Peters, Anja; Sonnberger, Marco; Dütschke, Elisabeth; Deuschle, Jürgen

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Theoretical perspective on rebound effects from a social science point of view: Working paper to prepare empirical psychological and sociological studies in the REBOUND project

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Anja Peters
Marco Sonnberger
Elisabeth Dütschke
Jürgen Deuschle

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Fraunhofer ISI

Abstract

The replacement of appliances and other energy using products by more efficient ones is generally regarded as an effective strategy to reduce energy demand. However, the savings realized by this strategy may be lower than those theoretically expected or calculated from a technological point of view due to changes of behaviour following the acquisition. This phenomenon is known as the rebound effect. While scientists generally agree on the existence of rebound effects, size, relevance and explanations of such effects are controversially discussed. This paper discusses concepts to explain rebound effects from a psychological as well as sociological point of view. In particular, an approach which combines variables from psychological action theories with the sociological lifestyle concept is suggested as a framework for studying determinants of rebound effects.

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Table of Contents

1 Introduction

Increasing the energy efficiency of appliances and other energy-using products is generally regarded as an effective strategy to achieve energy and climate policy goals by reducing energy demand. Thus, the energetic modernisation of buildings or the promotion of energy-efficient vehicles are considered to have great potentials for reducing energy consumption. However, in reality, the potentials realized by investments in energy efficiency are often lower than those theoretically expected or calculated from a technological point of view, a fact that is generally explained by changes in behaviour following the investment. This effect is known as the rebound effect (cf. Berkhout et al., 2000; Greening et al, 2000). The idea of energy rebound was first proposed by Jevons (1865). According to his theory, the improved efficiency of a coal-fired steam engine does not result in less, but more use of coal, due to lower per unit costs which in turn stimulates diffusion of this technology and new applications (cf. van den Bergh, 2001). Similarly, Brookes (1979) and Khazzoom (1980) pointed out that gains in energy efficiency in other technologies may lead to levels of energy use which are higher than without this improvement. While scientists generally agree on the existence of rebound effects, the exact definition, size, relevance and explanations of such effects are controversially discussed (Sorrell, 2007).

Rebound effects have been mostly studied within economic research and have been mainly defined as effects induced by changes of relative prices: if a product or service becomes more efficient, lower operating costs per unit result and may in turn induce increased use (Berkhout et al., 2000; Greening et al., 2000). For example, the purchase of a more energy-efficient vehicle could lead to an increase of kilometres driven due to lower costs per kilometre (known as the direct rebound effect, cf. Section 2.1).

However, most individuals do not have full information or an exact overview of prices and costs related to technologies and their usage. Moreover, they do not react only to changes in energy price and costs. Some researchers already pointed out that psychological mechanisms may also induce rebound effects (de Haan et al., 2006; Hofstetter et al., 2006; Wörsdorfer, 2010). Thus, rebound effects may occur, but they may not necessarily correspond to the exact amount of financial (or other) savings (Wörsdorfer, 2010).

Rebound effects may also occur for other non-energetic resources such as water or metals, though evidence for such rebound effects is very limited (cf. also Maxwell et al., 2011).

We therefore define rebound effects more broadly, as the behavioural response to efficiency improvements in the direction of a higher demand of resource-consuming products or services. This behavioural response can be induced by a decline in product utilization or production costs, but also by other factors, e.g., for sociological or psychological reasons (adapted from Wörsdorfer (2010)).

However, empirical studies analyzing psychological and sociological factors in relation to the rebound effect are scarce. Thus, our paper will develop a theoretical framework to study rebound effects, based on psychological and sociological concepts which are well established in the field of consumption behaviour in general, in particular with regard to energy consumption behaviour.

Psychological *action theories* enable a deeper analysis of the reasons for specific behavioural patterns by identifying relevant determinants of behaviour and explaining behaviour as a result of individual processing and evaluation of information. However, psychological theories largely blend out aspects of social context in which individual behaviour is embedded (Hunecke, 2002). Sociological *lifestyle concepts* can help to capture aspects related to peer-group influence and to the social meaning of behaviour more precisely. Thus, with regard to the study of rebound effects, we consider the combination of both approaches as fruitful to identify relevant psychological mechanisms and behavioural determinants which may vary between noticeable sub-groups (cf. Hunecke, 2002). Thereby, we focus on energy rebound effects of private consumption in the housing as well as the mobility sector.

