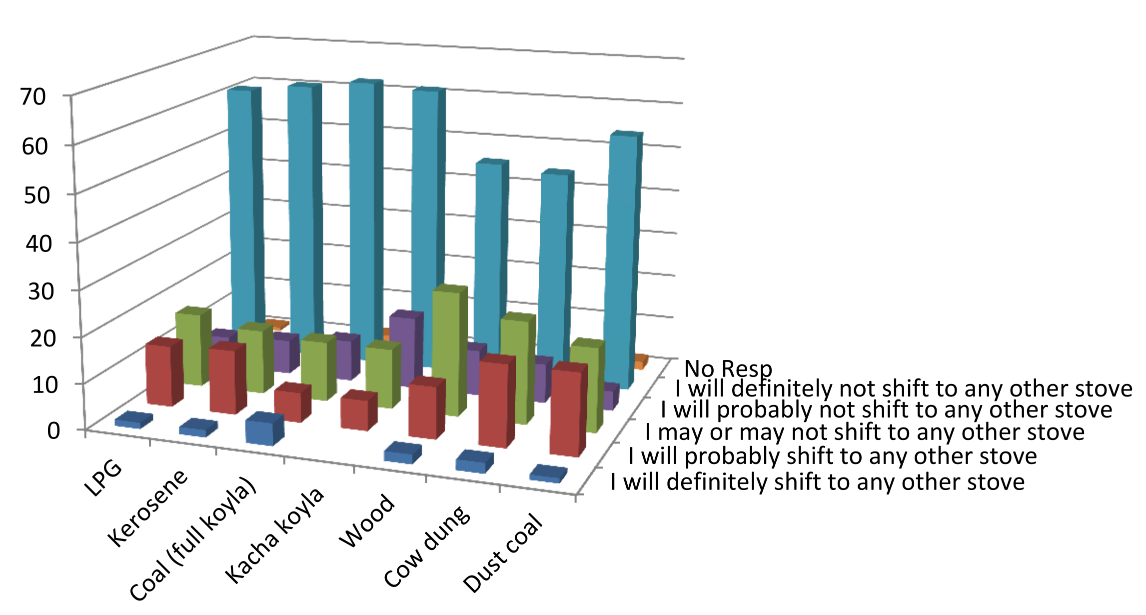


Figure 46: Expressed expectation of shifting stove/fuel in following 12 months per primary fuel used (% of households), survey areas, West Bengal, 2008



The results from this section indicate a high level of inertia acting against change in the choice of cooking technologies and fuels employed by households in the survey area. However the design of the survey did not allow analysis of the factors influencing this inertia and in hindsight a more sophisticated approach would be required to fully understand the factors influencing a change in cooking system. A study has been undertaken recently in Bangladesh to understand the factors influencing uptake of improved stoves. This study, employing a large sample (4,000 households in 60 villages), involved a randomized intervention study analyzing the relative quantitative importance of a number of factors in improved stove adoption, followed by a round of social network surveys to understand the importance of different social networks (eg extended family, opinion leaders) in influencing change (Bailis 2010).

4.4 Calculation of total fuel quantities consumed, and associated emissions of greenhouse gases and health damaging pollutants

The survey gathered data on quantities of fuel consumed for each household. This allowed the emissions from all fuels used (not only primary fuels) to be assessed from a health, as well as greenhouse gas, perspective, as presented below.

4.4.1 Fuel quantities consumed

Respondents were asked how much fuel they used in the month preceding the survey. In the case of LPG they were asked how long their cylinder would last (in days) and the size of cylinder was noted. By way of checking, respondents were also asked to show the quantity of fuel used in a typical day; for solid fuels this quantity was weighed by the survey data gatherers. Since the survey was undertaken over a 5-week period in August (rainy season) it was not possible to physically check for seasonal variations in fuel use, although such variability is known to exist (for example to overcome the problem of accessing dry wood in the rainy season). Therefore respondents were further asked whether their fuel use varied in different seasons and by how much. Further details of the data gathering and analysis methodology are presented in Annex 2.

Table 22 and Table 23 show the average annual quantity of fuel used in urban and rural households, averaged across all households in Bardhaman and Midnapore. The figures are used for the following calculations but it should be noted that since they are averaged across the urban and rural populations, they do not represent typical fuel usage in any individual household.

Table 22: Annual average fuel consumption (in kg) for an urban household (averages across all urban households in Bardhaman and Midnapore) (n= 2,122 for urban)

	Total Urban	SEC A	SEC B	SEC C	SEC D	SEC E
Base:	*2122*	*206*	*408*	*450*	*476*	*582*
LPG	53	126	106	65	24	0
Kerosene	57	48	53	65	72	48
Coal	142	118	125	142	176	137
Kacha koyla	41	24	17	29	41	79
Fire wood	485	142	255	410	583	752
Cow dung cakes	430	184	296	407	527	565
Dust coal	323	244	234	358	403	330
Saw dust	0	12	0	9	32	17
Jute / agricultural waste	135	24	53	90	148	251

Table 23: Annual average fuel consumption (in kg) for a rural household (averages across all rural households in Bardhaman and Midnapore) (n= 1,024 for rural)

	Total Rural	SEC R1	SEC R2	SEC R3	SEC R4
Base:	*1024*	*39*	*80*	*332*	*573*
LPG	17	89	84	24	0
Kerosene	60	69	41	65	53
Coal	159	200	171	212	125
Kacha koyla	29	0	41	41	29
Fire wood	680	227	498	630	766
Cow dung cakes	573	435	406	593	583
Dust coal	247	277	148	340	207
Saw dust	12	12	0	12	12
Jute / agricultural waste	337	94	147	250	429

These figures were used together with the data for the number of households in different SEC groups in the survey area (see Annex 2) to arrive at the total use of each fuel for urban and rural areas in the survey areas (see Table 24 and Table 25).

Table 24: Total annual fuel consumption projections (tonnes) all urban households – (Bardhaman and Midnapore, 2008)

	Total Urban	SEC A	SEC B	SEC C	SEC D	SEC E
Base:	*2122*	*206*	*408*	*450*	*476*	*582*
LPG	**21,143**	5,196	7,705	5,306	2,935	0
Kerosene	**29,593**	1,980	3,852	5,306	8,804	9,650
Coal	**74,609**	4,867	9,086	11,593	21,522	27,542
Kacha koyla	**25,488**	990	1,236	2,367	5,014	15,882
Fire wood	**280,333**	5,856	18,535	33,472	71,291	151,178
Cow dung cakes	**240,359**	7,588	21,516	33,227	64,443	113,585
Dust coal	**171,920**	10,063	17,009	29,226	49,280	66,342
Saw dust	**8,560**	495	0	735	3,913	3,418
Jute / agricultural waste	**80,747**	990	3,852	7,347	18,098	50,460
TOTAL	**932,752**	**38,025**	**82,791**	**128,579**	**245,300**	**438,057**

Table 25: Total annual fuel consumption projections (tonnes) all rural households – (Bardhaman and Midnapore, 2008)

Figs in kg	Total Rural	SEC R1	SEC R2	SEC R3	SEC R4
Base:	*1024*	*39*	*80*	*332*	*573*
LPG	**22,773**	3,791	6,259	12,723	0
Kerosene	**64,219**	2,939	3,055	34,459	23,766
Coal	**189,702**	8,520	12,741	112,389	56,052
Kacha koyla	**37,794**	0	3,055	21,736	13,004
Fire wood	**724,246**	9,670	37,105	333,986	343,484
Cow dung cakes	**624,577**	18,531	30,251	314,371	261,425
Dust coal	**295,896**	11,800	11,027	180,246	92,821
Saw dust	**12,254**	511	0	6,362	5,381
Jute / agricultural waste	**339,860**	4,004	10,953	132,534	192,369
TOTAL	**2,311,321**	**59,766**	**114,446**	**1,148,806**	**988,302**

4.4.2 Greenhouse gas emissions

Emissions factors for each fuel (see Table 4) together with the total quantity of each fuel used (see above) were used for to calculate the total emissions of the Kyoto basket of greenhouse gases: CO_2, CH_4 and N_20 (detailed results presented in Annex 2, for both urban and rural areas). Following (Venkataraman et al 2010) a number of assumptions were made in using the emissions factors in Table 4:

- net CO_2 emissions from dung and agricultural residues were assumed to be zero, since the fuels are renewable;
- different values were used for the 'non-renewable biomass' (NRB) fraction of wood; since reliable data is not available for the areas surveyed values used were 5%, 10% and 15% NRB fraction;
- no account was taken of the climate forcing effect of black carbon and other non-Kyoto compounds. Research suggests that black carbon is a significant contributor to climate change, although scientific uncertainty remains in quantifying this (see section 1.3.3).

The overall estimate of total greenhouse gases produced by the calculations in this research is probably an under-estimate since the NRB fraction is likely to be higher than 15% in some cases, and the significant climate forcing effect of black carbon and other 'non-Kyoto' compounds has not been accounted for.

The summary of the findings for CO_{2e} (Kyoto basket) emissions for all urban and rural households in the survey areas (Bardhaman and Midnapore) are shown in Table 26. Total greenhouse gas emissions from cooking for the survey areas (population 8 million) were found to range between 3.1 – 4.4 M tonnes CO_{2e}, depending on the NRB fraction assumed for wood. In most other parts of India the NRB fraction would be a much greater factor in this sensitivity analysis due to the higher prevalence of wood use for cooking. However, since coal (in different forms) is more prevalent in the survey areas than in most of India, the influence of NRB is relatively reduced.

Urban and rural emissions of Kyoto gases as a proportion of total emissions match precisely the population split (68% rural and 32% urban), as confirmed by Table 27 which shows that the per-household emissions are similar (on aggregate) for urban and rural areas.

In both urban and rural areas the *lower half* SEC groups produce the majority of total emissions (around 75% in urban areas, and over 90% in rural areas). This is partly a result of the larger proportion of people in the lower SEC groups (see Annex 2). However it is also partly due to the fact that the lower SEC groups have higher per household emissions (see Table 27), a result of the higher prevalence of coal and wood use amongst the poorer half and LPG in the richer half. Further analysis shows that in both urban and rural areas around 40% of the total greenhouse gas emissions derive from the lowest SEC groups. These findings have important ramifications for climate policy and for carbon offset developers, highlighting the need to target the poorer segments of the populations in order to achieve significant carbon reductions from cooking.

Table 26: Summary of calculated annual greenhouse gas emissions from cooking (tonnes CO_{2e}) – Kyoto basket only - for all households in the survey areas (Bardhaman and Midnapore)

	Urban				Rural					
CO_{2e} emissions (tonnes)	all urban	upper half SEC urban groups	lower half SEC urban groups	% lower half SEC of total	all rural	upper half SEC rural groups	lower half SEC rural groups	% lower half SEC of total	Total emissions CO_{2e} (M tonnes)	% of total emissions from lower half SEC groups
Total assuming 100% NRB for wood	1,388,837	323,343	1,065,494	77%	2,982,197	260,835	2,721,362	91%	4.37	87%
Total assuming 15% NRB for wood	1,065,249	275,870	789,380	74%	2,146,200	206,841	1,939,359	90%	3.21	85%
Total assuming 10% NRB for wood	1,046,215	273,077	773,138	74%	2,097,024	203,665	1,893,358	90%	3.14	85%
Total assuming 5% NRB for wood	1,027,180	270,285	756,895	74%	2,048	200,489	1,847,358	90%	3.07	85%

Note: 'upper half SEC urban groups' relates to the number of households in SEC A plus SEC B, plus half SEC C, while 'lower half SEC urban groups' refers to half SEC C plus SEC D plus SEC E. For rural areas the division between 'upper' and 'lower' is R1 plus R2 and R3 plus R4 respectively.

Table 27: Per household average greenhouse gas emissions (tonnes CO_{2e}/household) – urban and rural households in survey areas

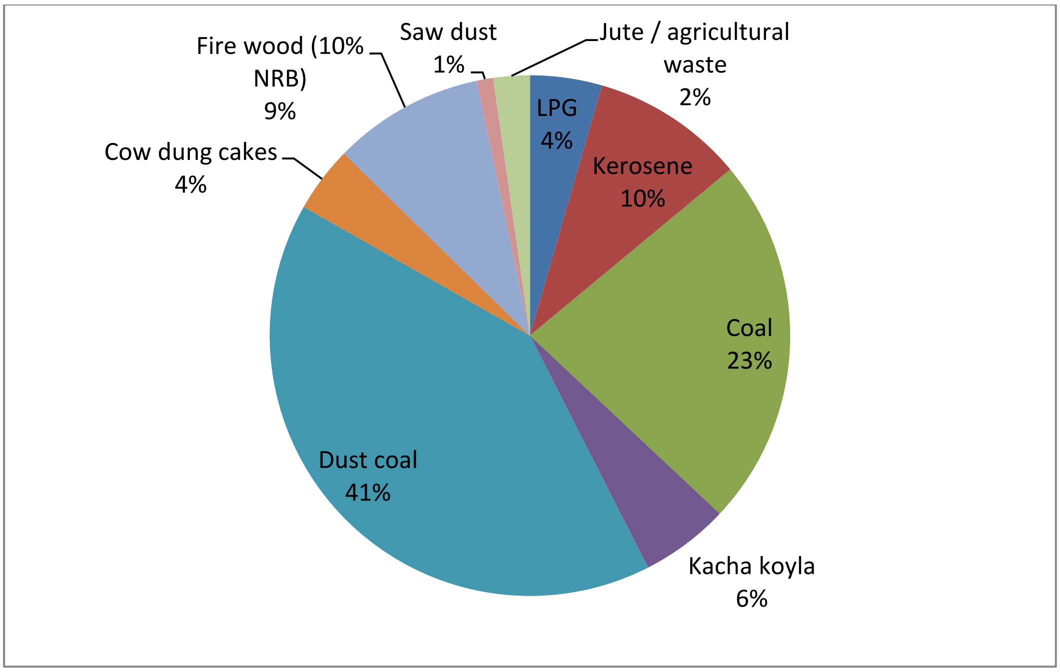
	All urban households	All rural households	lower half SEC groups – urban and rural	Upper half SEC groups – urban and rural
Total assuming 100% NRB for wood	2.7	2.7	2.8	2.2
Total assuming 15% NRB for wood	2.1	2.0	2.0	1.8
Total assuming 10% NRB for wood	2.0	1.9	2.0	1.7
Total assuming 5% NRB for wood	2.0	1.9	1.9	1.7

The average figures for per household greenhouse gas emissions mask a wide variation between fuels. Other researchers have performed calculations for greenhouse gas emissions (per stove-day) for different fuels, based on the assumption that an average of 11MJ/day of energy (delivered to the cooking pot) is the mean cooking energy usage in India (Venkataraman et al 2010). On this basis, and making further assumptions for stove efficiency, figures provided by one study for CO_2, CH_4 and N_20 emissions show that total greenhouse gas emissions (Kyoto basket in kg CO_{2e} per stove day) are nearly 6 times higher for a traditional coal stove (2.7 tonnes CO2e per year [36]) than for an LPG stove performing the same amount of cooking (Venkataraman et al 2010, page 5). Greenhouse gas emissions (Kyoto basket) for a traditional wood stove (assuming 10% NRB), and chullahs burning dung and agricultural residues are similar to those for LPG (assuming that net CO_2 emissions from dung and agricultural residues are zero), taking into account emissions of methane and nitrous oxide. Many improved biomass stoves claim to reduce emissions by 50% or more (Simon et al 2012).

Analysis of the proportion of greenhouse gas emissions from the various fuels used for cooking in the survey area is shown in Figure 47.

[36] Figures are derived from (Venkataraman et al 2010) Table 3, page 67.

Figure 47: Proportion of greenhouse gases (Kyoto basket) emitted by different fuels in the survey areas - all urban and rural households (assuming 10% NRB fraction for wood-fuel)



Coal (in its three forms) dominates, producing 70% of the total emissions (in CO_{2e}), if wood is assumed to be 10% renewable. The impact of cow dung and agricultural waste is minimal since it has been assumed that net CO_2 emissions are zero, and hence only the climate-forcing effect of methane and N_20 has been accounted for. If the NRB fraction of wood were assumed to be 100%, emissions from wood increase to 35% of the total (from 9% if NRB is assumed to be 10%).

4.4.3 Emissions of health damaging pollutants

As highlighted in Table 4 and Table 5 emissions of health damaging pollutants vary between fuels and stoves. While a large number of different compounds emitted from stoves are health damaging, carbon monoxide (CO) and particulate matter (PM) are frequently used as proxies for the overall health impact of different cooking options (Torres-Duque et al 2008).

Using the emissions factors presented in Table 4, and the projected quantities of fuel used in urban and rural parts of the survey areas (Table 24 and Table 25 respectively), the total emissions of some key household air pollutants were calculated for the survey areas, as well as the quantities of pollutant per household (see Table 28 and Table 29).

Table 28: Calculated annual pollutant emissions (tonnes) from cooking in the survey areas (urban and rural combined)

	Total emissions	Emissions from upper half SEC	Emissions from lower half SEC
CO	356,069	43,237	312,832
NMVOC	40,861	4,768	36,093
PM	22,825	2,737	20,088
BC	5,282	686	4,597

Notes: NMVOC = non methane volatile organic compounds. BC = black carbon.

While the absolute quantities of emissions (Table 28) are difficult to contextualize, it is interesting to note that almost 90% of these health-damaging pollutants are from houses in the lower half of the SEC groups. As for greenhouse gases this is partly a result of the larger number of houses in the poorer categories (see Annex 2), and partly due to higher per household emissions in this group. The latter effect is more pronounced than for greenhouse gases, with emissions per household of the pollutants analysed between 36% and 54% higher for the lower SEC groups compared with the higher SEC groups. This is clearly a result of the higher prevalence of traditional fuels (especially coal) and stoves in poorer families.

Table 29: Calculated annual polluting emissions per household (kg/household) in the survey areas– urban and rural areas combined

	Emissions/household (kg) all households	Emissions per household (kg) upper half SEC	Emissions per household (kg) lower SEC	Ratio emissions per household, upper half SEC to lower half SEC
CO	220.5	159.0	233.0	1 : 1.46
NMVOC	25.3	17.5	26.9	1 : 1.54
PM	14.1	10.1	15.0	1 : 1.48
BC	3.3	2.5	3.4	1 : 1.36

Finally analysis of the proportion of total health-damaging pollutants emitted from the use of different fuels in the survey areas again highlighted the importance of coal. In its three forms (full koyla, kacha koyla and dust coal) coal use resulted in 61% of total carbon monoxide emissions from cooking (20% for fuel-wood) and 63% of particles (14% for wood). Disproportionate to its use in the survey area, burning cow-dung fuel was found to be responsible for 51% of the emissions of non-methane volatile organic compounds (NMVOC). On average households in the survey area are exposed to higher levels of health-damaging pollutants than the general Indian population, due to the prevalence of coal use.

The findings of this analysis of health-damaging pollutant emissions highlight the need for cooking programmes aiming to improve public health to target the poorer segments of the population, with a focus on those in rural areas, since that is where the majority of the poor live. In the survey areas the use of traditional chullahs predominates amongst those elements of the population in the lower SEC groups, which emit over 85% of the greenhouse gas emissions (Kyoto basket) from cooking in the survey areas. In both absolute and per household terms the quantity of health-damaging pollutants is significantly higher in the poorer half of the population than the richer half, raising important equity issues with respect to public health policy. Emissions of household air pollution are likely to be far in excess of international standards (see Chapter 1). Similarly greenhouse gas emissions are significantly greater, in per household and absolute terms, for poorer households. These results are relevant to the current Indian context, in which a new cook-stove programme is being developed along market lines; the rural poor are least likely to benefit from such an approach due to their relative lack of buying power and distance from urban centres on which markets generally focus. However within the survey area they present the greatest potential for generation of carbon offsets.

4.4.4 Limitations of the survey

This survey, while producing a valuable and comprehensive dataset, was subject to a number of limitations. While the author was able to incorporate some questions directly for the purposes of this research, the questions asked would have been further enhanced if the author had been able to accompany those undertaking the primary data collection, which was not possible given the large number of households surveyed.

The survey sample was not fully representative of the population surveyed; sample sizes for urban and rural populations were roughly the same, while the latter makes up more than two-thirds of the number of households. This has been overcome in this research by calculating absolute numbers of households. More generally the survey involved research in an area atypical of India as a whole (coal use was high); thus the results cannot be extrapolated to the whole country.

While the data gathered for stoves and fuels by SEC group referred to primary and secondary stoves and fuels, the data for secondary stoves proved difficult to analyse, although it was useful for calculating overall emissions. By presenting averages of fuel used based on primary fuel – similar to most analyses of cooking – some of the nuance and complexity of individual household behaviour is lost. Overcoming this problem would require very detailed monitoring of individual households, preferably over a complete seasonal cycle, to fully understand stove/fuel use patterns. Enhanced use of census and other periodic survey methods might help to some extent, for example by asking additional questions about secondary fuel use and seasonal variations.

Concerning the qualitative aspects of the survey, one limitation concerned the questions which were asked. An initial list of questions was developed, tested on a small sample of respondents and then refined. The refined list was used for the main survey, resulting in a fixed set of questions concerning attitudes and beliefs, not allowing for nuances and discussion of either the responses themselves or their relative importance (weights). This limitation of the survey implies the need for more in-depth and nuanced qualitative research to tease out the weight of different factors by cooks. The next chapter, which involves dialogue with cooks in focus group settings, aims to address this shortcoming.

4.5 Discussion and conclusions

The analysis in this chapter, based on detailed primary data from a household survey, has enabled geographically specific insights into existing cooking practices and attitudes, divided into different socio-economic groups. Such analysis is not possible using data from the census or National Sample

Survey (NSS) data employed by other researchers (Venkataraman et al 2010, Reddy et al 2009). The areas studied were chosen given the high level of coal use for cooking and hence even higher adverse expected health impact, compared to the rest of India where the predominant traditional fuels used are biomass based. While the methodology applied could be replicated in other parts of India, the results from this survey cannot be extrapolated to the rest of the country given the atypical fuel use patterns in the research area.

A novel aspect of the research is the separation of data into socio-economic groupings, allowing analysis of variations in current practice and attitudes between groups. Use of traditional chullahs is shown to be the target in terms of reducing harmful pollutants in the survey areas. The chapter finds that users of traditional mud chullahs, used as a primary stove, represent over 70% of households in the survey areas, the majority of which are in the lower half of the SEC groups. A focus on poor rural households, at least in these survey areas, would thus be key if widespread health improvements were to be made; in absolute numbers over 60% of the users of traditional chullahs are in the lower half of the SEC groups in rural areas. Analysis is complicated by the variety of stoves and fuels used in various combinations. The broad finding of the need to focus cook-stove efforts on the rural population is in line with India-wide studies; one finds that together low and middle income rural households using traditional stoves make up 58% of all Indian households (Reddy et al 2009).

Satisfaction levels reported with respect to existing cooking practices were predominantly above average for all existing stoves and fuels, amongst all SEC groups. The skeweness of reported satisfaction towards the higher levels of satisfaction is surprising given the number of problems reported with various fuels. However, it was found that satisfaction levels were highest for LPG, and that satisfaction with traditional fuels was similar except for wood, users of which seem to be less satisfied. Benefits and problems associated with different fuels focussed on issues of convenience, availability and cost, with speed of cooking a major factor. While users complained about levels of smoke from traditional stoves and fuels, such expressions related more to issues of hygiene than to the serious health implications of smoke, which were barely mentioned. The findings are in line with a study in India analysing factors influencing energy choices for cooking (Reddy et al 2009); of factors studied (availability and cost of fuel, income, the opportunity cost of women's time, occupation and education levels) the study finds that availability and affordability are the key factors determining fuels choices.

Despite the number of problems reported with the use of traditional stoves and fuels, there was generally a low expectation of change to alternatives in the near future; only 16% of respondents stated that they would definitely or probably shift in the following 12 months. However the design of the survey did not allow for analysis of the factors behind this low expectation of shift, a draw-back of methodology.

This chapter has thus hinted at a problem of behavioural inertia (low demand) with respect to a transition to clean cooking, a problem identified by other cook-stove studies (Miller et al 2010). While financial barriers are expected to be a major factor inhibiting change within poor households, the research also finds a surprising number of households that could afford modern fuels continuing to use traditional stove/fuel combinations. One study suggests that ease and familiarity of use of traditional stoves acts as a source of inertia (TERI 2008, page 10). It has been also suggested that one reason for inertia is *risk aversion*, particularly prevalent amongst low income communities (Yesuf et al 2009). The implication is that the poor, in particular, tend to take fewer risks, as they are not able to pass on risk to others, as the rich are. Risks relevant to the adoption of new stoves/fuels include the fact that the new technologies may fail (reference past experience with NPIC). Consideration of user risk could be a useful perspective for enhancing understanding of user behaviour with respect to cooking. This issue of apparently low demand for change is further explored in the following chapter.

Calculations were undertaken to find the level of health-damaging and greenhouse gas emissions in different SEC groups, a novel aspect of the research. Levels of health damaging pollutants were found to be between 35% and over 50% higher in the lower SEC households than the higher ones. A high level of total polluting emissions was found to derive from coal burning for cooking (61% of total CO emissions and 63% of particles). Actions to reduce exposure to harmful indoor air pollution in the survey areas would require a focus on improved coal-burning stoves, or measures to encourage fuel-switching.

Of the total greenhouse gases (CO_2, methane and N_20) emitted from cooking in the research areas, around 85% were found to be from the lower SEC households. Per household levels of these greenhouse gases from cooking were found to range between 1.7 – 2.8 tonnes CO_{2e} per household per year depending on the assumptions made, and were higher in poorer households. These levels of greenhouse gas emissions highlight the potential for carbon finance to support a future cooking programme in the area. It is important to note that these are average figures across the whole survey population and likely mask a wide variation; the poorest households are very likely to produce household polluting emissions and greenhouse gases at higher levels than the averages presented, due to their use of the lowest quality fuels and stoves. If a 50% reduction in emissions were achieved through the adoption of an improved stove, savings of 0.8 – 1.4 tonnes CO_{2e} per stove per year would be achieved on average. The estimates are in line with others (Bailis et al 2011, MacCarty et al 2008), but are in reality an under-estimate of the climate forcing effect of cooking, since the effects of black carbon have not been accounted for. While much uncertainty exists regarding the level of carbon offsets yielded by improved stove programmes, the findings are of the same order of magnitude as a number of cooking offset projects either verified or in the pipeline[37];

[37] For example CDM PoA "Improved Cooking Stoves in Bangladesh" (awaiting registration) assumes a saving of 1.04 tonnes CO2e/stove/year, while registered CDM project "Efficient Fuel Wood Stoves for Nigeria" claims that one improved stove will save 2.72 tonnes of CO2e per year (source: www.cdm.unfccc.int, access 8th August 2010)

the newly launched Global Alliance for Clean Cookstoves of the UN Foundation claims that "...*A clean cook-stove can reduce carbon emissions by up to 3 tonnes per year...*" GACC website (2011).

The findings are relevant to public policy related to cooking. It is clear that if public health related objectives associated with cooking are to be achieved, the target group in the research areas needs to involve mainly households in the lower SEC groups, the majority of which are in rural areas.

Given the nature of the data underlying this chapter, based on a market survey, people are necessarily represented as data points. The positive aspect of this approach is the ability to deliver data representing a large population sample, in this case over 3,000 households. To a degree it has been possible to analyse the qualitative data from the cooks' perspective, highlighting some broad trends associated with everyday living that influence cooking choices. However the binary and aggregate nature of the data has the side-effect that many of the individual, subtle, socio-cultural and behavioural issues – required to present a practice perspective of cooking –are lost in such analysis. In order to shift the existing socio-technical cooking regime towards cleaner cooking, it is suggested that a more nuanced practice perspective of cooks, set in their socio-cultural contexts, is required. Such an approach allows a more people-focussed approach, in order to understand how everyday practices might present opportunities for change rather than being regarded as barriers to it; this is analogous to the approach taken with in the sanitation sector in Bangladesh, presented in the previous chapter. The following chapter, which focuses mostly on the lower SEC groups in two parts of India, provides insights into cooking, set within a more personal, practice, perspective.

"Where the clear stream of reason has not lost its way into the dreary desert sand of dead habit"

Rabindranath Tagore, from Gitanjali

5 Understanding the practice of cooking – focus groups in West Bengal and Karnataka

5.1 Introduction

This chapter is the second within the thesis analysing the key agents of change in any transition to clean cooking – individuals at household level, mainly women. In order to shed light on some of the reasons behind the findings within the previous chapter, in particular the low level of expected change reported, this chapter undertakes analysis of qualitative data, based on the results of five focus groups with women undertaken in West Bengal and Karnataka. The aim is to analyse some of the underlying discourses associated with cooking practices, following the advice of one researcher: "…*[d]evelopment projects are often criticised for not being sufficiently participatory and for failing to take into account local discourses*…" (Lewellen 2002 page 85). Practice theory outlined in Chapter 2 is a starting point for the design and analysis of the research in this chapter. However it is acknowledged that the use of practice theory adopted here departs to some extent from the traditional use of the term, whereby individuals are perceived of as *carriers of practices* (Reckwitz 2002, p 249-250, as quoted in Bartiaux et al (2011), p 68). Within this research an attempt is made to enhance understanding of existing practices, with a view to understanding how they might actively be harnessed to improve processes of technology adoption and design in the future.

A rich vein of complexity is associated with the change of deeply rooted patterns of cooking behaviour. Not only does the transition to cleaner cooking involve the adoption of new technologies, in many cases it will also represent a shift from non-market to market-based cooking practices, in which either stoves or fuels, or both, previously freely available for many, become market goods. For the populations studied, this chapter provides insights into why a shift to cleaner cooking might be desired and what factors might inhibit such a change. To what extent is the issue of affordability a factor, and what does affordability mean? Is there awareness of the options for change and how do attitudes to new and unfamiliar technology shape patterns of adoption? What is the effect of long-established habits and culture? Is it the case that the underlying motivation to change is not sufficient to drive a transition? One study suggests that "… *there are three principal dimensions affecting adoption of any radically new product or service by the poor: motivation, affordability, and level of engagement required*…" (Slaski 2009, page 4). The same study points out that there is anecdotal evidence to suggest that it is difficult to convince people to shift to cleaner cooking for the simple reason that motivation levels are not high enough (Slaski 2009). Results from ongoing research in Bangladesh confirm this and indicate that while the price of cook-stoves is an important factor, in many case the underlying motivation for change is low; the research found that there was only a 70% initial take-up of improved stoves when people were offered one a at zero cost, and this does not take into account the number of people for whom an initially adopted stove would later fall into disuse (Miller 2009).

Numerous studies have undertaken quantitative or semi-quantitative analyses to uncover relationships between various socio-economic variables and use of different stove and/or fuel types (Reddy et al 2009). However it has been argued that as well as socio-economic factors (eg income, age, gender and education) the influence of factors specific to cooking technologies is essential to understand but has not been sufficiently studied (Lambe et al 2009). Research was undertaken in Addis Ababa, Ethiopia in 2008 to study the influence of product-specific factors in stove choice, including indoor air pollution, and cost of using and initial price of different cooking systems. This research employed *discrete choice analysis*, to analyse the relative importance of different factors and trade-offs between them. The study found, unsurprisingly, that across all locations and socio-economic groups increased cost of use, higher capital outlay, higher risk smoke levels all reduced utility of stoves to respondents. Additionally it found that "... *when compared to a low-income group, a high-income group was willing to pay ten times more for a unit reduction in indoor smoke, two times more for increased efficiency and ten times more for increased safety*..." (Lambe et al

2009, page 7). Indoor air pollution was found not to be an important factor in stove choice of fuel or stove for poorer households.

While these results are instructive, they have little to say about the subtle behavioural or cultural factors that shape current cooking practices and influence change. This chapter attempts to tease out some of these factors. More generally, the conceptualisation of cooks used within this chapter is as individuals being influenced by their socio-economic and cultural environments, and in turn having agency in shaping these (Giddens 1984).

There has been little anthropological work published on the way socio-cultural issues affect cooking technology choice in developing countries. One anthropological study of cooking in India was undertaken, which focussed on the role of - and problems associated with the predominance of - male and western technical 'experts' in the implementation of improved stove programmes (Crewe 1997). While this raises a number of useful lessons, it does not provide an anthropological perspective on why individual people cook as they currently do, what they like/dislike and how socio-cultural influences might influence their choices to adopt, or not, improved cook-stoves. It is the aim of this chapter to at least partially fill this gap, although further work by anthropologists in this area is also essential.

5.2 Methodology

The methodological approach employed involved qualitative research using focus groups, with the aim of teasing out the beliefs and attitudes underlying the reported satisfaction levels and likelihood of switching presented in the previous chapter.

The methodology followed an approach employed in many qualitative social science projects, and followed recognised guidelines as far as possible (Jayanthi et al 2002). While not truly ethnographic in nature, due to the limited time available and the consequent need to develop a structured line of questioning, it is helpful to call on some aspects of the anthropological approach in order to provide a context for the study. It is important to remember however that the research focussed on a specific question – attitudes to current cooking technologies (fuels and stoves) and to the possibility of switching to new technologies – and was not attempting to undertake in-depth anthropological work.

Anthropologists and social scientists employ two categorisations when referring to data relating to human behaviour gathered through work in the field:

- "emic" information and analysis of human behaviour refers to an approach from the perspective of the subject or actor in question. In other words it refers to an *insider's* view or description of this behaviour from a cultural perspective. Normally gaining an emic perspective requires a considerable degree of understanding of the culture in question, gained through spending long periods embedded within that culture;
- An "etic" approach to the analysis of behaviour or set of beliefs uses a description that "…*is primarily concerned with generalized statements about the data*…" (OED 2012). The etic approach can be considered to provide an *outsider's* or culturally neutral view.

From an anthropological perspective, the researcher's position with respect to the data collection was clearly *etic*. However it should be pointed out that the researcher has some personal experience of the issues and problems associated with traditional cooking technologies, having cooked on a three-stone fire for over a year while working in Sierra Leone in the 1980s, and also having lived in several mountain villages in Nepal, where cooking technologies similar to those used in the areas under study are prevalent. This experience was shared with the focus group participants at the start of each group in an attempt to convey – as far as was possible – a sense that the male researcher had some understanding of, and empathy with, the situation of the subjects (Jayanthi et al 2002).

During the focus groups themselves, the author attempted to maintain a neutral stance with respect to normative goals, and encouraged the facilitators to do so, in order to understand what the focus group subjects actually thought without the influence of external advice. However an ethical decision was taken that, at the end of each focus group, a short explanation would be given outlining the findings of the growing public health research on the importance of reducing exposure to harmful pollutants from cooking fire smoke, especially for children and women (Smith et al 2000). This was followed by some simple recommendations, including to switch to a cleaner stove and/or fuel. If this was not possible the author recommended trying to minimise exposure to indoor air pollution by improving ventilation and keeping children away from the fire when cooking. The majority of focus group participants reacted with interest to this information and advice, displaying a lack of previous knowledge regarding the serious health implications of household air pollution, and the solutions.

5.2.1 Methodology applied

The analysis below relates to data obtained from 5 Focus Groups undertaken by the author in March and April 2010 in West Bengal and Karnataka. The Focus Group areas were selected, with the help of local facilitators, to reflect populations predominantly using traditional stoves. Facilitators were chosen to have a good understanding of the local culture and language (the author did not speak the local languages) and an appreciation of gender and development issues, such that they could be considered as *insiders* to the greatest extent possible (Jayanthi et al 2002). Participants were gathered from the communities visited by community leaders, following the instructions of the facilitators. These community leaders were asked to find a representative sample of 10-15 women using traditional stoves and fuels; none of the people interviewed were using advanced biomass stoves (ABS), an issue discussed further in Chapter 6. In practice the composition of focus groups was opportunistic to an extent, depending on who was available; prior screening of participants, which would have been ideal, was not possible (Jayanthi et al 2002). Nevertheless, it is considered that all focus groups were generally representative of the communities visited.

The questioning route for all focus groups followed a simple logical pattern, although as the format was semi-structured, diversions were made where appropriate (full instructions to focus group facilitators and questions are provided in Annex 3):

1. Participants were asked to talk about the current stove (or stoves) and fuel(s) that they use: what they like/ do not like, benefits or problems they may have;
2. They were encouraged to discuss whether they had a desire to change the current stove and/or fuel they are using and the reasons. At this stage no mention was made of any alternative (improved) methods of cooking;
3. If a desire to switch was expressed, participants were asked which stove/fuel they wished to switch to and why, as well as factors that might make such a switch difficult;
4. On introducing the concept of modern *improved* biomass cook-stoves, participants were asked for their opinions and whether they would consider switching;
5. Participants were further asked who makes decisions concerning new purchases (such as cook-stoves) within their household;
6. Participants were asked how they hear of novel ideas such as new stoves, and what is most likely to persuade them to switch;
7. Finally an attempt was made to encourage the groups to imagine and discuss a better future with regard to the way that they cook, how problems to achieving this might be overcome etc. However this exercise was either misconceived and inappropriate for the research setting, or was misinterpreted by the translators. In practice little of value resulted.

