Beyond the attitude-behaviour gap – involvement in direct load control explained by meaningful systems of motivations, routines and housing conditions

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Abstract

Aside energy savings, the need for electricity demand management grows in a context where networks have to become smarter to lighten the cost of higher peaks and less flexible generation. The efficiency of this demand management will rely on a good understanding of people's consumption behaviours and reactions to the signals coming from the system. In this work, the diversity of people reactions is explored based on the qualitative and quantitative analysis of a load shedding field trial involving 473 households. How do people perceive those interventions? How do they change their daily practices? Who accepts the signal and why?

This diversity in the energy related gestures are often thought to result directly from people attitudes, especially those toward environmental issues, according to planned behaviour theories. However, many empirical studies reveal a gap between attitudes and behaviours. Various interpretations of this gap can be found from measurement issues, to the strength of unconscious routines; this gap can even be considered irrelevant, like attitudes themselves, when referring to the social practice theory.

In this experiment, the causes of the reactions diversity were investigated by means of in depth interviews, observations at home, quantitative surveys and temperature and consumption monitoring. People's *energy projects* were described from their motivations to take part in the experiment to the underlying fields of meanings and the antagonisms structuring them: individualism/community, comfort/frugality, transformation/balance, and efficiency/morality. The relationship between projects, constraints and routines was first described in the qualitative study before the same structures were searched for in the quantitative data, leading to nine clusters of people showing differentiated reactions to the load shedding signal.

As a result, It was possible to describe consistent combinations of attitudes, material environment and routines, that together explain the reactions to the signal. In this model, attitudes play an indirect role on the final behaviour, as part of a complex but intelligible system.

Introduction

Alongside the quest for energy savings, the need for electricity demand management grows in a context where networks have to become smarter to lighten the cost of higher peaks and less flexible generation (Poignant and Sido, 2010). Demand can be managed by means of variable or peak prices in reaction to which consumers are expected to reduce, anticipate or delay their consumption, or via direct load control (with override option or not) agreed and priced beforehand. The efficiency of this demand management will rely on a good understanding of people's consumption behaviours and reactions to the signals coming from the system.

THEORETICAL FRAMEWORK

Reactions to critical peak pricing and load shedding interventions are usually anticipated and modelled in terms of economics, mainly price elasticity, as seen in the analyses of experimental results collections by Ahmad Faruqui (Faruqui and Malko, 1983, Faruqui and Sergici, 2010, Faruqui and Palmer, 2011). Making a rational economic choice, consumers compare the

cost difference between consuming now, later or not, and the associated practical (in)convenience or service. But the measured price elasticity values are averages of heterogeneous individual behaviours. If this average is relevant to measure the resulting performance it is not enough to design more efficient and targeted signals. For that it is necessary to understand who reacts or not to different types of interventions.

This diversity in the energy related gestures is often thought to result directly from people's attitudes, according to planned behaviour theories (Ajzen and Fishbein, 1977, Ajzen, 1991). People supporting the protection of the environment (Hurst et al., 2013, Gadenne et al., 2011) or people willing to save money would be more likely to take part into energy saving or load shedding actions. In this model people behave according to their attitudes, hence changing the later would result into energy savings and better response to load shedding signals.

However, many empirical studies reveal a gap between attitudes and behaviours: it seems people say they care but do not act accordingly (Kollmuss and Agyeman, 2002). Various interpretations of this gap can be found, from measurement issues, cognitive biases (Kahnman and Tversky, 1979), to the strength of unconscious routines (Marechal, 2010); this gap can even be considered irrelevant, like attitudes themselves, when referring to the social practice theory (Shove, 2010).

We investigated the question of energy related behaviours diversity and the specific roles of attitudes and expressed motivations, based on rich qualitative and quantitative data describing a load shedding intervention.

EMPIRICAL CASE AND PRIOR RESULTS

In this research, we focus on a load shedding experiment in which domestic electric heating is remotely and temporarily shut down by the system at peak time. Participants can either turn their heating back on (override) or accept their heating to be off for one or two hours.

Prior unpublished work investigated the quantitative performance of this load shedding program, demonstrating the total amount of power that could be spared with this intervention. Situations when participants are more likely not to accept their heating to be turned off were precisely described in terms of living room temperature and presence at home (overriding risk varies from 0.13 % to 4.00 % for a 10 minutes period of load shedding). Overriding rates are higher during the evening. Lower than usual indoor temperature at the beginning of a load shedding event was identified as one of the main trigger of overriding reactions. However, little was explained of the differences in the overriding rates of the 473 participants studied, except households with children under three years old are more likely to override the signal, and the use of a secondary heating system can help to stand the load shedding period in some cases. In similar situations, some people always accept load shedding (35 % or 79 % depending on the intervention type), while some others refuse it repeatedly (overriding).

Our research focused on the explanation of this diversity. Can we explain the acceptance of the heating disruption by the motivations for the experiment, more general environmental values, more interest for the monetary reward, or other motivations differentiating the participating households? Or perhaps what people say is irrelevant because this speech serves other purpose than describing their actual logics of action and will never translate into practical behaviour in favour of energy savings and efficiency?

Contrary to the idea of an attitude-behaviour gap or cognitive biases, the initial qualitative analysis revealed a strong consistency between people expressed motivations, and their domestic choices and everyday practices. This can be illustrated by the case of the *Le Goff* family (fictitious name), whose environmental values are translated into many fields of everyday life, but result in a high domestic electric consumption with no major contradiction.