This working paper is structured as follows: In Section 2, we shortly elaborate on the definition of the term rebound effect, the state of empirical research and causal explanations for its occurrence. In particular, a socio-psychological perspective on rebound effects is introduced. In order to develop an approach which combines psychological theories of action with sociological lifestyle concepts, in Section 3, we first outline a feasible psychological approach. In particular, we discuss psychological concepts to explain energy-relevant behaviour in general, to identify in a next step factors that may be relevant for explaining rebound effects and, thus, develop a psychological framework to study rebound effects. In Section 4, we outline the concept of lifestyle and suggest a typology

which we consider feasible for studying rebound effects in combination with psychological models. Finally, in Section 5, we summarize our arguments for an approach which combines lifestyle concepts with psychological models for a deeper analysis of rebound effects and derive first assumptions on the relations between rebound effects, lifestyle and psychological factors.

2 The rebound effect

2.1 Definition of rebound effects

While the exact definition of the term *rebound effect* varies in literature, principally, the term rebound effect (or synonymously, take-back effect) describes the fact that an improvement of the energy efficiency of a product or service can induce changes, specifically an increase in demand which at least partially compensates the theoretically expected reduction of energy consumption. Important for the general definition of rebound effects is the causal relationship between the implementation of a more energy-efficient technology and the increase of the demand level (de Haan, 2009; Wörsdorfer, 2010). Three types of rebound effects are usually differentiated, according to the area where the increased demand occurs (e.g. Berkhout et al., 2000; Greening, 2000; Sorrell, 2007).

The term *direct rebound effect* relates to an increase in demand for or usage of a product or service after the product or service has become more energy-efficient. For example, a consumer installs energy-saving lamps at his home, however, afterwards, might use them more intensively.

The term *indirect rebound effect* denotes the phenomenon that, after an energy-efficient investment, the demand for other energy-consuming products or services may increase. For example, after buying a more energy-efficient vehicle, a consumer could increase the frequency of his long-distance air travelling.

A third type of rebound effects, the *economy-wide rebound effect*, refers to increases in energy consumption of a whole economy due to changes in demand, production and distribution patterns. The example cited most often in this context is the development of more efficient steam engines which laid the foundation for the industrialization of Europe and thereby for a massive increase in energy demand (e.g. Sorrell, 2007; van den Bergh, 2011).

The direct and indirect rebound effects are relevant with regard to the individual level. In this paper, we focus mainly on the direct rebound effect. In particular, empirical work on the indirect rebound effect faces various challenges, such as the definition of system boundaries and separation from other effects like a general increase of standard of living or diffusion of new technologies which can induce new habits and needs (cf. also de Haan, 2008). Thus, the evidence for indirect rebound effects is mainly based on theoretical assumptions and very technical methodological approaches (cf. Sorrell, 2007).

2.2 Empirical evidence of rebound effects

According to a comprehensive review by Sorrell (2007), the majority of studies concentrates on the direct rebound effect, in particular for a few energy-consuming services, i.e. automotive transport and household heating (cf. also Herring & Sorrell, 2009). Their empirical findings suggest that, at least in developed countries, direct rebound effects only partially compensate for the energy reduction from energy efficiency improvements in such areas. Rebound effects are estimated to be less than 30% for household heating and cooling and even lower for transport, although some studies – cited in Sorrell (2007) or van den Bergh (2011) - identify much higher effects, notably Frondel et al. (2008) for private car use. With regard to indirect and economy-wide rebound effects, there is even more uncertainty about the magnitude of the rebound effect. While some researchers even assume that such effects regularly fully compensate all savings[1] (Brännlund et al., 2007; Saunders, 1992; Wirl, 1997), others come to the conclusion that rebound effects are negligible in sum (cf. Lovins et al., 1988). In general, specific rebound effects or mechanisms are expected to differ between technologies, sectors and also countries, with smaller effects where the costs of energy consumption are relatively small compared to total costs or income, so that they or their change might have little impact on usage decisions (Sorrell, 2007).

