Driving towards More Flexibility?
China’s Environmental and Climate Policy in the Automotive Sector

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Driving towards More Flexibility?

China’s Environmental and Climate Policy in the Transport Sector

Abstract

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This doctoral dissertation examines the mode and efficacy of environmental and climate policy in China’s automotive sector. The ascent of China’s automobile market to the largest worldwide has detrimental effects on the country’s energy security situation, worsens environmental pollution, and increases greenhouse gas emissions. Environmental and climate policy measures to ameliorate these repercussions are the most apt tools available to the Chinese government. The objective of this dissertation is to identify the dominant mode of environmental and climate policies in China’s automotive industry and to assess the efficacy of select policy instruments. It does so by asking whether a uniform national approach to policy instrument adoption can be discerned that reflects China’s institutional and administrative history or whether modal exceptions exist. Secondly, if modal differences exist, to what extent do different instruments confirm the current understanding of the advantages and pitfalls of individual policy instrument types? And finally, how do Chinese instruments compare to those in other ambits in terms of policy mode and instrument efficacy?

The literature on policy instruments holds that, due to their alleged efficiency advantages, incentive-based instruments dominate the political agenda of industrialised countries and international organisations (environmental consensus). This favouring of flexible instruments in academic and political circles contrasts with an evident lack of incentive-based instruments in practice and an observed lack of efficiency of some of those instruments actually implemented. Moreover, the policy mode adopted in developing
countries and emerging markets has not yet received sufficient academic attention despite significant differences in institutional design, enforcement capacities, resources, and development paths that may imply reason for modal deviation.

Applying a blend of qualitative and quantitative social sciences research methods, I add the case of China to the comparative literature and show that command-and-control regulation indeed forms the backbone of environmental and climate policy in China’s automotive industry. At the same time, modal differences exist between national regulation and local/municipal incentive-based policy as well as in the electric vehicle sector, which shows a trend towards more incentive-based instruments and flexibility mechanisms in conventional regulation. Compared to other ambits, China has established a relatively flexible policy regime, at least for the case of vehicle efficiency standards. For the time being, incentive-based instruments remain comparatively ineffective and flexibility mechanisms in conventional regulation have an erosive effect on instrument stringency.
## Glossary

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>BEV</td>
<td>battery electric vehicle</td>
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<tr>
<td>CAC</td>
<td>command-and-control regulation</td>
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<tr>
<td>CAFC</td>
<td>corporate average fuel consumption</td>
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<td>EREV</td>
<td>extended range electric vehicle</td>
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<td>EPI</td>
<td>environmental policy instrument</td>
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<td>EV</td>
<td>electric vehicle</td>
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<td>HEV</td>
<td>hybrid electric vehicle</td>
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<tr>
<td>MBI</td>
<td>market-based instrument</td>
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<tr>
<td>NAFC</td>
<td>national average fuel consumption</td>
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<tr>
<td>NEV</td>
<td>New energy vehicle</td>
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<tr>
<td>PEV</td>
<td>plug-in electric vehicle</td>
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<tr>
<td>PHEV</td>
<td>plug-in hybrid electric vehicle</td>
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<tr>
<td>VES</td>
<td>vehicle efficiency standard</td>
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Chapter One

1. Introduction

1.1 Terms and Definitions

The subject of this research project is environmental and climate policy in China’s automotive sector, approached from an interdisciplinary perspective. This introductory chapter serves to provide the overall framework for the presentation of this thesis, and it will begin with the explanations of the terms and definitions relevant to this project.

The doctoral research presented here touches upon three areas of policy. As the title indicates, the central theme of this dissertation is environmental and climate policy. The Oxford Dictionary defines policy as “a course or principal of action adopted or proposed by an organisation or an individual” (www.oxforddictionaries.com). Throughout this thesis, the unit of analysis is that of the State or, more specifically, that of the government at different levels of the State, i.e. central, provincial/ municipal, and local. With regard to the environment, policy then applies to the impact of human action on the physical ecosystem.

As this dissertation examines the environmental and climate effects of the automotive sector, it will concentrate on the direct and indirect emissions of vehicles, i.e. greenhouse gases (GHG) and criteria pollutants. For the purposes of this work, environmental policy describes those political
measures that aim to directly or indirectly influence automotive emissions of criteria air pollutants, e.g. lead (Pb), carbon monoxide (CO), sulphur oxides (SO₃), nitrogen oxides (NO₃) and particulate matter (PM).

It is important to underline the common yet not necessarily intuitive differentiation applied in international climate negotiations between environmental policy targeting such criteria pollutants and international climate policy, which focuses on greenhouse gas emissions, e.g. nitrous oxide (N₂O), methane (CH₄), and carbon dioxide (CO₂). Regulatory approaches to governing the emissions of such greenhouse gases are subsumed to climate policy. As CO₂ is the foremost greenhouse gas in the automotive sector, this dissertation will concentrate on climate policies tackling CO₂.

A third and final policy area this research project touches upon is industrial policy. The automotive industry is a major component of the international economy. It constitutes sizeable shares of national gross domestic products, labour markets, multilateral trade relationships, and technological innovation. As such – and due to the sensitive role of technological advancement, technology leadership, and competition in this industry – policies influencing this industry are intimately scrutinised by a wealth of stakeholders ranging from automobile manufacturers, to suppliers, environmental and climate interest groups, and government bodies. Changes, strategies, and outcomes in the realm of environmental and climate policy thus have an economic dimension that must not be underestimated.
The means by which environmental, climate, and industrial policy is translated into practice are policy instruments. In this dissertation, I classify two groups of policy instruments: command and control (CAC) regulations and incentive-based instruments (IBIs). Due to their alleged efficiency advantages, the latter class has come to dominate the theoretical literature and political agenda of international institutions (Bell, 2003; Bell and Russell, 2003). This dominance of market ideology in academic and political circles contrasts with an evident lack of incentive-based instruments in practice (Cole and Grossman, 1999; Jordan et al, 2013) and an observed lack of efficiency of some of those instruments actually implemented (Barde, 1997; Blackman and Harrington, 2000).

The selection, successful implementation, and enforcement of policy instruments depend on the institutional context of a specific country (Da Motta et al, 1999; Bell, 2003; Bell and Russell, 2003). Consequently, different institutional regimes, contexts, traditions, and paths produce different, nationally distinct policy modes (Martin, 2003). This institutional aspect of environmental and climate policy is especially relevant in the case of developing countries and emerging markets, where enforcement is often impeded by a lack of resources (Da Motta et al., 1999), skills (Shi and Zhang, 2006), and insufficiently equipped or empowered enforcement agencies (Lo and Tang, 2006). In the transport sector – and here increasingly the automotive sector – the choice, assessment, and categorisation of policy instruments are integral to understanding the legislative path or its policy mode.
Policy instruments in the automotive sector are multifaceted and range from industry development plans to criteria pollutant and GHG emission standards. One group of instruments that receives particular attention worldwide is that of vehicle efficiency standards (VES) (iCET, 2011b; ICCT, 2011a). Such standards refer to (binding or voluntarily agreed) measures that limit the amount of fuel a vehicle is permitted to consume per distance driven. Individual vehicle consumption is tested in standardised drive cycles. Depending on the standard regime, consumption limits either outlaw any excess consumption by individual vehicle models or allow offsetting them via a fleet average per automobile manufacture (or groups thereof). In any case, vehicle efficiency standards have significantly influenced vehicle technology and average energy efficiency, i.e. fuel economy, of automobiles in the most important vehicle markets worldwide. Such standards are thus an integral part of climate policy in these ambits (ICCT, 2004; 2007; Plotkin, 2001).

As this dissertation has a distinct geographical dimension, I should point out the different geographic, administrative, and institutional levels I incorporate in my work. I compare policy modes at the level of the nation state. References to “China” in this work pertain to the geographic confines of the People’s Republic of China. Although former British and Portuguese colonies, such as Hong Kong and Macao, have been returned to China in the last millennium, the statistics, laws, and technical standards referred to in this dissertation exclude these territories unless otherwise stated. This is due to the fact that China officially pursues a political strategy of ‘one country, two systems’, i.e. a blend of communist and liberal systems in the political and
economic integration of the former colonies and its special administrative zones. As will be shown in the body of this dissertation, many of the China-specific issues and challenges in the automotive sector arise from its historic institutional path as well as its unique history of economic development, such as the vast scale of its domestic automotive market as well as its enormous and fast-paced growth. The individual histories, developmental paths, experiences, and regulatory responses of the former colonies render these cases distinctly dissimilar from the Mainland Chinese case. They should thus be subject to separate revision and investigation. For similar reasons, the case of Taiwan is omitted from the investigations outlined in this work. In addition to international comparisons and an account of China’s dominant national policy mode, I compare different policy instruments across Chinese municipalities. The geographical level of my analysis is thus multi-layered.

The final dimension of my research I would like to define exceeds mere political and geographical consideration. Rather, this research project investigates a technological field that has received tremendous international attention both from industrial practitioners and technical experts as well as academia and politics over the past five or so years, i.e. the area of electro-mobility. For the purpose of this dissertation, electro-mobility refers to the political, regulatory, industrial, and technological areas of the automotive sector that support, develop, regulate, design, adopt or otherwise pertain to road-going automobiles with partially or wholly electrified drive trains. This definition excludes non-automotive modes of transport, such as trains, trams, and subways. Although investments in such public transport systems have
reached record heights in China, their inclusion would exceed the limits and boundaries of this research, and I hence decided to exclude non-automotive transport modes from this dissertation.

Similarly, I decided to exclude another sizeable and growing form of vehicle electrification from this analysis, i.e. the tremendously successful Chinese e-bike. This latter omission is motivated by a more normative definition of what electro-mobility should be – namely environmentally and practically sustainable. While some authors argue that electric two-wheelers can constitute a sustainable, energy-efficient, and hence ‘green’ mode of urban transport (Ji et al, 2012), my research, interviews with practitioners, and exchange with experts on Chinese electro-mobility have led me to believe that electric two-wheelers are not (yet) a sustainable alternative to conventional vehicles. This is as much due to their out-dated technology, i.e. environmental and climate issues related to the production and recycling of their lead-acid traction batteries, as it is to socio-economic patterns of their use: electric two-wheelers in China tend to replace more environmentally friendly modes, such as walking and conventional bicycles, rather than substitute journeys by internal combustion engine vehicles.

Instead of public transport and electric bikes, I define electro-mobility to include battery-electric vehicles exclusively powered by (advanced) electric propulsion systems as well as plug-in electric hybrid vehicles that use both electric propulsion systems as well as internal combustion engines (either for electricity generation or to propel the vehicle itself). The ‘plug-in’ component
is crucial in this differentiation, as the environmental and climate aspects of the electric vehicles examined in this dissertation are the direct result of upstream emissions associated to the charging of traction batteries with electricity from the grid. In China, the electro-mobility sector is often referred to as the New Energy Vehicle sector. Lacking official and comprehensive definition, this terminology often refers to both the abovementioned (partially) electrified vehicles as well supposedly highly efficient or otherwise environmentally beneficial alternative fuel vehicles, such as automobiles using liquefied petrol gas (LPG) or compressed natural gas (CNG) as fuel. This dissertation excludes such New Energy Vehicles and instead concentrates on the abovementioned plug-in electric vehicles.

So far, I have presented some raw definitions of the terms used in the title of my thesis as well as the basic policy fields it is situated in. In the remainder of this introduction, I describe the topic of my project more broadly and present the methodological approaches adopted. In the next section, I state the overall objective of the dissertation, list its main research questions as well as discuss the significance of the project. Section three positions the dissertation with regard to the different academic disciplines it pertains and contributes to. In section four I present the methodology of my research, while section five outlines the structure of the whole dissertation. In the final section, I conclude the introductory chapter by clarifying the scope and limitations of my research.
1.2 Objectives, Topic and Significance

My interest in the topic of this thesis stems from a broader fascination with the automotive sector. The automotive industry is a powerhouse of the international economy. Over the past decades, the sector (and with it its auxiliary services and supply industries) has developed into one of the most globalised industries in terms of manufacturing, sales, marketing, supply chains, and distributive channels. Car ownership (especially of the more expensive, luxurious type) has become a symbol of prosperity, individual success, and status all over the world. This is increasingly true for countries undergoing rapid economic reform and development. China is a prime example of this development as its domestic automotive market has been jumpstarted from negligible size in the 1990s to one of the world's most important and sizeable markets. This development has sparked aspiration and concern alike. With the growing international political and economic standing of the country, the Chinese government is adamant to complement its market with a strong, internationally competitive domestic automotive industry. China is thus a prime case study to investigate the development and influence of the automotive sector.

On the less market-driven side, the societal, climate, and environmental repercussions of the global automobile market have risen to the political agenda. Growing levels of motorisation have led to an ever-increasing ‘thirst for oil’ despite advancements in individual vehicle efficiency. Similarly, the concentration of internal combustion engine vehicles in urban centres is cause for rising air pollution levels. This is especially true for the case of
China where automobile exhaust fumes contribute the majority of urban criteria air pollutants (He et al, 2005; Wu et al, 2012).

As a result of these societal implications, regulatory measures to control and ameliorate environmental and climate effects of the growing fleet of vehicles have grown in significance. Why is it important to analyse these measures? Environmental and climate policies are the most apt tools available to governments to curb the impact of any industrial sector and to increase energy efficiency. Over 120 years of automobile development and production have led to a highly segmented international market. As a result, cheap yet inefficient and highly polluting vehicle technologies exist to cater to the more price-sensitive end of the market. Similarly, powerful and luxurious high-consumption vehicles, such as sports utility vehicles (SUVs), are becoming increasingly popular in sophisticated vehicle markets. The market evidently fails to align its product portfolio with the constraints posed by a limited resource base and the challenges of global warming and environmental degradation from vehicle emissions. Voluntary agreements between the industry and State authorities to address the responsibility of the automotive industry have failed to improve vehicle efficiency significantly (UBA 2010).

The need for binding legislation is thus unquestioned. As the influential markets in the US and Europe are subjected to increasingly more ambitious and stricter regulation, the international automobile industry develops vehicle technologies to meet these regulatory criteria. Especially in the area of vehicle efficiency standards, major car manufacturing countries and the
European Union seem to compete for the most stringent targets in order to foster efficient vehicles and increase their domestic manufacturers’ competitiveness (ICCT, 2004; 2011a; 2011b; iCET, 2011a/b).

Given the vast size and commercial importance of the Chinese automotive market, environmental and climate policies governing the automotive sector are of high relevance to international manufacturers and policymakers alike. The nature of the very instruments chosen thereby plays a major role – both in terms of the dominant policy mode in this sector as well as with regard to instrument efficacy. The literature on policy instruments attributes distinct efficiency and effectiveness advantages to specific instrument types. Generally, instruments granting more flexibility are thereby seen as efficient albeit lacking in effectiveness. Conversely, rigid regulation is seen as producing the desired environmental outcome at the cost of inefficient implementation. The objective of this dissertation is to describe and account for the most important policy instruments in China’s automotive sector and to analyse the efficacy of select instruments.

Finally, my research pertains to a very recent but highly significant phenomenon in automotive policy, i.e. the integration of electric vehicles in the existing canon of laws, regulations, and standards. Electro-mobility has time and again been seen as the necessary and unavoidable technological solution to transport-related problems. Following this paradigm, a number of geographically scattered, mostly uncoordinated technology development programmes and pilot projects have been implemented worldwide by
governments, companies, and public-private partnerships over the past decades (Hoogma et al., 2002). While some of these projects showed initial success in promoting electric vehicle (EV) technology, they have failed to pave the way for a successful introduction of EVs that are competitive in terms of overall costs and performance.

Recently, the combination of volatile and generally high oil prices, rising international awareness of the repercussions of criteria pollutant and greenhouse gas (GHG) emissions, ensuing political movements to curb CO₂ emissions, advances in key EV technologies, e.g. traction battery and lightweight materials, as well as a more structured and concerted political approach towards the development and deployment of electric vehicles seems to have changed the tide in favour of a sustained large-scale marketisation of electric vehicles. Dijk et al. interpret this favourable combination of pull and push factors as an emerging worldwide trajectory towards electro-mobility (2012).

The prospective gains from mostly electrified transport, such as lower emissions, more efficient use of energy, decreased dependence on oil imports, and especially technology leadership in the global electric vehicle market have motivated several countries to develop their associated sectors and become the global ‘lead market’ for EV applications. As a result, the technical, institutional, regulatory, and market environment of electro-mobility is highly dynamic. Paramount forces in this development are Japan, the United States, several European countries, such as Germany, the United
Kingdom, and France, as well as China (McKinsey, 2008; 2012; BMBF, 2008). In these countries, political support and industry endeavours have been institutionalised in a range of co-operations between State and industry¹. Support by political authorities is particularly strong in China, which is unanimously seen as one of the most promising markets in terms of EV development and deployment (McKinsey, 2008; 2012).

The objective of this dissertation is to investigate the dominant mode of environmental and climate policies in China’s automotive industry and to assess the efficacy of select policy instruments. The guiding question of this undertaking is: how flexible is China’s policy regime, i.e. is Chinese policy in this sector dominated by a command-and-control or incentive-based approach? Given the vast scale of the country as well as the industry, the question arises whether a uniform national approach to policy instrument adoption can be discerned that reflects China’s institutional and administrative history or whether modal exceptions exist geographically or by policy fields, e.g. electro-mobility. If modal differences exist, to what extent do different instruments confirm the current understanding of the advantages and pitfalls of individual policy instrument types? For instance: what are the implications of increased flexibility on policy effectiveness? Finally, how do Chinese instruments compare to those in other ambits in terms of policy mode and instrument efficacy?

¹ See for instance the Nationale Plattform Elektromobilität (national platform electro-mobility, NPE) in Germany (BMU, 2010).
The answers to these questions have implications both in theory and in practice. From a practical perspective, the investigation of China’s dominant policy mode in the automotive industry provides actors in this sector with a degree of certainty regarding future policy. Vehicle efficiency standards are a good example for the demand for certainty from both regulated parties and regulators. Such standards set the political (and hence industrial) target for efficiency improvements for vehicles for the immediate future. They thereby allow to compare the level of (nominal) standard stringency of different standard regimes with each other and to align individual policy goals accordingly. Similarly, such standards provide manufacturers with a degree of certainty concerning the political request for technology innovation and increased energy efficiency. The automotive industry, i.e. manufacturers and suppliers, profits from a reliable policy environment that guides its abatement endeavours. My research project helps increase this degree of reliability by characterising China’s policy mode, identifying trends in the adoption of different instrument types, comparing the degree of flexibility granted to industrial actors, and putting these aspects into a wider context of China’s institutional and administrative traditions.

While the work in this project is thus beneficial to the industry side, Chinese politics and policy analysts stand to profit as well. The investigation into instrument efficacy performed in this dissertation creates an empirical basis against which to assess the performance of individual instruments. This analysis and assessment can contribute to future improvements in policy
design and instrument choice – and hence can ultimately lead to better policy.

Finally, the research presented in this dissertation concerns the integration of electric vehicles into the existing regulatory regime for conventional vehicles. This integration is particularly (but not exclusively) relevant to vehicle efficiency standards. The investigation of current integration approaches presented here can serve to improve policy design in the future – particularly with regard to the environmental and climate effects of electromobility.

Apart from the potential contributions to policy-making and manufacturer strategy, the project is also significant from the perspective of existing theories and empirical research. These aspects of the project are considered in the following section on the theoretical perspectives and methodology of this dissertation.

1.3 Theoretical Perspective and Contributions

In this section, I position the research project presented here in relation to existing theories and research traditions in geography and environmental policy. The academic area of transport “is not necessarily a science, but a field of application borrowing concepts and methods from a wide variety of disciplines” (Rodrigue, 2013). Accordingly, the investigation in this dissertation touches upon a wealth of academic disciplines, i.e. transport geography and transport studies, environmental and climate policy, energy
studies, and area studies to name but a few. As the main objective of this work is to identify, categorise, analyse, and assess environmental and climate policy instruments in China’s transport sector, I shall position my thesis first and foremost in those academic disciplines that directly pertain to this approach.

Transport geography and transport studies classically concern themselves with the implications of transport structures in spatial systems and the interactions in spatial networks and relationships (Hoyle and Knowles, 1992; Tolley and Turton, 1995). Specifically, these disciplines traditionally concern themselves with themes such as mobility, urban transport, or regional development. Contrary to this general notion of transport geography, geographic aspects of my work pertain to spatial scales, i.e. the comparison of different instruments across nations (meta-scale) and between locales (micro-scale).

The second academic discipline my research touches upon concerns policy instruments. The literature on policy instruments is divided into two interconnected fields. The first field addresses instrument choice and aims to find trends in policy adoption. Drawing on institutionalist theory (Da Motta et al, 1999; Bell, 2003; Bell and Russell, 2003), varieties of capitalism (Peck and Theodore, 2007; Hall and Soskice, 2004), policy advocacy and network theories (Sabatier, 1988; Bressers and O’toole, 1998), different contributions to this field find different determinants for instrument choice. This literature identifies rather inconsistent trends for instrument adoption. While some
authors hold that incentive-based instruments have become the first choice of decision-makers and academics alike (e.g. Bailey, 2010), several authors believe that the adoption of such instruments strongly depends on the economic and institutional context of a specific country. Accordingly, they argue that a deficient institutional environment impedes the adoption of incentive-based instruments in developing countries and emerging markets (Bell, 2003; Bell and Russell, 2003; Cole and Grossman, 1999). My research contributes to this academic debate by systematically classifying and cataloguing the most important policy instruments in China’s automotive sector.

The second literary field assesses policy efficacy (Lotspeich, 1998; Tietenberg, 1990; Santos et al, 1999). This literature is concerned with how effectively and efficiently different instruments reach a stipulated environmental goal, what the effects of different instruments are on innovation (Cohen, 1998), and how much coercion is needed by the State to enforce specific instruments (Blackman and Harrington, 2000). The debate in this literature is as old as environmental policy itself and has traditionally centred on the classic dimensions of instrument efficiency and effectiveness.

While the number and exact nomenclature of instruments differs over time and between publications, most contributions to this literature identify command-and-control legislation on the one hand and incentive-based instruments on the other. According to this traditional conception, command-and-control regulation is effective but inefficient while incentive-based instruments are more efficient, but potentially less effective. Increasingly, a
hitherto mostly disregarded third dimension is gaining in popularity, namely that of instrument *flexibility*. This latter dimension traditionally pertains to the ease and degree of freedom granted to regulators, the monitoring and enforcement apparatus, or (most significantly) the polluters themselves. The most important contributions of this literature are the detailed classification of different policy instruments and the analysis and evaluation of individual policy instruments.

The case of China is underrepresented in all fields of the literature. The few studies on China’s policy mode have shown that, contrary to textbook assumptions, command-and-control regulation is to a large degree ineffective in China. Reasons are seen in a lack of proper enforcement and implementation (Blackman and Harington, 2000), especially at the local level (Ross, 1984; Beyer, 2006). The implementation gap and lack of conversion of legislation into business practices of (mostly state-owned) enterprises has motivated scholars to solely emphasise institutional implementation problems in Chinese environmental policy.

This one-sided focus runs at least two risks: first, the pessimistic view of China’s institutional capacity to implement incentive-based instruments hinders scholars to adequately describe the status quo of and trends in Chinese environmental policy. In developed countries, some authors see a trend towards the increased adoption of incentive-based instruments – a development that Bell and Russell (2003) call the *environmental consensus*. The many differences between these countries in terms of their institutional
tradition and context, economic orientation and system, political history, bureaucratic capacities, and experience with policy implementation render the success and efficacy of individual instruments highly uncertain. In the case of China, scholars have long identified and condemned systemic deficiencies in policy design and implementation. The root causes of deficient and ineffective policy are generally seen in China’s institutional environment, such as its inability to follow through with centrally devised action plans all the way down its many line ministries to their actual implementation at the local level (Zhang, 2008), a lack of technical, financial or human resources at the implementation level (O’Connor, 1998), or the adverse influence of polluters and other interest groups on China’s partially corrupt enforcement apparatus (Tang et al, 1997). Chinese policy design, on the other hand, is often seen as ambitious and mostly technically sound – at least on paper. This prevalent focus on institutional aspects of policy effectiveness (and with it, the implied reliance on path dependence as the primary explanatory paradigm in instrument choice) ignores important characteristics of environmental and climate legislation in China, such as an emerging trend towards more flexible instruments (SEI, 2012).

Secondly, academic analyses of China’s environmental and climate policy have mainly focused on labour-intensive and highly polluting industries that are sheltered from international competition or otherwise protected by the interests of the Chinese state. A consensus seems to exist among Chinese policymakers at the national and the local level that strict environmental regulation of these industries is too expensive to comply with, or the cost of
production added by environmental regulation would lead to a relocation of production facilities to other countries (Zhang, 2008; Blackman and Harrington, 2000; Wang and Lu, 1997). Increasingly, however, Chinese environmental policy has become the focal point of international conglomerates, companies, and original equipment manufacturers (OEMs) that either target China as an export market for their products or run sizeable manufacturing capacities in the country. Accordingly, the environmental and climate regulations governing these internationally competitive sectors are a worthwhile area of investigation.

As mentioned above, the Chinese automotive industry bears prominent importance due to the vast size of the Chinese market and the associated high volume of sales by national and international OEMs, the emissions and oil consumption of its many vehicles, and the tremendous political support for the development of an export-oriented domestic automotive sector. Recently, the electric vehicle sector within this industry has received tremendous governmental support, both financially and politically, despite uncertainties as to the projected development of this sector worldwide (Tran et al., 2013). While several academic studies include modal differences between policy instruments in several sectors of the Chinese economy (Ross, 2005; Hills and Man, 1998), an empirical investigation of policy instruments in China’s automotive sector both at the national and the local level has so far been omitted from thorough classification of the instruments used as well as from investigations of their efficacy and especially flexibility.
Correspondingly, the overarching contribution of this thesis to the different academic fields is threefold. First, it aims to determine the mode of environmental policy instruments applied in China’s automotive sector according to the command-and-control vs. incentive-based instruments framework. It thus adds the case of China’s automotive sector to the body of comparative literature. Second, it assesses and compares internationally the degree of flexibility select instruments grant polluters in their abatement strategies. Finally, it determines the efficacy of select instruments and enables future comparison of similar instruments in other ambits.

Especially with regard to the last point, this research project concerns the assessment of instrument efficacy in very specialised policy fields, i.e. electromobility and vehicle efficiency standards. The literature on vehicle efficiency standards traditionally compares such standards according to their nominal stringency. Individual flexibility mechanisms, however, render such comparisons mostly inexact. A thorough analysis of these potentially erosive mechanisms is only starting to take shape. First academic studies have shown the relevance of such mechanisms and have begun quantifying their erosive effect for the case of US standards (Lutsey and Sperling, 2012). A thorough comparison of flexibility mechanisms in fuel economy standards or a quantification of their effect for the Chinese case is as of yet missing.

1.4 Methodology

In order to meet the demands and research traditions of the different theoretical and academic disciplines introduced in the last section, the
doctoral research presented in this dissertation uses a blend of methodological approaches. As this work is first and foremost a geographical and political investigation into the policy regime governing environmental and climate aspects China’s automotive industry, the qualitative and quantitative methods applied stem from established research traditions of the social sciences.

As the core of this research project is the analysis of individual policy instruments, the principal methodology applied in this work follows the canon of methods in traditional policy analysis. Policy analysis clusters into qualitative and quantitative methods (Morgan and Henrion, 1990; Walker, 2000). I applied qualitative methods in this research project in two different ways. The very analysis of the canon of policy instruments in China’s transport sector is part of a detailed case study. The case of China’s vehicle efficiency standards is thereby compared at the national level to standard regimes in the US and Europe. At the sub-national level, I analyse different cases, i.e. local instrument applications in different Chinese cities. Where possible and feasible, I code qualitative data for quantitative analysis.

In addition to case studies, I apply textual analyses of legal documents as another qualitative research method. Similar to other scholars in the field (Tietenberg, 1990; Mickwitz, 2003), I categorise individual policy instruments according to a pre-defined set of criteria, e.g. command-and-control based regulation vis-à-vis incentive-based instruments.
Quantitative methods cluster into two groups of statistical processes, i.e. descriptive and exploratory statistical techniques. Where possible, I underline, emphasise, portray or otherwise illustrate facts, relationships, and developments over time via descriptive statistics. Any form of data analysis requires valid and reliable data. For both my qualitative and quantitative analyses, I apply a wealth of primary data in the form of official laws, standards, communications, statistical reports, proprietary statistics, and other documents sourced from the relevant practitioners, decision-makers, and government authorities in China.

The findings presented in this dissertation are the result of five years of research – including 3.5 years of fieldwork in China. The parts of this work investigating Chinese laws and regulations required extensive desktop research of primary legal texts, communications, and official announcements. This qualitative review of national and local policy plans, laws, regulations, and standards is based on original legal texts procured from the websites of and personal contacts to the relevant authorities or via proprietary databases such as LexisNexis (http://www.lexiscn.com). In cases where original legal documents were unavailable online, I contacted the relevant Chinese authorities directly or procured information from newsletters, e.g. Young Crane E-News on Transport and Climate Change in China, contemporary press reporting or scientific literature as indicated in the body of this dissertation.
I enrolled for one academic year at Peking University for Difficult Language Training (DLT), sponsored by my studentship with the British Inter-University China Centre (BICC). During that time, I succeeded in founding an extensive network of personal contacts with practitioners and decision-makers in the Chinese transport sector. The most significant and by far most fruitful of these relationships is that with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, the implementation agency of the German government for international cooperation. My cooperative relationship with GIZ greatly facilitated my access to information and data. As part of this partnership, I have been working with the GIZ project Electro-Mobility and Climate Protection in China since the end of Trinity 2010 as consultant and project manager in the design of the project component on integrating electric vehicles into Chinese fuel economy standards for light-duty vehicles and in the technical cooperation with Chinese implementation partners, the coordination of events, conferences, and workshops on the development of electric vehicles in China and their integration into environmental standards. The cooperation was a direct result of my stay abroad (DLT) in Beijing and the related network of specialists I have been able to build. Working with the GIZ has greatly enhanced my research through daily interaction with key Chinese institutions, such as the Ministry of Industry and Information Technology (MIIT), the Ministry of Science and Technology (MoST), the National Development and Reform Commission (NDRC), the Chinese Automotive Technology and Research Centre (CATARC), Tsinghua University, and Chinese as well as international automobile manufacturers. The cooperation with GIZ ensured that my research remained
up to date and relevant to both academic as well as practitioner discourses. Please refer to the ‘Limitations’ section below for a discussion of my GIZ association.

1.5 Structure

Before turning to the limitations of my research and what it is and –more importantly –is not about, I shall like to present the structure of the dissertation. Following this introduction, the dissertation starts with a brief survey of the literature that introduces the theoretical framework for the later comparison and analysis of policy instruments. In this survey, I delineate different policy modes, i.e. mostly distinct policy instrument types that feature specific advantages and pitfalls, and link the design and application of these instrument types to the institutional environment in which policymaking takes place in China. I also introduce the concept of instrument flexibility in relation to the efficacy, i.e. effectiveness and efficiency, of different instrument types. I conclude this general theoretical section with a more detailed description of the internationally most significant instruments used in the context of climate and environmental policy in the automotive sector.

In the subsequent chapter, I highlight the omissions and gaps in the literature with regard to China and its automotive sector. The chapter points out the current Chinese institutional environment of policymaking in the automotive sector. Together with the literature review, this chapter sets the frame for the
subsequent analysis of the dominant policy mode and individual instrument efficacy.

Chapters four to seven present the core of this doctoral research. This research project follows the publications route of the School of Geography and the Environment of the University of Oxford. Accordingly, the core of the dissertation consists of four independent chapters that have been submitted as manuscripts to peer reviewed journals. The requirements of the respective journals prescribe that each chapter has its individual research questions, literature review, and methodology. This requirement has led to four separate and independent papers that form the core of this dissertation. As a result, the core chapters are more stand-alone and independent as would be the case in a conventional doctoral dissertation. They do, however, form a cohesive and complementary investigation into the efficacy and flexibility of policy instruments in China's automotive sector.

Chapter four attempts to answer the question: what is the dominant mode of environmental and climate policy in China's automotive sector? It aims to change the analytical paradigm of Chinese policy assessment towards the inclusion of the effects of increasing flexibility of policy instruments on instrument effectiveness. It does so by categorising over 35 of the most important national and local policy instruments in China’s automotive sector according to the command-and-control vs. incentive-based instruments framework. The chapter shows that – contrary to the dominant view in the literature - environmental and climate policy in China’s automotive sector is
not exclusively rigid and command-and-control oriented. While CAC regulation forms the backbone for policy in this sector, a drive towards increased flexibility can be discerned in the form of 1) flexibility mechanisms (especially in fuel economy standards) that render classic regulation more flexible, 2) a significant application of incentive-based instruments in the policy field of electro-mobility, and 3) a geographical divide in terms of policy mode that shows a higher concentration of command-and-control regulation at the national level and more incentive-based instruments at the local level.

The chapter was submitted to the Journal of Environment and Development and has been accepted for publication. The chapter is published in the print edition of the journal under the title “Overview and Analysis of Environmental and Climate Policies in China’s Automotive Sector” and can be accessed online (Journal of Environment and Development, Vol. 22, No. 3, pp. 284-312, DOI: 10.1177/1070496513492520).

If modal differences exist in policy instrument adoption according to geographic lines and the electro-mobility policy field, what are the implications for instrument effectiveness? Chapter five investigates the effectiveness of two major policy instruments in China’s electro-mobility sector, the national demonstration programme for electric vehicle deployment and the local license lottery quota for electric vehicles in Beijing. The results show that – despite tremendous support by the government - neither instrument succeeded in bringing about its stipulated results. Reasons for this ineffectiveness cluster around technical boundaries.
diminishing the attractiveness of electric vehicles and deficiencies in policy design.

If – as suggested by the findings in chapter four – certain mechanisms can render Chinese standards more flexible, what is the extent of this flexibility and how does it compare to international benchmarks? This question is the guiding theme of the final two core chapters. Chapter six takes the most significant and influential policy instruments in China’s automotive sector, i.e. fuel economy standards, as a case study. The chapter compares the degree of flexibility granted to automobile manufacturers in the most important fuel economy standard regimes of the US, EU with that of China and shows that all three ambits have moved to a wider use of flexibility mechanisms both in number and scope. While Chinese standards set relatively inflexible and comparatively lenient fuel consumption limits in the first phases, the latest revision has raised nominal stringency to the level of EU standards. At the same time, Chinese standards have been amended by a wealth of flexible mechanisms, particularly in the electro-mobility sector.

The final core chapter examines the effect of flexibility mechanisms in Chinese vehicle efficiency standards. The academic literature has only recently begun to quantify the erosive effect of flexibility mechanisms for electric vehicles on the stringency of (US) fuel economy standards. Chapter seven therefore calculates the erosive effect of flexibility mechanisms for electric vehicles on the fuel economy obligations of Chinese manufacturer BYD over the period from 2012 through to 2015. The chapter also gives an
outlook on the effect current accounting methods for electric vehicles could have on national average fuel consumption if applied beyond 2015. This industry-level analysis implies that zero-counting and super-crediting electric vehicles in combination with the ambitious market penetration plans of the Chinese government could lead to foregone fuel economy improvements of 4.5 per cent in 2015 and up to 22.8 per cent in 2020. This is equivalent of additional \( \text{CO}_2 \) emissions of 224,161 tonnes and up to 11.5 million tonnes, respectively.

The latter three core chapters have also been submitted to peer reviewed journals. A decision on all three manuscripts is pending. Chapter six has been submitted to the Journal of Energy Policy under the working title “Flexibility Mechanisms in fuel Economy Standards”, chapter five to the Journal of Transport Policy as “Electro-Mobility in China: Rationale and Instrument Effectiveness”, and chapter seven has been submitted to the Journal of Energy Policy under the working title “The Erosive Effect of Integrating Plug-in Electric Vehicles in Chinese Fuel Economy Standards”.

The main chapters are followed by a conclusions chapter, which reiterates the aims, research questions, and methodology of the dissertation. It then summarises the findings of the core chapters, underlining the links and interrelations of the respective findings. Finally, it provides an outlook for further research.
1.6 Limitations

Finally, I should point out the scope and the boundaries of my research project and make its theoretical and spatial limitations explicit.

The limitations of this research project can be grouped into three classes, i.e. limitations of scope, limitations of the subject, and methodological limitations. Concerning the first limitation, this research project focuses on the Chinese automotive industry as a case study. Therefore, its scope is limited to an in-depth analysis of the Chinese case. The reason for this limitation to one country and one industry is the abovementioned relevance of the Chinese automobile market for the global sector. This limitation does not imply that other markets and political or regulatory developments therein are less relevant. Quite the contrary - where possible, comparisons are drawn to other international markets and ambits to underline Chinese trends or peculiarities. As this thesis should be seen as a comparative case study and an investigation into the flexibility of Chinese policy, the limited focus is to be expected. At the same time, the in-depth analysis of the Chinese case permits generalisation and implications for other cases. These ‘lessons learnt’ are pointed out in different parts of the dissertation.

Secondly, the scope of this project is limited to the light-duty vehicle sector. While heavy-duty vehicles, such as trucks and lorries, contribute to total energy use and greenhouse gas emissions, most forecasts of the Chinese market focus on passenger cars. Given China’s low car ownership rates per capita, the light-duty vehicle market will continue to grow tremendously and
thus remain at the top of the political agenda. Furthermore, standards regulating heavy-duty and commercial vehicles have entered the political scene relatively late, even in forerunner ambits for vehicle efficiency standards.

Limitations of the subject mainly concern omissions in this dissertation with regard to the instruments analysed. Vehicle efficiency is first and foremost dictated by vehicle design. Vehicle efficiency standards directly pertain to this aspect. In real life, vehicle efficiency also depends on other factors, such as vehicle use and driving style. These latter aspects of vehicle efficiency are more difficult to regulate and can affect different strata of the society unevenly. A good example is fuel pricing. Fuel-efficient vehicles decrease the marginal cost of each kilometre driven. As a result, more efficient vehicles tend to incentivise higher annual mileages (Small and van Dender, 2007; Sterner 2007). This so-called rebound effect counteracts efficiency gains from fuel economy standards. Intelligent fuel pricing can ameliorate this effect and educates drivers to adjust their driving behaviour and car usage patterns. In China, fuel pricing is currently underdeveloped. This research project, thus, focuses on vehicle efficiency standards that directly affect vehicle design.

Methodologically, the analysis of instrument efficacy and flexibility is limited by a lack of data. This is particularly true for data on the automobile market itself. Such data are, to a large degree, proprietary and hence extremely expensive. Furthermore, data quality varies across sources and proprietors.
For this research project, a close cooperation was established with the GIZ project ‘Electro-Mobility and Climate Protection in China’, as mentioned above. The GIZ is a federally owned enterprise employed by the German government to achieve its objectives in the field of international cooperation for sustainable development. The project is funded by the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety and the Chinese Ministry of Science and Technology (MoST). It is jointly implemented by GIZ and the Chinese Automotive Technology and Research Centre (CATARC) and is supported by four official project partners (Chang’an Automotive Group, Volkswagen Group China, BMW Group, Daimler Northeast Asia Ltd.). As part of this cooperation, CATARC agreed to provide light-duty vehicle registration data for the years 2007 to 2010. The research presented in this work was fully funded by a studentship awarded by the British Inter-University China Centre (BIACC, via a grant by the Economic and Social Research Council). Neither the GIZ nor the BICC have been involved in the design, implementation, formulation, or proofing of the contents of this dissertation. The opinions voiced, findings presented, and conclusions drawn in this work are purely my own.
Chapter Two

2. Policy Instruments and the Institutional Dimension

This chapter reviews the relevant literature and research traditions in policy instrument choice, categorisation, and assessment. The chapter begins with a review of the most influential literature on the institutional context of policy-making. Then it turns to instrument choice and differentiation. The chapter closes with an overview of the literature on instrument assessment. As this research project concerns the automotive sector, the latter overview will also present the most commonly used environmental and climate policy instruments in this industry.