> The Le Goff family shows very deep environmental concerns relying on the care for future generations and opposition to consumerism. These concerns translate into many fields of consumption: living room temperature is restricted (measured at 18.6 °C on average during the winter), appliances are not changed unless they can't be repaired, homemade and local products are preferred to industrial ones, the house is an old building in the town centre to limit car usage and nibbling rural areas ("mitage de l'espace rural"). The domestic energy consumption associated to this committed way of life is higher than average families of the same composition, off peak hours are not used efficiently and consumption during the load shedding periods of the intervention remained high. These high and inflexible domestic direct energy consumptions result from the reintegration of external consumptions and associated constraints driven by strong environmental values. This paradox does not result from cognitive biases or attitude behaviour gap of any kind provided our observation is not limited to domestic energy consumption. These people behave according to their expressed motivations.

Beyond their diversity, the choices and daily activities performed in this household form a consistent set of practices.

ASSUMPTIONS AND RESEARCH QUESTIONS

The general aim of this work is to better understand the differences in the energy related behaviours observed between different consumers.

From the previous *Le Goff* family case, it is clear that studying attitudes and motivations alone is not enough to understand the meanings, or logics of action, at work in the domestic practices. Indeed, not all the people expressing environmental values do behave in the way of the *Le Goff* family. Which means different sets of meanings can be related to the same expressed motivation. According to Bovay (Bovay and al., 1987), the study of domestic energy consumption must "put energy related attitudes and behaviours back into a set of daily routines" to "discover the converging reasons leading different people to consume energy in specific ways." Following Bovay, we assume these converging reasons or meanings can be identified through the study of how motivations, daily practices and the appliances used, are associated together.

From our qualitative observations, these sets of meanings do not only explain what people currently do but also describe what people try to achieve in the field of energy consumption. For this reason we interpret the set of meanings used in a household as its *energy project*.

The first aim of this paper is to generalise the description of *energy projects* to quantitative data. Can we find similar mean-

ings and *energy projects* in the quantitative sample based on the collected measurements and questionnaires? Do the qualitative and quantitative analyses of the relationship between energy related motivations, appliances and everyday practices, reveal similar structures of meanings? Are we able to identify groups of people sharing similar *energy projects*? Are these *energy projects* relevant to tell consistent stories explaining specific energy related behaviours?

Our second aim is to explain the diversity of people reactions to direct load control thanks to the understanding of their *energy projects*. Are specific *energy projects* associated with more people overriding, or with other specific behaviours in reaction to the load shedding event? Does the description of different *energy projects* enlighten different reasons for overriding?

Materials & Methods

INTERVENTION PROTOCOL

This work relies on a local intervention carried out in Brittany (France) during the winter of the years 2011–2012. It involves a total of 600 voluntary households, recruited by direct mail among owners of a detached or semi-detached house with some electric heating, in the Brittany administrative area, in towns, suburban or rural areas equally. Before the 2011–2012 trial, participants already took part into similar experiments during one or two previous winters.

The intervention consists in the remote control of the electric heating by the supplier by the mean of an electronic device installed in the house. The device receives radio or ADSL signal from the supplier, and sends orders by radio to the house electric panel to switch electric heating on and off. Occupants can also interact with the device, which displays a specific violet light when load shedding is going on, and allows people to easily turn the heating back on, by pressing a button to "override" the signal. The device sends electric consumption and overriding behaviours information back to the system. Load shedding was performed on 20 cold days, chosen by the supplier one day ahead based on weather forecast, during the week, between December and March.

Different interventions were applied to two groups of participants based on the year when they entered the experiment. In the first group (Evening Peak group – EP), recruited in 2009, load shedding happened at a fixed time in the evening from 6 PM to 8 PM, which is the actual peak time for the French national electric demand. In the second group (All Day group – AD), recruited in 2010, load shedding happened four times a day, with two possible durations (1 or 2 hours) and intervals depending on their heating system (longer durations for high inertia systems like floor heating). In both cases load shedding happened on the same 20 cold days. It's to be noticed load shedding durations where particularly long so as to trigger some reaction from the consumers and study the limits of comfort.

The EP group had several other features. During the recruitment, more emphasis was put on the possibility to save energy. In this group, participants received gift vouchers as a reward: a fixed amount for taking part in the experiment (€30), and an equivalent variable amount depending on their measured electric consumption during the load shedding periods (<€30). Those participants were also given energy saving advices at the beginning of the intervention and two intermediary consumption reports. They were informed of the load shedding events one day ahead via SMS and e-mail. The AD group had access to an extra online daily consumption monitoring display. These differences are summed up in Table 1. Given the large number of aspects differing in the protocol applied to the two groups, they are not to be compared, but instead provide some variability that is likely to be found again in the results (differing understandings of the intervention and overriding rates).

MEASUREMENTS AND SURVEYS

The data collected for the analysis of the intervention is very rich, including: electric consumption, temperature and overriding measurements, quantitative survey, and qualitative in depth interviews and observations at participants' dwellings.

Consumption, temperature and overriding measurements

Total house electric consumption was measured by 10 minutes steps all along winter, for each household.

Temperature in the living room was measured by 10 minutes steps all along winter for 366 households (255 in EP + 111 in AD). Outside temperature was collected from the nearest weather station at 1 hour step.

Load shedding periods were described by: household, day, start time, end time, overriding event (Was it terminated by the system or by the occupant?). In the AD intervention when load shedding happens at different times of the day.

Table 1. Intervention groups features.

	Evening Peak (EP)	**All Day (AD)**
Households	321	278
Load shedding periods/day	1	4
Load Shedding period duration	2 h	1 h or 2 h (floor heating)
Interval between two periods	–	3 h or 2 h (floor heating)
Load shedding time range	18 h–20 h	6 h–22 h
Day ahead warning (SMS and e-mail)	YES	NO
Online consumption monitoring tool	NO	YES
Fixed and variable reward	YES	NO

Quantitative survey

At the end of the winter, a questionnaire was answered over the phone by 473 participants (257 in EP +218 in AD). It was made of several hundreds of questions covering:

- Household Socio-demographics.
- Building features.
- Heating system features.
- Everyday rhythms and heating habits.
- Load shedding events perception and reactions.
- Reward and pricing evaluation (EP).
- Consumption online display evaluation (AD).
- Initial motivations and final evaluation of the experiment.