Most empirical studies refer to estimates about the own-price elasticity (i.e. percentage change in energy demand in response to a one percent change in energy price) to assess the direct rebound effect[2]. These estimates tend to be based on time-series data at an aggregate level or on cross-sectional data at individual (household) level (cf. e.g. Wörsdorfer, 2010). A few studies have analyzed panel data (e.g. Frondel & Vance, 2011). However, various studies pointed out that the common approaches to estimate rebound effects also measure other effects which occur in parallel with efficiency improvements (Maxwell et al., 2011; Wörsdorfer, 2010). For example, for the case of insulation measures a significant part of the gap between actual and expected savings may not be caused by behavioural changes, but by other factors, e.g., by

1 For the case of rebound effects larger than 100% the term back-fire effect or Jevons' paradox is also used, which is also described as the Khazzoom-Brookes postulate (Sorrell, 2007).

2 For conceptual and empirical limitations of this approach, see Frondel & Vance (2011).

suboptimal installation and building or product elements and unrealistic calculations of the reduction potential of the measure (Sanders & Phillipson, 2006).

All in all, alternative explanations, i.e., driving forces inducing the rebound effect have hardly been studied. In the following section, we outline and discuss different explanations of the rebound effect.

2.3 Explanations for the occurrence of rebound effects

Neo-classical economics usually assumes that rebound effects are induced by the changes in energy service costs following energy efficiency improvements: for example, if an individual reduces his costs per vehicle kilometre by using a more efficient vehicle than before, this individual is expected to translate these financial savings either into higher mileage (direct rebound effect) or to spend the money elsewhere for other energy-intensive activities, e.g., for travelling more extensively by plane (indirect rebound effect).

However, when considering decision-making behaviour, in particular reactions to prices and costs, according to the concept of bounded rationality (Simon, 1955, 1956), constraints due to limited time, knowledge and available information as well as human information-processing capabilities and motivations have to be taken into account (cf. also Kahneman, Slovic & Tversky, 1982). For example, interviews conducted with automobile buyers reveal that most consumers do not possess the basic knowledge for - according to the neo-classical meaning - rational decision-making, e.g. they do not know their fuel expenditures over time or the exact fuel economy of their vehicles. This indicates that consumers hardly take real cost savings into account when making purchasing decisions such as buying an energy-efficient vehicle (Turrentine & Kurani, 2007).

Moreover, financial aspects are not the only argument inducing individuals to value energy-efficient technologies; environmental aspects and symbolic meanings also play a role (cf. Turrentine & Kurani, 2007). In analogy, with regard to the accounting of financial expenditures and savings, Girod and de Haan (2009) postulate that individuals or households may also apply some kind of mental accounting for the environmental impacts caused by their behaviour. Thus, if a individual switches to a more efficient product, he could thus feel justified in using it more.

Besides these mechanisms of perceiving and calculating financial or environmental costs or consequences, socio-psychological research has also pointed

to various factors such as personal norms, beliefs and attitudes as determinants of human behaviour which could also lead to an increased usage of energy services after an efficiency improvement. However, they have not yet been considered in the rebound discussion so far.

With regard to factors which may limit the occurrence of rebound effects, some authors suggested considering the degree to which needs are satisfied (Hofstetter et al., 2006; Madlener & Alcott, 2009; Wörsdorfer, 2010). While neoclassical economists usually assume that human needs cannot be satisfied (non-satiation principle), the theory of the learning consumer (Witt, 2001) assumes specific levels of satiation for each need. These levels are assumed to be temporary and can change in the course of time, due to learning processes. Learning processes concerning the usefulness of a product for satiating needs can also lead to changes in usage patterns. The amount of need satisfaction which can be achieved by consuming a specific service or product unit can differ between consumers. However, with regard to the need for social recognition, consumers may again be more homogeneous by complying with social norms and standards with regard to product quality and quantity. As the upper limit for social standards with regard to needs, e.g., for the cleanliness of clothes, Wörsdorfer (2010) assumes the level of consumption beyond which additional consumption is not perceivable to others. Consequently, it seems important to understand to what extent the needs related to a technology have already been satiated or if further increases in consumption or usage of the technology might be induced due to unsatisfied needs. The role of needs satiation is also reflected in previous findings which point out that the likelihood of rebound effects may be higher for lower income groups and in less developed countries[3] (Small & Van Dender, 2007; Sorrell, 2007; van den Bergh, 2011).

