BEHAVIORAL ASPECTS IN RESIDENTIAL ENERGY USE

Viera Pechancová

Abstract

Residential energy use is a field, which calls for a dynamic theoretical and analytical approach. Bearing in mind the instant technological innovations, the decision models in the energy use need to be designed in holistic way. As the energy consumption is influenced also by non-technical and non-economic factors, sustainable energy use is expected to include behavioral aspects as well.

The aim of this article is to provide insight into theoretical concepts in behavioral research especially in residential energy use. Behavioral aspects relevant for the energy use are detected and the main emphasis is given to the prospect theory. Energy efficiency is explained and analysed in broader perspective. This paper shows that following the complexity of relationships in energy field the behavioral economics has a good potential to be more influential in the future of the energy.

Keywords: residential energy use, energy efficiency, prospect theory

1 INTRODUCTION

After 1970s energy crises scientific considerations about energy consumption began to gain more importance. Intensive discussions about security of supply, natural resources and efficiency related issues appeared subsequently. The energy use and energy efficiency were firstly concentrated on technical improvements of equipment. With rising importance of environmental issues and sustainability aspects, energy use demanded more complex view.

To be able to provide holistic approach to the energy use research, the „classic" economic model of general-equilibrium needs to be behavioralised. Within the neoclassical synthesis, it is based upon profit maximization by firms and utility maximization by consumers. Behavioral economics tries to clarify some phenomena, which cannot be explained by classic utility theory in microeconomics.

The combination of behavioral research and energy use originates in the thought that even the technical world of energy is influenced by non-technical and non-economic factors overreaching up to the fields of psychology. Generally speaking, the price is not the only motivation in case of reduced energy consumption.

In particular, weather, buildings and technical parameters of devices are researched by meteorology, physics, and engineering. Consumer behavior related to purchase of energy devices and how the devices are used is studied by theories in economics, sociology, psychology and anthropology.

Moezzi et al (2010) identified four basic residential energy use dimensions, which represent broad theoretical and practical applications. *Engineering* focuses on characteristics of buildings and technology. *Economics* studies price signals and considers the consumers from the perspective of maximizing utility. *Psychology* then concentrates on individual consumption choices and hence conservation behavior. Finally, *social studies and anthropology* as opposed to individual considerations, reflect variability and patterns of consumption within cultures and social systems.

Following the broad perspectives in energy use research, the article analyses the behavioral considerations of energy consumption. Beginning with introduction to behavioral finance, principles of prospect theory are explained. Energy efficiency is then further elaborated and relevant research areas identified. Behavioral biases in energy use and implications for energy policy interventions are summarized in conclusion.

2 BEHAVIORAL FINANCE

Observed behavior and application of psychologogy into finance is reflected in the behavioral finance: “Behavioral finance is the study of how psychology impacts financial decisions in households, markets and organizations.” (De Bondt et al 2008). At the microeconomic level, individual decision biases on the contrary to the rational investor choice need to be included. In macroeconomics, the deviations from efficient market hypothesis assigned to the assymetric information in markets are to be reflected.

The basic theoretical concept in behavioral finance is the *Prospect Theory* (PT) (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992). Originally, it was developed as a critique of expected utility theory. One of the main principles within the theory is bounded rationality as consumer decisions are not always perfectly rational and behavioral failures occur. The energy consumption decisions are thereby not an exception.

The PT is based on *value function* (lower positive effect from a gain in an investment than the harm felt from a similar loss), *weighting function* (tendency for individuals to overweight low probability outcomes and underweight high probability outcomes) and the concept of *reference point* (usually status quo situation). Further, the PT postulates heuristics and loss aversion.

The framework for PT includes also specific behavioral effects and biases. The effects include *representativeness* and *availability* (judging probability of an event by stereotypes and neglecting Bayes rule of probabilities) and *anchoring* (estimates compared to the initial value). Further biases include *framing* and *mental accounting*: categorizing financial decisions and evaluating thus separate accounts instead of overall portfolio performance (Perren et al 2015).