The author was assisted in all focus groups by local experts (called 'facilitators') who helped to arrange the focus groups following overall guidance concerning the desired characteristics of the target audiences. In all cases the general questioning route developed by the author was used by the facilitators, with questions being asked in the local language. This was frequently followed by discussion within the focus groups, indicating that participants were interested in the topic.

Responses from participants were translated into English by the facilitators for the author, who also took notes during each focus group and made recordings throughout.

Some limitations of this approach are important to highlight. Firstly the act of undertaking focus groups in languages unknown to the author (Bengali in West Bengal and Kannada in Karnataka) provided significant challenges; it could not be determined at the time whether the questioning route provided had been followed strictly by the facilitator and, more importantly, the summary nature of the translated participant responses undoubtedly lost some of the richness of their content. In order to attempt to overcome these problems, a full translation of the West Bengal focus group recordings was undertaken in Oxford by a colleague at Wolfson College, Kanishka Bhattacharya[38].

The second issue that must be considered when analysing the relevance of the findings of these focus groups is the means by which the focus groups were undertaken, specifically the people undertaking them. In all cases those involved with organising the focus groups (the researcher and focus group facilitators) were male. While this may be thought to be inappropriate given the subject matter of the research, which is almost exclusively a female preserve, expert opinion was obtained indicating that male researchers frequently conduct such work in India, and that results obtained should not be adversely affected to any significant degree (personal communication, Professor Ishita Mukhopadhyay, Director of Women's Studies Research Centre, University of Calcutta. March 2010). In addition the presence of a European researcher, introduced as coming from Oxford University - an elite academic institution - might be expected to have had some influence on the focus group participants. In an attempt to overcome this, the author tried to blend in as much as possible by, for example, sitting amongst the group and not accepting offers of a chair when the focus group subjects were sitting on the ground. All those organising the focus groups were unknown to the subjects, thus providing a *neutral space* in which the groups were undertaken.

[38] I am most grateful to Kanishka for spending many hours with me, spread over a number of sessions, translating the recordings of the focus groups, as well as for his thoughtful insights into Bengali culture.

Finally it must be acknowledged that the primary research involved relatively short periods of time in each of only 5 communities in India. While research planning had anticipated more focus groups, backed up with individual interviews, a number of logistical difficulties meant that these ambitions were not fully achieved. Thus - given the relatively small sample - while the findings provide useful insights into the attitudes and beliefs under question caution must be exercised when extrapolating them to a larger population.

Consideration was given to use of qualitative data analysis software to analyse focus group transcripts, as sometimes recommended (Jayanthi et al 2002). However, given the limited number of focus groups undertaken, difficulties in comparing certain language between translations in the different regions (different languages and facilitators) and the desire to avoid becoming 'seduced' by the process of data coding and hence losing some of the nuance of the data contained (Schiellerup 2008), the approach taken was to produce detailed notes and selectively transcribe; this approach was confirmed as an appropriate choice by an expert in qualitative data analysis (pers. Comm. Dr. T. Thornton, 3/3/10). The notes were repeatedly analysed, with key themes and narratives being developed and iterated during each round of analysis.

5.2.2 Description of focus groups

The choice of the focus groups (FGs) followed an overall logic which was to concentrate on the priority population –identified in the previous chapter - those in the lower socio-economic groupings (with the exception of FG4). At the same time a range of settings and socio-economic groupings was selected to given some breadth to the data. Two of the focus groups were in rural villages, two in peri-urban areas, and one in a rural agglomeration (rural town) Table 30.

Three of the focus groups were undertaken in Bardhaman District, West Bengal, the same area in which survey data (previous chapter) was collected. This area was selected to allow for some triangulation and the formation of general conclusions. The other two focus groups were conducted in Karnataka, where easy access to rural populations was known to be possible through existing contacts. The data collection in Karnataka also allowed a broadening of the research, by drawing on findings from different parts of India, as well as focussing on a switch to a different type of technology (in this case biogas rather than improved cook-stoves).

Table 30: Summary description of Focus Groups

	Venue and setting	*Socio-economic classification of the area (see Annex 4)*	*Date, time and functioning of the focus group*	*Composition of Focus Group*
Focus Group 1	Baliara village [meaning Brave Place], Baikunthapur, Bardhaman District, West Bengal. The village is situated around 15km outside Bardhaman town, in a rural setting	Mostly SEC R4 category, with some R3. Houses mostly *Kuchha*, a few *semi pucca.* Main wage earners mostly illiterate, with a few having studied up to 4th standard (field work assistant Benoy Hazra pers comm.)	Saturday 27th March 2010 from 15.15 to 16.20. Mehebub Anam, from the Women's Studies Research Centre at the University of Calcutta undertook the questioning and provided simultaneous translation of responses. He was assisted by Faruk Abdulla from the same institution, and by Benoy Hazra from the University of Burdhaman who helped with local logistics	11 women of different ages, with infants and male observers on the margins
Focus Group 2	Tej Gunj Balamath peri-urban slum area, situated on the outskirts of Bardhaman town, West Bengal	Mostly SEC E category, with some SEC D. Education of the main wage earner mainly to 4th standard with a scattering of people studying to SSC level. Employment of the main wage earners generally unskilled, with a few having small businesses (field work assistant Benoy Hazra pers comm.)	Sunday 28th March 2010, from 11am to 11.55am. Mehebub Anam, from the Women's Studies Research Centre at the University of Calcutta undertook the questioning and provided simultaneous translation of responses. He was assisted by Faruk Abdulla from the same institution, and by Benoy Hazra from the University of Burdhaman who helped with local logistics	9 women, with a number of male observers and children on the margins
Focus Group 3	M.A.M.C. peri-urban area, around 2km north of the main road running east/west through Durgapur, Bardhaman District, West Bengal	Mainly SEC D category. Education of the main wage earner 5th-9th standard. Employment of the main wage earner ranged from office boy, to manual workers at the nearby Durgapur Project Ltd, and some petty traders. Women participating in the Focus Group were employed as maid-servants, governesses etc. (field work assistants Mehebub Anam and Faruk Abdulla pers comm)	Sunday 28th March 2010, from 14.45 to 15.50. Mehebub Anam, from the Women's Studies Research Centre at the University of Calcutta undertook the questioning and provided simultaneous translation of responses. He was assisted by Faruk Abdulla from the same institution.	10 women, plus 10 girls with various men and children on the margins

	Venue and setting	***Socio-economic classification of the area (see Annex 4)***	***Date, time and functioning of the focus group***	***Composition of Focus Group***
Focus Group 4	Yaluva Halli village, Godlu Muddana Halli Panchayat, Devana Halli Taluk, Bangalore Rural District. The village is situated around 30km north-east of Kolar town, in south-eastern Karnataka, and is composed of a rural agglomeration (small town).	Mainly R2 category. Houses *pucca* houses throughout. Education level of the highest earner was determined to be SSC. (Kiran Kumar pers comm.)	Saturday 3rd April, 15.30 to 16.25. Kiran Kumar, Secretary of the NGO SKG Sangha undertook the questioning and provided simultaneous translation of responses	7 women, all either young or middle-aged
Focus Group 5	Mithana Halli village, Venkatapura Panchayat, Siddlaghatta Taluk, Chikkaballapura District, Karnataka. The rural village is situated around 3km from FG4, although it is in a different district in south-eastern Karnataka.	Mainly R3, with some in R4 category. Houses *pucca* or *semi-pucca* and the education level of the highest household earner was determined to be 6-7th grade, with some having no education (Kiran Kumar pers comm.).	The focus group was undertaken at 17.30 on Saturday 3rd April for 1 hour and 5 minutes. Kiran Kumar, Secretary of the NGO SKG Sangha undertook the questioning and provided simultaneous translation of responses	6 women of various ages with several men on the margins

Further brief descriptions of the areas in which the focus groups were conducted are provided in Annex 4.

Figure 48: Location of Focus Groups 1, 2 and 3 in Bardhaman District, West Bengal

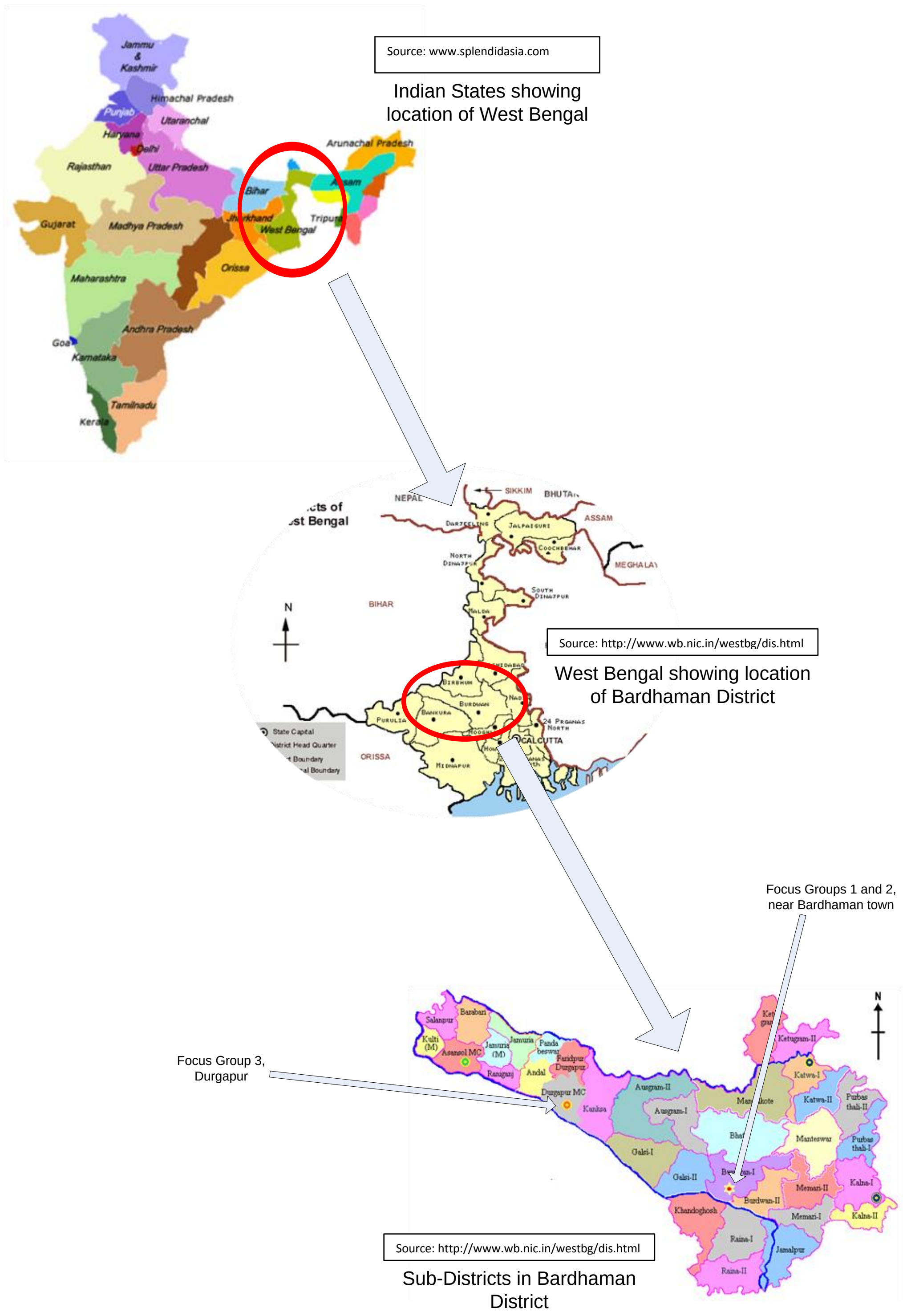
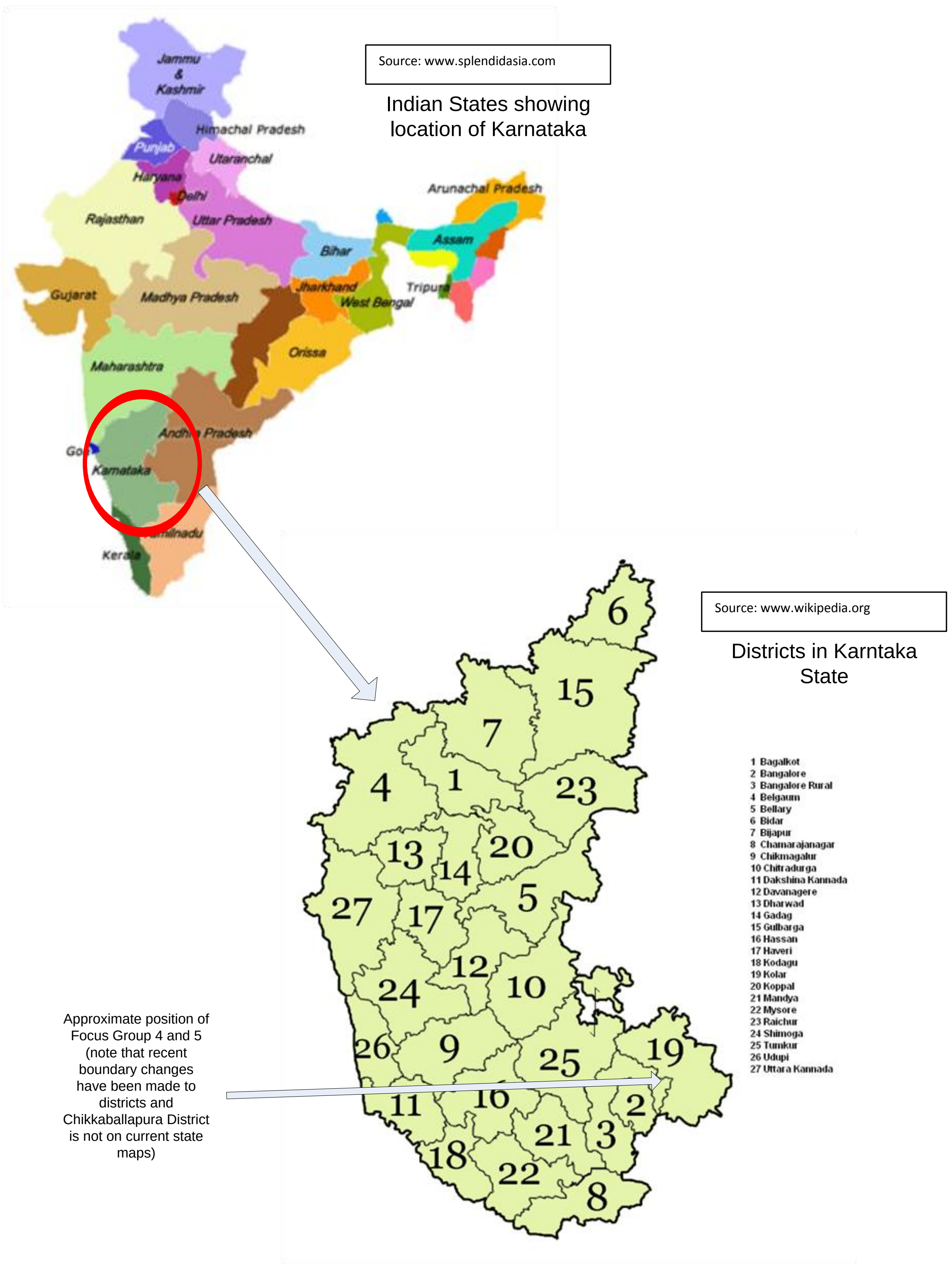


Figure 49: Location of Focus Groups 4 and 5 in Karnataka



5.3 Research findings

5.3.1 Current cooking technologies and practices

Firstly focus group subjects were asked about the reality of their current cooking practices: what stoves and fuels they use (Figure 32 was used as an aide memoire during Focus Groups, where necessary, to identify the type of stove used), where they cook, and what factors have shaped these practices. Table 32 provides a summary of the stove and fuel combinations used in the different focus group communities. The findings with respect to fuel and stove use for Bardhaman are generally in line with those of the household survey reported in the previous chapter. All three Bardhaman communities were within the lower SECs and used mainly traditional stoves and fuels, mainly different forms of coal, wood, dung and agricultural residues.

With regard to fuel use the focus groups revealed a high level of variability in fuel (and stove) use, from day to day and month to month depending on changing circumstances; one woman in FG2 stated that "…*we use whatever is freely available*…". It was clear from this and other responses that sophisticated and flexible strategies, deeply embedded in the everyday routine are employed to adapt to changes in fuel availability and price, as well as the food being cooked. Flexibility is clearly a key part of the cooking strategy, with single houses being observed using combinations of dung cakes, paddy sticks/straw, wood, twigs, coal dust and dung, the latter two sometimes mixed together (observation FG1). Coal dust is mixed with water, formed into pellets and dried in the sun for later use as a fuel. Dust coal was reported to be cheap and affordable in both FGs 2 and 3, and in many cases was collected rather than purchased (Mehebub Anam, pers comm.). FG4, which is the only focus group in the upper half of the socio-economic spectrum, was the only one in which LPG was the main primary fuel. Using a theoretical requirement of 11 MJ/day as the energy required to be delivered to the cooking vessel in India (Venkataraman et al 2010), Table 31 provides the quantities of each fuel that would be required per day if each provided all cooking needs. It can be seen that much lower quantities of coal (by weight and also by volume) are required compared with biomass.

Table 31: Calculations of the theoretical quantity of different fuels required per day, assuming each provides 100% of the cooking requirement

	Thermal efficiency (%) (note 3)	Energy required per day (MJ)	Calorific value of fuels (MJ/kg)		Quantity of fuel required per day (kg)
BBS / wood	18	61.1	15	IPCC default	4.1
BBS / agro residues	11	100.0	15	(Hedon)	6.7
BBS/ dung	10.5	104.8	17	(Hedon) dried	6.2
BBS/coal	14.3	76.9	34	average of 26-42 MJ/kg quoted by National Physical laboratory	2.3
LPG	57	19.3	46.1	IPCC default	0.4

Notes: 1) assumes 11 MJ /day needed to be delivered to pot (Venkataraman et al 2010) 2) BBS = baseline biomass stove (traditional chullah) 3) Source: (Venkataraman et al 2010)

Figure 50: Baliara village (Focus Group 1). 1) Dung cakes drying on the ground 2) coal dust pellets ('gool') drying on the ground with dung cakes on the side of the house (photographs by the author)

For all but FG4, wood was reported to be a preferred fuel, with many respondents asserting that it is a quick way to cook; a distinction was made between *solid* wood, the fuel of choice, and twigs which are generally more readily available but not as convenient.

In order to understand the origin of current cooking approaches and the level of cultural embededness women were asked whether they used the same type of stove as their mothers and grand-mothers; those using traditional chullahs typically responded that they did, with one woman stating that "…*I learned how to make traditional chullahs from my mother and grandmother and I still use the same type*..." (FG1).

Figure 51: Picture of focus group 1 participants) - (photograph by the author)

Many reported use of kerosene as a back-up fuel, either when dry wood was unavailable or when there was insufficient time to prepare a traditional stove, such as when a guest arrives unexpectedly. However kerosene was not seen as a primary fuel of choice by most due to its expense and in some cases the difficulty of maintaining a reliable supply. Kerosene is subsidised in India, although a limited supply is available to each household[39]. It was noted that the subsidised quota amount of kerosene is far from sufficient for use as a main cooking fuel (FGs 1, 3, 4 and 5).

[39] The Government of India historically provides subsidies for kerosene through the Public Distribution System [PDS]. While there is liberalisation in the sector, the subsidised fuels are handled only by 4 state oil companies, with guaranteed minimum returns.

The majority of subjects in FG4 were using LPG or biogas, the latter promoted and installed by the NGO SKG Sangha, of which the focus group facilitator is a leading figure. Most said they were very happy with their biogas (locally called *gobar gas*) system, although this response may have been influenced by the presence of an SKG Sangha representative. The biogas system generally provided 100% of the cooking fuel needs and also provided a useful (and marketable) fertiliser by-product[40].

Whether cooking is undertaken inside or outside has an important bearing on the level of comfort and exposure to indoor air pollution, in particular for the women and children. Within FG1 cooking inside and outside was reported, with the latter generally proceeding under a thatch canopy, depending on space available in different compounds and the season. If cooking outside, cooking under canopies was reported to be essential during the monsoon, although some said that they did not have space for canopies, in which case they might ask their neighbour to use theirs. In the peri-urban areas (eg FG2) outside space was not available for many, and much cooking was undertaken inside the house, often in the only room in which the whole family live and sleep. One woman reported having only one room in her house with no windows, explaining that "…*my bedroom is my kitchen*…" (FG3), creating much amusement within the group, while highlighting the very real issue of lack of space for domestic activities.

[40] 1 cow is necessary to feed a small (2 m^3) biogas system; 2 or 3 cows are required for a larger system (Kiran Kumar, pers comm.)

Table 32: Summary of stove and fuel use within the focus group communities

	Traditional fixed mud chullah (Type 2 Figure 32)	Traditional movable mud chullah (Type 4 Figure 32)	Kerosene stove	LPG stove	Other
Focus Group 1 (Mainly SEC R4 category, with some R3) - rural village					
Majority	Wood, sticks, dung cakes, agro-residues, leaves etc	Dust coal pellets, kacha koyla			
Minority			Used during rainy season		
Other					Large wood stoves for commercial use
Focus Group 2 (Mainly SEC E category, with some SEC D) – peri-urban slum					
Majority		Dust coal			
Minority	Dung and wood sticks				
Other					Three-stone fire, wood sticks, dung
Focus Group 3 (Mainly SEC D category) – peri-urban area					
Majority	Wood (mainly sticks)	Dust and solid coal			
Minority	Solid wood, dung		Used during rainy season		
Other					
Focus Group 4 (Mainly R2 category) - rural town					
Majority				LPG	Biogas
Minority			Kerosene		Electric stove
Other	Wood and mulberry stems				
Focus Group 5 (Mainly R3, with some in R4 category) – rural village					
Majority	Wood and agro waste				
Minority			Kerosene (as back-up)		
Other					Biogas

Figure 52: Typical stoves used in the focus group 1 village (for coal – left and for biomass – right) – (photograph by the author)

5.3.2 Attitudes to existing cooking practices

To understand attitudes to current cooking practices, all focus groups were asked the following question:

> *"Think about the cooking stove (or stoves) and fuel(s) you use to cook in your house. What do you like about these and why did you choose them? Is there anything you do not like about them (problems you have)?"*

In order to elicit responses reflecting actual attitudes to current practices, not subject to external influence, no reference was given at this stage of the focus group to the idea of changing cooking technologies or to the options available for change.

A wide range of opinions was expressed with respect to current fuels and stoves in use. These are outlined below. In summary, when asked what advantages women see in using traditional stoves, there were few responses and little enthusiasm shown, except for the simple fact of familiarity; of her traditional stove one woman (FG3) said "*…there are no particular advantages; I am just used to it…*".

It was not possible to obtain meaningful rankings of benefits and problems from focus group participants as originally conceived in the research design. However it is interesting to note that an almost identical pattern emerged in the order in which issues and attitudes were raised within the focus groups, perhaps indicating a hierarchy of importance within the minds of those responding. The factors, grouped into three categories by the author, were generally presented in the following order:

1. **Availability and affordability issues**: physical availability of fuels and stoves, and cost of different cooking options was always the first topic of conversation;
2. **Time spent in the cooking process**: issues of speed of cooking, time involved setting the fire and collecting fuel;
3. **Smoke issues**: where mentioned as an issue, this was generally referred to as an inconvenience (cleanliness) and minor health irritant, only occasionally as a significant health problem.

It is interesting to compare this inferred ranking of respondents' priorities with those of researchers and development practitioners involved in the cooking sector, for whom the priorities are generally: 1) public health; 2) local environment, especially forestry and 3) climate change mitigation (see for example (Venkataraman et al 2010). Such differences in normative objectives between the two groups are not highlighted in the literature, a significant omission.

Availability and affordability issues

Analysis of the focus group discussions clearly revealed, unsurprisingly, that the practical issues of availability and price were the main factors guiding choice of fuels used, being the first issues mentioned in the majority of discussions on fuel choice. The importance of price is confirmed by another study of cooking choices (Lambe et al 2009). Availability of fuel was also a major topic of conversation within the focus groups.

In several cases fuel-wood shortages were severe: "…*there is not enough wood out there so I just use whatever I can find; twigs, leaves and other things*…" (FG1). It was noted that the local Forest Department in the area around FG1 is known to be strict in enforcing live tree preservation, although dead wood collection is allowed (Benoy Hazra, University of Burdwan pers comm.). Fuel collection was found to be a dedicated task in some cases, taking around 5-6 hours per week (FG5), whereas in other cases it was integrated into everyday routines: "…*I just gather what's available around the place. If I have a good crop I just pick up the waste hay. When working in the fields, if I see something I could use for cooking fuel I pick it up; I am always on the look-out*..." (FG1). Respondents in FG2 noted that wood is not available in the area and hence "…*there are no other fuel options*…" (apart from coal dust and dung).

Between the focus groups there was no fixed pattern of wood acquisition, with some buying and others collecting freely. FG5 respondents in particular noted the increasing difficulty in obtaining wood by either means, reporting that "…*the price of wood has increased a lot in recent years; a truck load cost IRs.1,000 in 2008 and now costs IRs.3,000*…" (note: a truck load is approximately 2-3 tonnes). In the FG5 area it was specifically noted how difficult it was to obtain dry wood in the rainy season, indicating that stores of dry wood are not being replenished outside the monsoon season.

The problems of availability and price were not restricted to wood-fuel, with many respondents also describing difficulties in obtaining LPG and kerosene, for example a woman in FG5 who switched to LPG when it was easy to obtain but now found herself spending hours queuing to obtain refills.

Figure 53: 1) Focus Group 2 (Tej Gunj) participants 2) coal dust pellets drying on the ground in Bardhaman town (photographs by the author)

Time spent in the cooking process

Second only to issues of physical availability and cost of fuel, the most common issue mentioned was time spent in the overall cooking cycle, with some highlighting the time spent cooking (including setting the fire) and others the time and effort involved with fuel collection. One woman in FG3 joked that "…*its so much work that you end up sweating*…" to much amusement by the other participants. The only group that did not raise the problem of time spent in cooking were those using LPG or biogas in FG4, except one woman who complained that her LPG stove cooks too fast and the food boils over; using LPG is recognised to be the fastest way to cook a meal, being quick to light and high power. However, as noted above, increasing amounts of effort and time were involved in obtaining LPG refills in the area.

Opinions varied to some extent as to the merits of different *traditional* fuels with respect to speed of cooking, probably indicating a difference in time spent gathering fuel rather than cooking. Within FG1, wood was a preferred option, when compared with twigs, sticks, leaves and agricultural residues, given its perceived relatively high speed of cooking. Using wood on a traditional chullah was said to be faster than using a standard (non-pressurised) kerosene stove, while coal dust pellets were considered faster than burning dung cakes. In FG2, where wood was not available but dust coal was available and affordable, one woman noted that "…*cooking with traditional chullah is very laborious*…"; on further questioning she explained that the process of setting the coal fire took a long time. Within FG3 time spent in the cooking process was also said to be a problem, although the emphasis here was on the difficulty in collecting wood. One woman in FG5, using a traditional chullah, complained that "…*I have to sit by the fire (tend the fire) to keep it going and cannot then do any other work, which wastes time. It doesn't cook fast enough*…".

Participants in both FGs 4 and 5 noted particular time pressures in the mornings before their children go to school. One woman using a traditional chullah (FG5) said "…*my kids go to school very early and I have to prepare everything before they leave which is a problem; my chullah takes a long time…*". It is interesting to note that net primary school enrolment (both sexes) increased in India as a whole from 71% in 1999 (EFA 2010) to 95% in 2004 (MDG Monitor 2010), perhaps indicating that wider changes (within the socio-technical landscape) are changing the importance for women of time spent cooking; as well as rushing to prepare children for school in the morning, these children are also less available to help collect wood.

Figure 54: Self-made coal stoves in Tej Gunj (photographs by the author)

Smoke issues

While the issue of smoke was raised frequently by those using traditional stoves and fuels, the main emphasis was not placed on serious associated health risks, the focus of much recent public health literature (Wilkinson et al 2009, Torres-Duque et al 2008). The problems raised about smoke fell into two main categories:

i) health issues (minor and major – with an emphasis on the former);
ii) convenience/cleanliness issues – houses, utensils, clothes and hands.

Most women complained of burning eyes and head-aches associated with their use of traditional chullahs, even when cooking outside. One woman in FG1 complained that "…*smoke gave my child an eye problem*…". Women in FG3 seemed surprised to be asked if smoke caused any problems with one remarking that "…*obviously our eyes burn quite a lot*…". Another woman said that her eyes stung even when using kerosene. Frequent references to coughs and asthma were made with regard to smoke inhalation (FGs1, 2 3 and 5), although the sense conveyed in the responses was that these were irritants rather than serious health problems. A respondent in FG5 stated that she wanted a safe stove as her sari had once caught fire using a traditional chullah.

When FG3 participants were asked if they had any breathing problems, the initial response – and one that typified the sequence of question/response from others - was "…*no but we do have problems with our eyes burning from the smoke, although our children are still able to read without problems…*"; the latter remark indicates that they are aware that in some cases eye problems from the smoke may be so bad that reading becomes difficult. On further questioning about the health impacts of smoke on women and their families, the same woman added that sometimes she had to take her children to the doctor with breathing problems. The interesting point here is that it took a leading question for the respondent to provide information about her child's health that had not been forthcoming previously using an open line of questioning. Another woman who offered information about her child's asthma said, with an air of resignation "…*yes it's a problem but what can I do about it?*" (FG1). While some women volunteered information about breathing problems, which they associated with smoke from their stove, and a few stated that they had no problems, a larger number only offered this information after the issue was specifically raised in discussion. One family (FG2) was observed living in a small, single-roomed shack with a traditional chullah burning in the corner and only a small door for ventilation; two children in this room were audibly wheezing.

The FG3 discussion turned to the issue of where their children were when they cooked, with the author volunteering the advice (note change of stance from neutral facilitator of an open discussion to adviser, which was avoided during most focus groups until the end of each session) that it would be better if the children were away from the fire. One response was that "…*quite often they go out to play but often they are here (ie in the kitchen) too*…". One elderly lady responded "…*we can't really do anything can we? I have raised my children with the smoke around and they are now big. We never kept them away from the smoke*…", implying that as her children had prospered, and change would be difficult anyway, it would be fine for others to proceed as usual. The tragic irony is that it is the youngest children, who cannot be left alone away from the mother, who are both most vulnerable to, and most exposed to, indoor air pollution from cooking.

Frequently expressed issues of inconvenience associated with use of traditional stoves and fuels, were the way that it makes the house dirty and the time spent cleaning utensils, house, clothes and themselves. One woman in FG5 complained that using the chullah spoiled her hands. Another, in FG4, stated that since moving into their new house they could not use a traditional chullah as it would spoil the house. It is interesting to note that while much of the international development policy debate centres around indoor air pollution and related public health issues, marketing messages used by commercial distributors of improved stoves focus more on cost reduction (less fuel) and convenience issues (speed of cooking and cleanliness of houses) (Envirofit 2010). The general attitude to smoke amongst the lower SEC focus groups is in line with a discrete choice experiment undertaken in Ethiopia, which found that for poor households there was a low willingness to pay for reductions in indoor smoke (Lambe et al 2009).

Figure 55: Typical view of woman cooking inside one-room house in Tej Gunj (photograph by the author)

5.3.3 Expressed desire to switch to a different cooking stove and / or fuel

The motivation of cooks to switch from their current to a new stove/fuel is one of three key determining factors said to affect adoption by the poor, the other two factors being affordability and level of engagement required (Slaski 2009). It is often assumed that given the appropriate technology, offered at the right price, users will be keen to adopt. However recent research in Bangladesh has *"…analysed the results of focus groups and found surprisingly low demand for improving air quality, suggesting that lack of information about the problem is not the key barrier to adopting cleaner stoves…"* (Miller 2009, internet page). These findings are supported by the results from the previous chapter, which found that:

- Satisfaction levels reported for all current stoves/fuels in use were concentrated in the middle/upper levels (ie more satisfaction than dissatisfaction reported); however greater levels of satisfaction were reported for modern fuels (LPG) than traditional fuels;

- Problems reported with current use of traditional fuels focussed around issues of time spent cooking and smoke, although for the latter the emphasis was on cleanliness more than health. Benefits of using traditional fuels were mainly described as low price and easy availability;
- When asked if they expected to shift fuel use to another in the following 12 months, there was generally a low expectation of changing across all fuels; nearly 65% of respondents said that they would either 'definitely not' or 'probably not' shift. Only 16% stated that they would 'definitely' or 'probably' shift. Although there was a lower expectation of not shifting, and a consequent higher expectation of change, for wood, cow dung and dust coal compared with the other fuels, the general trend for the traditional fuels was still towards the low expectation of change end of the spectrum.

5.3.3.1 Expressed desire to change without prompting of the option of modern improved biomass stoves

In order to unpack this reported low expectation of change, and understand the attitude of focus group subjects to the possibility of changing the way they cook, all focus groups were asked the following question. Note that this question was asked before introducing the concept of, or explaining any specific form of, 'improved' technology:

> *"Do you want to change the stove and/or fuel you use? If so, why? If not, why not? If you want to switch, please tell us which stove/fuel you would like to switch to and why (in other words, how would this make your life better)?"*

This question asked was about *desire* to change rather than *expectation* of change, as asked in the survey reported in the previous chapter. The initial response to this question – which is clearly a leading one - was almost universally in the affirmative, with the majority of women expressing a desire to switch to another form of cooking. Although most of the respondents were using traditional chullahs and fuels, it is interesting to note that this finding even held true for some of those few women using LPG (FG4); however this response amongst LPG users may be a special case, given specific local circumstances - within FG4 those using LPG wanted to change as they considered this form of fuel dangerous, especially when there were children in the house (it was reported that there had been specific incidents of leaks and explosions involving children, probably explaining this reaction). One woman said "*…I can't leave my children in the house with the LPG; I'm very worried about the risk of a leak or explosion. I switched to LPG when our new house was constructed; we did not want to spoil it with smoke. But, now LPG re-fills are hard to get and we have to go to town and stand in a queue…*".

Figure 56: Focus Group 3: 1) Woman cooking outside with traditional chullah 2) some of the Focus Group participants plus various children (photographs by the author)

Of the minority not expressing a desire to shift to another cooking technology, these respondents were either using biogas (two respondents within FG's 4 and 5) or were older than the average, in the age range for whom children would be expected to be grown up.

The reason that these overall results (the high level of expressed desire to shift) appear to run counter to those from the previous chapter, could be explained in two ways. The first possible explanation is that while there was a low *expectation* of change found within the quantitative data of the previous chapter, this was due mainly to a perception that change was not possible, rather than it being not desirable. The other possible explanation is that the nature of focus group process, and in particular the keenness of respondents to provide the answer that they thought those running the focus group were seeking (known as the *interviewer effect*), influenced their responses. Commenting on interviews as a research method, it has been noted that "…*the general tendency is for respondents to bias their answer to conform with what they believe to be the norms and expectations of the interviewer*…" (Dohrenwend, Colombotos 1968, page 410). Discussing the problem of *too much social distance* this researcher goes on to say that "… *much of the available evidence concerning which types of interviewers affect which types of respondents suggests that bias is found where there is a difference in the statuses of the interviewer and respondent*…" (Dohrenwend, Colombotos 1968, page 410). It is clear that in the case of the focus groups undertaken, there was considerable social distance between the respondents and those organising and facilitating the groups, and the findings need to be considered with this in mind. It should be noted that great care was taken by the author in the design of the introduction to the focus group, and the formulation of the questions asked to this point, not to indicate a preference for any particular cooking solution, or even to promote the idea that change was a desirable outcome in general; however there are indications, obtained from the full translations of the West Bengal focus groups, that the focus group facilitator (the person asking the questions in Bengali) may have hinted at the desirability of change at the introductory stage of the focus groups, thus possibly influencing the results.

For those expressing a desire to switch, the option of choice was generally uniform within each focus group, although varied between groups depending on knowledge of the options available. In very few cases did participants suggest a preference to switching to modern improved biomass cook-stoves, explained by the simple fact that knowledge of them was revealed to be limited or non-existent. Participants within FGs 1, 2 and 3 broadly agreed that a switch to LPG was the preferred option, due to its perceived speed of cooking and cleanliness. However none of those wishing to switch to LPG expected to be able to do so due to its price. A small minority expressed a preference for switching to kerosene. It was interesting to hear a number of respondents commenting that if it were possible to buy LPG, they would use it to supplement use of a traditional chullah in order to limit the expenditure on LPG. Given the increasing evidence that emissions of health-damaging pollutants need to be reduced to very low levels in order to be safe (Venkataraman et al 2010), such a strategy is unlikely to achieve the same level of health benefits as use of a modern, low-emitting biomass stove used all of the time (see Chapter 1 discussion giving a summary of current public health/cooking literature).

A minority of FG2 and FG3 subjects said that the addition of chimneys to their stoves would be helpful. This un-prompted reference to the use of chimneys was explained by the presence of stove makers in both villages, although further questioning revealed limited understanding of the use of such chimneys. Follow-up with the stove makers indicated that they undertook very few installations in practice. All respondents in FGs 4 and 5 expressing a desire to change wished to shift to biogas, clearly due to the fact that knowledge of biogas was high due to years of work by the NGO SKG Sangha, and several installations were already present in these villages; *early adopters* - in the language of market transformation – were clearly influential.