Van den Bergh (2011) also discusses differences in knowledge or in the accessibility of information as being relevant for the size of rebound effects. However, the question whether certain societal groups are more prone to show rebound effects than others has not been studied in more detail. Sociological research showed that lifestyle approaches can be useful in explaining various behaviours (Hermann, 2004) and could be useful to study rebound effects, as they capture the social aspects of consumption and, thus, the broader context of behavioural

3 By neo-classical economics, these findings would be merely explained by higher price effects due to a higher income share of energy expenditures in low-income groups or countries.

patterns (cf. Wiswede, 2000). A study by Bohunovsky et al. (2011) which applies the lifestyle concept of the "experience milieus" (Schulze, 1995) to the study of general energy consumption styles of households, already provides some hints for the occurrence of rebound effects by indicating that households showing a high level of energy efficiency often compensate these reductions by a higher usage of energy services.

To sum up, rebound effects have been identified as a relevant problem on the path leading towards a more sustainable society, although existing findings on the size of rebound effects are mixed and still limited. However, knowledge about the driving forces for the rebound effect is scarce. Most studies analyzing the rebound effect are based on neo-classical economic models and therefore ignore sociological and psychological aspects. Against this background, this paper provides a theoretical framework for studying rebound effects from a psychological and sociological perspective which will be described in detail in the rest of this paper.

3 Psychological explanations of behaviour and rebound effects

In order to explain rebound effects from a psychological point of view, we firstly summarize the state of knowledge about psychological determinants of energy-relevant behaviour. Therefore, we outline the relationship between environmental awareness and corresponding behaviour, as well as more comprehensive models to explain behaviour by means of various determinants. In a next step, we discuss variables and mechanisms that may be relevant in explaining rebound effects. To this end, we focus on variables which are most likely to be affected, i.e., to change due to an efficiency improvement of a product or service used by an individual.

3.1 Environmental awareness and behaviour

Many studies were conducted over the last decades to investigate the determinants of different types of environmental behaviour, such as energy-relevant behaviour from a psychological point of view. Repeatedly, it was assumed that environmental behaviour is determined by and closely related to environmental awareness (cf. de Haan & Kuckartz, 1996). However, empirical results have indicated only a weak relationship between general environmental awareness or attitudes and environmental behaviour (cf. also Homburg & Matthies, 1998; Kals, 1996).

Different reasons are cited for this gap between attitudes and behaviour (cf. de Haan & Kuckartz, 1996; Homburg & Matthies, 1998; Kals, 1996), amongst others:

- Lack of specificity of environmental behaviour: often various types of environmental behaviour have been summarized into a global score of environmental behaviour, though environmental behaviour is not a homogeneous construct. Thus, an individual may hardly engage in all possible forms of environmental behaviour, but in specific types, e.g. due to the specific behavioural costs or the individual attitude towards the behaviour. For example, he may engage in recycling behaviour, but refrain from using public transport instead of driving car.
- Different specificity of measurements of attitudes and of behaviour: environmental awareness is often measured as a general attitude, whereas the behaviour is often assessed as a specific type of action. Closer relations are reported for specific attitudes towards a concrete behaviour. For example, atti-

tudes towards using specific transport modes are more predictive for mode choice than general environmental awareness.

- Different perspectives on environmentally relevant behaviour: the environmental assessment of behaviour is often not straightforward. A behaviour which is defined as environmentally friendly behaviour by the researcher is not necessarily perceived in the same way by the individual. For example, the purchase of milk or drinks in reusable bottles could be classified by the researcher as environmental friendly behaviour, while a survey respondent could disapprove it due to other ecological reasons such as increased energy use for the transport of glass bottles in comparison to carton packages.
- Neglect of various motives influencing behaviour: human behaviour and behavioural intentions usually do not aim to fulfil single motives, but have to be seen within a field of motives and purposes. For example, the choice of a specific transport mode may be influenced by the desire to travel in an environmentally friendly way; however, additional motives like safe, flexible and quick travel may also play a role.
- Neglect of situational variables which influence behaviour: further determinants such as behavioural control, awareness of environmental consequences of own behaviour, habits or further positive or negative consequences of behaviour have to be considered as determinants of behaviour. For example, if public transport is not available nearby home, the likelihood of choosing it is reduced.