In the quantitative analysis, only the 473 households responding to the phone questionnaire will be analysed.

Qualitative interviews and observations

Among all the participants, 19 households (10 in AD +9 in EP) were met at their home for an average 1 h 20 interviews in the beginning of the winter and then called back for complementary interviews on the telephone during the winter for 6 of them. All the quotes reported in the paper are associated with fictitious names.

ANALYSIS DESIGN

In the first two steps of the analysis, quantitative and qualitative material was used together to build a typology of *energy projects*, as defined in the introduction. Then we studied how participants reacted to the load shedding events depending on their *energy project*.

Expressed motivations for the experiment

The motivations expressed by the participants during the in depth interviews were classified in four fields: saving money, caring for the environment, technological and social innovation, and good citizenship. Then the quantitative data collected via the phone questionnaire was searched for items covering similar fields of motivation. Most of these items asked respondents their level of agreement with several propositions. They were treated in a comparative way, removing the average agreement of the respondent from each of its single answers, so that the resulting values translate the preference for one item rather than for the others. Then, for each respondent, the questions relevant to one field were averaged together in a single score. Table 2 lists the themes and questions related to each field.

These motivations first relate to the participation to the load shedding experiment but can also qualify more general attitudes toward energy, how it's consumed or generated. The scores computed for each respondent and motivation field from the average of the related centred questions can vary from -2 to 2 (from totally disagree to totally agree). The four motivations are not balanced, not having as many pros and cons. Economic motivation is skewed toward negative values, environmental motivation is skewed toward positive values while innovation and good citizenship are nearly balanced.

Energy consumption meanings

As observed in the original case of the *Le Goff* family, people's expressed motivations alone are not specific enough to understand the meaning given to energy in every day practices. However the analysis of these fields of motivation together with the observed domestic environment and described routines can reveal the logics of action playing in the household. We looked for underlying meanings in the qualitative and quantitative materials.

Regular patterns of oppositions and choices emerging from specific combinations of motivations and detailed practices in the field of energy were identified in the qualitative analysis. For the quantitative sample, the relationships between the motivations for the experiment and usual heating practices were studied by means of a multidimensional analysis of the motivation scores associated with other variables from the questionnaire and measurement instruments regarding heating routines and equipment (perceived and measured indoor temperature, type of regulation, electricity consumption, and main heating system) (Table 3). Two variables in the questionnaire already related to the qualitative axis of meaning (Comfort and "Play the game", which is one of the main reasons given by participants for not overiding more, the main alternative reason being "Not feeling the need"). Items were first transformed into categorical variables before performing a Multiple Correspondence Analysis (MCA) of the data.

Four directions of the multidimensional space resulting from the MCA were matched to the axis of meaning built in the qualitative analysis. The qualitative findings helped to interpret the structure of the quantitative variables, and the quantitative data brought more robustness to the qualitative observations. The position of each of the 427 participants in the multidimensional space was then interpreted as a combination of meanings, that is a specific *energy project*.

Energy projects

A clustering analysis of the respondents was performed based on their position in the MCA space in order to identify a limited number of typical *energy projects* shared by groups of participants. A hierarchical ascending classification applying the Ward criterion to the squared distances was used for this purpose. A large number of clusters were chosen, because in our case the internal consistency of each group matters more than the global structure. The specific features of these *energy projects* were singled out using statistical tests for their difference compared with the other clusters. Chi-square tests were used for categorical variables and Duncan multiple-comparison tests were used after the analysis of the variance of continuous variables. Links were considered significant when we could reject independence with a risk lower than 5 %.

Reactions to load shedding events

Reported and monitored overriding events were compared by *energy projects*. It's meaningful to pay attention to the reported overriding, because we're trying to explain participants' conscious actions, and we know a part of the monitored overriding is unintentional. We focused on the percentage of participants overriding once or more rather than on the overriding rate itself because we're interested in the differences between households, and a large proportion of the sample never overrode.

Table 2. Fields of motivation revealed in the interviews and translated into the questionnaire.

	Quote	Qualitative fields	Quantitative items
Money	"That's always in the conversation with friends: And you, how much do you spend for electricity?" Le Cam	1. Bill reductions 2. Avoid wasting money 3. Balanced deal 4. Investment incentive	1. The program can help me reduce my bills 2. The price offered is financially attractive
Environment	"We have to think of future generations. When we hear within 50 years problems will arise on the coasts, because of global warming; we've got to be careful." Le Bellec	1. Consumption reduction 2. Energy efficiency 3. Energy independance 4. Renewable generation	1. I use the energy I need, and avoid wasting energy 2. Take part in an environmental program
Innovation	"I'm used to take part into experiments. At that time, when France Telecom launched the "Minitel", I was part of the experiment." Le Bellec	1. Technical and social novelty 2. Experimentation 3. Bring solutions to contradictory goals	1. Move research forward in the field of energy 2. This program is modern 3. Take part in an innovative program
Good Citizenship	"If we can avoid a black out for the population, it's something!" Le Bihan	1. Local community 2. Peak pricing 3. Civic involvement	1. Help to solve Brittany electricity supply problems 2. The price offered is relevant to mitigate demand peaks 3. Electricity should be more expensive when demand is higher

Table 3. Variables analysed for the quantitative building of underlying meanings and energy projects.