For those wanting to change, expressions of this desire and the reasons for it were highly variable, ranging from explanations of hard physical realities, especially difficulty in obtaining the current fuel used, to those involving questions of affordability and issues more associated with long-established beliefs or modes of thought, which can be conceptualised as *cultural norms*. The problems associated with smoke were cited by many although, as noted above, cleanliness of the house and cook were more frequently raised as issues than serious health problems associated with smoke.

At the same time there was a common expression of pessimism regarding the likelihood that change would be possible, supporting the finding of the previous chapter that when survey respondents were asked if they would be likely to change cooking practices within the next year, around two-thirds said that they would either definitely not or probably not shift.

Ground realities

Those within focus groups where traditional fuel is increasingly hard to obtain (FG5) expressed the strongest desire to switch from traditional fuels: "*…10 years ago, wood was plentiful; now its not. Then cooking on the traditional chullahs was not a big problem, we did not have to switch but now wood is not available we do*…". LPG was not considered an appropriate option in FG4 or FG5 due to the difficulty in obtaining refills, and the expressed desire for self-sufficiency, principally to be free of the uncertainties of cost and availability associated with LPG; even those currently using LPG (FG4) expressed the desire to switch for these reasons.

As discussed above, the issue of time spent cooking was frequently cited as a major driver for change, the hope being that the new stove/fuel would use less time. This supports previous findings that in many places "...*cooks value the speed at which a stove functions above all other features*..." (Crewe 1997, page 64). One woman reported "*…I want to switch from my traditional chullah because it takes too much time for collecting wood and I am very busy*…" (FG3).

A common finding was that respondents were simply not aware of options available to them, for example modern improved biomass cook-stoves. While knowledge of LPG was widespread amongst all focus groups, and all within FGs 4 and 5 knew of the potential for biogas, very few had any knowledge of the modern generation of improved biomass stoves available. As LPG and biogas were largely considered unaffordable (see below) this lead to a common view typified by the following: "*…traditional chullah is bad but there are no options*…"and "*…smoke is a problem for my children but what can I do about it?...*" (FG1).

Affordability issues

Affordability issues might also be considered to represent ground realities, and in many cases they are; 34% of the Indian population lived on less than US$1/day in 2004 (MDG Monitor 2010), a level at which most simply cannot afford additional capital and ongoing expenditure. However it is worthy of consideration that, in some cases, affordability is a subjective judgement rather than an objective reality; hence the issues surrounding affordability are dealt with here separately. This thought was initially driven by the following comment by a native of West Bengal that "… *even poor families in West Bengal tend to save a high proportion of their income*…" (Kanishka Bhattacharya, pers comm.). This is supported by the findings of a survey of how Indians spend and save money in 2005 (NCAER 2005), which found that over 81% of Indian households have some savings, even those in the lower income groups. It was also found that a large proportion of households saved in informal ways (eg cash or jewellery kept at home), that is outside of the official banking institutions.

Table 33: Annual savings in Indian households by type of household

Type of Household	Average savings per annum (Indian IRs.)	Savings per annum in Pounds Sterling (£) exchange rate £1=IRs. 86.4
Landless	IRs 7,608	£88
Marginal land owners	IRs 7,991	£92
Small land owners	IRs 13,550	£157
Medium sized land owners	IRs 22,370	£259
Large land owners	IRs 42,490	£492

Source: adapted from (NCAER 2005)

While an analysis of the reasons for saving amongst poor households is beyond the scope of this research, it is clearly a necessary and rational insurance strategy to mitigate the impact of unforeseen events, and for children's education and marriages. However the levels of saving reported do place the findings of this research in context; some modern biomass stoves cost in the order of IR 1,000 – 2,000 (US$ 19 – 38) for example those available from First Energy and Envirofit, see next chapter[41].

[41] Note that the cost of the new generation of modern biomass stoves is highly variable, ranging from US$3 (IRs. 165) for a rocket combustion chamber from StoveTec (www.stovetec.net) to over US$ 80 (IRs.4,400) for some fan assisted stoves.

As already noted the general preference was for switching to LPG in FGs 1, 2 and 3, and to biogas in FGs 4 and 5. There was also widespread, almost universal, expression that such a switch would not be affordable; it is worth noting that the financial implications of using LPG and biogas are quite different – low capital and high running costs for the former, and high capital and zero running costs for biogas.

The expression of lack of affordability was typified by a woman in FG3 who said "…*its all very well, we have our desire to change to something better, but who is going to pay?...".* The issue of government grants was raised in all but one focus group (FG2). The facilitator in West Bengal warned that during qualitative research in India it is common to find examples of people over-emphasising their poverty; the explanation provided was that the frequent government surveys undertaken can result in some form of economic benefit for the poorest segments of the population identified, and it is thus to the advantage of individual households to be classified as poor (Mehebub Anam, pers comm.).

Cultural norms

The term *cultural norms* has been used here to group several issues raised during focus groups. The separation from the seemingly more tangible issues of ground realities and affordability does not imply however that this set of issues has been demoted in importance relative to the others, as has been warned against (Crewe 1997, page 69). On the contrary a key conclusion is that this group of issues, touched upon during the focus groups, is of central importance and requires considerably more attention in future efforts to promote improved cooking.

One woman explained that "...*if I was from a decent family I wouldn't have to use these traditional chullahs and my clothes would not be this dirty*..." (FG1); this remark was presumed to be referring to the effect of the smoke from cooking. The concept of respectability is important in Bengali culture and in this regard clean clothes are seen to have a direct bearing on the level of respectability.

Another expression of a cultural norm included an issue related specifically to the intricacies of the cooking process itself. Of all the focus group participants only one raised the issue of food taste, stating that "…*traditional chullah using wood makes dhall more tasty*…" (FG3); however the other participants in FG3 argued that this was not the case and following lively discussion the woman in question agreed that taste was not a major concern when switching from a traditional chullah.

However, perhaps of more relevance is one issue that was not explicitly raised by focus group participants but was highlighted by the facilitator of the Karnataka focus groups, who said "...*I have observed very precise and deliberate use of different traditional fuels in India depending on what is being cooked, as well as a high degree of skill in using fuel to regulate the temperature of cooking and the amount of heat delivered to the pot*..." (Kiran Kumar, pers comm. 3/4/10). He went on to explain that this skill is handed down over many generations. This innate skill is a key part of the "…*silent traditions of developing cooks…"* (Crewe 1997, page 59) and the absence of discussion of it during focus groups may be explained by the telling phrase "...*What is essential goes without saying because it comes without saying: the tradition is silent, not least about itself as a tradition*..." (Bourdieu 1977, page 167). It may be that the uncertainty amongst women about whether their innate cooking skills, which might be termed *tacit knowledge*, could be transferred to modern biomass stoves is acting as a major barrier to their uptake; in simple terms, it would be rational to be concerned about not being able to cook as well on a new, and unknown, technology. It clearly essential to ensure that modern stoves allow the same degree of control that can be achieved on traditional stoves and to find ways to assure women of this fact.

Figure 57: Focus group 4 participants – this focus group differed from others, being made up of participants in the upper half of the socio-economic groups (author far left)

5.3.3.2 Expressed desire to change after prompting about the options for modern improved biomass stoves

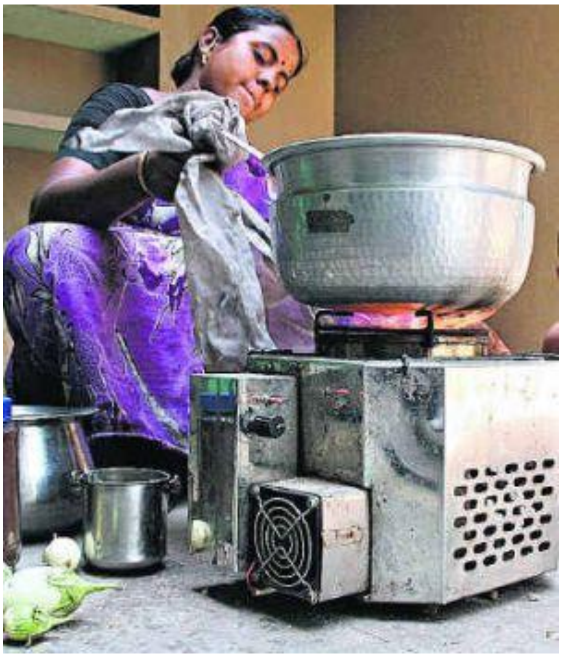
The next step in the questioning line was preceded by a description of some modern improved cook-stoves available in India. In West Bengal the operation of two modern biomass cook-stoves (one ABS and one rocket stove) available in India today (pictured in Figure 58) was briefly outlined, together with an explanation of the current widespread distribution of these stoves in Southern India. Originally it had been planned to show actual examples of these stoves to the groups, and demonstrate their use in practice; however despite the stoves being delivered to the author's hotel in Kolkata, they later disappeared. For the focus groups in Karnataka, these modern stoves were briefly discussed although the focus of discussion was on biogas. The following question was asked in order to ascertain whether attitudes to switching changed following acquisition of new knowledge of the possible options:

> *"Did you know that some modern stoves, using wood and other fuels, are available in India now? These make much less smoke in the house, and cook cleanly and efficiently. What do you think of them?" [Picture showed, and explanation about the stoves offered, as well as*

statement saying that these are only two examples of modern stoves available – many other types also exist]

Figure 58: Examples of two *modern* biomass cook-stoves available in India today (photographs used as prompt during questioning)

Envirofit G-3300 model rocket stove, for use with traditional biomass (source: http://www.envirofit.org)



Oorja fan driven efficient pellet stove originally marketed and distributed by BP Emerging Consumer Markets India, now taken over by First Energy ltd (source: http://biopact.com/2007/07/revolution-in-kitchen-5000-indian-rural.html)

Within all focus groups there was much animated discussion on showing pictures of the two examples of modern biomass stoves, and explaining their operation. First reactions were typically surprise that such stoves exist and questions about how much they cost, and what fuels they burn.

After some discussion and consideration a range of views was expressed about whether the participants would wish to adopt the stoves, ranging from the very positive to the cautious and the negative.

Many participants within FGs 1, 2 and 3 expressed an interest (strong in some cases) in adopting improved biomass stoves, if they were made available at an affordable price, and were of sufficient quality. The issue of quality was expressed in various ways, with a focus on durability and speed of cooking: "...*I would like one if it can cook as fast as my chullah using wood*..." (FG1). On learning that the stove would use 40-50% less fuel, one woman in FG2 who currently purchases fuel said "...*any money I save in fuel I will save and use for my children to go to school...".* A woman in FG3 responded "...*obviously we will switch if its affordable and we know its safe, as we are fed-up with traditional chullahs, because they take lots of time and as domestic servants and workers we are all busy and do not have sufficient time for the traditional chullah which takes lots of time to gather coal and wood-fuel*...".

Participants in each of FGs 1, 2 and 3 were asked how much they would be prepared to pay for one of these improved stoves, with FGs 1 and 2 stating, on average that IRs.300-400 was the maximum amount, while responses from FG3 were that IRs.300 would be the most they would pay; these figures do not compare favourably with the cost of the cheaper of the two alternatives presented (Envirofit stove – at around IR1,500). It is interesting to note that the reported willingness to pay for an improved stove was lower in the wealthier FG3 than in FGs 1 and 2, where lower rates of employment were reported, indicating that ability-to-pay may not always be related to willingness-to-pay. One woman in FG1, interviewed separately after the focus group, expressed clear interest in the modern improved stoves initially, but stated that IR 300 would be the most she could afford; intriguingly, on further discussion about the improved stoves (eg cost and benefits), she finished by saying that she was happy enough with her existing (traditional) 2-pot stove. Many participants asked about the availability of government subsidies, with one woman in FG3 explaining that the stoves should be free, possibly a reference to the expected role of the state in West Bengal.

Those expressing cautious interest in the modern stoves were mainly concerned, understandably, that they knew little about the stoves and needed to be re-assured about their functioning. A participant in FG1 said *"...we want something that works quickly. We know how to use our traditional chullahs so we can be very efficient with them and get our food cooked quite quickly. The new stoves, we do not know how to use them and are not sure they will be as quick...".* Several participants in FGs 2 and 3 were concerned about the stoves' longevity: One woman in FG2 asked *"...will the stove break, how long will it last?...";* on hearing the response that the stove might last for 3-5 years, the reply was that IR300-500 was too much to pay, a sentiment echoed by others. Participants in FG5 were initially negative about the concept of improved biomass stoves, with their attention focused on the adoption of biogas; however discussion about the ability of these stoves to use significantly less fuel increased interest, especially as wood prices are increasing in the area as availability falls.

The most common reaction amongst those negative about adopting the improved stoves was that they would be too expensive. Other reactions were more subtle and hard to interpret; despite complaining about the smoke emanating from her traditional stove, and previously expressing interest in switching, on seeing pictures of the modern improved stoves, one woman in FG1 explained "...*No I wouldn't use it. When my stove produces a lot of smoke I try to fix this by using a different type of traditional chullah for a short time. I love the stove that I've got. I have got used to it, and I don't want anything else*..." to which there was much nodding. This reaction might be explained simplistically by the general conservatism that is thought to permeate much of rural India, although a more nuanced and balanced explanation would be necessary, to incorporate such hidden factors as those outlined above under the heading *cultural norms*. It might also be explained as a result of a lack of trust of *improved* stoves generally, that is known to have resulted from the relatively failure of those models distributed under the National Programme on Improved Chullahs (NPIC). However, on questioning about the NPIC, few if any of the participants in any of the focus groups had heard of it; despite the programme having been active in West Bengal and Karnataka (see Chapter 3) it had clearly not operated within the communities studied.

Within FG5 an interesting discussion ensued about the affordability of biogas, the preferred option, for which the capital costs are high at around IRs.20,000. Seasonality of income in the area (from cash crops including silk) was considered a major factor when considering affordability. With one main income per year, wood was thought to be an attractive option as a load of wood could be bought annually and stored, as opposed to LPG which required regular payments for refills. Micro-finance options for biogas were discussed but were not considered favourably, with one woman saying "...*the interest rates are too high and I am worried what will happen if I do not keep up payments*..."[42]. The issue of government grants, available sporadically (at a level of 60% of cost) for a limited number of biogas systems, was raised frequently, and clearly considered the only way to adopt biogas by the majority. However on further questioning it was revealed that biogas was still considered unaffordable by many even with a government subsidy. One woman said - "...*we see interest as a burden*..." while another stated "…*so I will carry on as before and find wood somehow…even if I have to borrow or steal it*".

Thought experiment on affordability of biogas compared with purchasing wood for Focus Groups 4 and 5 (figures supplied by Kiran Kumar, pers comm.):

Scenario 1: Wood purchasing – annual cost of wood (if all wood is purchased) would be around IRs.4,000 – 5,000 (payment over 3 years = IRs.12,000 – IRs.15,000).

Scenario 2: Micro-finance payments for biogas with no subsidy – assuming cost of system at IRs.20,000 and a loan paid over 3 years at 20% interest. Payment in the first year would be around IRs.9,000; second year IRs.8,300; third yearIRs.7,500. Total payment c. IRs.25,000. This would take 5-6 years of wood payments to yield a return, assuming all wood is purchased.

Scenario 3: Micro-finance with subsidy of 60% - system cost to the user is now IRs.8,000. Paid back over 3 years at 12% interest. Payment in first year is IRs.3,600; second year IRs.3,300; third year IRs.3,000. Total payment IRs.9,900 which is cheaper than purchasing wood over the same 3 year period.

With reference to the illustrative figures in the box above, the findings from this focus group may not make sense to a rational economist; why would someone choose not to adopt scenario 3? However Kiran Kumar (pers comm.) noted later that "…*the logic of economics does not necessarily operate at the village level*…" following up that there is a tangible fear of having houses or other possessions appropriated by loan companies, and that given this most people would choose to

[42] Questioning revealed that micro-finance interest rates of 12-20% or higher were commonly experienced.

continue to buy or find wood somehow rather than take on a loan, even if they can afford it. Clearly the issue of maintaining personal control over their financial situation is central.

Figure 59: Focus group 5 participants (author far right)

5.3.4 Intra-household decision making processes

Intra-household bargaining, and the processes by which the relative roles of men and women are constructed is discussed in (Agarwal 1997), stressing the importance of social norms, as well as issues such as the gender balance in ownership of property. The process of decision making with respect to energy at household level has been the subject of academic and policy debate (Cecelski 2000). From a practitioner's perspective it is clearly essential to understand the process by which decisions are made within households if a transition to clean cooking is to be achieved. At the same time, the case of decision-making surrounding purchases of cook-stoves can be used as an example to test the broader findings of anthropological studies.

Received wisdom has it that many women in developing countries are dis-empowered. This view is typified by the following statement "…*as is true throughout rural India, in Rajasthan, women live within a strong patriarchal, kin-based, and semi feudal ideology…They are secluded, often even within the family, where they are subordinate to their husband's kin and* ***have little say in family***

decision making. *Paradoxically, rural women are considered strong and outspoken by town dwellers …*" (Lewellen 2002, page 85) (emphasis added by the author). Similarly the findings of a study on women's empowerment in India by IFAD (International Fund for Agricultural Development (IFAD), a specialized agency of the United Nations) on the Tamil Nadu Women's Development Project which took place in late 1999, found the following regarding intra-household decision-making: *"The evaluation concluded that there seemed to be a slight improvement in women's involvement in household decision-making in male-headed households, on such issues as credit, the disposal of household assets, children's education, and family health care.* ***However, the traditional gender-based divisions persist in intra-household decision-making. Women basically decide on food preparation, and men make the financial decisions****..."* (IFAD 2010) (bold emphasis added).

Thus the literature implies a limited role for women with reference to the decisions concerning the purchase (or not) of new household items. However it is not clear from the literature where the decision making power rests with respect to the acquisition of cooking technologies. Organisations such as Energia have assumed general female disempowerment and have sought to influence policy and practice and work by mainstreaming gender into the energy and development debate, for example within donor organisations operating in the energy sector (ENERGIA 2012).

To explore the household decision-making process within the communities under study, and test assumptions, all focus groups were asked the following question:

> *"How are decisions about buying new things (such as a new stove) made in your house? Do you discuss with your husband and decide together; do you tell your husband what you would like but leave it to him to make the decision; or do you decide yourself and go ahead and buy without asking anyone?"*

In all focus groups this question resulted in animated conversation within the groups. Surprisingly, very few respondents indicated that they had no say in decisions regarding the adoption of new cooking technologies. Overall the responses can be divided into three main categories:

- Those who said that they (the women) would make the decision themselves;
- Those jointly deciding with their husband;
- Those for whom the decision would be made by another person, generally the husband.

Between all five focus groups it is interesting to note that around two-thirds of the respondents were in the first group, with the women taking the initiative in decision making. While this finding should not be considered quantitatively significant, it is none-the-less important in that it runs counter to much mainstream thought. Several women emphasised the fact that they should make such decisions since they were the ones to suffer from the existing approach to cooking.

Typical responses to the question above in West Bengal included:

- *"if I ask my husband for a new chullah then he will get it",* said with intonation of surprise that there should be any doubt about this fact (FG1)*;*
- *"it's the woman of course. She controls the money and takes care of things inside the house"* (FG3);
- In a slightly joking tone "… *it doesn't matter what my husband says, if I decide I want a stove he will go and get it*…". (FG3);

Although responses were similar in Karnataka (FG's 4 and 5), more emphasis was given in these cases to the fact that it was easy to persuade the husband because he would also directly benefit, rather than simply follow the woman's will. In the case of biogas (technology of choice in FGs 4 and 5) there is a useful bi-product, namely fertiliser, which either helps to improve soil productivity for the husband's agricultural activities, or provides direct income through sale of the fertiliser. In addition, it is generally the husband who goes to buy fuel-wood, which is becoming increasingly expensive and hard to obtain in these areas of Karnataka; thus the husband is directly aware of the economic benefit of switching to biogas, and knows that using it would save him significant effort in wood buying. Note that wood is purchased to a much greater extent in the area of these focus groups compared with being collected in the West Bengal study areas.

In those cases where joint decision making was made, commonly expressed phrases included the words *persuade*, *convince* and *influence* directed from wife to husband. This is typified by the following: *"…if I tell my husband about the problem with* smoke, *and that we need to change, I hope to convince my husband; he will listen to me*…" (FG2). The theme of convincing husbands was a common one, repeated in FGs4 and 5. Within FG3, where more women had formal employment compared to the other groups in West Bengal, one woman explained that in her house the person who earns more should make the decision; she did not proceed to say that she was the one with the higher income, although her response did lead to animated discussion within the group indicating that this might be the case.

In the relatively few cases where a male member of the household was said to make purchasing decisions related to cook-stoves, both husbands and sons were involved in the decision-making role. Even in these cases, the sense remained that the wife retained some influence over the husband through explanations of the need to improve the cooking set-up. One woman, who expressed a desire to switch to improved cooking said: "… *the traditional chullah takes too much time…I feel bored and exhausted, and will tell my husband who will make the decision*…" (FG1); in this case the woman explained that her family did not have sufficient funds to switch, and thus the answer from the husband would be "no".

The key finding resulting from responses to this question was that women (say that they) play a significant, often determining, role in the decision making process with respect to purchasing decisions for cook-stoves and cooking fuels. While this finding appears to contradict mainstream thought, as outlined above, the academic literature is silent on the specifics of intra-household decision making with respect to cooking technologies. Econometric models have been used to determine gender bias in general with respect to household expenditure in India, although these models tend to focus on spending on specific items, such as education and the differential in spending between male and female children; one study finds that "… *the results of the test of gender bias vary sharply between households at different levels of adult literacy. This is particularly true of household spending on education. The gender bias in the case of this item is, generally, more likely to prevail in households with low levels of adult educational attainment than in more literate households*…" (Lancaster et al 2003, page 4). This research also finds that "…*male bargaining power is higher in larger households and lower in the more affluent households…*" and concludes that "…*The results of this paper on Indian data warn against making any generalised statement about the existence and nature of gender bias in the country as a whole. There are sharp regional variations reflecting differences in social and economic factors that need to be recognised in policy formulation*…" (Lancaster et al 2003, page 15).

Is it the case that decisions about cook-stoves are so specific to female household members that women take the initiative in decision making? Although not sufficiently comprehensive to prove this, the findings of this research point towards it. It is interesting to note that the translator used for the West Bengal focus groups, a native of Kolkata with some experience in anthropological work in rural areas of the state, expressed the view that the "…*inside powers rest with the woman, while men have the outside powers. If the woman decides something relating to the inside of the house needs to be done (going to the market, buying something, fixing house), she wouldn't go outside and do it, she would ask, or more likely instruct, her husband to do it. It is his duty to do these things...".* He continued that in West Bengal, the *"…woman controls the bulk of the money generally. But decisions about spending are often made mutually*…" (Kanishka Bhattacharya, Wolfson College, personal communication, 2010).

If such contentions are true, it would be rational to conclude that decisions concerning the purchase of new cooking technologies are under the control of the woman, if not completely then at least partially, at least within the research areas. Cooking is clearly an inside issue and affects the woman far more than the man. Further ethnographic work, lacking to date, would be required to confirm this finding, which is important for both policy and practice.

5.3.5 Learning of new ideas

In an attempt to improve understanding of how new ideas permeate through the societies and neighbourhoods under study, the focus group participants were asked the following question:

> *"How do you hear of new ideas such as new stoves, and what is most likely to persuade you to switch (advertising, newspaper, neighbour, radio/TV, women's group etc)? Follow up: would you be more likely to switch to another stove if your neighbour had already switched?"*

Most reported that their neighbours were the main source of new information (FGs1, 2, 3 and 5). One woman in FG1 said: "…*if they got a new stove and thought it was good, I'd probably go and get one*…". In some focus group communities (FG1 and FG5) a Self Help Group was operating, generally comprising a group of self-organised local women. These were felt to be helpful means of hearing of new ideas, although the issue of improved means of cooking had not been raised.

Participants in FG4 said that government TV can be a useful means of hearing of new developments, and remarked that there were occasionally information programmes on biogas. However the sense was that most had become informed about biogas through the actions of the NGO SKG Sangha, which has disseminated many biogas systems in the area over the past decade.

5.4 Analysis and discussion of focus group findings

The focus groups provided valuable data to help understand some of the attitudinal and socio-cultural issues concerning cooking and the possible adoption of new technologies. However language issues made data gathering and interpretation difficult. In addition the research involved relatively short periods of contact with only 5 groups of women. More in-depth and long-term anthropological/ethnographic work would be required to confirm the results and generalise them to the Indian population. To date the study of cooking in India by anthropologists appears to have been limited (Crewe 1997).

5.4.1 Summary of findings

Confirming the findings of the previous chapter, the focus groups revealed significant heterogeneity in cooking practices both between communities but also within them. At the level of individual households a wide variety of fuels is used depending on availability, cost and food cooked, and sophisticated strategies have been developed to adapt to changing circumstances. When asked about preferences for cooking stoves/fuels (ref. *Teleo-affective structures* Bartiaux et al (2011)), practical issues predominated; issues raised included: 1) cost and availability, 2) time spent cooking in particular amongst women with school-aged children, and 3) smoke, with more emphasis on cleanliness and inconvenience than serious health problems. The lack of emphasis given to the serious health consequences of traditional chullah use might be due to the fact that respondents were unaware of the problem, or that it has become so much part of life that it is not considered. It may also be that such personal issues as child health are not deemed to be appropriate topics for public discussion.

These findings are in line with those revealed by the survey data of the previous chapter. The focus groups however also highlighted the existence – either expressed or implied – of more deeply-rooted issues, associated with long-standing traditions and cultural norms with respect to cooking (ref. *Know-how and embodied habits,* Bartiaux et al (2011)).

A clear barrier to the adoption of modern improved cook-stoves was the almost total lack of knowledge of the options available. This is perhaps not surprising given their relatively new introduction; however there appeared also to be a surprisingly low level of awareness of the improved stoves introduced as part of a large government programme in previous decades (National Programme on Improved Chullahs). The use of existing community structures to disseminate information about improved stoves (such as women's village Self Help Groups) appears to be a promising avenue. From the responses gained through the focus groups, women appear to have more power in decision-making with regard to decision making about new purchases (specifically cooking technologies) than is often implied by the gender and development literature.

Affordability was reported to be a key inhibiting factor in the adoption of new cooking technologies. While many of those taking part in the focus groups were clearly too poor for extra capital outlays, there are indications that lack of affordability is for some a choice rather than an absolute, indicating that improved cooking is not a high priority relative to other issues. This raises a central ambiguity in the findings: while the vast majority of respondents expressed a desire – strong in many cases – to switch away from their current traditional stoves to other - quicker, cleaner and more convenient - stoves, there was a seeming resistance to such change and a relatively low level of initiative demonstrated with regard to putting such a switch into practice.

This is likely to be at least partly due to concerns about transferability of the in-depth and innate cooking skills that women possess with respect to their traditional stoves. Although not explicitly raised by the focus group respondents, it was hinted at through questions from women concerning the new (and unknown) technology of improved stoves: would they be able to control cooking speed? Would the new stoves be able to use the same fuels that the women were used to? There was also suspicion expressed concerning the durability of improved stoves.

While such concerns can be addressed through careful and detailed engagement with potential users of improved stoves, it is hypothesised that there are more entrenched issues at play. The focus groups revealed that traditional stove making and use had been passed down for many generations, leading to long-established habits and cultural practices. Routines embedded in everyday life are employed to ensure that fuel is available depending on changing circumstances. Some of these routines involve valued social engagement, for example during wood collection. Although a tentative finding, it may be that such cultural and social issues - what might be called *social, behavioural or cultural lock-in* – are behind the apparent disconnect between expressed desire to change and resistance to put such change into practice? Lock-in has been found to be prevalent in many systems, not only in traditional cultures, in both developing and developed economies (Barnes et al 2004).

5.4.2 Contextualising the findings

In an attempt to contextualise the findings, they are related here to the wider framework of practice theory, socio-technical systems and the literature on behavioural and cultural lock-in.

This chapter and the previous one have focussed on one specific element of the socio-technical cooking regime, namely the cooks themselves. The extent to which these cooks have agency concerning their cooking choices depends on a number of factors, including income, awareness and availability of alternatives. However there are other important parts of the socio-technical cooking regime, for example in those institutions responsible for designing, manufacturing and distributing improved stoves. The literature clearly demonstrates the importance of full engagement between end-users and these *outside* structures if cooking programmes are to be successful, highlighting the need for an increased role for women in particular (Crewe 1997).

Changes within the socio-technical landscape are – by definition – outside the control of end-users. However some of these changes will have an influence on the cooking regime. The issue of increasing school enrolment and consequent changes in time priorities for women is one example. More broadly, as Indian economic development proceeds more of the population will become involved in the market economy; however, it is not clear that this change will be fast enough to allow many poor Indian households (perhaps the majority) to adopt improved stoves without an external source of funding. Another change in the socio-technical landscape may help; the focus on climate mitigation, and the resulting mechanisms for carbon offsetting, may provide a new stream of finance for the cooking sector, one that is still at the early stages of development, and is explored further in Chapter 6.

Path dependence is employed as a device to show how past context and action shapes (and constrains) future choices (Barnes et al 2004, Yesuf et al 2009). In the STS context, path dependence can be seen as the ways in which the structures and institutions established within the existing STS are self-reinforcing and create *lock-in.* Much of the existing literature relating to *lock-in* relates to market-based goods, including such famous examples as the QUERTY keyboard and VCR video recorders, while the topic in hand – cooking – frequently involves not only technology shift but also shift from the current non-market situation, in which stoves and/or fuels are freely available, to a market scenario. However some useful lessons can still be drawn from the market-based literature. Discussing *path dependency* in relation to *technological lock-in* it has been stated that despite the fact that the dominant technology is "…*not the best technology, either economically or technically*…" the "…*technology which first makes large advances along its learning curve will emerge dominant*…" (Cowan 1990 page 566). The example used to illustrate this is that of the nuclear reactor sector, which might appear to be far removed and have little in common with domestic cooking in India (Cowan 1990). Nevertheless the same principle of path dependence applies to the cooking sector, albeit arguably involving more numerous and more complex factors in the determination of the *path*.

Network effects are identified as key explanatory variables in some examples of technology lock-in. These effects are said to operate on two levels, *actual* and *virtual* (Barnes et al 2004). Actual network effects exist when the network physically links consumers in some way (eg through a mobile phone network). Virtual network effects, of more pertinence to the cooking sector, exist where there is no physical connection between users, but where the utility of each user on the network increases as more users join. This relates to the distribution and maintenance networks for improved cook-stoves, in a simple example of critical mass, which has not been achieved to date.

Of perhaps more explanatory power for the cooking sector than technological lock-in, is the concept of *behavioural lock-in*, which exists where a new technology or practice is resisted by consumers, even when it is superior to the incumbent technology or practice, as a result of the time, effort or money invested in the former. One study finds that "…*Behavioural lock-in occurs when the behaviour of the agent (consumer or producer) is "stuck" in some sort of inefficiency or sub-optimality due to habit, organizational learning, or culture*…" (Barnes et al 2004, page 2). Differentiating producer and consumer behavioural lock-in, this study proceeds to explain that the reasons for such lock-in include factors such as "…*institutional pressure, the reluctance to give up power and control, and status quo 'inertia'*…" (Barnes et al 2004, page 3). While chapter 6 deals with the producer side, the issues of power and control, what might be termed *agency* also relate to the consumers, for example the confidence in women of their ability to cook with new stoves/fuels.

Although varying in extent, the findings of the focus groups clearly identified that the users/consumers (in this case women cooks) have some agency in decision-making about the purchase of cook-stoves at the level of individual households. However, more broadly, on hearing of the modern improved cook-stoves available, the reaction of many focus group respondents was suspicion. This resulted in two types of follow-up reaction. On the one hand were those suspicious respondents who wished to learn more about this new and foreign technology, while on the other were those who seemed to retract previously expressed problems about their traditional chullahs. This reaction might be explained as an attempt to maintain power and control (agency) over their cooking situation. On a very practical level there may be the fear that control of the actual cooking process, the high degree of skill that women currently possess in using their traditional cook-stoves, will be lost. It is certainly true that the deeply rooted skill in using traditional cook-stoves, handed down over many generations, has not received an appropriate level of consideration in debates on improved cook-stoves.

Although speculative, one issue raised in discussion about the adoption of improved stoves in rural India by two experts on Indian culture provides an interesting perspective concerning lock-in (Ashima Chopra, pers comm. 2010 and Kiran Kumar pers comm. 2010). There is apparently a long-standing resistance to and suspicion in Indian society of ideas that are introduced from the *outside*. Approaches to overcoming this problem in the cooking arena have involved some agencies focussing on promoting the local manufacture of stoves (GIZ 2011). However it is becoming apparent that "…*in order to make significant gains in terms of health benefits, it is critical to reduce the emissions from these devices as low as possible since there seems to be no 'safe' level of exposure and that the drop off in health impacts is significant even down to low levels of exposure*…" (Venkataraman et al 2010). This implies that high quality, sophisticated design and manufacturing of improved stoves is required, and that previous approaches, based on local manufacture of stoves, will not deliver the health outcomes required. However, mass-scale manufacturing necessarily puts a distance (geographic and cultural) between the user and the stove, which it is hypothesised is one reason for the negative reactions within the focus groups. The ways that manufacturers of some of the new breed of stoves have sought to reduce this distance are discussed further in the following chapter.

One way of conceptualising the impact of the behavioural inertia involves discussion of *pressure* on the socio-technical regime. While the market push from stove manufacturers exerts a pressure, this push is limited especially in terms of geographical coverage. Market pull pressure from consumers on the other hand appears weak. Confirming this, it has been found that there is often limited motivation to adopt devices such as improved cook-stoves, even if they are affordable (Pohekar et al 2005). One approach to stimulating demand involves the use of opinion leaders in communities, an approach that research has demonstrated shows some promise (Miller et al 2010).

The role of habits and behavioural lock-in and the inhibiting effect of these with respect to reducing energy use in Europe is highlighted in research findings (Marechal 2010). It is shown that habits are generally not conscious forms of behaviour, established in situations where the context is stable; in the STS context this might be seen as lack of pressure on the existing ST regime from consumers. The hidden nature of habits (even from those who maintain them) is their most difficult attribute. One approach suggested to deal with habits and related behavioural lock-in is to focus efforts on situations where there is a changed context for the user (Marechal 2010); the case of moving house is cited as an example of a phase when people are more receptive to adopting new ideas. Would this idea translate to the Indian cooking context? Might it be that improved stoves could be integrated as part of marriage arrangements, when women frequently move home to live with the bride-groom's parents? Perhaps the Government of India would consider giving all new brides a modern improved cook-stove!

5.5 Conclusions and policy implications

Following one of the conclusions of the previous chapter – that there appears to be behavioural inertia inhibiting the switch to cleaner cooking technologies – this chapter has provided insights into why this might be the case. By undertaking qualitative research to uncover attitudes and revealed behaviours to cooking, in the context of discussions set within real-life practices, this chapter has aided understanding in this area. It appears that while there is much stated demand to switch cooking technologies, this demand is somewhat superficial, and is not expected to result in actual purchase decisions on a mass-scale. This finding complements other research on the apparent low demand for improved cook-stoves (Miller et al 2010).

Overall there are two possible narrative conclusions that might be drawn from the analysis in this chapter regarding the issue of household decision-making with respect to cooking technologies. Firstly one might conclude that the issue of technology adoption with respect to cooking has been over-simplified, by making that assumption that if technology appropriate to cooks' needs is available and affordable, and known to these cooks, then adoption will follow naturally (given a little marketing push). This explanation follows the presumption of *rational choice*. However, while the issues of *appropriateness*, *affordability*, *availability* and *knowledge* are certainly necessary, the findings of these focus groups strongly imply that they are not sufficient for a mass-scale transition.

The second, and more persuasive, narrative conclusion is that in addition to these factors, and underlying them, is a more subtle and over-arching issue, involving a deep-rooted resistance in women to changing the way they cook. This may at least partly be due to the risk (perceived or actual) for the poor of experimenting with new technologies, as pointed at by other studies (Yesuf et al 2009). For the poor a new cook-stove represents a relatively high capital outlay, and is - in the main - a technology about which little is known. Questions women asked during focus groups included: Will the technology be durable? Will it be able to cook food as well as before, and will it be possible to use the same fuels as currently used? Will the stove cook quickly and improve cleanliness? Will it reduce fuel use as much as claimed? In general the option of using a stove for a trial period before purchase is not available, so it is not possible for women to assess these risks and uncertainties; *trialability*, said to be an important element in the adoption of innovations, is not available (Rogers 2001b). Useful experimental research could be undertaken to confirm the hypothesis proposed, that lack of trialability is an inhibiting factor in the uptake of improved cook-stoves. One cook-stove programme model, employed by the author in 1998 in Nepal, involved providing a free improved stove to one woman in each village through community or Self Help Groups, to encourage confidence amongst the community; the approach worked, sparking demand throughout the village. The utility of this approach was confirmed by SKG Sangha – an NGO distributing biogas systems in Karnataka: "…*non-tangible awareness-raising is not as fruitful as our approach, which is to catalyse demand by undertaking one or two installations in each area. This is one of the first things we do in a new area*..." (Kiran Kumar, SKG Sangha, pers comm 3/4/10).