Agency theory (Ross 1973, Mitnick 1973, Fama 1998 and others) might be applicable to solving energy using problems as well. The agency theory is relevant for the situations where one party (the principal) delegates authority – in terms of control and decision-making– to another party (the agent). The principle of ownership and control separation in the field of energy research is highly relevant. Number of case studies were perfomed to detect agency problems, such as information assymetry and moral hazard in energy efficiency (International Energy Agency, 2007).

3 ENERGY EFFICIENCY AND ENERGY CONSUMPTION

In the field of energy consumption the energy efficiency is being intesively studied. Thorough search in the academic databases revealed there is an increasing amount of literature related to the topic, including empirical research and field studies.

Quantification of the *energy efficiency* field is rooted in physics and in wider perspective in classical economics. Energy efficiency is generally defined as using less energy input to produce certain amount of output. The energy efficiency formula is broadly defined by following straight forward ratio (Patterson, 1996):

$$\frac{\text{Useful output}}{\text{Energy input}}$$

Reducing energy consumption is often related to increased efficiency. However, more efficient does not mean lower energy use and similarly, emissions reduction is different to increased efficiency. Energy conservation in form of reduced energy consumption is influenced by regulation, consumer behaviour and lifestyle. Examples include turning off lights, reducing device usage or unplugging appliances. Energy efficiency on the other hand, is more of a technical process when old equipment is replaced by newer one (Herring, 2006). It includes purchasing energy-efficient equipment or products (e.g., compact fluorescent light bulbs) or investing in structural or building envelope changes (Karlin et al., 2014). It is worth to mention that increased levels of both energy efficiency and energy consumption have been evidenced in the research (Herring, 2006).

Energy efficiency gap represents a key concept for behavioral contribution to the economic and technical analyses. According to Jaffe & Stavins (1994a) „an energy efficiency gap exists between current or expected future energy use, on the one hand, and optimal current or future energy use, on the other hand“. The explanation for under-investment in energy efficiency might be found in the lack of information, financial lack, incentives ineffectiveness or market barriers.

In relation to the efficiency, the *rebound effect* was identified. The behavioral response in case of higher achieved efficiency is connected to higher energy consumption and thus to certain decrease in the real efficiency. It is though relatively complicated to measure such counter-effect and due to lack of data only occasional studies were perfomed. Greening et al (2000) conclude that although the rebound effect is not insignificant, the efficiency measures should overweight this effect.

Behavioral theory can further contribute to the explaination of *the energy paradox*. This paradox states only gradual diffusion of convenient and cost effective energy saving technologies. The reasoning is explained by market failures and principal/agent causality. Non-market failures such as information cost and heterogenity of users were identified as well (Jaffe & Stavins, 1994b).

4 REVIEW OF BEHAVIORAL RESEARCH IN ENERGY USE

Within the behavioral model of energy use, van Raaij (Van Raaij & Verhallen, 1983) identified several categories of variables influencing energy use. The energy-related household behavior, energy-related attitudes, home characteristics, sociodemographic and personality variables, energy prices and feedback information about energy use were closely analysed.

A psychological model of energy use introduced by Stern (1992) contributed to the reasoning why some policy measures for energy conservation are not successful in implementation. Energy conservation programs examined by psychological research revealed the importance of framing of information in energy policy. Further, behaviorally interconnected topics included commitment to cut energy consumption, intentions to install energy saving appliances or belief that households can help with national energy problem.

Lutzenhiser (1993) in his review article "Social and Behavioral Aspects of Energy Use scrutinized the dominating physical-technical-economic model (PTEM) of energy consumption. Micro-behavioral studies and macro-social organization of energy use in energy demand forecasting and policy planning were considered as important.

Bin et al (2005) proposed a concept of lifestyle in relation to personal energy consumption. The framework includes a consumer-oriented integrated assessment for analysis of energy use and CO^2 emissions (the Consumer Lifestyle Approach). External environment, individual determinants, household characteristics, consumer choices and consequencies were considered there.

Interdisciplinary intervention policies were reviewed by Wilson et al (2007). The decision theories in residential energy use are based on neoclassical and behavioral economics, technology adoption theory and attitude-based decision making, social and environmental psychology and sociology.