Motivations and meanings	Good citizenship	Motivation score
	Money	Motivation score
	Environment	Motivation score
	Innovation	Motivation score
	Comfort	Preference for comfort rather than savings
	Play the game	Not overriding is about "playing the game" rather than considering the need for heating
Heating habits	Adjust by hand Keep control	Declared usually adjust T° manually Would prefer heating not to be controlled remotely
	Online use	Declared using the online consumption monitoring tool
	Off peak use	Declared using off peak hours for electricity consumption
	T°d	Declared T° in the living room when occupied in winter
	T°m	Measured average T° in the living room in winter
	Cold habit	Declared being cold at home during usual cold spells
	Tsensitiv	Tm varies steeply with outside temperature
Heating equipment and consumption	Elec. Consumption	Measured Average electric consumption in winter with no intervention
	Psensitiv	Electric power demand sensitivity to outside temperature
	Floor Heating	Main heating system is Electric floor heating
	Wood Heating	Main heating system burns Wood
	Radiators	Main heating system is Electric Radiators
Other equipment	Photovoltaïc	Photovoltaïc panels are installed on the roof

Relative indoor temperature at the beginning of load shedding events was also computed to give an idea of the comfort cost associated with the heating disruption. This temperature was expressed relatively to the usual indoor temperature measured at the same time on the days with no load control. Again chi-square and Duncan multiple comparison tests were used to identify significant differences in the number of people overriding and in the temperature respectively, between the *energy project* clusters.

Results

ENERGY CONSUMPTION MEANINGS

The qualitative and quantitative study of the relationships between participants' motivations, heating routines and appliances led us to the description of four axes defined by pairs of meanings opposed by consumers:

- Consumption aspiration can be aimed at comfort vs. frugality.
- Rationality can rely on the practical efficiency vs. on the morality of the action.
- Change can be seen as a transformation vs. maintaining a balance in a constraint world.
- Achievement level describes if the action addresses an individual problem vs. a collective problem.

The quantitative analysis showed that those axes are not independent in the sample. In particular, Consumption aspiration and Rationality are tightly related: comfort is associated with efficiency (and a little with innovation), while on the opposite side restriction stands with morality (Figure 1). The first three axes define the first plane, while the achievement level distinguishes between the individual problems in the front (dark colours) and the collective issues in the back (light colours). Follows a description of the axes illustrated with consumers' quotes.

Consumption aspiration and rationality axes: efficient comfort vs. moral frugality

Comfort is mainly understood as a norm and a need, as mentioned in Bovay (1987), "the comfort norm adopted in our society sets the level beyond which energy contribution to our comfort can't be reduced." Comfort is not about luxury, the later being massively rejected by middle classes (Moussaoui, 2007). It is not about distinction through more comfort, it is about being able to reach a normal comfort. Thermal comfort concentrates these primary expectations:

> That was a good thing to realise we can't go on this way as if nothing had happened. We're not going to freeze our butt off! But we'll see if we can do something … (Le Cam)

This ability to reach comfort often relies on the acquisition of more efficient heating appliances:

> My thirty bricks [recently acquired storage heater] here, they heat well. We've recovered comfort! Because, I think, before that, we were discouraged; we thought we would never make it through! (Le Mell)

When appliances alone fail to supply comfort, everyday gestures have to take over this task, closing doors to maintain the heat in specific areas, or repeatedly modifying the heaters settings to anticipate changing needs in the course of the day.

Comfort is associated to a specific rationality, focused on the practical efficiency of actions rather than on interpretations in terms of morality. These participants adjust their contribution to the intervention depending on what's possible after their needs are met. They want to keep the control of the situation, making rules coming from above optional and flexible, as expressed in the previous verbatim from the *Le Cam* family.

On the opposite side of the consumption and rationality axes, frugality is a reaction to the continuously increasing norm of comfort. A soft version of this frugality simply rejects excess, waste or unnecessary consumption. It's about setting a reasonable norm of comfort rather than reducing or rejecting comfort totally.

> But no, we try to pay attention, we don't overheat the house. It's not for saving money, because we live well enough, it's more not to pour money down the drain. (Le Floch')

Stricter frugality consists in choosing restriction, efforts and sacrifices, and not only in energy efficiency. This commitment applies to the consumption of goods and appliances as well as to daily practices.

> No, but actually, in terms of appliances, we don't have no coffee machine, we haven't changed the fridge for 10 years, we don't have no fully equipped, all electric, kitchen. We try to limit appliances. … For us, the flat screen, it will come when our TV set will be dead. (Le Goff)

The adoption of a frugal consumption comes with the will to "play the game". These participants try to follow the rules, and do what they think the system expects from them, putting morality before the practical outcome of their action.

Change axis: balance vs. transformation

The change axis differentiates two ways to solve the tension between the antagonist consumption aspirations and rationalities we've just described. Balance is a trade off offering a solution to a persistent problem in a closed world, while transformation supporters expect innovation to go over currently compulsory choices and deliver benefits with no constraints.

Balance consists in the negotiation of a fair economic trade stimulating and rewarding individual action to preserve people's comfort and the supply system in their current state. According to François Dubet, "For a long time marginal, or associated to conservative or reactionary traditions, the criticism of progress ideology spread widely in most of western societies from the seventies, where the environmentalist idea and movement acquired its rightful place. The idea of unlimited development was replaced by one of a finite and closed world." Here, preservation relies on a trade-off that will be met thanks to economic exchanges, participants thinking that actors' behaviour is driven by profit.

> For me, the logic is: 'You make an effort, in exchange for which …' And it's true that I'm sensitive to money savings. For me, it's a good incentive principle. (Le Guen)

For these participants, a fair energy pricing is seen as the way to find a good balance between comfort and savings or between the electric system and consumers requirements.

