

On Target? Examining the Effects of Information Displays on Household Energy and Travel Behaviour in Oxford, United Kingdom

Abstract

The energy literature is rich with information on the *targeted* effects of a behavioural intervention – numerous studies have examined if/how a particular energy behaviour changes over time. There has, however, been much less research on the *untargeted* effects of a behavioural intervention – limited studies have examined if/how a particular energy behaviour changes untargeted behaviour. More specifically, the relevant literature does not explicitly examine simultaneously *how* targeted and untargeted effects occur. The purpose of this paper is to examine the targeted and untargeted effects of an electricity display intervention on electricity, gas, and travel through a mixed methods (quantitative and qualitative) approach. The findings indicate that in a sample of 19 participants, 2 had no behavioural or attitudinal changes, 2 had changes in electricity only, 11 had changes in electricity and gas, and 4 had changes in electricity, gas, and travel. Reasons for this are explored through illustrative case studies. This is followed by a discussion and conclusion, where implications and areas of future research are identified.

Keywords: Behavioural change; energy use; mixed methods; qualitative analysis

1.0 Introduction

It is widely acknowledged that climate change is one of the greatest threats to mankind (1, 2). Scholars have acknowledged that changes to the energy mix are required (3). Both supply and demand side actions are needed, and this paper focuses on demand side measures with a focus on behaviour – a valuable area of research in the energy sector (4) as up to 20% of household energy consumed in households can be reduced through behavioural changes (5).

The demand side literature is rich with information on the *targeted* effects of a behavioural intervention, for example the impact of easy to understand electricity bills on electricity usage (6, 7). There has, however, been much less research on the *untargeted* effects of a behavioural intervention. Limited studies have examined if/how a particular energy behaviour changes the untargeted behaviour of interest, for example the impact of easy to understand electricity bills on gas consumption.

Exploring targeted *and* untargeted effects is of value because it can examine the relationships between different types of behaviour. This information is relevant for energy research, practitioners, and policy perspectives as it can help illustrate any relationships between energy behaviours, identify whether some energy behaviours are more similar than others, and help shed insights in the demand side energy management and research (8).

Electricity displays can reduce electricity consumption - some studies have found changes between 3 to 13% (9, 10). While the impact that electricity displays on electricity behaviour is well documented, the impact that it has on other energy behaviours is less well known. The objective of this paper is to examine the targeted and untargeted effects of an electricity display across a wide set of behaviours through a socio technical, longitudinal, research perspective.

The paper is structured as follows: A) a relevant literature (including rebound effect, spillovers, and social networks) is made, together with commentary on the relevance it carries towards examining targeted and untargeted effects; B) a methodology that builds on the interdisciplinary literature is presented, C) the sample, results, and case studies are presented, and D) a discussion and conclusion for future research is provided.

2.0 Background

The spillover effect occurs when “a change in attitude and/or behaviour concerning a specific activity, produced by a targeted effort or otherwise, [which] may ‘spill over’ into related areas and, hence, become more general” (11 p. 56). Self-perception theory explains the spillover phenomenon (12) though assuming that individuals use their behaviours as indicators of their own dispositions. From self-perception theory, Scott (13) has developed a spillover hypothesis. He stated that engaging in one behaviour can have two effects - first, it is likely to influence the behaviour that the individual is engaging in (14), and secondly, it is likely to influence other similar behaviours (15). For example, if someone starts to recycle, this will influence their recycling behaviour – and secondly influence other environmentally related behaviours – leading to a spillover (16).

Similarly, the rebound effect is a phenomenon that occurs when an attempt to decrease energy consumption can lead to overall increase in consumption because of unanticipated or unintended consequences (17) – and this outcome has also been called ‘backfire’ (18, 19). While relevant, the research field has limited applications across fuels or behaviours (20).

One way to overcome the limitations highlighted in the spillover and rebound literature is by examining the social networks of individuals. Social network theory is a growing field of literature that is relevant to targeted and untargeted effects and behavioural change as social networks can prompt individuals to rethink their behaviours/guide

individuals in their decision making processes. If an individual is uncertain about certain effects/decisions, the beliefs of others can play a role in decision making (21, 22). As Liu et al. highlight -“social network theory focuses on the role of social relationships in transmitting information, channeling personal or media influence, and enabling attitudinal or behavioural change” (23, p 1).

The relevance that social network theory carries towards examining targeted and untargeted effects is that understanding the social experiences of individuals can help understand how behaviour and change may occur across multiple behaviours and help measure how targeted and untargeted effects occur (Table 1).

Qualitative analysis of the impact of electricity displays on individuals and households has been undertaken (6) but limited studies have examined other behaviours. Hargreaves et al. asked individuals about their experience with the display (24). Some participants did note that while the monitor did give them information on energy use, “one thing that these devices haven’t told us is how to put our energy usage in the context of other things that we do like driving, flying, using water, using gas” (24, p. 6117). The objective of Hargreaves et al.’s study was to examine reactions to household energy displays, rather than untargeted effects, but this does reinforce the value of looking at multiple behaviours (24).

The influence of social networks on energy behaviours and the impact that it has on targeted and untargeted effects with electricity displays has not been studied. The intention of this paper is to develop a methodology that can achieve this and then apply it through a small scale exploratory study.

Table 1: Spillovers, Rebounds, and Social Parameters

Field	Theories	Strengths	Limitations/Future Research/Further Reading
Rebound	Initially SCOT (social construct of technology) and then expanded	<ul style="list-style-type: none"> -Extensive research on rebounds within a certain fuel -There has been some research that has looked at how money saved one on fuel can lead to spending on other fuels (25) 	<ul style="list-style-type: none"> - “the rebound effect is too narrow and needs to be extended to cover co-benefits, negative side effects, and spillover effects” (25, pg. 85); similar findings in Galvin and Gubernat (26) -Chitnis et al. (27) examined direct and indirect rebounds in the energy sector and argued for further research in the field -Most of the research looks at rebounds within a certain fuel and not across behaviours (electricity, gas, petrol, etc.) (20)
Spillover	Self-Perception Theory	<ul style="list-style-type: none"> -Examines multiple behaviours simultaneously and can encompass positive or negative spill overs (28) 	<ul style="list-style-type: none"> -Exploring positive and negative spillovers simultaneously is of value and an area of future research (29) -Diverse theoretical underpinnings (30, 12-14) and empirical assumptions¹ (31-34) – which may explain mixed findings -Clear areas of future research are identified
	Cognitive Dissonance Theory	<ul style="list-style-type: none"> -Can quantify whether or not a spillover has occurred 	
Social Parameters	Social Network Theory	<ul style="list-style-type: none"> -Technological diffusion tends to pass through sociometric rather than spatial networks (35) - Jaeger and other scholars found that environmental action is more likely to take place if there are interpersonal rules/norms that favour such action, and the efficacy of message delivery is contingent on existence, density, and structure of social networks that promote such messages (36). -Social learning (37) examines learning processes that occur for individuals or communities; in a case study, the findings indicated that those who read their electricity meters more regularly were more likely to install solar water heating or possess it (38). 	<ul style="list-style-type: none"> -May not identify macro changes that influence behaviour
	Social Learning Theory		

¹ Thøgersen and Olander’s (28) study examined behaviour, values, and ethical norms, while Bratt’s study (33) examined behaviour and attitudes (not values and norms).

