

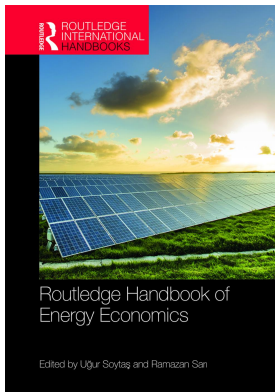
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Access details: *subscription number*

Publisher: *Routledge*

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Routledge Handbook of Energy Economics

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Behavioral economics and energy market

Publication details

<https://test.routledgehandbooks.com/doi/10.4324/9781315459653-38>

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Published online on: 30 Sep 2019

How to cite :- Özlem Özdemir. 30 Sep 2019, *Behavioral economics and energy market from:* Routledge Handbook of Energy Economics Routledge

Accessed on: 30 Mar 2023

<https://test.routledgehandbooks.com/doi/10.4324/9781315459653-38>

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Behavioral economics and energy market

Özlem Özdemir

1 Introduction

In neoclassical economics, individuals are assumed to be rational, to have full information and to be transitive in their preferences. Most policy suggestions are based on the analyses and models with respect to these assumptions. However, according to the empirical findings of the behavioral economics field, mostly because of the careful design of laboratory experiments (Bull, 2012), individuals are not rational and they do not optimize the cost/utility or benefit when they make decisions such as energy conservation or saving. “Behavioral economics is about formalizing and demonstrating consistent deviations from the rational economic model” (EIA Staff Meeting, 2013). More specifically, “it has taken up the difficult task of working out how cognitive biases, mental rules of thumb, interpersonal relations and social networks and norms can cause real-life economic decisions to deviate from the standards of rational, self-interested maximization” (Russell Sage Foundation; Kahneman and Tversky, 1982; Thaler and Sunstein, 2008; DellaVigna, 2009).

There are mainly three cognitive biases that may cause these behaviors that are contradictory to the classical theoretical results (Mullainathan and Thaler, 2000). The first bias is called bounded rationality, that “reflects the cognitive abilities that constrain human problem solving” which, for example, states that a person can perceive the same information differently when the information is framed differently (framing effect). In addition, an individual may perceive losing something more costly than gaining it (loss aversion). The second bias is the bounded willpower that “captures the act that people sometimes make choices that are not in their long-run interest” and thus, describes the gap between what a person believes and how he/she behaves. “Bounded self-interest incorporates the comforting fact that humans are often willing to sacrifice their own interests to help others”. It is defined as the motives that individual take into account when they make decisions such as social norms, altruism, thinking of others rather than optimizing their own interest, self-utility.

With respect to these biases, behavioral economics, while trying to explain the decision-making processes of individuals, aims to model the decisions of economic actors; the consumers, the producers, the distributors, the policy makers of different sectors. This approach complements

the classical economics theoretical and empirical claims about how the price, quantity, demand, supply, strategies are determined in the market through investigating different market mechanisms, mostly in experimental settings. An economic experiment allows to test the findings of theories, different policies (existing and/or suggested policies), and tries to explain the facts in a controlled environment.

Behavioral themes are categorized as four: limited consumer capacity (bounded rationality as explained above), status quo, loss aversion, and time inconsistency. Table 37.1 describes these themes taking into account the stages of the decision-making process:

Table 37.1 Consumer biases and effects on the decision-making process

Bias	What does it mean	How does it affect the decision?		
		Access	Assess	Act
Limited consumer capacity	Consumers have difficulties assessing many different options and large amounts of information about them	Consumers' awareness of the challenges they face means that they do not search at all	Consumers adopt filters or shortcuts to navigate the information (e.g. rules of thumb, reference points)	Consumers switch to an option that is better instead of the best one for them
Status quo bias	Consumers prefer the current option	Consumers do not search for alternatives deals beyond their current package and or provider	Consumers over emphasize knowledge of existing package and or provider	Consumers do not switch away from current package and or provider
Loss aversion	Consumers attach more weight to monetary losses than to monetary gains and avoid risk taking behavior	Consumers search less when energy prices fall than when they rise	Consumers give too much weight to possible losses relative to potential gains	Consumers postpone making decisions
Time inconsistency	Their preference for immediate gains means that they place too much weight on costs incurred now compared to future savings	Consumers do not search for new or alternative energy	Consumers over emphasize short term discounts	Consumers do not make a decision

Source: EON Energy Research Center Series, 2011.

“access (consumers find information about their tariff and other variable; assess (consumer evaluate the information and decide which deal is best for them; act (consumers choose the best deal).

2 Key principles of behavioral economics applied to energy market

We can categorize the key principals of behavioral economics as framing and psychological cues, bounded rationality, choice architecture and heuristics, prosocial behavior, commitment mechanisms, goalsetting, time inconsistency, incentives (Todd, Annika and Sebastien Houde; Mont, Lehner, and Heiskanen, 2014). Key types of behaviors that are related to these principles in energy market are energy consumption, both at home and at work, based on routine, automatic behavior; investing in energy efficiency improvements such as energy efficient appliances building insulation; and switching energy contract or provider.