As well as the risk of experimentation, the focus groups highlighted, or at least hinted at, deeply rooted cultural traditions and skills associated with cooking, which many are understandably resistant to changing. However such cultural traditions and norms are generally hidden from view, except for those researchers deeply embedded in the culture. For this reason further work by anthropologists in the cooking realm is recommended.

There appears to be a general cultural issue associated with cooking - that is widespread in India in other sectors, especially amongst the poor and uneducated – that when asked if they would like to adopt a new idea or technology, many people will immediately respond in the negative.

Research on the influence of *opinion leaders* in decision making regarding improved stoves in Bangladesh implies that it is only important at the nascent stages of technology adoption in a community (Miller et al 2010). Involving opinion leaders may play a role in enhancing adoption of improved cooking technology but is unlikely to overcome all of the barriers that might be termed *cultural* or *behavioural lock-in.* Another approach to overcoming behavioural lock-in, described in the literature, is to choose periods of change in people's lives to encourage adoption, such as moving house (Marechal 2010).

A conclusion from one of the only anthropological studies into cooking in developing countries is that there is a need to take better account of the innate wisdom and experience of cooks themselves when implementing cook-stove programmes, both in terms of stove design and programme implementation structures (Crewe 1997). There is a need for a paradigm shift in programme design and execution from top-down (development of stoves remote from users) to putting the cooks at the centre of stove programmes, taking a practice perspective which regards the innate wisdom and practices of cooks not as complicated barriers to be overcome or ignored, but rather as realities to be understood and taken as starting points. The design and analysis of the research for this chapter has taken such a practice perspective, seeing cooks as individuals not separated from their everyday contexts, which they in turn have a role in shaping, that is have *agency* over (Giddens 1984); it has thus complemented the market research data in the previous chapter. Such an approach helps to address the apparent excessive focus on technologically deterministic approaches, apparent in the past (for example within the NPIC), and emphasises the importance of placing the discussion of cook-stoves within the context of the ways of living within which it is undertaken; without this the *co-evolution* of cooking socio-technical regimes will not become a reality (Shove et al 2007). In order to achieve co-evolution of the cooking regime, the voice (agency) of cooks will need to be given an opportunity to be heard much more clearly.

In reality a balance needs to be struck between optimising user involvement and bringing the maximum benefits of scientific rigour and high quality manufacturing of stoves. The goal for work on a transition to clean cooking is to understand and fully utilise the expertise of all experts, in this case that of the cook and the stove technician. The trick will be to get these in the right proportions. This will certainly entail tilting the balance towards the cooks, while not ignoring what science has to offer. While some cooking programmes include the use of anthropologists, there is a surprising lack of literature on the anthropology of cooking. This would appear to be a rich seam waiting to be tapped.

The focus groups confirmed the findings of the previous chapter, that a wide variety of fuels and stoves are used, often in combination depending on availability, cost and food being cooked. Sophisticated strategies regarding stove and fuel use were highlighted. Flexibility was found to be important, to enable adaptation to changing circumstances. Thus, for developers of improved biomass cook-stoves, it will be important to gain more clarity about the ability of their products to use fuels currently employed (eg wood, coal, dung, agricultural residues). More generally there is a need for greater clarity about which combinations of stoves/fuels will co-achieve the goals of women (clean, fast, successful and affordable cooking), public health goals (reduced smoke) and achieve other goals such as GHG emissions, reducing deforestation and energy security.

The research in this chapter confirmed that cost is a key factor concerning decisions about cooking technologies; clearly this is more important for poorer households. In the majority of cases, poor households reported being unable (or unwilling) to pay for new cooking technologies and unwilling to take on loans, perceived to be a threat to their livelihoods. There were suggestions that in some cases lack of affordability may be a subjective judgement rather than an objective reality, indicating that if purchase of an improved stove were a high priority then it would be afforded. There was also a suggestion that women have more agency in decision-making regarding purchase of improved stoves than supposed in much of the literature.

Proposed market-driven approaches to cook-stove dissemination will not address the main part of the population subject to health-damaging pollutants, those in the poorer households, the majority of whom are in rural areas. When considering a mass-scale transition to clean cooking, two *transition paths* might be conceived: firstly one which is totally market-driven, with no support for the poor. In this transition path, adoption would principally be by wealthier households at least initially, presumably with the hope that technology prices would thence reduce, allowing for mass adoption by the poor. It is considered that such a pathway would take many years/decades to achieve the desired targets, and would not achieve – for example – the target of the Global Alliance for Clean Cookstoves (GACC) of 100 million households using clean cook-stoves and fuels by 2020 (GACC 2011), or the target scenario assumed in this research, adoption of over 140 million ABSs by 2030.

The other possible pathway involves a differentiated approach, involving the market-driven method for those who can afford cook-stoves or other clean cooking technologies, and a supported (subsidy) approach for those who cannot. Carbon finance holds some promise in this regard.

In addressing the issue of behaviour, public and private policy could do well to learn from the successes (and failures) in other sectors, such as the way participation and education was used to overcome inertia in the sanitation sector. A general conclusion from this research is that the priorities of users (cooks) are not necessarily aligned with those of researchers, policy makers and practitioners. While users focus on issues of time, convenience and cleanliness, with expressions of concern about health being relatively weak, researchers, policy makers and practitioners focus their efforts on reducing indoor air pollution to improve public health. Successful cooking - of course - is an over-arching priority of users, and women know that this can be achieved using their existing stoves. Although in practice the interests of users and policy makers/practitioners are generally aligned – most modern ABSs reduce indoor air pollution, as well as speeding up the cooking process – the mis-alignment of normative goals is something identified here for the first time. Strategies to address this mis-alignment could be to ensure that priorities of policy makers practitioners and researchers coincide with those of cooks, and/or to increase health education amongst users to raise awareness of the dangers of indoor air pollution for health.

In conclusion a transition to clean cooking, as it relates to real-life practice at the household level, provides an especially interesting and challenging problem, involving as it does deeply embedded cultural practices and norms, and high degrees of skill and comfort associated with the use of traditional stoves. Working with these in cook-stove programmes requires a step-change in the degree of participation and ownership by cooks, within all parts of the emerging socio-technical regime, not just the last mile in the distribution chain but also in the design of the technology itself. The extent to which cooks have been placed centre-stage by some of the larger, private-sector, stove developers is discussed in the following chapter.

"What if we mobilize the resources, scale and scope of large firms to co-create solutions to the problems at the bottom of the pyramid (BOP), these 4 to 5 billion people who live on less than a $2 a day?" Quote by C.K Prahalad from his book The Fortune at The Bottom of the Pyramid

6 Involvement of large private sector entities in domestic cooking markets in India

6.1 Introduction

This chapter addresses the emergence of corporate entities in the domestic cook-stove sector in India in recent years. Engagement of these corporate entities marks the second stage in the history of cook-stove activities in India over the past decades (see section 1.2.1), the first being the government programme (NPIC) reviewed in Chapter 3, and the third being the nascent National Biomass Cookstove Initiative. One broad conclusion of Chapter 3 was that under the NPIC the government had difficulties forming effective links with non-state actors, which prevented lasting impact of this government-driven, top-down programme. The corporate activities reviewed in this chapter mark a different approach, whereby private sector activities have been undertaken with little public sector engagement or support.

It is now accepted by many practitioners that private sector organisations have a key role to play in the push to increasing access to energy services in developing countries, including the provision of clean cooking solutions. Recently a high level group on energy under the leadership of the UN Secretary General noted that "...*Private sector leadership is also fundamental... given the role of businesses as solution providers, and primary drivers of investment*..." (Yumkella et al 2012, p7). A focus on the private sector role in efforts to increase access to energy services in developing countries is part of a more general trend in development thinking towards commercialised and neo-liberal approaches, often considered as part of the *Washington Consensus* (Bayer 2009). Concerning cook-stoves, this is set within the context that neither public sector driven activities or those lead by philanthropic NGOs, have succeeded in reaching mass-scale in most cases (China excepted) in the past (Shrimali et al 2011).

One explanation of the evolution of the role of the private sector, offered by a senior manager in one of the corporations studied in this chapter, is that the private sector offers the potential to reach mass-scale, using market-oriented approaches, when compared with the limited results achieved through public sector, subsidy-based approaches (Hoffman 2006).

The activities of private sector actors have been noted in the context of environmental governance: "…*New actors-including consumers,* ***corporations****, and nongovernmental organizations-are expanding the focus on institutions of government (such as parliaments, bureaucracies, and law) to broader conceptions of environmental governance, where diverse groups in society wield power and authority*..." (author's emphasis) (Liverman 2004, page 735). The literature on the rise of business oriented approaches under neo-liberalism is helpful in asking critical questions about the lasting impact of this trend. Is it the case that neo-liberal approaches, left to their own devices, will result in inequity in the distribution of development benefits and hence uneven development (Harvey 2006)? Does corporate engagement lead to a weakening of the state (Liverman 2004)? Is the case that the activity observed is simply an attempt to increase legitimacy on the part of the organisations concerned, or part of attempts to seek out new markets?

The strategies of corporate organisations with regard to their involvement in the cooking space is still evolving and has not yet reached the level of mass scale-up; their engagement can thus be classified as currently residing in socio-technical *niches* as a set of *niche transition experiments*, which have not yet reached the mainstream socio-technical *regime*. Governance structures and processes are seen as an integral part of socio-technical systems within this thesis, which exert landscape pressures, and shape and steer both niches and regimes. Governance can be used to assess the power relationships between actors and institutions. Accounts of corporate social responsibility (CSR) have argued that the vastly superior power of corporations (material, discursive and institutional) over the communities in which they operate often results in inequitable development outcomes (Garvey et al 2005). The degree of community engagement, and the extent to which communities are able to hold corporations to account, are key factors in determining success (Newell 2005). Is it the case that the corporations studied have been subject to appropriate levels of scrutiny and pressure, by both public and civil society bodies, to steer their activities towards equitable development and poverty alleviation (Graham et al 2006)? This chapter seeks to use empirical data from the four key corporations engaged with cooking in India, to address these issues.

Within the cooking and development community, the debate about the role of the private sector in achieving a transition to clean cooking is ongoing, especially with regard to its role in reaching poor households, and some are critical of the extent of public sector withdrawal (Bailis et al 2009). The last decade has seen a unique development in the domestic cooking sphere in developing countries, namely the emerging involvement of large multi-national private sector corporations, including Shell, BP, Philips and Bosch Siemens. Each has worked on the development of different technical approaches, marketing and deployment models. The involvement of these organisations with such financial power, technical and marketing know-how and geographical reach is considered by some to have the potential to be significant in terms of a transition towards clean cooking in developing countries (Shrimali et al 2011, Hoffman 2006). In particular it is largely these organisations that have developed, and are now marketing, the Advanced Biomass Cook-stoves (ABSs) noted in this thesis as the most advanced technical solution for cooking for a large proportion of Indian households. While the emerging involvement of large private sector entities marks a potentially significant development, the activities of these organisations have been little studied in the academic literature on clean cooking[43], and the value of their engagement has remained largely unchallenged.

There are deeply entrenched, and opposing, views with respect to the involvement of large corporations serving markets composed of poor people; these range from CK Prahalad on the one

[43] Around the time of completion of this chapter, one published paper analysed private sector involvement in cooking in India (Shrimali et al 2011). This comes to broadly the same conclusions as this chapter, and has been used to supplement these findings.

hand who stated "...*The world's most exciting, fastest-growing new markets? It's where you least expect it: at the bottom of the pyramid. Collectively, the world's billions of poor people have immense entrepreneurial capabilities and buying power. It's being done – profitably*..." (Prahalad 2004, p29), to Martin Luther King on the other: "...*With righteous indignation... look across the seas and see individual capitalists of the West investing huge sums of money in Asia, Africa and South America, only to take the profits out with no concern for the social betterment of the countries, and say: 'This is not just*.'..." (King 1967, speech, no page numbers).

Certainly, key governance questions arise with respect to the emergence of these corporate entities in markets serving poor people: who has agency (and hence does the governing), how do they govern, and what are the resulting distributional impacts (Newell et al 2009)? Who protects the interests of the poor? These, and other questions, are explored within this chapter. The critique focusses on the degree to which corporations add new resources to the cook-stove sector, and the extent to which their activities contribute to an *equitable* mass scale transition to clean cooking in India. This chapter offers critical insights using the frame of governance to highlight shortcomings and challenge the claims of the corporations. Informed by debates on the impact of CSR on development (Newell 2008, Prieto-Carron et al 2006) this chapter aims to fill gaps in knowledge about the involvement of these influential organisations in the cook-stove sector which remain unanswered, namely:

1. What overall approaches and business models have the corporations adopted and to what extent has their engagement allowed agency to be exercised by community level actors within the cooking system?
2. What have been the material results in terms of technologies developed, markets researched and stoves disseminated? Have the results been equitable in the sense of serving poor households?

3. What particular skills (or lack of) have these organisations brought to the sector and what is the perceived social value of stoves they have developed?
4. Why are these corporations engaging in the cooking/development sector?

6.2 Research methodology

The scope of the chapter focuses exclusively on four large corporations and their partners, since these organisations are the primary manufacturers and distributors of ABSs. It is acknowledged that the cooking sector in India is also composed of a large number of small private sector and civil society actors. The focus on corporations has been selected given their recent emergence in the sector and the fact that they have remained little studied to date; this is not to negate the importance of the multitude of Indian private sector and civil society organisations. Four corporations, active to varying degrees in India, were selected for analysis: BP/First Energy, Shell Foundation (a charitable organisation) supporting Envirofit, Philips and Bosch Siemens. These were selected as all are multi-national corporations, implying similar characteristics and hence the possibility of comparison of findings; they are the only multi-nationals engaged with cook-stoves in India.

A mixture of methodologies was employed for data collection. An internet questionnaire was distributed to a small number of *key* informants in mid-2011, and followed up with several telephone interviews (Table 34); the questioning route for both the internet survey and telephone interviews was the same and is shown in Annex 5. Jointly the internet questionnaire and telephone interviews are here termed the *survey.* This primary data collection was delayed until near the end of the research given the rapidly changing situation. In addition field notes from during the period of the author's consultancy work with BP informed the analysis. Finally grey literature and publicity material was used to outline the activities of the corporations.

Table 34: Data sources

BP / First Energy	Personal observation, 2008 Various publicity material and BP reports Survey response, 21st July, 2011 - Mahesh Yagnaraman CEO First Energy
Philips	Publicity material No response to either internet survey or e-mail requests for telephone interview
Shell Foundation	Publicity material Telephone interview, 8th September, 2011 - Pradeep Pursnani, Business Director, Breathing Space programme, Shell Foundation.
Bosch and Siemens	Publicity material Survey response 17th July 2011 and telephone interview 28th July, 2011 - Sam Shiroff, Director in the Growth Markets Department, at B/S/H Bosch and Siemens Home Appliances Group

While the overall approach follows a presentation of four case studies of large private sector corporations, a much greater emphasis is placed on BP/First Energy for three reasons. Firstly the author had special access to the activities of this organisation during the research, as a consultant employed by them. Secondly, although useful material was collected, the process of gathering primary data through the internet survey and telephone interviews did not prove as valuable as anticipated for the four corporations. For one of the corporations the data gathered did not extend significantly beyond material in the public domain; one other organisation, Philips, did not respond despite repeated requests. This relative paucity of primary data collected is probably explained by the commercial environment in which the organisations are operating and hence the tendency towards secrecy in order to maintain competitive advantage. Thirdly, BP/First Energy has had the greatest impact in terms of stoves distributed, as outlined below.

Insights gained from *inside* the BP organisation provided a valuable opportunity for novel analysis. In reality the position of the author was between "emic" (ie inside) and “etic” (see chapter 4 for explanations) since a true *etic* perspective would have required a long period embedded within the corporate culture, which was not the case; despite the fact that the author worked as part of the team within BP, he was employed as an external consultant, and undertook the majority of his work away from BP premises.

There are several reasons for caution to be applied with regard to the application of these data sources to this research. Firstly there is the obvious fact that material presented publicly by the corporations may be biased and over-state the positive aspects of their involvement, or omit shortcomings, for commercial and public relations purposes. Secondly, it might be considered that there is potential for observer bias on the part of the author, who worked for BP as a consultant. Nevertheless all efforts have been made to maintain a neutral stance, and these potential influences are not considered to influence the findings.

6.3 Overview of Activities and material contribution to date

This section describes the history and main elements of involvement of the four corporate entities, summarised in Table 35.

Table 35: Summary of activity of the four corporate entities

	Stoves distributed to date	Target for future stove distribution
BP/First Energy	450,000 [1]	Current aim 1 million customers in 3 to 5 years [2] Original BP aspirational target - 20 million households across rural India by 2020 [4]
Envirofit/Shell Foundation	120,000 [1] 350,000 sold globally [5]	No target for India but an overall objective of 10 million stoves sold in five countries in the five years (from 2008) [6]
Philips	Few	Unknown
Bosch Siemens	1,200 globally. 130 in India [7]	40,000 units by 2014 [7]. Assessed market potential for Protos in India at over 1 million households [8].

Sources: 1) figure as of June 2010, deduced from (Shrimali et al 2011); 2) Online Survey, July 2011; 3) Phone interview, July 2011; 4) Lord Browne speech quoted in (Hindu Business Line 2005); 5) As of July 2012, according to (Envirofit 2012); 6) according to (Envirofit 2012); 7) (Shiroff 2011a). 8) (BSH 2010).

6.3.1 BP/First Energy

BP had a business selling an advanced biomass cook-stove model, the 'Oorja' (Figure 14 and Figure 58), and an associated biomass pellet product fuel (using agricultural waste) until 2008; the company started operation as a partnership between the Emerging Consumer Market group at BP and the Indian Institute of Science which was active in stove design (Bairiganjan et al 2010). In 2009 the business was transferred to First Energy Private Ltd.

BP became interested in cooking and development around 2002/3, coinciding with the development of Lord Browne's (chief executive of BP at the time) vision of the company as being *Beyond Petroleum.* This followed BP's front-runner stance on climate change and ethical business, with the company being amongst the first international oil companies to acknowledge the problem of climate change and announcing steps to tackle it; in BP's case this was in the form of company carbon targets and later efforts at trading emissions. Initially the cooking programme clearly enjoyed high level support within the corporation; in 2005 Lord Browne commented that "...*We are starting to develop this business but our aspiration is to make it quite substantial so that it could reach perhaps*

20 million households across rural India by 2020..." (Hindu Business Line 2005). To date the Oorja has sold more than any other of the advanced biomass cook-stoves, with around 450,000 distributed as of June 2010 (figure deduced from Shrimali et al (2011)). Throughout, BP, and subsequently First Energy, have clearly prided themselves in taking a commercial approach, with the current CEO of First Energy noting that *"...the main differentiator is private players who focus on [commercial] sustainability, versus the not for profit sector who may be focused on dissemination through government programs/aid foundation support etc*..." (Yagnaraman 2011).

The stoves business operated within the Emerging Consumer Markets Department of BP Alternative Energy. The team directly involved in cooking included around 10 people in London and 35 people in Bangalore. In addition the business drew on the full range of expertise within the larger BP group, including business strategy, contracts, financial control, and specific technical and marketing expertise. Working from inside, the author's impression was of a team - up to at least the level of head of the Emerging Consumer Markets division - with a high level of personal commitment to the concept of providing improved cooking solutions to poor people in India. This manifested as a highly motivated hard-working team, willing to make the effort to promote the business internally within the company hierarchy, latterly sometimes running counter to the corporate culture which focussed on fossil fuel extraction and processing. A higher level of strategic business development skills were apparent within the cooking team than is observed in most NGOs and international donors.

In addition it was observed by the author that the BP name made possible a level of engagement, a *door opening* quality, through institutional power (Newell et al 2009), that would not have been possible for smaller companies and NGOs. For example, contacts with Indian Government at senior level were frequent; also within the UNFCCC, easy access to officials responsible for the development of CDM methodologies was afforded.

Lord John Browne resigned as CEO of BP on 1st May 2007, and in 2008, under the new CEO, Tony Hayward - with a background in BP's traditional business - a general restructuring of BP occurred as a result of the global economic slowdown, focusing back on mainstream activities (oil). Tony Hayward is reported to have commented that when he took over in 2007, the company had "...*too many people that were working to save the world*..." (Crooks et al 2009). As one (small) element of the restructuring, BP decided to exit from the stoves market in India. A new company was formed, First Energy, to take over the cook-stove business in February 2009, including some managers from the BP business in partnership with a consulting firm in Pune, India, Alchemists Ark (Kumar Sharma 2011). The commercial terms of the transfer of the business from BP to First Energy are not in the public domain.

Several reasons might explain BP’s exit from this business. Firstly, the poor performance of BP’s shares at the time, compared with other oil majors, resulted in pressure from shareholders to focus on profitability, which was generally taken to mean following traditional business lines (ie fossil fuel exploration and production). This may have resulted in a less strategic (and patient) approach to the allocation of company resources, than was apparent at the start of the Emerging Consumer Markets business. Finally, it may simply be that BP recognised the difficulty of working on household product distribution lines in India and took the view that there was little likelihood of profit in the medium term.

Since taking over, First Energy has developed a commercial Oorja stove model for restaurants; the reason for this development is thought to be problems with cash-flow concerned with operating purely at domestic level. This finding is supported by recent analysis indicating that financial sustainability is ‘unlikely’ while focusing on the domestic market only, while it is ‘likely’ with a combined commercial/domestic approach (Shrimali et al 2011). The Indian Government has recently nominated First Energy’s Oorja stove as one of only four domestic stoves to pass government testing procedures (MNRE 2011b); hence it might be anticipated that First Energy’s fortunes in the domestic market will improve when government subsidies for approved stoves start to flow.

As well as developing a novel technical solution, BP developed a considerable distribution network, involving local NGOs and women entrepreneurs (termed *village level entrepreneurs, VLE's*), operating within a *Jyoti* (meaning *light* or *flame*) network. At its peak, over 2,000 VLE retail outlets stocked Oorja stoves and fuels, although that has reduced to around 1,000 following rationalisation of the business under First Energy (Yagnaraman 2011). These women entrepreneurs profit financially from sales of stoves and fuel and play a key role in demonstrating the stove within their villages and then promoting sales (personal observation, Karnataka, 2008).

6.3.2 Other corporate engagement

Shell Foundation, a UK-registered charitable organisation, has been supporting efforts to promote cook-stoves for almost a decade. In addition to supporting activities in various countries, their engagement has expanded to the global level in recent years with Shell Foundation playing a central role in the development of the Global Alliance for Clean Cookstoves. In India their work has focussed on support for **Envirofit** (see Figure 58), which is based in Colorado, USA, with its main market to date in India represented by an office in Bangalore; operations are also currently expanding in Africa. Envirofit is a U.S. tax-exempt corporation, and follows an "...*enterprise-based model ... relying on market mechanisms to guide product development and drive consumer demand*...". It is described as "...*an NGO able to function like a business*..." (Envirofit 2012).

Shell Foundation operates on the interest from a charity endowment of US$400 million from Shell (Pursnani 2011). The foundation has provided considerable financial support to Envirofit; in 2011 it was reported that the foundation had provided US$3.5 million to Envirofit, with the aim of leveraging US$25 million in total (The World Bank 2011). Another source reported that Shell Foundation had provided US$14 million to Envirofit, Including all costs for basic R&D, as of September 2011 (Pursnani 2011).

The general approach for Shell Foundation support to Envirofit is couched in terms of *angel philanthropy* (Pursnani 2011). Shell Foundation reports that Shell does not seek a financial return from its charitable activities (Pursnani 2011). The foundation operates through a board of six trustees, three of whom are senior Shell executives; all trustees are European except for one Ugandan private sector individual. The ethos of the Shell Foundation is based on a belief that entrepreneurship is central to reducing poverty and that to put this into practice it is necessary to "...*take an enterprise-based approach...to create financially viable solutions*..." (Shell Foundation 2012).

In addition to money, Shell Foundation provides managerial support to Envirofit, with the aim of building the organisation to achieve financial independence. For example Shell India has helped Envirofit by providing guidance on "...*recruitment, stakeholder engagement, HSSE (health, safety, security and environment) guidelines, local business practices and the manufacturing and distribution landscape*..." (Shell Foundation 2012). Shell Foundation is seeking to scale back its support to Envirofit in India as soon as it becomes financially self-sustaining through increased sales; this is expected around late 2013 (Pursnani 2011).

Bosch and Siemens Home Appliances Group (referred to throughout as B/S/H) has been working on a novel cook-stove for the poor, the Protos, based on plant oil use, since 2003 (Figure 62). B/S/H provided resources for technical development, market research and field testing of Protos, as well as a manufacturing plant. The main site for activities was Indonesia, due to the availability of plant oil, while there were also market testing activities in Ethiopia, Tanzania, the Philippines and Costa Rica. In India, pilot projects were carried out in Karnataka. By July 2011, around 1,200 stoves had been distributed world-wide and serial (mass) production had just begun in Indonesia (Shiroff 2011a). At that time the company had set itself the deadline that at least one country business should be breaking even by 2014 in order to allow B/S/H support to continue.

However, in May 2012 B/S/H announced in a press release that it was withdrawing from the Protos project (BSH 2012). Reasons cited focussed on "...*Complex technical and operational factors, coupled with the difficulties in the supply of sustainable cultivated plant oil, have meant that the* *project has not met with the success originally envisaged*...” (BSH 2012). The key difficulty identified was the high price of the stove, which was necessary to cover costs of this sophisticated device, but which deterred customers from purchasing it. In addition it had been found that many cooks did not find the lighting and cleaning procedure for the stove convenient. In announcing its exit, B/S/H recognised that the project had “...*taught B/S/H a great deal about the market and about the consumption habits of customers in emerging and developing countries*...” (BSH 2012). It also confirmed its ongoing support and commitment to the cook-stove sector in general as a member of the Global Alliance for Clean Cookstoves. B/S/H has made its intellectual property resulting from this project publicly available, in the form of detailed technical designs and blue-prints for its Protos stove, which are available on its web site.

Philips has been engaged in biomass stove development and testing for around 10 years (Figure 14 and Figure 61). Despite a number of attempts to contact Philips for this research, no responses were forthcoming; thus the limited findings are derived from the grey literature or from third parties. The engagement of Philips in cooking is reported to be one element of their corporate sustainability drive, alongside activities to investigate business opportunities at the bottom of the pyramid (other sectors investigated include vision glasses and clean water provision) (Mancheron 2011). Despite stove testing of Philips biomass stoves in India in the past, the current status of activities is unclear and appears to be in a state of flux, casting some doubt over the willingness of the company to pursue their biomass cook-stove project.

6.4 Technology development

6.4.1 BP/First Energy

BP market research revealed that consumers required an affordable solution, with reliable availability of fuel, and one that was well adapted to prevalent cooking styles (Brugman et al 2007); safety and cleanliness were also cited as objectives (BP 2008). These findings are in line with those of Chapter 5. Based on this knowledge, BP worked with the respected Indian Institute of Science in

Bangalore to develop appropriate cooking technology solutions. Numerous technology iterations were produced and tested with consumers; such extensive consumer testing, combined with employing the expertise of a respected scientific institute, would be beyond the financial reach of most small private sector organisations and NGOs.

The first product offering involved a stove which would use either LPG or a processed biomass fuel, thus offering the flexibility that was seen to be required, albeit only to relatively well-off households. However this stove model was quickly changed and in 2006 BP started marketing a fan-driven stove, burning only processed biomass pellets made from agricultural waste - the *Oorja* stove. The Oorja stoves are manufactured in India. The reasons for this shift in technology strategy are not documented publicly, although in the author’s opinion this was probably driven by a variety of factors, including possible adverse consumer reaction to the initial product, the complexity and unreliability of the LPG supply chain, the desire to reach consumers not yet able to afford LPG, and the potential to achieve greater profit through sales of pellet fuel, which is distinctly different from existing products on the market.

The Oorja stove (Figure 14 and Figure 58) includes a fan and a combustion chamber, optimally designed for clean burning. From an emissions perspective, the Oorja stove could be expected to perform as well as other forced air stoves (see Figure 16) and achieve very low emissions of carbon monoxide and particulates. Indeed an independent analysis concluded that the “…*Oorja stove... is an example of a very clean-burning pellet stove*...” (US EPA 2012). As noted above the Oorja has recently been approved under the Indian Government’s stove testing regime.

Use of the stove requires purchase of a specified fuel product by customers, who are specifically informed that burning other forms of biomass would result in stove malfunction. Usage of the stove involves batch-loading of pellets into the combustion unit and lighting with kerosene; the batch nature of the stove thus required changed cooking practices by both biomass and LPG users. A later model incorporated a facility to adjust fan speed and thus the speed of cooking, hence providing a cooking experience somewhat akin to LPG.

In 2011 the Oorja domestic stove was reported to cost between IRs. 1,050 and IRs.1,750 (Yagnaraman 2011) while in 2010 a 5kg bag of fuel pellets cost between IRs. 40- 60 (Bairiganjan et al 2010, Kumar Sharma 2011). First Energy advertises the fact that users can "...*Cook a meal for 5, for under IRs.6*..." (First Energy 2012). As of 2010, 32,000 tonnes of pellets had been sold (The World Bank 2011), implying constant use of a large number of stoves.

A high degree of emphasis on users' health and safety on BP's part was noted by the author, reflecting general practice within the organisation. This focus on health and safety was observed by the author to be alien to many of BP's Indian partners and their customers.

6.4.2 Other corporate engagement

Envirofit has developed a portfolio of cook-stoves (Figure 60) including rocket stoves and a new forced-air stove in pre-production as of July 2012. In addition it supplies a number of stove related accessories. Stoves were originally mass-manufactured centrally in China, although production was moved to Maharashtra around 2010 (Bairiganjan et al 2010). In addition it is reported that "...*Envirofit will shift further towards localised assembly and manufacture in India so as to continue efforts to lower end-user costs*...." (Shell Foundation 2011); plans are also being advanced to start manufacturing in Nairobi with a view to serving African markets.

A basic Envirofit model (GS3300) retails in India at around IRs.1,500, and is provided with a 2-year guarantee. Of the various Envirofit products only the forced-air stove (3GT) is anticipated to achieve air pollution improvements to qualify as an ABS. At the time of writing none of the Envirofit stoves were listed as having passed the Government of India testing requirements (MNRE 2011b), although it might be anticipated that the forced-air stove could pass this test once it is in mass production.

The basic Envirofit stove (GS3300) has a cylindrical structure and two layers of fire-kiln brick material, which retain heat well, and fuel inlets that rely on a natural draught to provide good air circulation. The stove operates using wood, the same fuel used with many traditional stoves, although the fuel has to be cut into smaller pieces.

Figure 60: Range of stoves produced by Envirofit including rocket stoves (eg G3300) and fan-driven forced air stove (3GT Turbo – in pre-production)

Source: (Envirofit 2012)

Between 2003 and 2012 B/S/H worked on the development of a plant oil stove, together with universities in Germany and Philippines. A sophisticated design was developed to burn plant oil cleanly. Particular challenges were associated with the high flash point of plant oil, requiring high quality, expensive metals to be employed. Early considerations of providing an adjustable nozzle to allow for heat regulation were abandoned as being too expensive to manufacture, although a simmer plate was provided as a compromise, illustrating B/S/H's appreciation of this need of the cooks (Shiroff 2011b). A one-year guarantee was provided. At the start of the project the cost of the Protos stove was estimated to be US$250 (IRs.14,000), which was reduced through research and manufacturing innovation to US$50 (IRs.2,750). Throughout the project B/S/H focussed on ensuring that plant oil could be sourced sustainably; however the difficulty in achieving this was cited as one of their reasons for ending the project (BSH 2012).

Philips developed several biomass cook-stoves, including an improved natural draught stove, for which the designs were made freely available, and a forced air fan-stove, which is considered an ABS (Figure 61). In so doing it has worked in India in collaboration with local NGOs, entrepreneurs, and communities. It has partnered with ARTI (Appropriate Rural Technology Institute), an Indian NGO developing and promoting innovative technologies for rural people.

In one comprehensive, independent, test of different cook-stoves, it was found that "...*the Philips stove had the best overall performance and the lowest pollutant emissions...*" (Jetter et al 2009, p6). The forced air stove employed a novel thermo-electric device which generated small amounts of electricity from the heat of the stove, in order to charge the fan battery and power a low-energy device such as an LED light. The stove incorporated the possibility of heat control by the cook. Although not in mass-production, the cost of this stove has been estimated to be US$80-100 (IRs.4,400-5,500) (Mancheron 2011). One version of the Philips fan stove has recently been approved as part of the Government of India's stove testing for the new national programme (NBCI) (MNRE 2011b).

6.5 Business motivations and target markets

6.5.1 BP/First Energy

It could be concluded from the material presented by BP, and by a consistent internal focus during internal discussions on rates of return observed by the author, that their cooking business had the main objective of achieving profitability as an end result. However, it was also clear at the early stages that BP was prepared to take a *patient capital* approach, in which slower returns than would normally be required were anticipated. As noted in a magazine targeted at BP staff, the business "...*focussed on giving access to cleaner, safer affordable energy,* ***profitably*** *and sustainably..."* (author's emphasis) (BP 2007a). The head of the India side of the business, Mahesh Yagnaraman is quoted as saying that "...*we are doing this, and can only do this, through a business model that is commercial and sustainable..."* (BP 2007a), further emphasising the need to keep the business firm and lean.

It is argued however that gaining direct financial returns from this business is unlikely to have been the sole motivation driving BP's engagement, perhaps not even the main motivation. Given the relative complexity of the operation when compared with BP's traditional business, combined with the relatively low margins that might be expected, profit seems unlikely to be the core motivating factor for BP in the view of the author; the reality it is suggested is somewhat more complex.

The experience of the author, operating within the business, suggests a high level of personal motivation of the staff immediately involved in the business. In particular, the attraction of BP staff to a business that could help solve social development problems, reduce greenhouse gas emissions and result in an innovative and profitable business (a triple bottom line) was apparent. There was a high level of interest from internal staff within the wider BP group in response to the posting of advertisements for positions within the business. This is perhaps explained by the fact that cooking is a subject to which everyone can relate, and combining this with an operation which directly supports enhanced livelihoods for the poor, resulted in the subject being attractive to many people within BP. This personal motivation at working level, within BP, acted as an internal lobbying force on behalf of the stoves business that appeared stronger than within other BP business units. The fact that BP promoted this business within internal staff magazines for example, suggests that its very existence within the company was expected to provide a motivational effect on staff within the wider BP group (BP 2008).

The second factor motivating BP's involvement is likely to have been the external reputational capital that would result. BP went to considerable lengths to spread the message, including articles in BP general publicity brochures, in local Indian newspapers (Gopal Raj 2007) as well as in the international grey literature (Brugman et al 2007, Cohen 2008, Gopalan 2007). The effort to which BP went to promote its activities indicates that they expected a high degree of reputational benefit, as part of BP's drive to emphasise its *corporate social responsibility* (CSR). These promotion efforts in the early days of BP's involvement are in sharp contrast to BP's exit from the business which was clearly managed carefully and quietly to limit reputational damage; nothing has been found in the press or grey literature pointing to BP's exit from the cooking business or the terms on which the transfer to First Energy was made. This potentially reduces the perceived transparency of the organisation in the eyes of the communities in which it worked, and runs counter to the need for local accountability identified by (Garvey et al 2005).

Thirdly, from the name of the BP group in which the business operated – *Emerging Consumer Market* group - one might surmise that BP's involvement in the cooking sector in India was part of a more strategic business approach. Cooking activities may have been used to gain knowledge and access to the huge numbers of potential consumers in India currently out of company's reach, with a view to developing other profitable business lines. Indeed, referring to the cooking business, a BP magazine aimed at an external audience specifically stated that *"...BP's aim is to use the knowledge gained and lessons learned in India to create a sustainable, material and profitable global ECM (Emerging Consumer Markets) business that offers a range of solutions to meet consumers' various energy needs. By 2020, BP believes it can reach some 20 million under-served households – the equivalent of 100 million people..."* (BP 2007b).

Target markets: The main states in which BP operated were Maharashtra, Tamil Nadu, Karnataka and Madhya Pradesh. First Energy is aiming to further extend its reach within India. It is reported that the business targets households with incomes of US$2-8 per day (IRs. 3,300 – 13,000 per month) (surmised from (Shrimali et al 2011)), while results of the survey undertaken for this research highlighted that the target market "...*is focused on all segments ... Rural households with or without LPG access, lower income to lower middle income being main target segment, also urban/peri urban lower to lower/middle income target*..." (Yagnaraman 2011). Given the cost of the stove of over IRs.1,000, and the need for ongoing payments for fuel, it seems unlikely that the majority of truly poor households will be able or willing to pay for Oorja stoves without some form of subsidy. While capital subsidies appear likely under the new NBCI, it is not anticipated that fuel subsidies for pellets will be provided, despite the fact that they are provided for other cooking fuels such as LPG, which in turn distorts the market, penalising alternatives such as pellets used with the Oorja stove (Yagnaraman 2011).