Dietz et al. (2009) proposed a specific categorization of energy conservation behavior. The major categories are desribed as WEMAD (Weatherization, Equipment, Maintenance, Adjustments, and Daily behavior). Weatherization and equipment both involve adoption of equipment, adjustments and daily behavior both involve changes in equipment usage. According to the research, national implementation of behaviorally targeted policies could save 20% of household direct emissions within 10 years with little or no reduction in household well-being.

5 BEHAVIORAL BIASES APPLICABLE TO RESIDENTIAL ENERGY USE

Residential energy use is affected by overall consumer behavior as well as by specific aspects related to the character of energy commodity. The energy demand can be described as indirect, depending on lifestlyle and reflecting longterm household values, beliefs or environmental concerns. Domestic energy use is largely invisible to the consumers, behavior is thus governed by unconscious, habitual actions. Also, energy use is rarely individual, rather collective.

As argued by Allcott (2010), the price and information relevant for traditional economic models can be updated by inclusion of behavioral aspect serving thus as more complex model than strictly rational choice. Energy use decisions are matter of bias, influencing thus the energy efficiency. The challenge is to detect individual biases and introduce effective interventions reflecting those findings. Individual decision biases in energy use are grouped and further scrutinized in detail: framing, bounded rationality, pro-environmental behavior, time inconsistency and incentives (Houde et al, 2011).

The basic theoretical finding of *framing* of decisions reveals that preferencies are not independent. On the contrary, it is important to know how the information, situation or product is presented. Related *loss aversion* preference documents that people dislike losses much more than they like gains. As people concentrate more on loss than potential gain, it is more effective to stress the loss in energy (and money) when not replacing some old energy device, than to appeal for money saving (see Fig. 1). As people tend to make comparison relative to a reference point (status quo or average energy consumption), optimal benchmark in residential energy consumption should be defined.

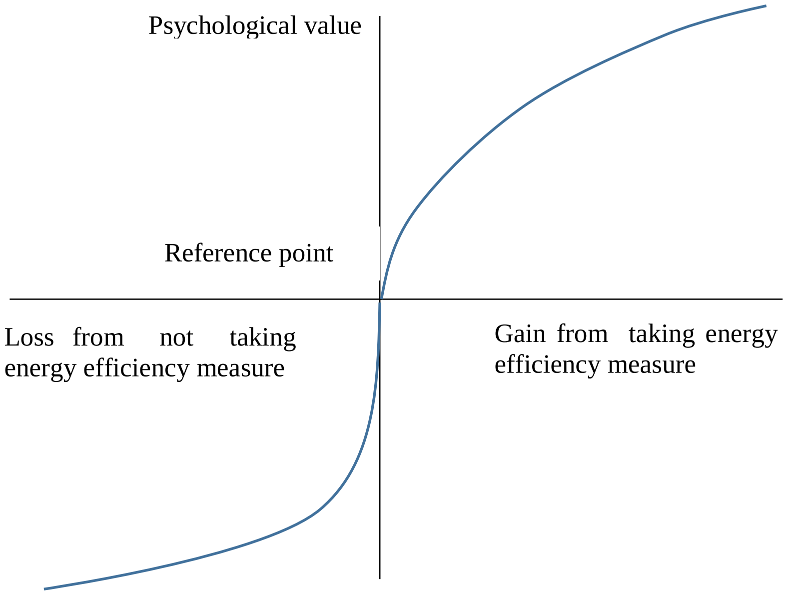

Fig. 1 Value function of losses and gaines in energy saving programmes applied from (Kahneman & Tversky, 1979)

Bounded rationality in energy use decisions can be seen as supplier choice overload. The consumers do not benefit from the massive supply tarrifs variability in the liberalised energy market. Similarly, too many information on possibilities for energy saving can lead to suboptimal decisions. On the other hand, most consumers only hardly estimate the energy use for different purposes. Hence, in case adequate information feedback on consumption is available (using of smart meters), consumers tend to change their energy behaviors. Feedback on consumption is therefore important for energy savings (Darby, 2006).

Pro-social behavior is in case of energy use reflected directy into the pro-environmental behavior. Lifestyle, social norms and society opinion build important basis for environmental action. The information about comparison to neighbours has positive effect on the own action of energy conservation (Nolan et al 2008).