2.1 The Institutional Context of Policy-Making

Institutional factors are very relevant both in the choice of individual policy instruments as well as in their effective and efficient implementation. Institutions shape the process in which policies are designed and chosen. They also provide the enforcement mechanisms and apparatus needed to implement policy. Institutions thereby differ along spatial scales, i.e. countries, regions, and locales. These national or regional differences are significant and lead to differences in policymaking, policy enforcement, education and behaviour.
The literature on instrument choice is particularly rich in theories putting major emphasis on the institutional context. ‘Old’ institutionalism, for instance, dates back to the Greek antique and remained most influential throughout the 19th and early 20th century (Peters, 2005). This traditional approach is mainly descriptive, i.e. trying to explain variance in policy outcomes through case specific differences in the legal and other structures of a given political system. Since then, a range of new institutionalist theories has emerged. New institutionalist theories come in many flavours, ranging from the original normative approach (March and Olsen, 1984) over rational choice institutionalism (Ostrom, 1986) to historical institutionalism (Hall, 1986; Steinmo, Thelen and Longstreth, 1992). Such institutionally deterministic conceptions see institutions as durable shared belief systems that form and sustain common norms, values, and habits, which determine the design and setup of organisations as well as policies (Hodgson, 1998; North, 1993). Institutions are complementary, i.e. they create an institutional framework that influences new institutions to adapt to and hence to perpetuate the incumbent mode of institutions (Hall and Soskice, 2004). The resulting path dependency of institutions leads to a continued adoption of similar policy instruments in institutionally stable ambits. Different institutional contexts thus produce quite significantly different policy outcomes (Martin, 2003).

How do different institutional contexts affect the choice and efficacy of different policies? A branch of heterodox economic theory, new institutional economics, tries to integrate institutional determinants into neoliberal
thinking (North, 1993) to answer this question. According to this school, environmental policy takes place in a geographic, social, economic and institutional context that greatly affects instrument choice as well as effectiveness and efficiency. With the recess of Eastern European communism and the subsequent analysis of diverging economic, social and institutional paths within the ‘capitalist block’, an influential branch of heterodox economics claims that variations in the institutional setup of capitalist societies account for differences between capitalist systems.

Under the umbrella of the varieties of capitalism (VoC) theory, a bifocal worldview has emerged in this field that classifies capitalist systems into either of two factions: coordinated market economies, which rely on cooperation and consensus, a comparatively ‘strong’ state, long-term considerations in economic relations, and are backed up by equally long-term oriented patient capital; and liberal market economies, which are characterised by market-based standard setting, competition, and short-term and risk-intense profit seeking (Peck and Theodore, 2007; Hall and Soskice, 2004). These systemic distinctions result from historically grounded differences in national culture and institutional frameworks, which “incentivize and sustain different patterns of (economic) behaviour” (Peck and Theodore, 2007: 736). The institutional context of coordinated market economies thereby implies a policy mode that pertains to the ‘strong state’ paradigm, i.e. a relatively pronounced focus on command-and-control regulation by the State. Liberal market economies, in contrast, put major
emphasis on the power of the market and hence tend to prefer less State-dominated and more incentive-based modes of policy-making.

The VoC approach has been applied successfully to the case of developed capitalist societies. It has, however, paid little attention to the case of developing countries. The historic-institutionalist elements of VoC, such as institutional sustainability and path-dependency, allow for relatively little change in a nation's institutional environment. This is especially true for systemically different, former communist countries such as China. The mere transposition of capitalist rules, laws, norms, and values (i.e. institutions) or administrative and regulatory organisations is unlikely to yield the same results in formerly communist hosts. Second, the unit of analysis in this literature is the nation state. Such methodological nationalism is likely to impede the explanatory power of any institutionalist theory. Institutional economic geography offers a change of perspective that can overcome this problem: by breaking up limitations of national boundaries and looking at both supra- as well as sub-national levels, institutionalist geography can help identify local explanations for system-external change (Peck and Theodore, 2007). This means that regions with comparatively high degrees of administrative freedom, i.e. provinces and municipalities, can develop a new institutional context, which is better suited to face the demands of efficiency and effectiveness posed by market reforms and modernisation.

Institutions and the institutional context thus matter in both the choice of instruments and the degree to which individual instruments can be
implemented effectively and efficiently. The following section will shed light on what instruments are chosen in the current institutional setting of developed and developing countries.

### 2.2 Policy Instrument Differentiation

The debate on policy instrument choice and categorisation is as old as environmental policy itself. Different approaches categorise policy instruments along different continua, i.e. coercion, motivation, or diverse attribute and performance scales. In practice, policy instruments are differentiated into two classes that pertain to all three of these scales, i.e. command-and-control regulation and incentive-based instruments.

#### 2.2.1 Differentiation by the Degree of Coercion

In their quest to categorise different types of policy instruments, some parts of the literature highlight the degree to which these instruments apply power and authority vested in the State as a differentiating criterion (Hood, 1983; Woodside, 1986; Macdonald, 2001). The spectrum of instrument coerciveness ranges from laissez-faire, i.e. minimum or almost no coercion, to higher forms of obligatory measures (Doern and Phidd, 1992). On this scale, more suasive tools aiming to bring about behavioural change through persuasion and moral appeal score on the less coercive side. Pecuniary or other incentives score relatively higher, while coercive instruments such as standards, regulations, and nationalisation reach the highest scores on the scale.
The Canadian literature on policy instrument coerciveness is particularly rich and highlights the importance of this differentiation criterion. This school of thought is heavily influenced by a common understanding highlighting the reliance on ‘coerciveness’ as the sole criterion for instrument categorisation:

“[F]or academic policy analysts ‘coerciveness’ is the salient characteristic for distinguishing instruments, since any discussion of the various means used by governments must inevitably focus on the essential function of the state. Coercion, defined as the extent to which government forcefully attempts to mould activity in the market or the home, has always been the central subject of political debate” (Macdonald, 2001: 164).

Based on this common understanding, instrument categories and types differ between authors. Hood (1983), for instance, differentiates between “effecting” and “detecting” instruments that differ in their respective degrees of coercion applied. The former aim to change behaviour, the latter pursue the collection of information, e.g. on non-compliant behaviour. Woodside (1986), on the other hand, lists five categories of instruments: taxation, regulation, expenditures, public ownership, and moral suasion. Here, too, coercion is the differentiating and classifying criterion of policy instruments. Probably the most significant author in this field, Doern invented a single continuum model of instrument choice based on the degree of coercion. The model includes a scale of self-regulation, exhortation, i.e. compliance through persuasion and voluntarist approaches, subsidies, regulation and taxation, and public ownership, which signifies the highest degree of coercion (Doern
and Phidd, 1992; Doern and Wilson, 1974). Doern holds that instruments with a low degree of coercion are relatively more easily implemented, as political or economic opposition to such measures is likely low. The passing and implementation of policies using higher degrees of coercion requires more political capital and is therefore less incentivised. The model holds that governments thus prefer the least-coercive solution to a problem and will employ more coercive means against societal resistance if necessary.

Although the literature on instrument coerciveness does not apply a uniform taxonomy, most of the instruments assessed fall into one of two categories that are positioned on a ‘coerciveness’ continuum. On the most coercive side of the spectrum, regulation and standards compose the most binding policies. The State employs a wide range of resources and coercion to ensure the abidance of regulated parties by such policies. At the other end of the scale, incentive-based instruments that guide behavioural change through financial or other stimulation utilise a moderate degree of coercion.

2.2.2 Differentiation by the Motivational Underpinning

Rather than looking at the amount of monitoring and other authoritative resources or the degree of coercion used in the implementation of policy instruments, another literature differentiates policy instruments by their respective motivational aspects for compliance. Drawing on the ‘social
dilemmas'\(^2\) literature, Karp and Gaulding (1995) discuss the underlying motivational mechanisms of the same categories of policy instruments, namely regulation and incentive-based measures. In their model, Karp and Gaulding hold that regulatory instruments capitalise on the regulated party's fear of detection. Incentive-based tools, on the other hand, appeal to greed or to a sense of ecological or social responsibility.

According to this differentiation, regulation enforces rules through sanctions. If a sufficiently high level of applicable punishment is met with a substantial risk of detection, compliance with regulation is effectively enforced for fear of punishment. Incentive-based instruments, on the other hand, evoke compliance through benefits and thus appeal to individuals’ greed to capitalise on prospective profits of compliance. While this mechanism does not render enforcement obsolete, it alleviates the need for central monitoring as profit-maximisation is the rational self-interest of potential polluters. In this context, voluntarist approaches are effective if they induce intrinsic motivation for compliance by sufficiently appealing to “biospheric” and/or “social-altruistic” value orientations (Karp and Gaulding, 1995: 454). Drawing on sociological concepts especially from the social behaviour and social dilemma literature, this approach helps policymakers understand the motivational underpinnings of compliance and thus can prove fruitful in the process of choosing instruments. It is less appropriate to differentiate

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\(^2\) ‘Social dilemmas’ describe market inefficiencies and negative externalities, i.e. “situations in which autonomous individuals act in their own rational self-interest, yet the collective outcomes of these independent actions threaten misfortune to all” (1995: 444).
instruments solely on this basis, as it does not shed light on the theoretical efficacy advantages of some instrument types over others.

2.2.3 Differentiation by Policy Paradigms and Evaluation Attributes

A third body of literature categorising policy tools evaluates the relative advantages and disadvantages of instruments along a range of policy paradigms and their assessment criteria. Policy paradigms in this literature embody the prevailing frameworks of ideas, norms, and values that guide policymaking (Mehta, 2007). The criteria by which environmental policy instruments are assessed are constantly changing. Tietenberg describes three paradigmatic changes, called ‘waves’, in instrument assessment in the environmental policy field (1990). During the first wave in the 1970s, a results focus could be discerned as the predominant idea in environmental policymaking (Scriven, 1991). Attributing the highest relevance to the degree to which environmental goals are attained by a given instrument, this approach advocated the effectiveness of policy tools as the sole criterion for success. Where measurable, the success of a policy is ascertained by the effect it has on the state of the environment (OECD, 1994). Instrument effects are, however, not always clearly visible and changes in the state of the environment can often be attributed to co-impacts of other policies or other confounding factors (Gunningham and Grabosky, 1998). Some authors hold that it is therefore viable to quantify instrument success from a polluter perspective. Such an assessment includes the number of polluters targeted, the amount of pollution abatement undertaken by each polluter as well as the
impact of the policy on the number of polluters in the market (Alberini and Segerson, 2002: 159).

Following the general paradigm shift in other policy fields, the second wave of environmental policy assessment in the 1980s moved evaluation criteria away from Keynesianism and the ideal of a strong state towards liberalisation and the expected benefits of a free market mechanism. Efficiency gained more importance as a decisive criterion of the successful implementation of environmental policies. Capitalising on economic concepts and externality theory, the success of an environmental policy instrument was no longer measured in the mere change in the state of the environment, but also in the efficiency with which resources were used (Porter, 1991). Analysts thus started to pay attention to “the extent to which the instrument economises on resources (use of capital, labour, materials and energy)” (OECD, 1994: 22), i.e. whether the resources used in the abatement, monitoring, and enforcement process were utilised in a cost-effective fashion.

The latest wave in the development of evaluation criteria includes more procedural and civic aspects of environmental policy. Since the 1990s,
suasive and contractarian approaches have entered the field (Dana, 2000). These measures often take the form of voluntary agreements between the legislator and polluters to reduce pollution. Pollution reduction is put into effect either by immediate changes in the polluting activity, e.g. via industry standards or pollution reduction commitments, or through a change in consumer behaviour via the provision of environmental information of polluting products. Such inclusive and participatory instruments are assessed on a spectrum of criteria ranging from flexibility, transparency, predictability to equity and legitimacy (Mickwitz, 2003).

For the purpose of this research project, flexibility is defined as the flexibility of response to changing conditions in the environment, the technology base, or the economy (Bohm and Russel, 1985), i.e. the polluters’ degree of freedom with respect to the strategies, methods, and quantitative efforts employed to reduce pollution. The flexibility to act on an exogenous change is limited if a centralised decision maker prescribes uniform abatement strategies to all polluters irrespective of their marginal abatement costs and economic situation. Such a regime is likely to be inefficient in obtaining the necessary information on individual polluters and to incorporate such knowledge into the political decision-making cycle. Conversely, a decentralised decision structure theoretically allows firms to react independently and to arrive at solutions tailored to their individual situation (Gunningham and Grabosky, 1998; Doern and Phidd, 1992). Flexible instruments thus potentially lower implementation costs, which, in turn,
“increases the likelihood that the policies will actually be followed and the goal achieved” (Toman et al, 1999: 431).

Legitimacy as an assessment factor is closely related to ‘acceptability’ as defined by the OECD (1994: 22): “the extent to which the instrument can be properly implemented and enforced without incurring problems of non-concordance with existing regulations, principles and policies, or of resistance by targeted groups or indirectly affected agents on the bases of alleged unfairness or un-proportional burden-sharing implications (equity considerations)”. The legitimacy measure is rather subjective. In environmental policy-making, legitimacy applies to the degree to which a policy instrument or its enactment is perceived as fair by the regulated agents, i.e. polluters, the victims of pollution as well as the administrative actors involved in the enforcement process. A high degree of legitimacy will translate into higher levels of acceptance by the regulated parties and hence a higher level of compliance (Gunningham and Grabosky, 1998). Low levels of legitimacy, on the other hand, will cause questions of rightfulness and necessity of the given policy and can hamper compliance in the absence of sufficient monitoring and enforcement capacities.

In summary, policy instruments can be differentiated according to different scales. In environmental policy, most instruments cluster in one of two groups, i.e. command-and-control regulation and incentive-based instruments. The following section gives an overview on which instrument types build the preferred policy solution in different countries.
2.3 Policy Instrument Choice in Theory and Practice

Over the past 40 years, CAC legislation has been the instrument of choice in OECD countries (OECD, 1994: 9; Cansier and Krumm, 1996). The command-and-control approach highlights the need for public organisation of environmental action through strict regulation by monitoring authorities. This can take the form of laws, guidelines, or “regulations, which force consumers and producers to change their behaviour” (Santos, 2010: 2). CAC policies regulate pollution through either performance-based or technology-based environmental standards (Jiang, 2003). The former specify for instance permissible pollutant levels and restrict their emissions (Helfand and Berck, 2003). A typical example in the transport sector are emission standards for automobiles, which specify the permissible exhaust discharges of major pollutants (EEA, 2005).

Technology-based standards define pollution abatement systems as best available technology (BAT) and make their use compulsory (Sorrell, 2002). Examples of this kind of CAC regulation include compulsory catalytic converters in cars or legislation requiring the replacement of chlorofluorocarbons (CFC) in air conditioning systems. While technology-based standards can be effective at achieving the desired environmental target, the regulatory authorities may suffer from “imperfect information” regarding current environmental technological developments or their cost-efficiency and hence “CAC regulations may require technology that is more expensive than necessary” (Fullerton, 2001: 225).
To the extent that CAC measures can make certain pollution abatement procedures mandatory and enforce their compliance, the environmental outcome of such policy tools is to a large degree reliably predictable. CAC instruments are easily implemented, enforced, and understood if the political capital for their implementation suffices. In this case they are seen as ‘strong legislation’ against polluters, especially if the pollutants concerned pose a high risk to society, i.e. if the optimal level of pollution is close to nil (Santos, 2010). Especially in combination with strong community support CAC legislation can produce the desired environmental goal (Gunningham and Grabosky, 1998).

Once performance-based or technology-based standards have been defined, a functional monitoring and enforcement apparatus needs to be devised to guarantee their effective compliance. CAC regulation is therefore often criticised for its allegedly inherent inefficiency as it not only does not generate revenues but requires substantial expenses to establish monitoring and enforcement capacities (Cohen, 1998, Tietenberg, 1990). These constraints lead to assumptions that CAC legislation is “six to ten times as expensive as the minimum abatement cost made possible by market-based instruments like taxes or permits” (Fullerton, 2001: 238).

A further negative aspect, CAC regulation requires policy-makers to have a substantial knowledge of the market and the polluting activity in order to design the standard appropriately, effectively, and efficiently. As a result, standards tend to follow a ‘one-size-fits-all’ approach. Such uniform
stipulations usually do not assign individual polluters individual abatement obligations and do not give incentives to polluters with relatively low abatement costs to go over and beyond their prescribed abatement targets. Moreover, the political process to design, pass, and implement a standard is likely time-consuming, command-and-control regulation is generally perceived as inflexible.

In some cases, the correlation between policy types and instrument characteristics such as flexibility is imperfect (Mickwitz, 2003). Command-and-control regulation can grant some flexibility to manufacturers via flexibility mechanisms, such as delayed compliance deadlines for emission standards, exemptions, and staggered rates of non-compliance fees. In most instances, flexibility provisions allow polluters to choose between different options in their compliance efforts. In the case of CAC regulation, flexibility mechanisms exceed simple denial of access to the market for noncompliant products. Instead, they offer fees and charges for noncompliance. Alternatively, they can take the form of staggered standards that gradually increase in stringency or phase-in required pollution targets over a clearly defined period of time (lead-in time provisions). Such flexibility mechanisms are an integral part of modern environmental policy (Barde, 1997) and can significantly increase the degree of flexibility granted by CAC instruments. At the same time, they are likely to erode the environmental effect of the very instrument they are applied to (Lutsey and Sperling, 2012).
The deficiencies of CAC regulation (in terms of inefficiency, high costs of the bureaucratic enforcement apparatus, need for information in the design process) have become more apparent over time (Oates, 2003). Economists have played an important role in addressing these deficiencies and offering potential solutions in the form of incentive-based instruments. As a result, OECD countries increasingly make use of such flexible policy (Oates, 2003). The most prominent group of these applications are environmental taxes and charges, such as the duty on mineral oils in Germany, landfill taxes in the UK and Austria as well as the Finish oil-waste levy (Jordan et al, 2005: 486; Wurzel et al, 2003; Zito et al., 2003; Bailey, 2010; Flynn, 2003). These fiscal instruments were particularly effective in Scandinavian countries: the SO₂ tax in Sweden resulted in a reduction of sulphur content in fuel oils of up to 40 per cent beyond the legal standards (Barde, 1997: 45). Applications of such revenue-earmarked IBI, however, have so far mainly been limited both in the sense that only few (developed) states adopt them and that these applications form complementary rather than major items of national environmental policy strategies.

The second class of environmental policy tools in this framework describes incentive-based instruments, such as market-based instruments (MBIs) and new environmental policy instruments (NEPIs). Incentive-based instruments accommodate the abovementioned flexibility attribute more strongly than classic command-and-control regulation as they aim to change polluting behaviour through incentives, i.e. financial or via suasive motivation. Market-based instruments "encourage behaviour through price signals rather than
through explicit instructions on pollution control levels or methods” (Stavins and Bradley, 1996: 3). The underlying principle of MBIs builds on the notion of environmental pollution as an economic externality, i.e. “a cost or benefit arising from an economic transaction that falls on a third party and that is not taken into account by those who undertake the transaction” (McTaggart et al, 1992: 467). Market-based environmental policy instruments are designed to internalise the cost of the externality in the polluting activity. This internalisation takes place through the alteration of existing or the creation of new markets for such externalities (Santos, 2010). In the case of price-based MBIs, this internalisation is manifest in different varieties of a Pigouvian tax, i.e. a tax that is “levied on an agent causing an environmental externality (environmental damage) as an incentive to avert or mitigate such damage” (OECD, 1994). The Pigouvian element hence increases the costs of producing or consuming the polluting product.

Quantity-based MBIs set a limit to overall pollution that is similar to a CAC-style pollution cap. In a tradable permit system, polluters can then trade and utilise the right to pollute within the defined total amount of permissible emissions. Each polluter can manage a personal portfolio of primary pollution permits, which describe the right to discharge a fixed amount of pollutants and are obtained through means other than permit trading among polluters. The idea behind these instruments is to exploit the different

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4 Primary pollution permits are either grandfathered, i.e. the legislative authority grants pollution rights to established polluters according to their proven needs prior to the introduction of the trading system (Roberts, 2004: 199), or sold to the highest bidders at an auction. In both cases the environmental agency in charge can define the absolute permissible pollution levels and ratchet down the amount of annual pollution permits according to changing environmental targets.
marginal abatement costs of polluters, i.e. polluters with lower marginal abatement costs will reduce their emissions to a level lower than legally prescribed if they can profit from selling excess permits. A tradable permit system thus encourages pollution abatement as polluters can either economise on primary emission permits expenditure or raise revenues by selling available and dispensable permits to other polluters. A tradable emission permit system may link environmental sustainability with economic incentives as “each successive reduction in permissions saves the firm from paying tax, allows it to sell its tradable permits to ‘dirtier’ competitors or allows it to meet future targets at lower costs” (Golub, 1998: 5).

To the extent that incentive-based instruments provide sufficient financial or other incentives to reduce pollution voluntarily, they are efficient (Santos, 2010). This efficiency, however, comes at the cost of uncertainty with regard to the environmental outcome. If market instruments are implemented outside a capped quota system the environmental outcome is directly dependent on the amount and design of the Pigouvian element. Incentive-based instruments can be ineffective if the Pigouvian element of a tax or the total amount in a quantity-controlled regime are set to ineffective levels.

A further negative aspect of incentive-based instruments is that decision-makers have a considerable need for information on the marginal abatement costs, which renders these instruments not necessarily efficient if they require substantial monitoring efforts or transaction costs to assure
compliance. In the transport sector, incentive-based instruments are often difficult to implement as the marginal external cost imposed by vehicles “is difficult to measure: it is challenging to measure and quantify in monetary terms the environmental externality associated with transport” (Santos, 2010: 3). Such instruments also suffer from a moral problem as they sanction pollution if the monetary cost of the emissions is accounted for (Fullerton, 2001: 242). Rather than declaring pollution abatement an end in itself, market instruments give polluters the choice to either economize on discharge costs or pay for the right to pollute. Furthermore it is difficult to assess the economic costs of pollution since the repercussions of environmental degradation are not necessarily explicitly measurable.

A further variation of incentive-based instruments, suasive instruments try to actively include polluters and/or consumers in the abatement process. Suasive instruments such as eco-labels and -audits offer consumers information on the pollution involved in the production or consumption of a product. These labels are the displayable result of official licensing and certification of environmental commitment and give consumers a choice between different environmental standards of goods. They constitute a marketable incentive for polluters to capture the market potential of “green consumerism” (Golup, 1998: 6).

While suasive instruments may be legislated by a governmental agency after mere consultation, the contractarian approach aims at including polluters in the designing process of environmental policy. According to Dana this
method makes use of agreements “in which regulators agree not to enforce various laws applicable to regulated entities in exchange for the entities’ agreements to fulfil additional obligations not required by existing law” (2000: 51). Contrary to some classic CAC legislation, the actual design of such environmental policy is the result of consultation and mediation between regulatory authorities and regulated entities.

Often, certain command-and-control elements prevail in contractarian agreements as both an incentive to commit to stricter pollution abatement and a kind of ‘last resort’. While the environmental agencies in charge can threaten polluters to subject them to these backup measures, which are potentially costly to both regulating and regulated entities, both parties have an interest in finding individual solutions to environmental problems in a case-to-case fashion. Since such voluntary agreements require a consensus between both regulating and regulated parties, polluters gain greater control over the formation of environmental regulation in a contractarian setting. This approach differs from market-based instruments in that pollution abatement is not achieved through the “invisible hand of the marketplace” but through case-to-case negotiations between regulators and the regulated (Dana, 2000: 53). The locus of decision-making is hence local, i.e. inherently complex environmental problems are dealt with by regional office holders.

More complex incentive-based instruments, such as tradable permits, have been applied less frequently than could be expected from their academic backing: “the experience with the most highly sophisticated [market-based]
instruments is not very large or deep even in the mature environmental regimes – indeed, some instruments popular with advisors are still more theoretical than applied” (Bell, 2003: 6). Nevertheless, they have become increasingly popular and are increasingly being transferred into applied policy. Voluntary agreements and eco-labels have been integrated into environmental legislation in Europe, e.g. Germany and the Netherlands (Jordan, et al, 2005; Wurzel et al, 2003D), Australia (Jordan et al 2003) and Japan (Arimura et al, 2008). However, these new environmental policy instruments are mostly backed by (the threat of) CAC regulations and at best complement the existing body of environmental legislation (OECD, 1994).

As in OECD countries, the core of environmental policy in developing countries is mainly comprised of command-and-control regulation (O’Connor, 1998). These regulatory measures, however, tend to yield less effective results than in OECD countries. Reasons are chiefly seen in the ill-equipped administrative frameworks in developing countries, which manifest in practice in a lack of resources (Da Motta et al., 1999), skills (Shi and Zhang, 2006), and insufficiently equipped or empowered enforcement agencies (Lo and Tang, 2006).

Incentive-based environmental policies in developing countries are mainly applied in the form of effluent charges (OECD, 1994 for Malaysia, Taiwan, Singapore, China and South Korea; Blackman and Harrington, 2000 for Poland). Most of these market-based instruments share similar deficiencies, rendering them partly inefficient and ineffective. "Institutional weaknesses
such as under-funding, inexperience, lack of political will, or unclear jurisdiction” (Da Motta, 1999:198) are especially significant in the context of developing countries since the functional institutional environment necessary to enforce compliance with IBI policies is likely missing. Several studies on the enforcement of national environmental policies by local governments indicate that enforcement bodies are inadequately equipped and their enforcement efforts are contingent on the political goodwill and interests of their local governments (Economy, 2006; Sims, 1999). Moreover they have in common that IBI policies are designed to raise fiscal revenues rather than steering polluting behaviour through incentives (OECD, 1994: 8).

In summary, the literature on policy instrument categorisation has brought forth a classification scheme that differentiates between command-and-control regulation and incentive-based instruments. CAC regulation is thereby seen as effective but inherently inefficient, while incentive-based instruments do not guarantee the environmental outcome, but are advantageous in terms of instrument efficiency. The following section will apply this classification scheme to the most common policy instruments in the automotive sector.

2.4 Common Environmental Policy Instruments in the Transport Sector

This section introduces the most relevant policy instruments in environmental transport policy and categorises them according to the framework expounded in the above section. Table 2.1 gives an overview of these instruments. This set of policy measures will function as the blueprint
according to which the categorisation and classification of instruments applied in China will be performed. The set consists of strategic industry plans, standards and regulations, taxes, fees and levies as well as suasive instruments.

### Table 2.1:

**The Most Common Environmental Policy Instruments in the Automotive Sector**

<table>
<thead>
<tr>
<th>Category</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry Plans</td>
<td>Policy goals</td>
</tr>
<tr>
<td>Standards and Regulations (mainly CAC)</td>
<td>Fuel Economy Standards</td>
</tr>
<tr>
<td></td>
<td>Emission Standards</td>
</tr>
<tr>
<td></td>
<td>Fuel Quality Standards</td>
</tr>
<tr>
<td></td>
<td>Regulations on Vehicle Ownership and Use</td>
</tr>
<tr>
<td>Incentive-based Instruments</td>
<td>Taxes on Vehicle Ownership</td>
</tr>
<tr>
<td></td>
<td>Taxes on Vehicle Use</td>
</tr>
<tr>
<td></td>
<td>Scrappage Schemes and Purchase Incentives</td>
</tr>
<tr>
<td></td>
<td>Incentives</td>
</tr>
<tr>
<td></td>
<td>Labels</td>
</tr>
<tr>
<td></td>
<td>User Privileges</td>
</tr>
</tbody>
</table>

### 2.4.1 Industry Plans

Not policy instruments in the strictest sense, industry plans build the strategic basis for transport policies. Such plans include near- and mid-term goals for the industry sector as a whole as well as its environmental and technological development. Often, they prescribe specific policies for immediate adoption and the attainment of specific environmental goals,
earmark funds for research and development efforts, and formulate targets for the market penetration of specific technologies.

Owing to the economic significance of the automotive industry in many industrialised countries and emerging markets, industry plans for this sector are reasonably common. Especially the introduction and politically supported market penetration of new technologies, such as unleaded fuel and catalytic converters in the 1980 or electric vehicles today, is often facilitated through industry plans. A good example of such an initiative, the cooperation of the industry and polity in Germany regarding the introduction and fostering of electric vehicles is based on the National Development Plan for Electro-Mobility (*Nationaler Entwicklungsplan Elektromobilität*⁵). In addition to a quantitative political goal of one million electric vehicles on German roads by 2020, the Plan formulates specific policy goals in order to establish Germany as the lead market for the development and production of electric vehicles and their components (*Leitmarktdirektive*). The Plan helps to achieve these aims by bringing together technical experts from the industry and political decision-makers of four Ministries for a deliberative exchange of ideas and opinions on the need for and implementation of research and development projects as well as the preparation of and introduction of electric vehicles (EV) to the market.

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2.4.2 Standards and Regulations

Standards and regulations are classic command-and-control instruments that build the backbone of most environmental policy regimes. The transport sector is no exception. Santos et al (2010) give an overview of the theoretical aspects and empirical applications of the most influential command-and-control as well as incentive-based policy instruments in the transport sector. Based on their description and input from other works (OECD, 1994; Bell, 2003; Mickwitz, 2003), the following subsection will introduce the four most prominent sets of standards in the transport sector, namely vehicle efficiency standards, emission standards, fuel quality standards, and regulations pertaining to vehicle ownership.

2.4.2.1 Vehicle efficiency standards

Vehicle efficiency standards (VES), such as Fuel economy or CO₂ emission standards, are one of the most important policy instruments in the transport sector and heavily rely on command-and-control enforcement⁶ (An and Sauer, 2004; An, Earley, and Green-Weiskel, 2011). Vehicle efficiency standards form the backbone of environmental transport policy in the most advanced vehicle markets such as the United States, Europe, Japan, and China. Table 2.2 gives an overview of such policy regimes applied worldwide.

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⁶Fuel economy standards (FES) and CO₂ emission standards tackle the common goal of energy efficiency as fuel consumption and CO₂ discharge are directly related. For gasoline, 1 litre of fuel translates into app. 23.2 gCO₂/km. For diesel, 1 litre translates into app. 26.5 gCO₂/km. For this reason, the acronym FES will refer to regulations on fuel efficiency as well as CO₂ emissions for the remainder of this work.
To date, 7 countries\(^7\) have passed VES regulations, with Brazil, Mexico, Thailand, India, and South Africa planning to follow in the near future. Exemplified by Table 2.3, existing VES regimes cover the most sizeable and influential vehicle markets. Over 70% of all new cars in 2010 were registered in countries with fuel economy standards. According to the Global Fuel-Economy Initiative\(^8\), over 75% of annual light-duty vehicle sales occur in countries with fuel economy or CO\(_2\) emission standards.

\(\text{Table } 2.2:\) Fuel Economy Standards Worldwide

<table>
<thead>
<tr>
<th>Country</th>
<th>Year Adopted</th>
<th>Measure</th>
<th>Utility Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>1975</td>
<td>MPG</td>
<td>Footprint</td>
</tr>
<tr>
<td>EU</td>
<td>1998</td>
<td>CO(_2)/km</td>
<td>Mass</td>
</tr>
<tr>
<td>Japan</td>
<td>1978</td>
<td>km/L</td>
<td>Mass</td>
</tr>
<tr>
<td>South Korea</td>
<td>1996</td>
<td>km/L</td>
<td>Displacement</td>
</tr>
<tr>
<td>Canada</td>
<td>1978</td>
<td>L/100km</td>
<td>Footprint</td>
</tr>
<tr>
<td>Australia</td>
<td>1978</td>
<td>L/100km</td>
<td>Mass</td>
</tr>
<tr>
<td>China</td>
<td>2005</td>
<td>L/100km</td>
<td>Mass</td>
</tr>
<tr>
<td>India</td>
<td>Planned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>Planned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>Planned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>Planned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>Planned</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MPG = range measured in miles per gallon

Adapted from: An et al, 2011; Ehsani, 2010

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\(^7\)A supranational organisation, the EU technically is not a country. For the sake of simplicity and due to the fact that European CO\(_2\) emission standards are enforced in all member states, the EU will be included in references to ‘countries’ in this work.

Table 2.3:

Vehicle Sales and Car Production in VES Countries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>13.8x</td>
<td>17.8</td>
<td>16.9</td>
</tr>
<tr>
<td>China</td>
<td>18.1y</td>
<td>23.3</td>
<td>18.2</td>
</tr>
<tr>
<td>USA</td>
<td>11.55z</td>
<td>14.8</td>
<td>7.8</td>
</tr>
<tr>
<td>Japan</td>
<td>5</td>
<td>6.5</td>
<td>9.6</td>
</tr>
<tr>
<td>Canada</td>
<td>1.6</td>
<td>2</td>
<td>2.1</td>
</tr>
<tr>
<td>Australia</td>
<td>1</td>
<td>1.3</td>
<td>0.2</td>
</tr>
<tr>
<td>South Korea</td>
<td>1.5</td>
<td>1.9</td>
<td>4.3</td>
</tr>
<tr>
<td>India</td>
<td>3</td>
<td>2.8</td>
<td>3.5</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.8</td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.8</td>
<td>1</td>
<td>2.3</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.45</td>
<td>4.4</td>
<td>3.6</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.4</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Worldwide</td>
<td>77.3</td>
<td></td>
<td>77.6w</td>
</tr>
</tbody>
</table>

x ACEA, 2011  
y Marklines, 2011  
z OICA, 2011  
w Worldwide car production output according to OICA, 2011

The three most influential VES regimes are US corporate average fuel economy standards (CAFE), the European CO2 regulation as well as the Japanese front-runner system. All three approaches feature unique characteristics and differ significantly in the most relevant aspects, such as the drive-cycle test used to measure vehicle compliance, the utility parameter according to which vehicles are subjected to consumption limits, and in the degree of flexibility they grant automobile manufacturers in their compliance efforts (An and Sauer, 2004; An et al, 2011). The three approaches have been and continue to be the toolkit other countries select their policy instruments from. Canadian fuel economy standards, for example, closely follow US
standards. This is due to a close integration of both vehicle markets and the resulting high volume of cross-border production and trade. Similarly, European drive cycle tests are applied in China and Australia to determine local fuel efficiency.

To the extent that VES impose absolute fuel economy or emission targets on vehicle manufacturers, they resemble classic command-and-control regulation. Given appropriate monitoring and enforcement, VES are highly effective. In several ambits, however, VES include flexibility mechanisms to incentivise manufacturers to achieve lower emission/consumption levels. Such mechanisms are designed to alleviate the burden on individual manufacturers and aim to increase the overall efficiency with which the environmental goal is achieved. At the same time, these mechanisms have the potential to erode standard stringency (Lutsey and Sperling, 2012).

### 2.4.2.2 Emission Standards

Emission standards for criteria pollutants are the second regulatory backbone of environmental transport policy. Similar to vehicle efficiency standards, emission standards are a ubiquitous and integral component of the comprehensive environmental policy strategy in almost all vehicles markets worldwide (DELFI, 2011).

The mere application of emission standards is, however, only a weak indicator of the stringency of vehicle emission policy in general. This is due to the fact that emission standards are easily politically established when their
environmental (and hence economic) implications are minimal. Such ‘weak’ standards can work as an agreeable and politically easily enforced entry to environmental transport policy as they are unlikely to evoke strong opposition from manufacturers. Most countries following progressive US, European or Japanese standards are host to a very limited number (either in absolute terms or with respect to market share) of small, technologically less capable domestic manufacturers. Emission standards with a low level of ambition therefore are likely to crowd out only the worst polluters, while importers or technologically sophisticated foreign manufacturers have been exposed to more challenging standards abroad and are thus able to offer (still out-dated) technology compliant with such ‘weak’ standards to local joint ventures. The adoption of emission standards is thus a necessary but no sufficient indicator for a comprehensive and suitably tuned environmental policy regime.

Most emission standards are performance-based and as such set absolute limits for the discharge of pollutants per distance travelled for the following pollutants: CO, HC, NOx, PM, PN. They also differentiate between the vehicle class as well as the type of fuel combusted. In order to identify and include all relevant vehicles, most countries classify them according to their weight (light-duty vs. heavy-duty vehicles) or entrepreneurial/private use.

2.4.2.3 Fuel Quality Standards

Fuel quality standards refer to the quality of different fuels and regulate combustion characteristics, other qualities of the fuel as well as the
maximum permissible content of specific additives and pollutants. Concentration limits are given for each type of fuel and each pollutant. The most common fuel types are different grades of gasoline, diesel, compressed or liquefied natural gas as well as fuels based on non-fossil sources, such as organic diesel oil, alcohol or blends of these organic types with fossil fuels. While the most commonly regulated pollutants in gasoline are sulphur, lead, benzene, and the olefin content, diesel standards mainly focus on the sulphur content.

The effect of fuel quality on vehicle emission performance is twofold. The quality of a fuel has a direct effect on a vehicle's performance in emission tests. High levels of pollutants such as sulphur and lead cause high counts of these pollutants in tailpipe fumes. Secondly, and more importantly, modern after-treatment technologies require 'clean' fuels in order to provide full functionality. The use of catalytic converters for gasoline engine systems, for instance, requires the use of unleaded fuels. Modern diesel after-treatment solutions require very low fuel sulphur contents. In addition to fuel ingredients that contribute to pollution after combustion, the vaporisation of fuels from storage terminals and vehicles is a major concern of fuel standards. Successful fuel quality policies thus require a generally low level of pollutant concentrations and low vapour pressures.

The main mode of policy to ensure quality and environmental characteristics of fuels is command-and-control legislation. Fuel standards dictate the maximum permissible levels of lead and sulphur and require mineral oil
providers to adhere to these standards. Such standards build the legislative basis on which manufacturers can develop their technology and hence future emission reduction strategies. In some instances, market incentives are given to support long-term strategies or to accelerate the introduction of politically preferred fuels. The ‘phasedown’ of leaded fuel in the US made use of market-based incentives that established a rudimentary market for leaded fuel production permits (Hahn and Stavins, 1991). In 1982 the lead trading programme allowed US refineries to trade lead credits and thus granted them ‘greater flexibility in meeting emission standards” (Stavins, 2003). Similarly, differential tax rates on diesel and petrol in the EU increased the share of diesel vehicles in the market and hence to absorb a portion of the increase of CO2 emissions (Crist, 2011; Murray, 2011).

2.4.2.4 Regulations on Vehicle Ownership and Use
Regulations on vehicle ownership and local temporary or permanent restrictions on vehicle use are common command-and-control practice (Santos, 2010). All of these restrictions prevent the most polluting vehicles from access to the inner city area on the basis of their certified emission levels. An extreme case of a restriction on vehicle ownership is the vehicle quota system in Singapore (Seik, 1998). Owning to its very limited land resources, the city-state implemented a restrictive quota on vehicle ownership in 1990. The system requires vehicle holders to apply for a Certificate of Entitlement in order to register a car. The number of these Certificates is set centrally by the government. The total increase of the vehicle population is thus regulated. An auction system, however, is used to
allocate Certificates of Entitlement to motorists. The system thus combines elements of CAC measures and market-based incentives.