Framing of information about a certain energy efficient products attributes, energy consumption (e.g. how much electricity a household consumes monthly) or applied/planned energy policy programs is very important for the consumers to understand the provided information correctly and effectively when they make choices. Energy labeling/rating is one of the examples that clarifies the energy efficiency gap for electrical appliances. Supplementing the information about running costs and emissions regularly is another. In addition, consumers are found to be loss averse, they can take any precaution to avoid loss. In particular, the adoption of home insulation is found to increase by presenting bill reductions as avoided extra costs rather than savings. Moreover, if appliances with energy conservations is set as a default, there will be higher energy savings. Finally, consumers value energy-efficiency more highly when running cost information is provided for the operational life rather than for a shorter time period.

In terms of the choices, people act as bounded rational. In fact, they do not buy the cheapest or the most expensive appliance, instead they tend to choose the one that represents a compromise (extremeness aversion). In addition, in terms of energy usage, the in-home energy consumption displays play an important role to decrease the energy consumption (information feedback effect). Social approval is one of the most significant principal that can be applied to the energy efficiency programs. Households are found to reduce energy consumption when they know that their community is saving, they do not care about the absolute levels of performance, and rather they look at the relative performance and participation level. Consumers tend to procrastinate when the products or equipment's are expensive such as insulation. Small actions and immediate (rather than long run) rewards are found to be effective in overcoming procrastination. In fact, the nudge-inducing policies, mostly in the form of particular taxes, subsidies, or other regulations can improve the choices of the consumers in terms of efficient energy usage and “green” behavior. Finally, by considering solely the energy efficiency rating, consumers may end up purchasing appliances which are very energy efficient with respect to other goods in their class, yet energy intensive in absolute terms (Wells et al., 2016)

Loss aversion bias is one the most important behavioral action that arises when the cost associated with giving up something is perceived as greater than the benefit that would accrue to the acquisition of the same thing (Kahneman, 2003; Gsottbauer and van den Bergh, 2011). Individuals tend to keep their status (the status-quo bias), try not to lose something they own and value it more than when the same is good is evaluated as a gain (endowment effect).

Behavioral insights can be used as a tool to policy makers. “Behaviorally tested interventions are defined as initiatives based on an ad-hoc test, or scaled out after an initial experiment”;

whereas, “behaviorally informed interventions as initiatives designed explicitly on previously existing behavioral evidence”, and “behaviorally aligned interventions as initiatives that, at least a posteriori, can be found to be aligned to behavioral evidence” (Sousa Lourenço et al., 2016). These insights can be used to diagnose a problem, design and implement or evaluate a policy. Further, the behavioral interventions tackling environmental problems aim to encourage energy conservation through smart meters that provide real-time feedback to consumers or social comparisons that benchmark a household against that of relevant social group in terms of energy consumption. They also incentivize environmentally sustainable consumption patterns through informing about for example CO₂ emissions from cars (OECD, 2017a, 2017b)

3 Literature review and sample cases that use behavioral economics in energy markets

In energy market, the existing literature shows that preference orders are different among consumers that makes modeling of energy consumption difficult. Further, the value that an individual give to the energy saving or energy efficient products is not the same as the value that the policy makers give to them. Yet, these kinds of energy issues are far behind the consumer expenditure for work, health, family, and education in terms of their priorities when they decide where to spend their budget. Economists mainly focus on equipment cost, energy prices, and personal electricity consumption topics when they try to model the energy market. However, behavioral economics research on energy show that consumers fail to purchase energy efficient vehicles, appliances, and lighting, hence they perceive energy efficiency as a “shrouded attribute”. Energy efficiency is not a prior idea on the top of the mind. Individuals also perceive the energy efficient product purchases or energy saving types of decisions as procrastinate. They delay and often look at these as long-run. the non-priced based behaviors should be investigated in order to understand the reasons behind the consumer perception of energy efficiency. The non-priced concepts are social approval, consumption feedback, goal setting (Allcott and Mullainathan).

Many of the empirical studies related to energy attempt to reduce energy demand; though energy conservation and efficiency. Energy conservation “is used to mean reductions in energy use, holding the energy use per unit of output constant. Energy efficiency “measures energy use per unit of output. Literature implies that individual responsiveness to energy price changes, consistent with the law of demand, yet vary a lot in different contexts. Informing consumers about their energy use works but may not be cost-effective all the time. Finally, the use of social norms can decrease energy consumption in many contexts (Hahn and Metcalfe, 2016). The objective of the price related experiments was to increase the price of energy for consumers during high demand periods.

Most of the studies investigating the applications of behavioral economics through field or laboratory experiments have been done in developing countries, mainly in the United States (Parker, Hoak, Meier, Brown, 2006; Schweiker and Shukuya, 2010). The energy consumption of ten identical all-electric homes in the United States shows that households with similar demographics exhibit very diversified electricity consumption with a range of two to three times. According to the Logica Survey (2007) conducted to 10,048 Europeans in ten countries, 80% of the respondents are found to care about climate change and 45% do not know how much energy they use at any one moment, while more than half of them believe they have done enough to save energy.