3.0 Methodology

Given the focus on targeted and untargeted behaviours, it is important to be clear on which behaviour(s) and policies provide the focus of this paper. Direct energy activities are behaviours/activities that lead to energy consumption and carbon emissions while in use (such as electricity use, heating, etc.), while indirect energy use are activities that lead to energy consumption and carbon emissions indirectly (food consumption, clothing decisions) (39). Here the focus is on direct energy activities in household and transportation.

There are a variety of policy tools that can be used to change behaviour: providing information (voluntary change), economic incentives (fiscal), administrative changes (regulations), or physical (40).

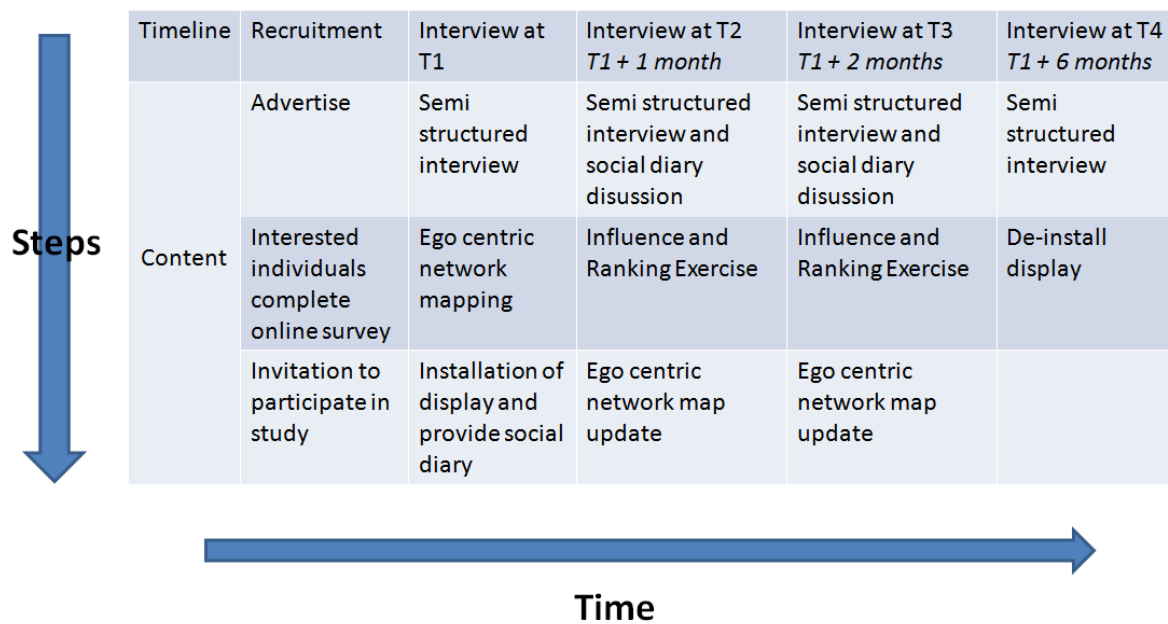
Here the focus is on the role of information and voluntary change. The rationale for focusing on information as a tool is because of its value in behaviour change, its adoption across various contexts, and its use in demand side management. For example, the Department of Energy and Climate Change (DECC) and the Behavioural Insight Team has encouraged individuals to green their homes/use less energy by “focus[ing] on how we can use information more effectively to encourage people to be more energy efficient” (41, p. 5). Additionally, they carry relevancy to UK policy as goals have been stated to install energy displays in all homes by 2020 (74, 75).

Therefore, a display based system was used as an intervention as they are easy to use, affordable, accessible, and policy relevant. Electricity displays were used (and not gas) as gas was more challenging as not all homes use gas, as it is a seasonal fuel, and finding gas displays is not as easy or policy-relevant as electricity displays.

A mixed methods approach was adopted as the research objective is to examine untargeted effects across behaviours, and this approach has the greatest opportunity to explore whether they not occur and why. The advantage of conducting this type of research

was that it was able to address some ‘how’ and ‘why’ research questions that were being overshadowed by a technical research agenda as highlighted in the previous section. The benefits of a mixed methods approach include triangulation (greater validity when both methods are combined), completeness (a comprehensive understanding can take place when both are included), credibility (integrity of results increase when together), and context (contextualized relationships can be uncovered where not possible when using qualitative or quantitative methods alone) (42). Risks of a mixed methods approach include the appropriateness of being able to mix different methods (43), the potential for ‘selective searching’ (44), and being more expensive and time consuming than the other methods (45).

Figure 1 introduces the relevant research methods and timeline. At the onset, it is acknowledged that Figure 1 does not represent the interwoven and embedded nature of the research strategy, which is why it is important to highlight that the research tools outlined are used in an integrated and longitudinal fashion first. Longitudinal energy behaviour evaluation has been used in a case study framework (46). Risks involved include self-selection (47, 48), those that will feel most strongly will respond (49), and the potential of seasonality change instead of a behaviour change (50, 51). However, the ability to monitor the participants allows for an understanding of how time may influence behaviour (52) and therefore, a longitudinal element is embedded in this research strategy. Given this acknowledgement, each phase in Figure 1 (recruitment, interviews, etc.) will be described next.

Figure 1: Research Methodology

3.1 Recruitment

This study sought out individuals that are interested in having an electricity display installed and willing to participate in a research project – they would provide an exploratory perspective of what is it like to take up novel technologies and measure the impacts on untargeted effects. Studies that engaged in longitudinal qualitative research had samples between 10-15 participants (24, 53). Acknowledging attrition, the aim was to recruit approximately 20 participants with the intent that 10-15 would remain. The sample for this exploratory study was recruited from Oxford, United Kingdom (more on the sample in the next section).

If individuals showed an interest in participating, there were two requirements to qualify for inclusion in the study. First, participants were required to own/mortgage their homes and to have resided in their home for at least one year. Secondly, participants were asked whether they have had an electricity display currently or previously installed (having one would exclude them). If they met the requirements (assessed via an online survey), they were invited to participate.

Given these requirements, this research purposively incorporates a non-random sampling strategy - for example, one of the requirements of the study was that participants were required to own/mortgage their homes and to have resided in their home for at least one year. The sample is therefore a subsection of society that is not representative of the United Kingdom, England, or even Oxford. These results cannot be generalized or applied to a statistically representative segment of society. This is acknowledged.

3.2 Interview 1 (T1):

As highlighted in Figure 1, Interview 1 consisted of A) Semi structured interview, B) egocentric network mapping, and C) installation of the electricity display and providing a social diary.