2.4.3 Incentive-Based Instruments

Taxes, levies, fees, and feebates are classic market-based instruments aiming to change behaviour by increasing the pecuniary cost of pollution. The range of fiscal and financial instruments is wide and often this approach is used complementarily in combination with standards and regulations. The most significant incentive-based instruments in transport policy are taxes and levies on vehicle ownership and use as well as financial incentives to foster the replacement of old and inefficient vehicles with new, more efficient cars.

2.4.3.1 Taxes on Vehicle Ownership

A tax on the ownership of a vehicle (purchase or excise tax) is common in many countries (Crist, 2011). Empirical examples of ownership taxes are value added tax (VAT) in the EU as well as registration taxes based on fuel economy, car price, displacement, CO2 emissions or vehicle weight in the EU (Santos, 2010) and Singapore.

Such taxes aim at reducing the number of vehicles on the streets, but as a side effect they lead to increased average life-cycles and thereby a prolonged use of old and potentially highly polluting technology, if they are levied on new vehicles only. They also address externalities (i.e. emissions) only indirectly as they do not incentivise less driving per se.
Value-added tax is an important component of transport policy in many countries (DIW, 2009). It is usually levied on car purchase prices and provides the State with a double dividend. First, it increases the price on vehicles, thus reducing demand and collateral pollution. This is especially true for cars in the luxury segment, which tend to consume more fuel and sell at higher prices compared to relatively more fuel-efficient smaller cars. Second, VAT is an important source of revenue for the State. VAT income thus increases the financial leeway of the state to invest in environmental protection.

As the tax system is already in place in most countries, the implementation of fiscal instruments is straightforward and cost-efficient. If levied periodically, tax levels are easily adjusted and hence further incentivise the frequent updating of the vehicle pool. If however, designed as a one-off tax, this incentive is rather weak if these one-off taxes are meant to reflect the life-cycle emissions of the car they are likely prohibitive for fuel-inefficient vehicles and furthermore do not provide incentives to drive less during the life span of the car (Santos et al, 2010).

2.4.3.2 Taxes on Vehicle Use

Fiscal instruments aimed at vehicle usage comprise fuel and emission taxes, tolls and congestion charges as well as parking fees. Despite the large number of registered vehicles and the related high costs of enforcement, taxes and fees based on the emission characteristics of cars are implemented widely (Crist, 2011). In the EU for instance, 16 out of 27 states include a
component cognisant of $CO_2$ emissions in their registration and annual circulation tax regimes (DIW, 2009). Taxes on fuel may effectively complement or even replace vehicle-based emission taxes. Such taxation has proven highly effective as it increases the price of fuel and can thus ameliorate rebound effects\(^9\) resulting from more efficient vehicles (Sterner 2007). Empirical examples of further usage taxes include carbon taxes in most Scandinavian countries, the Netherlands, and Italy (all Santos, 2010).

Congestion charges are often opposed politically and publicly. Examples include: Norwegian toll rings, highway tolls in the UK (see for instance the M6 toll\(^10\)), high occupancy lanes (in the US vehicles with only 1 passenger need to pay in order to use the lanes), the Singapore Area Licencing Scheme, the London congestion charge and the Stockholm cordon toll.

Differentiated parking price schemes contribute to keeping vehicles out of urban centres and hence help improve ambient air quality in these regions (CE Delft, 2006). While some cities, such as Beijing, apply a purely geographical approach and price parking space according to its distance from targeted areas, other concepts envision fee differentials on the basis of the environmental impact of specific vehicles. Such ‘green parking fees can “help encourage in-town use of low emission vehicles and discourage use of ‘gas guzzlers’” (CE Delft, 2006: 1).

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\(^9\) The ‘rebound effect’ describes unintended higher aggregate emission levels due to increased fuel-efficiency and the resulting lower marginal costs of each km travelled.

\(^10\) [http://www.m6toll.co.uk/](http://www.m6toll.co.uk/)
2.4.3.3 Scrappage Schemes and Purchase Incentives

Subsidies and feebates can pose a strong incentive to purchase new vehicles. The environmental and fuel-efficiency criteria for vehicles purchased in these schemes can assure an impact on the constellation of the vehicle pool and a trend towards more fuel-efficient and generally less polluting vehicles. Examples of such scrappage and purchase incentives are the British and French voluntary accelerated vehicle retirement programmes as well as the German scrappage premium (Abwrackprämie) (Santos et al., 2010).

While market-based incentives can contribute to changing the vehicle market towards more fuel-efficient models, subsidies that are not linked to mandatory scappings can result in higher vehicle ownership and thus in a continued high stock of old, inefficient, and highly polluting vehicles that can offset possible consumption gains.

2.4.4 Suasive and Voluntary Measures

Generally, suasive and voluntary measures fall into the category of new environmental policy instruments (NEPIs). In the transport policy sector these instruments are a relatively new phenomenon. As such, their scope and spread are rather limited. The best-known contractarian arrangement between the car industry and the ‘government’ is the 1998 voluntary agreement between European car manufacturers and the EU to curb average CO₂ emissions to 140 grammes of CO₂ by 2008. Instead of legally binding CO₂ standards, the agreement was meant to provide the car industry with a high degree of flexibility and freedom to achieve the goal as efficiently as possible.
Ultimately, the non-binding agreement failed to bring about the desired (T&E 2010) and it was replaced with the abovementioned standards.

### 2.4.4.1 CO$_2$ and Fuel Economy Labels

CO$_2$ and fuel economy labels provide consumers with information on the environmental characteristics of vehicles and thus increase market transparency and the degree to which consumers can make enlightened decisions in the market. Additionally, such labels offer manufacturers the opportunity to capitalise on ‘green consumerism’, i.e. to better penetrate market niches that value and request ecologically advantageous vehicles.

In the EU, Directive 1999/94/EG regulates the provision of information on the fuel economy and CO$_2$ emissions of new passenger cars marketed. In order to provide consumers with reliable and accessible information, car dealers are required to display the label on fuel economy and CO$_2$ emissions. Published visibly on the windshields of all new cars on display for sale as well as in any information and promotion material in print or online, the label is meant to enable consumers to identify and compare different vehicles and to choose the environmentally most advantageous model, accordingly.

In addition, the directive requires the establishment and publication of national fuel economy guides listing the 10 most fuel-efficient new vehicles available in the Member State at least once a year. For each make on sale, the dealer must also display on posters or in any other form (including electronic displays) a list of the fuel consumption data of all the models. These data are
to be broken down by the type of fuel and ranked in order of fuel efficiency as indicated by CO₂ emission levels.

### 2.4.4.2 User Privileges

The last environmental policy instrument in this overview concerns privileges attached to environmentally friendly use patterns of conventional vehicles and the use of alternative energy vehicles. This category comprises high occupancy lanes (HOL) and user privileges of electric vehicles. A measure to curb congestion in urban centres, high occupancy lanes are open to vehicles with a specified count of passengers. In Ontario, CA, for instance, the leftmost lanes of Highways 403 and 404 are exclusively open to vehicles with 2 or more passengers every day of the week (Ministry of Transportation¹¹). Similar use privileges apply to electric vehicles in many urban centres worldwide. In London, cars that meet Euro 5 emission standards and emit less than 100 gCO₂/km as well as all battery-electric and plug-in hybrid electric vehicles are exempt from the congestion charge (Transport of London¹²). User privileges can thus offer a significant incentive to consumers to purchase electric vehicles and highly fuel-efficient cars.

In summary, a wealth of policy instruments exists to bring about desired environmental and political outcomes in the transport sector. Both the kind of instrument chosen as well as the efficacy of individual instruments largely

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depend on the institutional traditions of the legislative structure. The institutionalist literature on instrument choice holds that historical traditions in the decision-making bodies, past instruments chosen, and the administrative tradition determine what instruments are chosen and how effectively they are applied. So far, however, empirical studies have focused on industrially and institutionally developed countries in a capitalist context. The literature has failed to examine the case of developing countries and emerging markets. Similarly, the geographical perspective of this literature has been that of the nation state. Institutionally and administratively fragmented countries that grant regions, provinces, and municipalities substantial legislative leeway, on the other hand, have not been subject to research in this field. The research project presented here aims to fill these gaps in the literature by a thorough investigation of the potentially deviant case of China. Specifically, the following chapters aim to ascertain the dominant policy mode, i.e. the preferred type of instrument chosen, in China as well as differences in instrument adoptions across different administrative levels and policy fields.

This chapter also reviewed the literature on policy instrument categorisation and assessment. It has shown that the literature is at odds over the number of instrument classes and distinctions between instrument types as well as their individual effectiveness and efficiency. For the purposes of this dissertation, environmental policy instruments are differentiated into two classes, i.e. command-and-control regulation and incentive-based instruments. Command-and-control regulation traditionally builds the
backbone of environmental and climate policy in developed and developing countries alike. Over the past 20 or so years, however, efficiency and flexibility considerations have led scholars to an environmental consensus that favours incentive-based applications over regulation. This theoretical preference of flexible instruments is slowly being translated into policy as more and more developed countries apply more flexible and incentive-based legislation (Jordan, Wurzel, and Zito, 2005: 486; Wurzel et al, 2003; Zito et al., 2003; Bailey, 2010). In this context, Cole and Grossman note: “It has become an article of faith among economists, legal scholars, and policy makers that economic forms of regulation such as effluent taxes and emissions trading are inevitably more efficient than traditional command-and-control regimes for environmental protection” (1999: 887).

With regard to developing countries and emerging markets, the literature is less explicit on the preferred mode and actual policy outcomes. The following chapters therefore aim to – at least for the case of China - qualify this ‘article of faith’ and investigate the preferred policy mode at different spatial levels. Moreover, they aim to assess and compare the efficacy of different instrument types.
Chapter Three

3. Institutionalism and Chinese Policy

The literature and research traditions surveyed in the previous chapter show remarkable gaps and omissions when it comes to characterising instrument choice or concerning the appropriate categorisation and assessment of different policy instrument types in the case of developing countries and emerging markets. Despite its vast market and major role in this industry, China has so far been mostly omitted from academic investigations into its prevalent policy mode. As a result, the institutionalist literature on instrument choice may not truthfully depict current trends in Chinese instrument adoption.

Likewise, the literature on instrument assessment holds that command-and-control regulation is inherently inefficient but essentially effective. Especially in the area of automotive standards, however, regulation is increasingly subject to flexibility mechanisms and other developments that aim to improve the efficiency of such regulation. The literature is only beginning to recognise this trend and has only started to assess the effectiveness of such regulation-turned-flexible (Lutsey and Sperling, 2012). Similarly, the same literature has repeatedly pointed out the theoretic advantages of incentive-based instruments in terms of flexibility and holds that these can achieve satisfactory degrees of effectiveness. An empirical analysis of incentive-based
instruments in the Chinese automotive sector testing or substantiating these claims, however, is so far missing.

This research project aims to close these gaps and contribute to both literatures. The remainder of this chapter describes these gaps and omissions in greater detail and puts them in the context of environmental and climate policy-making in China’s automotive sector. The chapter begins by placing the Chinese case in the literature on and research tradition in the area of policy instrument choice. Subsequently, it positions the case of China’s automotive industry in the literature on policy instrument assessment.

3.1 Policy Choice and the Institutional Context of Policymaking in China

As the literature survey in the previous chapter showed, the institutional context has a significant effect on the policy mode of a given country, particularly with regard to the types of instruments chosen. At the same time, the literature has so far mostly ignored institutional or other influences on the choice of policy instruments in China. The few academic contributions to this field that deal with China rather make general characterisations of the environmental legal system. These characterisations hold that China’s environmental agencies and laws have experienced considerable upgrading since the 1980 evolving into “a comprehensive legal basis of environmental policy” (Zhang et al, 1999). Following the historic-deterministic perspective of institutionalist theory, the communist legacy of Maoist China would indicate a continuation of centralist modes of policymaking. Accordingly, Chinese environmental and climate policy should be dominated by
command-and-control regulation. Some parts of the literature support this view (Gloria and Sterner, 2010).

At the same time, public administration in China has experienced several paradigmatic changes over time, both in its actual implementation as well as in its perception in the West. For most of Mao’s rule, Western views of the Chinese policy process have been tainted by ideological and stereotypical assumptions, which resulted in the perception of a unitary, highly centralised authoritarian regime that effectively delegates orders along bureaucratic lines from the Centre to the locale. This line of submissive bureaucratic obedience was understood to operate through an excessive degree of coercion and Party discipline within the bureaucratic/Party apparatus.

As a result of political reform and mass campaigns that caused significant social upheaval, such as the Cultural Revolution (1966 to 1976), and especially the opening of China and its subsequent market reforms (beginning in the 1980s), the bureaucratic structure appears far more fragmented and the policy process within this structure considerably more diffuse than expected. Accordingly, policy choice and the enforcement styles of both agencies as well as officials differ across Chinese provinces and municipalities (Lo and Fryxwell, 2003; Lo and Tang, 2006). This high degree of fragmentation results from both the very structure of the State bureaucratic system as well as the intricate net of relationships among bureaucratic units that bear varying degrees of binding power.
The structure of authority in China is divided into four tiers. At the top of this structure resides the central leadership, which consists of a group of 25-35 leaders, who articulate national policy. In the order of respective power this group is made up of the preeminent leader (Mao Zedong, Deng Xiaoping, and Hu Jintao in the past, Xi Jinping today), elders, generalists, and small groups of experts that are members of the Politburo, the Secretariat and the Standing Committee of the Chinese Communist Party (CCP or the Party), top military commanders, and the leaders of the most influential provinces and municipalities (Lieberthal and Oksenberg, 1988). These individuals draw their political power from their rank and office as well as from their respective standing within the CCP. This position provides them with privileged information (through access to decisional meetings and loyalty bonds with senior bureaucrats) and thus allows them to spin information and policy contents in their favour.

The second and third layers consist of State Council commissions and ministries with supra-ministerial status as well as line ministries, respectively. The first two allocate staff to the respective line ministries and thus directly influence their power in the administrative hierarchy. Moreover, they coordinate resources and construct a consensus for policy implementation. Commissions (weiyuanhui) thereby enjoy a higher status and can give instructions to lower ministries (bu), which manage specific aspects of the economy. Line ministries, in turn, execute the orders from above and carry political decisions into the provinces and down the organisational hierarchy to the county level. Experts in research institutions
as well as coordination offices build the final tier. Formed around specific policy fields, these experts ‘feed’ the top leaders and other tiers with data, information, and opinions to make informed decisions.

*Figure 3.1*

*Structure of Administrative Hierarchy in China*

The formal process by which ideas are translated into drafts and finally implemented as policies is rather straightforward: the top leadership, ministries or provinces can initiate policy ideas. The actual policy draft is then proposed by the pertinent line ministry or province, which consults with other concerned ministries in the drafting process. Upon submission, the policy drafts can be approved at different levels in the hierarchy
depending on their scale, importance, and expenses involved. During the drafting procedure, a substantial need for cooperation and consensus arises among the different line ministries and other bureaucratic units at each hierarchical level.

The policy process in China thus includes elements of a centralist and cellular system: formally, policy drafts can be devised by the top leadership and handed down through the respective line ministries until they are implemented at the county level. This theoretically allows for a very efficient chain-of-command system. In reality, however, such centralist delegation of policies has not always been effectively implemented at the provincial level. Indeed, there exist some “instances where central policy has had little effect on the activities and incentives of local officials” (Lieberthal and Oksenberg, 1988: 136). Given the considerable concentration of power in provincial level governments and officials, bargaining and consensus building is central to the policy process, both vertically down the line as well as horizontally between different line ministries. As a result, the policy process is protracted, tends to produce gradual rather than paradigm shifting change, and is disjointed with decisions being made in a number of different bureaucratic units (Lieberthal and Oksenberg, 1988).

These units are positioned in a system of parallel administrative hierarchies interacting either vertically down the line ministry ladder and related units in other ministries (tiao) or horizontally along geographic authority lines in a province/ municipality (kuai). Tiao relations work in a system (xitong) of
vertical functional hierarchies in the bureaucracy: this includes the normal chain-of-command along the line ministry as well as functionally related units in other ministries, e.g. planning or financial bureaus in other ministries cooperating with the Ministry of Finance. *Kuai* influences differ across policy fields (Lieberthal, 1997) and have been subject to change in the process of ‘soft’ centralisation (Mertha, 2005).

The relative leverage a bureaucratic unit enjoys over another depends on its rank in the hierarchy as well as on the rank and stature of the leader of that unit (Mertha, 2005). For most of Mao’s rule and until the mid-1990s, every unit used to answer to its direct superior along the line ministry’s hierarchy as well as its local government (Lieberthal, 1997). This complex net of authority led to significant degrees of local protectionism (*dijiang baohuzhuyi*). Since the late 1990s, the Centre has been trying to curtail local government interference by streamlining and standardising policy implementation (‘soft’ centralisation, see Mertha, 2005). As a result, bureaucratic units are no longer subordinate to their local government (*kuai* relations), but have a merely consultative relationship instead. Lema and Ruby (2007) describe this centralisation process in the wind energy sector, where initially fragmented authoritarianism impeded the development of a national infrastructure and wind energy market. Only with the establishment of a coherent national strategy and the subsequent empowerment of central government units the hitherto prevailing administrative coordination problems could be overcome. In the process of such centralisation *tiao*
relations were strengthened and thus line ministries from the provincial level downwards display a high degree of centralisation.

Tiao relations are ordered along vertical lines and the immediate subordinate bureaucratic unit receives binding orders (lingdao) from its direct superior (Lieberthal, 1997). Every unit can issue non-binding instructions (yewu) to any other unit, which bear less immediacy and can theoretically be ignored. The individual unit leaders’ rank is comparatively more influential: every leader enjoys three sources of authority, namely his or her formal governmental title, the position within the Party as well as the career past in the CCP. Similar to the highly personalised system of authority at the national top, also leaders at lower levels thus exert a high amount of influence on the policy process.

The influence of the institutional organisation of public administration on policy implementation is profound. Due to the significant fragmentation of personalised power at the central level the general policy process is aimed at finding a consensus amongst the government bodies involved (Lieberthal and Oksenberg, 1988, Lieberthal, 1997). As a result, potentially stringent environmental policy items are subject to a number of gatekeepers in the administrative hierarchy and can thus be diluted by economic and other interests before they reach the implementation apparatus.

Once policies reach the line ministry and hence their implementation stage, the organisational structure of public administration allows for further
setbacks. The empowerment of centralised *tiao* relations between bureaucratic units has led to a relative empowerment of provinces (Lieberthal, 1997; Mertha, 2005). Although staff allocations are still planned at the central level, the provincial governments exert great influence in allotting their staff contingents to their provincial/municipal ministry lines. To the extent that the successful implementation of environmental policies is subject to suitable resources in the enforcement administration, this budget sovereignty allows regional governments to undermine central environmental prescriptions.

‘Soft’ centralisation has thus led to a partial shift of power: as the Centre retains its right of policy initiative and overall strategic planning, provincial/municipal governments and especially the line ministries have gained in influence. At the local level, institutional cleavages changed from horizontal/geographic (between local administration units and local government) to vertical/functional lines (Mertha, 2005). This administrative level hence appears to be the fitting unit of analysis when looking at institutional aspects of environmental policy.

In summary, decision-making at the national level is the result of negotiation and compromise in a multi-stakeholder structure. This contractarian approach of policymaking amongst line ministries implies that policies, which involve the competences and jurisdictions of different line ministries, tend to represent the smallest common denominator and thus likely do not pose overly ambitious goals. Similarly, as negotiations tend to follow the same pattern, they should show a high degree of modal coherence and thus
reproduce similar instrument types over time. Path-dependency implies that the top-down mode of policy-making of Maoist China has created a highly centralised Chinese administration that favours command-and-control regulation to more flexible legislation. However, the institutional context in China is more complex and heterogeneous than one would expect.

Amidst China’s opening process towards the West as well as internal reforms towards markets and a quasi-capitalist system China’s environmental policy seems to have changed in practice. The Chinese State Council issued a guideline in 1992, requesting “that every level of government makes full use of market-based instruments to promote sustainable development and to protect the environment” (Wang and Lu, 1997: 15). This more flexible approach can be expected from the above description of a locally decentralised decision-making landscape in contemporary China. Chinese public administration is not as highly centralised and top-down as would be expected from a purely institutionalist point of view. This institutional heterogeneity is likely to have an effect on policy mode, i.e. the types of instruments chosen. The potential needs and wishes for more flexibility of administrative bodies further down the hierarchical line are likely to find representation in policy negotiations. Similarly, the defragmented institutional environment has empowered these administrative bodies quite considerably, which allows for local applications of different policy types (Mertha, 2009). This implies that policy modes may differ according to spatial scales (central-local) and between locales.
The academic literature has so far not paid attention to either of these possibilities. This research project aims to fill this gap. Accordingly, chapter four identifies the dominant policy mode as well as spatial patterns in and exceptions to instrument adoption in China’s automotive sector.

3.2 Policy Assessment in China

The literature on policy assessment holds that command-and-control regulation is potentially effective but inefficient, while the environmental outcome of potentially efficient incentive-based instruments is not necessarily predictable. This bifocal view of policy instruments does not quite capture all aspects of environmental policy instruments applied today. Command-and-control regulation at times features flexibility mechanisms that can render this policy mode more efficient. At the same time, such mechanisms jeopardise the environmental outcome of a policy. Similarly, the institutional context – especially of developing countries and emerging markets – can impede the efficiency benefits and the effectiveness of incentive-based instruments. Western-derived theories thus do not necessarily depict the realities of developing countries and emerging markets.

In line with traditional conceptions of command-and-control instruments, Chinese standards, norms, and regulations portray the paradigm of a strong state and are generally well conceived and reasonably stringent (Zhang et al, 1999). However, contrary to textbook assumptions, Chinese command-and-control regulation is to a large degree ineffective, due to a lack of proper enforcement and implementation (Blackman and Harington, 2000) especially
at the local level (Ross, 1984; Beyer, 2006). This implementation gap and lack of conversion of legislation into business practices of (mostly state-owned) enterprises has motivated scholars to solely emphasise institutional implementation problems in Chinese environmental policy.

Such a one-sided focus ignores other causes for ineffective implementation, e.g. too flexible policy design. This is especially true if flexibility mechanisms that can render command-and-control regulation more efficient but less effective are ignored (Lutsey and Sterling, 2012). The literature is only beginning to recognise this erosive effect in the automotive sector. Accordingly, this research project gives an overview of the most important environmental and climate policies in China’s automotive sector, paying particular attention to the flexibility these measures grant polluters in their compliance efforts. It thereby aims to change the analytical paradigm of Chinese policy assessment towards the inclusion of efficiency aspects and the effects of increasing flexibility of policy instruments on their effectiveness. The international orientation of both automobile manufacturers as well as environmental and climate regulation in this sector renders the Chinese automobile market a worthwhile case study. Since almost every international automobile manufacturer is present on the Chinese market, the regulatory and legislative framework governing this industry is being scrutinised by manufacturers, politicians, and scholars alike. Although automobile manufacturers are known to lobby for less stringent regulation worldwide (ACEA, 2008), vehicle regulations in most ambits have been made more stringent over the past decades (Ewing et al, 2008). At the same time,
international automobile regulation has been a policy laboratory for Pigouvian tax incentives and flexibility mechanisms (Austin and Dinan, 2005; Lutsey and Sperling, 2012).

As the literature survey also showed, international scholars see a trend towards the increased use of incentive-based instruments, even in developing countries and emerging markets. Proponents of such instruments hold that incentive-based instruments can exploit differences in marginal abatement costs and thus achieve the envisioned environmental goal very efficiently. However, the literature has so far produced relatively little empirical evidence to substantiate this claim. This is particularly true for the case of China. A notable exception is the pollution levy system of the early 1980s, which has received considerable academic attention (Wang and Wheeler, 1999; Yang and Dong, 1997). While some authors claim the pollution levy system has been effective in some instances (e.g. in reducing water pollution, see Afsah, et al, 1996: 8), others hold that market-based instruments in general and the pollution levy system in particular have failed to bring about effective and efficient results in China (Zhang, 2008; Blackman and Harrington, 2000; Wang and Lu, 1997).

Several reasons account for these deficiencies. First, the poor design of incentive-based instruments in China fails to produce economic incentives to fully internalise the costs of polluting externalities. Pollution levies in China are set at such low levels that polluters prefer to pay the fine even when the appropriate abatement facilities have been installed (Yun, 1998 in: Blackman
and Harrington, 2000: 28). A second reason is found in the institutional context, as environmental protection bureaus are financially dependent on their local governments, which tend to have a more economy-oriented agenda, and thus have an interest in the continued discharge of pollutants if the levy is directly fed into their budgets (Tang et al, 1997; O’Connor, 1998). Also, differences in the political agenda of local governments and the central administration can lead to dysfunctional enforcement. Zhang (2008: 3911) describes how local governments do not enact environmental fees and charges because the revenues stemming from these charges are earmarked for the national government.

Incentive-based instruments and flexibility mechanisms in China’s automotive sector have so far not been investigated. Taking Chinese fuel consumption standards and policies fostering the new-energy vehicle sector as a case study, this research project provides an in-depth comparison and analysis of such flexibility mechanisms in the Chinese context. The literature on international vehicle efficiency standards traditionally compares standards according to their nominal stringency. Individual flexibility mechanisms, however, render such comparisons mostly inexact. A thorough analysis of these potentially erosive mechanisms is only starting to take shape (Fischer, 2008). First academic studies have shown the relevance of such mechanisms and have begun quantifying their erosive effect for the case of US standards (Lutsey and Sperling, 2012). A thorough comparison of flexibility mechanisms in fuel economy standards or a quantification of their
effect for the Chinese case is as of yet missing. The following core chapters will address this gap in the literature.
Chapter Four

4. Modes of Environmental and Climate Policy in China’s Automotive Sector

4.1 Introduction

As the survey of the literature shows, international environmental and climate policy tends to rely on command-and-control regulation rather than incentive-based instruments. Following an institutionalist perspective, the long history of centralist Party rule in China also suggests command-and-control regulation as the dominant policy, at least on the national level. Empirical investigations of China’s preferred mode of policy instruments have so far investigated single instruments or local applications.

At the same time, the administrative reform process initiated in the 1990s has led to a locally fragmented and decentralised decision-making process in China. This development is likely to produce different modal outcomes at different spatial scales and in different industries. A comprehensive assessment of spatial differences or a whole industry is as of yet missing. Focussing on China’s automotive sector, this chapter categorises the mode of the most important environmental and climate policy instruments and identifies challenges to instrument implementation as well as potential ways to overcome them. The analysis suggests that, while command-and-control standards are the dominant
mode of environmental policy in China's automotive industry, a trend towards more flexible legislation can be discerned. These incentive-based exceptions are mainly found at the local level as well as in the policy field of electro-mobility and vehicle efficiency standards.

This chapter sets the frame for the subsequent analysis of the electro-mobility policy field and the related discussion of flexibility mechanisms in Chinese fuel economy standards. It gives an overview and analysis of the mode of environmental and climate policy instruments in China’s automotive sector. It does so by categorising the most important policy instruments in China’s automotive sector and identifying modal differences.

4.2 Environmental and Climate Policy Instruments in China’s Automotive Sector

This section identifies the main mode of China’s environmental and climate policy in the automotive sector. It sets out with an overview of national policy plans and instruments and continues with an overview of instruments used in the policy field of electro-mobility. Finally, the analysis turns to local applications in the municipality of Beijing. The categorisation of policy instruments helps to assess the rigidity of China's policy regime. The categorisation in this section places China in the CAC-incentive-based continuum and helps assess whether China as an officially communist country applies a rigid CAC regime or whether a trend towards more flexibility can be discerned.
4.2.1 Chinese Laws and National Industry Plans

At the national level, a range of environmental laws and industry plans governs the automotive industry. Since its revision in 1982, paragraph 26 of the Constitution of the People’s Republic of China addresses environmental protection and resource efficiency. In addition, the government passed several laws during the 1980s and 1990s to protect ambient air quality (see table 4.1). Complementing this legal foundation, industrial policies and policy plans outline the desired development and environmental protection efforts for the automotive industry. The overarching objectives of these policy instruments are to improve the technology base of China’s domestic automobile sector, develop a functioning market environment in the industry, encourage private car ownership, and to promote the development and marketing of more fuel-efficient vehicles.

In the 1994 Automobile Industry Policy the State Council prescribes strategic and technological goals for the automotive industry in China as a whole. It establishes the car industry as a sector of high political and economic relevance. In this regard it sets the sector’s political agenda with respect to its environmentally sound development. Addressing the comparatively low standard in fuel efficiency and pollution abatement technology at the time, the Policy required “the popularisation of new technologies and materials” that “economise on energy and cause little pollution” (Articles 15 and 45).
Table 4.1:

National Environmental Legislation and Plans Affecting the Automotive Sector

<table>
<thead>
<tr>
<th>Policy Item</th>
<th>Year of Enactment</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constitution of the People’s Republic of China</td>
<td>1982</td>
<td>CAC</td>
</tr>
<tr>
<td>National Five Year Plans</td>
<td>10th (2001-5)</td>
<td>CAC</td>
</tr>
<tr>
<td></td>
<td>11th (2006-10)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12th (2011-15)</td>
<td></td>
</tr>
<tr>
<td>Environmental Protection Law (EPL)</td>
<td>1989 (nationwide)</td>
<td>CAC</td>
</tr>
<tr>
<td>Law on the Prevention of Atmospheric Pollution (LPAP)</td>
<td>1995</td>
<td>CAC</td>
</tr>
<tr>
<td></td>
<td>2000 (revised)</td>
<td></td>
</tr>
<tr>
<td>Automobile Industry Development Policy</td>
<td>1994</td>
<td>Mostly CAC, some flexibility provisions</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td></td>
</tr>
<tr>
<td>Restructuring and Rejuvenation Programme for the Automotive Industry</td>
<td>2009</td>
<td>IBI</td>
</tr>
</tbody>
</table>

CAC: Command-and-Control Measure
IBI: Incentive-based Instrument
Source: author’s own

In 2004, the Policy was reformed and replaced by an Update promulgated by the national development and reform commission (NDRC). The Update addresses challenges and requirements brought about by China’s 2001 WTO accession and prescribed measures to make the automobile industry a “pillar industry in the national economy by the year 2010”. To this end, it aims to “promote the readjustment and upgrading of the structure of the automobile industry” by cultivating a “healthy automobile market” (Article 2), protecting intellectual property rights, and establishing “a number of large competitive automobile groups in the ranks of the world’s top 500” by 2010 (Articles 3 and
It also encourages the development of energy-saving and environmentally friendly vehicles with small displacement (Article 8) as well as research on alternative energy vehicles with a focus on hybrids and diesel engines for passenger cars. Moreover, it stipulated that the national average fuel consumption be reduced by more than 15% by 2010 (compared to 2004 levels) and a publicly accessible database be established, listing the fuel economy of all new vehicles (§10). Finally, the Update defines the role of the State in developing the auto industry. Article 1 enforces a “unified market environment with fair competition” through market-based resource allocation and integrated macro-control by the government. At the same time, it requires local authorities to set a level playing field for the market: Article 63 assigned the central State the right to impose and set the level of charges related to automobiles, while local governments were “not permitted to add new administrative charges or fees related to the purchase, registration or operation of automobiles” unless they obtained approval from the State Council. This last provision aimed to reduce local favouritism of regional manufacturers, but also limited the range of MBIs available to local governments to guide the local car market.

The most recent and by far most ambitious industrial plan is the 2009 Restructuring and Rejuvenation Programme for the Automotive Industry. The Programme recognises the rise of China’s auto market to one of the most important international markets and at the same time criticises the relatively weak position in terms of competitiveness and the technological standards, especially with regard to environmental technology. The State Council promulgated the Programme in response to the economic impact of the
international financial crisis in early 2009. Directly targeting the automobile sector as a key industry of the Chinese economy, the Programme puts forth a development plan with high short-term investments for the period of 2009 to 2011. These investments are meant to spur economic development by providing Chinese consumers with financial and fiscal incentives to buy new, environmentally friendlier vehicles. A special focus is put on financial incentives for electric vehicles and in the concentration of market power in the hands of few, bigger auto manufacturers by the end of the Programme.

Pursuing these industry plans, the Chinese leadership follows a dual strategy. Primarily focused on energy security and the consequential emancipation from oil imports, an improvement in the technology base is seen as a key aspect of economic policy (Oliver et al, 2009). At the same time, technologies that reduce the national average fleet consumption improve environmental aspects of the transport sector and help reduce GHG emissions.

The second objective concerns more economic considerations. The policies and plans function as the blueprint for the establishment and strengthening of market-measures in production and research processes. Furthermore, they advertise market mechanisms in the allocation of resources and the general competition for customers and elevate the automotive industry to a key pillar of the Chinese economy. Recognising the vast size of the domestic market as well as the demand for mobility, fostering private consumption has been a key element of Chinese economic policy since the mid-1990s. This aspect has become particularly prominent in the latest plan for the automotive industry.
Ameliorating the repercussions of the global financial crisis, this plan includes a sizable investment programme, which is aimed at increasing private vehicle consumption and significantly modernise the existing car stock.

From a modal perspective, the plans follow a predominantly command-and-control-style modus operandi. CAC plans and programmes set the political framework in three fields: market structure, political importance, and technology standards. With regard to the structure of the market, the policy plans mandate the supply-side consolidation of the number of manufacturers. To this end, all three plans encourage the automobile sector to form bigger players that yield the biggest share of the market. At the same time, they prescribe concrete market shares for specific vehicle types. With regard to the political significance of the industry, the plans define the automobile sector as a key economic pillar. This is a strong directive for ministries and local government agencies to foster the industry at all levels. Lastly, the plans prescribe specific technology standards. The 1994 Automobile Industry Development Plan, for instance, required a nation-wide phase-out of leaded fuel by the year 2000. Incentive-based instruments are underrepresented at this level. Notable exceptions to this rule are fiscal and financial purchasing incentives of the Rejuvenation Plan.

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13 The 2009 Programme sets specific goals for the vehicle market: it demands that the share of small displacement vehicles (less than 1.5 litre) shall reach 40% or more; that of passenger cars with engines smaller than 1.0 litre shall reach 15% or more; and heavy trucks shall account for 25% of all trucks sold. It furthermore quantifies the desired output of EV at 500,000 units by 2011 and holds that all major passenger car manufacturers shall have new-energy vehicles in their portfolio, with NEV sales amounting to 5% of total passenger auto sales that year.
4.2 Chinese Policies on the Automotive Market and Individual Vehicles

Regulations on vehicle emissions, monitoring, and fuel consumption apply strictly CAC regulation (see table 4.2). Emission standards and fuel economy standards are among the most effective policy instruments in the transport sector (ICCT, 2004; 2011a; 2011b). Both sets of standards are designed after equivalent legislation in other sophisticated markets.

Encouraged by positive experiences made in the developed vehicle markets of the US, Japan, and Europe, the Chinese government adopted fuel economy standards relatively late (Wang et al, 2010). Designed as a classic CAC instrument, the standards describe weight-based fuel consumption limits for every vehicle produced in China. Fuel consumption is tested prior to market homologation by means of a drive cycle test. The results of the test are then compared to the fuel economy limits for that model's weight class. In phases 1 and 2, non-compliant domestically produced cars are denied homologation and cannot be marketed, sold, or registered in China. This restriction to market access has shown considerable success as the national average fuel consumption has been reduced from 9.11l/100km in 2002 (Wang et al, 2010) to approximately 7.8/100km in 2006 (GFEI, 2012). Phase-3 came into force in the summer of 2012 and aims for a further decrease to about 6.9l/100km by the

\footnote{Due to this inbuilt inflexibility regarding non-compliance, phases 1 and 2 do not pose overly strict fuel economy standards (FES) on domestically produced vehicles and even allow for exceptions. All Chinese FES phases differentiate between 'normal' and 'special' structure vehicles. In phases 1 and 2, 'special' structure vehicles are subject to more lenient consumption limits than 'normal' structure equivalents. In addition, and most notably, imported vehicles are exempt from drive cycle testing and do not have to abide by any economy standards (which facilitated an unintended increase in the SUV population). These alleviations are meant to provide domestic manufacturers with some leeway on the way to stricter FES in phase-3 and thereafter.}
end of 2015. It has introduced a range of flexibility mechanisms\textsuperscript{15} that are designed to ease manufacturers’ compliance and increase the efficiency of this policy.

Chinese emission standards closely follow very stringent European standards and cover the most important vehicular pollutants (CO, HC, NOx, and particulate matter). This requires automobile manufacturers to bring cleaner vehicle technologies to the market. Similarly, tougher emission standards oblige oil companies and refineries to market cleaner, unleaded fuels with lower sulphur content. Given China’s effective enforcement in homologation procedures for new vehicles and fuels, the environmental effectiveness of these standards is thus very high.

\textsuperscript{15} Manufacturers will need to achieve individual corporate average fuel consumption targets based on weight-specific emission targets and the sales-weighted vehicle fleet. Phase-3 still categorises vehicles in kerb-weight classes and defines consumption targets for each weight group. Rather than banning non-compliant models straight away, the new standard assigns manufacturers a sales-weighted average fleet economy target. This means that the sale of models with excessive consumption can be offset with credits earned in other weight classes that year. Furthermore, the new standard grants manufacturers a lead-in time of 3 years during which corporate average fuel consumption limits are ameliorated by 12, 9, and 6 per cent, respectively, as compared to the undiscounted phase-3 standard values (Wang et al, 2010). Although concrete measures have not been published yet, it is likely that phase-3 will include financial incentives to make manufacturers comply with the standard.
Table 4.2:

National Environmental Policies on the Automotive Market and Vehicles

<table>
<thead>
<tr>
<th>Law/ Regulation</th>
<th>Year of Enactment</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaded Fuel Phase-out Notice</td>
<td>1998</td>
<td>CAC</td>
</tr>
<tr>
<td>Procedures on the Monitoring and Management of Environmental Pollution through Automobile Exhaust Discharges</td>
<td>1990</td>
<td>CAC</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>CAC</td>
</tr>
<tr>
<td>Circular on the Standards on the Elimination of Out-dated Automobiles</td>
<td>2001</td>
<td>CAC</td>
</tr>
<tr>
<td>Emission Standards for LDVs</td>
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<tr>
<td>China I</td>
<td>2000</td>
<td>CAC</td>
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<tr>
<td>China II</td>
<td>2004</td>
<td>CAC</td>
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<tr>
<td>China III</td>
<td>2007</td>
<td>CAC</td>
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<tr>
<td>China IV</td>
<td>2010</td>
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<tr>
<td>Fuel Economy Standards for LDVs</td>
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<tr>
<td>Phase-1</td>
<td>2004</td>
<td>CAC</td>
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<td>Phase-2</td>
<td>2006</td>
<td>CAC</td>
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<td>Phase-3</td>
<td>2012</td>
<td>CAC</td>
</tr>
<tr>
<td>Fuel Tax</td>
<td>2009</td>
<td>IBI</td>
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<tr>
<td>Regulations on the Vehicle Excise Tax and Circular on Reducing the Vehicle Excise Tax on Vehicles with Low Pollution Discharge</td>
<td>2000</td>
<td>IBI</td>
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<td></td>
<td>2004</td>
<td>IBI</td>
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<tr>
<td></td>
<td>2009</td>
<td>IBI</td>
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<tr>
<td>Vehicle Sales Tax</td>
<td>2006</td>
<td>IBI</td>
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<tr>
<td>Environmentally Friendly Vehicle Database and MIIT Vehicle Consumption Database</td>
<td>2007</td>
<td>IBI</td>
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<tr>
<td>Environmental Label</td>
<td>2007</td>
<td>IBI</td>
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<tr>
<td>Green Car Subsidy</td>
<td>2009</td>
<td>IBI</td>
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<tr>
<td>Old-for-New Policy</td>
<td>2010</td>
<td>IBI</td>
</tr>
<tr>
<td>Fuel-Efficient Vehicle Subsidy</td>
<td>2011</td>
<td>IBI</td>
</tr>
</tbody>
</table>

LDVs: Light Duty Vehicles with a kerb mass <3,500 kg  
CAC: Command-and-Control Measure  
IBI: Incentive-based Instrument  
Source: author’s own
Classic market-based instruments that form the backbone of transport policies in Europe and elsewhere are underrepresented in China. A good example is the negligible taxation of fuels\textsuperscript{16}. The most important national measures in this category are vehicle excise taxes, purchase subsidies, and trade-in incentives to spur the automobile market and increase the turnover rate in the national vehicle fleet towards more fuel-efficient automobiles. In 2000, the State Council set the rate of the vehicle excise tax to 10% of the purchasing price. The tax is levied on private and public vehicles. Implementing the policy plan to support the popularisation of low emission vehicles, several exceptions and incentive rates have been defined since\textsuperscript{17}. In addition to the excise tax payable by consumers, vehicle manufacturers are taxed according to the displacement of their sold vehicles. Encouraging the marketing of presumably more fuel-efficient small displacement vehicles, the tax applies to 7 classes of engine size ranging from 3% to 20% of the vehicle price.