Thus, the concept of environmental awareness proved to be too holistic to have significant explanatory power. Accordingly, psychological research showed that various and more specific variables better explain specific environmental behaviour. In order to integrate further and more specific variables which influence environmental behaviour, one important approach was to apply well established psychological theories of action to specific types of environmental behaviours (cf. Bamberg & Möser, 2007).

3.2 Psychological theories of action

The action theories which were most often applied to explain different environmental behaviours, including energy-relevant behaviour, are the theory of planned behaviour (TPB; Ajzen, 1991) and the norm-activation model (NAM; Schwartz, 1977; Schwartz & Howard, 1982).

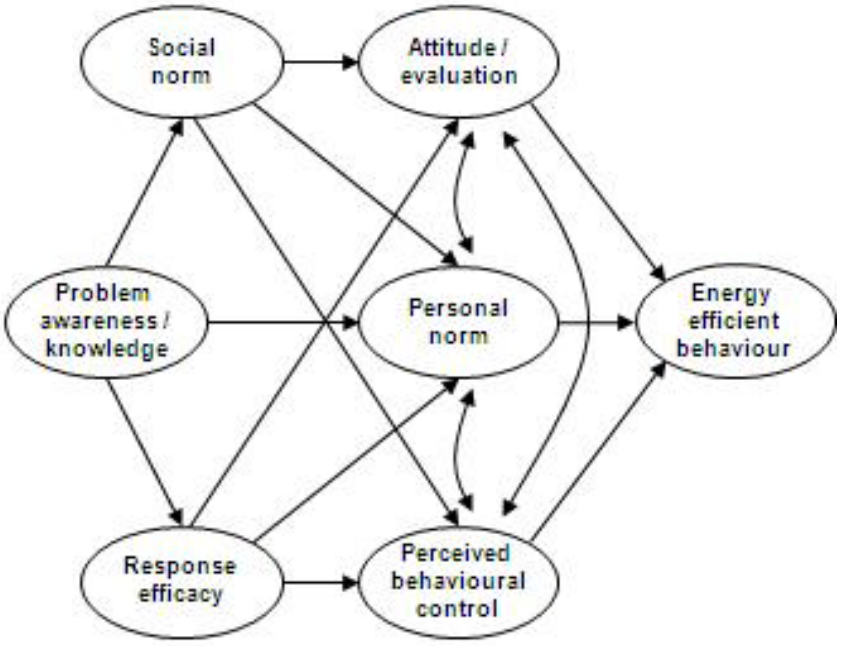
According to the TPB, behaviour is directly influenced by an individual's intention to perform the behaviour. Intention, in turn, is determined by (1) an individual's attitude towards the behaviour, defined as an overall evaluation of its possible consequences, (2) subjective norms, referring to the perceived expectations of other important persons, e.g., family, peers, neighbours (we will speak of social norms in the following), and (3) the perceived behavioural control (PBC), defined as a person's perceived ability to perform the behaviour due to non-motivational factors such as availability of opportunities and resources. The attitude towards the behaviour is conceptualized by Ajzen (1991; cf. also Fishbein & Ajzen, 2010) as an expectancy-value model. According to this model, the expectancy that a specific behaviour results in particular consequences and their evaluation, i.e., the valence of these consequences, are assumed to determine the overall evaluation of the behaviour.

Studies using the NAM explain behaviour as being influenced by (1) a personal norm to engage in the specific behaviour, denoting a strong intrinsic feeling of obligation. Prerequisites of the formation and activation of this personal norm are (2) the awareness of a related problem that needs to be solved, (3) the awareness or identification of the specific behaviour as an effective action that contributes to mitigating the specific problem (we will speak of response efficacy in the following, according to Lam and Chen (2006)) and (4) the recognition of the personal ability to engage in these actions which may correspond very well to the TPB's PBC. Besides personal norms, the consideration of (5) social implications, i.e., a perceived social norm, as well as (6) non-moral implications of action influence the behaviour. These influences are also included within the TPB by the concepts of subjective norm and the attitude concept. A further influential variable contained in the NAM approach is (7) the assumption of responsibility for one's own actions and their consequences.