The main market for Oorja stoves would appear to be for those switching from LPG or kerosene, or currently using monetised biomass. The difficulties of running the business purely based on poor domestic clients has been acknowledged by First Energy in recent years, with their CEO, Mahesh Yagnaraman, recognising that "...*his business cannot rest solely on a customer base of low-income households. So last year, First Energy began to explore the commercial segment with large stoves aimed at restaurants, caterers, community kitchens, among others*..." (Kumar 2011).

6.5.2 Other corporate engagement

The motivation of Shell in supporting Envirofit through the Shell Foundation appears to be purely philanthropic, although clearly such philanthropy is to be seen through a lens of reputational capital (CSR). Shell Foundation's overall strategy is to provide enterprise capital and expertise until the time when the business supported (in this case Envirofit) is self-sustaining. To date Shell Foundation appears to understand that in the case of cooking there is a need for such support to extend over considerable incubation periods; however, it has been made clear that pressure on Envirofit to reach that stage in the next few years is increasing (Pursnani 2011).

Figure 61: Philips forced air stove

Envirofit is reported to be targeting households with an income of more than US$7 per day, which is higher than the starting level for First Energy (US$2-8 per day) (figures surmised from (Shrimali et al 2011)). It is now operating throughout India. However sales in India have been less than expected, which has been put down principally to the fact that many households do not purchase fuel and are thus unwilling to pay the full cost of the stove (Pursnani 2011).

B/S/H undertook their Protos activities with the same overall objective as Shell Foundation, that it is to develop and nurture a business which would later become self-sustaining, taken over by entrepreneurs and continue to grow following B/S/H's exit (Shiroff 2011b). Economically their objective was cost-recovery, with the operation being run on the lines of a *social enterprise* (BSH 2010). In addition to social objectives, B/S/H is transparent in reporting to have been motivated by reputational advantage– seen as a significant benefit - and strategic market development, in particular by targeting households with potential to become customers for other B/S/H products (Shiroff 2011b). The project was seen as an internal learning tool, through which B/S/H could gain experience of production and marketing in developing countries (Shiroff 2011b). Finally B/S/H was motivated by the project, as its social value was perceived as a means of attracting and keeping a talented work-force (Shiroff 2011b).

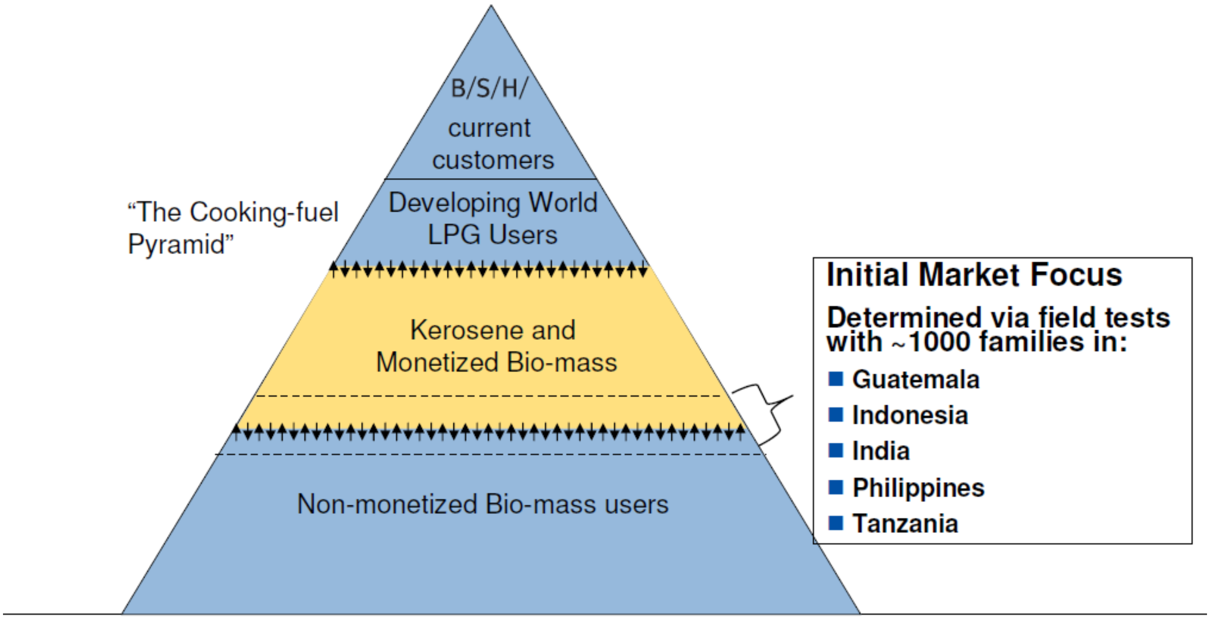
Despite considerable technical difficulties in developing the Protos stove, executive level support for the project was reported to be high as of July 2012 (Shiroff 2011b). B/S/H is not a publicly listed company and therefore does not have to yield to pressure from shareholders. Thus, it is possible that direct communication between an internal Protos *champion* and the board of B/S/H extended the life of the project beyond that which would have been possible within a publicly-listed company.

Figure 62 B/S/H Protos stove

Source: (BSH 2010)

B/S/H undertook considerable market research in the early years of their involvement. This led B/S/H to recognise that their Protos stove is a niche product which does not target the bottom of the pyramid but rather middle income households (Shiroff 2011b), Figure 63. Results from field testing indicated that the majority of Protos adopters were found to switch from using kerosene as their primary fuel (Shiroff 2011b).

Figure 63: Conceptualisation of target market for B/S/H's Protos stove



Source: (BSH 2010)

Philips characterises its development of a natural draught stove (for which designs have been made freely available) as *philanthropy by design* (Philips 2010). Motivations behind the design of the forced air stove appear to be based on an attempt to develop a profit-making business. However it is reported that market trials in India revealed that expressed willingness to pay did not result in the expected number of purchase decisions (Mancheron 2011). Both affordability concerns and lack of Philips distribution channels are thought to be core questions being considered with regards to a future Philips strategy. The Philips forced air stove is unlikely to be suitable for the bottom-of-the-pyramid given its price, and is thus thought to be targeted at aspirational middle/lower middle-income households.

6.6 User engagement and marketing

6.6.1 BP/First Energy

Trials undertaken by BP in India were large scale and termed *commercial pilots*, with a strong focus on meeting the needs of users and hence the potential of future economies of scale to allow profitability. It is interesting to note that in BP's terms a *commercial pilot* was of a scale way beyond that of most completed NGO programmes; when the author was engaged by BP a *pilot* of around 75,000 stoves had been completed.

BP's approach was to consult widely amongst *customers* to "...*develop deep insights*..." of their needs, and hence *co-create* solutions together with the customer (BP 2008). Extensive research was commissioned by BP to understand the markets into which they might enter (TNS Pvt. Ltd 2008), and evaluate the *social value* (positive or negative) of their offering in areas in which they had been operating for some time; for example an extensive survey of users and distributors was undertaken in Karnataka, Maharashtra, Tamil Nadu and Madhya Pradesh (BP commissioned report 2008). Key findings of this survey are presented in section 6.7 below.

BP worked through partnerships with local NGOs (for example Covenant Centre of Development, IDPMS and Swayam Shikshan Prayog) which supported BP's understanding of the market and gave them access to local expertise. It also engaged with local women's self-help groups with the aim of *co-creating cooking* solutions and marketing strategies (Gopalan 2007). Within the partnership, NGOs performed cooking demonstrations, distributed information pamphlets, and occasionally undertook television, radio and newspaper advertising campaigns (Bairiganjan et al 2010). These partnerships not only resulted in an understanding of consumer needs and motivations by BP, but was also seen as strategically important, given the recognised need for ongoing partnerships with local NGOs, to bridge the gap between the corporation and the end-users.

The trust between BP and NGOs was reported to have strengthened when BP made a long term commitment to the cooking business (Brugman et al 2007). Two NGOs working with BP (Swayam Shikshan Prayog (SSP) and Covenant Centre for Development (CCD)) were surveyed and reported the following benefits in their association with BP (BP commissioned report 2008): scale-up and greater community reach for stoves, which also offered a potential route for provision of other services; increased business orientation; enhanced image for the NGO; increased entrepreneurship amongst women involved. However, the same survey also found the NGOs reporting some difficulties with the partnership including: not being able to contribute to overall strategy; problems delineating between the development and business aspects of the operation; achieving community ownership; limited ability to innovate within partnership (BP commissioned report 2008).

The model of large private sector corporations working in partnership with social NGOs to *co-create* new business opportunities has been described as being of potential mutual benefit, bringing reputational benefits and access to new markets for the former, while the latter gains from the business acumen and resources provided by the corporations (Brugman et al 2007). The net result of a successfully co-created business would be products valued by consumers and hence greater delivery of the product (in this case stoves) than would have been possible by each of the partners operating individually. However, while the partnerships are presented as being mutually beneficial, it might be concluded that BP held the majority of the discursive power; the extent to which the engagement with NGOs has enabled a strong voice at the household level, other than via the sanction of the market (ie choosing to buy or not buy the product) is debatable.

6.6.2 Other corporate engagement

Detailed data on means of user engagement was not available from the other corporations studied. However, the survey yielded some findings of interest.

In India, Envirofit undertook considerable engagement with users in developing its stove models (Pursnani 2011). For distribution, it started by establishing its own channels, including some local employees in combination with relationships with existing retailers; increasingly Envirofit is choosing to work through existing partners, given the complexity and expense of developing its own channels (Pursnani 2011).

In 2011, Shell Foundation reported that "…*Envirofit India's business has created over 500 local jobs and supported enterprise development through the growth of its 400-strong network of manufacturing, sales and distribution channel partners*..." (Shell Foundation 2011). However given challenges with 'last mile' distribution, as well as lower than anticipated sales, which were attributed partly to lack of awareness and affordability, Shell Foundation broadened its partnerships in India "...*engaging rural entrepreneur networks such as Dharma, microfinance institutions such as Basix and Grameen Koota (a microfinance organisation) and running awareness campaigns with major NGOs such as Art of Living as well as government health workers..*." (Shell Foundation 2011). Congruent with the findings of Chapters 4 and 5, Envirofit has come to believe that the key *value proposition* for Indian women is not health, but speed of cooking, cost and convenience (Pursnani 2011).

6.7 Perceived social value of an ABS stove model

In 2007, BP commissioned an extensive survey in areas in which it had been operating; the purpose was to increase understanding of the *social* value of the BP business, either positive or negative. This section draws almost entirely on the results of this survey (BP commissioned report 2008), with several additional insights from a field trip by the author to Hubli, Karnataka (5-7 July 2008), an area in which Oorja stoves were being distributed, which allowed for informal interviews with three Oorja users (Mann 2008). The BP commissioned survey included all levels of the supply chain, including cooks (here termed *consumers*), village level entrepreneurs (VLEs) and NGOs associated with the business. A summary of the results relating only to consumers is presented here. The objective of the study was to understand "…*The changes (positive or negative) the product and business model bring to the lives of consumers (individual and the family), as perceived by them…*" (BP commissioned report 2008).

The survey was undertaken, by an independent research company, in the four Indian states in which BP was active, Maharashtra, Tamil Nadu, Karnataka and Madhya Pradesh between December 2007 and January 2008. At that time around 100,000 Oorja stoves had been sold in total between these four states in over 2,000 villages. The survey included a sample of 404 households between the four states, using selection methods to ensure a representative sample; both qualitative and quantitative questioning routes were undertaken. The household selection method was designed to ensure that

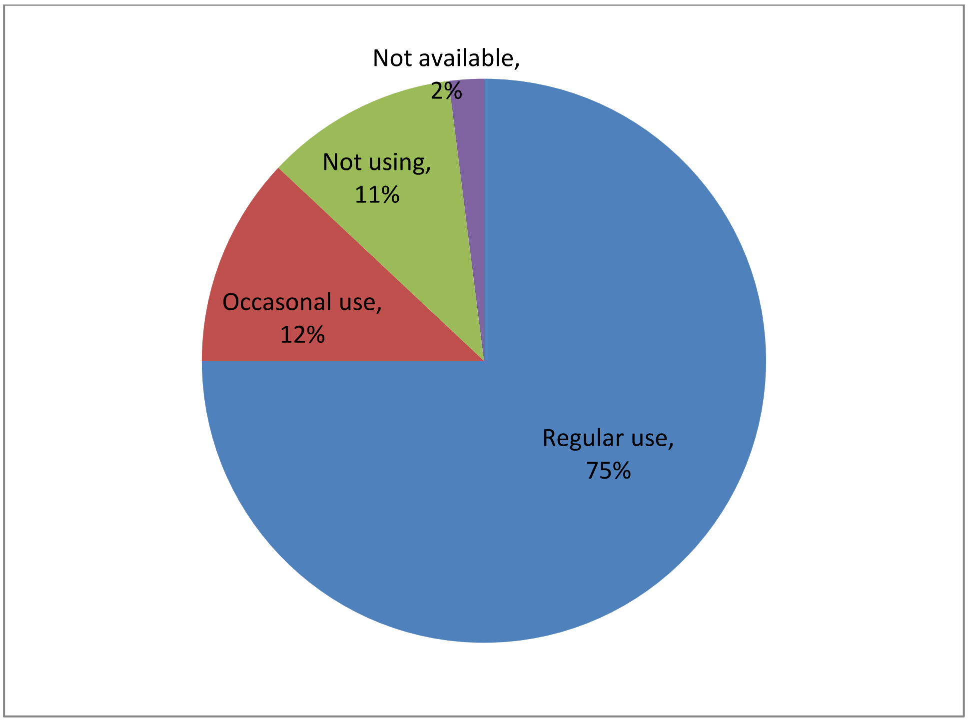
Oorja consumers had bought stoves at least four months prior to the survey. The sample was made up of households in the following areas: 67% rural, 17% peri-urban and 16% urban, and the following household economic categories: 40% low, 20% middle and 40% high [44]. Before adopting Oorja, consumers were found to have been using various fuels, with the majority previously employing either wood, kerosene or LPG; most reported using a combination of these three fuels, while none were reported to switch from dung which is freely available. It can be assumed that the majority of wood users adopting Oorja stoves were buying wood, rather than gathering it freely.

To assess satisfaction with the Oorja stove, the survey asked questions about the level of its use. Figure 64 shows that the majority of those purchasing Oorja stoves used them regularly. However the survey revealed that, even for those that used the Oorja regularly, it was not the only stove used for cooking. Of those having an LPG stove, 65% reported using Oorja as their first choice following its adoption, while the figure for those with kerosene stoves was 91%.

A broad range of fuel/stove strategies were reported in the survey. This was confirmed in an interview with one woman by the author, who was using a combination of Oorja and LPG (the former for heating water, replacing kerosene, the latter for cooking requiring higher degrees of heat control); this woman reported that she would not switch from LPG to Oorja for cooking unless LPG availability became a problem, which might happen if rationing of LPG increased (Mann 2008). Another woman used a combination of Oorja, wood, LPG and kerosene, with the former used for around 40% of cooking tasks (Mann 2008). Thus, while overall satisfaction with the Oorja was relatively high, its adoption did not result in it being used for all cooking purposes, reflecting an extension of the *energy stacking* approach outlined in Chapter 1 (Masera et al 2000).

[44] Note that the definitions used for the economic categories were similar, although not the same, as the SECs used in Chapter 4 (ie based on employment type, housing type etc)

Figure 64: Use of Oorja stoves by those who have purchased one

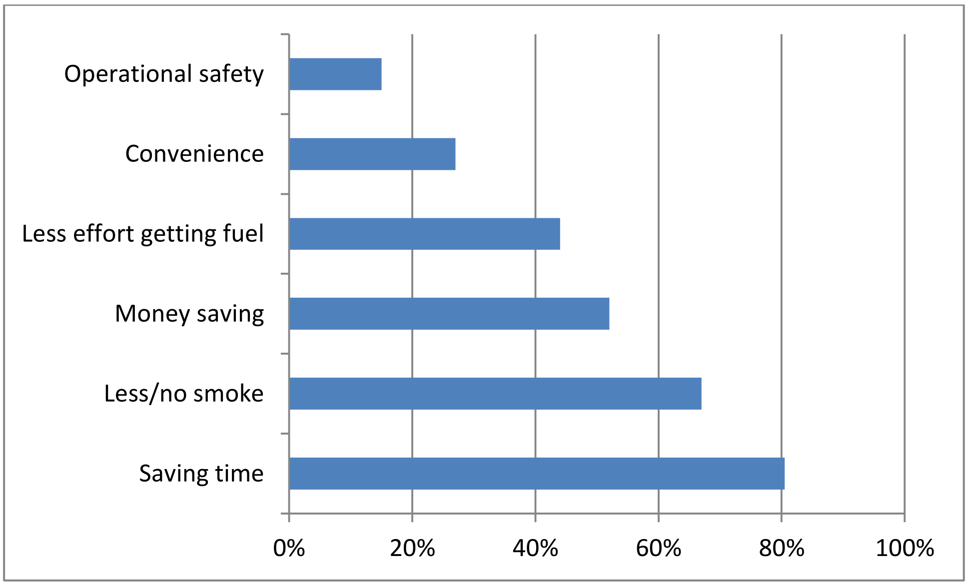


Source: (BP commissioned report 2008)
Note: 'regular use' denotes use of Oorja almost every day, either for cooking, boiling water or both, while 'occasional use' implies use of Oorja during festivals, family functions, etc.

Of those who had purchased the Oorja, but were not using it regularly, 47% reported operational difficulties, including with managing the batch loading of the fuel or lack of suitability of the stove due to large family size. Furthermore 29% reported difficulties with service or lack of pellet availability, while 18% switched back to wood as it was freely available. Of those not using the Oorja, some reported problems with smoke, which were apparently due to re-loading fuel before the fuel batch had fully burned, an approach not recommended by BP. The approach to fuel use of the Oorja, which uses batch loading, rather than continuous fuel loading employed by wood stoves, presents a significant change of practice which some cooks appeared to resist. Others reported lack of heat control of the Oorja stove. However, since the period in which the survey was undertaken, BP recognised this problem and designed an Oorja stove with adjustable flame control.

All Oorja consumers were asked of the overall changes to their lives (positive or negative) following adoption of Oorja stoves. Of the regular and occasional users 93% reported positive changes (ie benefits), while 5% reported both positive and negative changes, and 2% reported no change after adopting the Oorja. A range of specific benefits of adopting the Oorja were reported, as presented in Figure 65.

Figure 65: Proportion of Oorja adopters reporting different benefits



Source: (BP commissioned report 2008)

The finding that the most frequently reported benefit was time saving (80% of respondents) matches the reported desire of cooks expressed in Chapter 5. This benefit was reported to reduce time pressure in the morning, especially for those with school-aged children. In the case of Oorja use for those previously collecting fuel, time saving would have included both time for cooking and for fuel collection. One Oorja user interviewed by the author was using wood prior to switching to her new stove; she found the Oorja convenient, in particular because of the reduced burden of collecting fuel-wood, and the fact that her house was much cleaner due to the reduction of smoke (Mann 2008). The relatively low proportion of users reporting convenience as a benefit may reflect difficulties with operation of a new type of stove, including issues such as batch loading, and lack of heat control when compared with the existing LPG stove. The fact that around 50% of users report money saving as a benefit tends to confirm that a large proportion of Oorja adopters were previously purchasing fuel, including wood. Of those reporting money savings 40% were saving in the range of IRs.101 to IRs.250 per month (BP commissioned report 2008).

Finally, within the survey areas 166 households which had not purchased the Oorja were questioned about their reasons for not buying. Of the sample 87% were aware of the existence of the Oorja stove in their area. The social make-up was similar to that for purchasers of the Oorja (37% 'backward caste', 50% from 'other castes', 12% from 'Scheduled Caste and Tribes'). A higher proportion of non-Oorja users were classified as low income (53%) compared with the Oorja users in the sample (40% low), while a lower proportion were classified as high income (16% of non-Oorja using population compared with 40% of the Oorja population sample). The most frequently reported reasons for not adopting the Oorja were cost (reported by 22%) and free availability of fire wood (22%).

In conclusion, it is clear that BP went to considerable lengths to understand their market, both potential and actual users of Oorja stoves, and the social value of their product. This reflected their understanding that only by creating *social value*, would they meet consumer needs, and thereby continue to sell Oorja stoves and pellets resulting in a profitable business. This mind-set can be contrasted with the approaches of some NGOs chasing government targets and associated subsidies, under the previous government programme (NPIC), reported in Chapter 3. The independent survey commissioned by BP found relatively high level of use and satisfaction with the Oorja, and a range of benefits associated with its use consistent with findings of previous chapters. However, it should be cautioned that the survey was undertaken after a relatively short period following adoption; further surveys, after several years of adoption, would be required to fully analyse long-term satisfaction levels.

6.8 Engagement with carbon markets

Section 1.5 of the thesis highlighted that, given relatively conservative assumptions, improved stoves could generate 0.5 – 1.5 tonnes CO_{2e} per stove per year in carbon offsets, worth around €2.5-€7.5

per stove per year at a value of €5/ tonnes CO_{2e}. Over the life-time of a typical Clean Development Mechanism (CDM) project, 7 years, these offsets would be worth between €17.5 and over €50, highlighting a potentially significant financing resource for the sector. This chapter has demonstrated that developing viable cook-stove businesses, even those focussing on the middle and lower middle income households is challenging. Thus it is not surprising that each of the corporations studied were found to have been investigating the possibility of using carbon markets to provide an extra revenue stream. As shown in Chapters 3, 4 and 5, affordability is one of the issues inhibiting adoption of improved cook-stoves. Carbon offsets offer a potential source of subsidies, both to reduce up-front costs as well as running-costs in the case of those improved cook-stoves requiring the purchase of fuel (eg Oorja).

This section briefly reviews the efforts of each of the four corporations to exploit the value of carbon offsets. While some of the information was gained from the interviews undertaken, commercial confidentiality concerns meant that only limited information was made available; little exists in the public domain.

6.8.1 BP/First Energy

Recognising the difficultly of developing a profitable business at the bottom of the pyramid, in 2007 BP starting exploring the potential to develop a carbon offset funding stream. This interest is simple to understand; assuming the figures quoted above, carbon offset revenues of more than the retail cost of the Oorja stove – between IRs.1,050 (£13 or €15) and IRs.1,750 (£21 or €25) – could technically be generated by one stove, assuming that it continued to operate for seven years (which is not proven). Clearly the actual value of carbon offsets created will depend on which baseline fuel was being used previously, as well as factors such as the degree of non-renewability of biomass, and how long the stove lasts and continues to be used for.

The author was employed as a consultant for one year to undertake a specific market survey (on which the results of Chapter 4 are based) and initiate business links with professional offset organisations that would be able to monetise the carbon value of Oorja sales. The potential revenue from carbon offsets from sales of Oorja stoves was recognised throughout BP Alternative Energy. Options explored included engagement with the voluntary carbon market, the development of a number of small-scale CDM projects and the development of CDM Programmes of Activity (PoAs), which create an umbrella structure under which offset projects can be developed with relatively lower transaction costs. Despite considerable efforts, BP did not manage to monetise carbon offsets from its cooking activities in India. It is considered that the reasons for this failure include inadequate CDM methodologies at the time, high transaction costs and the complexities of developing credible baseline scenarios given widely dispersed and variable populations.

Nevertheless BP exercised some influence over the CDM process as a whole. Recognising difficulties with the CDM methodologies available at the time, BP wrote to the CDM secretariat within the UNFCCC in 2008, requesting consideration of methodology changes; changes requested included clarification of statistical sampling approaches and amendments to baseline emissions calculations. The relevant CDM methodologies were eventually changed in 2009, perhaps partly due to the influence of BP and its considerable convening power.

First Energy continues to explore the possibilities of exploiting carbon offsets with a view to ensuring profitability of the business, in order to help "...*entrepreneurs along the chain and provide some direct subsidies to end consumers...*" (Yagnaraman 2011); it is thought that these attempts have not generated revenue to date.

6.8.2 Other corporate engagement

Envirofit's response to the recognition that lack of affordability is a key barrier to adoption has been to pursue the generation of carbon offsets. The results of early attempts at developing offset activities are not known. While Envirofit has voluntary offset cook-stove projects in India registered with the Gold Standard Foundation, details of the relevant project documents were not available and Gold Standard records show that the projects had not generated validated offsets as of July

2012 (Gold Standard 2012). Records also show that Envirofit is seeking validation of CDM PoAs in West Africa and Honduras, although none are recorded for India (UNEP Risoe 2012).

Reflecting difficulty in implementing carbon offset projects, in particular the need for up-front, patient, capital, a new facility was developed recently by the Shell Foundation. The Shell Foundation Envirofit Carbon Fund was initiated in 2011, with initial capital of US$1 million, and intentions to increase this to US$5 million (Pursnani 2011). In India, the Shell Foundation intends to use carbon finance, generated with support of this fund, to provide "...*tailor-made solutions to stove manufacturers, women's groups and MFIs (micro-finance institutions) to make sale and purchase of stoves affordable*...", with the expectation that the normal retail cost of a stove of IRs.1,500 would be reduced to IRs.1,000 (Mehra 2011).

B/S/H was active in pursuing the potential of carbon offsets as a means of reducing the cost of the Protos stove, to the extent of developing and submitting a CDM methodology for plant oil cookers in 2008 (SSC NM5) (UNEP Risoe 2012). It was estimated that use of the Protos would produce carbon offsets of approximately 0.5 tonnes CO_{2e} per stove per year, with users switching from kerosene (Shiroff 2011b). No offsets were created before B/S/H finished their involvement with the Protos stove.

Philips is also known to have explored the potential for carbon offsets from cook-stoves from at least 2005, when one Philips expert attended a workshop organised by the author (Mann 2005). Given the high cost of the Philips stove, only through significant subsidies from carbon offsets, or another source, would the Philips fan stove be available to a mass market at the bottom of the pyramid. No details were available concerning current efforts by Philips to monetise carbon.

It can be concluded that despite significant potential for generating revenues from carbon offset activities, the corporations encountered practical difficulties in realising these revenue streams. Difficulties encountered, from the author's experience are likely to have included complexities in developing baseline emission scenarios, given the diverse and heterogeneous populations concerned, high transaction costs and latterly low carbon prices. In the particular case of India, there is a specific difficulty in estimating the proportion of non-renewable biomass, given the quality of the data available, and reluctance of public authorities to acknowledge forest degradation. Nevertheless there is evidence that several of the corporations have exercised their discursive power in shaping the CDM, including through the development and adaptation of CDM methodologies. The fact that three of the four corporations were observed by the author to be attendees at a *UNFCCC Practitioners Workshop on improvement of the Usability of CDM Cooking Methodologies* (26th October 2009, Bonn), indicates their interest in engaging with, and presumably influencing the process.

Assuming that the value of carbon offsets from cook-stove activities in India is realised, a key question remains about how that revenue would be employed. Would these corporations use the value of offset to increase coverage of poor households, by providing targeted end-user subsidies, thus realising a more equitable outcome than achieved to date? Or would the new revenue stream be employed to shore up profits? It is concluded that there is value in exploring alternative governance arrangements for cooking carbon offsets in India, with the state taking a significant role to both increase efficiency through aggregation, and to improve equity by developing approaches to target finance towards poorer households. Perhaps reflecting recognition by the Indian Government of its need to engage, it is interesting to note that a CDM PoA entitled “National Programme for Improved Cookstoves in India” is currently under validation (as of September 2012); the lead partner is the Ministry of New and Renewable Energy (MNRE) (pers. Comm. Onkar Nath, GIZ, India, September 2012).

6.9 Governance and equity implications

From a governance perspective, the entry of corporations into the cook-stove sector in India, has changed the previous framework of power relationships, in terms of who governs, how they do it and why (Newell et al 2009). Ultimately these corporations - through their executives, in most cases reporting to shareholders seeking profits - hold the *material* control of production and finance, *institutional* power and much of the control over framing of strategy (*discursive power*) (Newell et al 2011); at the community level, while the corporations have actively engaged, there is seen to have been little opportunity for communities to exercise power and ensure the accountability of the corporations (Graham et al 2006).

The corporations themselves ultimately decided where to work and how, and critically they held the veto of deciding whether to continue funding or to withdraw. While it appears that internal advocacy through *cooking champions* within the corporations, combined with the recognised potential returns through reputational advantage (corporate social responsibility) and strategic issues around access to markets in the longer-term, have enabled significant resources to be expended to cooking, there are signs of this interest reducing, at least for some of the corporate players studied. Some of the corporations appear to have gone to great lengths to exploit the reputational benefits associated with their entry into the cooking market in India, highlighting their interest in gaining legitimacy (Newell 2005). Their exit from the same market has however received much less publicity, and hence accountability to the communities in which they work does not seem to have been achieved (Garvey et al 2005).

Shareholder pressure on corporate boards might be expected to continue the trend away from the cooking sector during an economic slump unless, an alternative form of pressure is exerted, for example through a "...*parallel movement... associated with shareholders and memberships of large institutional investors... requiring that funds focus on low carbon, sustainable, or socially just investments...*" (Liverman 2004, p735).

At the same time, the corporations studied have gone to considerable lengths to engage with cooks to understand what they want, through partnerships with NGOs and women's self-help groups. Such partnerships could be framed as being mutually beneficial, since they provide the companies with understanding of, and access to, the market, and specifically the needs of cooks, while giving some agency to the ground level organisations through a *co-creation* of the business approach (Graham et al 2006).

However while partnerships with civil society were said to be "...*jointly envisaged and structured*..." (Gopalan 2007), in some cases NGOs were frustrated by their lack of agency in the ultimate process of decision and strategy making (BP commissioned report 2008). More generally the huge distance, both in terms of geography and epistemology, and the vast disparity in power between the boards of these corporations and the households being served, raises questions about the extent to which effective and equitable governance of these corporations is possible without the mediating effect of suitably empowered local level institutions. In an attempt to reduce this *distance*, key donors (eg GIZ) have based their programme models largely on local level, artisanal, stove production (Kees 2009). A core question regarding the engagement of corporations in the cooking sector is whether, through their relationships with local actors, their decision-making can remain sufficiently *ground level* and give agency to local actors. A legitimate argument could be made that it would be preferable for the transition to clean cooking to be led by local (Indian) private sector organisations, rather than multi-national corporations. This could help maintain the benefits of the commercial approach, while bringing governance processes closer to the ground, and increasing the possibility that accountability, possibly mediated through local state institutions or civil society, will be achieved.

The activities by the corporations studied have, on the face of it, resulted in inequitable, uneven, outcomes; the poorest households have remained largely unserved. However, it could also be argued that in the absence of these corporate programmes, new technologies would not have been developed, and the low/middle income households who have adopted ABSs, would also have remained unserved.

Governance by the state appears to have been largely absent during the process of corporate engagement. At federal level, this is perhaps explained by the fact that the corporates all entered during the interregnum between the end of the previous government programme (NPIC) in 2002, and the start of the new one (NBCI) which is only now beginning (as of 2012). The main influence of the state is reported by one executive to have been negative, in the form of continuing subsidies for LPG distorting the market to the detriment of ABS alternatives (Kumar Sharma 2011). It could be considered that during this interregnum, these corporate entities have taken over a number of the roles that might be considered natural candidates for state support and governance, such as support for technology R&D, basic market research, public awareness-raising, and enterprise support for the development of nascent companies. It remains to be seen whether the Indian Government will take on these roles in the future, as appears necessary, although there are signs that a number of them will be undertaken as part of the NBCI.

Regulation of the sector by the state could be considered as a means of achieving more effective and equitable outcomes. It has been argued that, given the attractiveness of the energy market in India to investors generally, the Indian government should have considerable leverage in terms of regulating their activities (Newell et al 2011). As part of the new cooking programme the Government of India is applying technical standards for stoves on the market, as a mechanism to determine which stoves receive public subsidies. Such market pressure can be a useful means of regulating the social impacts of corporations, although it is unlikely to be sufficient to achieve the broad-based and equitable results required (Graham et al 2006). In addition measures to enhance transparency, concerning reporting of corporate activities, may increase public scrutiny of the corporations, thereby exploiting their *moral liability* as opposed to legal compliance approaches which will be difficult to apply in practice (Lye 2008). It is hard to envisage regulatory measures being effective in coercing corporations to serve poor households, districts or states.

Below the federal level, the involvement of state bodies is found to have been largely absent also. The corporations have either developed their own channels for communicating at ground level, or have engaged with existing local civil society and private sector actors. Mediating the activities of private sector players through the existing local government machinery (eg panchayat system), sufficiently boosted in its capacity, could be explored as a route to enhancing the agency of local populations and increasing accountability of the corporations (Simon 2010).

6.10 Discussion and conclusions

The prevailing view within development policy circles is that the private sector has an important role to play in providing energy access to poor people, in terms of financial resources, technical and management capability and efficiency of operations. This chapter analyses the activities of four corporations and their associated businesses involved with developing and distributing advanced biomass stoves. These corporations have generally applied what can be called a *social enterprise* model which combines a commercial approach to providing social goods with a relaxed attitude to the period over which financial returns are made (Shrimali et al 2011).

The added value of the private sector is summed up by one of the CEO's responding to the survey on which this research chapter is based: "...*Private sector organizations can bring to bear the ability to create a value chain for the product(s) and an eco-system that eventually reach larger numbers of households, treating them as customers. This is the main benefit a private organization can bring. The private organization can also focus on the household's convenience... We are clear that the households need an energy solution and not a stove. A solution that gives greater choice, convenience and of course better health. The use of this offer needs to make them feel good*..." (Yagnaraman 2011). This quotation recognises a fundamental synergy between the driving force behind private sector involvement, profit, and meeting the social needs of cooks; without achieving the latter, companies will not continue to sell and hence make money, differentiating them from suppliers under the NPIC who were often driven by government installation targets and associated subsidies rather than user needs. A key question remains however about whether multi-national corporate engagement will achieve equitable results by reaching poor households. Furthermore it is not clear whether overall the corporate engagement is preferable to more local, Indian, private sector activity. One benefit of the corporate engagement identified relates to their deep pockets and the extensive investment in technology development that this has allowed. Apart from that specific role, given the tradition of entrepreneurship in India, it is likely that local private sector firms could bring most of the benefits of following a commercial approach, while avoiding some of the pitfalls associated with the engagement of corporations.

The lengths to which the corporations have gone to understand existing cooking practice is impressive; given their lack of existing access to customers, all have needed to do this through either partnering with existing local entities, including strategic partnerships with NGOs (Gopalan 2007) or establishing their own channels. In order to achieve lasting outcomes, the findings suggest that multi-actor, multi-level governance arrangements will be required, involving strong links between state, civil society and private actors.

Products have been developed recognising the needs of cooks (importance of fast, convenient and controllable cooking, as per the findings of Chapter 5); in several cases an ABS was developed to include heat control. One of the corporations, BP, termed the process of developing their stove as *co-creation* with the user. In the process of evaluating use of their Oorja stove, post adoption, it was found that a large proportion of cooks were using the stove, but very few, if any, used the Oorja for all cooking operations, and some only used it occasionally. This finding confirms the need to take a practice perspective, of actual ways of living, in both pre and post adoption monitoring and analyses. In order to achieve the indoor air quality improvements sought, it is necessary for both mass adoption of ABSs and *use* of the stove for the majority of cooking tasks.

It is shown that, given complexities of building new markets associated with poor customers, in the early stages the private sector requires financial support, to nurture its nascent businesses as they develop. In terms of the socio-technical system multi-layer perspective, the activities of corporations thus remain as *niche experiments,* both in terms of the technologies developed and the novel marketing and distribution strategies employed. The logical question is thus: what are the prospects of these niche experiments becoming mainstream and entering the *regime*?

In the two cases presented in this chapter that reached any significant scale, international corporations have been performing the task of nurturing the businesses, providing significant enterprise funding on what is presented as a philanthropic or social enterprise basis. The extent to which such philanthropy will continue remains to be seen, although it is clear from the fact that two of the corporations have exited, that it cannot be relied upon in the long term, highlighting the probable need for input from the public sector, as noted by one executive: "...*However, the private sector organization will gain a lot in collaboration with government agencies who are willing to support catalyst earlier stages where commercial viability is doubtful*..." (Yagnaraman 2011).

An explanation of the motivations of the four corporations as simply being part of globalised capital seeking short-term profits in new markets in developing countries does not appear to tell the whole story. It seems unlikely that these corporations would have anticipated rapid, significant profits in these new and complex markets serving relatively poor people. The reasons for investing large sums of money are thought to be more complex. Some genuine philanthropic motivations were observed at the middle level within the corporations, especially amongst project champions who have become personally engaged with the cooking sector. At the same time, motivations need to be observed through the eyes of those with ultimate control, the boards of these organisations. It is shown that the companies have sought to gain reputational capital and legitimacy through their engagement in cooking in India, promoting their *corporate social responsibility*. This was clearly one of the motivating factors. Furthermore, implied by some and explicitly stated by others, there was the motivation of learning about new markets in developing countries, as a means of facilitating strategic market entry with a range of other products in the future. Such strategic motives are considered to have been a major driver, considering the hundreds of millions of potential new customers present in India. Indeed the "...*the attractiveness of the Indian market and the existence of – and critically a perception of – a positive investment climate*..." (Newell et al 2011, p91) is widely recognised.