\textsuperscript{16} The Chinese government directly regulates fuel prices. The National Development and Reform Commission (NDRC) supervises the pricing of fuels. In 2009 the tax on oil consumption was increased from RMB 0.2 per litre to RMB 1 per litre for gasoline and from RMB 0.1 per litre to RMB 0.8 per litre for diesel. The same year, price changes are now permissible if crude oil prices change more than 4% within 22 consecutive working days. However, pricing does not always follow this formula. In particular, the government avoids steep price increases to maintain affordable prices, especially for farmers. This policy results in substantial gaps in the cost balancing of Chinese refineries, leading to shortages and hoarding in the market.

\textsuperscript{17} The State Administration of Taxation and the Ministry of Finance issued a directive that provided a tax cut of vehicles compliant with Euro 2 emission standards in 2002. Vehicles that achieved the Euro 2 standard ahead of time enjoyed a 30% reduction of the excise tax. In 2004, a similar tax break was introduced for vehicles fulfilling the Euro 3 standards. In the context of the national industry development plan introduced in the above section, the 2009 tax reform set the tax rate for fuel-efficient vehicles with a displacement of 1.6 litres or less to 5% and 7.5% in 2009 and 2010, respectively.
Vehicle taxes are complemented by financial measures to promote fuel-efficient vehicles. In this context, the 2010 ‘Old-for-New’ policy offered a premium to purchasers of new vehicles when trading-in their old car. The joint initiative of the Ministry of Finance, Ministry of Commerce, and the Ministry of Environmental Protection provided buyers of new vehicles with a ‘green car subsidy’ of RMB 3,000-6,000. The policy was extended to 31 December 2010 and the subsidies were raised to a more substantial RMB 5,000-18,000. In the same year, the Ministry of Finance and of Commerce issued a circular permitting participants in the plan to benefit from simultaneous advantages of the ‘Old-for-New’ programme and the reduced vehicle excise tax. In October 2011, the Ministry of Finance presented the latest reform of the fuel-efficient car subsidy programme. The subsidy was reduced to a mere RMB 3,000 and now mandates even stricter fuel efficiency targets for eligible vehicle models.

In summary, environmental policy instruments applied at the national level predominantly follow the command-and-control approach and have had a substantial impact in some areas. National policy measures have successfully phased out leaded fuel and required manufacturers to market cleaner and more efficient cars. CAC standards on fuel consumption have contributed to increasing average fuel economy of cars on the Chinese market. At the same time, financial and fiscal incentives exist to complement these regulations. However, since incentive levels are low in absolute terms and can thus incentivise the consumption of relatively costly vehicles only to a certain extent, the efficacy of such flexible instruments is likely limited. Due to rather low financial incentives, most subsidised vehicles belong to the lower segment of
the market and do not feature state-of-the-art fuel-saving technology. The long-term effect of this policy is thus questionable. The positive outcomes of emission and fuel consumption requirements on individual vehicles have been counteracted by the enormous growth of the vehicle market as a whole. Despite increasing efficiency levels of individual vehicles and constant improvements in abatement technology, the absolute increase in the number of vehicles on the roads has led to higher absolute levels of pollution and fuel consumption.

4.3 Policies on Electro-Mobility in China

The Chinese leadership assigns major importance to the new energy vehicle industry. Over the past three Five Year Plans it has explicitly underlined its ambition to develop the electric vehicle sector (see table 4.3). Equipped with high-level political support, several policies and programmes have been implemented and heavily rely on incentive-based instruments.

Named after the year and month of its inception (March 1986), the 863 Programme aims to foster research and development as well as the marketisation of products in the most advanced technology fields. With respect to the automotive sector, the Programme’s most significant projects are the “EV Key Project” and the “Key Project of Energy-saving and New Energy Vehicles”.

The Electric Vehicle Key Project was devised during the 10th Five-Year Plan (2001-2006) and invested a budget of RMB 880 million in the development and research of electric vehicle components. Focused on the early development of the EV industry, it identified best practices, technology standards, and suitable
domestic manufacturers to produce electric vehicles in China. The Project built the foundation for the Key Project of Energy-Saving and New Energy Vehicles implemented during the 11th Five-Year Plan (2006-10). This project prepared the Chinese market for the industrialisation of EV production. Investing a total of RMB 1.1 billion, the focus was on the development of key technologies and system optimisation as well as research and development of power train technologies, and key parts.

Table 4.3:

Policies on Electro-Mobility

<table>
<thead>
<tr>
<th>Policy</th>
<th>Year of Enactment</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>863 National Programme</td>
<td>1986</td>
<td>CAC</td>
</tr>
<tr>
<td>Electric Vehicle Key Project</td>
<td>10th Five Year Plan (2001-5)</td>
<td>CAC</td>
</tr>
<tr>
<td>Key Project of Energy-Saving and New Energy Vehicles</td>
<td>11th Five Year Plan (2006-10)</td>
<td>CAC</td>
</tr>
<tr>
<td>National Programme of EV Pilot Projects “10 cities, 1,000 Vehicles”</td>
<td>2009</td>
<td>IBI</td>
</tr>
</tbody>
</table>

CAC: Command-and-Control Measure  
IBI: Incentive-based Instrument  
Source: author’s own

The 2009 “10 Cities, 1,000 Vehicles” programme introduced purchasing subsidies for electric vehicles. The programme was originally designed for 10 cities, but has meanwhile been extended to a total of 25 cities.\(^\text{18}\) It provides

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\(^\text{18}\) Today, the programme is being implemented in Beijing, Shanghai, Chongqing, Changchun, Dalian, Hangzhou, Jinan, Wuhan, Shenzhen, Hefei, Changzutan, Kunming, Nanchang, Tianjin, Haikou, Zhengzhou, Xiamen, Suzhou, Xiamen, Tangshan, Guangzhou, Chengdu, Shenyang, Nantong, Xiangfan, and Hohot.
public authorities with subsidies for the purchase of electric passenger cars, light-duty commercial vehicles, and buses\textsuperscript{19}. Institutionalising the programme in a somewhat more coordinated fashion, the “Energy-Efficient and New Energy Vehicle Pilot Programme” was set up in 2009. Currently, 25 cities participate in the programme and offer local subsidies for new energy vehicles that are purchased for public and commercial use. The subsidies amount to up to RMB 50,000 for PHEVs and RMB 60,000 for each electric vehicle, subject to their emissions and the capacity of the traction battery. In six cities, Beijing, Shanghai, Changchun, Shenzhen, Hangzhou, and Hefei, these subsidies are extended to private consumers. Notably, all of these cities host sizeable manufacturer plants.

In May 2012, the Ministry of Industry and Information Technology (MIIT) passed its industry development plan for energy efficient and new energy vehicles. The plan quantifies concrete goals for the market penetration of plug-in electric vehicles for 2015 (500,000 units) and 2020 (5 million units), respectively.

Contrary to otherwise CAC-dominated policy for conventional cars, the Chinese strategy to develop the electro-mobility sector heavily depends on sizeable, locally restricted subsidies for manufacturers as well as private and public consumers. The tremendous efforts have, however, so far met with limited success. By mid-2012, only approximately 8,500 new energy vehicles had been purchased.

\textsuperscript{19} The former two categories are subsidised with up to RMB 250,000, depending on the electric output and fuel saving rate compared to a base model. The latter class is incentivised with up to RMB 600,000, depending on the type of traction battery and the fuel saving rate compared to a base model.
set to the streets (CGTI, 2012). If electro-mobility in China reaches a sizeable market, environmental advantages will be miniscule due to the large carbon footprint of the energy sector and upstream emissions relating to vehicle charging (Ji et al, 2012). Benefits will most likely occur in the area of energy security due to reductions in oil demand.

4.4 Local Policy Instruments: The Case of Beijing

Beijing is very active in both adopting national measures ahead of the national schedule as well as passing local policies. A municipality directly under the State Council, the city holds considerable administrative power in the political hierarchy. Its central position in the Chinese government as well as economy and culture makes Beijing a role model for other major cities and underlines its ‘lighthouse function’ in progressive environmental policy. As a result, Beijing is (sometimes overly enthusiastically) “considered a pioneer in controlling vehicle emissions in China, similar to the role California plays in the U.S.” (Wu et al, 2012).

The local leadership faces severe environmental problems, especially concerning ambient air quality. Transport emissions thereby play a major role and have been the focus of several local policies and campaigns (see table 4.4). Vehicular emissions have become a major concern of Beijing policymakers, amounting to 22.2 per cent of PM 2.5 concentrations. In an attempt to reduce PM 2.5 by 15 per cent by 2015, the city government issued a plan to monitor, report, and reduce particulate (Xinhua, 20 March 2012).
Beijing’s leading role experimenting with local provisions for later application in other urban centres is best exemplified by the 2008 temporary measures for the Olympic Games. For the duration of the Games, 70% of governmental vehicles were banned from the streets. In addition, private vehicles were prohibited from driving on the roads every second day, depending on the odd or even last digit of their licence plates. This temporary measure has been continued with slight modifications since the Games and cars are still banned 1 day per week depending on their licence plate. The trial has been extended recently until the end of 2012 and has either been discussed or copied in other cities.\(^{20}\)

In addition to temporary measures and the early adoption of national standards, the municipal government in Beijing passed a rule preventing outside-registered vehicles from entering the area inside the 5th ring road during peak hours. Similarly, Beijing imposed a ban on new motorbike registrations inside the 4th ring in 2001, effectively limiting the population of motorbikes in the inner city. In January 2011, the Beijing authorities also capped the number of licences for passenger cars to 240,000. 80 per cent of licences are allocated to private households, while 10 per cent are earmarked for public and business use, respectively. This CAC provision is carried out via a televised lottery.

\(^{20}\) For instance, Guangzhou, capital of Guangdong province and host of the 2010 Asian Games, has made use of the experiences learned during the Beijing Games. Similar to the measures in Beijing, the Guangzhou government banned private vehicles from city roads from 7am to 8pm following the odd-even licence plate principle for the duration of the Asian Games. This measure, too, has been institutionalised after the end of the Games, so that private cars are banned from the streets 1 day per week. In addition to Guangzhou, CAC-style bans have been implemented in Yinchuan in Ningxia and Chengdu in Sichuan province, respectively, to restrict access to environmental zones for vehicles with yellow labels during daytime.
Tickets are free, but registration incurs an administrative fee and chances to ‘win the lottery’ diminish constantly as all applicants, who were not granted a licence, remain in the lottery for one year and are included in the next round. Offering a soft incentive-based mechanism to support the marketization of electric vehicles, the Beijing lottery did temporarily not apply to electric vehicles, in the meantime, electric vehicles have been integrated into an updated quota system.

Aiming to keep traffic outside the city core, Beijing also applies incentive-based instruments to tackle congestion. In 2011, the municipal government reformed the pricing system of the three-tiered parking scheme. The new parking fee system categorises parking facilities according to their distance from the city centre into three classes. The most central areas are charged with a premium, thus giving a financial incentive to motorists to park outside the centre and continue the journey by public transportation.

Beijing is also a pilot city in the development scheme for electric vehicles. As such, the city offers local purchase incentives that complement national incentives. Subsidies amount to up to RMB 50,000 for plug-in hybrids and RMB 60,000 for battery-electric vehicles, depending on the capacity of the traction battery. So far, especially the latter subsidies for electric vehicles have met with little success.
### Table 4.4: Environmental Policies in Beijing

<table>
<thead>
<tr>
<th>Policy</th>
<th>Year of Enactment</th>
<th>Mode</th>
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<tbody>
<tr>
<td>Emission Standards for LDVs</td>
<td></td>
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<tr>
<td>China I</td>
<td>1999 (1 year ahead of national standard)</td>
<td>CAC</td>
</tr>
<tr>
<td>China II</td>
<td>2003 (1 year ahead of national standard)</td>
<td>CAC</td>
</tr>
<tr>
<td>China III</td>
<td>2005 (2 years ahead of national standard)</td>
<td>CAC</td>
</tr>
<tr>
<td>China IV</td>
<td>2008 (2 years ahead of national standard)</td>
<td>CAC</td>
</tr>
<tr>
<td>China V</td>
<td>2012 (ahead of national standards)</td>
<td>CAC</td>
</tr>
<tr>
<td>Leaded-fuel Phase-out</td>
<td>1998 (2 years ahead of national standard)</td>
<td>CAC</td>
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<tr>
<td>Ban of Outside-registered Vehicles</td>
<td>2011</td>
<td>CAC</td>
</tr>
<tr>
<td>Motorbike Ban</td>
<td>2001</td>
<td>CAC</td>
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<tr>
<td>Vehicle Registration Regulations</td>
<td>2011</td>
<td>CAC</td>
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<tr>
<td></td>
<td>1994</td>
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<tr>
<td>Scrapping incentives</td>
<td>1998</td>
<td>IBI</td>
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<tr>
<td></td>
<td>2010</td>
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<tr>
<td>EV Subsidies (in addition to national subsidies)</td>
<td>2010</td>
<td>IBI</td>
</tr>
<tr>
<td>Parking Fee Scheme</td>
<td>2011</td>
<td>IBI</td>
</tr>
<tr>
<td>Eco Labels</td>
<td>1998</td>
<td>IBI</td>
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</tbody>
</table>

**LDV**: Light Duty Vehicles with a kerb mass <3,500 kg  
**CAC**: Command-and-Control Measure  
**IBI**: Incentive-based Instrument  
**Source**: author’s own

In summary, environmental policy in Beijing is CAC dominated. The municipality introduces national regulation sometimes ahead of the national schedule and complements it with local standards, bans, and regulations. Some of these CAC measures, such as the licence plate lottery, have been implemented rigorously and effectively. At the same time, the local government uses incentive-based instruments to enforce national policies or to deal with local pollution and congestion issues. Local subsidies for new energy vehicles...
complement the national programme and pose a sizeable financial incentive for electric vehicles and plug-in hybrids. However, similar to the wider national programme, the effect of this measure is questionable. This is partly due to technical and performance-related issues with new-energy vehicles and partly because of the underdeveloped charging infrastructure.

4.5 Challenges for Environmental Policy in China

The above characterisation and analysis of national as well as local policy plans, laws, and regulations has shown that, while the backbone of Chinese policy in the automotive sector follows the command-and-control approach, flexibility mechanisms in regulatory standards and incentive-based instruments are becoming more popular. This is particularly true for the policy field of electro-mobility and at the local level in Beijing. This section relates these trends in policy mode in this sector to the overall challenges in environmental and climate policy in China that threaten both the effectiveness and efficiency of these policy instruments.

*Development objective:* modernisation has been the dominant theme of China’s opening and reform era. Mirroring development ideals of industrialised countries, private car ownership is widely accepted as an indicator of modernisation and personal success. Per capita vehicle ownership levels are thus bound to increase, leading to higher oil consumption and pollutant emissions. Environmental and climate policy will have to respond to the associated threats of environmental degradation and energy security.
From a policy perspective, the development objective implies a stronger focus on more sophisticated incentive-based instruments in lieu of CAC regulation. The development of fuel economy standards from relatively stringent command-and-control regulation towards the inclusion of substantial flexibility mechanisms could be indicative of a general shift towards incentive-based instruments. Taking into account the mediocre effect of current taxation and subsidy benefits, a widespread shift towards incentive-based instruments would likely require substantial changes to the enforcement and monitoring apparatus in China.

*Economic growth paradigm*: China’s development strategy has so far followed a purely growth-oriented paradigm, which has put a significant strain on the country’s resources and environment. Recently, the Chinese government declared its ambition to shift the development strategy towards more sustainable, high value-added growth in the 12th Five Year Plan. However, as urbanisation progresses and Chinese customers become more affluent, some scholars predict a growth of the vehicle stock to over 407 million vehicles in 2050 (Wang et al, 2011). This exorbitant number of cars is bound to exacerbate environmental problems and energy consumption problems.

The Chinese government sees the root of this problem in the low energy efficiency of the transport sector. Accordingly, it has invested political and financial capital in industries that promise to improve energy efficiency. The electro-mobility sector has been singled out as a key element to future mobility. However, problems in the implementation of these policies and technological limitations pose challenges to the sustainable development of this sector.
**Technological limitations:** Against the background of exorbitant market growth, increasingly efficient and cleaner vehicle technologies are needed to ameliorate environmental effects. Currently, Chinese manufacturers lack the technological skill to develop such advanced technologies (Gallagher, 2006). Given issues with the protection of intellectual property rights, a technology transfer from more advanced international manufacturers seems unlikely. At the same time, the Chinese leadership has set its mind on supporting the nascent electro-mobility sector. Electric vehicles can indeed improve the energy efficiency and environmental implications of the transport sector (Oeko, 2011). However, given technological constraints as well as so far ineffective incentive-based policy in this field, substantial market shares of new energy vehicles are not to be expected before 2020 (McKinsey, 2012).

**Institutional ambiguities in rulemaking:** The administrative landscape in China divides responsibility for many aspects of the policies introduced above among a multitude of institutional bodies. The electro-mobility sector is a key example of this administrative cacophony. At present, five ministries and ministry-like state-owned enterprises compete for the lead in different aspects of this sector: the Ministry of Industry and Information Technology (MIIT) is in charge of standardisation and norms – a crucial aspect in the development of electric vehicles; the Ministry of Science and Technology (MoST) is responsible for the many pilot programmes, which have so far failed to bring about the desired results; the National Development and Research Council (NDRC) oversees the market development of electro-mobility; the Ministry of Finance (MoF) decides on grants and loans for the development of the sector; and, finally, State Grid Corporation of China (SGCC) has the state-monopoly on building and running
the charging infrastructure in China. The diverging interests of these key players and, consequently, the transaction costs implicated in the negotiation of these interests severely impede the effective and efficient development of policies as well as their implementation.

Secondly, the discrepancy between national, provincial, and local laws on the one hand and their actual implementation on the other has become a well-known problem in Chinese studies. Several authors describe the ‘implementation gap’ phenomenon in Chinese policy (Ross, 1984; Beyer, 2006). Some studies find that the reason for weakly enforced policies lies in the relative institutional weakness of local enforcement agents, such as environmental protection bureaus (Da Motta et al., 1999; Tang et al, 1997), as well as the changing role, commitment, and environmental conviction of regulators (Shi and Zhang, 2006).

For the most part, environmental policy in the automotive sector seems to be a notable exception. This is due to the fact that the majority of policy instruments follows the CAC approach and is implemented by a well-established enforcement apparatus. The electro-mobility sector remains, however, a major area of concern. At current penetration rates, China’s goals to become a world leader in this industry are jeopardised. This is partly due to a lack of attractive electric vehicles in the market in terms of price, performance, safety, quality, and appeal (McKinsey, 2012). However, uncoordinated and ineffective implementation at the local level, especially with regard to the development of the charging infrastructure, is a major obstacle to environmental policy in this field.
Poor and counterproductive policy design: several national policies use flexible instruments to provide fiscal and financial incentives for the procurement of efficient cars. As these incentives are given for cars with relatively small displacement, they are predominantly designed to increase the sales of domestic manufacturers. The amounts offered are too small to incentivise the purchase of highly efficient vehicles with modern, state-of-the-art technology. The strategy of subsidising vehicle sales furthermore increases overall vehicle ownership and thus exacerbates environmental problems and energy consumption.

Deficient policy design also impedes the effectiveness of CAC regulation. The first two phases of Chinese vehicle fuel consumption standards, for instance, excluded imported vehicles from homologation procedures. As a result, highly inefficient luxury cars such as sports-utility vehicles (SUVs) have been excluded from fuel economy requirements (Wang et al, 2010).

4.6 Possible Solutions

Potential solutions to the abovementioned problems include a strengthening of the administrative organisation and of institutions in the design and enforcement of policies: Irrespective of policy modes, regulatory instruments require effective monitoring and enforcement mechanisms. Laws and regulations need to be clearly formulated and unambiguous in order to provide both regulators and regulated parties with reliability in their compliance efforts. Clearly defined responsibilities and powers are key to both effective enforcement as well as rulemaking. Both of these aspects require a significant restructuring of the
administrative organisation in China. With regard to the latter, clear competences for the different ministries and other governmental bodies need to be defined. A key example for this need is the electro-mobility sector, where the administrative confusion needs to be overcome by a clear assignment of ministerial responsibilities and lead functions of an overseeing body. In this context, areas of particular importance are flexible policy instruments supporting the marketization of electric vehicles in China and specifically the local influence of manufacturers and other stakeholders on local governments’ decisions (Fraunhofer, 2012). The latter exertion of influence needs to be minimised in order to bridge the implementation gap.

Amending the growth paradigm by sustainability: China's development strategy has so far been dominated by a resource-intensive growth paradigm. However, in the latest Five Year Plan, the leadership underlined its dedication to ameliorate the ensuing environmental and economic repercussions. To this end, the government aims to shift the economy towards higher value-added activities (APCO, 2010). This commitment to economic and environmental sustainability needs to be institutionalised in real world policy. China's tremendous investments in the public transport sector are a step in the right direction. With regard to the automotive industry and particularly its stance on growth in individual transport, China seems only at the beginning of this process.

Improving policy design: China’s canon of environmental policy is reasonably sophisticated. However, several instruments leave room for improvement. Chinese fuel consumption standards, for instance, are nominally reasonably
stringent. However, a range of flexibility mechanisms introduced in the current phase has the potential to significantly erode standard effectiveness. This effect should be quantified and the results should be included in the design of future standards or the setting of future fuel economy targets. Similarly, pricing signals in China’s automotive sector are underdeveloped. The low financial incentives for fuel-efficient vehicle purchases as well as minimal fuel taxation are good examples.

*Relying on CAC regulation:* The most effective examples of environmental policy in China’s automotive sector are CAC regulations, e.g. vehicle efficiency and criteria pollutant emission standards. Contrarily, current incentive-based instruments fail to bring about effective or efficient results in China (Blackman and Harrington, 2010). Flexible policy instruments will achieve efficiency gains only if their design as well as implementation and enforcement infrastructure are reformed substantially. For the time being, command-and-control instruments have the highest efficacy despite design flaws and potentially erosive flexibility mechanisms. For this reason, further research on flexibility mechanisms in CAC standards, which can render CAC regulation more efficient, needs to be undertaken. The role of flexible instruments as complementary policy instruments providing compliance incentives, e.g. penalties or feebate systems, should be strengthened.

*Information and public support:* Effective policy depends largely on committed participation. The societal problems caused by the automotive sector provide a high degree of motivation for remedial action, especially for urban citizens. Chinese governments at all levels should utilise this untapped support and link
political action with information and education programmes, which point out the effectiveness of parking fee policies and programmes tackling PM 2.5.

*International cooperation:* Finally, China can learn from as well as give guidance to countries and regions with similar environmental and industrial problems. Such cooperation can include the methodological support in designing new policies as well as exchange of experience and remedial technologies. In the area of electro-mobility, the Chinese government is taking this approach and closely cooperates with international partners\(^{21}\).

### 4.7 Summary

The above analysis shows that – contrary to the dominant view in the literature - environmental and climate policy in China as the biggest automobile market is not exclusively rigid and command-and-control oriented. While CAC regulation forms the backbone of environmental policy in this sector, a drive towards increased flexibility exists in at least three areas. First, several CAC standards include flexibility mechanisms that likely make such regulation more efficient (but potentially less environmentally effective). Phase-3 of Chinese fuel economy standards is a good example. The paradigmatic shift away from purely vehicle-based performance standards towards fleet averaging endows manufacturers with a considerable degree of flexibility in their compliance

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\(^{21}\) As part of its new energy vehicle strategy, the Chinese leadership closely cooperates with the German government in a Strategic Partnership. The environmentally sustainable development of the electro-mobility sector is a major focus of the Partnership. Against this background, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Chinese Automotive Technology and Research Centre (CATARC) jointly implement the project Climate Protection and Electro-Mobility in China ([www.electro-mobility.cn](http://www.electro-mobility.cn)).
efforts. Secondly, modal differences exist along policy fields. One such field of particularly high central support, the new energy vehicle sector, presents a significant exception to CAC dominance. Here, national programmes and initiatives combine regulatory measures with incentive-based instruments.

A third exception to a rigid CAC regime follows geographical lines. Traditionally, environmental policy in China is seen as being hampered at the local level (implementation gap). This is often due to a conflict of interest of local governments, which are legally obligated to maintain a clean natural environment for their citizens, but that either depend on local polluters for tax revenues or as local employers, or that have a stake in such companies themselves. In the case of Beijing, the situation seems to be more complex. Its government implements national standards vigorously and sometimes ahead of the national schedule. It answers local problems (such as traffic congestion) with legislation that goes over and beyond national prescriptions. While most of these measures adhere to CAC ideology and provide little flexibility, the number of flexible instruments in Beijing is significantly higher compared to the national regime.

Whether a focus on incentive-based instruments is the way forward for China’s car-related policy remains to be seen. Given the higher effectiveness of current CAC measures, flexible instruments are more likely to complement environmental policy rather than become the main paradigm in the automotive sector. Moreover, flexibility mechanisms in fuel consumption standards – while potentially efficient – have the potential to erode instrument effectiveness. The
subsequent chapters thus investigate the effectiveness of these flexible instruments in China’s automotive industry more closely.
Chapter Five

5. Electro-Mobility in China: Rationale and Instrument Effectiveness

5.1 Introduction

The analysis of environmental and climate policy instruments in China’s transport sector performed in chapter four showed that a modal change towards the adoption of incentive-based instruments can be discerned in the policy field of electro-mobility. This chapter analyses select deployment policies for electric vehicles to see whether these flexible instruments are effective in bringing electric vehicles to the streets.

The literature on instrument choice and policy implementation shows that instruments can only unfold their full efficacy in terms of efficiency, effectiveness, and equity, if the institutional context of the host country is taken into account (Bell and Russell, 2002; 2003). This is especially true when incentive-based instruments, that were conceived and designed in a Western political and social context, are applied in a different cultural and institutional environment (Wang, 2010). This chapter adds the case of China to this literature and assesses the effectiveness of incentive-based policies applied in the electro-mobility sector.

Two instruments, a national programme and a local EV deployment incentive in Beijing are examined. Both instruments signify a directional change in Chinese
EV policy away from market preparation through research funds and towards the active development of the EV market.

This chapter is structured as follows: section two provides a background on the motivation and benefits of electro-mobility in China. Section three presents China’s EV strategy by introducing the most important developments in EV policy. Part four assesses the two instruments under study. Section five discusses the findings before the final section draws the main conclusions.

5.2 Background: China’s Motivation for Electro-Mobility

This section presents the key motivating factors for China’s substantial support of its electro-mobility sector.

Since the beginning of China’s reform and opening era in the late 1980s and especially since the country’s accession to the World Trade Organisation in 2001, the country has experienced remarkable economic growth. Driven by this economic spur, the passenger car market in China has grown tremendously as well (see figure 5.1). Growth in this sector averaged approximately 4 million units per annum in the period from 2005 to 2008. Growth rates have even spurred to over 10 million units per annum since 2009 (China Passenger Car Association, 2011). Despite this extended growth period, per capita vehicle ownership in China remains low. In 2010 vehicle ownership was a mere 43 cars per 1,000 inhabitants compared to 530 in Europe and over 800 vehicles in the US (Roland Berger, 2012). Academics and market researchers thus see
enormous potential for further market development in China. Conservative estimates expect a vehicle stock of up to 200 million cars in 2020 (MIIT, 2010).

Figure 5. 1:

Stock of Passenger Cars in China

The societal repercussions of this unprecedented growth are manifold, but three areas have come to paramount prominence in Chinese automotive policy, i.e. energy security and concerns regarding the dependence on oil; greenhouse gas and criteria pollutant emissions from vehicles with internal combustion engines; and industrial policy considerations aiming to equip the domestic automotive industry with the technology and expertise necessary to compete on the global market.

The first of these areas is best summarised by the fact that - despite growing output - Chinese mineral oil resources are too limited to meet a satisfactory share of private oil demand. A net oil importer since 1993, China’s share of imported petrol in total oil consumption has risen parallel to the vehicle market. Today, more than 56 per cent of all petrol is imported (NDRC, 2012). Dependence on oil imports from politically instable countries, incalculable
fluctuations in price, and the high prospective growth of the domestic vehicle mark have given rise to concerns within the Chinese government with regard to the country’s energy security. In its 12th Five Year Plan, the government accommodated these concerns and specified concrete goals for improvements in energy efficiency and GHG emissions. The development of energy-saving vehicle technology has since ascended to the top of the political agenda. Consequently, the government plans to reduce energy consumption by 16 per cent and to lower overall CO₂ emissions by 17 per cent in the period from 2011 to 2015, relative to GDP (ECN, 2011).

One policy means to achieve this target are vehicle efficiency standards. Such standards have achieved a decrease in average fuel consumption in China from 9.11l/100km in 2002 (Wang et al, 2010) to approximately 7.8l/100km in 2008 (GFEI, 2012). The present third phase of Chinese vehicle standards prescribes an average fuel consumption of 6.9 l/100km of all new vehicles by 2015. The goal for 2020 has been set to 5l/100km (State Council, 2012). However, against the background of tremendous market growth, improvements in individual vehicle efficiency are likely more than offset by the strong increase in new vehicles on the road. Consequently, even if per capita car ownership were to reach current American levels, China’s oil demand would exceed current global oil production (McKinsey, 2012). China’s transport sector is thus likely to remain highly dependent on imports unless substantial improvements in overall energy efficiency in the transport sector can be achieved and the resource base can be transitioned from oil-based fuels to other forms of energy.
The electrification of the road transport sector, i.e. via plug-in electric vehicles, is seen as one way to reduce China’s dependence on oil.

From an energy security perspective, China’s abundance in coal and other fossil energy carriers supports this view. The country’s rich coal supply guarantees a rich energy supply for decades to come. The environmental and climate implications of this paradigm, however, are substantial. The second area of focus therefore concerns the environmental and climate effects of the transport sector. Vehicle emissions already account for the majority of criteria pollutant concentrations in urban ambient air (He et al, 2005; Wu et al, 2012). At the city level, progressing urbanisation rates in combination with a concentration of vehicle ownership in conurbations has given rise to environmental concerns and discontent among urban dwellers. Several Chinese cities, such as Shenzhen, Beijing and Shanghai, are among the most congested cities worldwide (IBM, 2011). Anticipating further gridlock and ensuing civil discontent, Beijing and Shanghai have passed legislation to limit the number of new registrations on their roads each year. Increasing urbanisation rates in combination with a concentration of automobiles in China’s many conurbations has also given rise to car-related environmental concerns among the urban population. In this context, the People’s Congress announced that monitoring particulate emissions (PM2.5) in select cities commenced in 2012 and that this programme will be extended to all cities at or above prefecture level by 2015 (YCC, 2012).

Pursuing these efforts, electro-mobility is regarded as an environmental technology that has the potential to significantly reduce transport emissions
(McKinsey, 2008). As EVs cause little to no direct emissions, they are considered local zero-emission vehicles. If, however, charged with China’s coal-dominated grid mix electro-mobility will not significantly ameliorate the pollution and GHG emission problem. According to al (2010), charging EVs with the current electricity mix would increase SO$_2$ emissions up to ten times and could double NO$_x$ emissions compared to conventional petrol cars. Upstream CO$_2$ emissions of battery electric vehicles vary significantly between regions but amount to up to 260 g/km (Wu et al, 2012). This compares to well-to-wheel emissions of approximately 270 g/km for conventional petrol cars. Hybrid electric vehicles that do not plug in to the net are least CO$_2$-intense at around 180 g/km in all grids. Due to the high carbon-intensity of the national grid mix, purely electric vehicles do thus not produce significantly lower CO$_2$ emissions. In a coal-dominated grid, hybrids are the most efficient and at the same time cost-effective technology for the near future (Yao et al, 2011; Huo et al, 2010; Wu et al, 2012).

The CO$_2$ impact of electric cars can only be improved via a significant reduction of CO$_2$ intensity in energy production. Initially, this can be achieved via improvements in the efficiency rates of existing power plants (Huo et al, 2010). However, a substantial contribution to emission reductions and cleaner ambient air in cities by the electro-mobility sector requires a parallel and concerted integration of renewable energies in the grid mix (T&E, 2009; ETC/ACC, 2009; CE Delft, 2010; BUND, 2009). For the time being, EVs are at best local zero-emission vehicles that can help relocate emissions from power plants to less densely populated areas, thereby cleaning up China’s city centres (Ji et al, 2012).
The final motivator for the electrification China’s automobile sector concerns industrial policy. Academics, international experts, and political decision-makers see a vast potential for electro-mobility worldwide. China is thereby seen as a future lead market in both EV production as well as applications (Dijk et al, 2012; McKinsey, 2008, 2012). Technological leadership in all aspects of EVs, ranging from research and development for key technology components to production capacities and resources, will become a key element for future industrial policy in this sector. Given the current technology gap to Western and Japanese manufacturers in the area of conventional petrol cars, the Chinese leadership is keen to leapfrog internal combustion engine technology and become a world leader in EV know-how (Gallagher, 2006). China can thereby rely on competitive advantages in its domestic EV sector, e.g. its relatively advanced traction battery industry and the highly centralised agenda-setting process, which theoretically supports the large-scale investments necessary in EV infrastructure and EV deployment. At the same time, the Chinese leadership complements environmental and climate policy measures with industrial policy. This motivation is grounded in the conviction that an increasingly more stringent legislative environment, which requires automobiles to become more efficient and less polluting, contributes to crowding out out-dated technology and thereby strengthens the technology base and competitiveness of the domestic automotive sector.

In summary, the substantial environmental and climate repercussions of the fast-paced automotive market as well as aspirations to become a global lead market for new energy vehicles are key drivers for China's electro-mobility
sector. The following section outlines how these drivers are translated into actual policy to foster the electric vehicle market.

5.3 Key Players and Policies

Having identified the main motivators for China’s electro-mobility sector this section presents the main players as well as policies in China’s electro-mobility sector.

5.3.1 The Institutional Environment

Three main ministries, several subordinate government bodies as well as state-owned enterprises drive the development of the Chinese electro-mobility sector at the central level. In particular, three line ministries, NDRC, MIIT, and MoST have been most influential in setting the national agenda and strategy. The NDRC had been in charge of China’s overall strategy for the development of the electro-mobility sector since the early inception of the sector in the 1990s. In 2009, faced with an unfolding financial crisis and the related plunge in domestic vehicle sales, the NDRC decided to concentrate on revamping the domestic automobile industry and the implementation of the restructuring and rejuvenation programme for the automotive industry. Retaining the central lead for the development of a national charging infrastructure for electric vehicles, the NDRC passed the responsibility for the early market preparation and technological research to MoST in 2009. This transition from NDRC to MoST initiated a new phase of central policies and supporting instruments that concentrated on the development of crucial EV technologies, such as traction
batteries, electric motors, and vehicle electronics on the one hand and, most importantly, demonstration programmes for technology solutions as well as applications of use cases on the other. The national EV demonstration programme presented below is the most significant of these political measures.

Amidst this general restructuring of the political lead in the electro-mobility sector, the issue of technology standards and norms has proven a formidable challenge for a unified, sustainable, economically viable, and comprehensive development of both electric vehicles as well as the charging infrastructure. In 2008, the newly founded MIIT became the line ministry responsible for all standardisation work concerning norms and technical standards related to in-vehicle technology. Moreover, MIIT is in charge of vehicle efficiency standards for internal combustion engine as well as electric vehicles, an area of high political and industrial importance. In addition to MIIT, several other administrative bodies under the State Council, such as the General Administration of Quality Supervision, Inspection and Quarantine (GAQSIQ) and the Standardisation Administration of China (SAC), and state-owned utility and power grid enterprises, such as State Grid Corporation of China and China Southern Power Grid, collaborate in the setting of national as well as international standards and norms for electric vehicles and the charging infrastructure.

This set of national stakeholders is complemented by local governments and local branches of both the line ministries as well as the involved state-owned enterprises that retain a high level of influence on particular aspects of local EV
development. The local governments of the EV demonstration cities are responsible for the implementation of the EV charging infrastructure.

5.3.2 Electro-Mobility Policy in China

Pursuing the abovementioned energy security, emission reduction, and technological leadership goals, the different line ministries, government organisations and state-owned enterprises have enacted a range of policies at the national and the local level to foster the EV market. China’s Five Year Plans (FYPs), in which the central government outlines its investment priorities and defines medium- and long-term targets as well as political measures to attain them, have given increasing importance to the new energy vehicle policy field. The 8th FYP (1991-1995) promoted research and development in the EV sector for the first time via the National Key Scientific and Technological Project. While conventional automobile technology was the focus of the 9th FYP (1996-2000), new energy and electric vehicles were already considered as mid- and long-term technologies. Subsequently, the 10th (2001-2005) and 11th (2006-2010) FYPs included key EV projects to direct technology innovation in the sector and to explore commercial markets for EVs, respectively\(^{22}\). The most recent FYP (2011-2015) elevated China’s automobile industry to a key sector of the economy and declared the EV sector one of seven strategic emerging industries. This status guarantees the industry significant financial and regulatory support from the government (Zheng et al, 2012).