Many field studies designed experiments for two groups of households, one paying standard price for electricity all day (control group), the other (treatment group) pays different prices for peak and off peak times (e.g. Caves and Christensen, 1980; Caves, Christensen, and Herriges,

1984; Faruqui and George, 2005; Wolak, 2006). Results indicate peak period electricity usage reductions. Allcott (2011a) conducted a field experiment to 700 households in Chicago, setting hourly electricity rates for the treatment group each day based on the supply costs of energy. Consumers are found to reduce electricity consumption, mainly during peak times, and welfare increased by hundreds of millions of dollars, yet this was a small portion of households' total electricity expenditures. Jessoe and Rapson (2014) investigated the effect of price increases and real-time information on energy consumption and concluded that price increase alone decreased electricity usage by 0% to 7%, adding information feedback decreased usage by 8% to 22%. LaRiviere et al. (2014) used the price and nudge on investments in energy efficiency (ads for an in home energy audit). They stated that nudge was effective, yet less than installing an equipment.

Most of the studies examining the energy efficiency and saving through experiments (mainly field experiments) have been done in the United States. In Ito, Ida, and Tanaka (2015), moral suasion and price increase were taken as the treatment to 700 households in Kyoto, Japan. Moral suasion is found to have an effect on electricity usage only a few days, the price increase reduce the usage by 14% to 17% during peak periods more sustainably. Pellerano et al. (2015) conducted a natural field experiment in Quito, Ecuador, to 28,000 households and concluded that social comparison among households' energy consumption was effective only by 1%, however, adding financial incentives may be counterproductive.

In sum, the literature on experiments related to the effects of pricing of energy usage has mainly been done for residential customers in the United States and for electricity. Hence, experiments for the other forms of energy such as gasoline, heating oil, and natural gas and in other countries need further research.

Few studies have been done on the impact of providing additional information about an energy conservation and energy efficiency products. Ivanov et al. (2013) conducted a field experiment in Minnesota, putting smart meter (programmable thermostat). The treatment group was found to use 15% less energy on peak days. Similarly, Gans, Alberini, and Longo (2013), in their experiment in Northern Ireland, found the reduction to be 11% to 17% with smart meter. Additionally, informing households about energy consumption, this time not through an installation of an equipment, rather mentioning that they are being monitored for a study, decreased usage by 2.7%. In Allcott and Taubinsky (2015), customers were asked to choose between energy-efficient light bulbs and conventional bulbs. Having information about relative electricity use and replacement costs increased market share of energy-efficient bulbs by about 12%. However, the information about products with Energy Star labels, such as water heaters, did not change consumer purchasing behaviors (Allcott and Sweeney, 2014). In that case, the financial incentives like a USD 100 customer rebate increased the buying rate of Energy Star products by 22%. In 2014 study of European Commission, London Economics and IPSOS, for nine European countries (Czech Republic, France, Italy, Norway, Poland, Portugal, Romania, Slovenia, and United Kingdom), alphabetic labels are found to be more intuitive and better understood than labels with numeric scales for energy efficient products. In sum, proving information about the energy efficiency of a product has been found to be effective to increase the purchasing most of the time, depending on the context. The most successful treatment that reduces the electricity usage is the combination of smart meters with the installation of real time information display.

As about the use of social norms to increase the energy conservation and the adoption of energy efficient technologies, very few studies exist and the definition of social norm changes in different disciplines. It is generally defined as an expected type of behavior in a particular

situation (Cialdini and Trost, 1998). “Economists and psychologists doing field experiments often use a descriptive social norm (e.g. describing how a subject’s energy consumption compares with her neighbors) or an injunctive social norm (e.g. describing how other people think about the subject’s energy consumption). In the energy World, the norm is typically assumed to be average behavior of people in similar markets” (Hahn and Metcalfe, 2016).

In the recent work, OPOWER sends home electricity and gas use reports to consumers and compares it with that of similar households and as a result the electricity consumption in average household reduce by over 2%. If scaled nationwide, this program may reduce carbon emissions in the United States by 0.5% saving \$165 per metric ton of reductions (Allcott, 2011b). Dolan and Metcalfe (2013), however, investigated the effect of social norm separately from information on energy efficiency. As a result of their natural field experiment to 600 households in London, they found that social norms reduce the energy consumption. In their extended study, they combined social norms with financial incentives, concluded that these two mechanisms when applied together did not work effectively. In fact, in Herberich, Price, and List (2011) studied the effects of subsidy to lower the price of lightbulbs and a social norm statement mentioning the number of households in a specific neighborhood that have adopted the lightbulbs on electricity usage, and they found social norms being effective on the adoption margin but not on the number of lightbulbs purchased. However, subsidies were found to affect both behaviors. Moreover, LaRiviere et al. (2014) informed households on how their electricity usage related to other households, then they offered them an in home energy audit; they provide the usage information as (1) the relative use in KWh, (2) the relative use in monthly expenditure, (3) the relative use in CO₂ emissions, (4) their absolute use in KWh. Only the KWh comparison increased the likelihood of audits. In recent work, the Social and Behavioral Sciences Team with the White House paired with US Department of Energy to design and assess the Home Energy Score, residential buildings’ energy efficiency profiles and provides recommendation for improving them (2016).