The corporations analysed have provided significant resources in analysing markets and the needs of cooks, have invested in research to develop new *niche* products and provided resources to develop novel supply chains. Sales from the two organisations that have reached any sort of scale are over 600,000 in India, indicating that they have developed products which many customers like, or what have been called *value propositions* (Shrimali et al 2011). Nevertheless there has been some softening of support from some of the corporations, and their future engagement is uncertain; two have ended their engagement, and one other, Shell Foundation, is seeking to phase out support for Envirofit soon, based on the assumption that it will become profit-making.

Of the activities studied, none can be considered to be serving customers at the bottom of the pyramid, which is unsurprising given the fact that the products cost over IRs.1,000 (nearly US$20) and in some cases over US$80 (IRs 4,300). To put this in perspective, Chapter 1 showed that of rural biomass using households 67 million were middle income (monthly household income between IRs2,060 and around IRs4,500 – US$39 to US$85), while nearly 50 million were low income (monthly households income less than IRs2,060 - US$39)[45]. This finding might be considered to represent a classic case of *uneven development* whereby the neo-liberal, market-based approaches employed and associated differences in power relationships between the corporations and the users results in inequitable distribution of development benefits (Harvey 2006).

Nevertheless some poor/middle income households within the *regime* are being reached through the efforts of these corporations or the businesses they have nurtured. At the same time, while data on the viability of business models was not gathered, others have concluded that that in India

[45] Assuming 5.03 people per household (Patil 2010).

“*...financial sustainability of improved stove sales to households remains far from assured*...” (Shrimali et al 2011, p7543). The largest company in terms of sales – First Energy – has increasingly focussed on commercial stove sales to restaurants as a means of shoring up cash-flow. All companies have investigated the generation of carbon offsets as a means of generating extra revenue, although it appears difficulties have been encountered and it is not clear that any have yet realised their ambitions. Some of the difficulties corporates have had exploiting the value of carbon offsets, might be overcome through an increasing role of the state, which – suitably arranged – could also improve prospects of using the revenues generated to achieve equitable results; this is further explored in the final chapter.

Thus it can be concluded that the corporations have invested considerable resources, both financial and in terms of time and skills, and achieved some valuable results. Of the activities of these corporations one commentator has noted that “...*although many of these efforts are still in an early stage, the extensive work on stove design, quality control, and product marketing are at the heart of efforts to have successful programs...*” (Barnes et al 2012, p123). However, as things stand, the markets being served are centred around the lower middle, not bottom, of the pyramid which even if saturated would represent only partial, not mass-scale transition. Even focusing on these markets, profitability - and hence the prospects of scaling up to reach more households - appears uncertain. Affordability is a key problem even for those households at the middle/lower of the pyramid. Thus while the *niche experiments* continue, it is too early to tell whether they are likely to spread into the mainstream regime, and even if they do a large proportion of the population in poor households will remain unserved with clean cook-stoves. It is clear that for these niche experiments to form a regime, there will be a need for continuing support for some time to come, including support for research, for developing businesses and, unless huge production cost reductions are achieved through scale, some form of end-user subsidy; without the latter it seems very unlikely that the private sector will be able to serve a large proportion of the (poor) households needing to be tackled in order to achieve mass-scale transition. While corporations have played an important role to date, they have not yet proved that there is a fortune to be made at the bottom of the cooking pyramid.

"Knowledge is a treasure, but practice is the key to it" Arab proverb

7 Conclusions, policy recommendations and future research

7.1 Introduction

This chapter outlines the findings of the main empirical chapters of the research, including descriptions of what was found and conclusions that can be drawn. Following this, reflections are provided on the findings with respect to existing empirical and theoretical literatures. The chapter finishes with policy recommendations and suggestions for future research.

The objective of this research was to provide insights into how to achieve a mass-scale, equitable transition to the use of improved cook-stoves, in order to improve public health. The research is based on the premise that major public health and livelihood benefits can be delivered through a mass-scale transition to improved cook-stoves, and in particular the advanced biomass stoves (ABSs) which have emerged in recent years. ABSs are shown to be the only stoves currently available that are likely to meet low emissions levels for household air pollutants required by the Government of India under its new cooking initiative (NBCI)[46]. A number of questions logically follow from this assumption: is the ABS technology yet at the stage where it achieves the performance required in household use (as opposed to in the laboratory)? Are ABSs reliable in continuous use? These questions, while legitimate, are not the subject of this thesis. While it is certain that further technical advancement will be required in the coming years, it is assumed here that this will be achieved. At the same time, it is acknowledged that although a mass-scale transition to ABS use is the preferred end point for large parts of the Indian population, this may well be achieved by transitioning through intermediate solutions such as rocket stoves. Although technology development does not form part of this research, the general issue of whether new cooking technologies are acceptable or not to cooks within different social and cultural settings is addressed.

[46] Performance in terms of health-damaging, polluting emissions is required to be similar to that achieved by LPG stoves

The topic is shown to be situated at the inter-section between several core policy agendas: development (gender and livelihoods), environment (local: deforestation; regional: brown cloud; and global: greenhouse gases) and governance (public and private). The adoption and use of ABSs can in principle achieve a *win-win* situation (social development and environmental improvement) although a clear focus on the former is strongly suggested, given the difficulties caused by a confusion of normative goals in past programmes and the fact that if more than one policy target were to be sought, policy makers would need to devise more policy instruments (Tinbergen's Rule, see Chapter 1).

The required transition represents a significant undertaking, involving the adoption and use of ABSs in over 140 million households, with a large proportion of this population made up of low and middle income rural households – almost 50 million and 67 million households respectively – together representing around 70% of all Indian households. An equitable and complete transition must include a large number of poor, rural households. Aligning with the UN Secretary General's *Sustainable Energy for All* initiative, it is suggested that the mass-scale transition should be achieved by 2030.

7.2 Findings and Conclusions

This section takes the analysis of the core empirical elements of the research to summarise key findings and draw conclusions, in order to address the overall research aim: "What insights can be drawn from analysis of past cook-stove programmes, the practices of cooks and the recent activities of large corporations in the sector, and how can these insights be used to enhance policies, institutions and governance to improve prospects of a future transition to clean cooking?".

7.2.1 A cautionary note on generalising findings

Empirical inferences from the research are outlined below; these can be used to highlight associations, trends and general tendencies, but need to be distinguished from hard causal effects which are more difficult to uncover in such social science research (King et al 1994). It is recognised that given the size (hundreds of millions of households) and heterogeneity of the Indian cooking population, caution is required in generalising the results of this research, which was based on limited research areas, with their own specific contexts. However, the combination of approaches and perspectives employed for the research, allows for a degree of conceptual triangulation and hence greater generalisation than would have been possible from using only one of these approaches or perspectives. For example the data resulting from the, relatively large, market research sample, was complemented by the more detailed and nuanced data obtained from the focus group research.

Thus it is argued that combining research frames – analysis of past programmes, cooks and multi-national corporations - has justified the drawing out of some systematic conclusions, while recognising that these research frames do not represent a complete coverage of the cooking system as a whole. Such system-wide conclusions are outlined below and used to inform a set of policy recommendations outlined in section 7.4.

7.2.2 Lessons from past government programmes

This section responds to the research question: "*What can be learned regarding transition success or failure from analysis of past public programmes and the comparison between them? How can these insights be employed to improve prospects of achieving a future transition to clean cooking in India?*"

An analysis of the literature on three past government programmes – improved cook-stoves in India (NPIC) and China (CNISP), and sanitation in Bangladesh – yielded some important findings concerning success or otherwise in achieving mass-scale transitions and pointed to some reasons for these; the analysis provided the opportunity for comparison across geographies and sectors. While the comparison provides valuable insights, there are some core differences in political structure and cultural context between China and India that are touched upon but not studied in detail within this research. The Total Sanitation Programme in Bangladesh was introduced as a third comparative programme, given the high degree of success of this programme - 90 million people gained access to (and used) latrines in Bangladesh over a period of 5 years in the 1990s, increasing coverage from 20% to 80% (ESMAP 2010) - with the aim of supporting cross-sectoral learning.

Both China and India had extensive government improved cook-stove programmes, the former distributing 120 million, while around 35 million were distributed in India. The Chinese programme was considerably more successful than the Indian one. In China the programme managed to create niches which appear to have entered the socio-technical regime, with improved cook-stoves being replaced voluntarily by cooks when no longer functioning. In India by contrast the niches created failed to reach the regime and either contracted or disappeared following withdrawal of government support; the number of improved cook-stoves still in use in India is small and it appears that most cooks were not sufficiently motivated to replace them when the stoves provided under the NPIC failed. Analysis of the literature uncovered some of the key reasons for the relative success in China and Bangladesh and failure in India.

A number of the overt reasons for lack of success in India compared with China have been identified in the literature (Pachauri et al 2008, Bailis et al 2011, Barnes et al 2012). These include distribution of poor quality stove technology (especially in India but also initially in China), as well as lack of training and support for maintenance of disseminated stoves. Low levels of monitoring in India failed to identify programme faults and thus inform improved approaches; by contrast the design of the sanitation programme in Bangladesh, and to an extent in China, ensured active monitoring of progress, allowing timely corrections to programme design to be made.

In India there was only weak evidence of competitive innovation amongst stove developers, where programme design tended to encourage chasing of government subsidies through distribution of government approved stoves. By contrast, China developed more dynamic rural energy industries, incentivised to improve upon initial stove designs in response to user needs. Both in India and China there is some evidence that progress was inhibited because of the multiple and shifting programme objectives over time, which included variously forest conservation, social development and public health. In contrast the objective of the Bangladeshi sanitation programme was clear and focussed.

An inadequate level of engagement with cooks was apparent in both China and India, although this was more prevalent in India. In China, programmes were targeted initially at communities known to have some motivation to adopt improved cook-stoves, for example in those areas where fuel was in short supply; this provided enhanced starting conditions for engagement, given the initial motivation of the audiences addressed. In India the lack of targeting and generally poor engagement at community level, resulted in a lack of understanding of user needs and the socio-cultural settings in which they were operating. The Bangladesh sanitation programme provides some valuable lessons in this regard, with active community engagement being central to programme design from the start and achieved through active outreach efforts, by local administrations, to communities and civil society.

Conclusion 1: Achieving transitions through government programmes requires active engagement with users and strong governance links between administrative levels and effective partnerships with non-state actors

One conclusion from the analysis of the three programmes analysed is that to achieve mass-scale transition in socio-technical areas such as cooking and sanitation, active engagement with users is essential, at both the design and implementation stages. This is widely acknowledged in the literature (Bailis et al 2011, Ruiz-Mercado et al 2011, Barnes et al 2012, Lambe et al 2012). However it is found that some of the underlying reasons for the relative failure of the Indian programme to engage successfully with cooks, and to catalyse a sector developing and producing stoves that cooks wanted to buy and use, have been poorly characterised to date.

It is argued that a governance lens helps to explain some of the reasons for failure in India. While both Indian and Chinese programmes can be characterised as centralised, top-down programmes, in China it appears that a greater degree of ownership, and hence motivation, was achieved within local level administrations, private sector suppliers and at community level than in India. This is partly explained by the active selection of motivated local administrations and target audiences by central Chinese authorities. Although not studied within the thesis, it is also likely that specific political structures in China, as well as cultural factors, helped to shape more effective links between programme levels in that country. In addition, the degree of autonomy passed on to local institutions (public, private and civil society) in China and Bangladesh, in turn resulted in increased opportunities for achieving agency and ownership of cooks.

It is concluded that poor functional links between different levels of government in India, and between government, civil society and private sector, failed to create a programme structure which created the appropriate incentivises at each level; specifically the implementation of the programme appears to have resulted in a lack of ownership and agency amongst the cooks, and has led to a legacy of suspicion amongst cooks in India regarding improved cook-stoves. Centrally devised targets for stove distribution were devolved to state level administrations, and subsequently on to lower level officials, NGOs and other nominated bodies. However, the fact that millions of stove were distributed, but that most of these appear to have been not highly prized by their recipients, might be taken to imply that the lower levels within the programme structure were simply reacting to directions from above, without sufficient incentives or motivation to understand and respond to the real needs of cooks. It appears that while responsibility for achieving targets was devolved in India, material and discursive power remained at higher levels, effectively creating systems at lower levels which were motivated to respond to the needs of the higher levels, rather than those of the ultimate recipients, the cooks. In addition overall responsibility for the programme was maintained by a federal department responsible for energy, effectively side-lining other departments with relevant policy interests such as public health and gender equality. Improved cooking is an area requiring effective working across sectors and thus between different line ministries.

While this broad characterisation of the failure of governance in the Indian programme generally holds true, there are exceptions in states which managed more effective links between levels of administrative operation, and between official bodies and civil society (Barnes et al 2012). For example relative success in Haryana state is attributed to active engagement of the programme with women's self-help groups, while in Andhra Pradesh the successful programme was achieved through "…*remarkable interagency coordination*…" (Barnes et al 2012). This is comparable with the sanitation programme in Bangladesh, for which programme structures, and specifically effective links between levels of programme administration and with local civil society, effectively mobilised innovation at community level. It is concluded that when considering design of future cooking programmes in India, an increased focus on multi-level and multi-actor governance processes, and in particular means of incentivising and giving agency to the delivery levels, and a voice to the cooks, will yield significantly improved results.

7.2.3 Users: Cooking practices, attitudes, social and cultural context

This section responds to the research questions posed: "W*hat are current cooking practices and attitudes to these? What are the material impacts of cooking in terms of polluting emissions and greenhouse gases? How are these distributed across socio-economic groups? What socio-cultural and behavioural factors need to be accounted for in achieving an equitable transition to clean cooking?"*

Market research was undertaken in West Bengal focusing mainly on households using traditional stoves. This yielded quantitative data about the cooking practices and their material impacts. While this data is valuable in its own terms, it is highly location specific and not generalisable to India as a whole, especially given the widespread use of coal in the region which is atypical for India. It was found that over 70% of households in the research area were using traditional mud chullahs as their primary stove. Over 60% of these traditional chullah using households were in the lower half of the socio-economic classification system (SEC) employed for the research.

In terms of the material impacts of cooking practices, in the areas covered by the market research, higher levels of emissions of household pollutants and greenhouse gases, both in absolute and per household terms, were found to derive from the households in the lower half of the SEC. The higher absolute emissions are partly a result of the higher numbers of poorer households in the survey area. The higher per household emissions for poorer households is an inversion of the situation in most energy using sectors (eg other domestic energy uses or transport), whereby the wealthy populations tend to have higher per household emissions than poorer ones. Levels of per household polluting emissions (those causing household air pollution) from stoves were between 35% and over 50% higher in the lower SEC households than the higher ones, while nearly 90% of these health damaging pollutants were emitted by these poorer households in total. For greenhouse gases (CO_2, methane and N_20 only) 85% of all emissions from cooking in the research area were found to be from the lower half SEC households; per household levels of these greenhouse gases from cooking were found to range between 1.7 – 2.8 tonnes CO_{2e} per household per year across the whole survey population, highlighting the potential for benefiting from carbon offsets, given that use of improved stoves reduces these emissions. It is important to note however that the carbon offset potential of individual households switching to improved stoves depends on the baseline fuel/stove combination used and – for biomass – the assumptions made about the non-renewability of the fuel. Chapter 1 showed that for a coal using household, annual emissions from cooking are around 2.7 tonnes CO2e, while for a biomass using household they are 0.5 tonnes CO_{2e} /year, 0.9 tonnes CO_{2e} /year and 2 tonnes CO_{2e} /year assuming 10%, 40% and 100% non-renewable biomass fractions respectively; these figures are derived from (Venkataraman et al 2010, Table3, page 67).

While the survey produced these and other quantitative findings, it was enriched and complemented by qualitative data collection, gathered through focus groups. Combined, these two research approaches inform the following conclusions.

Conclusion 2: Cooking practices are highly contextualised, sophisticated, adaptable and culturally embedded

Running counter to an oft implied – if not stated - narrative, the cooking practices of the households researched demonstrated highly skilful, adapted, flexible and sophisticated strategies in response to changing external conditions and social and cultural norms. Most households used multiple fuels and stoves, changing practices hour-to-hour, day-to-day and month-to-month depending on fuel availability and cost, food being cooked, and social factors such as the type of occasion (eg everyday or with guests). The degree of flexibility of strategies was probably greatest for poorer households, many of whom were in rural locations with a high dependency on agriculture. Such households are less likely to rely on fossil fuels (kerosene and LPG); the focus groups revealed a degree of opportunism, with women using whichever fuels happened to be available at the time.

With regard to traditional stoves, women complained about a number of the consequences of using them, complementing the findings of other researchers (Ruiz-Mercado et al 2011, Lambe et al 2012). However it became clear that there was also a high degree of comfort and security (what Giddens calls *ontological security* (Giddens 1991)), as well as skill, through familiarity, associated with their use; this comfort and security is less well documented and represents a gap in current understanding. Traditional stoves, which have been embedded within Indian society for many generations, were said by many to be convenient, in terms of their flexibility (burning different fuels) and controllability. The tacit knowledge and skill associated with traditional stove use is likely to be one of the reasons for inertia to change, reflecting itself as behavioural or cultural lock-in. It also - combined with bad experiences under the previous government programme (NPIC) - probably explains expressed risk aversion and suspicion concerning new stove types. Poor cooks are cautious about change, and are less willing and able to take on the risks associated with change than richer households. Such risk aversion is documented in the context of other poor communities, for example in Ethiopia where it is found that new ideas are frequently rejected due to the inability of poor households to take on the risk of failure (Yesuf et al 2009).

Deeper understanding of the complex strategies employed by cooks helps to improve analysis of past failures. A simplistic conclusion regarding the reasons for the failure of the previous Indian Government cook-stove programme might focus on the non-durable technologies used; while this conclusion holds true, it does not tell the whole story. It seems likely that had the stoves disseminated been considered of great value by the women, they would have been repaired when damaged and replaced when completely broken; they were not. It seems that the technologies used may have been associated with some undesirable characteristics from the users' perspective; while these undesirable characteristics are reported (Simon et al 2012, Masera et al 2000), there is too frequently a focus on the opposite perspective - why cooks do not choose stoves which are technically superior from the perspective of stove designers (Lambe et al 2009). The voice of cooks needs to be listened to more carefully.

Conclusion 3 – Weak bottom-up demand is a core impediment to achieving a transition to clean cooking

The research highlighted a degree of ambiguity with regard to the demand of cooks to switch to improved cook-stoves. While many of those researched highlighted problems with existing, traditional, cooking arrangements, the binary-type market research questions asked yielded little expressed dissatisfaction with current stoves overall. At the same time the demand for improved cook-stoves, although expressed, appeared weak; the market research presented in Chapter 4 highlighted that only 16% anticipated change in the following 12 months, while the focus groups showed that few, if any, respondents were willing to pay anything close to the real cost of improved stoves. While affordability was found to be a real issue for many poor households, it was also apparent that in many of those households that could afford an improved cook-stove, demand was not strong. *Path dependence* has been employed as a means of explaining how historical context shapes (and constrains) future choices (Barnes et al 2004). The implication is that cultural and social norms, structures and institutions making up the socio-technical regime act in ways that perpetuate the existing patterns of activity, creating *lock-in.* In the case of the research areas this was found to have elements of technological, cultural and behavioural lock-in; thus the *adaptive pressure,* said to be essential in order to achieve a transition of socio-technical *regimes*, was not apparent (Smith et al 2005).

Such weak bottom-up demand for the cook-stoves on offer has been highlighted by other researchers (Miller et al 2010). Some of the reasons cited for low demand by other researchers - lack of knowledge, suspicion about new technologies, lack of financial resources - (Barnes et al 2012, IIT Delhi et al 2010, Pohekar et al 2006) chime with the findings of this research, others do not; certainly knowledge of the existence of ABSs was very low in the areas studied. However, while lack of agency of women in intra-household decision making is frequently cited as an impediment to the adoption of cook-stoves (see Miller et al 2010 and Lewellen 2002), in the focus groups for this research, many women considered that they *did* hold considerable agency over financial decisions concerning household appliances.

A general conservativeness was also observed ("...*aversion to changes in taste and tradition*..." (Miller et al 2010)) which may be explained by suspicion generated by past failures of technologies, or lack of ability to experiment with the new technologies (*trialability* (Rogers 2001a)) before purchasing. The value of *social marketing*, using local opinion leaders within communities, or peer-to-peer learning (neighbour to neighbour) is emphasised in the literature, as a means of overcoming suspicion to new ideas (Barnes et al 2012, Miller et al 2010). Promoting ABSs as modern and aspirational devices within communities is also likely to prove a powerful means of gaining the attention of cooks, although ultimately this will only result in mass adoption and use of these stoves if they meet the actual needs of the cooks.

Conclusion 4 – A mis-match in normative objectives exists between policy makers and cooks

An important finding was the recognition of a discrepancy between the normative objectives of policy makers and researchers, now generally focussing on public health matters (including this author) and the expressed motivations of cooks. The research highlighted that key issues identified as important by cooks were cost and availability of fuel, convenience (eg lighting or flame control), time spent cooking and smoke (utensils, clothes and health); these findings are in line with those reported by other researchers (Bailis et al 2011). While the research did not allow a ranking of these issues, it was clear that health was not generally considered as *the* primary driver by cooks, and in some cases it did not feature at all as an issue. This matches the conclusions of others (TERI 2008); one researcher has noted in particular that poor households value health benefits much less than wealthier ones (Lambe et al 2009).

Given the mis-match between the motivations of policy makers and programme designers and their target audience – cooks – three strategies could be considered. Firstly, financial incentives could be employed, in the form of subsidies to encourage cooks to follow the desires of policy makers. However, while subsidies have their place, as noted by a major review of cooking programmes in India, they are unlikely to have lasting success by themselves, as "...*the most important incentive is when users recognize that switching to better stoves has a high value for them*..." (Barnes et al 2012, p124); given the fact that many rural households do not pay for cooking fuel, and that women's' time is generally not monetised, the *value* of improved cook-stoves needs to be mostly social and cultural. Experience with subsidies administered by the Indian Government programme in the 1980s demonstrates the limitations of the target-driven, subsidy approach, in the absence of measures to ensure that stoves disseminated meet the needs of cooks.

Secondly, a means of creating *value* for the user might be through education campaigns, designed to inform the target populations about the health consequences of cooking with traditional stoves, and thereby persuade them to adopt alternatives. Since cooks generally do not have access to the findings of health research, it might be reasonable to expect that promoting this knowledge would have an effect on cook-stove adoption. In order to achieve this, there would be a need for much greater involvement of health authorities (which has been largely absent to date in stove programmes), bringing them in from the STS *landscape* to the cooking *regime*. While such a health education approach appears necessary, it is unlikely to be sufficient; others have concluded that persuasion campaigns are likely to have only short-term effects unless consumers are recognised "...*more explicitly as utility maximizers (rather than health maximizers)...*" (Miller et al 2010). The case of the successful sanitation programme suggests ways of addressing this, implying the need to combine top-down education with community engagement, facilitated by strong links between central and local government and involving community innovators; in this way a participatory movement might be developed which resolves "…*social dilemmas at the micro and macro level*…" creating demand for lasting change (Woolcock 1998, p186).

This leads to the third strategy, designing interventions that simultaneously meet the expressed needs of cooks (maximising their social, cultural and economic utility) and those of policy makers (improved public health). This chimes with a commentary on the political economy of programmes to reduce energy poverty, which concludes that "...*policymakers should shift their effort away from the technical to focus at least partially on addressing barriers at social, political, and cultural domains*..." (Sovacool 2012, p280). While the ABSs advocated as a core of this research appear *prima facie* to achieve both objectives (technical performance and socio-cultural adaptedness), it has yet to be conclusively demonstrated either that they reliably perform technically as well in real households as they do in the laboratory, or that they generally meet the needs of cooks. Both areas need considerable further research to confirm how well ABSs perform and meet the needs of their users.

The literature on socio-technical transitions highlights one specific strategy for overcoming lock-in. Suggesting that one of the key problems with behavioural lock-in is its hidden nature (even to the people concerned), the approach proposed is to focus on situations of change for the user (eg moving house) during which there is apparently more receptivity to change in other habitual areas of life (Marechal 2010). Regarding cook-stoves, such an approach has been suggested in the case of maternity clinics, whereby pregnant women would be informed about the effects of household air pollution on their unborn babies, and provided with free or subsidised ABSs (Wilkinson et al 2009). The author also suggests consideration of the case of marriage in India as an opportunity to promote changed cooking technologies; providing a free, or subsidised, ABS to new brides might help to promote the image of the technology as an aspirational and modern appliance.

Conclusion 5: Different conceptualisations of cooks - the need for a 'practice' perspective

The research has highlighted some profound but subtle issues concerning different conceptual stances that can be taken regarding cooks. There has been a tendency, albeit implicit, in past cooking research and policy analysis to take an object-oriented technology stance, while considering cooks as rational actors who balance costs and benefits of different stoves (the objects) (Barnes et al 1994, Ramanathan et al 1994). Following this approach, it would be logical to conclude that where benefits exceed costs for the cooks, but adoption does not follow, then barriers exist (eg lack of knowledge, money) which must be overcome. It is suggested that this conceptual approach, while useful in some regards, does not adequately capture all of the subtleties associated with cooking, for example by leaving out social and cultural context and the agency exerted by cooks themselves on social and political structures, and thus limits the analysis possible. In addition to an incomplete analysis, this stance tends to ignore the complex reality of cooking as it actually happens from day-to-day, and also relegates cooks to the position of passive observers who either adopt, or not, the improved stoves on offer.

A more subtle stance is required to capture the reality of cooks, going about their everyday lives following highly complex strategies, adapted to their environment, culture and history. Also, going beyond conventional usage of practice theory, it is necessary to capture the role of cooks in shaping technology, through a variety of processes, rather than being mere passive recipients. Taking a socio-technical view of the cooking system supports such practice perspectives, which have been missing in much of the thinking until recently. While practice theory is not referred to specifically within cooking literature, recent papers have started to place a much greater emphasis on cooks, their agency, and their actual household practices of cooking, grounded within their social and cultural settings (Lambe et al 2012). One recent paper implicitly takes an active, practice theory (or perhaps more accurately *usage theory*) perspective, noting "...*the dynamic interactions between fuels, stoves and users*..." and that the fact that "...*the adoption of a new cookstove should not be seen as an on/off static state that ends with the initial acceptance of the stove or its mere first uses*..." (Ruiz-Mercado et al 2011, p7560). This trend in representing cooking practice in its full context needs to continue if the mistakes of the past are to be avoided.

It is acknowledged that within this research, both perspectives (object-oriented and socio-technical practice) have been adopted at different times, and to varying extents, largely as a consequence of the process of the research itself, and in particular the type of data collected. The market research survey produced highly aggregated data, both quantitative and qualitative, and naturally led to the first perspective, with generalisations losing the complexities of individual household cooking strategies, and findings being couched in terms of descriptions of barriers to adoption. The limitations of this view led the researcher to undertake focus groups, which naturally lent towards the second, practice, perspective. While both perspectives have their value, it is suggested that the current need is for a greater emphasis on practice.

In the author's experience of observing improved cook-stoves programmes on the ground, there can be a sense of two very different worlds meeting: to stereo-type the situation, the stove developer/seller talks in technical terms about issues of efficiency or pollution levels, while the woman focuses on issues such as how to control stove heat in subtle ways to cook the food as she likes it, how reliable the stove is, or whether it will burn a new type of fuel which happens to be available on a certain day.

It is suggested that, by taking a practice perspective, the importance of understanding the real-life cooking activities of women and their socio-cultural context will be enhanced in the eyes of those designing and implementing cook-stove programmes and technologies. Such a shift in perspective appears necessary if a mass-scale transition to clean cooking is to be achieved, in terms of both the *adoption* and the *use* of new cook-stoves. With regard to the latter, the research has highlighted that even in cases where ABSs are adopted and used, they are not employed for all cooking activities, and in some cases not even for the majority; thus adoption of ABSs results in an extension of the energy stacking model, already present in most households, whereby a number of fuel/stove combinations are used within the same house (Masera et al 2000, Ruiz-Mercado et al 2011). Appropriate practice-based research into the reasons for this have only emerged recently (Hanna et al 2012), and it will be essential to enhance understanding of actual stove use following adoption; unless ABSs, once adopted, replace traditional stoves and are used for all, or the majority of, cooking tasks, neither the desired health improvements nor the associated carbon emission reductions will be achieved.

There appears to be a core need for the integration of the tacit knowledge and skill, or practice*,* of cooks to be integrated into the design and implementation of the next generation of cooking programmes (both publicly and privately implemented). In this way women would be given a voice – some agency - rather than being passive recipients of technology developed far from their own realities. Such a bottom-up approach is not new and has been advocated for many years with respect to cook-stove programmes (Mearns et al 1989) and more recently with regard to global transformations to sustainability generally (van Vuuren et al 2012). One, rare, anthropological study of cooking in developing countries concluded that engagement between cooks and other parts of the cooking system needed to be significantly enhanced for cooking programmes to be successful (Crewe 1997). The question is not whether users should be integrated into the design of technologies and the governance of programme design and implementation but *how.*

Adopting a practice approach to such a wide and diverse population, as represented by Indian cooks, presents considerable methodological challenges for research and policy, in particular with regard to the data used for analysis. The current centralised data collection processes within India (principally NSSO and the census) could usefully be enhanced to gather data on the full range of fuels and stoves used within individual households, as opposed to the current collection processes involving data collection for primary fuels only. However, this would need to be complemented with, and connected to, widespread, in-depth, research within a large number of individual households over extended periods. Such data collection could be undertaken by social anthropologists in order to increase understanding not only of what cooks do but also *why* they do it; however, this represents a lengthy, complex and costly proposition. Recent technological developments have produced remote stove use monitoring equipment, using heat sensors connected to mobile phones, to report on actual stove use over extended periods (Ruiz-Mercado et al 2011). This new technology offers promise of providing data representing a more complete description of the real practices of cooks.

7.2.4 Large corporations engaged in cooking in India

This section responds to the following research questions: *"Why are corporate entities involved in the cooking/development sector? What business approaches and strategies have they employed (including carbon finance) and what has been the material contribution to date? What are the likely distributional impacts of their engagement? What does their involvement imply about governance in the sector and the achievement of equitable outcomes?*"

The activities of four corporations, engaging to varying degrees in domestic cooking in India, were researched. Two were found to have catalysed the creation of separate businesses, one by design and one due to the withdrawal of the corporation from the sector. Activities of the corporations were found to follow a *social enterprise* model, whereby commercial principles were central but a relaxed attitude was taken to the period over which financial returns were made (Shrimali et al 2011).

Conclusion 6: Material contribution of corporations to date has been significant but prospects for the future are uncertain

To date two of the corporations studied have distributed around 600,000 cook-stoves between them. This happened over a period of around 7 years, and compares with 35 million stoves distributed by the Indian Government under the NPIC between 1985 and 2002.

These corporations provided significant resources for technology development, marketing and business development, in terms of technical and managerial skills and finance. Motivated overtly by philanthropy, the research revealed other underlying drivers of this activity. The corporations have sought publicity for their activities, motivated by gaining reputational advantage and the promise of promoting their *corporate social responsibility.* In addition, there is evidence that some of the corporations were motivated by strategic objectives, using their cooking activities as a means to learn about, and enter, the huge emerging consumer markets in India.

At the time of writing, of the four corporations, two had left the domestic cooking sector, one spawning a business which is still operating, but has diversified to selling commercial cook-stoves in order to shore up cash-flow. One other is at a very nascent stage of business development, and uncertainty remains about its activities going forward. The fourth is still providing what amount to philanthropic donations, in the hope that the business they are supporting will soon be self-sustaining financially. While an economic analysis of the business prospects of these organisations was not possible, another study referring to the same corporations concluded that "...*financial sustainability of improved stove sales to households remains far from assured*..." (Shrimali Slaski et al 2011, p7543).

Given the fact that two of these corporations have exited the sector, and that the prospects for one other are uncertain, there is evidence of a softening of support from their management boards. This can perhaps be explained by the generally difficult economic climate, but it is also suggested that the corporations have found it much harder to make a business case for their activities than originally anticipated, especially because of the dispersed and heterogeneous nature of the sector. In terms of the socio-technical systems, multi-layer perspective, the activities of these corporations are seen as a series of *niche experiments* both in terms of the technologies and the business models and approaches adopted. Prospects for these experiments being raised into the mainstream *regime* are unclear at present, although there is the possibility of two of them benefitting from some form of end-user subsidy under the new Indian Government programme (NBCI).

Conclusion 7: Corporations have generally not served bottom-of-the-pyramid (poor) households and are unlikely to do so in future in the absence of incentives or coercion

While promotional articles from some of these corporations use the language of *bottom of the pyramid*, none are generally reaching the poorest households. One of the organisations questioned was transparent in highlighting that it was targeting middle/lower income households.

The current stoves on offer by these corporations (or their associated business off-shoots) range in price from around IRs.1,000 to around IRs.4,500, prices out of reach for the majority of poor households. This compares with expressed willingness to pay, highlighted by the moderately poor households within the focus groups for this research, of around IRs. 300 – 400. National statistics highlight almost 50 million low income households (monthly household income less than IRs.2,060) using biomass; most of these are burning non-monetised biomass. In making ABSs affordable to poor households consideration needs to be given not only to capital cost of these stoves but also running costs in the cases of stoves requiring the purchase of specific fuels.

Without significant technology production cost reductions or government subsidies, including funding from the carbon offsets produced, most poor households will not be served by the programmes of these corporations, run as they are along commercial lines. Price reductions to the level of expressed willingness to pay are not considered likely, even given economies of scale. Thus it can be concluded that while a substantial number of households have been served by the actions of these corporations to date, relatively few were lower income households.

Conclusion 8: The corporations have developed plans to exploit carbon offsets, although progress is slow

All of the four corporations analysed had explored, or were actively pursuing, carbon financing. However, it appears that progress with realising this funding stream is faltering at best, due in large part to the complex and costly processes required to monetise carbon offsets, but also as a result of low prices associated with uncertainties surrounding the future of carbon markets and lack of clarity about the future of the Kyoto Protocol.

It has been noted that seeking the co-production of development benefits and carbon offsets with cook-stoves brings the potential for both *mutually supported benefits* as well as *mutually supported impediments* (Simon et al 2012). To benefit from the value of carbon offsets and maximise development outcomes, the corporations will need to exploit the former, for example by developing advanced monitoring of actual stove usage, while minimising the latter including the detrimental effects on user acceptability of limiting stove choice - an unwanted side-effect of carbon offset accounting procedures.

In order to clarify ends and means, it is suggested that carbon offsets should be considered as the latter - a potential means of funding cook-stove programmes, rather than an objective per se. This distinction is considered an appropriate moral choice given the relative magnitude of the public health issue (over 400,000 premature deaths in India per year from cooking plus many more disability adjusted life-years (Gopal Raj 2007)) and the climate issue (80 million tonnes CO_{2e} emissions from cooking, or around 4.1% of national greenhouse gas emissions (not including black carbon) (Venkataraman et al 2010)[47]).

Despite the practical difficulties in exploiting carbon offsets, the research suggests that - in the areas studied - the technical potential for carbon financing of cook-stoves in poor and middle income households is high. Greenhouse gas emissions were found to be higher in poorer households than

[47] Assuming that 10% of the cooking biomass fuel in India is non-renewable.

richer ones on both a per-household and absolute (total) basis. However, even if finance from carbon offsets were to be realised by corporations, it seems likely that it would be employed by the businesses to sure up profitability within the existing middle income household market, rather than to cross-subsidise poor bottom of the pyramid households. Thus alternative governance means would need to be employed to ensure that carbon revenues contributed to serving more poor households, as well as to wider market development (public good) activities, rather than purely to enhance corporate profits.

Conclusion 9: Engagement of these corporations in cooking has changed governance and power relationships

The engagement of corporations in cooking in India has occurred largely without involvement of the state, and can be regarded as case of *private governance of private finance* (Newell et al 2009).

The corporations have, in most cases, gone to considerable lengths to engage with cooks (*consumers*) in order to understand their needs. In one case, a process of *co-creation* of the business was reported, involving partnerships with local NGOs, and significant expenditure on market research and assessment of *social values* created by the business. The desire to understand the needs of the consumers is explained by the fact that without meeting these needs, sales would not be achieved, nor profits made. In this sense, there is a convenient synergy between the realities of the market and the social needs of cooks, and it might be concluded that these commercial actors will be more naturally motivated to engage with, and give agency to, cooks than those selling stoves under the target and subsidy driven government programme of the 1980s and 1990s (NPIC) for whom the customers of stove providers were effectively government bodies.

However, from a governance perspective there are indications that the partnerships developed between corporations and civil society were not between equals. NGOs reported some frustration within their partnerships due to the lack of ability to influence overall strategy (lack of discursive power) and difficulties with reconciling commercial and developmental priorities. The fact that the businesses were unable and unwilling to cross-subsidise poor households must have been a cause of considerable difficulty and self-reflection on the part of development NGOs involved.