\(^{22}\) In this context, the Three Parallels and Three Verticals Research and Development Strategy was established by MoST. The Three Verticals refer to the three NEV technologies supported, i.e. fuel cell vehicles, hybrids, and battery electric vehicles. The Three Parallels represent three key vehicle components, i.e. the power train system, the motor or engine, and traction batteries. (http://www.most.gov.cn/kjbgz/200602/t20060219_28821.htm)
The most significant EV deployment policies have been implemented during the lead of the Ministry of Science and Technology under the umbrella of the National High-Tech Development Programme (863 Programme). These policies cluster into 2 phases, i.e. a technology development and market preparation phase until the first half of the 11th Five Year Plan, and the current EV commercialization phase that commenced in 2009. In the initial phase, political EV support concentrated on grants and loans for the development of key components of electric vehicles. In this context, the Electric Vehicle Key Project invested a total of RMB 880 million in research and development. The project built the foundation for the subsequent Key Project on Energy-Saving and New Energy Vehicles implemented during the 11th Five-Year Plan (2006-10). This latter project prepared the Chinese market for the industrialisation of EV production, investing a total of RMB 1.1 billion in research and development (ITEC, 2010; MoST, 2010).

The second phase is characterised by sizeable, locally concentrated subsidies for manufacturers as well as private and public consumers. The most notable of these subsidy programmes, the national EV demonstration programme, has met with quite harsh criticism as all participating pilot cities have failed to achieve their set targets (see below). In an effort to foster EV deployment, the State Council released the Energy Saving and New Energy Vehicle Development Plan in March 2012. The plan earmarks a total of RMB 10 billion for investments in

23 In March 1986, the Ministry of Science and Technology (MoST) initiated the 863 Programme as China’s first nationwide programme addressing centralised research and development for advanced technologies. The Programme aims to improve China’s capacity in the development of high-tech innovations and to leapfrog out-dated generations of technologies (MoST online). These objectives have been pursued in every national Five Year Plan in different sectors of the economy. Thus equipped with both political support at the ministerial level as well as sizeable funds, the 863 Programme has played a key role in China’s EV strategy.
continued research and development of the EV sector as well as demonstration programmes in several cities by 2020 (Zheng et al., 2012). It also sets concrete deployment targets for EVs: 500,000 EVs are to be put on the road by 2015 and 1 million by 2020. These efforts aim to achieve an average fuel consumption of new vehicles of 6.9l/100km in 2015.

In what can be interpreted as a challenge to the MoST leadership of the political management of China’s electro-mobility sector, the plan was submitted to the State Council and other ministries by the Ministry of Industry and Information Technology (MIIT). The actual promulgation of the plan was considerably delayed. The delay was due to disagreements between the different ministries, mainly MIIT and MoST, with respect to the concrete quantitative goals stipulated in the plan as well as the technology roadmap for EV types included. The differences between MIIT and MoST are the result of their continuing struggle for the administrative leadership in China with regard to the development of the electro-mobility sector. While traditionally MoST had been in the lead in electro-mobility questions and has been responsible for most of the EV deployment programmes, the MIIT has been gaining in importance over the last few years. This is especially due to its lead involvement in standardisation aspects, which is currently one of the most influential fields in global and Chinese electro-mobility.

The following sections take a selection of these policies as a case study and investigate their effectiveness in bringing electric vehicles to the streets.
5.4 Assessment of EV Policy Effectiveness

This section chooses two policies to assess the effectiveness of EV deployment instruments in China’s transport sector. While Chinese transport policy instruments tend to follow a *command-and-control* approach, allegedly more efficient and flexible *incentive-based instruments* have grown in popularity among the Chinese leadership in the policy field of electro-mobility. The first instrument analysed is thus a national policy under the leadership of MoST that provides substantial subsidies for EV deployment. At the local level, these subsidies are complemented by further incentive mechanisms. Accordingly, the second instrument chosen is a local EV deployment incentive integrated in the licence lottery system in the municipality of Beijing.

5.4.1 EV Demonstration Programme

The by far most ambitious and important national EV deployment policy is the “Energy-Efficient and New Energy Vehicle Pilot Programme”. Based on the “10 cities, 1,000 vehicles” programme initiated in 2009, the pilot programme financially incentivises the deployment of electric vehicles in participating cities. The original programme included 13 cities for the “demonstration of energy-saving and new energy vehicles” (MoST, 2010: 3). In the course of the programme, the number of cities participating has been extended to a total of 25. Individual deployment targets differ greatly and range from 600 in Hohot to 9,000 EVs in Shenzhen. In total, the programme aims to deploy over 52,000 vehicles by 2012 (MoST, 2010).

Supervised and administered by the Ministry of Science and Technology (MoST), the programme is supported by individual policies of different
branches of the government. These include the Automobile Industry Restructuring and Revitalisation Plan issued by NDRC, lists and directories of approved EVs included in the programme (MIIT) as well as tax and subsidy policies by the Ministry of Finance (MoF). In all 25 participating cities, the programme provides public authorities with subsidies for electric vehicles that are purchased for public and commercial use, i.e. buses, taxis, government vehicles, and postal service vehicles.

Six of the 25 cities participating in the national EV demonstration programme extend the subsidy scheme to private consumers and provide complementary local incentives24. Subsidies for light-duty passenger vehicles amount to up to RMB 50,000 for plug-in hybrids and RMB 60,000 for battery electric vehicles, subject to their emissions and the capacity of the traction battery.

Progress in the deployment of EVs has been very slow despite these subsidies. By the end of June 2011, i.e. approximately 2 years into the programme, less than 6,000 EVs had been registered (McKinsey, 2012). By 2012, this number had risen to approximately 8,500 (CGTI, 2012). In the summer of 2012, i.e. half a year from completion of the initial phase, the “Energy-Efficient and New Energy Vehicle Pilot Programme” was still falling short of most of its targets (see Figure 5.1). In absolute numbers, programme subsidies have brought approximately 20,000 vehicles to the streets in 25 cities. In terms of vehicle deployment, the policy has thus been mostly ineffective. None of the cities participating has achieved its stipulated target. On average, the pilot cities have reached a fraction

24 The six cities are Beijing, Shanghai, Changchun, Shenzhen, Hangzhou, and Hefei.
of their EV deployment goals and only about 30 per cent of the overall deployment goal has been achieved. Beijing and Shenzhen currently top the list of participating cities with over 3,000 and 2,000 EVs on the roads, respectively.

A major reason for the current lack of effectiveness of this deployment measure is local protectionism in the participating cities. This is especially true for those six cities that extend the subsidy scheme to private EV purchases. In these cities, additional local subsidies are only granted to private customers if they fulfil additional local requirements that primarily support local automotive manufacturers. In essence, local subsidies only apply to locally produced vehicles. Electric vehicles produced in other parts of China as well as imported vehicles are not eligible to local subsidy schemes.
At the same time, EV sales have picked up over the first half of 2012. This may be indicative of a gradual acceleration of EV deployment. The efficacy of the overall programme as well as potential improvements is being discussed by the stakeholders. The lessons learnt and conclusions drawn from the initial phase of the demonstration programme will be integrated in the subsequent phase beginning in 2013. EV support efforts, such as the development of the charging
infrastructure and smart grid applications, might then either be concentrated in (select) existing pilot regions or extended to a greater number of cities.

5.4.2 Beijing Lottery Exemption

While all of the cities participating in the pilot programme pursue individual deployment targets for private EVs separate from the goals for public EVs in the pilot scheme, Beijing links this policy with a further incentive-based instrument in order to support the deployment of 23,000 battery-electric vehicles and 7,000 plug-in hybrids by the end of 2012 (MoST, 2010).

Over the last decade, the vehicle population in Beijing has followed a steep growth trajectory (Figure 5.2), increasing the total number of automobiles amounted from 1 million in 1997 to over 5 million in 2012. In the same period, the average time to add one million to the vehicle stock decreased from 6.5 years to 2.4 years. The high demand for vehicles in Beijing has led to an average growth of over 400,000 vehicles per annum in the period from 2001 to 2011. This figure includes an unprecedented hike in vehicle registrations following the announcement of the lottery system in late 2010.
In response to exacerbating levels of urban congestion and ambient air quality, the municipal government issued a range of policies in late 2010 to limit the increase in the number of vehicles on the road and to raise the overall cost of driving in the city. The two most effective items in this policy package are a tiered parking pricing system effectively raising hourly parking fees in the city\textsuperscript{25} as well as a strict limit on the number of new automobile registrations.

From 2010 to the end of 2013 the city effectively limited the number of new registrations to 240,000 vehicles per year. 80 per cent of this amount was reserved for private vehicles, while 10 per cent was allocated to business and

\textsuperscript{25}Inside the 5\textsuperscript{th} ring road hourly fees have been increased from RMB 2 to RMB 10. (Xinhua, 23 December 2010)
governmental use, respectively. From 2014 onwards, the Beijing Municipal Commission on Transport has set the quota to 150,000 vehicles per annum.

Contrary to the municipality of Shanghai, where vehicle licenses are auctioned in a tender on a monthly basis, the Beijing government implemented a lottery system allocating vehicle licences. Residents with a Beijing household registration (hukou) and outsiders, who provide proof that they have paid their local taxes for 5 consecutive years, can take part in the monthly draw. Conceived as the allegedly most just and socially fair allocation system, the lottery assigns the right to licence a private car to 17,600 citizens each month (under the 240,000 quota). The participation process is handled online and registered users are notified by SMS whether they won a licence (BMCT).

Figure 5.2 also shows that the Beijing lottery system has significantly reduced the number of new annual LDV registrations in the capital. In the first year of the lottery programme, only about 180,000 vehicles were newly registered (BMCT). The discrepancy to the total permitted number of 240,000 vehicles that year is due to the fact that lottery participants are permitted to wait up to 6 months before acting on the licence permission and because the low odds of winning a licence incentivise the participation of applicants, who have not yet fully committed to actually buying a car.

In the first week of its inception, the lottery system attracted over 200,000 applicants, over 180,000 of which were eligible to take part in the draw. Since then, the number of participants has risen by an average of over 42,000 per
month (see Figure 5.3). In May 2012, over 900,000 residents competed for one of the 17,600 permits for private licences. Effectively, chances of winning a licence are very low at one in 51 and decrease with each new round of application. To improve the odds slightly, the municipal government amended the system in March 2012 and required unsuccessful applicants who joined the popular first draw of the lottery in 2011 to renew their application. As a result, participation dropped in May 2012 for the first time since the inception of the lottery system. The following month saw, however, a particularly strong increase in participation numbers, thus further decreasing the chances of individual citizens to win a licence.

In order to incentivise private consumption of electric vehicles, the municipal government temporarily exempted EVs from the licence cap in May 2012. This measure provided EVs with a theoretically significant competitive advantage, as EV drivers did not have to try their (very low) chances to obtain a licence permit. The exemption of EVs from the lottery requirement thereby offered a strong incentive to consumers. Instead of betting on their diminishing chance to win a registration permit, EV customers could buy their vehicle and use it legally immediately. However, despite national and local subsidies for private EV purchases that amount to up to RMB 120,000 and despite the lottery exemption, total EV sales in Beijing were far off the 30,000 target for 2012. By July 2012, not a single EV had been registered via the private EV subsidy programme in the capital (BMCST, 2012).
Faced with these sobering statistics, the Beijing municipal government reformed the lottery system in 2014 in order to jumpstart the local EV market. Abolishing the temporary lottery exemption for EVs, the new lottery system contains an annually increasing share dedicated to New Energy Vehicles as depicted in table 5.1. Effectively further diminishing the chances to register conventional ICEVs, the local authorities significantly incentivise the registration of electric vehicles and other New Energy Vehicles.
Table 5.1:

**New Registration Quota: Share of ICEVs and New Energy Vehicles**

<table>
<thead>
<tr>
<th>Year</th>
<th>ICEVs</th>
<th>NEVs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>130,000</td>
<td>20,000</td>
<td>150,000</td>
</tr>
<tr>
<td>2015</td>
<td>120,000</td>
<td>30,000</td>
<td>150,000</td>
</tr>
<tr>
<td>2016</td>
<td>90,000</td>
<td>60,000</td>
<td>150,000</td>
</tr>
<tr>
<td>2017</td>
<td>90,000</td>
<td>60,000</td>
<td>150,000</td>
</tr>
<tr>
<td>total</td>
<td>430,000</td>
<td>170,000</td>
<td>600,000</td>
</tr>
</tbody>
</table>

Source: YCC, 2014

Complementing the EV incentive policy in the city, the municipal government launched the Electric Partnership Programme ([http://www.evbeijing.cn/](http://www.evbeijing.cn/)) in May 2013 in order to raise public awareness and give its citizens an opportunity to experience electro-mobility first-hand. The Programme is designed and organised by the Beijing Municipal Science and Technology Commission (BMSTC), the administrative body subordinate to the line Ministry of Science and Technology (MoST) and is thus part of the national EV demonstration programme. The Programme schedule includes the erection of 12 charging stations with a total of 300 slow and 30 fast charging poles for 600 battery-electric vehicles within one year. Registered customers can rent EVs rather inexpensively (at present, rental rates are RMB 49/2h, RMB 99/day, and RMB 1,999/month).

### 5.5 Discussion

The above analysis shows that both the EV demonstration programme as well as the Beijing licence lottery exemption are ineffective in bringing the stipulated
number of EVs to the market. Reasons for this failure are manifold, but fall into two clusters: technical boundaries diminishing EV attractiveness and policy design.

First and by far the most important reason is the blatant lack of competitive EVs on the market (McKinsey, 2012). This lack is particularly apparent in the private EV market of Beijing, where sizeable subsidies and strong licence incentives have not led to significant EV deployment. Compared to conventional petrol cars, EVs offer much less utility to consumers at comparatively higher costs. The main reason lies in the fact that EVs are rarely purpose-built but are instead derived from heavy and comparatively inefficient internal combustion engine vehicle (ICEV) designs. This leads to technological constraints pertaining to vehicle range, battery life, reliability, vehicle safety, and inconvenient charging duration.

Secondly, the EV infrastructure is underdeveloped in all pilot cities, despite accelerating construction of charging stations. This factor is of less concern for the penetration of EVs in public service with a closed duty cycle, i.e. for bus routes, postal services, waste disposal and other applications that require EVs to operate on a predetermined route. In these use cases, battery charging logistics can be prearranged, e.g. via overnight charging, charging facilities along the duty cycle route, or via battery swapping stations. For the case of more flexible applications, however, such as taxi services or the private use of EVs, a convenient, comprehensive, inexpensive, and fast charging infrastructure is
indispensable to consumers. This is particularly true for current EV models with limited electric range.

Also, a clear and unambiguous decision as to the mode of EV charging has not yet been made. While most manufacturers prefer home charging, i.e. the charging of traction batteries inside the vehicle at home, the workplace, or at public charging stations, the politically influential State Grid Corporation of China, a quasi-monopolist in the development of the EV infrastructure, advocates centralised battery charging in battery swapping stations. In the absence of a decision on the main charging mode, costly infrastructure development will likely be further delayed and both manufacturers as well as consumers face a trade-off between potential gains from EV use and betting on the winning technology for future use.

Thirdly, the design of the EV subsidy is deficient. A battery electric vehicle, such as the BYD E6, costs approximately RMB 230,000. Even after the deduction of a maximum local and national subsidy of RMB 120,000 it is still more expensive than the ICEV version F6, which is priced at RMB 90,000. The scheme does thus not offset the price premium of EVs enough to significantly increase attractiveness to consumers.

Further reasons for ineffective EV policy in China pertain to the instruments policy themselves. Both instruments investigated in this chapter suffer from ineffective implementation and a lack of coordination between local government stakeholders. The process of EV subsidy application and execution,
for instance, is reportedly bureaucratic, confusing, and very time-consuming (ElMo PP, 2012). As a result, pilot city authorities have to advance subsidies for EV purchases and collect the funds in arrears. Moreover, the subsidy programme is coordinated at the national level, while local authorities are responsible for the development of the charging infrastructure. In the absence of crucial standardised norms and procedures, this can lead to locally isolated charging standards and protectionist solutions that favour local EV manufacturers but ultimately impede the advancement of the EV sector at a national level (Brown et al, 2010). Local EV deployment is also characterised by a lack of coordination between local science and technology commissions administering the subsidy scheme on the one hand and environmental protection bureaus, urban planners, and traffic authorities on the other. This latter point likely significantly impedes the environmental and transport-related effectiveness of the programmes even if the deployment targets were reached.

Finally, the targets in both programmes have been set to overly ambitious levels. Spurred by high-level political support and a zealous motivation to secure generous government funding, the authorities in the 25 pilot cities have set very demanding EV deployment targets. This assessment is substantiated by a recent survey conducted by Zheng et al showing that the key motivation for participation in the Programme is the opportunity to develop the local auto industry (2012: 19). Local decision makers were thus likely to report impressive deployment targets with little regard for their actual feasibility to gain pilot status for their locality and obtain government funds.
Possible solutions exist for all of these challenges. The most crucial remedy is, however, a paradigm change in the understanding of the political support necessary for the electro-mobility sector in China. This includes the realisation that meaningful numbers of electric vehicles will only penetrate the market if the market is driven by private demand. Public and semi-public fleets are insufficient to achieve the goal of 500,000 EVs in 2015 and 5 million EVs in 2020. A first step in this direction is evident – the Electric Partnership Programme in Beijing is an example at hand. Although it does not incentivise private customers to purchase EVs, it exposes potential customers to the benefits of electro-mobility and lets them experience these vehicles first-hand. Moreover, it demonstrates that the technology is developed and mature enough to substitute certain use cases for internal combustion engine vehicles with EVs. Lastly, the charging stations are scattered throughout the city and will eventually add to a network of public charging infrastructure – a crucial aspect for the spread of private electro-mobility.

5.6 Summary

The analysis in this Chapter shows that both the motivation as well as political support for electro-mobility in China are substantial. However, neither the national EV demonstration programme nor local EV deployment incentives in Beijing are effective in bringing the envisioned number of EVs to the market. The reasons for this lack of instrument effectiveness are market- and instrument-specific. While incentive-based instruments can encourage EVs sales, they cannot guarantee an effective, large-scale deployment. This is particularly true when design flaws in concrete policies deter municipalities and
private consumers from making use of subsidy facilities. Instrument effectiveness is even more bounded if assessed against the background of overly ambitious deployment targets.

From a market perspective, EV deployment in China suffers from a lack of attractive products and infrastructure. As long as EVs are in the development stage, i.e. not competitive vis-à-vis conventional petrol cars in terms of performance and price, and as long as an appropriate charging infrastructure is non-existent, market development policies such as the subsidy schemes for EV purchases and the incentive mechanism in Beijing appear premature. This is especially true when they are combined with overly optimistic deployment targets as this leads to a 'blind' effort to reach the target with little regard to the (economic, environmental, and transport-related) usefulness of chosen EVs.

In addition to the underdeveloped market for EVs and the charging infrastructure, the current Chinese strategy does not assign sufficient importance to the private vehicle market. The national EV demonstration programme is an example at hand. While the programme encompasses a full 25 cities, only 6 participating cities extend the substantial purchasing incentives to private consumers. Given China's overly ambitious goal of 500,000 EVs by 2015 and even 5 million vehicles by 2020, the private EV market will need to pick up in order to meet targets. However, subsidies alone will not suffice to develop the private market. The licence lottery alleviation for electric vehicles in Beijing is a potentially very effective alternative to financial incentives once technologically and economically competitive electric vehicle models exist in the market.
A further market-related roadblock to a comprehensive development of the electro-mobility sector in China is the current lack of nationally and internationally harmonised technology standards. At present, a myriad of locally applied, technologically incompatible and at times incomplete standards and norms exists in the 25 Chinese demonstration cities. This regulatory cacophony severely impedes the ubiquitous development of a comprehensive, interoperable charging infrastructure as well as safe and easy-to-use vehicles. Having identified this strategic shortcoming, the Chinese electro-mobility industry is slowly beginning to participate in international harmonisation efforts, such as the International Electrotechnical Commission (IEC) or the International Organisation for Standardisation (ISO). Similarly, leading Chinese governmental institutions are cooperating with international partners in the harmonisation of standards and standardisation roadmaps for electric vehicles (see for instance the Sino-German cooperation in the sub-working group of the commission of standardisation in electro-mobility; DIN, 2012).

From a climate and environmental perspective, EV deployment as the sole criterion of instrument effectiveness does not recognise the full potential of electro-mobility in China. While the Chinese EV strategy focuses on mere market deployment, actual increases in energy efficiency and improvements in GHG and pollutant emissions via EV use are currently not included in assessment criteria. Such an inclusion would, however, open the EV discussion to improvements in energy efficiency in the power and transport sectors as well as a wider integration of renewable energies in China’s grid mix. Future EV policies and the integration of EVs in existing regulations, such as fuel economy
standards for conventional petrol cars, should therefore be improved and include a more realistic setting of targets and better policy design. With regard to the former, policy targets should be based on the potential benefits of electromobility in terms of energy efficiency and emission reduction, i.e. focus less on market development and subsidies for local manufacturers.

Concerning policy design, subsidies should (if used at all) be postponed to a time when EVs can successfully compete with conventional petrol cars in terms of utility, safety, and convenience. If subsidies are deemed desirable, price incentives will likely be perceived more strongly, if they are paid directly to the consumer instead of the manufacturer. Similarly, flexible instruments, such as the temporary Beijing lottery exemption, need to be communicated better to potential customers. Customers may have been unaware of the temporary exemption for EVs from the license lottery as a note on the lottery registration website expounding this facility was missing until the reformed quota system became effective.

Finally, electric vehicles have an influence on the existing legal and regulatory framework for conventional vehicles that must not be underestimated. An area of particular concern is the integration (or future separate treatment) of electrically propelled vehicles in current vehicle efficiency standards. The following chapters will present this problematique in more detail.
Chapter Six

6. Flexibility Mechanisms in Vehicle Efficiency Standards

6.1 Introduction

The analysis of policy instruments in the previous chapter indicates modal differences in the type of instruments chosen. This chapter takes the example of vehicle efficiency standards (VES) to illustrate the trend towards increased flexibility both in Chinese standards as well as the international benchmark. Vehicle efficiency standards are classic command-and-control regulation, which is made potentially more efficient by the inclusion of so-called flexibility mechanisms. Focusing on the comparison of nominal stringency VES regimes, the academic literature has so far treated mechanisms that increase compliance flexibility fairly abstractly. While such mechanisms can have an erosive effect on VES stringency, an adequate analysis and assessment is so far missing. This chapter compares flexibility mechanisms of three most influential VES regimes, i.e. the US corporate average fuel economy system, European CO₂ emission standards, and Chinese fuel consumption standards. Assessing the relative compliance flexibility each standard regime grants automobile manufacturers, the chapter thus lays the empirical foundation for further investigations into the effects of flexibility
mechanisms. The findings show that all three ambits have moved to a wider use of flexibility mechanisms both in number and scope. Similar to the findings in chapter four, flexible mechanisms are particularly significant in the area of electro-mobility. It is shown that all three systems integrate electric vehicles via super credits and zero-counting. This has a potentially negative effect on fuel economy requirements for conventional petrol cars. Possible solutions to this problem are phasing out flexibility mechanisms for electric vehicles and developing scientifically accurate and environmentally sound integration methods.

The tremendous growth in the global light-duty vehicle market as well as increased levels of vehicle activity have given rise to a range of societal problems, such as greenhouse gas (GHG) and pollutant emissions, urban congestion as well as increasing energy and oil consumption. Against the background of unprecedented growth in private passenger car markets in developing countries, these problems are likely to exacerbate (He et al, 2007; Hao et al, 2011; Zhang et al, 2010).

In an effort to ameliorate these societal problems, governments have implemented a wealth of policy instruments to reduce the environmental impact of the transport sector. Policy measures aiming to reduce automobile activity comprise - amongst others - oil pricing mechanisms (Austin and Dinan, 2005), intelligent travel demand management (Meyer, 1999), city planning and related zoning measures as well as policies that aim to shift travel behaviour from higher- to lower-impact transport modes, e.g. public
transport, car-pooling and car sharing (Ewing et al., 2008). One of the most widely utilised command-and-control (CAC) policy tools, vehicle efficiency standards\(^\text{26}\), is seen as a very effective tool in reducing the environmental impact of cars (ICCT, 2004; 2011; iCET, 2011). Especially for the case of China, VES are believed to lead to potentially large oil-saving benefits (He et al., 2007).

Despite harmonisation efforts, VES differ significantly across countries and regions. These differences range from the degree of coercion applied in enforcing the standards, i.e. from voluntary programmes to binding and enforced regulation, to technical aspects of the drive cycle used to test vehicle compliance and the utility parameter applied to differentiate vehicles, e.g. by gross vehicle mass (GVM) or footprint\(^\text{27}\).

Automobile manufacturers and their industry associations have repeatedly criticised VES regimes for imposing overly ambitious fuel-efficiency targets, claiming standards required unreasonably costly abatement measures and left manufacturers with too little flexibility in their abatement strategies.

\(^{26}\) Throughout this chapter, the term ‘vehicle efficiency standards’ and the acronym VES describe all forms of vehicle efficiency standards unless stated otherwise. VES include fuel economy and fuel consumption standards as well as standards on GHG emissions. The former set of standards regulates the permissible amount of fuel used during a standardised test cycle to cover a given distance, e.g. l/100km, or the reciprocal distance travelled for a given unit of fuel consumed, e.g. km/litre or miles per gallon (mpg). GHG standards mainly regulate the discharge of GHG during a standardised test cycle and use metrics expressing the discharge of GHG per distance travelled, e.g. gCO\(_2\)/km. Fuel economy is directly related to CO\(_2\) emissions. This is due to the carbon content of fossil fuel used in internal combustion engines, which translates approximately into 2.33 kgCO\(_2\) for every litre of petrol burnt.

\(^{27}\) Vehicle footprint is defined as the area between the 4 tyres of a vehicle, i.e. the product of track-width and wheelbase.
(ACEA, 2008). Often, manufacturer associations succeed in lobbying for alleviations in VES regulation. Such flexibility mechanisms are designed to increase manufacturers’ flexibility of response, i.e. the degree of freedom with respect to the strategies, methods, and quantitative efforts employed to comply with VES stipulations. Phrased positively, flexibility mechanisms potentially lower implementation costs, which can “increase the likelihood that the policies will actually be followed and the goal achieved” (Toman et al, 1999: 431). Theoretically, these measures thus allow manufacturers to achieve the desired environmental outcome at lower cost or greater ease.

In practice, however, flexibility mechanisms have been criticised frequently by environmental lobby groups. These see such provisions as impediments to environmental protection efforts that dilute or unnecessarily delay feasible emission reduction obligations or impose inadequately low fines for non-compliance (VCD, 2010; T&E, 2010). Some flexibility mechanisms create an incentive structure, which allows manufacturers to evade actual improvements in fleet efficiency, for instance when excess emission penalties are lower than the costs of introducing abatement technology to vehicle fleets. In other cases, highly flexible voluntary agreements have led to factual non-compliance due to dysfunctional incentive structures and a lack of a binding command-and-control back-up\(^2\) (IEA, 2008a). While nominally

\(^2\) Command-and-control backup-up in this sense pertains to legislation that mandates a minimum efficiency goal (for instance in the form of a maximum company fleet average requirement or a minimum per-vehicle fuel economy standard) and that is effectively monitored and enforced.
efficient, a high and unchecked degree of flexibility can thus undermine the effectiveness of fuel economy standards.

The discussion of the benefits and pitfalls of flexibility mechanisms in VES has so far been confined to the technical correspondence between manufacturers and rulemaking authorities. This exchange of intentions and information is primarily characterised by a strong focus on *commensurability* in the context of reasonable additional technical and monetary efforts demanded from automobile manufacturers in response to stricter VES phases (Alliance of Automobile Manufacturers, 2012). In some instances, the environmental repercussions of flexibility mechanisms are discussed by interest groups and non-governmental organisations in the field (T&E, 2009B; 2010; UBA, 2010). The academic literature has, however, so far not paid particular attention to the role and spread of flexibility mechanisms in VES. Instead, it has concentrated on comparing nominal VES stringency (ICCT, 2004; 2007; Plotkin, 2001). While technical and socio-political differences render comparisons of VES regimes a challenging task, such comparisons can help identify disparities, strengths and weaknesses of different VES approaches. However, comparisons of VES regimes that pay singular attention to nominal stringency run the risk of exaggerating the positive effects of such legislation. Only a very narrow section of the literature concentrates on the role of flexibility mechanisms and their potentially erosive effect on nominal VES stringency levels (Fischer, 2008; Lutsey and Sperling, 2012). A comprehensive account and inventory of flexibility mechanisms in international VES is so far missing in the literature.
This chapter aims to fill this gap by identifying and assessing flexibility mechanisms in the regulatory regimes of the three most important vehicle markets, namely the US, EU, and China. The analysis presented here identifies a trend towards a wider use and scope of flexibility mechanisms. Second, it points out challenges of future VES applications, especially in the emerging field of electric vehicles.

This chapter is structured into three parts. The first section introduces the most common flexibility mechanisms in VES. Part two presents regulatory flexibility mechanisms in the standard regimes of the US, EU, and China. The last part compares these flexibility mechanisms before the conclusion summarises the findings and provides an outlook for further research.

6.2 Flexibility Mechanisms in Vehicle Efficiency Standards

Vehicle efficiency standards are widely regarded as a very apt tool to improve vehicle efficiency as well as reduce oil consumption and greenhouse gas emissions (ICCT, 2004; 2007; Plotkin, 2007). Their effectiveness depends, however, significantly on three factors: the degree to which standards are binding to manufacturers, i.e. the degree of coercion employed by the State to enforce the standards; the level of ambition and stringency of fuel economy

29 The Chinese government is paying great attention to the integration of EVs in VES. As part of its new energy vehicle strategy, it closely cooperates with the German government in a Strategic Partnership. The development of the electro-mobility sector is a major focus of the Partnership. Against this background, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Chinese Automotive Technology and Research Centre (CATARC) jointly implement the project Climate Protection and Electro-Mobility in China (www.electro-mobility.cn).
targets; and the degree to which these targets represent actual fuel economy requirements, i.e. are not diluted by flexibility mechanisms. The spectrum of coercion applied in enforcing VES ranges from voluntary agreements to binding standards. As long as arrangements in the industry are not subject to binding emission reduction targets and related enforcement measures, their environmental outcome is unpredictable. The 1998 Voluntary Agreement\(^{30}\) between the EU and major manufacturer associations is a good example of an ineffective agreement that failed to bring the desired results.

The level of VES ambition can be gauged by the fuel economy targets such standards impose on manufacturers (ICCT, 2004; 2011; iCET, 2011). Since manufacturers argue that more ambitious targets put a significant financial strain on their compliance efforts (Alliance of Automobile Manufacturers, 2012; ACEA, 2008), most fuel economy standard regimes include mechanisms that grant manufacturers certain flexibility in their compliance efforts. Flexibility in this sense pertains to provisions that allow individual manufacturers to achieve their specific fuel economy targets with greater efficiency either individually or jointly with other manufacturers. Such instruments have, however, the potential to dilute the stringency levels of VES by offering manufacturers ways to delay, game or evade compliance. Table 6.1 gives an overview of the most important flexibility mechanisms applied in fuel economy standards.

\(^{30}\)The Agreement required three major manufacturer associations to achieve an industry-wide average emission level of 140gCO\(_2\)/km by 2008. While initial emission reductions were within anticipated levels, all three associations failed to meet the target, achieving an average industry-wide level of CO\(_2\) emissions of 155g/km in 2008 (UBA 2010).
Table 6.1:

**Flexibility Mechanisms in Fuel Economy Standards**

<table>
<thead>
<tr>
<th>Flexibility Mechanisms</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead-time Provisions</td>
<td>Phasing-in fuel economy requirements for new VES phases</td>
</tr>
<tr>
<td>Fleet Averaging</td>
<td>Allowing manufacturers to offset fuel economy deficits of specific models with more efficient vehicles.</td>
</tr>
<tr>
<td>Credit and Debit Banking</td>
<td>Permitting manufacturers to carry forward or backward fuel economy credits</td>
</tr>
<tr>
<td>Alleviations and Special Credits</td>
<td>Allowing manufacturers to account only parts of their fleet in the calculation of corporate fleet averages. Granting fuel credits for special fuel-saving technologies</td>
</tr>
<tr>
<td>Super Credits</td>
<td>Multiple preferential accounting schemes for favoured technologies such as electric or highly efficient vehicles</td>
</tr>
<tr>
<td>Zero-counting</td>
<td>Emission/ consumption exemptions for favoured technologies</td>
</tr>
<tr>
<td>Penalties</td>
<td>Permitting manufacturers to pay fines in lieu of increases in vehicle efficiency</td>
</tr>
<tr>
<td>Exemptions and Derogations</td>
<td>Subjecting small-volume and niche manufacturers to no or alleviated targets for individual fleet averages.</td>
</tr>
<tr>
<td>Pooling</td>
<td>Permission for groups of manufacturers to average individual corporate fleet consumption across group members’ fleets</td>
</tr>
<tr>
<td>Credit-trading</td>
<td>Permission for manufacturers to trade excess fuel credits to adjust corporate fleet averages</td>
</tr>
</tbody>
</table>

**Source:** Author’s own

To date, the literature has treated flexibility mechanisms in VES sporadically and very abstractly. Fischer (2008) gives an overview of potential measures that increase compliance flexibility for manufacturers through collective measures. She discusses the advantages of theoretical additions to the US standard regime, such as feebates and output-related fees. In addition, she presents the advantages and pitfalls of applied flexibility mechanisms, such as tradable credits and banking provisions across standard phases. She
comes to the conclusion that flexibility mechanisms have the potential to improve VES efficiency via their financial incentive structure, but that these mechanisms alone do not suffice in improving fuel economy. Rather, clear and binding requirements need to go hand-in-hand with flexibility mechanisms to guarantee effective improvements in fuel economy. While Fischer discusses the complementary merits of collective flexibility in a VES setting, numerical analyses of the erosive effect of these mechanisms are rare. Lutsey and Sperling (2012) present a notable exception. In their work, they investigate the environmental effect of current accounting methods of new energy vehicles (PEVs) in US VES. They find that zero-counting and super-crediting electric vehicles in the US could lead to an erosion of 20 per cent of the GHG emission benefits from stricter standards.

While VES are generally regarded as a very effective tool to reduce fuel consumption, flexibility mechanisms in all major standard regimes have been criticised repeatedly. This criticism centres on a significant exercise of influence by the automotive industry on the agenda setting process (T&E, 2009A; 2011; UBA, 2010). Several environmental interest groups (T&E 2010; VCD, 2010) argue that automobile associations lobby for diluted and delayed VES targets that are “ecologically and economically contra-productive as well as unnecessary” (UBA, 2010: 47). The same interest groups criticise the results of the reform process, especially with regard to potentially erosive effects of flexibility mechanisms on the stringency of VES. They hold that measures such as the delayed phase-in of emission targets, the related requirements for selective compliance of a share of a manufacturer’s vehicle
fleet, and the lump sum crediting of non-vehicle measures ('eco-innovations') can lead to an actual increase in average CO₂ emissions (stern.de, 12 Dec 2008).

Despite this criticism, flexibility mechanisms have been introduced in increasing number and scope. This is especially true for the VES regimes of the three most important vehicle markets, i.e. the US, the EU, and China.

6.3 US National Programme: Corporate Average Fuel Economy and CO₂

Emission Standards

US corporate average fuel economy (CAFE) standards were the first standards worldwide to address the average fuel consumption of light-duty vehicles, i.e. fleets of passenger vehicles and light trucks. The administrative authority in charge, the National Highway Transport Safety Agency (NHTSA), defines CAFE as “the sales weighted average fuel economy, expressed in miles per gallon (mpg), of a manufacturer’s fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 lbs. or less, manufactured for sale in the United States, for any given model year” (NHTSA online). ‘Fuel economy’ thereby refers to the “average mileage travelled by an automobile per gallon of fuel consumed as measured in accordance with the testing and evaluation protocol set forth by the Environmental Protection Agency (EPA)” (NHTSA online).

In 2007, President Obama announced a ‘National Programme’ to establish strong and coordinated federal greenhouse gas and fuel economy standards. In response, NHTSA and the Environmental Protection Agency (EPA) proposed a joint rulemaking combining fuel economy and CO$_2$ emission limits to the automotive industry in 2010 (EPA, 2010). The National Programme establishes separate but complementary CO$_2$ emission and fuel economy standards for the US. EPA tests compliance with either standard with drive cycles reflecting urban and highway drive modes.

Prior to the reform, US CAFE standards applied uniform fuel economy goals to all manufacturers irrespective of their capacity to market more efficient vehicles. With the reform of the US CAFE system in 2007, flexibility increased notably. The utility factor changed from gross vehicle weight to vehicle footprint. This attribute change is intended to provide manufacturers with more flexibility in achieving model-specific fuel economy targets, for instance by reducing vehicle weight. As part of the reform, individual fuel economy targets were introduced for each manufacturer, depending on the composition of the vehicle fleet and based on individual fuel economy targets for specific vehicle footprints. This represents a shift away from uniform fuel economy targets. While manufacturers’ compliance is thus flexible to the extent that their specific fleets vary in size, a CAC ceiling provision requires manufacturers to achieve a corporate average fuel economy that is not less than 92 per cent of the average fuel economy projected for the combined domestic and non-domestic passenger automobile fleets manufactured for sale in the US by all manufacturers in the model year (*industry standard*). In
addition to individual fleet targets, CAFE standards incorporate the following flexibility mechanisms.

**Fleet Averaging:** From their inception US CAFE have allowed manufacturers to average fuel economy throughout the sales-weighted fleet of vehicles produced in a given model year for the US market. The averaging provision is applied separately to the different fleets of passenger vehicles on the one hand and light trucks on the other hand until 2012, with the latter being subject to more lenient targets than passenger cars. Under the reformed provision, manufacturers are permitted to use credits earned after model year 2010 in one vehicle class to offset fuel economy deficits in another. In general, fleet averaging implies that inefficient vehicle models do not need to meet fuel economy limits as long as more efficient vehicles sales offset potential fuel economy deficits of less efficient models. US CAFE have thus provided considerable flexibility to manufacturers and have had an exemplary effect on VES in other ambits.

**Zero-counting:** Incentivising an early marketization of advanced fuel-saving and CO₂ reducing technologies, US CAFE assigns special credits to electric vehicles, plug-in hybrids and fuel cell vehicles. This facility allows manufacturers to credit the first 200,000 electric vehicles sold as zero emission vehicles (ZEV) from model year 2012 to 2016. The 200,000 ZEV rule is applicable to manufacturers with a grand total of 25,000 electric vehicles and less per model year. If a manufacturer exceeds 25,000 units, the number of electric vehicles accountable as ZEV increases to 300,000. Only the
percentage of the test cycle driven in purely electric mode is counted as zero-emission for PHEV. Hybrid electric vehicles are treated as partial ZEV and their electric drive is accounted for on a pro-rata basis.

Super Credits: In addition to zero-counting, Advanced Technology Credits multiply the number of EVs such that each EV produced between model years 2012 and 2016 counts between 1.2 and 2 vehicles. Electric vehicles selling above the quota of 200,000 vehicles are not treated as zero-emission vehicles. Instead, they are accounted for according to the upstream emissions associated with the energy used to charge these vehicles using the average US grid CO$_2$ emissions per Wh. The accounting method for electric vehicles after 2016 is as of yet unclear. While EPA informs on its website that a value\(^{32}\) for the amount of CO$_2$ emitted per distance travelled will be calculated on the basis of well-to-wheel CO$_2$ emissions, the latest joint Notice of Intent by NHTSA and EPA announces a continuation of zero-counting as a further incentive mechanism ‘with no limit on the quantity of vehicles eligible’ until 2021 (EPA, 2011: 13). Depending on the market penetration of electric vehicles, ZEV credits for electric vehicles may be capped for each manufacturer from 2022 to model year 2025.