A) Semi Structured interviews:

Data was collected on how participants responded to the electricity display and if/how their attitudes/behaviours changed over time through the use of interviews. Generally, interviews can be structured, semi structured, or unstructured (54). Semi structured interviews allow the researcher to explore certain topics, yet gives the participants an opportunity to convey their thoughts in an exploratory manner (54). For this research, it is critical that the interview allows the researcher to explore issues that have not been examined before. Unexpected or unforeseen variables may have been a cause of change over time, and the interview provides a space to explore those in a free and exploratory manner, hence making a clear case for a semi structured approach. However, there is a danger of bias through the researcher's word choice and engagement, and it can be easy to move off topic because of the semi structured format (55). Semi structured interviews have been used to explore how people perceive energy use programmes (56).

B) Egocentric network mapping:

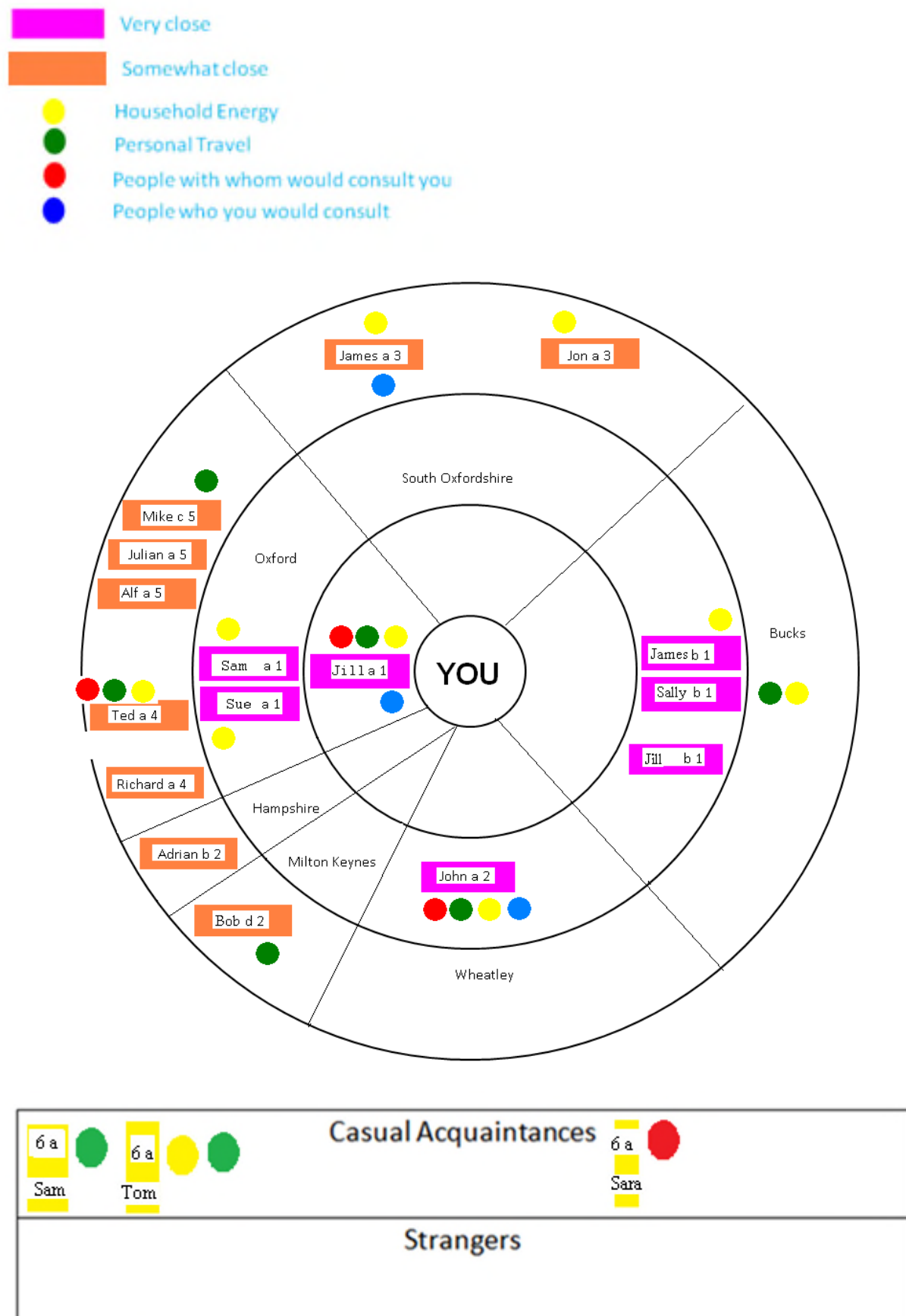
Social networks can be mapped in a myriad of ways and it is no surprise that there is a specific terminology associated with different mapping processes. One approach, the whole network approach, attempts to map out entire networks and all relevant interactions (57, 58) – such as relations between organizations (59). Another approach, the egocentric network approach, focuses on an individual (also known as the ego) and maps out the relevant social interactions that the researcher is interested in. For example, if the researcher is interested in mapping out who is close to the individual of interest, the research questions will be structured in a way that captures those individuals. Those that are identified as being close to the ego (the individual being studied) are known as the alters – people with relations with the ego (60, 61). Therefore, the research asks the *egos* to map out who the *alters* are. This research adopted an egocentric network mapping approach as the aim was to examine how individuals (the ego) was influenced by others (the alters).

The network mapping: There are six steps described² - 1) name generation, 2) identifying roles, 3) identifying communication pathways, 4) social network mapping, 5) identification of energy and transport alters, and 6) identification of geographic location. More details are in the Appendix (A). Figure 2 represents the outcome.

Network Mapping Debrief: Participants are asked a series of questions, which include elaborating why they communicate with specific alters about: 1) household energy matters, 2) travel related matters, 3) both household energy and travel, and finally 4) why they don't communicate about either. These questions are designed to examine who individuals communicate with about direct energy usage and why.

² The author would like to thank Dr. Bernie Hogan for his comments towards developing this methodology

Figure 2: Social Network Map and Key



C) Installation of display and providing a social diary: At the end, the electricity display is installed. The OWL+USB display was used in this study as it was easy to install (no contractor was required), simple to use, and provided real time electricity consumption (62). For an illustration, please refer to Figure 3 for an image and more details in the Appendix (B).

Figure 3: OWL+USB



Source: 62

Additionally, participants are given a social diary and asked to keep a record of any social conversation about the display. If a conversation took place, participants were asked to identify who it was with, the date, and write down a few details about the conversation.

Participants were asked to keep the social diary between interview 1 and 2 and interview 2 and 3. Asking participants to record social interactions between interviews 3 and 4 (over a period of 4 months) seemed unreasonable – the 4th interview was amended to address this.