Values which are a common variable of lifestyle concepts (cf. Section 4.3) are not an explicit determinant within these two psychological theories of action. Values are central, but rather distant determinants of human behaviour: They influence and thus are mediated by variables such as attitudes and norms which represent more direct and more specific determinants of behaviour. Consequently, these specific determinants have more explanatory power to explain specific behaviour and are common components of psychological action theories. Values, in contrast, are useful concepts for holistic lifestyle concepts which are applicable to various fields of behaviour.

Figure 1 summarizes an integrated model adapted from Bamberg and Möser (2007) to explain energy-relevant behaviour such as the adoption of a more energy-efficient product or the use of an energy-consuming product or service such as car driving.[4]

Figure 1 Integrated model to explain energy-relevant behaviour adapted from Bamberg and Möser (2007)



For both theoretical frameworks, the TPB and the NAM, substantial empirical evidence has been collected for a variety of behaviours[5], such as environmental behaviours (for the TPB, e.g., Haustein & Hunecke, 2007; Kaiser & Gutscher, 2003; Kalafatis et al., 1999; Tonglet et al., 2004; for the NAM, e.g., Gärling et al., 2003; Hopper & Nielsen, 1991; Hunecke et al., 2001; Thøgersen, 1999). More recently, various researchers proposed to integrate both concepts into one model (cf. Bamberg & Möser, 2007; Matthies, 2005). The combined model

4 In contrast to the NAM and the model of Bamberg and Möser (2007), our suggested model does not explicitly include internal attribution of responsibility for consequences of one's action or inaction, as it should be closely related to response efficacy, i.e., the awareness that the own behavior has an effect with regard to the problem.

5 Another prominent area where the TPB was proved to be a feasible predictor is the topic of health behaviour (cf. Armitage & Connor, 2001); the NAM was actually developed – and effectively applied – to explain altruistic behaviour (cf. Schwartz, 1977; Schwartz & Howard, 1982).

suggested by Bamberg and Möser (2007) was further developed and applied amongst others to explain the purchase of energy-efficient vehicles (Peters et al., 2011) or mode choice in individual transport (Wall et al., 2007).

3.3 A psychological perspective on rebound effects

To our knowledge, psychological theories of action have so far not been applied to the topic of rebound effects. Thus, based on the following theoretical outline, we identify those variables from the model presented above that might influence whether the investment in an energy-efficient product or service leads to a rebound effect.

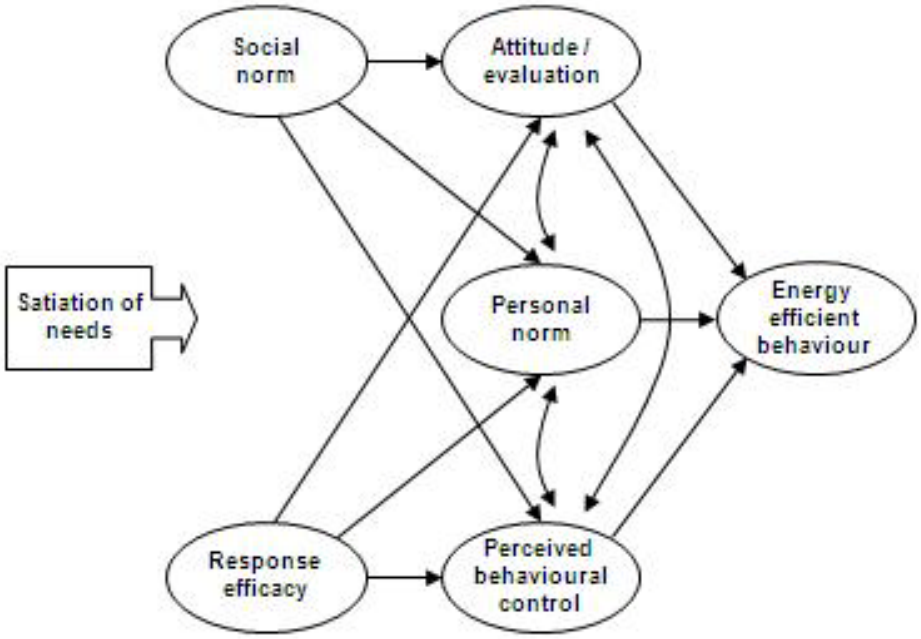
In sum, we assume that five variables of the psychological model presented in Section 3.2 could be influenced, i.e., changed, by the improved energy efficiency of a technology in such a way that they contribute towards inducing direct rebound effects: the response efficacy with regard to a specific behaviour, the attitude towards this behaviour, i.e., its overall evaluation, the perceived behavioural control as well as the personal and perceived social norm towards the respective behaviour (cf. Figure 2).