On the opposite side of this axis, those looking for transformation expect technological innovation to make the current compromises obsolete and bring sustainable comfort.

> We do the laundry and flush the toilet with rain water. We grow vegetables. We've got bees. I ride my bicycle, but otherwise, we're not … we're not going to eat organic only. We've got a modern house, using modern technology, we use Internet, and all, you see, it's not … we're not trying to go back ten years ago, definitely not. That's not the goal; quite the opposite! (Le Bihan)

Achievement level axis: individual vs. collective

The intervention can be seen as a resource to solve individual problems or as a transmission lever to participate in the resolution of collective issues. In the first case participants expect to save money or to get information that will help them to manage their consumption.

> – The fact it involved Brittany: that was something important for you? – No. They say I've avoided 7.2 tons of CO_2 emissions. Interesting to know, but for myself, the point was to get the "suivi conso" [online monitoring tool]. (Le Mouster)

To the opposite, participants focused on the collective level insist on the benefits for the generation side of the electric system, but also on regional network issues, and global environmental issues.

Energy prices varying with demand are seen as a fair and efficient system to manage the system and involve consumers.

> Electricity pricing is an important matter. For me it was mainly for the idea to progress, to reduce consumption peaks. (Le Bihan)

ENERGY PROJECTS

Eight groups resulted from the clustering analysis of the participants based on their positions on the meaning axes described in the previous part. Their differences can be summarized in the three-dimensional representation of the axes of meanings (Figure 1). Follows a description of each group based on their specific motivations, heating routines and appliances. All the specific features attached to a group are quantified and differ significantly from the other groups (p-value < 5 %). In these descriptions, the axes of meanings helped us to make sense of the combined features, explaining how they relate to each other in a typical *energy project*. In the following results each group is named after its *energy project*. The mechanisms described in each *energy project* provide us with insights on the specific reasons and expectations leading people to take part in the experiment and on the domestic practices and material environments in which the intervention will try to fit. The size of the groups, their specific features and positions on the underlying meaning axes, and the socio-demographic constraints and resources in which the *energy projects* were more frequently found are detailed in Table 4.

Comfort consumers first refuse the moral injunction to restrict their consumption for environmental reasons (their agreement with environmental motivations is half the average of the sample). They prefer to keep the control of their heating system, and consider remote control as an intrusion, but also disregard the online consumption monitoring display they see as prescribing restrictions. Lower income is more frequent in this group (20 % under €1,200/month vs. 12 % on average), which could mean this energy project is nested in a more general quest for the ability to consume. Here, specific energy restriction messages sound irrelevant in a context of more general economic pressure, and the collective need for moderation is discarded face to the individual need for consumption.

Comfort adjusters consider comfort as a need (only 3 % would give up on comfort to play by the rules, compared to 33 % in the whole sample) and report a higher indoor temperature (twice more than average report temperatures higher than 20 °C). This need is achieved by the mean of regular manual adjustments of the individual electric heaters (50 % adjust manually vs. 25 %), and by the use of the online consumption monitoring display when available (30 % use it vs. 17 %). For this group, efficiency lies in the everyday routines, not in the technological performance. This need for comfort is related to the presence of more children under 3 years old, while the everyday mean of action is structured by individual heaters, forming a constraint energy project focused on daily actions.

Moderators reject comfort they associate with costly and immoral waste. But their acceptance of the moral norms (52 % accept load shedding to *play the game* vs. 33 %) does not translate into a lower heating usage or electric consumption. The first goal of their *energy project* is to belong to a balanced norm of consumption, rejecting both comfort and restriction as abnormal extreme situations, as described by Isabelle Moussaoui (2007). This central energy project could be considered close to an absence of marked energy project. It's also likely to be more spread in the overall population compared to this sample of volunteer participants to a load shedding experiment.

Cold greens not only reject comfort but actively seek restrictions as a proud materialisation of their environmental values. Their declared and measured indoor temperatures are significantly lower than average (31 % declare a temperature under 19 °C vs. 15 %) and most were used to be cold at home during cold spells before the intervention (96 % vs. 18 % of the total sample). This low temperature could result from the association of older buildings (53 % before 89 vs. 37 %) while electric consumption is not particularly high or sensitive to outside temperature. This energy project is found among upper social layers (22 % of executives vs. 14 %) with income not significantly different from the mean. The Le Goff family could belong to this group of energy project expressing restrictions in many fields. Not subject to any structural constraints, they adopt very constraining routines that leaves little space for change.

Unable savers like Moderators try to limit their consumption, and their energy bill in particular (74 % hope the intervention will reduce their bills vs. 55 %). They do not seek a low consumption for the sake of it, but instead struggle to reduce currently high bills resulting from an electricity consumption 37 % higher than in the other groups. This high consumption is related to older buildings (78 % before 1989 vs. 27 %) with poor insulation (50 % higher power sensitivity to outside tem-

Figure 1. Position of the energy projects on the meaning axes.

perature than average), and to an extended occupation of the dwelling. People sharing this project type are older pensioners (74 % over 60 vs. 27 %) with heterogeneous incomes. They're in the typical situation when the large family house becomes unsuitable after children have left (22 % are even alone vs. 6 %), and there is no will for refurbishment or changes in the daily routines. Given these constraints, these participants expect the intervention will help them reduce their bills in exchange for the load shedding effort. They see the intervention as a balanced trade that will solve their individual problem, placing them on the balance side of the transformation axis and on the individual side of the Level of achievement axis.