3.3 Interviews 2 and 3 (T2, T3):

As highlighted in Figure 1, Interviews 2 and 3 had the following parts: semi structured interview and social diary discussion, influence and ranking exercise, and a social map update.

Semi structured interview and social diary discussion:

Participants were asked in a semi structured interview format to describe their experience with the display. This included how many times they checked the display, whether or not it influenced their attitudes, and what behaviours may or may not have changed. Furthermore, participants were then asked about other energy behaviours that may have also changed because of the electricity display.

Additionally, participants were asked to walk me through their social diary experiences – who did they talk to, what was it about, and when did it take place? This helped illustrate the experience and identified who in their social network they communicated about the display with. This would feed into the next exercise.

Influence and ranking exercise:

This exercise asked participants to rank which interactions were influential to them as it would be worthwhile to ask them which experiences were more influential than others. It was built and modified from other studies (53), and it highlighted which conversations were influential, with whom, and why.

Interactions were in two categories –technological/technical and social (63). Technological interactions were defined as any experience(s) that took place with the display (checking the display before going to bed, using appliances less, checking how much electricity is being used, etc.). Social interactions were defined as any experiences that took place with the display where there were social interactions about the display (face to face, on the phone, etc.). Participants were asked to rank the influence of these experiences. This

exercise helped tabulate to what extent different participants interacted with the display as well as develop an understanding of why the experience was or was not influential (63).

Social map update: At the end of these steps, the social network map developed in the previous interview is brought out, and any new alters from the social diary are added to the map.

3.4 Interview 4 (T4):

This interview was semi structured and participants were asked about other energy behaviours that may have also changed because of the electricity display since the 3rd interview. This was carried out in an interview format to capture all relevant information. After this, the electricity display was de-installed.

Analysis:

In order to evaluate whether an untargeted effect occurred, a clear definition is required. Various definitions were scoped, including Merton (64), Frey (31), and Thøgersen and Crompton (11). Building on these definitions, an untargeted effect is defined here as a change in attitude and/or usage where there is an inclination to engage in a behaviour that is not targeted³.

Subsequently, the data was analyzed in order to evaluate self-reported changes for electricity, gas, and travel from social diaries, transcribed interviews, field notes, influence templates, tabulating social and technical interactions, and interview notes. Sources of data were interrogated until no new themes were found - a common procedure in qualitative data analysis (65-67).

The transcripts were read in order to develop an understanding of how and why attitudes and/or behaviours changed – and what factors the participants highlighted as

³ Attitude is defined here as positive or negative evaluations of the behaviour that is of interest (72). Usage is defined as changes in the behaviour of interest (electricity examples include turning off the lights more, turning off the computer, etc.)

important – with an emphasis on how this may have changed over the course of the interviews. Subsequently, cases were developed to illustrate these points.

4.0 Results:

4.1 Sample

From the e-mails sent and approximately 900 physical flyers distributed, 70 e-mails were received, and 55 individuals completed the online survey. The first households that met the requirements of the study were selected. Attrition did take place – 2 participants out of the original sample of 21 did not complete the 4 interview waves.

As highlighted in Section 3, the sampling was non-random and the sample differed when compared with the Oxford average⁴ by having a greater representation of females, a greater proportion of older residents, and car ownership (having fewer individuals that do not own cars, more individuals that own 2+ cars. This is highlighted in Table 2.

Table 2: Comparing the Sample to Oxford Average

	Sample	Oxford	Source
Male – Female	32 – 68%	50-50%	68
Over 40 years of age	89%	35%	68
Car ownership – 0, 1, 2 or more, 3 or more	0 cars = 15.8%; 1 car = 52.6%; 2 or more cars = 31.6%, 3 or more cars = 0%	0 cars = 33.5%; 1 car = 45.6%; 2 or more cars = 16.6%, 3 or more cars = 4.3%	69

The occupations of the participants also varied – the largest group consisted of retired participants (7). Other occupations included researcher, mother, doctor, lecturer, teacher, community manager, administrator, scientist, and management consultant. The total number of occupants living in each household varied from living alone, to living with a partner, to living with a family, to living with lodgers. 8 participants mortgage their homes while 11 own their homes. Since one of the requirements of the study was to own or mortgage the home – this is not surprising. More detailed demographic information can be found in Table 3.

⁴ No Oxfordshire Census data was found – hence the Oxford Census data was used

Table 3: Demographic Information

ID	Gender	Age	Residential Area	Own or Mortgage		Council Tax Band	Occupants	House Type	Years in Residence	Cars	Occupation
A	F	50's	Abingdon		Mortgage	D	Two lodgers	Terraced	2	1	Market Researcher
B	F	40's	Abingdon		Mortgage	E	Husband and 3 children	Semi-Detached	3.5	2	Mother
C	F	60's	Jericho		Mortgage	G	Husband	Terraced	27	1	Retired
D	M	60's	Summertown	Own		G	Wife, 2 children	Detached	4	2	Doctor
E	M	70's	Summertown	Own		G	None	Detached	28	2	Lecturer
F	F	60's	Summertown	Own		E	2 lodgers	Terraced	21	1	Teacher
G	F	70's	North Oxford	Own		H	Husband	Semi-Detached	20	1	Retired
H	F	30's	Blackbird Leys		Mortgage	C	Daughter	Semi-Detached	14	1	Community Manager
I	F	40's	Summertown		Mortgage	G	Partner, 3 children	Terraced	10	2	Administrator
J	F	70's	Abingdon	Own		E	2 lodgers	Detached	44	1	Retired
K	M	40's	West Oxford		Mortgage	D	Wife	Terraced	9y 5m	1	Scientist
L	M	40's	West Oxford		Mortgage	D	Wife, 2 children	Terraced	10+	2	Researcher
M	F	60's	Summertown	Own		E	Husband	Semi-Detached	20+	0	Retired
N	M	60's	Headington	Own		F	None	Semi-Detached	31	0	Lecturer
O	F	20's	West Oxford		Mortgage	D	Husband, 1 child	Semi-Detached	3	2	Mother
P	M	70's	Summertown	Own		G	Wife, 2 children	Terraced	12	1	Retired
Q	F	60's	Jericho	Own		G	1 lodger	Semi-Detached	11	0	Retired
R	F	40's	Jericho	Own		E	Partner	Semi-Detached	11	1	Management Consultant
S	F	60's	Jericho	Own		F	Lodger	Semi-Detached	40	1	Retired

4.2 Targeted and Untargeted Effects

From the findings, there were four groups of change identified (no change; electricity only; electricity and gas; electricity, gas, and travel). Each group can defined in the following ways:

- 1) No Change: The display had no effect on my electricity usage and/or attitude or on any other energy behaviours (2 participants)
- 2) Electricity Only: The display only influenced my electricity attitude and/or usage (2 participants)
- 3) Electricity and Gas: The display influenced my electricity attitude and/or usage and also my gas (11 participants)
- 4) Electricity, Gas, and Travel: The display influenced my electricity attitude and/or usage and also my gas and travel (4 participants)

The findings indicate that the more experiences (combined technical and social) took place with the display, the higher the likelihood that there would be an untargeted effects towards other energy related behaviours. For the first group (no change), it was found to have an average of 3 technical and 2.5 social experiences, electricity related change had an average of 6 technical and 6.5 social experience, electricity and gas related change had an average of 9 technical and 8.7 social experiences, and electricity, gas, and travel related change had an average of 13 technical and 8.3 social experiences. Further information on each specific participant is presented in Table 4.