Behavioral nudges can change behavior. It is difficult to determine the effects of policies without randomized, controlled field experiments. Governments can fund behavioral programs among the other type of energy innovation programs; they can encourage private sector to nudge consumers to make more energy saving, efficient choices through behavioral incentives; finally, it is possible to provide information disclosures such as vehicle and appliance energy efficiency ratings to demonstrate the financial value of energy efficiency to consumers (Allcott and Mullainathan, 2010).

There are so many further research needed to be done on energy use behavior: still very little has been known about the effects of behavioral insights on energy consumption in developing countries, very few studies have looked at the loss aversion and its impact on energy demand, more research is necessary on how technology adoption affects energy consumption and economic efficiency. Another area that needs to be investigated is the subsidies in the commercial and industrial sector for energy efficiency. Two studies by Bloom et al. (2010) and Gosnell et al. (2016) suggest that productive efficiency can improve energy efficiency. The first study examined the effect of management practices in over 300 manufacturing firms in the UK and they found that better managed firms are more productive and use less energy per unit of output. Second study showed that lowering energy use in the aviation sector is beneficial for workers, shareholders and the environment. “A key motivation for doing behavioral science experimentation on energy use is to generate new insights for the purpose of changing policy” (Hahn and Metcalfe, 2016). Tables 37.2 and 37.3 summarize the behavioral studies about households’ and workplaces’ energy saving, respectively (e.g., Xu and Binyet, 2018; Park and Kwon, 2017; Iwata et al., 2015).

4 Behavioral studies about households' energy saving

Table 37.2 Behavioral studies about households' energy saving

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors			
								Demographic Variables	Individual Subjective characteristic Factors	External Factors	Behavior
2010	Ek and Söderholm	The devil is in the details: Household electricity saving behavior and the role of information	The purpose of this paper is to analyze Swedish households' willingness to increase their daily efforts to save electricity.		Sweden	1 200	ordered probit model	X	X	X	Electricity Saving Behavior
2011	Gadenne et al.	The influence of consumers' environmental beliefs and attitudes on energy saving behaviours	In this article, a conceptual framework of consumer environmental behaviour and its antecedents is developed.	Theory of Planned Behavior	Australia	218	MANOVA, Multiple Regression Analysis	X	X	X	Environmental behavior
2011	Feng and Reisner	Factors influencing private and public environmental protection behaviors: results from a survey of residents in Shaanxi, China	"What demographic variables differentiate between high and low levels of private (shallow environmentalism) and public (deep environmentalism) attitudes and behaviors?"		Shaanxi	347	Multiple Linear Regression Analysis	X	X		Individual Behaviors; Public Behaviors

2011	Wang et al.	Determinants and policy implications for household electricity-saving behaviour: Evidence from Beijing, China	The current paper attempts to address three issues: What is the present situation of household electricity conservation in Beijing? What are the major determinants that influence the household electricity saving behaviour in China? Does policy direction exert any impact in encouraging household electricity saving behaviour?	Theory of Planned Behavior	Beijing	816	Logistic Regression Analysis	X	X	X	Electricity Saving Behavior
2011	Sütterlin et al.	Who puts the most energy into energy conservation? A segmentation of energy consumers based on energy-related behavioral characteristics	The present paper aims to identify and describe different types of energy consumers in a more comprehensive way than previous segmentation studies using cluster analysis.		Swiss	1506	Cluster Analysis	X	X	X	Energy saving actions

(Continued)

Table 37.2 (Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors		
								Demographic Variables	Individual Subjective characteristic Factors	External Behavior Factors
2011	Martinsson et al.	Energy saving in Swedish households. The (relative) importance of environmental attitudes	The aim of this study is to figure out what more exactly makes which households save or not save energy. It examines the main determinants of household energy saving and the relative importance of various factors by using a large survey data set on Swedish inhabitants and their environmental attitudes and energy-related behaviours.		Sweden	data from the period of 2004–2007 of an institute	Regression Analysis	X	X	Energy Saving Behavior_ heating and hot water usage

2012	Liu et al.	Sustainable consumption: Green purchasing behaviours of urban residents in China	This paper develops an overall analytical framework based on the reasoned action theory and discusses three major topics which are current level of urban residential involvement of green purchasing (GP) practices, the variables affecting the individual's GP behaviors and the relationship between the predicting variables and the level of actual GP behaviors.	Theory of Reasoned Action	Suzhou	336	Path analysis, multiple regression	X	X	Green Purchasing Behavior
2012	Kang et al.	The Energy-Saving Effects of Apartment Residents' Awareness and Behavior	This study aims to raise awareness about the need for promoting energy-conservation and distributing relevant information, and to seek additional roles for apartment residents' in their energy-saving efforts.		The subjects were selected from among those living in the "Best Energy-Saving Apartments," designated by the Busan Metropolitan Government and Korea Energy Management Corporation, and other apartments	First test: 197 Second test: 78	T-test	X		Energy Saving Behavior