The variable problem awareness is not expected to directly change due to the increase in energy efficiency of a product or service as its specific value does not depend on the specific characteristic of energy efficiency of the product or service: Thus, it is not likely that the general problem awareness, e.g., the awareness of car use contributing to climate change, will rise after the purchase of a more efficient car. It might rather be strengthened before the final decision to adopt a more energy-efficient technology. A high problem awareness, in turn, might be an important factor that prevents or contains rebound effects. However, while problem awareness is still assumed to be relevant and influential for individual behaviour, we do not assume that it will directly change due to an improvement of energy efficiency and thereby cause direct rebound effects.

Besides the relevant psychological variables, we integrate the concept of satiation of needs to account for the occurrence of rebound effects. We assume that satiation of needs represents a further predictor for rebound effects, i.e., we expect that the rebound effect will be higher in the case of unsatisfied needs than in the case of satisfied needs. Thereby, satiation of needs might also be a relevant determinant that explains a change in the other predictors: in the case of unsatisfied needs an individual might be more inclined to re-evaluate response efficacy and to change his or her attitude as well as personal and social norm

after an efficiency improvement in order to allow and justify, respectively, a change of behaviour to better satisfy his needs. Thus, the actual occurrence of direct rebound effects might depend significantly on whether needs related to the specific technology are already satiated or not.

Figure 2 Hypothesized variables which are assumed to influence whether an investment in an energy-efficient product leads to rebound effects



In the following, we concentrate on the five variables which could directly change due to an investment in an energy-efficient technology and which are, thus, expected to be relevant in causing direct rebound effects if the needs related to the specific technology are not yet satiated. In detail, the following factors and mechanisms could play a role:

- *Response efficacy:* the response efficacy, i.e. the awareness of the specific behaviour as an effective action to mitigate a perceived problem may change after an investment in the energy efficiency of a product or service. For example, a person might evaluate driving or refraining from driving as having less impact on her overall energy consumption after she has changed to a more energy-efficient vehicle.
- *Attitude/ evaluation:* the overall evaluation of a certain behaviour may change after an investment in the energy efficiency of a product or service is made. As outlined above, the attitude towards a specific behaviour is conceptual-

ized as an expectancy-value model. This means that individuals take into account the expectancy that a specific behaviour results in particular consequences as well as the valence of these consequences. After improving the energy efficiency of a product or service, it is likely that the perceived consequences may change, e.g., that use is perceived as less harmful for the environment as well as inducing lower operating costs. While this perception is generally correct, it may lead to the effect e.g. that a more efficient car is used more intensively than the former vehicle, thereby reducing the potential energy savings the purchase of the car could have realized.

- *Perceived behavioural control*: Due to a change of the costs of usage behaviour, the perceived behavioural control, i.e. a person's perceived general ability to perform the behaviour could change. For example, if in case of little financial resources, operational costs of vehicle usage are perceived as a barrier to driving more, this barrier may be weakened (i.e. behavioural control may be increased) after changing to a more efficient vehicle with less operational costs per kilometre.
- *Personal norm:* the strength of personal norms related to the relevant behaviour may decrease, i.e., the inner feeling of obligation not to use the car, e.g., for the trip to the nearby bakery, may be weakened when the use of the more efficient car is perceived as less harmful than before.
- *Social norm:* similarly, the strength of the perceived social norm may be reduced. An individual may have the perception that relevant others, e.g., his peers and family expect him to use environmentally friendly modes of transportation. However, after purchasing a more efficient car, he may perceive fewer expectations to refrain from car use than before.

As indicated above and in Figure 2, these determinants partly influence each other, e.g., the personal norm may be influenced by a change in the social norm and by a change in attitude, i.e., the overall evaluation of the behaviour.