Managing citizen also give a central role to the bill but in a collective perspective. They find normal that their efforts are rewarded with lower bills but also to pay more when consuming at peak time (73 % vs. 51 %). They already use regularly off peak hours (86 % vs. 48 %) and reduce heating when away or asleep, which result in more variations in their indoor temperature. For them electricity prices is a tool that make it possible for individuals to solve the collective problem of peak demand through a balanced economic exchange. Heating time management and the use of off peak hours is also automated and facilitated by the use of an energy manager device (73 % vs. 43 %). Similarly to the users of the TEMPO commercial critical peak tariff, they also have more wood based secondary heating. They are families with older children and more executives (30 % vs. 14 % in the total sample). This *energy project* is made of automated patterns relying on variable pricing, fairly reflecting the cost of the consumed energy for the system, and on automation and substitution devices. This type of *project* offers mixed opportunities for load shedding programs: the needs of the system are well understood, the economic incentive is appreciated, but consumption is already organised and constrained according to off peak times and set back times, reducing the potential for more change.

Innovative greens see innovation as the mean to take part into the preservation of the environment while making no specific effort on the side of comfort. The regular use of an efficient wood-burning heating system (90 % of stove or closed fireplace vs. 20 %), in a very recent building (27 % after 2006 vs. 17 %), provides enough heating from a renewable source and reduces ("nuclear") electricity consumption to the minimum (15 % less than average). Participants sharing this type of project are young families (16 % under 35 years old vs. 8 %) with young children, and working in technical intermediate occupations. Their action for the environment lies in the quality of the resource used rather than on a quantitative individual restriction. The environmental preservation is reframed in systemic terms, and does not require choosing between comfort and restriction anymore. It's clear the wood-burning heating system adopted for environmental reasons gives these households a lot of flexibility to accept load shedding events applied to their complementary electric heating.

Innovative comfort supporters choose technology to reach a higher comfort without consuming more energy. They're often equipped with electric floor heating (87 % vs. 20 %) and energy manager (62 % vs. 43 %) and leave in a recent building (43 % between 2001 and 2006, vs. 26 %). Indoor average temperature is higher than average (20 °C vs. 19.5 °C) but electric consumption is not significantly higher than average. Participants in this group are aged between 35 and 45, and earn more than others (12 % more than €5,000/month vs. 6 %), in spite of their more frequent worker positions (24 % vs. 12 %). The technical efficiency of these households would offer good load shedding opportunities, but they could be reluctant to accept the reduction of their high level of comfort.

REACTIONS TO THE INTERVENTION

Once the consistency of each *energy project* described, we used this knowledge to explain the differences in the way participants received the intervention and reacted to it.

Energy projects by intervention group

The distribution of energy projects in the two intervention groups clearly differ based on the expressed motivations (Figure 2). The three projects associated with savings motivations are overrepresented in the EP group, while the projects expressing comfort are overrepresented in the AD group. This difference could be explained by differences in the recruitment of the two groups, and by differences between the two interventions. First, the recruitment of the EP group presented the experiment as an opportunity to save energy, which could have attracted more people motivated by money saving (*Moderators, Managing Citizen, and Unable Savers*). In addition to this initial argument, the reward mechanism in the EP group, based on the electricity consumed during the peak, could also have emphasised the economic aspects. In comparison, the more frequent interruptions in the AD group could have put the focus on comfort issues. As a result, some of the *energy projects* we described were partly selected and partly transformed by the messages and proposal carried by the intervention. Still, the energy projects relying on other motivations are balanced in the two experimental groups.

It's also crucial to remember the two interventions did not put the same pressure on households heating, and did not result in the same level of reactions from the participants. *Relative indoor temperature* at the beginning of the evening load shedding periods was much lower in the AD group (-1 °C compared to the average temperature at the same time for the same type of day) than in the EP group (-0.65 °C). The proportion of people overriding at least once during the winter reached 65 % in the AD group, 21 % only in the EP group. Both temperatures and overriding rates differ significantly (p-value<5 %) between the two experimental groups.

Behaviours by energy projects will be compared separately in the AD and EP groups. However, because of the biased distribution we've just described, some *energy projects* don't have enough participants to be analysed in one intervention group or the other.

Overriding by energy project

Chi-Square tests indicate *energy projects* have significantly different proportions of people overriding at least once according to reported (p-value = 0.010) and monitored (p-value = 0.047) overriding events in the AD group, and to reported events only (p-value = 0.027) in the EP group (p-value = 0.426 for the monitored events in this group). Shares of participants overriding once or more and *relative indoor temperature* at the beginning of the load shedding events are detailed by *energy project* in Table 5. There are more people overriding at least once in the AD intervention than in the EP one. The differences between *energy projects* are also more significant in the AD group. We tried to explain why some of the energy projects are associated with significantly more participants overriding.

The *Innovative Comfort* group has the highest rate of participants overriding in the EP intervention, and close to the highest rate in the AD. In the AD intervention, *Comfort Adjusters* are significantly more to override according to both reported and monitored rates. These high rates of overriding are not associated with colder *relative indoor temperature* than in the other groups. Compared with these two *energy projects* involving comfort, *Comfort Consumers* are not more likely to override.

Table 4. Energy projects described by their statistically significant features, and implications.