(Continued)

Table 37.2 (Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors			
								Demographic Variables	Individual Subjective characteristic Factors	External Behavior Factors	
2013	Yue et al.	Factors influencing energy-saving behavior of urban households in Jiangsu Province	In this research, the willingness of households to adopt different energy-saving behavior has been analyzed, and factors influencing energy-saving behavior in Jiangsu Province, China, have been examined.		Jiangsu	638	Regression Analysis	X	X	X	Energy Saving Behavior
2013	Webb et al.	Self-determination theory and consumer behavioural change: Evidence from a household energy-saving behaviour study	The present study tests a simplified model combining constructs from the Model of goal directed behavior with self-determination theory to explain consumers' energy conservation intentions and behaviour.	Self determination theory and modified version of model of goal-directed behavior	Australia	200	Structural Equation Model		X		Energy Saving Behavior
2013	Hori et al.	The determinants of household energy-saving behavior: Survey and comparison in five major Asian cities	This study aims to clarify the differences among factors influencing energy-saving behavior across five major Asian cities		Dalian, Chongqing, Fukuoka, Bangkok and Ho Chi Minh	2302 + 386 + 215 + 422 + 745	Tukey-Kramer method, OLS Regression	X	X	X	Energy Saving Behavior; Environmental Behavior

2013	Ma et al.	Chinese consumer attitudes towards energy saving: The case of household electrical appliances in Chongqing	This paper reports the findings of a survey carried out in 2009 and 2010 in order to reveal information about attitudes towards energy and energy saving in the context of household electrical appliances	Chongqing	246	Correlation analysis	X	X	X	Energy Saving
2013	Mizobuchi and Takeuchi	The influences of financial and non-financial factors on energy-saving behaviour: A field experiment in Japan	This study integrates both financial and non-financial factors to identify key internal and external variables that determine household electricity-saving behaviour.	Japan	236	Econometric model	Financial variables consist of reward, household income and standard socio-demographic elements.	Non-financial variables consist of com- parative feedback, social norms	Electricity Consumption	
2013	Yu et al.	Evaluating the direct and indirect rebound effects in household energy consumption behavior: A case study of Beijing	This paper examines whether increases in energy efficiency of major household items cause additional short-run utilization of these end uses and other end uses for households in Beijing.	Beijing	775	An Integrated Model (by combining logit model and resource allocation model)	Energy efficiency, Accessibility, Employment, Income, Household size, Children presence	Household Energy Consumption		

(Continued)

Table 37.2 (Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors			
								Demographic Variables	Individual Subjective characteristic Factors	External Behavior Factors	
2014	Wang et al.	Factors influencing sustainable consumption behaviors: A study of rural residents in China	This study develops the scales of rural residents' sustainable consumption behavior (SCB) and their antecedents and tries to bring forward a multifactor model for the first time to analyze whether there is significant influencing path existing from the antecedents to the rural resident's SCB.	Sustainable Consumption Behaviors	50 villages among 35 selected regions in China	1403	K-means cluster analysis, path analysis, stepwise regression	X	X	X	Sustainable Consumption Behavior
2014	Wang et al.	Determinants of energy-saving behavioral intention among residents in Beijing: Extending the theory of planned behavior	This paper provides an empirical analysis that identifies and explores the determinants of an energy-saving behavioral intention among residents from the perspective of the theory of planned behavior.	Theory of Planned Behavior	Beijing	276	Structural Equation Model	X	X	X	Energy Saving Behavior

2014	Arikawa et al.	Attitudes toward nuclear power and energy-saving behavior among Japanese households	It evaluates Japanese attitudes toward nuclear power and energy-saving behavior after the Fukushima Daiichi Nuclear Disaster . In the first part of the paper, it is examined the relationship between socioeconomic characteristics and acceptance of nuclear power in light of global warming. In the second part of the paper, it is examined the relationship between electricity demand and acceptance of nuclear power.	Japan	830 + 503	Ordered probit model	X	Intensity of use of electrical appliances, energy saving behavior
2015	Iwada et al.	Do households misperceive the benefits of energy-saving actions? Evidence from a Japanese household survey	This study attempts to provide further evidence on whether and the extent to which individuals misperceive the potential energy savings (mone- tary benefits) of energy-saving actions.	Tokyo	1200	Bivariate regression	X	Perceived benefit
2015	Jridi et al.	Household preferences for energy saving measures: Approach of discrete choice models	The aim of this paper is crystallized around the research of the energy saving measures adoption's determinants in the residential sector.	Economic Theory Tunisia	3000	Discrete choice model	X	Energy Saving Adoption

(Continued)