Ultimately all of the material and discursive power remained within the corporations themselves. Despite partnerships with NGOs, strategic decisions regarding geographies within which to intervene, or markets to serve, were made within the corporations. More broadly, while internal *cooking champions* within the corporations were able to act as internal lobbying forces, promoting continuation of activities for as long as possible, corporate boards were ultimately making the decisions, and in two cases at least, they decided to leave the cooking sector. While the corporations have made significant contributions, and showed the benefits of following a commercial approach, there may be advantages to increased activity by local, Indian, private sector companies, in place of multi-national corporate engagement. While the corporates clearly have deeper pockets, the local private sector might be likely to demonstrate greater transparency and accountability to local communities, given the fact that decisions would be made closer to the populations affected.

In the interregnum between the end of the previous government programme in 2002 and the start of the new one recently, the corporations analysed appear to have taken over some of the basic functions that might naturally be expected of state institutions: basic research, market development, public awareness-raising and support for nascent enterprises. If there is widespread disengagement by corporations in the sector, the Government of India will need to reclaim some of these basic governance functions. There are indications that it is preparing to do so, within the NBCI. Under this initiative, the development of stoves standards is being enhanced, and national testing laboratories for stoves are being initiated, early signs of state regulation of the sector.

7.3 Contribution, relating findings to the wider literature, future research

Much of the early literature relating to cook-stoves reflected the origins of the field, largely driven as it was by technologists, including many who might be regarded as hobbyists; the focus was on fuel efficiency and other technical factors related to stove performance (Geller 1982). During the late 1990s attention shifted to the health impacts of cooking, led by seminal papers such as (Smith et al 2000), and this topic has now achieved widespread recognition (Wilkinson et al 2009, Dherani et al 2008). Increasingly sophisticated technical analyses of the emissions (health damaging and greenhouse gases) of different fuel/stove combinations have become available in the last decade, highlighting the potential benefits of improved stoves (Bailis et al 2007, MacCarty et al 2010). Today we thus have a relatively strong characterisation of the problem, as well as good understanding of solutions from a technical stand-point. However analyses of the means of achieving a mass transition to the use of improved stoves, and conversely the reasons for the failure of many past programmes, are poorly developed by comparison; this is a gap which this research begins to fill.

Until recently many approaches to dissemination have taken broadly techno-economic approaches to the topic, relating success in dissemination largely to the technical characteristics of the stoves and the economic situations of those adopting the technology (Jones 1988, Agarwal 1983, Gupta, Ravindranath 1997). The importance of cooks and their behaviour, beliefs and socio-cultural contexts has come relatively late to the debate (Hanna et al 2012, Lambe et al 2012). Increasingly such factors are being introduced into the literature analysing practical approaches to scaling up the use of improved stoves (Bailis et al 2011, Barnes et al 2012). Even so, the research and analysis related to cook-stoves is still dominated by those with a technology slant, and there has been insufficient attention to date on inter-disciplinary research.

Thus, while there are recent examples of detailed, policy-relevant, analysis of past programmes (Barnes et al 2012), it is argued that there remains a lack of conceptual richness in much of the policy literature, much of which is developed by donor organisations (The World Bank 2011). This reflects the general difficulty of reconciling the wide range of scales involved and the associated diverse drivers and processes of change, which range from international and national policy processes to the socio-cultural and psychological factors affecting the private lives and choices of hundreds of millions of individual cooks.

From an academic standpoint the issue of cooking, and specifically adoption and use of improved cook-stoves has remained largely untheorised. This thesis contributes an analysis of the issue through three theoretical and conceptual lenses: 1) socio-technical system transitions; 2) governance and 3) practice theory. None of these have been applied to the cooking problem to date. While theoretical assimilation is not attempted, the application of these theories to cooking is novel, and points to ways of achieving reconciliation between processes of change at different scales and between disciplines. Put simply the theoretical and conceptual approach taken highlights the need for a more holistic, inter-disciplinary analysis; this thesis provides a starting point for such an endeavour.

7.3.1 Empirical contributions

The research analyses existing literature on previous government programmes, and adds richness to this by comparison between Chinese and Indian cook-stove programmes and with a sanitation programme in Bangladesh (Pachauri et al 2005, Hanbar et al 2002, Smith et al 1993, ESMAP 2010). In this sense some triangulation of previous findings is achieved. Furthermore the addition of governance as a frame for analysis has added explanatory understanding of the reasons for past success and failure, which has helped to re-frame the considerable existing body of knowledge and move from analyses of what went wrong in the past, as outlined by researchers such as Kishore et al (2002), to a more policy relevant analysis of *why* this was the case and *what* lessons can be learned.

Primary data, both quantitative and qualitative, was analysed on cooking practices and associated beliefs and attitudes. Specifically this included disaggregation of data into different socio-economic groups. This added important detail to existing knowledge in the specific geographies in which the research was carried out. While national-level analyses of cooking in India have disaggregated findings between socio-economic groups - using government data collected through the census and

NSSO (van Ruijven et al 2011, Khandker et al 2012, Gundimeda et al 2008) - such analyses have focussed on primary fuel types only; they have not been able to investigate the different types of stoves used, nor beliefs and attitudes of individuals within different socio-economic groups, since such data is not gathered through the census or NSSO. The research complemented quantitative data with qualitative findings, adding further to the explanatory power of the conclusions. Given the reality that a mass-scale transition to clean cooking in India will predominantly involve poor and middle income households, much greater emphasis on such nuanced analysis, disaggregated between socio-economic groups, will be necessary in the future.

The research contributed primary data on the activities of large private sector corporations working on cook-stoves in India. This took the form of data from key informant interviews as well as personal observation. When the research started there was no academic literature on the cook-stove activities of corporations in India. However during the research one paper was published outlining factors influencing the success of different business models (Shrimali et al 2011); the findings of this thesis are broadly in line with those of this paper, concluding that the contributions made by these corporations are significant but that the longevity of the business models employed is not assured. The thesis complements Shrimali et al (2011) through the addition of governance analysis and concludes with the finding that while the private sector has an important role to play, some functions must remain the responsibility of government if an equitable transition is to be achieved; this finding - that a market-driven, neo-liberal approach, will not by itself be sufficient to achieve an equitable transition - is in agreement with some researchers (Bailis et al 2009) but appears to run counter to the orthodoxy promoted by some donors (The World Bank 2011).

7.3.2 Relation to theory

Although theoretical assimilation was not attempted, the key theoretical lenses employed (STS, governance and practice) were linked conceptually through use of the heuristic multi-level transitions model of niches, regimes and landscape (Genus et al 2008, Geels 2006). Cooks were conceived of as being at the heart of the incumbent regime, with their activities set in the context of social practices. While certain assumptions were made to map the various geographic and functional (governance) levels of the empirical matter of this research with these heuristic levels, further work is required to reconcile the theoretical approach of the multi-level model with units of empirical analysis; in preference to further theoretical refinement, this is perhaps best achieved through further attempts to use the multi-level model empirically, following a learning by doing approach.

In summary the theoretical approaches employed were applied to the research questions as follows:

1) Historical, comparative review of past experiences with government improved cook-stove programmes and an analogous sector (Chapter 3)

   Research questions: *What can be learned regarding transition success or failure from analysis of past public programmes and the comparison between them? How can these insights be employed to improve prospects of achieving a future transition to clean cooking in India?*

   Socio-technical system transitions theory was applied to characterise the degree of transition in India and China following major publicly funded programmes. Overall, the multi-level perspective was valuable in characterising where public efforts were successful (or not) in promoting new activities (use of improved stoves) from niches to the mainstream cooking regime. At a finer level of detail socio-technical systems was applied to investigate the degree to which ongoing innovation, a key aspect of transitions, was achieved by the programmes investigated.

   While useful in these regards, socio-technical systems was not considered a sufficient framework to describe some key factors behind success or otherwise of past public programmes, namely issues of structure and agency; for this, aspects of governance were applied to address questions such as the degree of agency held at different levels (federal, state, civil society, cooks etc). As well as enabling analysis of who was doing the governing, the governance of clean development framework enabled questions of how this governing was undertaken and on whose behalf. Comparing governance of the different programmes, this analysis yielded insights into the importance of devolution of agency to lower (state and community) levels, in particular with regard to the sanitation programme in Bangladesh. It is to be noted however that some key aspects relevant to governance were not addressed in detail, including the difference between political and cultural traditions in India and China, or the international politics of energy poverty (ref Sustainable Energy for All). In addition detailed comparative analyses of governance approaches in different Indian states was not attempted due to its complexity and lack of data; a starting point for such research in the future would be the report by Barnes et al (2012).

2) Users: Cooking practices, attitudes, social and cultural context (Chapters 4 and 5)

Research questions: *what are current cooking practices and attitudes to these? What are the material impacts of cooking in terms of polluting emissions and greenhouse gases? How are these distributed across socio-economic groups? What socio-cultural and behavioural factors need to be accounted for in achieving an equitable transition to clean cooking?*

Investigation of the everyday cooking practices and the impacts of these, employed both quantitative and ethnographic approaches, relatively neutral of theoretical stance. Following Bartiaux et al (2011), the research analysed factors such as the technologies and material structure of cooking, know-how and embodied habits and institutionalised knowledge and rules and underlying reasons why change might be desired by cooks. Such socio-cultural issues and the preferences of cooks were described to highlight those aspects requiring future attention for the achievement of a cooking transition. This is the first sense in which practice was used, to describe actual patterns of activity in daily life, and those influences, tendencies and preferences which should be considered to shape future activities. In this sense the use of practice was different from that employed in practice theory generally, where social practice is considered to be carried by individuals rather than shaped by them.

More congruent with mainstream use of practice theory, analysis of the socio-cultural context presented in Chapter 5 also supported a subtle re-framing of the problem. Such a re-framing suggests the need for socio-cultural context, attitudes and other factors to be considered as realities of the 'life-world' of cooking (Reckwitz 2002). As such these realities are not to be regarded as barriers to be overcome but as truths existing in the real world. In this was the research not only highlighted socio-cultural and behavioural factors that need to be accounted for in achieving an equitable transition to clean cooking, but also suggested a subtle but profoundly different way of perceiving of these factors.

3) The role of large multi-national private sector (Chapter 6)

Research questions: *Why are these entities involved in the cooking/development sector? What business approaches and strategies have they employed (including carbon finance) and what has been the material contribution to date? What are the likely distributional impacts of their engagement? What does their involvement imply about governance in the sector and the achievement of equitable outcomes?*

Governance was firstly applied to these questions as a means of placing the activities of corporations within the overall context of the cooking sector, involving as it does governing by the state, private entities, and civil society, including individuals. In this way a shift in governance approaches in recent decades was identified, from the government programmes of the 1980s to private entities operating relatively independently of government in the past decade.

Aspects of governance theory were employed to assess the reasons for multi-national engagement in cooking in India, including analysis of the corporate social responsibility driver. Questions of how corporations governed drew on issues of structure and agency, including the degree to which top-down corporate governance structures could (or should) engage with local actors and give real agency to the latter. One conclusion, that future effective governance of the sector requires effective multi-level and multi-actor governance structures, draws on the emerging literature in this field.

Socio-technical systems was employed, in a similar way to the study of past public programmes, to characterise the degree of success in achieving transition by the corporations.

7.3.2.1 Cooking and socio-technical system transitions

A considerable literature exists regarding transitions in socio-technical systems, much of which relates to issues of environmental sustainability (Kern et al 2008). The application of socio-technical systems to cooking is new, and contributes to a limited but growing literature concerning socio-technical systems transitions in a developing country context (Romijn et al 2010, Berkhout et al 2010b). This conceptual framework is helpful in constantly reminding researchers and practitioners of the importance of considering both technical and social aspects of transitions, including issues of culture, knowledge and cognitive routines (Bai et al 2009).

The socio-technical transition of cooking in India would necessarily involve decisions by many millions of people and is thus distinct from many of the existing studies of socio-technical systems, which more frequently use case studies involving large infrastructure such as centralised electricity systems (Verbong et al 2007), sewerage systems and factory facilities (Geels 2006). Socio-technical system transitions was a useful approach within this research, helping to characterise and differentiate the degree of transition achieved (or not) in past stove programmes in India and China. However the characterisation was found to be more complex than in the case of large infrastructure sectors in well-developed market economies; firstly the complexities of energy stacking (use of multiple stoves) do not easily map onto the transitions model. Secondly it is apparent that most of the transitions literature relates to situations in which an active market economy is operating, which is not currently the case for most traditional cook-stove users.

Another distinction between this thesis and the existing literature is the focus within this research on a normative, practical question regarding how to achieve an alternative future; the majority of case studies of socio-technical transitions relate to analysis of the processes associated with past transitions (for example Verbong et al (2007), Geels (2002)). There is however a burgeoning literature on the management of socio-transitions (Smith et al 2005, Raven 2010, Loorbach 2009). Nevertheless this remains a nascent area of learning, currently mostly residing within the realm of theorists. While this thesis draws upon some of the aspects of this realm, including the management of strategic niches (Raven 2010), the field requires further development to be applied generally to the topic at hand, in particular given the complex, dispersed and poorly characterised factors associated with the cooking sector compared with the more deterministic nature of transitions associated with large infrastructure.

In comparing transition management approaches, specifically strategic niche management, with development approaches based on learning-by-doing - as employed by development practitioners - it has been found that some aspects of the latter are beneficial in the case of bioenergy projects in India, for example the ability to deal with complex and heterogeneous situations on the ground, in particular understanding power relations within local institutions (Romijn et al 2010). It is further concluded that strategic niche management – and by implication other socio-technical transition management theoretical approaches - would benefit from adoption of some of the approaches used by practitioners (Romijn et al 2010), a conclusion with which this author agrees. In particular the difficulty of practically representing individual agency - shown to be a central factor in achieving a cooking transition - within the socio-technical transitions framework is a key draw-back (Smith et al 2005), and results in a lack of explanatory power; while socio-technical systems is useful in describing *what* happens, in applying it to practical situations it is found to be difficult to use socio-technical system to outline the reasons *why* these things happen. On the other hand strategic niche management as an approach is recognised to provide a more adequate "…*endogenous treatment of* *the larger context*…", which practitioners could usefully benefit from adopting (Romijn et al 2010, p326).

Future research into cooking transitions could usefully analyse, in more detail, the general field of management and governance of socio-technical transitions with a view to developing theoretical approaches benefitting from the strengths of the two perspectives (theory and practitioner) while reconciling differences between them.

The heuristic model of multi-level socio-technical systems, represented by *landscapes, regimes* and *niches* (Genus et al 2008, Geels 2006) has been employed within the thesis. This has been valuable in characterising the broad frames of reference and processes of transition. One of the core conclusions of the research – that there is a need for strong linkages between levels and between actors for transition to occur – is supported by the literature, which characterises the links required as both vertical and horizontal (Bai et al 2009). However there is a practical problem associated with empirically applying the multi-level approach to the issue of managing a transition to clean cooking; this is the difficulty of reconciling the heuristic multi-levels (niche, regime and landscape) with geographic and functional (governance) levels in the real world. In reality niches and regimes are seen to operate at a range of geographic and functional levels, such that no neat mapping of them into one multi-level model is possible. The choice of what is within the niche, regime or landscape is to some extent arbitrary (Geels et al 2007), giving a certain freedom of analysis, but also making it hard to apply the multi-layer model in empirical analysis. Recognising this problem it has been proposed that regimes occur within a broader hierarchy, such that a series of nested regimes exist (Smith et al 2005). While this resolves the problem from the perspective of the theoretician, it does not solve the problem of applying the multi-level model in practice, and potentially introduces an element of circularity into the analysis.

7.3.2.2 Governance and cooking

The thesis has contributed a novel conceptual framing of domestic cooking, employing key concepts from governance. An analysis of the broad political economy of cooking within India is provided, based upon the exercise of different forms of power (material, institutional and discursive) (Newell et al 2011) working through a range of agents and structures. It is shown that poor households, in particular those in rural areas, are lacking in all three forms of such power, leading to uneven development as a result of the activities of both government (eg subsidies for fossil fuels) and private sector corporations.

The analysis demonstrates a historical shift in governance with regard to cook-stoves in recent decades. The first broad phase of activities, under the NPIC, represents *public governance of public finance,* while the second involved the emergence of corporate activity and can be seen as *private governance of private finance* (Newell et al 2009). While both can be seen largely as top-down governance, some multi-level and multi-actor governance was also apparent, to varying degrees and with variable success.

Analysis of the corporate activity confirmed findings of other researchers concerning commercialised approaches to cook-stove dissemination, that while there are distinct advantages to commercialisation, including a focus on user needs, there remain essential governance roles for the state (Bailis et al 2009). These include (public good) market development and regulation activities (such as the setting and policing of standards), as well as other measures required to ensure that outcomes contribute to equitable development.

The motivations driving the engagement of corporates in India were shown to be a combination of reputation enhancement (corporate social responsibility, CSR), philanthropy and development of new strategic markets. The motivation of CSR is shown to be generally insufficient to ensure ongoing engagement of these corporates in the sector in the absence of other incentives; there is also found to be an apparent lack of transparency with regard to their activities. These findings are in line with those of others concerning the limits of CSR and private capital to achieve lasting, positive, and equitable development outcomes (Newell 2008). Following purely commercial approaches, in the absence of active governance by the state, the majority of poor households are found to be likely to remain unserved with improved cooking facilities, perpetuating the existing governance blind-spot within this large segment of the Indian population (Newell et al 2009).

In order to give a stronger voice to poor cooks within governance systems of cooking, there is found to be a need for middle-level institutions, firstly capable of understanding the priorities of cooks and the socio-cultural factors influencing them and secondly having the power to reflect those views horizontally to other institutions and to upper levels within the system. More generally the findings of the research are in accord with emerging debates on new modes of multi-level, multi-actor governance (which mostly relate to climate change), suggesting the need for "…*central governments and other public and private actors interface to design and implement policies from international to national and local levels of action, both vertically across different levels of government and horizontally in networks across sectors, regions and stakeholders*..." (Martinelli et al 2012, p2). The research suggests that in the case of cooking, horizontal linkages would be required between the state, private sector and civil society, including community groups. While such aspirations are laudable, describing the structures and processes that would be required in practice to achieve them is not a simple task, and is not well developed in the literature.

Three approaches to multi-level governance have been described: 1) 'top-down' frameworks – whereby central government develops policy and supports local administrations in its implementation (broadly analogous to the approach attempted during the NPIC); 2) 'bottom up' models – local structures and institutions take the initiative to act in the absence of signals or influence from above (reflecting previous civil society cook-stove efforts, many of which were successful but failed to reach the scale of implementation required); 3) Hybrid models – involving close collaboration and sharing of power between local and regional administrations and with private sector and civil society (OECD 2009). The fact that the currently developing Indian cook-stove programme (NBCI) has been instigated by a federal ministry implies the existence from the start of a strong top-down element; the need appears to be for the Indian Government to understand the importance of shifting towards the hybrid model, probably involving more active involvement of existing public institutions at the level of Panchayats, whose capacity with respect to cooking would need to be appropriately enhanced (Corbridge et al 2005), while ensuring appropriate motivations and the avoidance of special interest and corruption that has been reported (Newell et al 2011).

In addition to strong, well-functioning local and middle level public institutions, there is a need to develop functional governance links between these public institutions and those within the private sector and civil society. The study of corporate engagement within this thesis provides an example of engagement between the private sector and civil society, which might be regarded as a social-private partnership. However, limitations to this approach were associated with the difficulty of achieving an appropriate balance of power. In addressing such issues within the cooking sector, there is potential to learn from, and build upon, studies of governance issues at the interface of society and nature, for example those outlining the benefits of "…*hybrid modes of governance across the state-market-community divisions: comanagement, public-private partnerships and social-private partnerships…*" (Lemos et al 2006, p297).

7.3.2.3 Practice perspectives

The research introduces a practice perspective to address specifically the limitations of previous views of cook-stove adoption, whereby the adoption, or not, of cook-stoves was implicitly regarded as a function only of the stove attributes (Lambe et al 2009). This view effectively sees cooks as rational agents, adopting technologies (stoves) according to their analysis of costs and benefits; it does not sufficiently account for the wider socio-cultural context in which cooks go about their everyday business, or the active role that cooks have, or should have, in shaping cooking technologies.

This limited representation of cooks is also apparent within debates surrounding socio-technical system transitions as illustrated by the following quotation: "...*for all the talk of sociotechnical coevolution, there is almost no reference to the ways of living or to the patterns of demand implied in what remain largely technological templates for the future*..." (Shove et al 2007, p768). This quote highlights the importance of redressing the balance between technological determinism - apparently widespread in current cook-stove research and implementation, albeit implicitly - and the opposing idea of social construction. Technological determinism proposes that technology development inevitably proceeds, independently of the influence of social forces (Kline 2001), while social constructionists focus on the very centrality of such social influences. To date the cooking fraternity does not seem to have even recognised the existence of such debates. It is suggested than engagement with this debate would help expose the contradiction of the current, implicit, position which appears to place too much emphasis on technological determinism, and help find a middle ground between the two extremes. Useful lessons can be learned from existing studies of the *social shaping of technology* (Williams et al 1996), in terms of how social forces have influenced the development of specific technologies in the past, as well as how greater emphasis, and agency, might be given to those representing these social forces, to counter-act the currently dominant role of technology developers in the cooking sphere (Crewe 1997).

7.3.3 Future research

The process of undertaking this thesis highlighted the need for further research in a number of areas. Consistent with the approach taken to this research in general, the recommended future research areas outlined below focus on issues considered to have the potential to advance knowledge of how to create system-wide transitions. While the further technical development of improved stoves is not included, it is acknowledged as an essential area of future research.

1. **Anthropological research** - the process of developing this thesis has highlighted the need for further anthropological research into traditional cooking practices. While anthropologists have engaged with the topic to some extent, published literature is limited. One study analyses the role of experts and donor agencies, and their relations with cooks, in cook-stove programmes (Crewe 1997), while another article reports more specific, project based, findings from Guatemala (Engle et al 1997). From the author's experience some, more enlightened, donors and NGOs do engage social anthropologists during the implementation of cook-stove programmes, although their use is not widespread and their finding are generally not published. Thus while recognising the need to fully account for social, cultural and behavioural factors within the cooking system, researchers and practitioners are lacking in the required expert knowledge, and are not sufficiently exposed to the voices of cooks. Two recommendations are thus made. Firstly, cook-stove programmes should as a matter of course include social anthropologists. As well as informing project definition stages, to ensure that proposed technologies and implementation strategies are appropriate within the socio-cultural settings in which they will operate, anthropologists should perform post improved cook-stove adoption studies to increase understanding of how (and how frequently) the stoves are used, and how they are perceived to meet (or not) the social and cultural needs of cooks.

   Secondly a systematic research programme should be undertaken in India, involving social anthropologists and possibly social psychologists, to both describe cooking patterns – types of food cooked, and the multiple stove/fuel strategies employed – and highlight the associated discourses amongst individual women, at the level of household dynamics and at community levels. Such discourses will help to set existing cooking practices within their socio-economic and cultural contexts, highlighting what is and what is not possible regarding change to these practices. Results should remain in the public sphere for use in the design of government, donor, private sector and civil society cook-stove programmes.

2. **Governance research** – the thesis has highlighted the need for enhanced understanding, and improved practice of multi-level and multi-actor governance in the cooking sphere. The importance of extending studies of analysis beyond the levels of pure public and private governance, to include hybrid, co-management models including partnerships between public and market actors and communities is highlighted with reference to environmental issues such as climate change (Bulkeley et al 2010, Lemos et al 2006). This is a field which could valuably be extended to the area of cooking, building on the findings of this thesis. Complementing existing research (Simon 2010), further analysis of the links (actual and potential) between the public, private and civil society spheres is expected to add important insights into improved governance regimes in the future, specifically associated with the design of the new Indian Government cook-stove programme.

   As highlighted above, the transitions management literature is at a nascent stage. Further theoretical research, building on the findings in this thesis, would be valuable in highlighting the applicability (or not) of the emerging transitions management literature to cooking.

   More specifically research into the role of middle-level organisations is seen as having the potential to be especially instructive. Given the top-down nature of the nascent Indian Government programme, and the need identified within this research to achieve a strong voice for cooks, the role of middle level organisations is considered key to success in linking political processes with actors at ground level, and enabling agency for the latter and exchange of information between the two; reference to research agendas on *middle-out* approaches should be made as a possible means of reconciling the contradictions between bottom-up and top-down approaches (Janda et al 2011). Research should involve both a historical analysis of the functioning, or lack of it, of middle level organisations with the past Indian Government cook-stove programme, and the implications for improved middle level governance in the future. It is expected that optimum governance at the middle (meso) level would involve a variety of institutional types (public, civil society and private), as well as ensuring cross-disciplinary institutional links within public institutions, for example between health administrations and those responsible for energy, gender and forestry.

3. **Carbon offset architecture design research** – this thesis demonstrates the technical potential of carbon offsets to provide an additional revenue stream for a cooking transition; it is also shown that poor households have the potential to generate carbon offsets through the adoption of improved stoves, and that they have the need for additional finance given the problem of affordability within this group. Furthermore there are hypothesised to be advantages to having a core role for the state in generating and distributing the revenues from cooking carbon offsets, both in terms of efficiency and achieving equity of outcomes. At the same time the international architecture for carbon offsets is currently in a state of flux. The project-based Clean Development Mechanism (CDM) has further evolved into CDM Programmes of Activity (PoA), and there is much current consideration of the role of sectoral approaches (Baron et al 2009) and the funding of Nationally Appropriate Mitigation Actions (NAMAs) (Ellis et al 2009).

   Research is required into the technical feasibility and desirability of a centrally managed, sectoral, cooking carbon offset programme in India. Such research would outline various options concerning implementation modalities and institutional set-ups, in relation to different international carbon architectures possible in the near future, and analyse these from the perspective of their ability to support an equitable transition to clean cooking. Criteria against which different options might be assessed include: *practicality* – for example the degree to which appropriate data is available, or cost-effective to collect; *effectiveness* – the likelihood that different schemes would result in a self-perpetuating transition, which has largely been absent in the case of the project-based CDM in the past; *efficiency* – in particular the transaction costs in relation to the benefits achieved under different schemes; and *equity* – the degree to which poor households would benefit from carbon revenues generated.

4. **Inter-disciplinary research and practitioner approaches to cooking** – this research has demonstrated the need for more inter-disciplinary working in relation to the study and practice of cooking and cook-stoves. There are essential roles for experts from a range of disciplines including technology developers, energy policy analysts, governance experts, technology adoption specialists and social anthropologists. Despite this there appears to be a relative lack of inter-disciplinary working, with the field still dominated by technologists.

   There are known to be systemic obstacles associated with inter-disciplinary research, including a lack of identifiable peers and difficulties associated with poor researcher career progression (van Rijnsoever et al 2011). Meta-analyses have been undertaken into inter-disciplinary research projects, inter alia highlighting the need for functional coordinator roles to deal with the difficulties of communicating and sharing results for a common aim between disciplines (König et al 2012). Research into the broad area of inter-disciplinary working with respect to the cooking sector, drawing on existing research, would further develop understanding of why it is hard to achieve and point to potential solutions.

7.4 Policy recommendations

Broadening the conclusions of the research, three general inferences can be made with respect to core issues that would need to be addressed to achieve a mass-scale transition to use of ABSs. Firstly, given the cost of this technology and the fact that a large proportion of the population to be served is poor, there would be a need for additional financial incentives in some form. Public subsidies, for example resulting from a re-orientation of current subsidy regimes for LPG and kerosene, are one option, although the associated political difficulties of achieving this are significant. Another option might be the use of revenues from carbon financing schemes.

Secondly, it can be inferred that there is a need for processes by which technologies are continually developed, and *co-evolve* - through the involvement of both cooks and technologists - to meet rigorous technical standards, while being socially and culturally adapted to the needs of cooks.

Leaving aside the economic issue of affordability, the technical, social and cultural aspects of the technology are each crucial; without achieving all three simultaneously, it is highly unlikely that the transition required will occur. This implies the need for a profoundly different approach to that taken in the past, whereby most of the focus has been on the technical aspects of stoves. Thirdly real bottom-up demand of cooks for improved stoves is key to achieving a lasting transition. It is clear that "...*changing just one element of the current system—say, overcoming a financial barrier by deploying a subsidy—will not overcome barriers at deeper political, cultural, and social levels...*" (Sovacool 2012, p280).

This section presents three broad policy recommendations. These are chosen as extensions of the research and do not represent an exhaustive list of all of the policy actions required to achieve a mass-scale, equitable transition to clean cooking.

Recommendation 1: Public sector should take the lead in governing a transition to clean cooking, including measures to incentivise commercial approaches

In political economy terms cooking in India is a classic case of uneven development. The current *regime*, represented by differences in practices - whereby many of the rich use LPG or kerosene, while poor households burn biomass on traditional stoves biomass – appears stable and unlikely to change in the absence of significant new policies and approaches. In terms of the STS multi-layer perspective, there appears to be little adaptive pressure for change within the *regime* (weak user demand), or from the political landscape which appears to promote the status quo. It is suggested that public policy should take a leading role in creating positive and sustained adaptive pressure for transition, while reducing inhibiting effects of current policy.

For the former, the Government of India should take a lead role in facilitating joint envisioning processes (Loorbach 2009), involving a broad constituency of actors and interests, including those of cooks in rural areas. Such processes would ideally result in shared visions concerning clean cooking, possibly resulting in the development of appropriately articulated targets, learning lessons from the

Bangladesh sanitation programme, for example numbers of stoves in use (not simply stoves disseminated), or even involving targets for public health outcomes. Alongside envisioning processes, there is a clear need for extensive and ongoing public education, in particular with regard to the health impacts of household air pollution. As well as general health education, the government should consider using specific opportunities for change to encourage use of improved cook-stoves, such as maternity clinics, marriages and situations of moving home.

In terms of inhibiting national policies, current LPG and kerosene subsidies, are inefficient and generally regressive in rural areas (Rao 2012), and very unlikely to result in a mass-scale shift of poor households to the use of these fuels. However recent encouraging announcements have been made regarding the reform of subsidies for LPG (Sahu 2012). More generally, huge public funding of subsidies for LPG and kerosene have historically significantly outweighed the support given to improved cook-stove programmes. Although the political system appears to be in the process of reforming subsidies – reducing them for LPG and kerosene – it does not seem to have recognised that the benefits of mass-scale adoption of ABSs could actually outweigh the costs involved (Hutton et al 2007); only tentative steps are being made in the direction of new subsidies for improved stoves. At the same time politicians need to understand that economic incentives alone are unlikely to be sufficient to overcome the significant public health burden caused by the use of traditional fuels and stoves, the majority of which affects poor households; creating real demand from the bottom up will be essential, and requires considerably more engagement with cooks. Improved cooking for the poor in rural areas appears to have been a governance *blind spot* (Newell et al 2009). While there are initial signs of increased political interest in improved cook-stoves, with the recent launch of the new National Biomass Cook-stove Initiative, it is too early to tell whether the Government of India intends to give a strong political focus on cooking for the poor, commensurate with its importance.

There has been a general shift, globally and within India, towards neo-liberal market driven approaches. In the interregnum between the end of the previous government cook-stove programme in 2002 and the new NBCI programme, a number of niche experiments were undertaken by large corporations, focussing on commercial, neo-liberal approaches. Some successes were achieved, including the development of high-performance stoves, some of which reached a considerable number of households. The corporations went to considerable lengths to engage with consumers, driven by the recognition that achieving commercial success implied meeting social and cultural needs of cooks. Thus the commercial approaches, in some senses, gave more agency to the cooks than the top-down, governance from above, approach adopted by the Indian Government programme in the 1980s and 1990s. In addition the corporations took on some of the roles traditionally expected of state organisations, including basic research, public education and enterprise development. However it has been shown that the efforts of these corporations have ultimately resulted in inequitable outcomes, and would continue to do so in the absence of changes, with poor households remaining largely unserved. The assumption that a market-driven approach, initially targeting middle-income households would result in economies of scale, thereby achieving price reductions to a level that would enable adoption by the poor on a mass scale is not considered credible, at least within the timescales of 2020-2030.

More broadly, given the fickle nature of commercial organisations, and the fact that health is a public good, it seems natural that the state should take the leading role in governance of the sector; this is starting in India, with the establishment of regulations (eg technical stove standards), and will need to be supplemented with support for public education and research, and crucially building institutions capable of ensuring that the needs of households are represented in national policy and programme development.

In addition to (public good) market development activities and enhanced institutions, it is suggested that the Indian Government should encourage commercial approaches through a combination of both incentives and regulation. One important regulatory approach involves the development and monitoring of technical standards possibly including "...*product labelling for stove energy efficiency, combustion efficiency, safety, and durability so that consumers would know what they are getting when purchasing a stove*..." (Barnes et al 2012, p139); the author would add technical standards for emissions contributing to household air pollution to this list. Carefully designed, standards are likely to increase consumer confidence, which has been knocked by the dissemination of poor technology in the past. It seems that the Government of India is in the process of improving technical regulation under its new cooking programme. It is to be noted that while standards will be an important driver of consumer confidence, and possibly a means of organising the distribution of subsidies, it is not possible to introduce mandatory minimum standards for stoves in use, as has been undertaken with some Market Transformation programmes for consumer appliances in Europe (Boardman 2004), given the fact that traditional stoves are generally hand-made, non-market and unregulated goods.

Incentives for commercial organisations will also be necessary, with a focus on Indian private sector companies suggested. Given the lengthy periods that have been demonstrated to be required to develop commercial operations in this sector, the Government of India should provide financial support for enterprise and market development, nurturing new companies in ways analogous to the corporations studied in this thesis. Ongoing public support for research and development is also considered necessary given the, yet unrealised, need to develop low-cost biomass stoves with very low emissions, acceptable to cooks. The proposed use of technology competitions by the Government of India for stove development demonstrates that there is recognition of the need for the public sector to further stimulate technical innovation (X Prize 2010).

As has been noted with regard to cooking, "...*Without substantial incentives to promote behavioral changes, entrenched customs tend to persist*..." (Barnes et al 2012, p124). The research has shown that a necessary condition for transition is that new stoves meet the everyday needs of cooks. However it appears that while necessary, this will not be sufficient to achieve a mass-scale transition to clean cooking. Given the large numbers of poor households, some form of end-user financing, for both capital and running costs (where necessary) appears to be essential, although the practical difficulty of developing subsidy schemes that are efficient and equitable (that is target those in most need while not polluting existing markets) is well documented (Barnes et al 2012).

Recommendation 2: New programme structures, and enhanced institutions should be developed to enable effective communication between levels, and increase agency of cooks

In efforts to promote improved cook-stoves, broadly two forms of intervention or governance structure have been practised within the cooking sector to date: top-down (governance from above) and bottom-up (governance from below) (Newell et al 2009); in practice there is a spectrum in between these two. The cook-stove programmes analysed in India and China, as well as the activities of the corporations studied, can be broadly characterised as being in the former group. Civil society actors and a number of donors (for example GIZ), not studied within this research but reported in (GIZ 2011), follow a programme structure with more emphasis on bottom-up, participatory, learning-by-doing processes (Romijn et al 2010). In achieving mass-scale use of improved cook-stoves at the scale required in India (around 150 million households), it is hypothesised that neither approach is optimum, but that a third programme, and associated governance, structure will be required, with a greater emphasis on multiple links between levels and actors and a particular focus on the middle or meso level, drawing on the strengths of bottom-up and top-down, while avoiding their weaknesses.

While top-down approaches have the potential to reach mass-scale, given the depth of resources available, there is a structural paradox with regard to the way they approach the cooking sector. Top-down governance has the tendency to seek to produce standardised responses to particular issues (in this case cook-stoves); this is demonstrated both within the NPIC and through the activities of the corporations analysed, both of which promoted limited numbers of different types of stoves.

As has been shown, real-world practic*e*s of cooking are highly heterogeneous, adaptable and dynamic, implying the need for a multiplicity of technical solutions, as well as ongoing technical adaptation to address changed social and cultural expectations. The standardised responses produced by governance from above do not tend to meet all of the needs of the messy real world. In addition, as demonstrated by the relative failure of the NPIC, top-down approaches appear to be less flexible and responsive to changing needs.

To provide some further nuance to the characterisation, the top-down approaches adopted by, at least some of, the corporations studied, have included elements of participation and responsiveness to real-world cooking practices (ref. the *co-creation* approach applied by BP). It is argued that by their very nature, commercial organisations are more likely to be motivated to adapt products in response to changing consumer needs, since it is only by meeting these needs that products will be sold and profits will be made. Nevertheless it is not clear that the corporations will have the philanthropic staying power to continue the *niche experiments*, in order to keep iterating their product offerings in response to the changing and dynamic needs of cooks. As discussed above, it is also clear that these corporations will not be able to serve the bulk of poor households which cannot afford to pay for ABSs.

Bottom-up approaches on the other hand have a much greater chance of responding to the needs on the ground, given the participatory practices followed. The relatively smaller governance structures are also more able to adapt quickly as these needs change. However while responsive and adaptable, these bottom-up structures to date have not managed to reach anything like the scale of change required in India. At a recent workshop attended by the author, it was reported the total number of stoves disseminated by all major European development agencies and NGOs to date (GIZ, SNV, Shell Foundation, Practical Action, GERES and GVEP) globally was around 8.8 million (5.7 million of which were in Asia, 450,000 in India) (GIZ HERA Programme 2011); while this is a creditable number, it represents decades of work and large expenditures of time and money. More generally, it is not clear that bottom-up approaches, by themselves, will have the broader transformational effects on policy and the cooking system needed to achieve a mass-scale transition.