Time inconsistency and intertemporal choice reflect tradeoff decisions among costs and benefits within different time horizons (Shane et al 2002). Buying an energy saving device and discounting future savings are often not optimally analysed. Procrastination plays then a special role in decision making process - individuals do not make decisions in a time-consistent manner using a constant discount (thermostat regulation in buildings or capital investments in energy saving technologies).

6 POLICY IMPLICATIONS FOR COMMUNITY ENERGY INICIATIVES

Communities and social networks might have a higher positive impact on behavior change than individually aimed policies. The above mentioned individual biases can be therefore transformed into effective regional iniciatives. Public institutions such as regional energy agencies can develop effective measures and tools to enhance sustainable energy policy. The basic „trilemma of energy security, sustainable development and cost effectiveness“ can be transformed to economy, ecology and effectiveness (Wang & Poh, 2014). Within each of these elements, fields of behavioral applications can be detected.

The British Psychological Society set a behavioral research group and identified segmentation groups of potential energy saving program: „Monitor Enthusiasts",“ the Aspiring Energy Savers“ and „the Energy Non-Engaged“. Individual behavior change has been adressed and reflects climate change urgency. The appeal to energy conservation represents a part of governmental programme.

Another challenge is to support local energy sourcing and energy decentralisation. New promising technologies allow to use flexible sources (fuel cells, micro cogeneration). Trends in local district heating show new possibilies for renewable sourcing as well (i.e. solar energy storage systems). Also waste separation, waste-to-energy and recycling need to be supported not only by financial motives.

There are successful best practice examples of innovative energy sourcing in municipalities (Kněžice village in the Czech Republic), operating with biogas stations, using biodegradable waste from village and closed energy cycle producing publicly available electricity and heat for the local consumption. Generally, energy independency by off-grid energy sourcing for public institutions is desirable.

In the study by Masini & Menichetti (2012) the behavioral considerations were examined in regard to the decisions made by investors of renewable energy sources as a tool for low carbon economy. Investors aversion to technological and financial risk associated with investments in the renewable technologies were related to social acceptance of renewable innovations.

Detailed research of behavioral insights into regional energy initiatives might contribute to targeted energy policies. It is desirable to find common interaction points and possible scope of relevancy to the field of energy consumption planning at three levels: household, company and municipality. Behavioral motivation might be more effective for certain consumer groups. Potential research topics include then behavioral ways to cut energy consumption and CO^2 emissions. The role of energy taxes and regulation is to be considered in detail.

7 CONCLUSION

From the increasing amount of literature within the behavioral economics it is obvious that environmental aspects of energy use need more behavioral backround. The basic question is then, to which extent we want to understand and follow the non-financial and non-technical aspects in the future.

Individual decision biases might be helpful in search for behavior change regarding energy conservation and CO2 mitigation. Adequate framing of energy information contributes to energy efficiency increase and to better energy policy implementation in residential, commercial and regional energy consumption. Promotion of pro-environmental behavior needs to be supported by complexly determined combination of social and psychological factors.

The exlanatory power of the psychological and sociological concepts shows promising research area in sustainable energy use and adoption of new energy technologies. To conclude, targeted policy programs on state level as well as regional interventions and incentives need to be examined in terms of implementation effectivity.

References

Allcott, H., & Mullainathan, S. (2010). Behavior and Energy Policy. *Science*, 1204–1205. https://doi.org/10.1126/science.1180775

Bin, S., & Dowlatabadi, H. (2005). Consumer lifestyle approach to US energy use and the related CO2 emissions. *Energy Policy*, *33*(2), 197–208. https://doi.org/10.1016/S0301-4215(03)00210-6

Darby, S. (2006). The effectiveness of feedback on energy consumption. *A Review for DEFRA of the Literature on Metering, Billing and Direct Displays*, *486*, 2006.

De Bondt, W., Muradoglu, G., Shefrin, H., & Staikouras, S. K. (2008). Behavioral Finance: Quo Vadis? *Journal of Applied Finance*, *18*(2), 7–21.