On 29 July 2011 EPA and NHTSA put forth their proposed rules for CO$_2$ standards and CAFE for model years 2017-2025. The standards will

\(^{32}\) EPA will establish a mechanism to determine upstream GHG emissions associated with the electricity production for electric vehicles. This national grid electricity production factor for GHG, converted into CO$_2$ equivalent, will be assigned to electric vehicles on the basis of their electric efficiency (kWh/km).
incorporate super credits to further incentivise the marketization of electric vehicles. The supplemental Notice of Intent outlines a multiplier approach that counts each electric vehicle as more than one vehicle in the manufacturers’ compliance calculation of CO₂ standards (EPA, 2011). For battery electric vehicles and fuel cell vehicles the multiplier value is 2.0 for model years 2017 through 2019, 1.75 for 2020, and 1.5 for 2021. For plug-in hybrid electric vehicles the corresponding values are 1.6, 1.45, and 1.3, respectively. As an additional incentive, plug-in electric vehicles (PEVs) will be counted as zero-emission vehicles for the purposes of CO₂ emission calculation. The number of vehicles granted 0gCO₂/mile will remain unlimited through model year 2021. For model years 2022-25, a cap on zero-counted vehicles may be introduced depending on the market development of electric vehicles. Following a revision and comprehensive mid-term evaluation of both CAFE and CO₂ standards, the period from 2022 to 2025 will see the next stage of CAFE. These standards will be structurally similar to 2012-16 standards but will dictate tougher fuel economy limits.

*Credit and Debit Banking:* The US CAFE system also introduced the concept of fuel economy credits, i.e. when the average fuel economy of either the passenger car or light truck fleet for a particular model year exceeds the established standard, the manufacturer earns credits. The number of credits a manufacturer earns is determined by multiplying the tenths of a mile per gallon that the manufacturer exceeded the CAFE standard in a given model year by the amount of vehicles manufactured. Until 2012, these credits could be applied to any three consecutive model years immediately prior or
subsequent to the model year in which the credits are earned. Credits applied to past model years are termed ‘carry back’ credits; ‘carry forward’ credits allow manufacturers to amortise current fuel economy deficits with credits earned in subsequent model years. Failure to exercise credits within the three years immediately following the year in which they were earned results in the forfeiture of those credits. Up to model year 2012, credits could not be passed between manufacturers or between fleets, e.g. from domestic passenger cars to light trucks (NHTSA online). This crediting and banking provision allows for a relative degree of flexibility and provides an incentive to achieve a higher-than-demanded fuel economy to prepare for tougher fuel economy targets in the future.

Still applying averaging, banking, and trading, reformed CAFE regulations allow manufacturers to earn credits for both their passenger vehicle and truck fleets if the respective fleet average fuel consumption of a given model year exceeds the target. The maximum increase in fuel economy in any model category attributable to credit transfers is 1 mpg for the model years 2011 through 2013, 1.5 mpg from 2014 to 2017, and 2 mpg for model year 2018 and thereafter. The reformed standards extend the carry-forward flexibility mechanism to 5 consecutive model years after the credits have been earned.

\[33\] Vehicles are counted as domestically produced if ‘at least 75% of the cost to the manufacturer is attributable to value added in the United States or Canada, unless the assembly of the automobile is completed in Canada and the automobile is imported into the United States more than 30 days after the end of the model year’ (§32904 (b) (3)).
**Excess Fees:** The US CAFE system offers the payment of fines in lieu of achieving fuel economy targets. The pecuniary fee applies if the average fuel economy of a manufacturer falls below the universal standard for either of its fleets. Currently, the penalty amounts to USD 5.50 for every .1mpg under the standard multiplied with the manufacturer’s total annual production for the US market of that vehicle fleet (domestic or imported passenger cars or light trucks). This non-compliance fee provides a further incentive to achieve the annual target and to even earn credits in order to circumvent future pecuniary fees.

**Lead-time:** As a further flexibility mechanism, Optional Temporary Lead-time Allowance Alternative Standards (TLAAS) are granted to manufacturers with limited product lines and niche manufactures. Manufacturers producing between 50,000 and 400,000 units per model year in the US are granted a separate averaging fleet comprising 25,000 vehicles per year. This alternative fleet is subject to less stringent CO₂ standards that set a limit of 125 per cent of the otherwise applicable target. This separate fleet cannot generate credits for the remaining fleet. Manufacturers with an annual output of less than 50,000 units are granted the same provision for their whole fleet. Such manufacturers have to demonstrate that they attempted to purchase credits from other OEMs in order to comply with the TLAAS programme. The TLAAS programme will be terminated after model year 2016. However, manufacturers with an annual output of less than 5,000 automobiles will remain subject to special targets.
**Credit Trading:** Reformed CAFE extends the credit transfer system to credit trading between manufacturers. As no fleet pooling provision exists in CAFE, OEMs are empowered to average fuel economy across fleets by credit trading. Manufacturers failing to achieve their targets in either of their fleets are allowed to buy excess credits from other manufacturers in a way that “the total oil saving associated with manufacturers that exceed the prescribed standards are preserved” (USC 49, §32903). The CAFE reform thus introduces an incentive scheme that bears some resemblance of a market-based credit-trading scheme. However, neither traded nor transferred credits may be used to meet the minimum fuel economy standard for the domestic fleet, i.e. 27.5 mpg or 92 per cent of the industry standard.

### 6.4 European CO₂ Standards

European CO₂ emission targets were first introduced with the 1998 Voluntary Agreement between the European Union and the automobile associations of European, Japanese, and Korean manufacturers. The agreement included an industry-wide ‘commitment’ to achieve average CO₂ emissions of new cars in 2008 of 140 g/km\(^{34}\) with a view to a goal of 120 g/km in 2012. The Agreement did not specify how the burden of CO₂ emission reduction was to be divided between manufacturers. Nor did it include a regulatory command-and-control backup that would have guaranteed a minimum reduction effort. As a result, the non-binding

\(^{34}\)The goal of 140gCO₂/km applied to the vehicle fleet of all cars marketed in EU15 Member states. The target of 140gCOs/km for Japanese and Korean manufacturers was anticipated for 2009.
agreement failed to bring about the desired outcome and reached an average industry-wide level of CO₂ emissions of 155g/km in 2008 (UBA 2010). In response to this failure, the European Commission established a legislative framework for mandatory emission reductions. Regulation EC No. 443/2009 sets a mandatory goal of 130 gCO₂/km\(^{35}\) for average vehicle fleet emissions in 2015 (EuroLex, 2009). The CO₂ standard assigns clear responsibilities to all manufacturers and importers in the European market. They thereby grant significant flexibility to manufacturers. Instead of assigning uniform targets to each manufacturer, a CO₂ limit value curve assigns each manufacturer an individual fleet average target\(^{36}\). These specific CO₂ targets refer to gross vehicle mass (GVM) and are designed to achieve an industry-wide average of 130gCO₂/km. A further reduction of 10 gCO₂/km is envisioned via ‘other measures’, such as efficient air conditioning systems, and the widespread use of bio fuels.

*Fleet Averaging*: Instead of uniform emission limits for each vehicle model, the new standards allow manufacturers to average the CO₂ emissions of their vehicle models across the fleet of registered vehicles. This sets European standards apart from regulations that deny market access to non-compliant vehicles.

\(^{35}\) It also proposes a CO₂ limit of 95g/km for 2020. This latter target is, however, subject to revision. In 2013, the Commission will propose an addition to the Regulation outlining measures (and possible credits for further ‘eco-innovations’) to achieve the 95g/km goal in 2020.

\(^{36}\) From 2012 to 2015 the specific CO₂ emissions of a vehicle are calculated according to its mass: \(\text{CO}_2 = 230 + 0.0457 \times (\text{vehicle mass in kg} - \text{M0} (=1372\text{kg}))\). From 2016 onwards, M0 will be replaced with the average mass of all passenger cars in the previous three years. The OEM-specific target will be calculated as the average of all sold vehicles.
Lead-time Provisions/Alleviations: European CO₂ standards allow manufacturers to unilaterally select the share of vehicles accounted for in the calculation of average emissions. This provision phases in different shares from 2012 to 2014 in a way that 65%, 75%, and 80% of individual fleet sales are required to meet the 130g/km target. From 2015 onwards, 100% of the fleet is required to comply with the target.

Special Credits: While most of the CO₂ emission reductions have to be achieved through technological solutions tested during the standardised drive cycle, a flexibility provision allows manufacturers to earn an additional 7g/km in reductions through ‘eco-innovations’. The market penetration of such ‘eco-innovations’ must not exceed niche status before 2009 (i.e. fitted in 3% or less of all new passenger cars registered in 2009). At the same time, each individual innovation has to exceed an efficacy of 1gCO₂/km and its effects must not be accounted for in the test cycle, already (additionality).

EV Zero-counting: Emissions of all new energy vehicles, i.e. battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), extended range electric vehicles (EREVs), and fuel-cell electric vehicles (FEVs) are counted as zero in the calculation of fleet averages.

Super Credits: As a further flexibility mechanism, super credits are granted to vehicles with average CO₂ emissions below 50g/km. Such vehicles are weighted at 3.5 cars in 2012 and 2013, 2.5 cars in 2014, 1.5 cars in 2015, and 1 car from 2016 onwards, respectively (see table 6.2). In Member States with
a share of filling stations offering E85 fuel of 30% and more, the CO₂ emissions of vehicles with the technical capacity to run on such fuels are discounted by 5% until 31 December 2015.

**Table 6.2:**

*Super Credits for Low-Emission Vehicles (<50gCO₂/km)*

<table>
<thead>
<tr>
<th>Year</th>
<th>Multiplier (Super-Credit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>3,5 cars</td>
</tr>
<tr>
<td>2013</td>
<td>3,5 cars</td>
</tr>
<tr>
<td>2014</td>
<td>2,5 cars</td>
</tr>
<tr>
<td>2015</td>
<td>1,5 cars</td>
</tr>
<tr>
<td>2016 and after</td>
<td>1 car</td>
</tr>
</tbody>
</table>

**Source:** EuroLex, 2009

*Penalty Fees:* If a manufacturer or a pool of manufacturers fails to reach the specific target, excess emission premiums apply. Table 6.3 describes the penalty mechanism. From 2012 until 2018 the 1st, 2nd, 3rd gram in excess of the specific target is charged at a rate of EUR 5, 15, and 25, respectively. The 4th gram is charged at a rate of EUR 95. The latter rate applies to every gram in excess of the 130g/km target from 2019 onwards. This pecuniary mechanism thus grants manufacturers dual flexibility by giving them a choice to either meet emission targets or pay for non-compliance on the one hand and by easing the financial burden of non-compliance via the phase-in of the EUR 95 fee on the other.
**Table 6.3:**

*Excess Emission Premiums*

<table>
<thead>
<tr>
<th>Excess Emissions [g]</th>
<th>Punitive Amount 2012-2018 [EUR]</th>
<th>Punitive Amount 2019 and after [EUR per g and car]</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1</td>
<td>5</td>
<td>95</td>
</tr>
<tr>
<td>1&lt;x≤2</td>
<td>15</td>
<td>95</td>
</tr>
<tr>
<td>2&lt;x≤3</td>
<td>25</td>
<td>95</td>
</tr>
<tr>
<td>&gt;3</td>
<td>95</td>
<td>95</td>
</tr>
</tbody>
</table>

*Source:* EuroLex, 2009

**Exemptions and Derogations:** European CO₂ standards allow derogations for small and niche manufacturers. Niche producers are defined as manufacturers with an output of less than 10,000 units sold in the Community per year and that either are not part of a group of connected manufacturers, or are part of such a group but either have their own production facilities or the total group output is below 10,000 units per annum. These manufacturers are subject to individual and more lenient emission targets. Niche manufacturers that register less than 10,000 vehicles per year can apply for an exemption and will be assigned individualised targets. Manufacturers and groups of connected undertakings with an annual output between 10,000 and 300,000 units can apply for a special reduction target that requires them to reduce their average fleet CO₂ emissions by 25% compared to their 2007 average.

**Fleet Pooling:** Manufacturers on the European market are allowed to share the burden of CO₂ emission reductions with other OEMs. Rather than trading credits in a system similar to US CAFE, European manufacturers can register
a ‘pool’ of OEMs that share excess credits between pool members and thus can achieve their individual obligations collectively. Excess emissions by one OEM fleet can be offset by a pool member’s emission reductions. Pool agreements are timely limited to a maximum of 5 years and must be registered by 31 December in the calendar year for which emissions are to be pooled. Pools can be voluntary between independent manufacturers or take the form of closed pools within a group of connected manufacturers. Pools of independent manufacturers are required to allow open, transparent, and non-discriminatory participation on commercially reasonable terms by any manufacturer requesting membership of the pool. Members shall ensure that neither data sharing nor information exchange may occur in their pool, except with respect to the average specific emissions of CO₂, the specific emissions target, and the total number of vehicles registered. One pool member is designated the pool manager responsible for the compliance of the pool including the handling of monitoring data and the payment of excess emission premiums.

37 Regulation (EC) No 443/2009 Article 2.2 defines “a ’group of connected manufacturers’ as a manufacturer and its connected undertakings. In relation to a manufacturer, ‘connected undertakings’ means:

a.) undertakings in which the manufacturer has, directly or indirectly:
- the power to exercise more than half the voting rights;
- the power to appoint more than half the members of the supervisory board, board of management or bodies legally representing the undertaking; or
- the right to manage the undertaking’s affairs;

b.) undertakings which directly or indirectly have, over the manufacturer, the rights or powers listed in a);

c.) undertakings in which an undertaking referred to in b.) has, directly or indirectly, the rights or powers listed in a);

d.) undertakings in which the manufacturer together with one or more of the undertakings referred to in a.), b.) or c.) or in which two or more of the latter undertakings, jointly have the rights or powers listed in a.);

e.) undertakings in which the rights or the powers listed in a.) are jointly held by the manufacturer or one or more of its connected undertakings referred to in a.) to d.) and one or more third parties.”
6.5 Chinese Fuel Consumption Standards

Fuel consumption standards have been introduced to China relatively recently and followed a three-step approach. The first two phases were presented together and based on a study investigating feasible VES levels for the state of vehicle technology in the Chinese market (CATARC, 2001). They applied to light-duty vehicles manufactured and sold in China. The homologation process includes a vehicle compliance test via a mandatory standardised drive cycle that closely resembles the European New European Drive Cycle (NEDC). Phase-1 was issued in 2004 and applied to all newly homologated models from 2005 onwards. Certified models already on the market had to comply with phase-1 from model year 2006. Phase-2 was introduced for newly type-approved models in 2008 and became effective for all vehicles in model year 2009.

Both phases represent classic command-and-control regulation. They do, for instance, not allow offsetting excess fuel consumption of a particular model by more efficient vehicles in the same or any other weight bin\textsuperscript{38}. De facto, this means that vehicles that fail to comply with bin limits were denied market access. Since Chinese fuel consumption standards are the prerogative of the Ministry of Industry and Information Technology (MIIT), they apply to all vehicles produced in China. Imported vehicles, however, fall under the jurisdiction of the General Administration of Quality Supervision, Inspection, and Quarantine (GAQSIQ). The first to phases of the Chinese standards thus

\textsuperscript{38} The lack of fuel consumption credits and potential fleet averaging or credit trading was officially justified by concerns about monitoring and enforcement in a highly fragmented market with over 40 independent manufacturers (Wang et al, 2010).
excluded imported vehicles, which facilitated an unintended surge in the SUV population (Wang et al, 2010).

Some very limited compliance flexibility existed as both phases differentiated ‘special’ structure vehicles, which were subject to more lenient consumption limits than ‘normal’ structure equivalents (see table 2). The standards divided light-duty passenger vehicles into 16 weight bins (see table 2). Each bin was assigned a uniform fuel consumption limit. These limits rose progressively with vehicle mass, effectively granting heavier vehicles higher fuel consumption. Bin limits remained relatively lenient throughout both phases, hardly posing technological challenges to manufacturers on the Chinese market. The lax limits were partly due to concerns of the Chinese leadership that overly stringent standards would crowd out Chinese manufacturers, which lack the technological capacity to market more advanced and efficient vehicles (Sims Gallagher, 2007).

The third phase of Chinese VES is designed to lower the average fuel consumption of the national fleet from 9.11 l/100km in 2002 (Wang et al, 2010) to 6.9 l/100km in 2015 and 5 l/100km in 2020 (MIIT, 2012), respectively. Although it has become effective in July 2012, concrete technical guidelines have not yet been published. This is due to an on-going dispute regarding the procedure for VES targets for manufacturers. Originally, the MIIT published a draft standard that assigned manufacturers individual weight-based VES targets based on the composition of their respective fleet. This implied that some manufacturers would have been granted a VES target
above, others below the industry-wide goal of 6.9l/100km. Similar to the flexible systems in the US and Europe, this approach bears a high degree of uncertainty as to the actually achieved fuel economy in the industry as the fleet composition is difficult to determine ex ante. Just before the publication of the standard, a last-minute suggestion by the Ministry aimed to cap bin targets at 6.9 l/100km for all vehicles with a kerb mass over a given threshold (1,205kg). This approach would effectively assign uniform fleet targets to every manufacturer whose fleet average exceeds the threshold, irrespective of individual fleet compositions and average weight. While this approach still grants a higher flexibility, e.g. via fleet averaging, it would practically obliterates weight-bin targets. To date, the publication of the management rules for phase-3 is still pending and with it a final decision on bin limits and fleet targets. For the purpose of this chapter, the latest approach, i.e. the version including a cap on bin targets, will be used.

The weight-based proposal categorises vehicles according to kerb-weight and imposes specific consumption targets for each weight bin. Individual vehicles may exceed the bin-specific limit, but homologation procedures require them to abide at least by the fuel consumption limits specified in the old phase-2 standards. This command-and-control back-up ensures that a check is put on the most fuel-inefficient models of each weight bin. The new standards will also apply to imported vehicles, which are thus required to meet consumption targets for the first time. It is so far unclear, whether imported vehicles will need to fulfil a separate fleet target or whether domestically produced and imported vehicle fleets can be pooled.
Irrespective of these CAC elements, the new phase constitutes a paradigmatic shift toward more flexible legislation. Following the transition to more lenient VES in other regimes, China’s phase-3 incorporates noteworthy flexibility mechanisms.

*Fleet Averaging:* The new standards introduce average fleet *targets* that replace the fuel consumption *limits* of the preceding phases. This means that manufacturers are permitted to average the actual consumption of different models across their fleet. Thus, sales of models with excessive consumption can be offset with more efficient vehicles and credits earned in other weight classes. Contrary to the European and American system, manufacturers and importers in China are assigned individual footprint- or mass-based fleet average targets only to the extent that their fleets’ average kerb weight does not exceed the threshold.

*Fleet Pooling:* Manufacturers are permitted to form pools of manufacturers for accounting purposes. Pooling parties need to apply for their fleet pool in writing, designating one enterprise as the pool lead. The lead holds all responsibilities as to CAFC activities of the pool concerned. Pools are valid for a term of 4 years at a time, after which a new application has to be filed. Most significantly, the latest intervention by the MIIT does not permit manufacturers to pool their fleets of domestically produced and imported vehicles. This means that both fleets would need to meet the 6.9 l/100km goal separately. A final decision on this clause is pending.
Lead-time Provision/ Differential Fleet Accounting: Phase-3 fully accounts for all vehicles sold by a manufacturer. Contrary to the first two phases, the new standards now include imported vehicles. The weight-based proposal for phase-3 assigns alleviated fuel consumption requirements for all 16 weight bins. For the years 2012 to 2014 limits are raised to 109%, 106%, and 103% of the original values, respectively. Starting from 2015, manufacturers need to fulfil 100% of the targets.

Alleviations and Fuel Economy Credits for Special Technologies: Exceptions for special structure vehicles still exist in phase-3, granting vehicles with automatic transmission or people carriers slightly more lenient weight bin limits. However, the general incentive is to discourage the marketing of heavy vehicles with excessive consumption. Accordingly, 'special' structure vehicles do not include four-wheel-drive vehicles anymore and the alleviation for automatic transmission cars will expire on 1 January 2016.

EV Zero-counting: Up to and including 2015, battery electric vehicles (BEVs) and fuel cell electric vehicles (FEVs) are treated as zero-consumption vehicles. This means that the nominal consumption value for these vehicles is discounted in the calculation of corporate fleet averages. Plug-in hybrid electric vehicles are counted as ZEVs on a pro rata basis.

Super Credits: Phase-3 introduced super credits for highly efficient and new energy vehicles. Each unit of passenger cars sold or imported with a combined fuel consumption of less than 2.5l/100km, such as highly efficient
plug-in hybrid electric vehicles (PHEVs), is counted threefold in the calculation of fleet averages. BEVs and FEVs are counted five times.

**Table 6.4:**

*Bin Limits of Chinese Fuel Economy Standards*

<table>
<thead>
<tr>
<th>Weight Group</th>
<th>Vehicle Weight (VW) [kg]</th>
<th>Normal Structure Vehicles [l/100km]</th>
<th>Special Structure Vehicles* [l/100km]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase-1</td>
<td>Phase-2</td>
<td>Phase-3</td>
<td>Phase-1</td>
</tr>
<tr>
<td>1</td>
<td>VW ≤ 750</td>
<td>7.2</td>
<td>6.2</td>
</tr>
<tr>
<td>2</td>
<td>750 ≤ VW ≤ 865</td>
<td>7.2</td>
<td>6.5</td>
</tr>
<tr>
<td>3</td>
<td>865 ≤ VW ≤ 980</td>
<td>7.7</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>980 ≤ VW ≤ 1090</td>
<td>8.3</td>
<td>7.5</td>
</tr>
<tr>
<td>5</td>
<td>1090 ≤ VW ≤ 1205</td>
<td>8.9</td>
<td>8.1</td>
</tr>
<tr>
<td>6</td>
<td>1205 ≤ VW ≤ 1320</td>
<td>9.5</td>
<td>8.6</td>
</tr>
<tr>
<td>7</td>
<td>1320 ≤ VW ≤ 1430</td>
<td>10.1</td>
<td>9.2</td>
</tr>
<tr>
<td>8</td>
<td>1430 ≤ VW ≤ 1540</td>
<td>10.7</td>
<td>9.7</td>
</tr>
<tr>
<td>9</td>
<td>1540 ≤ VW ≤ 1660</td>
<td>11.3</td>
<td>10.2</td>
</tr>
<tr>
<td>10</td>
<td>1660 ≤ VW ≤ 1770</td>
<td>11.9</td>
<td>10.7</td>
</tr>
<tr>
<td>11</td>
<td>1770 ≤ VW ≤ 1880</td>
<td>12.4</td>
<td>11.1</td>
</tr>
<tr>
<td>12</td>
<td>1880 ≤ VW ≤ 2000</td>
<td>12.8</td>
<td>11.5</td>
</tr>
<tr>
<td>13</td>
<td>2000 ≤ VW ≤ 2110</td>
<td>13.2</td>
<td>11.9</td>
</tr>
<tr>
<td>14</td>
<td>2110 ≤ VW ≤ 2280</td>
<td>13.7</td>
<td>12.3</td>
</tr>
<tr>
<td>15</td>
<td>2280 ≤ VW ≤ 2510</td>
<td>14.6</td>
<td>13.1</td>
</tr>
<tr>
<td>16</td>
<td>VW &gt; 2510</td>
<td>15.5</td>
<td>13.9</td>
</tr>
</tbody>
</table>

*Special Structure requirements (1 condition qualifies for Special Structure status)*

**Phase-1 and -2:**
- automatic transmission
- 3+ rows of seats
- 4-wheel drive

**Phase-3:**
- 3+ rows of seats
- automatic transmission (phased out by 1 January 2016)

**Source:** Wang et al, 2010; Wagner et al, 2009; GAQSIQ, 2011, amended by a cap at 6.9 l/100km
Credit Banking: The draft provisions for monitoring and reporting of phase-3 standards allows for the transferral of excess fuel consumption credits to future model years. The basis on which excess fuel economy is calculated refers to the 100% targets as described in table 2. Fuel consumption credits have to be used within three years, following the “first-in-first-out” principle and may not be transferred between manufacturers unless they are members of an official pool.

Penalty Fees: In case fleet averages exceed targets, several infringement measures are being discussed. The enforcement measures proposed range from taxes and fines for manufacturers or consumers (consumer tax or reformed vehicle taxation/ registration scheme) to a combination of both, but penalty fees have not yet been set for phase-3. Since the setting of punitive fees involves an arduous and time-consuming political process, other enforcement measures are being considered. These include a ‘name-and-shame’ approach that denounces non-compliant manufacturers. A more tangible enforcement measure discussed could limit market access for non-compliant manufacturers. Repeat offenders could face either a temporary ban (1 year) of already accredited non-compliant vehicles or might not be allowed to newly accredit vehicles exceeding phase-3 standards (Wang et al, 2010). A measure that has been proposed in the draft of phase-3 bans manufacturers and importers that are found in violation of legal requirements or that have been found guilty of trickery in the system from pooling with other OEMs for a term of 5 years.
Exemptions: So far no exemptions for small volume manufacturers have been communicated. Contrary to the first two phases, the new standards include imported vehicles for the first time and treat vehicle importers as independent accounting units.

6.6 Comparison of Flexibility Mechanisms

In comparison, the three fuel economy standards under study have evolved significantly over the past 15 or so years. They thereby followed a trend towards increasing and converging levels of nominal stringency (ICCT, 2004; 2007; 2011; iCET 2011). Fuel economy standards have also been institutionalised considerably, leading to binding standards, which are monitored and enforced with high scrutiny and partly substantial financial (dis-)incentives. On paper, VES in the US, EU, and China have thus undergone a remarkable development towards a reasonably stringent legal framework for vehicle efficiency.

At the same time, the above presentation shows a clear trend towards increased flexibility in all three regimes. This development has led to a wide adoption of flexibility mechanisms depicted in table 6.5.

The comparison indicates that countries learn from their own experience and from each other. Fleet averaging provisions were first adopted in US CAFE and have subsequently been introduced in Europe and China. However, the exact mechanism applied differs across VES ambits, which leads to different incentive structures and thus abatement strategies. Chinese, US and
European standards assign fleet targets to manufacturers. Yet, only the US and EU assign individual fleet targets based on a manufacturer’s fleet average footprint or gross vehicle weight, respectively\(^{39}\). In China, manufacturers need to comply with a uniform fleet consumption target, irrespective of the constellation of their fleet. In the case of the US and China, fleet targets are (partially) backed up by a CAC floor provision. In the US, the rulemaking requires a minimum fuel economy for domestic passenger cars of at least 92\% of the industry average (US)\(^{40}\). In China, the phase-2 provision sets a maximum fuel consumption limit for individual vehicles. With regard to fleet averaging, European standards thus offer the highest level of compliance flexibility in this comparison. Conversely, European CO\(_2\) emission standards do not permit manufacturers to apply credits to past or future model years. Both, China and the US permit credit banking for 3 and 5 years, respectively. This renders US CAFE the most flexible regime in this respect.

All three VES regimes provide lead-time facilities for manufacturers. In the US, lead-time provisions are limited to small-volume manufacturers and take the form of elevated individual targets. Due to the small number of vehicles affected, this provision is unlikely to have a significant effect on VES

\(^{39}\) Some scholars argue that footprint-based standards incentivise manufacturers to market lighter and thereby more efficient vehicles, while vehicle weight-based standards may actually pose disincentives to manufacturers (T&E, 2007).

\(^{40}\) While the industry average provision was included in CAFE as part of a move to assure that production capacities for technically advanced vehicles remained in the US, it nominally represents a CAC-backup stipulating a minimum fuel economy for parts of the car fleet. However, this provision applies neither to light trucks nor to imported cars, therefore pertaining to only a fraction of all LDVs sold in the US.
stringency. Manufacturers on the Chinese market are granted uniform alleviations, which are gradually phased out by 2014. European standards allow manufacturers to discount substantial parts of their fleet during the phase-in period. This means that the worst performing vehicle models can be practically excluded from the European VES regime until the end of the lead-time provision. European standards thus offer the highest level of compliance flexibility with regard to lead-time provisions.

Table 6.5:

*Flexibility Mechanisms and Command-and-Control Elements in US, European, and Chinese Fuel Economy Standards*

<table>
<thead>
<tr>
<th>CAC Elements</th>
<th>US</th>
<th>EU</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory Standards</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>CAC Backup</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flexibility Mechanisms</th>
<th>US</th>
<th>EU</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead-time Provisions</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Fleet Averaging</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Credit and Deficit Banking</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Alleviations and Special Credits</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Zero-counting</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Super Credits</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Excess Penalties</td>
<td>+</td>
<td>+</td>
<td>(+)</td>
</tr>
<tr>
<td>Exemptions/ Derogations</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Pooling</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Credit Trading</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**NB:** "+" indicates that the flexibility mechanism is applied  
"-" indicates that the flexibility mechanism is not applied  
"(+)" indicates that penalties are envisioned but have not yet been specified

**Source:** own material
American and European VES regimes are enforced via excess penalties. In theory, these should be set higher than the marginal abatement cost of the majority of manufacturers in order to enforce VES effectively (TNO, 2006; UBA, 2008). In Europe and the US, regulatory agencies have determined the magnitude of excess penalties via comprehensive analyses of the compliance costs of manufacturers. The pecuniary amount levied on manufacturers for each excess gram in Europe, for instance, is based on the TNO study by Smokers and van Mieghem (2006). Following the marginal cost principle, the study performs a cost analysis of technical and non-technical measures necessary to achieve the 140g/km goal by 2008/9 and 120g/km by 2012.

While a fee system is envisioned in the accounting rules for Chinese phase-3 as well, no concrete penalty procedure has been formulated yet. This is due to currently unclear authoritative responsibilities among the involved agencies and ministries. Assigning these responsibilities will likely involve a lengthy law-making procedure. During this authoritative void, Chinese VES will not pose strong compliance incentives to manufacturers. In the absence of non-fiscal penalties, such as denial of market access to excessively inefficient vehicles, the environmental effectiveness of Chinese VES is thus rendered questionable.

European, US, and Chinese standards also permit manufacturers to achieve their VES targets collectively via manufacturer pools or credit trading. The US credit trading facility creates a ‘proto’ emissions trading scheme that has the potential to spread the efforts of fuel economy increases across the whole
industry. At the same time, it puts a price on fuel economy improvement. The European pooling facility theoretically allows manufacturers to achieve the same averaging benefits without paying competitors for their excess credits. In the case of China, imported vehicles may not be pooled with the domestic fleet. This measure is most significant for foreign manufacturers that tend to import heavier and more inefficient up-market models. This renders the Chinese regime the least flexible in this comparison.

Lastly and maybe most significantly for future VES, all systems offer beneficial credit schemes for new vehicle technologies. Special credits and alleviations are granted for certain conventional technologies in China and Europe. The Chinese ‘special structure’ provision thereby prescribes alleviated fuel consumption targets to so equipped vehicles. However, the special structure status of four-wheel-drive systems has been abolished in phase-3 and that for automatic cars will be phased out by 2016. European standards permit manufacturers to claim up to 7g/CO$_2$ in their CAFC calculation for independently certified ‘eco-innovations’ in addition to a lump sum reduction of 10 gCO$_2$/km for features such as efficient air conditioning systems and the widespread use of bio fuels.

In the field of new energy vehicles, all three systems allocate super-credits for each sold vehicle. While aimed at fostering the nascent market for new technologies, the combination of ignoring upstream emissions through zero-counting and multi-crediting innovative vehicles in the calculation of CAFC has the potential to considerably erode VES for conventional internal
combustion engine vehicles (BUND, 2009; Lutsey and Sperling, 2012). Chinese standards include the most lenient integration mechanism for advanced technologies, continuously assigning PEVs a super-credit of 3 and BEVs a factor 5 until the end of phase-3. European standards steadily devalue super-credits over time. Only the US standards put an absolute cap in the number of PEVs counted, thus limiting the erosive effect on VES for conventional vehicles.

6.7 Summary

To date, the academic literature on VES has treated flexibility mechanisms fairly abstractly, focussing on the comparison of nominal VES stringency. Some atypical studies are starting to fill this gap (Fischer, 2008; BUND, 2008; Lutsey and Sperling, 2012). They find that, while flexibility mechanisms have the potential to improve VES efficiency by giving a financial incentive structure to manufacturers, these mechanisms alone do not suffice in improving fuel economy. Rather, clear and binding requirements need to go hand-in-hand with flexibility mechanisms to guarantee effective improvements in fuel economy.

This chapter presented an inventory of the most important flexibility mechanisms in the three globally most influential VES ambits. It has shown that all three regimes are on a trajectory towards increasing compliance flexibility for manufacturers. European and American standards thereby offer the highest degree of compliance flexibility. This is due to the manifold exemptions, derogations, and phased-in penalties as well as fleet-obligations
in the two ambits. Especially the dual phase-in of penalties and accounted fleet shares in nominally strict European CO₂ emission standards alleviate manufacturers of compliance pressure and thus have the potential to erode VES effectiveness.

Chinese standards started out as relatively straightforward and inflexible command-and-control regulation, stipulating minimum fuel efficiency for individual vehicles. Initially imposing only moderately ambitious limits, they left (with the important exception of vehicle imports) very little space to game the system or reduce compliance pressure. With the introduction of phase-3, Chinese standards have moved tremendously towards a flexible system. Accordingly, domestic and foreign automobile manufacturers enjoy a range of flexibility mechanisms. As a result of the universal trend towards flexibility, VES levels pose factually less challenging targets than nominally implied.

Two major implications can be drawn from the above trend towards more flexibility. First, flexibility provisions that have negative effects on VES stringency should be phased-out. This is likely a difficult task as it required large amounts of political capital to add such mechanisms to the standard framework in all three ambits. Removing them will therefore require similar efforts. Given the structure of the decision-making process for vehicle efficiency standards, reforms could be scheduled along with the periodical revision process of respective VES phases every 4-6 years.
Second, flexibility mechanisms should receive more attention in the literature comparing international VES regimes. This is especially true with regard to the quantification of their erosive effect. Flexibility mechanisms that deserve special attention concern the integration of new energy vehicles and especially plug-in electric vehicles. Zero-counting PEV-related upstream emissions and assigning super credits to EVs in the calculation of fleet averages can substantially diminish VES stringency. At current levels of market penetration, the effect of plug-in electric vehicles is likely small. However, given tremendous State support especially in China for the development and marketization of plug-in hybrids and battery-electric vehicles in the form of research grants, purchase subsidies, and pilot projects, this vehicle class is becoming of significant concern for future standards. Accordingly, the following chapter will investigate the effect of integrating plug-in electric vehicles in vehicle efficiency standards in terms of VES stringency.
Chapter Seven

7. The Erosive Effect of Integrating Plug-in Electric Vehicles in Chinese Vehicle Efficiency Standards

7.1 Introduction

Vehicle efficiency standards in the most important vehicle markets worldwide follow a trajectory towards increasingly stringent nominal targets (ICCT, 2004; 2007; 2010a/b; 2011a/b; 2012a/b; iCET, 2011b). However, the level of actual VES stringency and hence the degree to which fuel economy has improved, has been undermined by a wealth of flexibility mechanisms that grant manufacturers varying degrees of freedom in their compliance efforts (Toman et al, 1999; Fischer, 2008; VCD, 2010; T&E, 2010). Most such mechanisms phase-in increasingly more stringent fuel consumption targets, provide manufacturers with a lead-time facility to slowly adapt to the changed regulatory environment, or adjust individual VES targets according to the fleet composition of individual manufacturers. Recently, the integration of plug-in electric vehicles (PEVs)41 in European and US vehicle efficiency standards (EPA, 2011; EuroLex, 2009) has added a new element of compliance flexibility. The integration mechanisms used treat PEVs as partial

41 PEVs comprise battery electric vehicles (BEVs) that rely on a purely electric drive train as well as plug-in hybrid electric vehicles (PHEVs) that combine electric drive with an internal combustion engine
zero-emission vehicles, although upstream emissions associated to vehicle charging can render such vehicles as polluting as conventional petrol cars (Oeko, 2011). This zero-counting practice is exacerbated by so-called super credits, which count electric vehicles multiple times in the calculation of average fleet consumption.

In July 2012, the Chinese Ministry of Industry and Information Technology (MIIT) introduced the latest phase of Chinese fuel consumption standards. The new standards include flexibility mechanisms for plug-in electric vehicles similar in design to European and US equivalents. This approach is likely to have an effect on overall transport emissions and fuel consumption for several reasons. First, China’s vast and growing light-duty passenger vehicle market already contributes significantly to ambient air pollution, CO₂ emissions, and especially oil consumption (He et al, 2005; Wu et al, 2012). This implies that any additional leniency in VES obligations translates into sizeable foregone reductions in greenhouse gas (GHG) emissions and energy use. Second, the effect of flexible PEV mechanisms is directly dependent on the number of electric vehicles in the market. Due to tremendous political, fiscal, and financial support, the Chinese PEV market is predicted to become one of the most important worldwide (iCET, 2011a). The most recent national plans aim for a market penetration of 500,000 PEVs in 2015 and 5 million in 2020, respectively, rendering China one of the leading markets for electro-mobility (SC, 2012). Third, zero-counted PEV upstream emissions add to the greenhouse gas balance of the transport sector. In the case of China, upstream emissions originate from a heavily coal-based power sector
(Huo et al, 2010; Wu, 2012). Ignoring these emissions undermines climate and energy policy and disregards the climate effects of a growing part of the transport sector. Lastly, and most significantly, the design of PEV accounting mechanisms, i.e. the magnitude, period of application, and limits on the absolute volume of super credits, directly affects VES stringency for manufacturers’ fleets of internal combustion engine vehicles (ICEVs). If treated as zero-consumption vehicles and counted multiple times in the calculation of corporate average fuel consumption, PEV integration methods have the potential to erode VES stringency for ICEVs (Lutsey and Sterling, 2012).

Scientific literature has only recently begun to quantify this erosive effect. At current PEV deployment levels, the effect is small. With growing market shares, however, it is due to become more significant (Lutsey and Sperling, 2012). An empirical quantitative analysis of PEV integration in Chinese fuel consumption standards is as of yet missing. This chapter aims to fill this gap in two ways. First, it investigates the erosive effect of the PEV flexibility mechanisms proposed in the latest phase of Chinese VES on the firm level. Second, the chapter gives an outlook on the effect current PEV accounting methods would have on national average fuel consumption if applied in VES beyond 2015.

A particularly vocal automobile manufacturer in the area of electric vehicles, BYD was chosen for the firm-level analysis due to its significant commitment to plug-in electric vehicles and the fact that it is one of few manufacturers on
the Chinese market that have rolled out electric vehicles for private consumption. Within the (currently very narrow) PEV market, BYD is thus a major player that furthermore (and quite uniquely for a Chinese manufacturer) also markets its electric vehicles in Chinese cities outside its home base (Shenzhen).

The part of the analysis performed in this chapter that concentrates on the firm-level analysis allows for a data-driven approach. While reliable data on the Chinese automobile market are both rare as well as (due to their proprietary nature) prohibitively expensive, the numerical analysis performed in this chapter is based on historical sales data provided by the relevant Chinese institution responsible for the collection of such data, i.e. the Chinese Automotive Technology and Research Centre (CATARC). This data source enables an accurate prediction of the development of the vehicle fleet in terms of size as well as composition (i.e. model shares in the product portfolio) in contrast to mere assumptions of vehicle sales in the total market.