Table 37.2 (Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors		
								Demographic Variables	Individual Subjective Factors	External Behavior Factors
2016	Yang et al.	Who exhibits more energy-saving behavior in direct and indirect ways in china? The role of psychological factors and socio-demographics	It examines how people's demographic characteristics and psychological factors affect their direct and indirect energy curtailment behaviors at home as well as the different effects of these antecedents.		Hefei, anyang, Beijing	526	T-test, ANOVA, SEM, OLS regression	X	X	Energy Curtailment behavior
2016	Boudet et al.	Clustering household energy-saving behaviours by behavioural attribute	The aim of the study is to cluster behaviours according to nine different attributes		All collected data between April 2010 and June 2013.	261 energy saving behavior	Content Analysis and categorization	Clustering based on 9 attributes which are energy savings, cost, frequency of performance, required skill level, observability, locus of decision, household function, home topography, and appliance topography		Energy Saving Behavior

2016	Poithou et al.	Environmental knowledge, pro-environmental behaviour and energy savings in households: An empirical study	The aim of this study is to test the relationship between house- hold occupants' environmental predisposition and knowledge versus their energy behaviour, attitudes, habits; and ownership and frequency of use of household appliances.	England	249	Correlation analysis and PCA	X	X	Energy Behaviours, Attitudes and Habits
2017	Ding et al.	Research on differences in the factors influencing the energy-saving behavior of urban and rural residents in China—A case study of Jiangsu Province	This paper conducts a comparative study of urban-rural differences in energy consumption activities and the influencing factors in Jiangsu Province to develop findings that can help guide China's low-carbon energy consumption policy.	Jiangsu	187	correlation analysis, multiple regression analysis	X	X	Electricity Saving Behavior
2017	Hasan and Mozumber	Income and energy use in Bangladesh: A household level analysis	It examines how energy use at the household level moves with income in Bangladesh	Bangladesh	1 2240	quantile regression, nonparametric and semiparametric regression	X	Expenditure per capita, income per capita/ rural or urban	Electricity Use and Other Types of Energy Use

(Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors			
								Demographic Variables	Individual Subjective characteristic Factors	External Behavior Factors	
2017	Hu et al.	A survey on energy consumption and energy usage behavior of households and residential building in urban China	One of the objectives of the paper is to understand the characteristics and trends of urban residential building energy consumption. Moreover, it explores a full picture of the urban residential building energy usage behaviors and understand the distribution of typical behaviors of urban households. Finally, the study investigates the effect and reactions of current energy efficiency policies and behaviors driven policies in urban residential building sector.		China	4964	Descriptive Analysis	X	X	X	Energy Consumption & Energy Use Behavior
2017	James and Ambrose	Retrofit or behaviour change? Which has the greater impact on energy consumption in low income households?	This study evaluated the efficacy of three programmes-retrofit, behavior change, retrofit & behavior change, designed to help low income households become more energy efficient		Australia	320	T-test				Energy Consumption

saving in energy consumption, saving in energy bills, saving in greenhouse gas emission, increased thermal comfort in hh

2017	Jareemit & Limmee-chokchai	Influence of Changing Behavior and High Efficient Appliances on Household Energy Consumption in Thailand	This paper presents the investigation of significant parameters regarding behavior changes and high energy efficient home appliances which could decrease energy consumption in Thai households.	Bangkok	Multiple Regression Analysis	two hundred combinations of forty-eight variables covering occupancy schedules and energy efficient home appliances	Household Energy Consumption
2017	Jareemit & Limmee-chokchai	Understanding residents' perception of energy saving habits in Households in bangkok	This paper investigates the existing residents' behavior and their interest in behavior change for reducing home energy consumption.	Bangkok	Descriptive Analysis	X	Energy-Saving Habits and Behavioral Changes
2017	Park and Kwan	What motivations drive sustainable energy-saving behavior?: An examination in South Korea	The current study thus explores the motivations influencing users' energy-saving behavior by examining their purchasing activities.	South Korea	Structural Equation Model	X	Electricity Saving Behavior

(Continued)

Table 37.2 (Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors	Demographic Variables	Individual Subjective characteristic Factors	External Factors	Behavior
2017	Sun et al.	Environmental Ideology and Household Energy Conservation in Beijing	The study figures out whether Chinese urbanites who label themselves as environmentalists consume fewer resources than the average urbanite.		China	1000	Econometric model	Choice of appliances, Expenditures for energy consumption, Choice of cars and gasoline consumption.				Energy Consumption
2017	Trombley and Hawala	Can further energy reductions be achieved through behaviour changes in low income households?	This work is based on a project which tries to see how education can initiate behaviour changes in participants to reduce their electricity usage.		Australia	476	Descriptive Analysis	Treatment				Energy Saving
2018	Zhang et al.		This paper aims to explore the mechanisms of factors affecting urban household energy-saving behavior including the habitual energy-saving behaviors and purchasing energy-saving behaviors		Shandong	297	SEM		X	X	X	Energy Saving Behavior