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. *Proceedings of the National Academy of Sciences*, *106*(44), 18452–18456. https://doi.org/10.1073/pnas.0908738106

Fama, E. F. (1998). Market efficiency, long-term returns, and behavioral finance1. *Journal of Financial Economics*, *49*(3), 283–306. https://doi.org/10.1016/S0304-405X(98)00026-9

Greening, L., A., Greene, D. L., & Difiglio, C. (2000). Energy efficiency and consumption — the rebound effect — a survey. *Energy Policy*, *28*(6–7), 389–401. https://doi.org/10.1016/S0301-4215(00)00021-5

Herring, H. (2006). Energy efficiency—a critical view. *The Second Biennial International Workshop 'Advances in Energy Studies'*, *31*(1), 10–20. https://doi.org/10.1016/j.energy.2004.04.055

Houde, Sebastien, & Todd, Annika. (2011). List of Behavioral Economics Principles that can Inform Energy Policy. Retrieved from http://www.annikatodd.com/Annika_Todd_Behav

International Energy Agency. (2007). Mind the Gap.

Jaffe, A. B., & Stavins, R. N. (1994a). Markets for energy efficiencyThe energy-efficiency gap What does it mean? *Energy Policy*, *22*(10), 804–810. https://doi.org/10.1016/0301-4215(94)90138-4

Jaffe, A. B., & Stavins, R. N. (1994b). The energy paradox and the diffusion of conservation technology. *Resource and Energy Economics*, *16*(2), 91–122. https://doi.org/10.1016/0928-7655(94)90001-9

Kahneman, D., & Tversky, A. (1979). PROSPECT THEORY: AN ANALYSIS OF DECISION UNDER RISK. *Econometrica (pre-1986)*, *47*(2), 263.

Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2014). Dimensions of conservation exploring differences among energy behaviors. *Environment and Behavior*, *46*(4), 423–452.

Lutzenhiser, L. (1993). Social and behavioral aspects of energy use. *Annual Review of Energy and the Environment*, *18*(1), 247–289.

Masini, A., & Menichetti, E. (2012). The impact of behavioural factors in the renewable energy investment decision making process: Conceptual framework and empirical findings. *Strategic Choices for Renewable Energy Investment*, *40*, 28–38. https://doi.org/10.1016/j.enpol.2010.06.062

Mitnick, B. (1973). Fiduciary rationality and public policy: the theory of agency and some consequences.

Moezzi, M., & Lutzenhiser, L. (2010). What's Missing in Theories of the Residential Energy User. Presented at the ACEEE Summer Study on Energy Efficiency in Buildings.

Patterson, M. G. (1996). What is energy efficiency?: Concepts, indicators and methodological issues. *Energy Policy*, *24*(5), 377–390. https://doi.org/10.1016/0301-4215(96)00017-1
Perren, M., Faseruk, A., & Cooper, T. (2015). Making Sense of Behavioral Finance. *The Journal of Business Diversity*, *15*(1), 14–22.
Ross, S. A. (1973). The Economic Theory of Agency: The Principal's Problem. *The American Economic Review*, *63*(2), 134–139.
Shane, F., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature*, *40*(2), 351–401.
Stern, Paul. (1992). What psychology knows about energy conservation. *American Psychologist*. https://doi.org/47:1224–32
Tversky, A., & Kahneman, D. (1992). Advances in Prospect Theory: Cumulative Representation of Uncertainty. *Journal of Risk and Uncertainty*, *5*(4), 297–323.
Van Raaij, W. F., & Verhallen, T. M. M. (1983). A behavioral model of residential energy use. *Journal of Economic Psychology*, *3*(1), 39–63. https://doi.org/10.1016/0167-4870(83)90057-0
Wang, Q., & Poh, K. L. (2014). A survey of integrated decision analysis in energy and environmental modeling. *Energy*, *77*, 691–702. https://doi.org/10.1016/j.energy.2014.09.060

Contact information

Viera Pechancová
Tomas Bata University in Zlín
Faculty of Management and Economics
Mostní 5139, 760 01 Zlín
Email: pechancova@fame.utb.cz

DOI: https://www.doi.org/10.7441/dokbat.2016.30