The Chinese automotive industry is fragmented into over 80 manufacturers, many of which are quite similar to BYD in their ICEV product portfolio and sales volume (MIIT Online). The investigation and results for BYD performed in this chapter– while not representative of the Chinese automotive industry as a whole – thus provide a good indication of the effect of PEV accounting on a number of BYD-like Chinese automobile manufacturers.
The industry-level analysis assesses the implications of PEV flexibility mechanisms for 2015 and beyond. The results show that zero-counting and super-crediting PEVs in combination with the ambitious market penetration plans of the Chinese government could lead to foregone fuel economy improvements of 4.5 per cent in 2015 and up to 22.8 per cent in 2020. This is equivalent of additional CO₂ emissions of 224,161 tonnes and up to 11.5 million tonnes, respectively.

The chapter is structured as follows. The next section presents the environmental and climate repercussions of PEVs powered by China’s coal-dominated grid mix. It is shown that upstream emissions of the power sector render PEVs in China currently more CO₂-intensive than conventional internal combustion engine vehicles. PEVs energy efficiency should thus be regulated either in separate standards or via an integration with vehicle efficiency standards for ICEVs. The subsequent section compares PEV integration approaches in US CAFE and European CO₂ standards to the latest phase of Chinese fuel consumption standards. It is shown that all three regimes currently apply zero-counting and super credits to integrate PEVs. The analysis section presents three market penetration scenarios for electric vehicles in China and quantifies the erosive effect of flexible mechanisms on the reduction obligations for the corporate average fuel consumption of Chinese manufacturer BYD over the period of the latest phase of Chinese VES (2012 to 2015). In a second step, the implications of perpetuated flexibility mechanisms in the accounting of PEVs beyond phase-3 are quantified for the national fleet. It is shown that super-crediting PEVs artificially lowers
corporate average fuel consumption and thus reduces the pressure on manufacturers to improve the fuel economy of their ICEV fleet. The final parts discuss the findings and present alternative regulatory approaches to regulate PEV energy efficiency or related upstream emissions.

7.2 The Environmental and Climate Impact of PEVs

Why do PEVs matter in fuel economy and CO₂ emission standards? Electric vehicles are often referred to as zero-emission vehicles, implying that they do not cause direct, i.e. tank-to-wheel, emissions (Doucette and McCulloch, 2011; Campanari et al, 2009). Several studies have shown that electric vehicles can indeed be instrumental in reducing transport-related emissions (Oeko, 2011; ifeu, 2011). If charged with renewable energy and integrated in smart grids that can level the grid load in an environmental and sustainable manner, electric vehicles feature an upstream CO₂ balance close to zero. If, however, charged with CO₂-intensive energy, PEVs can cause significant emissions upstream, i.e. emissions related to the energy used for charging. These upstream emissions can be higher per vehicle kilometre travelled than those of comparable ICEVs (Oeko, 2011).

The power mix used for charging thus strongly influences the CO₂ balance of plug-in electric vehicles. This circumstance is particularly relevant for the case of China, where the CO₂-intensity of the power sector varies by region but is on average at extraordinarily high levels. Figure 7.1 portrays the Chinese power mix in 6 interprovincial grids. While hydropower contributes sizeable shares in some regions, coal is the primary energy source in all
regions, providing between 98 per cent of all electricity in the North and Northeast and approximately 80 per cent in the other grids.

*Figure 7.1:*

*Grid Mix in China*

Two major studies have investigated PEV upstream emissions in China's regional grids. Huo et al (2010) find that the CO$_2$ emissions of battery electric vehicles (BEVs) per km driven are 7.3 per cent higher than those of petrol vehicles if powered by 100 per cent coal-based electricity. In the coal-dominated North, East, and Northeast, pure electric vehicles thus show no or only very limited CO$_2$ benefits compared to ICEVs. In regions with a high share of non-fossil energy, such as the South, pure electric vehicles reach the CO$_2$ efficiency of hybrids, i.e. approximately 30 per cent below conventional petrol cars. The authors conclude that due to upstream emissions associated with the coal-based grid mix, PEVs currently “do not promise much benefit in reducing CO$_2$ emissions” (Huo et al, 2010: 4856). Environmental benefits
may increase in the future if coal-based power production becomes more efficient and especially if the share of non-fossil energy carriers increases.

Wu et al (2012) come to a similar conclusion. In their investigation of the effect of different EV penetration scenarios on transport-related petrol use and CO$_2$ emissions in three Chinese regions, they find that PEVs have a very limited CO$_2$ reduction potential of 2 to 6 per cent vis-à-vis ICEVs in coal-dominated grids. In grids with significant hydropower shares, this figure rises to up to 33 per cent (Wu et al, 2012: 9).

The currently high CO$_2$ intensity of China’s power sector thus impairs the GHG balance of PEVs. In comparison to other relevant markets for electromobility, such as the US and Germany, the share of fossil fuels in the Chinese power mix is particularly high at approximately 79 per cent. As a result, average GHG emission factors of the power sector in China are comparatively high (see Table 7.1). For the PEVs included in this investigation, these emission factors translate into approximately 174 gCO$_2$/km upstream emissions for BEVs in China as well as 128 and 122 gCO$_2$/km in the US and Germany, respectively. This compares to the average tank-to-wheel emissions of conventional petrol vehicles of over 170 gCO$_2$/km (Wu et al, 2012).

Upstream emissions of PEVs thus matter and can add to overall transport emissions and energy use significantly. In the current VES regime, these emissions are not accounted for – quite the contrary: super-crediting PEVs in the calculation of corporate average fuel consumption artificially reduces
fleet averages. PEV upstream emissions or their equivalent energy consumption should therefore be recognised in vehicle efficiency standards.

Table 7.1

Grid Mix and Upstream Emission Factors in China, the US, and Germany [per cent]

<table>
<thead>
<tr>
<th></th>
<th>Fossil</th>
<th>Nuclear</th>
<th>Renewables</th>
<th>Average Emission Factor* [gCO₂/kWh]</th>
<th>Upstream Emissions BEV [gCO₂/km]</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>78.94</td>
<td>1.88</td>
<td>19.18</td>
<td>893</td>
<td>174</td>
</tr>
<tr>
<td>US</td>
<td>68.75</td>
<td>20.46</td>
<td>10.79</td>
<td>655</td>
<td>128</td>
</tr>
<tr>
<td>Germany</td>
<td>63.12</td>
<td>24.01</td>
<td>12.87</td>
<td>627</td>
<td>122</td>
</tr>
</tbody>
</table>

*a includes 10 per cent line loss

*b assumes an energy consumption of 19.5 kW/100km

Source: CARMA, 2012 (data from 2009); own calculations

7.3 Integrating PEVs in Fuel Economy Standards

Instead of placing electric vehicles in a separate standard regime, current regulatory approaches integrate PEVs exclusively in existing energy and environmental standards for conventional automobiles. This section introduces the integration methods for PEVs in the latest phase of China’s VES and compares them to the approaches used in the US and Europe.

The latest phases of CO₂ emission standards in the EU and US as well as fuel consumption standards in China integrate plug-in electric vehicles for the first time. They do so via flexibility mechanisms⁴², i.e. zero-counting and

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⁴² Flexibility mechanisms are designed to increase manufacturers’ flexibility of response, i.e. the degree of freedom with respect to the strategies, methods, and quantitative efforts employed to comply with standard targets. They allow manufacturers to reduce their individual VES targets and to achieve them with greater ease (Fischer, 2008). In this respect, flexible mechanisms can increase standard efficiency, e.g. by reducing compliance costs. At the same time, they have been criticised as impediments to environmental protection efforts.
super credits. The former mechanism discounts the energy and ensuing emissions associated to PEV charging in the calculation of fleet averages. This method implies that upstream emissions of purely electric vehicles are completely ignored, while emissions and fuel consumption of plug-in hybrids are usually accounted for on a pro rata basis, effectively ignoring upstream emissions associated to their electric propulsion system. Super credits for PEVs multiply the number of zero-counted PEVs manifold, exacerbating this erosive effect. The combination of zero-counting and super credits leads to a situation where the accounted fleet of a manufacturer increases in size without raising average fleet consumption or emissions adequately. As a result, calculated corporate average fuel consumption decreases without actual improvements in ICEV efficiency.

In the US, the degree to which zero-counting applies is limited by a cap provision. Manufacturers are allowed to credit the first 200,000 PEVs as zero emission vehicles from model year 2012 to 2016. Hybrid electric vehicles are partially zero-counted, accounting for their electric range on a pro-rata basis. Electric vehicles selling above the quota are not treated as zero-emission vehicles. Instead, their upstream emissions are included using the average US grid CO$_2$ emissions per Wh. Similar to the US, European CO$_2$

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43 The 200,000 ZEV rule is applicable to manufacturers with a grand total of 25,000 electric vehicles and less per model year. If a manufacturer exceeds 25,000 units of per model year, the number of electric vehicle accountable as ZEV increases to 300,000.

44 The accounting method for electric vehicles after 2016 is of yet unclear. While the Environmental Protection Agency (EPA) informs on its website that a value for the amount
emission standards assign PEVs zero-emission status. However, they do not yet cap the maximum amount of PEVs counted. In their most recent phase (applicable from 2012 to 2015), Chinese fuel consumption standards treat BEVs as zero consumption vehicles. The fuel consumption of plug-in hybrids is counted on a pro rata basis.

In addition to zero-counting, all three standard regimes assign PEVs super credits. In the US, so-called advanced technology credits multiply the number of PEVs produced between model year 2012 and 2016 with a coefficient of between 1.2 and 2 vehicles in the calculation of fleet averages. European standards grant super credits to vehicles with average CO\textsubscript{2} emissions below 50g/km until 2015. The magnitude of super credits is successively reduced from 3.5 to 1 by 2016 (EuroLex, 2009). Currently, there is no cap on the number of PEVs eligible to receive super credits\textsuperscript{45}. Chinese fuel consumption standards include uniform super credits of a magnitude of 3 for highly fuel-efficient automobiles, e.g. plug-in hybrid electric vehicles, with a combined fuel consumption of less than 2.5l/100km. BEVs are counted 5 times (GAQSIQ, 2011; ElMo PP 2012).

\textsuperscript{45} However, a July 2012 proposal by the European Commission envisions a cap on creditable PEVs to 20,000 per manufacturer for the coming phase of CO\textsubscript{2} emissions (2016 to 2020) (ICCT, 2012a)
The integration methods applied in the US, EU, and China aim less at the scientifically exact and environmentally sound accommodation of upstream emissions or the regulation of EV energy efficiency. Instead, the flexibility mechanisms used in all three ambits are complementary to fiscal and financial policies incentivising the early marketisation of advanced fuel-saving and CO$_2$ reducing technologies. The rationale behind these mechanisms is to motivate manufacturers to bring electric vehicles to the market despite continuing concerns about the maturity and reliability of the technology, a lack of a charging infrastructure, and safety concerns (McKinsey, 2012).

In practice, zero-counting emissions and super crediting PEVs in corporate average fuel consumption calculations have two major ramifications. First, zero-counting disregards the potentially sizeable upstream emissions presented in section 7.2. Given that PEVs cause emissions similar to those of ICEVs when charged in CO$_2$-intense power grids, they merely shift transport-related emissions and energy use to the energy sector.

Second, the combination of both mechanisms reduces the pressure on manufacturers to improve the fuel-efficiency of their fleets of conventional petrol vehicles. Given a sufficient number of PEV-generated fuel consumption credits, petrol car fleets may remain at current fuel consumption levels or even become less fuel-efficient (for instance, following current trends in the Chinese market towards increased weight or higher engine output). This effect is directly dependent on the design of PEV accounting methods, i.e. the
magnitude of super credits as well as whether or not the absolute number of credits given to a manufacturer or the industry as a whole is capped. This erosive potential is somewhat attenuated in European standards by the emission trading system (ETS), which technically impedes upstream emissions resulting from additional energy demand posed by PEVs until 2020 (Oeko, 2011) and by a gradual reduction in the magnitude of super credits.

For the case of the US, an absolute cap on vehicles accounted mitigates the negative effect. However, Lutsey and Sperling (2012) find that, despite this cap, zero-counting and super-crediting electric vehicles in the US could lead to an erosion of 20% of the GHG emission benefits from stricter standards. Super credits in China imply the highest erosive potential of all three regimes. The Chinese system offers the highest magnitude of super credits for BEVs and PHEVs, respectively. Moreover, credits are granted uniformly for the whole period and are not capped to a maximum amount per manufacturer. The following part quantifies the erosive effect of flexible PEV mechanisms in Chinese VES.

7.4 Analysis

To analyse the implications of flexible PEV mechanisms in Chinese VES, this section examines the effects of zero-counting and super credits on average fuel consumption obligations for three different market penetration scenarios. The analysis is split into three parts. First, three different scenarios
for the market penetration of PEVs are presented. In a second step, the effect of flexibility mechanisms is determined for all three scenarios\textsuperscript{46} for private Chinese automobile manufacturer BYD. Its position as major player in the battery market for mobile devices has committed BYD to a strong focus on electric vehicles. In this context, it has entered a joint venture with German car manufacturer Daimler to produce electric vehicles under a jointly owned brand (Denza) (Denza online). As a result, BYD is one of the few manufacturers in the Chinese market that already offers BEVs and PHEVs for sale to private customers nationwide. As mentioned above, however, the results for BYD should be seen as indicative but by no means representative for the situation of average Chinese OEMs. Third, the implications of zero-counting and super-crediting for the national fleet are shown. This latter analysis portrays the effect of PEV accounting for the third phase of Chinese VES and illustrates the potential consequences of a continuation of these accounting methods for a higher PEV market penetration in 2020.

\subsection*{7.4.1 PEV Market in China}

The three scenarios depicting the development of the PEV market in China presented here cover the period of the third phase of Chinese fuel consumption standards, i.e. 2012 through to 2015. The number of PEVs in the scenarios is based on policy plans (State Council, 2012) and reports on

\textsuperscript{46} Chinese authorities and manufacturers were still debating the methodology for VES targets at the time of research for this chapter. While several different approaches are being debated, this chapter assumes the latest draft proposal of MIIT, i.e. individual VES targets for individual manufacturers according to weight-based bin targets up to a maximum gross vehicle weight of 1205kg and a uniform target for all vehicles above this threshold of 6.9l/100km.
Chinese PEV deployment efforts so far (McKinsey, 2012, Roland Berger, 2009) (Table 7.2). Accordingly, the scenarios range from a low to a high level of the PEV market.

In the 11th and 12th Five Year Plans, the Chinese government elevated the automobile industry and particularly the electro-mobility sector to key pillars of the economy (ECN, 2011). In the course of this upgrade, the Chinese leadership has implemented a wealth of policies and industry plans to develop new energy vehicle technologies, to test electric vehicles in 25 pilot cities, and to incentivise public and private purchases with financial subsidies. It has repeatedly articulated concrete goals for electric vehicles. In the initial New Energy Vehicle Development Plan announced in 2009 the goal was to have 1 million electric vehicles on the roads in 2015, envisioning an overly optimistic share of EVs in total car sales of 5 per cent in 2012. The plan was postponed by almost three years, due to disagreements between the involved ministries.

In July 2012, the State Council published the long-awaited Energy-saving and New Energy Automotive Industry Development Plan (2012-2020) (State Council, 2012). Although tamed to lower interim deployment goals, the plan aggressively promotes the production and sales of PEVs. According to the plan, 500,000 PEVs are to be on the market in 2015 and 5 million PEVs by 2020, respectively. The national production capacity is to reach 2 million electric vehicles in 2020. These measures are designed to help achieve average fuel consumption targets for new vehicles of 6.9L/100km in 2015
and 5L/100km in 2020. In order to achieve these ambitious targets, the plan outlines a range of deployment measures. Amongst these, the government will continue financial subsidy schemes for PEV purchases. Accordingly, it has earmarked a total of RMB 26.5 billion in subsidies for energy-saving vehicles and other energy-saving technologies. Moreover, electric vehicles will be fostered via fiscal measures, such as preferential tax policies.

For the time being, China’s efforts have failed to bring about these overly ambitious targets. Total output of PEVs in 2011 reached only 6,000 units, instead of the 500,000 units anticipated in the original 2009 plan (McKinsey, 2012). Sales lagged behind expected figures as well, reaching a mere 1,000 PEVs in the third quarter of 2011 and a total of less than 8,200 in the whole year, i.e. 0.1 per cent of total automobile sales (McKinsey, 2012; NYTimes online; Gong, 2012). This casts doubts on China’s ability to push 500,000 PEVs to the market by 2015, let alone 5 million units by 2020. Furthermore, Gallagher (2006) sees China’s capacity to leapfrog ICEV technology critically. She holds that the combination of un-strategic and inconsistent policies, a weak domestic technological base, and international manufacturers’ reluctance to transfer technological know-how in the absence of functional intellectual property rights have so far kept China from making great leaps forward in the development of more efficient technologies.
Table 7.2:
Projected PEV Sales in China 2012 to 2015
[units]

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Total by 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National PEVs</td>
<td>6,000</td>
<td>9,000</td>
<td>14,000</td>
<td>21,000</td>
<td>50,000</td>
</tr>
<tr>
<td>BYD BEVs</td>
<td>496</td>
<td>740</td>
<td>1,133</td>
<td>1,698</td>
<td>4,067</td>
</tr>
<tr>
<td>BYD PHEVs</td>
<td>247</td>
<td>371</td>
<td>583</td>
<td>876</td>
<td>2,076</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National PEVs</td>
<td>10,000</td>
<td>80,000</td>
<td>180,000</td>
<td>230,000</td>
<td>500,000</td>
</tr>
<tr>
<td>BYD BEVs</td>
<td>413</td>
<td>3,291</td>
<td>7,284</td>
<td>9,299</td>
<td>20,287</td>
</tr>
<tr>
<td>BYD PHEVs</td>
<td>293</td>
<td>2,355</td>
<td>5,358</td>
<td>6,850</td>
<td>14,857</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National PEVs</td>
<td>200,000</td>
<td>500,000</td>
<td>1,280,000</td>
<td>1,700,000</td>
<td>3,680,000</td>
</tr>
<tr>
<td>BYD BEVs</td>
<td>6,196</td>
<td>15,426</td>
<td>38,847</td>
<td>51,551</td>
<td>112,019</td>
</tr>
<tr>
<td>BYD PHEVs</td>
<td>3,522</td>
<td>8,830</td>
<td>22,861</td>
<td>30,380</td>
<td>65,593</td>
</tr>
</tbody>
</table>

PEV = Plug-in Electric Vehicle
BEV = Battery Electric Vehicle
PHEV = Plug-in Hybrid Electric Vehicle
National PEV shares assume a market split of BEVs and PHEVs of app. 40 and 60 per cent, respectively based on Roland Berger (2009).

Source: based on Roland Berger (2009), SC (2012), and author’s own calculations

These sceptical assessments are the basis for the first scenario. Starting from the currently low level of PEV deployment, scenario 1 assumes a steady increase in the number of electric vehicles. However, the market of PEVs is set to remain low, reaching a mere total of 50,000 units in 2015, which split into app. 20,000 BEVs and app. 30,000 PHEVs. Given BYD’s relatively strong position on the PEV market in terms of its vehicle portfolio, a reasonably high market share of 20 and 7 per cent for BEVs and PHEVs is assumed, respectively. This translates into moderate annual sales for BYD of approximately 500 to 1,700 BEVs and 250 to 880 PHEVs per annum over the examined period of time.
The second scenario is based on the official target of 500,000 PEVs by 2015. Owing to the slow development of the Chinese market until now, only 10,000 PEVs are assumed to hit the market in 2012. In the following years, annual sales pick up to a maximum of 230,000 in 2015, accumulating to a full market penetration of approximately 200,000 BEVs and 300,000 PHEVs. Given this sizeable market, the share of BYD is estimated at a medium level, representing a share of 10 per cent of national BEV and 5 per cent of PHEV sales. This translates into total sales of BEV and PHEV of app. 20,000 and 15,000 over the period covered, respectively. While this scenario is based on official targets, achieving the desired level of PEV market penetration seems very optimistic.

The third scenario aims to show the significant erosive effect of flexibility mechanisms in Chinese VES given a substantial PEV market. It takes the official target of 5 million PEVs in 2020 as a basis and applies it to the third phase of Chinese VES. The 2020 target represents a PEV market share of approximately 20 per cent that year. The scenario scales the 2020 market share down to the projected light-duty vehicle market level for 2015. Assuming a market size of approximately 18.4 million vehicles in 2015 (Polk, 2011), this implies a PEV market of approximately 3.68 million vehicles (app. 1.5 mio BEVs and 2.2 mio PHEVs). Due to the vast size of the assumed market, the share of BYD for BEVs and PHEVs is reduced to 7.5 and 3 per cent, respectively, resulting in approximately 112,000 BEVs and 66,000 PHEVs sold in the period covered.
The three scenarios cover two extremes as well as the official PEV deployment target for 2015. While the electro-mobility sector is very high on the political agenda and has received tremendous political and financial support at all levels of government in China, bringing 500,000 EVs to the market by the end of 2015 appears a formidable task. This is especially true in light of significant financial and technological barriers in the PEV sector. Actual market penetration will probably yield numbers between the pessimistic first scenario and the official target depicted in scenario two. The third scenario serves purely academic purposes to illustrate the erosive potential of zero-counting and super credits for PEVs.

7.4.2 The Erosive Effect of Zero-counting PEVs on VES Stringency: Firm-Level

In order to quantify the erosive effect of zero-counting and multi-crediting PEVs on VES stringency, this section compares the corporate average fuel consumption (CAFC) achieved and the ensuing GHG emissions accrued by the BYD fleet for the years 2012 through to 2015 with the CAFC and CO₂ emissions accounted for the three PEV penetration scenarios introduced above. Although Chinese VES pertain to fuel consumption only, CO₂ emission statistics are given to illustrate the impact of PEV integration.

Table 7.3 presents the corporate average fuel consumption obligations of BYD for phase 3 of Chinese vehicle efficiency standards. Fleet size and average fuel consumption are based on automobile registration data (CATARC) and official test cycle fuel consumption data (MIIT LDV FC Database). The fleet is expected to grow from approximately 420,000
vehicles in 2012 to a total of 644,000 vehicles in 2015. This is equivalent to an annual share of the growing market of about 3.5 per cent.

Based on the assumed fleet composition, corporate average fleet consumption targets start at 7.32 l/100km in 2012 and fall to 6.75 l/100km by the end of phase 3. This represents an improvement of approximately 7.77 per cent over the 4-year period. Actual CAFC is projected to rise from 6.97 litres in 2012 to 7.23 litres in 2015 due to changes in fleet constellation towards higher shares of SUVs and heavier sedans\textsuperscript{47}. Corporate average fuel consumption thus stays below the VES target in 2012. However, BYD does not earn fuel consumption credits as the achieved average is above the non-alleviated target of 6.71 l/100km\textsuperscript{48}. In subsequent years, fleet consumption exceeds the VES target and the company’s average fuel consumption reduction obligation ranges between 0.01 to 0.48 l/100km per annum.

Total annual CO$_2$ emissions range between 1.16 and 1.83 million tonnes, aggregating into total fleet emissions of all vehicles sold between 2012 and 2015 of 15.85 million tonnes. In order to comply with its fuel consumption

\textsuperscript{47}Substantial improvements in ICEV fuel consumption are disregarded due to the short period of time covered and because the majority of BYD’s models easily meet VES targets. PHEV models are expected to achieve the efficiency threshold to qualify for super credits. While the lack of a factor describing improvements in fuel consumption leads to exaggerated fleet averages in the projected period, the effect of zero-counting and super credits is still clearly visible.

\textsuperscript{48}VES targets are alleviated by 9, 6, and 3 per cent, respectively (Wang et al, 2010, GAQSIQ, 2011) for the first three years of phase-3. Fuel consumption obligations accrue if the corporate average fuel consumption exceeds alleviated VES target for a given year. Fuel consumption credits are earned if average fleet consumption is below the unalleviated VES target. The difference between actual average fuel consumption and the respective target is then multiplied with the sales volume in order to obtain the number of credits/ obligations for each year.
targets, the company would have to reduce its CO$_2$ emissions by 175,099 tonnes, or 1.1 per cent over the same period. Phase 3 thus poses stringent reduction obligations only towards the end, when target alleviations are phased out. When integrating PEVs in these calculations, the effect is that fleet obligations are reduced even more. The following scenarios illustrate this effect.

**Table 7.3**

*Assumed Sales, Corporate Average Fuel Consumption and Total CO$_2$ Emissions, 2012 to 2015*

<table>
<thead>
<tr>
<th>Year</th>
<th>ICEVs sold [units]</th>
<th>VES Target [l/100km]</th>
<th>Achieved CAFC [l/100km]</th>
<th>CAFC obligations [l/100km]</th>
<th>Average CO$_2$ Emissions [gCO$_2$/km]</th>
<th>Total Fleet CO$_2$ Emissions [tCO$_2$]</th>
<th>CO$_2$ emission reductions obligated [tCO$_2$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>423,600</td>
<td>7.32</td>
<td>6.97</td>
<td>-0.35</td>
<td>161.07</td>
<td>1,159,859</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>499,200</td>
<td>7.18</td>
<td>7.19</td>
<td>0.01</td>
<td>166.07</td>
<td>2,569,174</td>
<td>-742</td>
</tr>
<tr>
<td>2014</td>
<td>574,600</td>
<td>6.96</td>
<td>7.20</td>
<td>0.24</td>
<td>166.44</td>
<td>4,195,031</td>
<td>-54,209</td>
</tr>
<tr>
<td>2015</td>
<td>644,000</td>
<td>6.75</td>
<td>7.23</td>
<td>0.48</td>
<td>167.25</td>
<td>7,924,063</td>
<td>-120,148</td>
</tr>
</tbody>
</table>

* assumed annual kilometres travelled: 17,000km

When multi-counting PEVs as zero-consumption vehicles, CAFC decreases without actual improvements in vehicle efficiency. Table 7.4 demonstrates this effect for the first scenario. In this scenario, BYD sells a total of 6,143 PEVs, representing approximately 0.3 per cent of total sales over the 4 years covered. Super-crediting BEVs with a factor of 5 and PHEVs with a factor of 3, respectively, increases this number to 26,566 or 1.2 per cent of total sales. Zero-counting BEVs and assigning a universal fuel consumption value to PHEVs of 2.5l/100km leads to a reduction of average fuel consumption below alleviated VES levels in the first two years.
However, the company does not earn credits because calculated average consumption still exceeds the unalleviated targets. In subsequent years, PEV credits lower BYD's calculated annual average fuel consumption between 0.05 and 0.12 l/100km. At the same time, BYD is still required to reduce average fuel consumption by 0.15 and 0.37 l/100km for 2014 and 2015, respectively. Assigning the company better fuel economy without actual improvements in fleet fuel efficiency, PEV credits in this scenario thus erode VES effectiveness by between 0.7 and 1.7 per cent per annum. In terms of GHG emissions, the effect of EV zero-counting is significant. Table 7.4 shows the amount of CO₂ discounted from BYD's fleet of ICEVs due to the zero-counting of electric vehicles. Over the period covered, this accounting mechanism disregards 68,039 tonnes of CO₂, equivalent to approximately 39 per cent of BYD’s total GHG emission reduction obligations.

In addition to this erosion, zero-counting the emissions associated to the energy consumption of PEVs in the period covered ignores cumulative upstream emissions of 34,239 tonnes CO₂ from 2012 through to 2015. This figure shows the relevance of the substantial CO₂ emission factor of China's power sector. If the emissions factor for the energy grid were reduced to German levels, the ignored emissions would ‘only’ amount to 24,040 tonnes CO₂.
The second scenario, which takes the official target of 500,000 PEVs by 2015 as its basis, assumes PEV sales of a total of 35,143 over the given period (Table 7.5). This represents 1.6 per cent of total vehicle sales. Super-crediting PEVs increases these figures to 146,004 vehicles and 6.7 per cent, respectively. Similar to the first scenario, this PEV share reduces BYD’s calculated corporate average fuel consumption to below VES targets. Between 2012 and 2015, PEV credits erode VES targets between 0.05 and 0.66 l/100km. The fleet of conventional internal combustion engine vehicles could thus consume between 0.7 and 9.1 per cent more fuel each year and still comply with VES targets. In terms of GHG emissions, PEV credits artificially lower fleet emissions by 366,753 tonnes over the four year period, approximately 2.1 times the company’s total GHG emission reduction obligations. In terms of upstream emissions ignored by zero-counting, scenario 2 results in over 167,000 tonnes CO₂ over the whole period. Taking

<table>
<thead>
<tr>
<th>Year</th>
<th>PEVs sold [units]</th>
<th>PEVs credited [units]</th>
<th>CAFC accounted (incl. PEVs) [l/100km]</th>
<th>Difference to CAFC achieved [l/100km]</th>
<th>ICEV GHG Emissions Discounted from PEV Zero-counting [Tonnes CO₂]</th>
<th>Ignored GHG Emissions from PEV Upstream Emissions [Tonnes CO₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>742</td>
<td>3,218</td>
<td>6.92</td>
<td>-0.05</td>
<td>8,021</td>
<td>2,066</td>
</tr>
<tr>
<td>2013</td>
<td>1,111</td>
<td>4,815</td>
<td>7.12</td>
<td>-0.07</td>
<td>12,381</td>
<td>3,093</td>
</tr>
<tr>
<td>2014</td>
<td>1,716</td>
<td>7,415</td>
<td>7.11</td>
<td>-0.09</td>
<td>19,050</td>
<td>4,771</td>
</tr>
<tr>
<td>2015</td>
<td>2,574</td>
<td>11,118</td>
<td>7.12</td>
<td>-0.12</td>
<td>28,587</td>
<td>7,154</td>
</tr>
<tr>
<td>Total</td>
<td>6,143</td>
<td>26,566</td>
<td>68,039</td>
<td>34,239b</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* assuming an energy consumption of 19.5 and 16 kWh/100km for BEVs and PHEVs, respectively (BYD online); average grid emission factor of 893gCO₂/kWh (CARMA, 2012); average annual mileage per vehicle of 17,000km (YCC, 2011).

* cumulative total counting the CO₂ emissions ignored of the whole fleet of PEVs over the whole period, i.e. the values for 2012 are counted four times, for 2013 three times, 2014 twice, and for 2015 once.
the German grid mix in comparison, this figure would fall to approximately 117,000 tonnes.

Table 7.5

<table>
<thead>
<tr>
<th>Year</th>
<th>PEVs sold [units]</th>
<th>PEVs credited [units]</th>
<th>CAFC accounted (incl. PEVs) [l/100km]</th>
<th>Difference to CAFC achieved [l/100km]</th>
<th>ICEV GHG Emissions Discounted from PEV Zero-counting [Tonnes CO₂]</th>
<th>Ignored GHG Emissions from PEV Upstream Emissions [Tonnes CO₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>707</td>
<td>2,946</td>
<td>6.92</td>
<td>-0.05</td>
<td>7,723</td>
<td>1,936</td>
</tr>
<tr>
<td>2013</td>
<td>5,645</td>
<td>23,518</td>
<td>6.87</td>
<td>-0.31</td>
<td>61,198</td>
<td>15,461</td>
</tr>
<tr>
<td>2014</td>
<td>12,642</td>
<td>52,493</td>
<td>6.62</td>
<td>-0.58</td>
<td>131,275</td>
<td>34,577</td>
</tr>
<tr>
<td>2015</td>
<td>16,150</td>
<td>67,048</td>
<td>6.58</td>
<td>-0.66</td>
<td>166,558</td>
<td>44,168</td>
</tr>
<tr>
<td>Total</td>
<td>35,144</td>
<td>146,005</td>
<td>366,753</td>
<td></td>
<td></td>
<td>167,449</td>
</tr>
</tbody>
</table>

* assuming an energy consumption of 19.5 and 16 kWh/100km for BEVs and PHEVs, respectively (BYD online); average grid emission factor of 0.93gCO₂/kWh (CARMA, 2012); average annual mileage per vehicle of 17,000km (YCC, 2011).

The erosive effect of PEV flexibility mechanisms is particularly strongly pronounced in the (purely theoretical) third scenario (see Table 7.6). In this case, PEV sales amount to 177,611 vehicles over the 4-year period, representing 7.66 per cent of total sales. Via super credits, the number of PEVs credited increases to 730,305, i.e. 31 per cent of actual sales. This leads to substantial deductions in calculated corporate average fuel consumption between 0.6 and 2.5 l/100km. As a result, BYD’s accounted average fleet consumption undercuts the VES target by between 0.35 and almost 2 l/100km. The erosive effect of PEV accounting in this scenario leads to total CO₂ emission reductions accounted of over 1.4 mio tonnes, i.e. over 8 times the company’s total GH emission reduction obligations. Ignored PEV
upstream emissions in this scenario amount to an additional 876,364 tonnes over the whole period. Given a substantial PEV market, upstream emissions thus become increasingly important. Leaving the erosive effect on VES aside, decarbonising the Chinese grid mix to current German levels would lessen the impact to approximately 615,000 tonnes CO₂.

\[ \text{Table 7.6} \]

\textit{Hypothetical Impact of Zero-Counting and Super Credits (Scenario 3) for BYD}

<table>
<thead>
<tr>
<th>Year</th>
<th>PEVs sold [units]</th>
<th>PEVs credited [units]</th>
<th>CAFC accounted (incl. PEVs) [l/100km]</th>
<th>Difference to CAFC achieved [l/100km]</th>
<th>ICEV GHG Emissions Discounted from PEV Zero-counting [Tonnes CO₂]</th>
<th>Ignored GHG Emissions from PEV Upstream Emissions [Tonnes CO₂](^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>9,717</td>
<td>38,326</td>
<td>6.36</td>
<td>-0.60</td>
<td>100,440</td>
<td>26,895</td>
</tr>
<tr>
<td>2013</td>
<td>24,255</td>
<td>98,802</td>
<td>5.99</td>
<td>-1.20</td>
<td>235,060</td>
<td>67,111</td>
</tr>
<tr>
<td>2014</td>
<td>61,708</td>
<td>255,401</td>
<td>5.01</td>
<td>-2.19</td>
<td>494,851</td>
<td>170,527</td>
</tr>
<tr>
<td>2015</td>
<td>81,931</td>
<td>337,776</td>
<td>4.77</td>
<td>-2.47</td>
<td>624,038</td>
<td>226,397</td>
</tr>
<tr>
<td>Total</td>
<td>177,611</td>
<td>730,305</td>
<td>4.77</td>
<td>-2.47</td>
<td>1,454,390</td>
<td>876,364(^a)</td>
</tr>
</tbody>
</table>

\(^a\) assuming an energy consumption of 19.5 and 16 kWh/100km for BEVs and PHEVs, respectively (BYD online); average grid emission factor of 893gCO₂/kWh (CARMA, 2012); average annual mileage per vehicle of 17,000km (YCC, 2011).

\(^b\) cumulative total counting the ignored CO₂ emissions of the whole fleet of PEVs over the whole period, i.e. the values for 2012 are counted four times, for 2013 three times, 2014 twice, and for 2015 once.

\[ \text{7.4.3 The Erosive Effect of Zero-counting PEVs on VES Stringency: National-Level} \]

In order to better portray the negative influence of PEV zero-counting and super-crediting on VES stringency, this section presents the effect of PEV flexibility mechanisms on national average fuel consumption (NAFC) levels.

Graph 7.1 depicts national average fuel consumption obligations with and without PEV flexibility mechanisms. The figure is based on policy-driven assumptions, i.e. the average fuel consumption of the national fleet of 8.06
l/100km (Wagner et al., 2009) is projected to reach 6.9 l/100km in 2015 and 5 l/100km\(^{49}\) in 2020, as suggested in the Energy-saving and New Energy Automotive Industry Development Plan (2012-2020) (State Council, 2012).

**Graph 7.1**

*National Average Fuel Consumption 2009 through to 2020*

The blue graph shows a linear decrease in average fuel consumption of 0.19 l/100km per annum from 2009 to the first intermediate target of 5 l/100km and a steeper linear decrease of 0.38 l/100km per annum thereafter until 2020. The integration of PEVs erodes VES tremendously (red graph). In 2015, accounting for 230,000 PEVs reduces NAFC by 4.5 per cent to 6.59 l/100km. This would permit the fleet of conventional petrol cars to consume more fuel

\(^{49}\)While the goal for 2020 is subject to revision and as such not yet binding, it is the most concrete official statement concerning vehicle efficiency beyond VES phase-3.
equivalent to approximately 224,161 tonnes additional CO₂ in 2015. If continued until 2020, PEV flexibility mechanisms have the potential to erode vehicle efficiency by up to 22.8 per cent, resulting in additional emissions of approximately 11.5 million tonnes CO₂.

7.4.4. Discussion of Results

The above scenarios show that flexibility mechanisms in Chinese VES significantly lower the barrier for BYD to achieve its fuel consumption targets. Over the whole period, BYD’s actual corporate average fuel consumption is projected to increase from 6.97 to 7.23 l/100km, failing to meet its target from 2013 onwards. This results in GHG emission reduction obligations of over 175,000 tonnes CO₂ from 2012 to 2015. The fuel consumption targets for conventional petrol cars would thus require significant efforts to reduce fleet consumption and make ICEVs more efficient. With the integration of PEVs, however, this obligation is attenuated (scenario 1) or reversed into calculated CAFC below VES targets (scenarios 2 and 3). This erosive effect of easing BYD’s pressure to comply with VES targets becomes more pronounced as the share of PEVs increases. In the medium and high market penetration scenarios, flexible PEV mechanisms are sufficient to offset actual increases in average fleet consumption of ICEVs. This not only relieves BYD of compliance pressure but also allows the manufacturer to market less efficient ICEVs and still meet its VES targets.

In addition to easing VES compliance, the flexible mechanisms for PEV accounting ignore upstream GHG emissions for vehicle charging. The
magnitude of these emissions varies with the number of PEVs sold. For the three scenarios in this study, total ignored emissions range from approximately 34,000 tonnes CO\textsubscript{2} to over 876,000 tonnes over the period covered. This is equivalent to between 0.22 and 5.53 per cent of total actual fleet emissions. Upstream emissions from the energy sector thus matter tremendously. The emissions factor in this sector has a direct effect on the climate-friendliness of PEVs. Reducing the CO\textsubscript{2} intensity of China's energy production to current German levels would reduce PEV upstream emissions by approximately 30 per cent.

While the above analysis depicts the erosive effect of flexible mechanisms, it is based on several assumptions that need qualification. For the case of BYD, relatively high increases in average fuel consumption were assumed for the fleet of conventional petrol cars. This is due to an increasing share of SUVs and high-consumption models on the one hand and the lack of a factor for efficiency improvements in existing models beyond 2012. Nevertheless, super credits for PEVs reduce the calculated corporate average fuel consumption in all three scenarios. In scenarios 2 and 3, PEV credits suffice to artificially lower corporate average fuel consumption below VES targets and even earn enough credits to theoretically market less efficient petrol cars.