Table 4: Groups and Total Interactions

Group	Interactions						ID
	Technical	Social	Total	Technical	Social	Total	
	Average	Average	Average	#	#	#	
No Change	3.0	2.5	5.5	3	3	6	D
				3	2	5	J
Electricity Only	6.0	6.5	12.5	5	6	11	G
				7	7	14	Q
Electricity and Gas	9.2	8.7	17.9	9	9	18	A
				7	7	14	B
				7	18	25	E
				6	11	17	F
				12	16	28	I
				7	3	10	K
				17	9	26	L
				7	2	9	M
				7	6	13	N
				12	4	16	P
				10	11	21	R
Electricity, Gas, and Travel	12.8	8.3	21.0	17	5	22	C
				11	15	26	H
				12	6	18	O
				11	7	18	S

Out of the 19 participants, 15 reported changes in attitude and/or behaviour with relation to gas use. Most participants developed a consciousness of gas use – meaning that the display prompted them to think about their gas consumption and how they could decrease consumption. Four participants mentioned that they would like to have feedback on their gas use or would like to monitor their gas use. Additionally, 5 participants had self-reported behavioural changes in gas use, such as turning the thermostat down. It can be argued that an untargeted effect of installing an electricity display is that the user is likely to develop a consciousness of gas use.

Out of the 19 participants, only 4 participants reported changes in travel. Most changes were attitudinal (felt guilty when travelling, thought about their travel footprint), and some were

behavioural (participant H made one less car journey and participant S travelled by train instead of car on one journey). Two participants that did have behavioural changes were those that used the car as one of the main modes to travel. The other two participants in the group indicated that their main mode of transport was on foot or bicycle, and they only had attitudinal changes. For a detailed summary of the attitudinal and/or behavioural changes in gas and travel for each participant over the course of the study, please refer to Table 5. More details on the longitudinal effects can also be found in the Appendix (B).

Table 5: Untargeted Effects

Changes in	ID	Primary Travel Mode	Gas		Travel	
			Attitudinal	Behavioural	Attitudinal	Behavioural
Electricity and Gas	A	Car, Foot, Or Bicycle	Thought about gas use	Turned the thermostat down	No untargeted effects	
	B	Foot or Bicycle	More aware of gas use	Described more efficient use of gas, got a new electricity/gas plan		
	E	Car, Foot, Or Bicycle	Developed a desire to have a gas display, like the electricity display			
	F	Bus and Train	Developed a desire to have a gas display, like the electricity display			
	I	Foot or Bicycle	Developed a consciousness of central heating use and gas use	More frequently turning down thermostat, better at calibrating heating timer daily		
	K	Foot or Bicycle	Wanted to have feedback on gas consumption over the winter			
	L	Bus and Train	Developed a consciousness of gas use,			
	M	Bus, Train, Foot or Bicycle	Developed a consciousness of gas use			
	N	Foot or Bicycle	Developed an interest in monitoring gas use			
	P	Bus, Train, Foot or Bicycle	Developed a consciousness of gas use,			
	R	Foot or Bicycle	Thought about gas use because of cooking	Used the cooker less		
Electricity, Gas, and Travel	C	Foot or Bicycle	Developed a consciousness of gas use in cooking		Felt guilty when travelling	
	H	Car	Started to become considerate about gas use, started to consider how to decrease waste in general		Thought about travel footprint, conscious about travel,	Made one less journey by car
	O	Foot or Bicycle	Developed a consciousness of gas use		Tried to decrease petrol use, inclined to walk and cycle more	
	S	Car, Foot, Or Bicycle	Developed a consciousness of gas use	Used less central heating	Thought about travel footprint, developed an inclination to walk/cycle more	Travelled by train instead of car on one journey

When examining the social network and influence data, the most influential experiences with the display from this study sample tend to be with 1) people who are very close and 2) family members within the social network. When qualitatively examining the overall sample, the participants illustrated that family members are likely to influence participants because learning can occur by and with family members, ideas for taking action can be discussed and encouraged with family members, and this can subsequently help develop a sense of control with the participant. Participants mentioned that discussing the numbers on the display, teaching their children the meaning of the numbers, or discussing why numbers are fluctuating.

In order to further understand how targeted and untargeted effects occurred and illustrate the experiences within the social networks, one case study building on the research data from each of the four groups (no change; electricity only; electricity and gas; electricity, gas and travel) will be introduced. Examining each of these cases will help better understand the role of social networks in targeted and untargeted effects.

Case 1: No Change

Fred Finchley (60) is a professor and has been living in his detached house with his wife (56) and daughter (17) – their son was on a gap year during the study. After receiving a flyer, Fred decided to join the study because he was interested in energy consumption and wanted to also help someone working towards their doctorate. He was particularly interested in understanding what he was using in the house and noted that his children many appliances on in the house.

Fred believes/is concerned about climate change – particularly with the melting ice caps and the long-term future. Fred noted that factors that influence his decisions to conserve energy in the house are primarily financial as well as trying to be green, whereas for travel, cost and

convenience are the primary factors that influence his decisions. The family owns two cars because he and his wife commute to work.

After having the display for a month, Fred noted that not much interaction took place with the display except for the occasional glance, estimated at about once per day. He did note that the display had high numbers at night when the lights and computers were on, and it went as low as 2 pence. When asked if any social interactions took place, he mentioned two in the very beginning – asking his family members if it was acceptable to have the display in the household for a study (no one objected). When asked if there were any reasons for the level of interest, Fred noted that his family was pretty much set in their ways and continued living life the way they do, using appliances the way they do. He also noted that he was in a fortunate position where he could pay for electricity. Carbon emissions were not the primary concern in his everyday living.

After having the display for two months, Fred noted that the family took a slightly larger interest than before by asking him what the numbers meant. One particular instance was when Fred's wife Fiona asked if the display meant they were being charged £2,000 and he explained to her that was not the case. However, the family continued to be set in their ways and the family did not pay much attention to the display.

After having the display for six months, Fred noted that the family didn't take an interest in the display. While the family is aware that it existed, interest didn't follow.

Social interactions were also minimal over the course of the study. While he has a diverse network for family, friends, and co-workers, the display was only discussed with two family members, both who did not really take an interest in the display and had low levels of influence.