2018 Borozan	Regional-level household energy consumption determinants: The european perspective	Starting from the assumption that household energy use is manifold and intertwined, shaped by many factors which overlap not only at the individual level, but also at a higher level of scales, the paper developed a more integrated approach to its determinants.	12 EU Member states_64 european regions	Panel Data Analysis	Socio-economic variables as Human capital, Economic dimension, Labor market, Poverty and Contextual variables as Weather and location, Level of development	Energy Consumption
2018 Baldini et al.	The impact of socioeconomic and behavioural factors for purchasing energy efficient household appliances: A case study for Denmark	This study aims to model influential factors behind Danish consumer choice of energy efficient appliances.	Denmark	Logistic Regression Analysis	X	X Propensity to purchase energy efficient appliances
2018 Camara et al.	Enhancing household energy consumption: How should it be done?	The first objective of this article is to examine how the actors -that influence household energy use through information campaigns on various energy-savings behaviours (e.g., use of public transportation, washing clothes with full machines, and use low-energy bulbs)- try to affect everyday life choices	Guinea-Conakry	Discourse analysis	11 Guinean websites and energy companies and 20 respondents	Consumer's knowledge on energy efficiency, effects of linking actors such as websites, newspapers and etc. Household energy behavior

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors	Demographic Variables	Individual Subjective characteristic Factors	External Behavior Factors
2018	Li and Just	Modeling Household Energy Consumption and Adoption of Energy Efficient Technology	In this study, the authors develop a unified structural model of household discrete technology choice and continuous energy consumption using a second-order translog flexible form for indirect utility to derive compatible household specifications for multiple types of short-run fuel demand and multiple types of long-run technology choice.		California	2408	Model Construction	Socio-economic characteristics, housing characteristics, appliance holdings by energy use, and annual consumption of electricity and natural gas.			Short run household demand for electricity and natural gas / long-run technology choices
2018	Prasanna et al.	Recent experiences with tariffs for saving electricity in households	In this paper, two simple tariffs are reviewed: progressive tariffs (PTs), which penalise high consumption of electricity, and electricity saving feed-in tariffs (ESFITs), which provide incentives to reduce consumption of electricity.	Prospect Theory, Loss Aversion	PT data is gathered from California, Canada, Japan, China, Germany, Switzerland, ESFIT data is obtained from Canada, US, Japan, Germany, Switzerland		Descriptive Analysis	Price elasticity for PT, incentive elasticity for ESFIT			Electricity Consumption

2018	Ru et al.	Exploring the effects of normative factors and perceived behavioral control, on individual's energy-saving intention: An empirical study in eastern China	The aim of the paper is to develop a more through understanding of what motives Chinese individual's energy saving behavior, which has a significant implication to deal with the increasingly serious energy overuse problems in China.	Theory of Planned Behavior	China	450	Structural Equation Model	X	X	Energy Saving Intention
2018	Thøgersen	Frugal or green? Basic drivers of energy saving in European households	This paper examines how energy saving at home relates to two of people's multiple self-identities as an environmentally friendly and a frugal person.		10 european countieres	320 for each country	Structural Equation Model	X		Energy Saving Behavior
2018	Trotta	Factors affecting energy-saving behaviours and energy efficiency investments in British households	The objective of this paper is to identify the socio-demographic, dwelling, and environmental factors that have the strongest influence on the daily energy-saving behaviours, the adoption of energy efficient appliances and the energy efficient retrofit investments made by British households.		England	2009	OLS and AMEs Probit	X	Dwelling type X	Energy Saving Behavior

(Continued)

Table 37.2 (Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors			
								Demographic Variables	Individual Subjective characteristic Factors	External Factors	
2018	Tumbaz and Moğulkoç	Profiling energy efficiency tendency: A case for Turkish households	This study investigates the behaviors and attitudes of Turkish households regarding energy efficiency.		Turkey	526	Two step cluster analysis	Current behavior and attitude		X	Energy Efficiency
2018	Wang et al.	Analysis of factors influencing residents' habitual energy-saving behaviour based on NAM and TPB models: Egoism or altruism?	This research takes the motivation of energy saving as the starting point, through the analysis of the impact of the daily energy-saving behaviour of residents, to explore the daily energy-saving behaviour of Chinese urban residents is out of "egoism" or "altruism".	Normative Activation Theory and Theory of Planned Behavior	China	561	Structural Equation Model	X	X	X	Energy Saving Behavior
2018	Wang et al.	Exploring the effects of non-cognitive and emotional factors on household electricity saving behavior	The main purpose of this research is to analyze the effects of non-cognitive (personal moral norm and habit) and emotional factors (positive anticipated emotion) on household electricity saving behavior.	Theory of Interpersonal Behavior and Theory of planned behavior	China	320	Structural Equation Model	Personal moral norm and habit and positive anticipated emotion			Electricity Saving Behavior