In governance terms, top-down approaches such as the NPIC can be said to have a tendency to dis-empower actors at the household level. The principal way in which agency could be exercised by households under the NPIC, was to choose to adopt (or not) an improved stove, then use (or not) that stove, and finally to replace the stove (or not) when the old one was broken. The end result was that while many households adopted stoves, these generally fell into disrepair and were not replaced; this can be seen as *agency by veto* on the part of cooks, rather than *agency by participation*. NPIC did not appear sufficiently responsive to the needs of households; it did not allow them to exercise sufficient agency by feeding up information on their opinions, needs and attitudes, to the levels at which decision-making was taking place. The process of governing by targets and subsidies under the NPIC achieved results directly reflecting the targets themselves (namely numbers of stoves installed) rather than reflecting the needs of the cooks. If these needs had been met, it is highly likely that a self-perpetuating transition would have resulted. By contrast, the sanitation programme analysed in Bangladesh focussed on community participation, agreeing objectives in terms of the final results required (clean, safe sanitation) rather than taking an object oriented stance, focussing on pre-determined technologies; this approach proved much more successful.

What appears to be required is a programme and governance structure that is dynamic and responsive to the (changing) needs of users, while being able to achieve mass-scale change. Without recognising the realities of cooking practice a transition to clean cooking appears very unlikely. The silent traditions, and innate wisdom, of developing cooks (Crewe 1997) must be heard both within the design and during the implementation of interventions; the very fact that they are silent (ie unspoken) does not relegate their importance.

The programme structure and governance approach required would allow for effective communication down (on health education for example), while giving cooks agency through the flow of information regarding their needs to the upper levels. Clearly it would be essential not only for the information from users to flow up, but also for it to acted upon – that is to have some agency. One option that might be considered is the use of citizen's juries, whereby a representative sample of cooks would be engaged over a sustained period, for example during programme definition stages, and periodically during programme implementation. In this way the programme structure would allow a *co-evolution* of technologies and associated support, representing active, reflexive governance (Loorbach 2009). Such co-evolution will be required on an ongoing basis, from the start of the new government programme and all of the way through the stages of programme implementation. At the programme definition stage, representation by at least some cooks is essential to try to achieve consensus of objectives and visions between programme designers and the general population, and hence ensure alignment and (some) political legitimacy of these objectives (Shove et al 2007).

On-going two-way communication and information flows will also be essential to assess both the technical performance and socio-cultural adaptedness of stoves disseminated, in order that learning from experiments is maximised (Loorbach 2009), and on-going iterations can be made. Not only is it highly unlikely that ABS designers will get it right first time for all cooks, but changes in the socio-technical landscape – such as demographic changes, changed household practices associated with adapting gender roles or increased school attendance by children – will require on-ongoing process of technology co-evolution. Cook-stove developers and manufacturers could consider more active engagement with cooks, through – for example – recruiting employees from representatives of the target populations.

While the very nature of the new Indian cook-stove programme implies that g*overnance from above* will be present, the weakness of meso level governance institutions, demonstrated by the poor representation of cooks within the previous NPIC, should be addressed in order to allow for more *governance from below* (Newell et al 2009). The suggestion is that a top-down approach needs to be complemented by a *middle-out* approach whereby institutions at the meso level have both the capacity and the power to represent cooks and influence change (Janda et al 2011). These meso level actors and institutions are likely to include existing sector-based institutions (eg civil society organisations working on community health, gender, or rural development), state structures in the form of Panchayats, and actors and institutions in, or working with, existing private sector actors. All would require sustained capacity development and knowledge enhancement to provide them with the required knowledge and skills regarding the cooking sector.

Meso level institutions would require enhanced data on an ongoing basis, to allow for effective tracking of the transition process and to maximise learning (Loorbach 2009). This could take the form of improved centralised data collection systems (eg NSSO and census) designed to gather a more complete picture of cooking practice involving multiple fuel/stove strategies within individual households. However this would need to be complemented with on-going, in-depth socio-anthropological studies to support understand of cultural and social factors. Finally, technical monitoring of improved stoves once adopted should be extensive, including through the use of remote stove-use monitoring equipment (Ruiz-Mercado et al 2011).

Recommendation 3: Exploit carbon financing scheme with the state taking a leading role

It is recommended that options for a state-run carbon financing cook-stove programme should be explored, to exploit the value of greenhouse gas emission reductions that are achieved through the adoption and use of improved stoves. Such revenue should be used to provide impetus for the transition to clean cooking.

At the time of writing (July 2012) the carbon markets are depressed, and there is considerable uncertainty regarding the future design of carbon market mechanisms as the world waits to discover what will follow the Kyoto Protocol. In recent years the single project approach of the Clean Development Mechanism (CDM) has been expanded to broader Programmes of Activity (PoA). However there is also much policy debate surrounding the potential for bi-lateral carbon offset deals (between a carbon offset generating developing country and a buying country) associated with Nationally Appropriate Mitigation Actions (NAMAs)[48], as a means of scaling up carbon revenue flows and achieving more transformative impacts than have been possible under the CDM (see for example (Baron et al 2009)).

The extent of the reductions of greenhouse gases depends on a number of factors including the previous (baseline) stoves and fuels used, the proportion of non-renewable biomass (NRB) in the fuel mix, the type of improved cook-stoves adopted and the extent to which they are used as a replacement for the baseline stoves. One study estimates that adoption of 160 million advanced biomass stoves in India would reduce national emissions by 80 million tonnes CO_{2e}/year (4.1% of national greenhouse gas emissions) or 0.5 tonnes CO_{2e}/household/year on average, conservatively assuming NRB fraction of 10%[49]. Even assuming the conservative figure of 0.5 tonnes CO_{2e}/household/year (which is in line with the findings of other researchers including MacCarty et al (2008)), if the price of carbon offsets were taken to be €5/tonne CO_{2e} [50], the revenue generating potential of adopting an ABS would be €17.5 per household over a 7 year crediting period, a significant proportion of the cost of many ABSs. Nationally, assuming a complete mass-scale transition involving the adoption of 142 million ABSs (ref Chapter 1), potential revenue of over €350 (£215) million per year would be available; note that previous estimates of over US$1 billion per year were based on higher carbon prices (Venkataraman et al 2010).

[48] NAMAs were first discussed within the UNFCCC COP/MOP in Bali in 2007, and later formed part of the Copenhagen Accord.
[49] This estimate accounts for CO_2, CH_4 and N_20 only, and thus represents an under-estimate since it does not include black carbon which would be reduced by "...about 0.15 MT annually, which is approximately one-third of the total national human-caused emissions of this pollutant..." (Venkataraman et al 2010, p71).
[50] Note that CER prices have ranged from a high of €20/tonne CO_{2e} in 2008 to the current low of around €3/tonne CO_{2e} (www.pointcarbon.com, July 2012).

While this figure involves considerable uncertainty, it highlights in broad terms the potential significance of this revenue stream. It is argued that there are benefits to using this revenue as an integral part of a national cook-stove programme, as opposed to its exploitation by individual project developers under the Clean Development Mechanism or one of the many voluntary carbon offset schemes. Firstly the transaction costs of individual carbon offset cooking projects are high in proportion to the revenues available; this is especially true given the current historically low price of carbon offsets on the market, and has resulted in a very limited success rate of carbon offset cooking projects in India; at the time of writing (July 2012) no cooking CDM PoAs had been registered by the CDM Executive Board in India[51].

Figure 21 highlights that of all Kyoto greenhouse gas emissions from solid fuel cooking in India, nearly 65% are from wood and charcoal (assuming 10% non-renewable biomass), while 11% each derive from agricultural residues and dung, and 15% are from coal stoves. Thus emissions from cooking in India are dominated by biomass using households. However this is a result of the fact that the vast majority of Indian households use biomass as a cooking fuel; on a per household basis emissions from biomass burning stoves are much lower than for coal, implying that the relative transaction costs of creating carbon offsets for the majority of Indian (biomass-using) households will be high compared with coal using households.

While this thesis does not explore the many intricacies of the design of carbon market mechanisms, it is argued that there are significant advantages to be gained from the government aggregating carbon offset generation from improved cook-stove use. State institutions would work to aggregate greenhouse gas reductions from cooking, in a manner analogous to a programme (CDM PoA)

[51] Note that cooking PoAs have been registered in Kenya, Nigeria and Bangladesh as of July 2012 (cdm.unfccc.int accessed 26th July 2012)

operated by the Indian Bureau for Energy Efficiency (a statutory body under the federal Ministry of Power) which aims to achieve widespread use of compact fluorescent light-bulbs[52].

A centrally managed carbon cooking programme, with the government acting as an aggregator, would reduce the relative importance of transaction costs, and act as a provider of up-front, patient capital, the absence of which has caused the failure of cooking carbon offset projects in the past. The Government of India is in a position to use existing data gathering exercises (eg NSSO, census), suitably adapted, as a means of verifying emissions reductions on a sector-wide basis, hence reducing the incidence of gaming which might be practised for individual carbon offset projects. For example the Government of India could use an upcoming national data collection process (eg NSSO) to generate a baseline for cooking sector emissions, comparing this with the same process in 5-10 years to demonstrate the emission reductions achieved. Centrally managed data collection processes could be complemented with a comprehensive monitoring of a sample of households adopting improved cook-stoves, using the recently developed remote monitoring systems to determine the actual use of these stoves (Ruiz-Mercado et al 2011).

The carbon offset revenues generated by a government managed scheme, could be used to support some of the transformative policy and strategic, sector-wide issues (eg user education, standards, R&D) required to catalyse a transition, as well as for end-user subsidies. This contrasts with individual CDM projects, for which carbon offsets claimed are required to be directly attributable to emissions reductions (Würtenberger 2012).

As noted above, subsidy schemes need careful design to ensure efficiency and equity, and avoid destroying existing markets for stoves. A government managed, carbon-based, subsidy programme has the potential to improve equity by targeting such finance at poorer households (for example through existing welfare scheme structures); this contrasts with individual carbon offset project

[52] Under the "Bachat Lamp Yogna" programme CFLs will be distributed to grid-connected households in exchange for incandescent light-bulbs and a subsidy of IRs. 15 will be provided (http://www.beeindia.in/content.php?page=schemes/schemes.php?id=1 accessed July 2012)

developers who are likely to be motivated to use carbon revenues to increase profits while continuing to serve middle income customers. The use of carbon finance for end-user subsidies could also be aligned with the Government's stove testing regime, whereby only those stoves achieving certified technical standards would be associated with end-user subsidies. Lastly, clever design of a subsidy scheme might be designed to support both *adoption* and *use* of improved cook-stoves, exploiting the carbon/development *mutually reinforced benefit* whereby generation of carbon offsets require monitoring of actual equipment use rather than merely its adoption (Simon et al 2012, Barnes et al 2012).

7.5 Concluding thoughts

As a practitioner in the field, the author deliberately selected a normative question (how to achieve a transition to clean cooking), aiming at producing policy relevant conclusions. An inter-disciplinary approach was adopted, integrating elements of natural science associated with cook-stoves and their material impacts, with social, cultural, political and economic aspects of the cooking sector. Theoretical and conceptual insights were taken from the areas of socio-technical systems transitions, governance and practice theory. In the event this broad-based approach necessarily resulted in a relatively wide but less deep analysis within each of the disciplines than would have resulted from limiting the research to just one of these disciplines.

In undertaking this research the author has become increasingly aware of the practical difficulties of undertaking inter-disciplinary research, especially when associated with a complex, multi-factorial sector such as cooking. Initial ambitions, targeting an integration of findings across disciplines and theoretical approaches, for all actors within the whole of the cooking sector in India, were quickly rejected as unfeasible given the paucity of data, and poorly characterised parameters and complex web of causal relationships associated with the cooking sector.

As noted by Professor Paul Collier (lecture for Social Sciences Division, Oxford 18/11/10) the social world is often "...*irreducibly complex and idiosyncratic... and hence defeats social science models*...".

He goes on to note that taking full account of context is essential if social scientists are to make sense of the world. The implication is that in solving particular problems (in this case how to achieve a transition to clean cooking) social scientists often have to tackle more general issues related to social science. This is the approach attempted within this thesis, to gather the empirical data that could be obtained within the time available, and place this in an overall social, cultural and political context using different theoretical approaches. This has resulted in analysis offering both descriptive and explanatory power regarding the past and present, leading to well-founded policy recommendations concerning enhanced approaches for the future.

E O Wilson describes the ultimate need for integration of disciplines and the knowledge each generates, bridging the natural sciences and humanities; he describes a *consilience* approach to scholarship as *"...a 'jumping together' of knowledge by the linking of facts and fact-based theory across disciplines to create a common groundwork of explanation*..." (Wilson 1998, p7).

This research has barely scratched the surface of a consilience approach to understanding cooking in India. Considerable further research and learning by doing is required to understand how to achieve an equitable mass-scale transition to clean cooking in India. Future research agendas are suggested, including some which might, with the benefit of hindsight, have proved more tractable, for example the study of meso level organisations in India and their role in supporting a transition to the use of improved cook-stoves. However, this thesis has contributed analysis of new primary data, as well as framing the issue in novel conceptual and theoretical ways, resulting in a contribution to scholarship and conclusions of relevance in the world of practitioners and policy makers.

8 Annexes

8.1 Annex 1 (Chapter 4): Socio-economic classification system employed for the survey

Using Socio Economic Classification (SEC) is a widely accepted means of classifying households in India. The classification system used to identify households in this Focus Group research is that established by the Market Research Society of India (MRSI). It provides a more nuanced determination of SEC group compared to methods relying on income alone, and is the same system used for the focus groups in the following chapter, making comparisons and cross-references easier.

In urban areas (and peri-urban areas) the MRSI system uses *occupation* and *education* of the Chief Wage Earner (CWE – the person who contributes maximum to household income) of a household to classify it into the following – A (A1 and A2), B (B1 and B2), C, D and E (E1 and E2), in descending order of socio-economic status. See Table 36.

In rural centres, the MRSI system uses the *education* of the Chief Wage Earner, and *Type of house* to classify households into R1, R2, R3 or R4 (again in descending order of socio-economic status). The type of house is categorised into three types: *Kuchha*, *Semi-Pucca* or *Pucca,* defined as follows[53]:

- Kuchha House: the walls and/or roof are made of material other than those mentioned below, such as un-burnt bricks, bamboos, mud, grass, reeds, thatch, loosely packed stones, etc. are treated as kuchha houses
- Pucca House: one which has walls and roof made of the following material: Wall material: Burnt bricks, stones (packed with lime or cement), cement concrete, timber, ekra etc. Roof Material: Tiles, GCI (Galvanised Corrugated Iron) sheets, asbestos cement sheet, RBC, (Reinforced Brick Concrete), RCC (Reinforced Cement Concrete) and timber etc.
- Semi -Pucca house: A house that has fixed walls made up of pucca material but where the roof is made up of the material other than those used for pucca house.

[53] http://www.mospi.gov.in/ecs_Ins_Manual_part_I_two.htm

Table 36: Socio-economic classification system for urban areas

		ILLIT-ERATE	SCHOOL UPTO 4 YEARS	5 - 9 YEARS	SSC/ HSC	SSC/HSC BUT NOT GRADUATE	GRADUATE / POST GRADUATE GENERAL	GRADUATE / POST GRADUATE PROF
		1	**2**	**3**	**4**	**5**	**6**	**7**
Unskilled worker	**1**	E2	E2	E1	D	D	D	D
Skilled worker	**2**	E2	E1	D	C	C	B2	B2
Petty trader	**3**	E2	D	D	C	C	B2	B2
Shop Owner	**4**	D	D	C	B2	B1	A2	A2
Business/Industrialist with No. of employees None	**5**	D	C	B2	B1	A2	A2	A1
1 – 9	**6**	C	B2	B2	B1	A2	A1	A1
10+	**7**	B1	B1	A2	A2	A1	A1	A1
Self Emp.Prof.	**8**	D	D	D	B2	B1	A2	A1
Clerical/Salesmen	**9**	D	D	D	C	B2	B1	B1
Supervisory level	**10**	D	D	C	C	B2	B1	A2
Officers/Executives Junior	**11**	C	C	C	B2	B1	A2	A2
Officers/Executives Middle - Senior	**12**	B1	B1	B1	B1	A2	A1	A1

Table 37: Socio-economic classification system for rural areas

		Type of House		
Education		**Pucca**	**Semi Pucca**	**Kuchha**
		1	2	3
Illiterate	1	R4	R4	R4
Literate but no formal school	2	R3	R4	R4
Up to 4th Standard	3	R3	R3	R4
Up to 9th Standard	4	R3	R3	R4
SSC / HSC	5	R2	R3	R3
Some college but not graduate	6	R1	R2	R3
Graduate / Post graduate – General	7	R1	R2	R3
Graduate / Post graduate – Professional	8	R1	R2	R3

8.2 Annex 2 (Chapter 4): Supplementary survey details

Supplementary data for fuel and stove use

Table 38: Stove most used (% of households in each SEC group) in all urban areas surveyed, West Bengal, 2008

	SEC A	SEC B	SEC C	SEC D	SEC E
Unweighted Base	*206*	*408*	*450*	*476*	*582*
Weighted base	160	300	341	551	770
LPG / Gas Stove	66	57	38	14	4
Kerosene Paraffin Stove	4	3	3	3	2
Kerosene Pump Stove	2	4	6	5	3
Chullah - Type 1 (Simple arrangement of 3 bricks)	0	1	2	2	1
Chullah - Type 2 (made of Mud) - Fixed to the ground	16	22	32	47	68
Chullah - Type 3 (made of Cement) - Fixed to the ground	0	0	0	1	1
Chullah - Type 4 (made of Mud) - Movable	12	13	20	28	20
Chullah - Type 5 (made of Cement) - Movable	0	1	1	1	2

Table 39: Stove most used (% households in each SEC group) in rural areas surveyed

	SEC R1	SEC R2	SEC R3	SEC R4
Unweighted Base	*39*	*80*	*332*	*573*
Weighted Base	*34*	*70*	*495*	*419*
LPG / Gas Stove	39	43	10	1
Kerosene Paraffin Stove	2	0	2	0
Kerosene Pump Stove	6	1	2	2
Chullah - Bricks	0	0	1	1
Chullah – Fixed Mud	45	49	68	83
Chullah – Fixed Cement	0	0	1	1
Chullah - Movable Mud	9	8	16	12
Chullah - Movable Cement	0	0	0	1

Table 40: Fuel reported as used most often (%) urban only (n=2,122), survey areas, West Bengal, 2008

	All Urban	SEC A	SEC B	SEC C	SEC D	SEC E
Unweighted Base	*2122*	*206*	*408*	*450*	*476*	*582*
Weighted Base	*2122*	*160*	*300*	*341*	*551*	*770*
LPG	21	62	49	33	12	3
Kerosene	2	0	1	2	2	1
Coal (Full Koyla)	9	4	7	8	10	11
Kacha koyla	3	1	1	2	2	5
Fire wood	18	4	8	11	20	28
Cow Dung Cake	13	6	6	12	15	16
Dust Coal	20	13	16	20	27	18
Saw dust	0	0	0	0	0	0
Agricultural waste	2	0	1	1	1	4
No response	*12*	*10*	*11*	*11*	*11*	*14*

Table 41: Fuel reported as used most often (% households in each SEC group) rural only (n= 1,204), survey areas, West Bengal, 2008

	All Rural	SEC R1	SEC R2	SEC R3	SEC R4
Unweighted Base	*1024*	*39*	*80*	*332*	*573*
Weighted Base	*1019*	*34*	*70*	*495*	*419*
LPG	8	30	34	8	1
Kerosene	0	0	0	1	0
Coal (Full Koyla)	12	18	6	16	8
Kacha koyla	3	0	2	3	3
Fire wood	26	7	24	23	30
Cow Dung Cake	20	17	10	18	24
Dust Coal	13	23	9	15	11
Saw dust	0	0	0	0	0
Agricultural waste	4	0	1	2	7
No response	*14*	*5*	*14*	*14*	*16*

Details of data gathering and analysis methodology for quantifying fuel consumed

Table 42: Questions asked of respondents concerning variation in current fuel use compared with other seasons (winter (Oct to Feb) and summer (Mar-Jun))

Likely to increase by more than 2 times than what I am using currently (Please specify)
Likely to increase by 2 times more than what I am using currently
Likely to increase by 1/2 more than what I am using currently
It is not likely to change
Likely to reduce to 1/2 of what I am using currently
Will not use at all

Approach to calculating the total consumption for each fuel type Source: (TNS India Pvt Ltd et al 2008)

1) Monthly data for each of the fuel types was collected, and seasonally adjusted;
2) Population data for Bardhaman (aggregating the population data for specific blocks) and Midinipur district (from Census data (www.censusindia.net)).
3) Number of Households by considering average number of member in each household (from sample data);
4) Average monthly consumption of each type of fuel in a household (separately for each SEC in Urban and Rural);
5) Total Annual Consumption for each type of fuel.

Table 43: Number of households in rural survey areas, split by SEC group

	Number Households				
RURAL	**R1**	**R2**	**R3**	**R4**	**Total households**
SEC Split by IRS 2007	**4%**	**7%**	**48%**	**41%**	
Asansol	2,213	3,871	27,544	23,298	56,927
Durgapur	3,184	5,569	39,622	33,514	81,888
Bardhaman North	8,512	14,888	105,927	89,598	218,925
Bardhaman South	8,149	14,253	101,409	85,776	209,587
Katwa	5,860	10,250	72,928	61686	150,725
Kalna	6,836	11,957	85,072	71,958	175,823
Midinipur Sadar Sub	7,846	13,722	97,633	82,583	201,784
Total	42,601	74,509	530,136	448,413	1,095,659

Table 44: Number of households in urban survey areas, split by SEC group

	Number Households					
URBAN	**A**	**B**	**C**	**D**	**E**	**Total households**
SEC Split by IRS 2007* - Asansol	**9%**	**14%**	**15%**	**20%**	**42%**	
Asansol	21,668	34,910	38,521	50,559	107,136	252,793
SEC Split by IRS 2007 - Rest of West Bengal*	**7%**	**14%**	**16%**	**27%**	**35%**	
Durgapur	11,606	22,400	25,565	42,527	5,5675	157,773
Bardhaman North	4,844	9,349	10,671	17,750	23,238	65,852
Bardhaman South	0	0	0	0	0	0
Katwa	83	161	184	305	400	1,133
Kalna	735	1,418	1,618	2,692	3,524	9,987
Midinipur Sadar Sub	2,306	4,451	5,080	8,450	11,062	31,348
Total	41,242	72,688	81,638	122,283	201,035	518,887

Table 45: Rural and urban populations and derived number of households for the survey areas

	Total rural population	**Total number of rural households (derived)**	**Total urban population**	**Total number urban households (derived)**
Asansol	284,634	56,927	1,263,967	252,793
Durgapur	409,442	81,888	788,865	157,773
Bardhaman North	1,094,623	218,925	329,262	65,852
Bardhaman South	1,047,937	209,587	0	0
Katwa	753,624	150,725	5,666	1,133
Kalna	879,114	175,823	49,933	9,987
Midinipur District	1,088,907	201,784	155,903	31,348
Total	**5,558,281**	**1,095,659**	**2,593,596**	**518,887**

Table 46: Summary cross-tabulation of satisfaction levels reported for main fuel used (% of households), survey areas, West Bengal, 2008

Main fuel		Satisfaction level reported						Total
		0 (no response)	1	2	3	4	5	
Coal	Count	8	23	98	150	13	0	292
	% within Main fuel	2.7%	7.9%	33.6%	51.4%	4.5%	.0%	100.0%
Cow dung cakes	Count	48	130	98	180	13	1	470
	% within Main fuel	10.2%	27.7%	20.9%	38.3%	2.8%	.2%	100.0%
Dust coal	Count	32	95	115	221	43	5	511
	% within Main fuel	6.3%	18.6%	22.5%	43.2%	8.4%	1.0%	100.0%
Kacha koyla	Count	16	6	28	26	0	0	76
	% within Main fuel	21.1%	7.9%	36.8%	34.2%	.0%	.0%	100.0%
Kerosene	Count	8	5	14	10	5	0	42
	% within Main fuel	19.0%	11.9%	33.3%	23.8%	11.9%	.0%	100.0%
LPG	Count	9	252	167	159	54	0	641
	% within Main fuel	1.4%	39.3%	26.1%	24.8%	8.4%	.0%	100.0%
Wood	Count	39	67	105	363	38	2	614
	% within Main fuel	6.4%	10.9%	17.1%	59.1%	6.2%	.3%	100.0%
Total	Count	160	578	625	1109	166	8	2646
	% within Main fuel	6.0%	21.8%	23.6%	41.9%	6.3%	.3%	100.0%

Table 47: Calculated GHG emissions (tonnes), Kyoto basket, all urban households (Bardhaman and Midnapore)

		CO_2 (tonnes)	CH_4 (tonnes)	C02e from CH_4 (tonnes) (3)	N_20 (tonnes)	CO_{2e} from N_20 (tonnes) (3)
LPG		65,225		26	3	945
Kerosene		88,333	20	517	11	3,527
Coal		179,881	589	14,735	17	5,336
Kacha koyla		61,452	201	5,034	6	1,822
Fire wood (100% NRB) (2)		380,691	1,401	35,041	25	7,518
Fire wood (15% NRB) (2)		57,103	1,401	35,041	25	7,518
Fire wood (10% NRB) (2)		38,069	1,401	35,041	25	7,518
Fire wood (5% NRB) (2)		19,034	1,401	35,041	25	7,518
Cow dung cakes (1)			1,081	27,040	72	21,488
Dust coal		414,499	1,358	33,954	41	12,295
Saw dust		11,624	42	1,070	1	229
Jute / agricultural waste (1)			613	15,342	4	1,203
Total	total tonnes CO_{2e}			**132,761**		**54,366**
	100% NRB	1,201,709				
	15% NRB	878,121				
	10% NRB	859,086				
	5% NRB	840,052				

Notes for this table and the following one:

(1) net CO_2 emissions from dung and agricultural residues are assumed to be zero, since the fuels are renewable

(2) Different values are used the 'non-renewable biomass' fraction of wood, since reliable data is not available for the areas surveyed (following (Venkataraman et al 2010))

(3) IPCC 2007 - 100 year Global Warming Potentials (GWP) have been used (Source: IPCC, 2007): CO_2 – 1; CH_4- 25; N_20-298

Table 48: Calculated GHG emissions (tonnes), Kyoto basket, all rural households (Bardhaman and Midnapore)

	$C0_2$ (tonnes)	CH_4 (tonnes)	$C0_{2e}$ from CH_4 (tonnes) (3)	N_20 (tonnes)	CO_{2e} from N_20 (tonnes) (3)
LPG	70,256	1	28	3.4	1,018
Kerosene	191,693	45	1,124	25.7	7,655
Coal	457,370	1,498	37,466	45.5	13,567
Kacha koyla	91,122	298	7,464	9.1	2,703
Fire wood (100% NRB)	983,526	3,621	90,531	65.1	19,424
Fire wood (15% NRB)	147,528	3,621	90,531	65.2	19,424
Fire wood (10% NRB)	98,352	3,621	90,531	65.2	19,424
Fire wood (5% NRB)	49,176	3,621	90,531	65.2	19,424
Cow dung cakes		2,810	70,265	187.4	55,837
Dust coal	713,404	2,337	58,439	71.0	21,162
Saw dust	16,640	61	1,532	1.1	329
Jute / agricultural waste		2,583	64,573	17.0	5064
Total	total tonnes CO_{2e}		**331,423**		**126,759**
	100% NRB	2,524,014			
	15% NRB	1,688,017			
	10% NRB	1,638,840			
	5% NRB	1,589,664			

8.3 Annex 3 (Chapter 5): Instructions to focus group facilitators and questioning route provided

Introduction

I am xxxx from the xxxx and I am helping Philip Mann, from the University of Oxford, who is undertaking research into cook-stoves and cooking fuels used in Indian houses. As part of this research he wants to hear your opinions on how the cooking is done in your house.

Participation in this research is entirely voluntary. Philip will record this session to help him remember what happened but he will not make the recordings public.

Please feel free to say whatever you want to during this session. There are no 'right' or 'wrong' answers. You are the experts and we want to hear what you have to say. Before we start, let's introduce ourselves briefly. *Introduce yourself and then me:*

"Philip lives in Oxford, UK. His work involves researching how people cook in different countries and how it affects their lives. Philip started working, over 20 years ago, in Sierra Leone in West Africa, where he was a teacher at a secondary school and cooked using a 3-stone fire for a year."

Then go round the group and ask each person to introduce themselves briefly (their name, where they live, family etc. Please ask for education of the main wage earner (rural, urban and peri-urban groups) and profession of main wage earner (urban and peri-urban only) and make a note if houses are kuchha, pucca or semi-pucca.

Focus Group Questions

1. Think about the cooking stove (or stoves) and fuel(s) you use to cook in your house. What do you like about these and why did you choose them? Is there anything you do not like about them (problems you have)? *[use the pictures on the card if necessary to identify the type of stove used]*.

Follow-up questions:

- 1\. What are the best 3 and worst 3 things about the stove you currently use (eg convenience, time spent cooking, time spent collecting fuel, food taste, cost, house cleanliness, availability of fuel, smoke inside house, safety etc.).

- 2\. Do you cook with the same type of stove and fuel that your mother and grand-mother used?

- 3\. Are there any differences in how you cook throughout the year (seasonal changes)?

- 4\. If you cook with more than one type of stove, which one do you use most often and how many meals do you cook with this stove?

2. Do you want to change the stove and/or fuel you use? If so, why? If not, why not *[The most important issue for me is the reason(s) that they do not want to – or cannot – switch. I would like to separate problems of affordability from other things that are stopping them from switching.]*

3. If you want to switch, please tell us which stove/fuel would you like to switch to and why (in other words, how would this make your life better)? *[Discuss alternatives that they know of, and the reasons why they like them or do not like them.]*

4. Did you know that some modern stoves, using wood and other fuels, are available in India now *[although not currently available in this area]?* These make much less smoke in the house, and cook cleanly and efficiently. What do you think of them? *[show picture, explain about stoves and say that these are only 2 examples of modern stoves – many other types also exist];*

5. How are decisions about buying new things (such as a new stove) made in your house? *[do you discuss with your husband and decide together; do you tell your husband what you would like but leave it to him to make the decision; or do you decide yourself and go ahead and buy without asking anyone?];*

6. How do you hear of new ideas such as new stoves, and what is most likely to persuade you to switch (advertising, newspaper, neighbour, radio/TV, women's group etc.)?

7. Thinking about the future, and try to imagine how you would like to be cooking next year. If you would like to change the stove and/or fuel that you use, what are the things that stop you from switching them and how might these problems be overcome?
   Follow up:
   - are there any particular circumstances that might make it easier to switch?

Do you have any questions or any other things that you would like to say?

End of focus group

Thank subjects for their participation, and say that this will be very useful for the research Philip is doing. Identify those we might want to interview separately, and ask them when would be convenient.

8.4 Annex 4 (Chapter 5): Brief description of areas in which focus groups were conducted

FG1*:* this rural village was observed to be the poorest of those visited, along with FG2. It comprised around 1,350 people over the age of 18 (source: electoral list), with 15 households officially Below Poverty Line (BPL), although direct observation indicated that a larger proportion of houses were in poverty. All houses were in the *Reserved* category, meaning that they were made up of *scheduled castes and tribes.* The main economic activity appeared to involve subsistence agriculture, some commercial rice production and brick making (in local factory).

FG2*:* this peri-urban area houses also included many in clear poverty and would be described as a slum. It housed around 1,500 people, with 7 houses officially Below Poverty Line, and 25% of the people in the *Reserved* category, meaning that they were made up of *scheduled castes and tribes* (Univ of Bardhaman person, pers comm.). Note that personal observation highlighted poor living conditions in this area.

FG3*:* this peri-urban area was on the edge of more formal settlement of apartment blocks providing accommodation for the workers in the nearby Durgapur factories. Most of the houses were not brick built. The immediate area has around 2,000 people in 500 houses. Durgapur town (which this community fringes) is highly industrialised, with evidence of a great deal of heavy industry powered by coal, which was in evidence everywhere.

FG4*:* this rural small town was made up of around 120 households, and was noticeably wealthier than any of the other Focus Groups. This rural area was largely agricultural with a mix of food and cash crops, the latter mainly mulberry grown as a food crop for silk worms. Other economic activities seen included brick-making. The area is known to be water limited, with bore-holes being driven to 1,000 feet to find water. The biomass in the Kolar District zone has previously been determined to be 78% non-renewable (Kiran Kumar, SKG Sangha, personal communication, reporting results of a report by the Indian Institute of Science, 2005), indicating that wood is increasingly scarce.

FG5: This rural village was adjacent to FG4, although it is in a different administrative district. The village is noticeably poorer than focus group 4, with more evidence of subsistence agriculture and less production of cash crops than FG4. Figures for caste make-up were not available.

8.5 Annex 5 (Chapter 6): Private sector questionnaire

Introduction

I am undertaking research into the cook-stoves market in India for my PhD, and am writing to seek your views on some issues as part of this work. The overall objective of my research is to analyse the current context of the clean cooking sector in India, as a means of improving understanding of how mass-scale transitions to clean cooking in India might be achieved. I am placing this work within the overall theoretical context of socio-technical transitions, viewing the cooking sphere as a system made up of institutions (in the widest sense) interacting in a variety of ways and at a variety of scales.

As part of this research I have already gathered and analysed data on the attitudes and behaviour of users (cooks) in India, and I am now researching the involvement of multi-national private sector organisations in the cooking sector. The emergence of large private sector involvement in the cooking sector clearly represents a very significant development and I am aiming to answer the following broad questions about this:

1) What has been the focus of activities to date, why do multi-nationals engage in the cooking sector, and what has been achieved?

2) What particular skills and resources do large private sector organisations bring, and how have these been deployed?

3) How can the impact of multi-nationals be optimised, either through actions by others (international organisations, public sector, local private sector or civil society) or by enhancing partnerships with them?

There are two options for your involvement:

1) Complete a short survey questionnaire which is available at http://www.surveymonkey.com/s/8GNWMF7. This could be followed up with a brief telephone interview to elaborate or clarify certain points. If you choose this option, I would be very grateful if you would complete the survey by 29th July.

2) If you are short of time, we could instead only undertake a telephone interview. This would take around 45-60 minutes and would be based on the questions within the survey referenced above. If you would prefer this route, please e-mail me with one or two available slots during which I can call you for the interview.

Your involvement in this research is entirely voluntary. The results will be used only for the purposes of my PhD research. Your responses can remain non-attributable to you and your organisation should you so wish.

Thank you in advance for your input into this research, which is much appreciated.

Questions

1. It would be helpful to be able to quote some of the responses, and attribute them to you, the respondent (for example "Jo Blogs from Stove Inc highlighted the achievement of his/her organisation, having ......"). However you can choose for some or all of your responses to be included in the research in an entirely non-attributable manner. If you would like all of your responses to be non-attributable, please write "YES" in the following box. If you would like some of your responses to remain non-attributable, please make this clear within the particular response(s), by saying "please do not attribute this response".

2. Please tell me about yourself and your organisation:
   - Name:
   - Company:
   - City/Town:
   - Country:
   - Email Address:
   - Phone Number:

3. What is your position in this organisation, and - briefly - what has your involvement been in the cooking activities of this organisation?

Activities of your organisation to date in the cooking space

1. What cooking research and development activities has your organisation undertaken, and what products have resulted? Did this involve partnerships with local research or other organisations? How did this process engage with users? I am very interested in how your company forges relationships with users, seeks their opinions and participation? How do you ensure responsiveness to user needs?

2. What market development activities has your organisation undertaken (eg social and/or product marketing) and in which states in India (or other developing countries)? Were local partners involved? If you can please highlight the particular expertise in market development that your organisation has brought to these activities. Please outline the level of activity to date and indicate over which period this has occurred (number of retail outlets in place, number of stoves distributed etc.).

3. Does the activity of your organisation focus on particular elements of the market, for example users of a specific fuel, peri-urban or rural consumers, low/middle-income households etc?

4. Please outline the cooking products that your organisation makes? Do you employ a centralised manufacturing model, and if so, where are your products manufactured?

5. What financial strategy/business model is your organisation using? – are products sold at commercial rates to all users? How much do they cost? - is there any price differentiation between high/middle/low income households? - are you – or do you have plans for – using carbon finance, and if so how will this revenue stream be used to develop the market (financing research, entrepreneurs or direct subsidies to low income households)

6. Does your organisation have any specific objectives/targets for say the next year, next 5 years, next 10 years in India (or other developing countries)? These could be numbers of stoves distributed, new markets or products developed etc.

Your views on the role of large private sector organisations in the cooking sector

7. The aim of this section is to give you the opportunity to present your views on the particular strengths that large private sector organisations such as yours bring to the cooking sector in developing countries, any weaknesses they may have and how the impact of their work could be optimised, either through actions by others (international organisations, public sector, local private sector or civil society) or by enhancing partnerships with them? Please feel free to answer either in general terms about multi-nationals, or in specific terms relating to your organisation. Please also use this section to add any other comments you feel are of relevance.

Thank you very much for your participation.

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