Fred reported no changes in his gas or travel over the course of the study because of the display. When asked to elaborate why that was, he noted that gas was used for heating and his

travel footprint primarily stems from non-changeable travel. When asked to elaborate on what that meant, Fred noted that: 1) each fuel had a different type of use and 2) the family (and himself) were set in their ways and continue to live life without really concerning themselves with carbon emissions.

Case 2: Electricity Only

Helena Hardy is in her early 70's and lives in a semi-detached house with her husband, Harry. They have lived in the same house for about 20 years and are both retired researchers. They heard about the study through a flyer and decided to participate in the study because they have an interest in energy/environmental issues and were looking to assist doctoral students research.

Helena believes in climate change and described some of the complexities involved (increase in energy demand globally, challenges of a global solution, etc.). She noted that being from the post-war generation, she is conscious of shortages and tries to be cautious and efficient – this applies to usage in her own household energy use. Helena has also installed a solar thermal energy system. She noted that Harry was driven by environmental considerations and notes that while it was not a brilliant investment in terms of reduced energy bills, it might be helpful for selling the house to potential future purchasers. With regards to travel, Helena described herself as a cyclist – she would cycle around town and take public transport for journeys that are convenient. However, the cars (the family owns two) would be used for journeys where driving was the only realistic option (using the car trunk).

After the display was installed, there was an interest in the display. Helena was surprised at how much electricity she used, particularly for background appliances (meaning those that consume electricity constantly - such as the fridge and freezer). Helena notes that she would

make ‘mental’ checks to see what was being used when she looked at the display and could relate better to the baseline and recognize increases or decreases in the house. Towards the end of the study, Helena noted that one is able to ‘keep an eye’ on the display in a way that isn’t intrusive or ‘fussy.’ Additionally, Helena found that she would occasionally turn the ‘odd light’ off or switch off the computer more regularly.

When the display was first installed, Helena noted that she had conversations with her husband about the display. Visitors would also discuss it when they arrived in their home. It was placed in the sitting room and so those who were coming through would see and discuss it. However, over time, the discussions tailed down because those that came to the house had seen it and discussed it already.

Helena discussed the display with her family, namely her husband and her son. Her husband caused the most amount of social influence. The other social interactions occurred with visitors to the house (her friends) and her son. While she does have a very diverse social network, the display was primarily discussed with family and visitors to her home. The most influential interaction was with her husband.

While the display translated into slight attitudinal and behavioural changes with regard to electricity use, the display did not translate into behavioural or attitudinal changes in gas or travel. Helena, throughout the course of the study, noted that the electricity display was useful for feedback on electricity and was not related to usage for other energy types. She noted that she was curious about how the carbon footprint between gas and electricity compare, but would have had those thoughts without the display. Helena also noted that her husband, Harry, had already recorded, and continued to record, their total energy usage prior to the installation of the display and so that was something that they were already aware of.

Helena also noted throughout the study that the display didn't influence her travel related decisions for a variety of reasons. One rationalization was that while the display did make one think about their electricity usage, travel was 'too many steps away' from electricity usage. Helena also noted that when people use energy in the home, they can choose what type of appliance to use, how many lights to have in the house, etc. – whereas for travel you, are choosing from a limited selection of choices. Helena also noted that even if one was to choose to take the train or the bus, there is not much one can do to improve the fuel efficiency of a particular type of vehicle. Therefore, while Helena noted that electricity and travel may be in the same 'ball park' when it comes to total energy usage, the levels that are needed to change from one (electricity) to the other (travel) has too many steps in between.

Case 3: Electricity and Gas

Gloria Gilbert (40) lives in an end terraced home with her husband (42) and three children (11, 9, and 3). Gloria works as a university administrator and her husband works in law and they have lived in the house for 10 years. After receiving the flyer through the door, Gloria decided to join the study for two reasons. First, she wanted to engage her children towards thinking about energy and the environment and secondly, she wanted to participate in post graduate research. Their daughter found the flyer when it arrived in their home and was eager to join the study too.

Gloria noted at the beginning of the study that there was a culture to conserve energy where possible in the house. The dryer broke down a few months prior to the study and Gloria noted that choosing not to fix it was a conscious decision – the reason being that they wanted to conserve energy. Other examples include nagging her family to turn off the lights and not running the heating overnight. Her youngest child even shouts 'it's wasting!' when the television

is on standby, and the children “have an instinct to turn things off at the wall.” Gloria notes that these are minimal behaviours in the grand scheme of energy conservation but relevant nevertheless. Gloria also noted that the factors that have developed this type of culture are primarily financial, but also an instinct not to waste along with an environmental concern.

Gloria is also an avid cyclist – she and her three children cycle to and from work. Even though the family owns two cars (the other car is for Gloria’s husband), most of the travelling she does during the week is on the bicycle. Gloria notes that she uses the car during the week for journeys that cannot be done on the bicycle (too late/dark or the children are tired from cycling). Fuel costs play a role in the decision making process as well as a lack of parking space at work, but Gloria also notes that cycling is actually more convenient, quicker, environmentally friendly, and healthier. She has developed a reputation with her family and friends as the ‘cycling family’ because of how much she and her family cycle. Gloria also notes that the family does not fly very frequently (once every 2-3 years) and most, if not all, of their holiday journeys are done by train.

During the first month with the display, Gloria and her family had an interactive experience with the display. Gloria noted that since having the display, she would only use the washing machine when there was a full load (no more half loads) as she saw the numbers increase. Other behavioural changes took place, such as turning off the lights more regularly when not in use and using the toaster more efficiently. Gloria’s children had developed a habit of putting 4 slices of bread in the toaster instead of 1 to conserve energy. The family even played a game to see how high the display could get by turning on all the appliances at the same time. Socially, Gloria talked about the display with her family (daily), friends, co-workers, and visitors.

After having the display for two months, Gloria noted that the family still took an interest in the display and her husband became particularly more interested than he was initially. A familiarity with the numbers started to progress and instead of simply observing the display, Gloria was able to understand which numbers related to which appliance. This translated into having an expectation of what the numbers should be. Socially, Gloria still had daily conversations with her family (in the house) about the display, and a few conversations with her architects and extended family.

After having the display for six months, Gloria noted that it became a part of her daily life. Gloria continued to check the display every time she went up and down the stairs – recognizing what numbers were taking place and if anything was acting outside the norm. This also helped Gloria recognize how different uses are attributed to different seasons (less lights in the summer for instance).

Gloria has a very diverse network and discussed the display with a wide range of individuals. The display was discussed with her family, friends, co-workers, community members, and architect. The most influential experiences were with her nuclear family (husband and three children). The display had the most influential conversations with family members. For Gloria, this was most influential because the family members could discuss their electricity consumption.

Outside of electricity usage, Gloria did note that the display made her think about the use of gas. Gloria noted that she was better than before about turning the thermostat down as well as developing a consciousness of gas usage. With the change of seasons, Gloria noted that she found herself more active with calibrating the timer so that it would use less gas, such as

matching it up with her daily schedule rather than automatically timing it at the same time each day.