5 Behavioral studies about workplaces' energy saving

Table 37.3 Behavioral studies about workplaces' energy saving

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Inflencing Factors	Behavior
2015	Dixon et al.	Saving energy at the workplace: The salience of behavioral antecedents and sense of community	The study investigates the role of organizational sense of community and its moderating role on the effect of subjective norms on energy conservation intentions and self-reported behavior.	Theory of Planned Behavior	US	2919	Multiple Linear Regression, Hierarchical Regression Model	Attitude, social norms, perceived behavioral control, sense of community	Energy Conservation Behavior
2017	Gao et al.	Application of the extended theory of planned behavior to understand individual's energy saving behavior in workplaces	The main idea of this research is to explore the determinants of individual's energy saving behavior in workplaces.	Theory of Planned Behavior	China	468	Structural Equation Model	Attitude, social norms, perceived behavioral control, descriptive norm, personal moral norm	Energy Saving Behavior
2017	Legue et al.	Saving energy in the workplace: Why, and for whom?	The aim of the present research is to investigate what motives employees to reduce their energy use at work when their job specifications do not include it.		United Kingdom	Study 1=293 Study 2=94	Exploratory Factor Analysis, OLS Regression	Motivation, intention, attitude	Save Energy

(Continued)

Table 37.3 (Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors	Behavior
2012	Nisifrou et al.	Behaviour, attitudes and opinion of large enterprise employees regard to their energy usage habits and adoption of energy saving measures	The present study aims in investigating energy usage habits of a large enterprise employees in Cyprus, in evaluating their perception on consumption on various energy saving measures and finally, in statistically analyzing their behaviour, attitudes and opinion on energy usage and energy saving measures.		Cyprus	303	Descriptive Statistics, Mann–Whitney analysis, Kruskal–Wallis one-way test, Correlation tests	Demographics, behavior, attitude	Energy Saving Measures, Energy Usage
2016	Wells et al.	The role of generativity and attitudes on employees home and workplace water and energy saving behaviours	this paper seeks to examine the links between home and workplace energy and water saving behaviours, within the under-researched tourism context, and to examine the influence of generativity on these relationships		Iran	447	Partial Least Square Regression	Generativity, attitude	Energy and Water Saving Behavior at home and at work
2017	Xu et al.	Investigating willingness to save energy and communication about energy use in the American workplace with the attitude-behavior-context model	This study examines how attitudinal factors (energy saving belief and belief about the link between comfort and productivity) and contextual factors (group norms and organizational support) were associated with employees' willingness to save energy in the workplace at some cost of comfort and the perceived ease of communicating to co-workers about saving energy.	Attitude-behavior-context model	USA	245	Logistic Regression	Attitude, group norms, organizational support	Save Energy

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Inflencing Factors	Behavior
2018	Zhang et al.	Promoting firms' energy-saving behavior: The role of institutional pressures, top management support and financial slack	The study builds a model integrating external pressures, top management support and financial slack.	Institutional Theory	Beijing	135	Partial Least Square Regression	Financial slack, Top management support	Firm's Energy Saving Behavior
2018	Endrejat and Kauffeld	Can't get no satisfaction? Motivating organisational energy efficiency efforts in Germany	The paper argues that satisfaction with a PI(participatory interventions) triggers a positive affect towards energy-savings, and thereby, helps participants to internalize energy-saving motivation	Self-Determination Theory	Germany	219	t-test, stepwise regression	Participation Intervention(PI), satisfaction with PI	Energy Saving Motivation
2013	Greaves et al.	Using the theory of planned behavior to explore environmental behavioral intentions in the workplace	The objective of the present study is to explore environmental behavioral intentions in a workplace setting.	Theory of Planned Behavior	UK	875	Path analysis	Attitude, social norms, perceived behavioral control	Behavioral intention to save energy

(Continued)

Table 37.3 (Continued)

Year	Author	Name of the Article	Research Question	Theoretical Framework	Survey Area	Sample Size	Method	Influencing Factors	Behavior
2017	Zierler et al.	The energy efficiency behaviour of individuals in large organisations: A case study of a major UK infrastructure operator	This paper addresses individuals' energy-use behaviours in organisations in three main stages, based on a survey among mid-level managers at a major infrastructure operator in Great Britain. First, a principal components analysis is performed to identify key determinant constructs driving energy-efficient behaviours in organisations; then cluster analysis is undertaken, in an effort to identify differences in behavioural influences between demographic groups and finally, a structural equation model of individuals' energy use intentions and behaviours using the newly-identified constructs is developed	Theory of Planned Behavior, The Theory of Interpersonal Behavior	UK	628	Cluster analysis, Structural Equation Model	Technology adoption norms, personal evaluations of the economic and environmental benefits to the organisation of energy efficiency, stated intention to save energy, perceived flexibility of performance goals, awareness of energy-saving information, and perceived efficacy of small-scale energy conservation actions	Energy Consumption Behavior
2011	Carrico and Riemel	Motivating energy conservation in the workplace: An evaluation of the use of group-level feedback and peer education	The primary aim of this study is to evaluate the effectiveness of the interventions which are group-level feedback and peer education in a real-world organizational setting		Canada	609	Factorial design, HLM	peer education, group-level feedback	Energy Conservation Behavior

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