Second, size and composition of the BYD fleet follow the assumption that the Chinese light-duty vehicle market will grow moderately over the period covered. After tremendous growth until 2010 with average annual growth
rates over 10 per cent, market development has slowed recently. In order to support economic growth and foster the automobile sector as a key economic pillar, the Chinese leadership is discussing a second stimulus package for the industry (faz, 2012). Growth rates for the period from 2012 to 2015 are thus estimated between 6 and 9 per cent per annum. Moreover, restrictive automobile policies in several Chinese cities have led to a further deflation of the market, especially affecting the share of Chinese manufacturers (iCET, 2012). This has led to a change in the composition of newly registered automobiles towards higher-end vehicles and especially SUVs. Given these limitations, the size of the BYD fleet as well as the estimation of its average fuel consumption may be exaggerated. However, most of this growth is attributed to its very successful SUV range as well as its F3 model, which used to be very popular during the last stimulus package. Given the market structure and prospect of a second stimulus package, the growth in the BYD fleet and its average consumption appear justified assumptions.

A third area of uncertainty is the development of the PEV market. Given China’s ambitious goals, PEVs will likely play a significant role in the future. It is as of yet unclear whether the 500,000 PEV target can be met by 2015, but given the affirmation of the goal in July 2012, tremendous political effort can be expected to achieve a result close to that number. The likely outcome will lie between the assumptions of scenario 1 and 2. BYD’s strong commitment to PEV technology, its relatively sizeable position in the PEV market and its strong position in the pilot city of Shenzhen (and increasingly elsewhere) render a significant share in the overall PEV market as depicted in the three
scenarios likely. This positive outlook is thus maintained despite negative media coverage concerning the safety of its E6 BEV model (Chinadaily online, 4 June 2012).

Notwithstanding these uncertainties, the analysis shows that flexibility mechanisms for PEVs can reduce compliance pressure for BYD beyond target values. If the share of PEVs in the fleet is high enough (or if the magnitude of super credits is raised), PEV credits reduce VES stringency further and may even lead to less efficient conventional petrol cars. Integrating PEVs in existing fuel consumption standards via the chosen flexibility mechanisms is thus contra productive from an energy-efficiency and emissions perspective.

7.5 Recommendations and Policy Options

The analysis presented in this chapter shows that PEV integration in VES grants manufacturers a high degree of compliance flexibility. Zero-counting and super credits were initially adopted in the US and EU to incentivise the early marketization of PEVs. China followed this approach, granting more flexibility to manufacturers via uniform and undiscounted credits that are higher in magnitude than their western ante types. The negative influence on VES stringency is thus a calculated effect to foster the PEV market in China. Continuing to disregard PEV upstream emissions and counting such vehicles multiple times in the calculation of fleet averages beyond the third phase of Chinese VES would provide a strong incentive for manufacturers to push PEVs to the market. Despite the currently disadvantageous CO₂ balance of
PEVs in the Chinese power grid, a spur in the electrification of the automobile market could help prepare the market for future efficiency gains.

On the negative side, the continuation of these flexible mechanisms has at least two ramifications. First, given the substantial political capital to include PEV flexibility mechanisms in the third phase, it is likely that similar efforts are needed to change future regulations. Currently, flexible mechanisms assign PEVs a highly favourable position in the VES apparatus in China. Contrary to the technology-neutrality paradigm of environmental policy, they thus pick winners (Lutsey and Sperling, 2012). Second and more importantly, the integration of PEVs in existing Chinese fuel consumption standards via the chosen flexibility mechanisms disregards upstream emissions and reduces the pressure on manufacturers to improve the fuel efficiency of their fleet of conventional vehicles. They thus significantly erode VES stringency. This effect is relatively small in the low market penetration scenario, but it is sizeable in the more realistic second scenario. A continuation of zero-counting beyond 2015, when PEV sales are likely to become more significant, has the potential to further reduce VES stringency. Increasingly more ambitious nominal VES targets and the intended improvements in actual vehicle efficiency could thus be easily undermined. Against this background, three alternative scenarios or political agendas can be identified to better account for energy efficiency of PEVs.
7.5.1 Attenuating the Effect of Super Credits

If continuing PEV integration in Chinese fuel consumption standards, the mechanisms used require revision. The aversive effects of zero-counting should be attenuated by capping the absolute number of super credits for plug-in electric vehicles and/or by phasing them out in magnitude. This method has been adopted by the US and EU and has provided regulatory authorities, automobile manufacturers, and customers with a degree of reliability and certainty. A similar approach should be taken in China in order to limit the negative effect of super credits.

Even more importantly, the energy efficiency of electric vehicles needs to be regulated similar to the fuel consumption of conventional internal combustion engine vehicles. Such regulation would take note of the fact that EVs are not per se zero-emission vehicles but are fuelled with scarce (and currently CO₂-intensive) electricity. Regulating the energy efficiency of EVs would require OEMs to design increasingly efficient vehicles and thus reduce upstream emissions.

7.5.2 Changing Standard Metrics

Two approaches can be taken to achieve higher EV efficiency: either EVs are integrated in existing VES or new standards need to be established to regulate EVs separately. Integrating PEVs with current fuel consumption standards could be achieved via a factor that converts average upstream CO₂ emissions to a fuel-equivalent score assigned to the electricity consumption of PEVs (EPA, 2011). Subsequently, in order to treat vehicle technologies
equally, upstream emissions related to the fuel cycle of conventional petrol cars would need to be included in the comparison of ICEVs and PEVs.

Alternatively, efficiency standards for conventional petrol cars and electric vehicles could be placed in a system based on energy consumption (MJ/km), fuel equivalents, or CO₂ emissions (g/km). This approach would treat all vehicle types equally, based on their direct or indirect emissions. A scientifically correct method to compare the environmental impact of different vehicle technologies ideally includes a cradle-to-grave life cycle analysis of direct and indirect emissions, i.e. a quantification of emissions during the production, use, and recycling phase (Ma et al, 2012, Oeko, 2011). However, in practice, CO₂-based standards for ICEVs applied in the US and EU exclusively focus on direct use-phase, i.e. tank-to-wheel, emissions. Electric vehicles could easily be integrated into such a system by accounting for the energy they use per distance driven (MJ/km or fuel-equivalent consumption per 100 km). This approach would more truthfully depict the energy efficiency of different vehicle technologies and incentivise manufacturers to market more efficient electric vehicles.

A meaningful and scientifically correct integration of PEVs would ideally require a comprehensive inclusion of upstream emissions (gCO₂/km) similar to the fuel-equivalent factor in the above recommendation. In the US, this approach is followed by relating actual PEV energy use (kWh/km) to the emission factors of the average US grid (gCO₂/kWh). This method assures a high degree of comparability between different vehicle types. Moreover, it
would integrate transport policy in national and international climate policy in different industries, such as the power sector. At the same time, a change from fuel consumption to CO₂ emissions or energy use could confuse consumers, who have been socialised to measure vehicle efficiency in fuel economy. Methodologically, it is a challenging task to approximate a meaningful upstream emission factor as emissions in different grids can vary significantly. This is particularly true for the case of China, where the PEV market is concentrated in several conurbations, which are powered by significantly disparate grid mixes. A uniform upstream emission factor based on the national grid mix would thus inadequately reflect actual upstream emissions associated to individual grids. Lastly, Chinese VES have been motivated first and foremost by energy security concerns and particularly the desire to reduce China’s dependence on oil imports. Climate protection has long been seen as a positive externality and only recently entered the discussion. A change from fuel consumption to a CO₂-based standard would thus be difficult to implement. Placing PEVs in the existing regulation of ICEV efficiency similar to the efforts in the EU and the US is thus not the way forward for China. Instead, separate standards regulating the energy efficiency of PEVs should be established as the next sub-section argues.

7.5.3 Separate PEV standards

While the above recommendations and alternatives change the metrics and accounting principles of existing fuel consumption standards, they do not fully and adequately regulate the energy efficiency of electric vehicles.
Furthermore, such an integration would not abolish the potential to dilute standard stringency via future EV flexibility mechanisms.

Instead of integrating EVs in ICEV standards, a structural change to the legislation is needed that places PEVs and ICEVs in two different standards. This approach would limit the scope of existing fuel consumption standards to ICEVs. Manufacturers would thus be required to achieve VES targets with improvements in conventional vehicle technology, including HEVs. Policymakers, on the other hand, would need to take into consideration the technological boundaries of internal combustion engines when devising new VES targets. Increased vehicle efficiency in this scenario would thus not necessarily be driven by technological advancement, but by changes in fleet composition towards lighter and more efficient vehicle models.

The electric propulsion system of electric vehicles, such as BEVs and fuel cell vehicles, should then be placed in a separate standard regime, which sets binding standards for vehicle efficiency. Similar to VES targets for ICEVs, these standards should prescribe a regulatory trajectory towards energy efficiency, e.g. measured in kW/km. Such a standard would require separate targets for different vehicle categories and technologies. The energy efficiency of purely electric vehicles and fuel cell cars is determined with relative ease. Placing such technologies in a regulatory framework prescribing minimum energy efficiency is thus feasible.
On the negative side, this approach does not adequately account for the energy efficiency of plug-in hybrid solutions that use both grid electricity as well as other means of propulsion. These vehicles thus pose a challenge to separate PEV standards. Especially the case of PHEVs and extended range electric vehicles that use internal combustion engine technology is difficult to place between ICEV and BEV energy efficiency standards. In order to overcome this problem, the relevant authorities and research institutes should focus their efforts on finding solutions for plug-in hybrids and EREVs, for instance, by subjecting their respective electric and internal combustion propulsion systems to the relevant energy-efficiency standards for ICEVs and BEVs.

7.6 Summary

Upstream emissions of plug-in electric vehicles matter. In China, emissions of the coal-based energy sector render PEVs at least as CO₂-intensive as conventional petrol cars. Ignoring these upstream emissions thus undermines the effectiveness of fuel economy standards. Similar to US and European equivalents, however, the latest phase of Chinese VES assigns PEVs (partial) zero-emission status and counts them multiple times in the calculation of corporate average fuel consumption. These flexibility mechanisms have the potential to reduce compliance pressure of manufacturers and erode actual fuel economy requirements for conventional petrol vehicles.
This effect has been mostly ignored in the literature, which predominantly focuses on the comparison of nominal VES levels. The analysis presented in this chapter has shown that for the case of Chinese manufacturer BYD flexibility mechanisms can reduce fuel economy obligations or reverse them into fuel consumption credits, depending on the number of PEVs accounted. As a result, the pressure to improve vehicle efficiency is alleviated at the firm level (scenario 1) or removed altogether (scenarios 2 and 3). In the worst case, the fuel consumption credits earned could be used to achieve the nominal VES target with even less efficient petrol cars. The same holds true for the national level. If continued past 2015, PEV flexibility mechanisms have the potential to erode VES stringency significantly.

Given the findings presented here, several conclusions can be drawn. First, the flexibility mechanisms currently proposed in China can be instrumental in fostering the nascent PEV market. Zero-counting and super credits give sizeable incentives to manufacturers to bring this technology to the market. Second, at current deployment levels, the negative erosive effect of EV credits on VES stringency for conventional petrol vehicles is relatively low at the firm level (scenario 1). However, with increasing PEV population, the effect becomes significant and reverses emission reduction obligations into substantial leeway for less efficient vehicles (scenarios 2 and 3). Integrating PEVs via zero-counting and super credits thus threatens China’s ambitions to reduce average fuel consumption in 2015 to 6.9 l/100km. While the assumed high market penetration of the third scenario is unlikely to materialise during the period covered, the findings strongly suggest that future VES
phases should apply reformed integration/ accounting methods, especially with a view to achieving 5 l/100km in 2020.

In the short-run, this can take the form of fuel-equivalent consumption values for PEVs in the current VES setting or via CO₂ upstream emission factors in a standard system based on CO₂ emissions. These approaches have been adopted in the US and the EU and integrate PEVs into current energy efficiency regulation to a certain degree. In the long-run, however, such an integrated system runs the risk of diluting the efficacy of the regulation. Therefore, separate efficiency standards for electric vehicles, which are the scientifically most accurate and appropriate approach, need to be devised. Plug-in hybrid electric vehicles constitute a significant challenge to this solution. More research is necessary to find adequate accounting methods of their hybrid propulsion systems.

Despite such reform, the environmental and climate impact of both ICEVs and PEVs could still be inaccurately depicted for at least three reasons. First, even when including upstream emissions associated to the use-phase, vehicle efficiency standards tend to ignore a significant part of life-cycle emissions, i.e. the CO₂ emissions associated to vehicle production, maintenance, and decommissioning. Such emissions are likely to differ tremendously across vehicle technologies. Second, vehicle efficiency standards measure harmonised CO₂ emissions for a standardised use case. This use case does not reflect the real-world energy consumption of different technologies. PEVs may be used in specific market segments with mileage and use cases
different from those of representative of conventional petrol cars. Any policy advocating PEVs thus needs to be based on scientific investigations into the actual effect of PEVs. Third, current type approval and standardised drive cycle tests do not necessarily reflect the relative benefits of different vehicle technologies. ICEV test cycles, for example, underrepresent vehicle fuel consumption (ICCT, 2012b).

Finally, although the electrification of road vehicles does not yet lead to actual improvements in terms of transport sector GHG emissions, the comparatively high efficiency factor of PEVs has a significant potential to lower emissions in the future. This can be achieved by de-carbonising the energy sector via the integration of renewable energy carriers and intelligent grid load management systems. As the analysis in this chapter has shown, effectively lowering the emissions factor of China’s energy grid to German levels would reduce upstream emissions by 30 per cent.
Chapter Eight

8. Conclusions and Implications

This concluding chapter aims to bring together the findings of the core chapters in order to answer the research questions posed in the introduction. It sets out with a recollection of the main findings in the form of five propositions. The subsequent sections discuss the implications of the project for literature and policy. The chapter concludes by indicating possible directions for future research.

Policymaking, be it in the environmental, climate, or industrial sphere, takes place in an institutional context that greatly affects the design, choice, enforcement, and implementation of policy instruments (Da Motta et al, 1999; Bell, 2003; Bell and Russell, 2003). Different conceptions abound as to which influential forces in a polity affect political design and outcomes most (Hodgson, 1998; North, 1993). As the network of political agendas, hierarchically tiered stakeholders, confounding external factors, and the overly influential implications of past decisions in a polity is highly complex, meaningful evaluations of the political environment and its influence on policymaking in any ambit are difficult and – at best – subject to a very tight temporal expiration date.
At the same time, there is no doubt that the institutional tradition of an ambit, its experience with and record of past decisions, its political culture, and its unique set of political challenges and approaches to solutions determine policymaking in a given polity (Martin, 2003). So far, (mostly Western) scholars have tried to identify institutional determinants of political action and their outcomes – or at the very least tried to interpret institutional characteristics of a political system to ‘explain’ or sometimes predict the results of that system (Martin, 2003). They have thereby concentrated on what they know best, i.e. the conditions, circumstances, and realities of Western, mostly developed, countries. In the wake of their academic, political, economic and other endeavours, scholars have developed theoretical approaches to differentiate distinct types of institutional settings, groups of countries with similar institutional parameters (Hall and Soskice, 2004; Peck and Theodore, 2007), or to categorise and evaluate policy instrument types (OECD, 1994).

However, policymaking and policy types do not solely exist in developed countries and the prerogative to alter, amend, and reform existing policy models – let alone inventing new ones – does not lie with Western decision makers alone. The many economic, environmental and climate-relevant problems of developing countries and emerging economies have created a tremendous demand for political solutions (Bell, 2003; Bell and Russell, 2003). Yet, as the review in chapters two and three showed, the academic literature on policy instrument choice in such countries is very thin. Moreover, the few studies that classify policy modes in different ambits
concentrate on the national level, leaving aside potential deviations and indigenous solutions at the sub-national level or in specific sectors of a given industry.

The case of China is particularly underrepresented in the literature, despite its relevance both in terms of its economic output and the environmental and climate issues that arise from it as well as in terms of theory and academic research. This research project addresses this gap and examines the case of policy instrument choice in China's automotive sector. More specifically, it asks: what is the dominant mode of environmental and climate policy instruments in China’s automotive sector? And: do modal differences exist across policy fields and spatial divides? Answering these questions is most crucial to understanding what policy instruments are chosen over others. It is also the prerequisite to evaluate the efficacy of the instruments chosen.

In addition to the abovementioned omissions, I showed that the literature on instrument choice and evaluation is divided with regard to the understanding of the very instruments it examines. No consensus exists as to the number, nomenclature, qualities, and differentiating attributes of different policy instruments. Attempts to classify instruments range from a differentiation by the degree of coercion applied by the State (Macdonald, 2001), over the motivational underpinning for compliance with different instruments (Karp and Gaulding, 1995), to diverse evaluation criteria (Tietenberg, 1990), such as the effectiveness and efficiency of different instruments. In the course of this research project, I have come to appreciate
the advantages of all of these schools of thought. With a view to a better assessment of individual instruments, however, I tend throughout this dissertation and its constituent core chapters towards the latter differentiation parameters – with the addition of instrument flexibility. I thus simplify the vast canon of possible policy instruments to two groups, allegedly rigid but effective command-and-control regulation as well as potentially flexible but seemingly ineffective incentive-based instruments, with hybrid versions of both types via the integration of flexibility mechanisms in command-and-control regulation.

This dichotomous differentiation allows for a straightforward assessment of the efficacy, i.e. the effectiveness and efficiency, of different policy types. The inclusion of flexibility as an assessment criterion furthermore allows for a supplementary differentiation of instruments and hybrids. Specifically, flexibility mechanisms in vehicle efficiency standards move this classic regulatory means towards a more incentive-based end of the CAC-IBI stratum.

As I have shown in chapter two, Western understanding of the Chinese political apparatus is often misconceived and signified by a lack of comprehension. As a result, the Chinese political system is often mistaken as a uniform, monolithic, and opaque entity that unidirectionally delegates policy input from the central to the local level. In reality, the many and profound reform endeavours by the central leadership have resulted in a fragmented system that is often subject to negotiation and local input – or at
least a significant degree of leeway for local interpretation and implementation.

I have chosen the automotive sector as a prime example of an investigation into Chinese policy instruments and the dominant mode of Chinese policymaking in this industry. This selection is due to three political drivers in this area. First, the already vast size of the vehicle stock and its high projected growth pose formidable challenges to the natural environment, both in terms of greenhouse gas as well as criteria air pollutant emissions. This problem dictates the political agenda in Beijing, Shanghai, Chongqing and other Chinese megacities that deal with exorbitant air pollution problems already today. The problem is due to exacerbate as vehicle ownership increases and leads to higher levels of congestion and pollution in other Chinese conurbations (He et al, 2005; Wu et al, 2012).

The second driver concerns China’s thirst for oil. The growing vehicle population puts a strain on China’s limited natural oil reserves and hence leads to a higher dependence on volatile oil markets and politically often instable procurement markets. Improving energy efficiency in the automotive sector is thus a prime political goal to at least ameliorate the negative effects of the growing vehicle market.

The final driver can be found in political reasoning pertaining to the automotive industry itself. The Chinese government has elevated its automotive industry to a key strategic national sector that enjoys a high
degree of political attention. In its efforts to build an internationally competitive industry that is not based on following technology leaders abroad, but that has its own innovation capacity, the Chinese government at varying levels has invested financial and political capital to improve the technology base and hence the competitiveness of its domestic automotive industry. The many policies and policy instruments described in chapter four emphasise this determination, especially with regard to the promising electro-mobility sector.

In the Chinese automotive sector, environmental, climate, and industrial policy takes place in an institutional environment that is characterised by empowered and relatively independent local clusters of political power (Mertha, 2005; 2009). These local clusters, i.e. provinces, municipalities, and major cities, adopt different policy modes and implement various instrument types with different enforcement styles and degrees of effectiveness and efficiency. At the same time, the central government – in the form of line ministries – retains the prerogative to initiate political processes. It also holds the highest amount of policymaking and decision power. Vis-à-vis local governments, however, vertical influence down the line seems less influential than one might expect.

This degree of local independence (fragmented authoritarianism) implies several important questions. First, if current policymaking in China is less centralised and tends to empower local authorities either in policy design and/ or implementation, can differences in policy mode be discerned? In
other words, do local policy instruments differ among locales and between the central and the local level? If such differences exist, what are the effects on instrument effectiveness and efficiency? Finally, who is in charge of policymaking in the automotive sector at the national and the local level? My research project presented in this dissertation touches upon all of these questions. Given the results of the four core chapters, I answer these questions in five propositions:

Proposition 1: Command-and-control regulation dominates environmental and climate policy in China’s automotive sector

The traditional view that environmental and climate policy is necessarily and best implemented with command-and-control regulation has been challenged over time (OECD, 2007; 2010). Over the last 20 or so years, however, an environmental consensus has developed that tends to favour market-based and flexible instruments, at least in theory. At the same time, the literature on institutionalism and instrument choice holds that ambits with a strong enforcement and monitoring apparatus tend to prefer command-and-control regulation to more flexible policy instruments. Following this logic, communist China should fall in the command-and-control camp and hence preferably apply standards and regulation over taxes and other flexible instruments. This research project has by and large added evidence to the general validity of this proposition for the case of environmental and climate policy in China’s automotive sector. However, parallel to China’s increasing integration with and opening to the
international economy, environmental and climate legislation in China shows growing signs of decentralisation and flexibilisation.

Chinese policy in the automotive sector indeed follows the command-and-control approach to a large extent. The many standards, norms, and regulations on vehicle efficiency and emissions prove this point. Given effective implementation, monitoring, and enforcement this implies a reasonable level of effectiveness but very limited flexibility for consumers and automobile manufacturers.

Proposition 2: A trend towards increasingly more flexible regulation can be discerned.

The abovementioned regulatory backbone is, however, complemented by incentive-based and more flexible instruments that pose a modal exception. These exceptions exist along geographic lines (centre versus city level) and in the policy field of electro-mobility, i.e. the Chinese new-ernergy vehicle sector. In both cases, the Chinese government at different levels is experimenting with incentive-based instruments to pursue its ambitious policy goals.

The modal shift away from rigid command-and-control regulation towards incentive-based approaches and more flexible instruments can best be seen in the classic regulatory field of vehicle efficiency standards. While Chinese standards started out as moderately ambitious and highly inflexible
regulation, their latest phase has quickly caught up with international benchmark standard regimes and now offers a wealth of exceptions, flexibility mechanisms, and incentive structures. Today, Chinese standards offer similar if not more flexibility mechanisms than their European and US equivalents. This is particularly true for mechanisms integrating plug-in electric vehicles with these standards.

*Proposition 3: Competences between and within authorities at the central as well as the local level are not unambiguously assigned.*

Institutions shape policies and ultimately policy modes of whole ambiets. In the case of China's automotive sector, it is difficult to find continuity in the institutional actors, i.e. the line ministries involved. Over time, a range of ministries and other authoritative bodies has had an influence on climate and environmental policy in the automotive industry. Interestingly, the Ministry of Environmental Protection seems to have played the least influential role, despite some legal output regulating emissions and manufacturing processes. Due to the high political and economic relevance of this sector, the National Development and Reform Commission and the Ministry of Industry and Information Technology have had the most visible impact. This is especially true for the most important policy, i.e. vehicle efficiency standards, which were initially developed by the NDRC and have subsequently been transited to the MIIT.
In the important and highly political policy field of electro-mobility, the dispersed jurisdiction is even more evident. Originally, the field was dominated by the NDRC. With the onset of the Financial Crisis in 2009 and the subsequent ramifications on the Chinese economy, the NDRC was primarily occupied in the Rejuvenation Plan for the domestic automotive industry – a key economic and strategic sector – to develop the electro-mobility industry effectively. Instead, it delegated political authority to the Ministry of Science and Technology, which in turn promulgated the national development plan for electric vehicles and designed and implemented the Chinese pilot programme for new energy vehicles. Four years after the initiation of the programme, the MoST’s failure to bring about the desired tangible results has become apparent. In a response to this failure, the MIIT is taking over the lead in the development of the electro-mobility sector, especially with regard to the international and bilateral cooperation in this field.

At the national level, the situation is even more confused. While the central line ministries enjoy the prerogative to initiate policies in this sector, the implementation of these policies does not necessarily reflect their original intentions. The national EV demonstration programme is an example at hand. Initially designed by the MoST to select a total of 25 pilot cities that were to put over 25,000 electric vehicles on the street via purchasing incentives, the policy has failed not least due to the insufficient implementation and selective subsidies by local authorities, which saw the programme more as a means to foster local automotive industries rather than an opportunity to
jumpstart the national electric vehicle sector. At least in the electro-mobility sector, this evidence of local protectionism shows the significant influence of local actors even on national policies. This leads to my fourth proposition:

*Proposition 4: Flexible policy instruments in the Chinese electro-mobility sector are at present ineffective*

The noteworthy application of flexible and incentive-based instruments in the electro-mobility sector is at present ineffective. The results of my research show that neither the prime national pilot scheme nor the local deployment incentives in one of the most important pilot cities are effective in bringing electric vehicles to the streets in the volume anticipated and stipulated. It should be mentioned here that chapter five only found a suggestive indication that policy design is at least partly responsible for this lack of effectiveness. The deployment of electric vehicles is not solely dependent on policy design but also on market- and product-specific criteria, such as the servicing and charging infrastructure, the utility gained from electric vehicles in terms of range, safety, price, and other aspects of customer satisfaction, and most importantly the availability of competitive and marketable vehicles.

Lastly, the trend towards increased flexibility, especially in vehicle efficiency standards, shows that Chinese environmental and climate policy in this area is rendered potentially less effective:
Proposition 5: Flexibility mechanisms integrating plug-in electric vehicles in vehicle efficiency standards have a significant erosive potential

Vehicle efficiency standards are classic command-and-control regulation. As such, they should be effective but potentially lack in efficiency. Flexibility mechanisms are designed to combine the best of two worlds and are designed to render vehicle efficiency standards still effective but at the same time more efficient. Some of these flexibility mechanisms, such as fleet averaging, can indeed increase efficiency while maintaining instrument effectiveness. Zero-counting and super-crediting plug-in electric vehicles in the calculation of average corporate consumption, however, completely disregards upstream vehicle emissions and at the same time erodes the stringency of the standard on reduction obligations for conventional automobiles. Chapter seven quantified this erosive effect for the case of a specific Chinese manufacturer and the industry as a whole for the current phase of Chinese fuel consumption standards. This quantitative investigation is the first for the case of China and while the authority of its findings is bounded by the fact that assumptions were made to forecast the development of the overall automotive market and the deployment of plug-in electric vehicles over the next few years, the chapter indicates a solid and valid tendency. It was shown that flexibility mechanisms for plug-in electric vehicles have a significant and sizeable erosive effect on fuel consumption standards in China. In combination with the disregarded (i.e. zero-counted) upstream emissions of plug-in electric vehicles, this erosive effect amounts to up to 640,000 tonnes of CO₂ until 2015. If continued until 2020, PEV
flexibility mechanisms have the potential to erode vehicle efficiency by up to 22.8 per cent compared to a case without flexibility mechanisms for plug-in electric vehicles, resulting in additional emissions of approximately 11.5 million tonnes of CO$_2$.

8.1 Contributions to the Literature

The topic of this dissertation is environmental and climate policy in China's automotive industry. The research project is interdisciplinary in nature, using and contributing to the scientific literature in such diverse fields as environmental policy instruments, electro-mobility, and vehicle efficiency standards.

Within the literature on environmental policy instruments the most notable contribution of this research project is the addition of the Chinese case to the body of comparative studies on policy mode. The literature on environmental policy instruments and dominant policy modes has, from its inception, featured an empirical element that puts major emphasis on the investigation and classification of national policy modes (Jordan et al, 2003). Until the early 2000s, this literature mainly focused on the theoretical benefits of new environmental policy instruments (NEPIs) (OECD 1994; 2007) and aimed to characterise the most important instruments in this policy type class as well as the the emerging pattern of their adoption - predominantly in developed countries. Soon, however, scholars began to question the appeal of NEPIs and tried to explain the apparent hesitance of political decisionmakers to apply
such flexible instruments in actual policy – again predominantly in developed countries (Keohane et al, 1998). In my view, the instrumental preference as well as instrument efficacy of developing countries and emerging economies has been only insufficiently recognised by this literature, despite an institutional environment that likely produces less efficient and effective policy results (with the notable exception of Ruth Bell (2003) as well as Clifford Russell (Bell and Russell, 2003)).

My research attempts to address this issue. Chapter four provides an in-depth analysis of the environmental and climate policy instruments chosen in China’s automotive industry. It shows evidence that the environmental consensus still holds true, even in the emerging economy of China: incentive-based instruments are a most preferred, advocated, and politically propagated policy tool in the automotive sector. Similarly, however, a mismatch between this theoretical preference and the policy mode actually implemented is apparent. The chapter shows that command-and-control regulation (expectedly) forms the backbone of such policy but also that modal exceptions exist along geographic lines and across policy fields. The literature on policy instrument adoption and policy mode has not yet established a comprehensive instrument catalogue for developing countries. The categorisation of instruments applied in China’s automotive industry performed in this research project is thus a first step in this direction.

Moreover, the literature has been at odds over the past 20 or so years as to whether the analysis of policy instruments is an intrinsically worthwhile
academic undertaking or whether instrument choice is a function of wider, more abstract trends in the polity. Jordan et al (2013) hold that empirical analyses of individual countries and cases, the analysis of the type of national policy instruments adopted, and the description of policy instrument choice as a mere technical-instrumental rationale detached from the political-institutional environment all pertain to an outdated hierarchical understanding of *government* that relies wholly on top-down regulation. In its stead, they believe, the current literature now emphasises a broader, more interdisciplinary focus that investigates the relationship of government and *governance* and that applies more flexible, incentive-based instruments. This broader approach “emphasises political processes and contextual factors in shaping the design, calibration, and actual usage of instruments in practice” (Jordan et al, 2013: 156).

The results of my research support this latter view for the case of China. As the core chapters show, incentive-based policy instruments have been increasingly applied at the local level and in the area of electric vehicles over the past years. Similarly, traditional command-and-control standards and regulations are increasingly rendered more efficient via the integration of flexibility mechanisms. This trend towards more incentive-based policy and complementary flexibility mechanisms takes place in a conducive institutional environment that seems to question traditional notions of State-led top-down regulation. It is also a sign of progressing fragmentation in the hierarchical-institutional design and implementation of Chinese policy as well as the related empowerment (both administratively as well as with
respect to the modal choice of instrument types) of sub-central levels of the Chinese government (Mertha, 2009).

Despite this development in the literature, most academic investigations of instrument choice still fail to adequately identify and describe current policy instruments. In my eyes, this is due to their mostly dogmatic differentiation and treatment of too many discrete instrument types. Traditionally, policy instruments have been categorised as standards, regulations, taxes, suasive instruments, new environmental policy instruments, and market-based measures (e.g. OECD, 1994; Jordan et al, 2005; O'Connor, 1999). Command-and-control regulation is thereby preconceived as effective but inefficient. Conversely, market-based instruments are allegedly efficient but ineffective.

In this dissertation, I subsume these different instrument types in two classes, command-and-control regulation and incentive-based instruments. I then link these two classes via the inclusion of flexibility as an assessment criterion. This inclusion of flexibility mechanisms allows treating nominally rigid regulation as more flexible legislation that can potentially feature efficiency benefits usually associated with incentive-based instruments. The investigation of vehicle efficiency standards in chapters six and seven shows that classic command-and-control regulation has been reformed to include flexibility mechanisms designed to increase standard efficiency.

With regard to the literature on electro-mobility, the research project provides an updated overview of the policies and policy plans of the Chinese government in this highly speculative policy field. Most academic studies
either focus on the global market for electric vehicles or concentrate on Europe and the US when investigating the chances and pitfalls of the electro-mobility sector (Tran et al, 2012). While different strategy consultancy publications describe the Chinese electro-mobility sector (McKinsey, 2008; 2012), this research project has added to the scientific literature by contributing a thorough and up-to-date overview of the most important political interventions. The daily exchange with Chinese and international practitioners as well as decision-makers has aided this update. As in other markets, the pace of the technological, political, and social developments that determine the success or failure of electro-mobility is incredibly high. While the political will to push this sector to market success is very strong - as can be seen in the tremendous level of political as well as financial support in this industry – the relatively slow roll-out and lack of an internationally harmonised charging infrastructure as well as technological limitations of electric cars and especially battery technology cast a shadow on whether or not the market will develop according to Chinese plans. This research project provides evidence that this shadow will stay for a while. It has quantified the effectiveness of two principal deployment policies for plug-in electric vehicles at both the local and the national level and has shown that China's ambitious short-and mid-term plans for the electro-mobility sector are being implemented relatively inefficiently and rather ineffectively. While any breakthrough in technology or policy is subject to a learning curve, the large volume of financial and other resources employed in this area puts a significant degree of pressure on all stakeholders involved.
Probably the most tangible input of this project has been made to the literature on vehicle efficiency standards. The main contribution of this dissertation lies in the evaluation of the degree of flexibility granted to automobile manufacturers and importers in the Chinese market as well as the quantification of the erosive effect of the integration of electric vehicles. The role of flexibility in these traditionally command-and-control standards has only recently been highlighted (Fischer, 2008; Lutsey and Sperling, 2012). Existing studies either outline the implications of flexibility mechanisms in a qualitative manner or provide very general quantitative descriptions of their erosive effect. They do, however, unanimously arrive at the conclusion that flexibility mechanisms in vehicle efficiency standards can have an erosive effect on standard stringency. The results of my research confirm this view.

In the efforts to describe the negative effects of flexibility mechanisms, the academic literature has so far solely concentrated on the case of the US standard system. To the best of my knowledge, this research project is the first to outline the case of Chinese vehicle efficiency standards and is also the first to include an in-depth case study of an individual manufacturer for different PEV deployment scenarios.

8.2 Implications for Policy

As the findings of the research project shed light on the mode and dynamics of Chinese environmental and climate policy in the transport sector, they consequently offer implications for Chinese (and to a certain degree
international) policy. Perhaps the most significant implication is that the instruments examined do currently not work effectively or efficiently. The reasons for this lack of efficacy are manifold and only partly mode-specific. Regardless of individual deficiencies in terms of instrument design, such as a limit of local subsidies to vehicles from local production, purchasing subsidies surely would help putting efficient vehicles on the streets if the products they try to incentivise were competitive. For the time being, however, neither the products available on the market nor the infrastructure for plug-in electric vehicles seems ready to support a sizeable market in China. Purchasing incentives or the lottery alleviation in Beijing thus appear to be premature policy. The findings show that future policy should take this current state into consideration and delay purchasing subsidies – if deemed necessary at all – to a later stage.

The core chapters show that China, like the US and Europe, pursues different goals with one policy. In the case of vehicle efficiency standards this means that a policy designed to limit the fuel consumption of vehicle fleets is abused to incentivise the deployment of plug-in electric vehicles as an energy-efficient technology. This multi-purpose approach has a very detrimental effect on the stringency of these standards. Integrating electric vehicles with current flexibility mechanisms significantly erodes standard effectiveness. For policy-makers, this implies that future standard regimes should clearly separate environmental objectives and market ambitions. In the case of vehicle efficiency standards, this could take the form of separate standards (regulating fuel consumption of conventional vehicles on the one hand, and
energy consumption of electric vehicles on the other hand) or a completely reformed standard regime regulating total energy consumption of all vehicles.

Finally, the research project suggests a paradigmatic change in the political support for electro-mobility. So far, policies in this area merely focus on the number of plug-in electric vehicles pushed to the market. This is grounded in the misconception that electric vehicles are intrinsically environmentally beneficial. The sheer number of the vehicles marketed is, however, neither a good nor a sustainable indicator of the benefits of electro-mobility. The environmental and climate effects of electric vehicles charged with the Chinese grid mix are as large as those of conventional vehicles. Putting more electric cars to the road thus has – as long as fossil fuels dominate the grid mix - the same effect as selling more petrol cars. In order to fully capture the unrivalled environmental and climate potential of electro-mobility, the quality of PEV deployment, i.e. the sustainability and long-term benefits of this sector, should be the political rationale. This could take the form of new policy goals, such as the amount of CO₂ saved by electro-mobility.

### 8.3 Suggestions for Further Research

The core chapters each indicate areas for further research. These areas mainly pertain to the two literary fields that form the theoretical basis of this dissertation, i.e. instrument choice and assessment. With regard to instrument choice, a more detailed analysis of the stakeholder networks
involved and the individual interests of manufacturers and official authorities is worthwhile. Specifically, this pertains to an investigation of the decision-making process at different spatial levels (national and city level) or between cities. The national pilot city programme for electric vehicles, for instance, invests a tremendous amount of financial and other resources with the aim to foster national electro-mobility. In practice, however, most of the supported cities are host to major automobile manufacturing facilities and local deployment measures, such as subsidies, are limited to local products. This constitutes an ineffective implementation of a national policy and national resources in favour of local protectionist industrial policy. Future research could look into the decision-making process of why and when incentive-based instruments are chosen by governments at different levels and which stakeholders, such as the local industry or lobby groups, are most influential in the selection of the instrument.

A second area for future research concerns the assessment of vehicle efficiency standards. A more in-depth analysis of the actual stringency of international standards – as opposed to their nominal stringency – is worthwhile. This requires the quantification of the flexibility mechanisms identified in chapter six and seven for all ambits and not just the Chinese case. The scope in the field of vehicle efficiency standards should also be extended to include heavy-duty vehicles. So far, most of the literature on such regulation concentrates on the vast market of passenger cars, i.e. light-duty vehicles. The market for heavy-duty vehicles, however, is growing very fast in China and other developing countries. Amidst economic growth, the
transport and logistics sector will play an increasingly important role – both in terms of economic output as well as environmental, climate, and resource repercussions. Future research should thus also focus on this area.

Another area of future research concerns the electro-mobility sector. Despite their current lack of competitiveness vis-à-vis conventional internal combustion engine vehicles, battery electric and hybrid electric vehicles will play a major role in the future. This is mostly due to limited oil resources and vehicle efficiency regulation that mandates decreasing average fuel consumption of automobiles. It is worthwhile to look past these technological limitations and focus research on the electro-mobility sector. This research must include the environmental and climate effects of electric vehicles, such as upstream emissions associated with EV charging or potential benefits to the electricity grid and the power industry due to grid load levelling effects of managed EV charging to name but a few.

Finally, I hope that my dissertation can encourage a further geographical analysis of environmental and climate policies in other countries and sectors. As mentioned above, the literature has so far mostly concentrated on developed, industrialised countries. Modes of environmental and climate policy in developing countries and emerging economies, such as China, Vietnam, Thailand, Brazil, and India have received much less attention. It is in such countries, however, that environmental problems are most evident and pressing. Policy will thus have to find effective and efficient solutions that work in the institutional, political, cultural, and economic environment of
these countries. The research project presented here has made a first step in this direction. However, its focal limitation to the important albeit not necessarily representative automotive industry allows for ample research in other areas and sectors, such as the utility and power industries.
9. Bibliography


EPA, Environmental Protection Agency Regulatory Announcement. 2010. EPA and NHTSA Finalize Historic National Program to Reduce Greenhouse Gases and Improve Fuel Economy for Cars and Trucks. EPA-420-F-10-014


Ewing, Reid H; Bartholomew, Keith; Winkelman, Steve; Walters, Jerry and Don Chen. 2007. Growing Cooler. The Evidence on Urban Development and Climate Change. ULI, Urban Land Institute; Washington.


T&E, 2007. Danger Ahead. Why Weight-based CO2 Standards Will Make Europe’s Car Fleet Dirtier and Less Safe. Available at: 


Available at http://www.umweltdaten.de/publikationen/fpdf-l/3505.pdf

UBA. 2010. Umweltbundesamt. CO2-Emissionsminderung im Verkehr in Deutschland.
http://www.umweltdaten.de/publikationen/fpdf-l/3773.pdf