When asked to elaborate about how the electricity display influenced her gas consumption, Gloria noted that the display reminded her not to waste in general. Gloria also noted that while heating is using gas, a small amount of electricity would be used for the pumps. These experiences helped link the two together and develop a consciousness of gas use as well as electricity use.

The display, however, did not influence any of Gloria's travel. Throughout the course of the study, Gloria noted that the display didn't have any influence on her travel because she was already quite conscious of those choices already (not flying, actively cycling) but also because travel decisions are not made by herself but rather with family members.

Case 4: Electricity, Gas, and Travel

Julia Jones (28) is a freelance writer that lives in a semi detached home with her husband (28) and son (1 year). Julia heard about the study via Twitter. She was interested to sign up because she was interested in helping with research and because the study was about energy consumption/saving.

Julia believes that climate change exists and believes that everyone has to do their little bit. She is slightly concerned because there has been a socially predominate attitude that believes "it is not going to affect me" which will compromise the future for incoming generations.

Living at home (instead of working), Julia noted that she is now more aware of her energy use than she was before and tries to consciously use less heating and electricity. Primary motivations to decrease consumption are financial, and secondary motivations are environmental. Julia used to walk and cycle everywhere – but having a small child changed that.

The family has two cars, and she finds herself using her car more often because it is more convenient and cycles much less. Cost, environmental impact, health, and convenience are primary factors that influence her travel decisions.

After having the display for one month, Julia didn't really notice the display except for a few notable experiences – such as noticing the cost increase when she switched on her hairdryer. Julia glanced at the display about 10 times per day and reported that it made her use the television less, turn off the lights, and turn off other appliances more frequently. Julia's social interactions with the display were primarily with her husband – such as discussing that she signed up to the display study or commenting on expensive appliances.

After having the display for two months, Julia noted that the display became a part of life and constantly glanced at it. It continued to do its job of reporting what appliances cost without any disturbance and helped keep her on track/recognize if anything was left on or off. Julia also noted that while she had 4 more months with the display, she told her husband that she would miss the display. She considered buying one after the conclusion of the study because it would help keep her on track as well as be a good educational resource for her son.

After having the display for six months, Julia noted that the display was still very much a part of life – checking it three to four times a day, noting how much each appliance is using, keeping an eye on things, and estimating how much the electricity bill may be. Purchasing a display after the study was something that Julia would do. When asked to describe her experience with the display, Julia noted that in the beginning there was a novelty factor. After having it for some time, the novelty naturally went away but the interest did not and became a part of her life. A similar trend occurred for her social interactions with the display. All of Julia's interactions were with her husband and in the beginning they had conversations about what the

display was and how much each appliance used. Over time they would glance at it independently without discussion, yet maintain their interest in it. Julia noted that her husband said that he would ‘miss’ the display too after it was gone.

Even though Julia has a wide network, she only discussed the display with her husband. Julia, however, found these social interactions to be quite influential. The most influential conversation Julia had with her husband was about the hairdryer and its high cost.

Outside of electricity usage, Julia also commented on how the display influenced other direct energy behaviours. During the first month, Julia noted that the display made her realise that everything in the house has in some way, shape, or form some energy related repercussions – from using the dish water, microwaving food, or charging her son’s toys.

After the second month, Julia noted that the electricity display had a knock-on effect on other energy types. Julia explained that while the display monitors only one type of energy (electricity), it does make one aware and think of other energy uses, such as gas and petrol. Julia noted that if, for example, the electricity use was quite high at one moment, it would make her think of ways keep her gas and petrol use down. Julia explained that all the forms of energy use are tied together in the back of her mind and the display does not only illustrate how reliant she is on electricity, gas, and petrol but also makes her think twice about using any form of fuel.

When asked to elaborate why they are all tied together in the back of her mind, Julia noted that each type of fuel is a source of energy that is paid for in one shape or form. While heating doesn’t affect electricity usage, Julia noted that it does cost money, depletes the Earth’s natural resources, and impacts the environment. Julia noted while payment structure for fuels is different (pay after use for household energy, pay before use for travel), it was all the same to her.

Finally, Julia noted that when one was concerned about one type of energy usage (like electricity), there is no reason not to be concerned or ‘care’ for other types of energy usages. Julia also noted that she had developed a mentality about monitoring the energy she used and found herself looking forward to monitoring her usage. Julia also noted that she was looking forward to selling her car – and while the display was not responsible for her decision to sell the car, she does note that the display has made her ‘look forward’ to selling the car. This change in attitude would not have taken place without the display because of the new ‘monitoring’ mentality that she had developed.

After having the display for six months, Julia noted that the display continued to make her think about other things she could do so save energy – like getting loft insulation, cavity insulation, etc. Julia noted that she did try to sell her car but could not get a reasonable price offer and therefore decided to keep it and thought about using it as minimally as possible (which encouraged her to think about walking and cycling more). Julia also noted that she did one big washing load at the end of the day (instead of two throughout the day) to use less hot water, which was related to gas use. All these little changes fed into what she called a “what else could I do?” attitude. Julia noted that the display helped ‘set the ball rolling’ to think about how one can use less energy, save money, and make the most out of the scarce resources on the planet.

5.0 Discussion

This study opens up an interesting debate over targeted and untargeted effects. The context is important. Some participants had a high number of social and technical interactions – but only changed behaviour in electricity and gas and not travel. The 4 participants that changed in electricity, gas, and travel were all car owners. Being cars owners meant that they had a greater perceived ability to change (as evidenced in Julia’s case). Conversely, Gloria felt like she was already ‘green’ in her travel choices – she was already an avid cyclist, used public transport

as much as possible, and is known among her friends as the cycling family. Additionally, Participants N and Q – both non car owners - indicated in the interviews that one of the reasons that they had already given up the car was for environmental reasons. Changing their travel patterns *further* was not really feasible due to the changes that they had previously made. Therefore, the *context* of what the participants had already been doing is relevant when considering and evaluating whether an untargeted effect would or would not take place. Those that had already possessed relevant environmental information or had acted environmentally before (such as giving up the car) were less likely to have untargeted effects than those that did not.

Secondly, the data suggests that the more interactions and the higher the influence that had taken place, the more likely that untargeted effects would occur. For example, Fred interacted with the display minimally and with a small social network with limited influence – this led to no change in electricity behaviour. Conversely, Julia had influential conversations with her husband and interacted with the display - she had changes in electricity, gas, and travel.

Thirdly, through learning and regular interactions with the display can cause individuals to reconsider their attitudes and/or usage towards electricity and contribute towards an untargeted effect. This was illustrated in Gloria and Julia's case that 1) people who are very close and 2) family members prompted participants to reconsider their energy behaviours. The extent to which it leads to an untargeted effect is subject to individual circumstances and what actions they had already taken (such as giving up a car).