Energy Project	Expressed Motivations	Heating Routines	Heating System	Underlying Significance	Ressources & Constraints	Consequences for the intervention	Sample Share
Comfort Consumers	**Comfort NOT Environment**	**Keep control NOT Monitoring**		Comfort Efficiency	*Employees Low Income*	Need to consume, Low involvement	12%
Comfort Adjusters	**Comfort NOT Play the game**	**Adjust by hand Monitoring High T°d**	**Electric Radiators**	Efficiency Comfort	*Young familly Young children (<3yo) Intermediate*	Use monitoring tools to manually improve comfort	13%
Moderators	**Money NOT Comfort Play the game**			Frugality Morality	*Small Dwelling Employees High occupancy*	Follow the rules & norms (no excess or privation)	16%
Cold Greens	**Environment Play the game**	**Low T°m & T°d Usually cold**		Morality Frugality	Old Dwelling *Executive Managers Low occupancy*	Already involved in restrictions (reached the limit of comfort)	11%
Unable Savers	**Money**	**High Electric Consumption**	**High Heat Loss (power variation)**	Balance Individual	Old Dwelling *Aged & Retired High occupancy*	Get financial reward for little effort, to reduce high bills	5%
Managing Citizens	**Good Citizenship Money**	**Off Peak Use Low T°m High T° variation Usually cold**	**Electric Heaters + Wood Stove Heating Manager**	Balance Community	Very Large Dwlg. *Familly Executive Managers Low occupancy*	Trade with the system. Already involved in energy time management	8%
Innovative Greens	**Innovation Environment**	**Low Electric Consumption**	**Wood Stove + Electric Heaters**	Transformation Community	Very Recent Dwlg. *Young familly Young children (<3yo) Intermediate*	Stove allows low & flexible electric consumption and no loss of comfort	11%
Innovative Comfort	**Innovation Comfort**	**High T°m**	**Electric Floor Heating Heating Manager**	Transformation Comfort	Recent & Large Dwlg. *High Income Familly Workers & Intermed. Low occupancy*	Reluctant to give up on a high level of comfort	16%
Unclassified							10%
						Total number of households	473

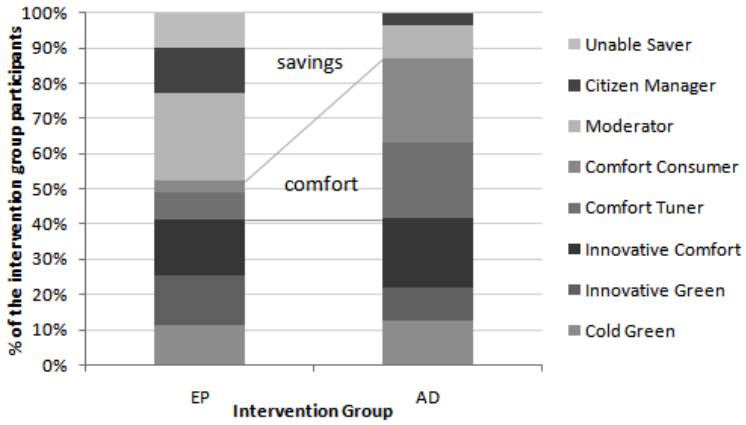

Figure 2. Distribution of the energy projects by intervention group.

Table 5. Relative indoor temperature and share of participants overriding by energy project.

	EP intervention				AD Intervention			
	Participants	Relative T°	% of participants overriding		Participants	Relative T°	% of participants overriding	
Energy Projects			Monitored	Reported			Monitored	Reported
Comfort Consumers	8	-	-	-	47	-0.86	53%	18%***
Comfort Adjusters	18	-0.45	22%	0%	42	-0.42	76%**	62%**
Moderators	58	-0.56	24%	16%	18	-0.93	56%	36%
Cold Greens	26	-0.59	19%	13%	25	-1.03	68%	50%
Unable Savers	23	-0.21	9%	5%	0	-	-	-
Managing Citizens	30	-1.65**	20%	7%	7	-	-	-
Innovative Greens	33	-0.15	12%	3%	18	-	38%**	40%
Innovative Comfort	37	-0.45	27%	26%***	39	-0.91	74%*	49%
mean		-0.58	20%	12%		-0.80	63%	42%

*, **, *** : chi-square test p-value respectively under 10%, 5%, 1%

Fewer of them report overriding in the AD intervention. Given their stated rejection of remote control and environmental prescriptions, this low level of reaction should not be interpreted as an acceptance of the intervention. Not interfering could be a way for them to keep their distance from the intervention, especially if the cold was not extreme. In their case not overriding means they ignore the intervention rather than they accept it. To sum it up, more participants override among *Innovative Comforts* and *Comfort adjusters* because they associate the need for comfort with a strong involvement in the management of their domestic heating, either through technology in the first case or by means of daily adjustment routines in the second case.

Contrary to the previous participants, *Innovative Greens* have significantly fewer people overriding in the AD intervention. This is made possible by the use of wood-fired heating during the evening load shedding period. The evening overriding is particularly low in this case, while the early morning rate is higher. The share of these participants overriding in the EP is also low but not significantly. In this intervention, the low overriding rate is associated with a *relative temperature* close to zero (-0.15), which means indoor temperature at the beginning of the evening load shedding events is not lower than on normal days. On these specific days, indoor temperature is maintained thanks to the electric heating not being cut during the day. This anticipation of the evening load shedding was made possible by the message received the day before in the EP intervention (91 % of declared anticipation among the *Innovative Greens* compared to 58 % in the EP sample). *Unable Savers* also show a small temperature drop (-0.21) and a low overriding rate (9 %). In this case the indoor temperature is naturally maintained during the day, occupants staying at home, and the acceptance of the interruption is motivated by the financial reward. In these two energy projects, not overriding results from avoiding the loss of comfort resulting from the electric heating disruption. In the AD situation it involves the use of an alternative heating system. In the EP intervention it means maintaining the indoor temperature before the load shedding happens. For *Innovative Greens*, this ability comes from past choices of a recent building with renewable heating motivated by environmental considerations. On the other side, *Unable Savers* simply maintain this temperature because they stay at home during the day, being retired in a old house, which is also at the root of their high electricity consumption, explaining their interest for energy and money saving.

In the EP group, *Managing Citizens* endure very low *relative temperatures*, but there aren't more of them overriding. These extremely low temperatures follow from their usual heating and occupation habits: low average temperature varying a lot with outside temperature, and not often at home during the day.