Fourthly, the research highlights that that when an electricity display is installed in the home, attitudinal and/or behavioural changes in gas were much more frequent and predominate over changes in travel. The implication here is that some behaviours are more closely interrelated

(electricity/gas) when compared to others (travel). More research is required to understand how/why some energy behaviours change and others do not.

This exploratory study is limited in its scope. First, the population that participated in the study can be described as energy enthusiasts - individuals who have an interest in energy issues and those that are willing to incorporate new technologies into their lifestyles. Given the nature of the study described earlier, the sampling was non-random and the findings are not representative or generalizable. Secondly, there was a tremendous amount of time and effort needed to capture the information and data (can be difficult to replicate). The need for 4 interviews over the course of six months did provide a longitudinal element. Finally, as Crosbie points out, mixed methods studies “have the advantage that they provide the depth of data necessary for an analysis of the social and cultural factors that underpin energy consuming behaviour. However, they also have the disadvantage that they are susceptible to self-report bias, expensive and do not lend themselves to statistical analysis” (73, p 741). This limitation is acknowledged, and while the study does not lend itself to statistical analysis, it can give a clear indication of what may or may not have changed in individual’s household behaviour.

6.0 Conclusion

This paper has examined the targeted and untargeted effects of an electricity display intervention on electricity, gas, and travel by focusing on the social networks. The findings have illustrated that in a sample of 19 participants, 2 had no behavioural or attitudinal changes in any fuel, 2 had changes in electricity only 11 had changes in electricity and gas, and 4 had changes in electricity, gas, and travel. Reasons include discussing energy consumption with very close and family members in social networks prompted participants to reconsider their behaviours and the capacity for that to lead to an untargeted effect was subject to context.

From this, different areas of future research are identified. First, there were many more untargeted effects in gas than there were in travel. Understanding the differences between how individuals conceptualize household energy and travel can help further understand untargeted effects. Secondly, behaviour in this study was influenced by examining how an intervention aimed at household energy behaviour may/may not influence travel. This was done by providing an electricity display. It would be equally interesting to explore the converse – if a travel related intervention may influence household energy use. Are targeted and untargeted effects more or less likely to take place? This is a current topic of interest, given the interface between electric vehicles and mobility, and the potential for home-charging.

Finally, this study adopted a socio-technical mixed method approach to examine untargeted effects. While the findings are based on a small (19) sample in the UK (which was required to investigate this in depth and qualitatively), the findings have a broader context. Electricity displays are used globally and the findings here can be relevant to research and policy practitioners outside of the UK that are interested in energy transitions, behavioural change, and policy packages. Further research can examine indirect energy behaviours by examining food, clothing, and other indirect energy uses alongside direct energy behaviours.

As the focus towards to a low carbon energy transition becomes increasingly important, understanding if and how different attitudes, behaviours, and sectors interact can help develop policy packages that are mutually reinforcing to support strategic objectives. Further understanding about who within social networks can encourage change would help structure policy measures by targeting relevant audiences for a successful impact.

Appendix (A) on Network Mapping:

- 1) Name generation: Using a name generation technique (70), participants will be given a name template (composed of Post its) and asked to identify anyone who is very close to them or somewhat close to them⁵.
- 2) Roles: The second step of the exercise is to identify the roles (family, friend, neighbour, etc.) of the names that they have generated. Participants are given a role template with a specific number (1 = family/relative, 2 = friend, 3 = co-worker, etc.) and are asked to write the number on the post it. If the participant wanted to add more names after seeing the template they can.
- 3) Communication pathways: Participants are asked to identify the main communication mode from the names they have generated. Participants are given a communication template with a specific letter (a = face to face, b = telephone, c = email, etc.).
- 4) Social network mapping: Next, participants will be given a social network map. Participants will be asked to construct a socio-gram using post-its to identify the social proximity of the alters to the ego (53, 61, 70, 71). The participants are told that the circles represent closeness. They are asked to place the closest people in the inner circle and work outwards.
- 5) Identification of energy, transport, and consulting alters: Once the socio gram has been constructed, a unique addition to this methodology is to ask participants to identify who they communicate and consult about household energy matters and personal travel matters by placing a coloured sticker for household energy/travel.

⁵ Very close is defined as “people with whom you discuss important matters, with whom you regularly keep in touch, or who are there for you when you need help” and somewhat close is defined as “people who are more than casual acquaintances but not very close” (70, p.123).

- 6) Identification of geographical location: The final part of this exercise is to ask participants to identify the geographical location of those that they have identified with stickers (any sticker). An example of a final map that has been digitized is shown in Figure

Appendix (B) on Longitudinal Effects:

According to the data, 17 out of the 19 participants indicated attitudinal/behavioural change at some point in time for the electricity (*targeted behaviour*). 15 participants had changes in the second interview, in the second and third interview, or throughout the intervention. Only one participant had a change for the first time in the third interview (participant G) and only one participant had a change for the first time in the fourth interview (participant K). Therefore, attitudinal/behavioural change is likely to take place in the beginning and throughout the intervention for the targeted behaviour.

The same cannot be said about untargeted attitudes/behaviours, as these seem to take place over time. Out of a sample of 19, 15 had self-reported changes in gas. 8 participants had changes in the beginning or throughout the intervention. The other 7 had changes for the first time in the third and fourth interview (participants H, O, R), or only the fourth interview (participants B, F, K, P) – almost 50%. For travel, only 4 reported changes out of a sample of 19. 2 of them were throughout (participants H, S), one was at the second interview only (participant C), and the other was in the third and fourth interview (participant O). Table 6 highlights whether or not self-reported change took place for electricity, gas, and travel over the course of the study and which different stages of the interview.

Table 6: Longitudinal Elements of Targeted and Untargeted Effects

Participant ID	Electricity			Gas			Travel		
	Interview Number			Interview Number			Interview Number		
	T2	T3	T4	T2	T3	T4	T2	T3	T4
A	yes	yes	no	yes	yes	yes	no	no	no
B	yes	yes	no	no	no	yes	no	no	no
C	yes	yes	yes	yes	no	no	yes	no	no
D	no	no	no	no	no	no	no	no	no
E	yes	yes	no	yes	no	no	no	no	no
F	yes	no	no	no	no	yes	no	no	no
G	yes	yes	yes	no	no	no	no	no	no
H	yes	yes	yes	no	yes	yes	yes	yes	yes
I	yes	yes	yes	yes	no	yes	no	no	no
J	no	no	no	no	no	no	no	no	no
K	no	no	yes	no	no	yes	no	no	no
L	yes	yes	yes	yes	no	no	no	no	no
M	yes	yes	yes	yes	no	no	no	no	no
N	yes	yes	yes	yes	yes	no	no	no	no
O	yes	yes	yes	no	yes	yes	no	yes	yes
P	yes	yes	yes	no	no	yes	no	no	no
Q	no	yes	no	no	no	no	no	no	no
R	yes	yes	yes	no	yes	yes	no	no	no
S	yes	yes	yes	yes	yes	yes	yes	yes	yes

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