Changes in temperature translate the use of very low setback temperatures during nights and unoccupied times. They're not changing this heating pattern, even if it doesn't maintain a reasonable temperature during the cold spells and does not offer a lot of flexibility for anticipation.

Comparing the declared and measured overriding rates show participants systematically underreport their overriding behaviours. Still, in most of the cases the relative positions of the *energy project* is similar according to both indicators. However, *Comfort consumers* in the AD group and *Citizen Managers* in the EP group underreport more than others. In the second case, this high level of **unreported overriding** could be explained by the high level of automation of the heating relying on an energy manager in this group. This device was indeed identified as the main source of unintentional overriding.

Understanding how attitudes, routines and heating systems are articulated in consistent *energy projects* helped to explain who overrides and who never does so. Overriding is a conjunction of comfort need with a strong involvement in domestic heating, either through technical investment or dedicated daily routines. Never overriding is primarily due to the practical ability to avoid the consequence of load shedding. This ability can result from very different situations: high technical performance driven by environmental values, or convenient occupation pattern associated with retirement.

Conclusion

The analysis of rich measured and declared data made it possible to build a structured quantified description of consistent combinations of attitudes, material environment and routines, that together partly explain the reactions to the signal.

Our first aim was to understand the meanings linking energy motivations, heating routines and appliances. The diversity of these combinations was qualitatively and quantitatively analysed and interpreted along four axes of meaning: consumption aspiration, rationality, change and level of achievement. It was also summarised into eight typical combinations we called *energy projects*, that is sets of meanings that structure a dynamic state of balance and tension between aspirations and practical arrangements. Two general results arose from the description of these energy projects:

- A single motivation can cover very different meanings. For instance, among the participants showing a strong interest for the financial reward, some see it as a way to lower their high energy bills (*Unable Savers*), while the others don't have any personal economic problem but see this money reward as a fair trade (*Managing Citizen*).
- The direction of the link between motivations and the other dimensions can go either way. For some people, environmental motivations played a role in their choice of a wood stove for heating (*Innovative Greens*). For some other participants, being retired in an old badly insulated house results in high heating consumption and bills, raising their motivation to save money (*Unable Savers*).

The practical consequence of these findings is that studying and trying to change people's attitudes and motivations is not enough to understand and change how they handle their energy consumption. However, when analysed together with heating practices and appliances we can understand what could be useful for specific groups of people (i.e. insulation for *Unable Savers*, or information for *Comfort Adjusters*)

Our second aim was to explain the diversity of people's reactions to direct load control thanks to the understanding of their *energy projects*. Results encompass a better understanding of participation, the identification of *energy projects* favourable and unfavourable for overriding, and the different meanings of overriding:

- *Energy projects* are not fixed, they are dynamic and can adapt to new situations. Different offers and promises are likely to both select and emphasise specific motivations and their related *energy projects*. Promising energy savings and financial rewards in the EP intervention resulted in more people participating with *Moderation*, *Unable Savers* or *Managing Citizen* projects.
- Participants are more likely to override when seeking comfort and being strongly involved in heating management (*Innovative Comfort and Comfort Adjusters)*. They are less likely to do so, when they have the ability to maintain the usual temperature at the time when the electric heating is interrupted (*Innovative Greens* and *Unable Savers*).
- There is a diversity of ways to be involved in heating management, and to be able to maintain the temperature. In both cases they can either rely on technical investments (*Innovative Comfort* and *Innovative Greens*) or daily routines (*Comfort Adjusters* and *Unable Savers*).
- The action of overriding has various meanings. These differences are first seen in the differences between monitored and reported overriding participants. Some overrides are unintentional, especially among participants using programmed energy managers (*Managing Citizen*). Not, overriding does not always mean accepting the intervention, for *Comfort Consumers* it can mean ignoring it. Conversely, for *Managing Citizen*s overriding can be seen as a way to interact with the system.
- Direct load control is interpreted differently depending on the *energy project*, bringing specific expectations or distrust. It can be seen as a way to delegate individual problems to the system (*Unable savers*), as an intrusion into domestic management (*Comfort consumers* and *Comfort Adjusters*), or as a way for the individual to take part in the electric system (*Managing Citizen*). Money savings will be expected in the first case while the last one will await feedback about the collective achievements.

All these results give us a better idea of the diversity and flexibility of the consumers' situations into which suppliers and other operators are trying to fit incentives and direct load control. They can help to anticipate the diversity of the response, target the relevant groups of people with tailored messages, or adapt the intervention to the need of a specific target.

To conclude, in our model, attitudes play an indirect role on the reaction to the intervention, as part of a complex but intelligible system. In our case environmental attitudes are not directly implied in lower consumption or positive reaction to the

load management intervention as it's often expected and sometimes found (Sapcia and Considineb, 2014). It's interesting to notice that attempts at linking directly attitude and behaviour would have been misleading in many of these cases. Innovative Greens consume less electricity, but it's not thanks to daily attention to their heating demand. Cold greens on their side do manage to heat less than others in their daily practices, but they do much more in many other fields for the environment that make this effort invisible in the electric consumption. But it just means other outcomes should be measured to know if they are successful.

However, a number of observations remained unexplained, and some of the interpretations would have needed more data to be confirmed. The complexity of the trial made it difficult to use the whole sample in a single analysis, limiting the power of the tests for significant differences. We would advise to limit this complexity as much as possible when designing trials. More importantly, it's to be remembered the people expressing strong and differentiated energy projects in this study are volunteer participants to an experiment about energy. The distribution of the whole population of Brittany or France by energy project is expected to be very different, and even to show other types of project compared to what was observed in this sample.

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