Thus, in order to explain the likelihood of individual rebound effects from a psychological point of view we concentrate on the level of need satiation as a precondition as well as on five variables which relate to the usage of an energy efficient product or service, namely, response efficacy, attitude, perceived behavioural control, social and personal norm. We expect that these variables may be influenced by an improvement of the energy efficiency of a product or service and, in turn, may induce a higher intensity of usage (direct rebound effect).

4 Lifestyle concepts and rebound effects

In the following section, we discuss in more detail the value of lifestyle concepts for the study of rebound effects. Starting by defining the term *lifestyle*, we demonstrate the additional value of a lifestyle perspective on the issue of rebound effects. Then we give a brief overview of the categorization and relevant dimensions of lifestyle concepts and present examples from research on environmentally relevant behaviour. Based on this overview, we identify a fruitful approach which could be applied to analyze the occurrence of rebound effects from a lifestyle perspective in combination with psychological models.

4.1 Definition of the term lifestyle

The diagnosis that common socio-demographic variables like income, education and profession have lost explanatory power for many areas of everyday life provided the starting point for lifestyle research (Brand, 2002). Hence, social scientists partly abandoned the assumption that social differences in modern societies are singularly due to the unequal distribution of resources, but largely depend on the different use of these resources which in turn is influenced by individual values, attitudes, and preferences (cf. Otte, 2005a). Lifestyle concepts integrate both differences in resource level and differences in value orientations and attitudes and thus, connect these levels and dimensions to explain social differences (cf. Müller, 1997).

Scientific literature provides a multitude of definitions for the term *lifestyle*. Until now, none of them is generally acknowledged (Enneking & Franz, 2005; Hartmann, 1999). Looking through the manifold definitions (e.g. Drieseberg, 1995; Georg, 1998; Giddens, 1991; Lüdtke, 1990; Müller, 1997; Reusswig, 2002; Zapf et al., 1987), it can be concluded that *lifestyle* is about distinction and differentiation as well as integration, identity formation, aesthetic stylization and expression of values as well as attitudes. Thus, the term lifestyle is applied to a wide range of sociological categories.

Overall, lifestyle approaches have become a popular tool for analyzing individual consumption patterns in several domains of everyday life (e.g., mobility, nutrition, and clothing). In the following section, we outline why we consider lifestyle concepts a promising approach for studying rebound effects.

4.2 A lifestyle perspective on rebound effects

As outlined above, there is some empirical evidence that rebound effects vary across different income groups, with low income groups showing higher magnitudes of rebound effects (cf. Section 2.3). However, consumption patterns and, thus, their changes are also embedded in a social context that is not only characterized by income level, but also by values and attitudes of an individual and his peer group (cf. Chapter 3). Thus, lifestyle groups with distinctive values and attitudes may also differ from other lifestyle groups with regard to changes of consumption behaviour following efficiency improvements. We therefore assume that rebound effects may vary across lifestyle groups both for structural reasons, such as income or education, and socio-psychological aspects, such as values and attitudes. Lifestyle concepts allow both dimensions to be taken into account. Furthermore, it should be noted that the structural and the socio-psychological dimension are likely to be interlinked, e.g., the educational level of a lifestyle group may influence its problem awareness.

In particular, the degree to which needs related to the consumption of a specific product or service are still unsatisfied and, thus, may render rebound effects more likely (cf. Section 2.3), may vary across lifestyle groups. The degree of satiation of specific needs may depend both on the material resource level and internalized values (e.g., environmental awareness, frugality), which distinguish specific lifestyle groups. Finally, if rebound effects prove to vary across lifestyle groups due to specific behavioural patterns as well as underlying values, motives and satiation levels, it would be feasible to tailor measures to reduce rebound effects to specific lifestyle groups and their relevant characteristics (cf. also Kleinhückelkotten & Wegner, 2008).

4.3 Categorization and structure of lifestyle concepts

Since the field of lifestyle research covers a broad variety of different lifestyle concepts, it is difficult to provide a brief and comprehensive overview. However, different lifestyle concepts can be roughly categorized into holistic and specific lifestyle concepts (Hunecke, 2002). Holistic lifestyle concepts use general attributes (like value orientations or general attitudes) to differentiate between lifestyle groups. It is assumed that these general attributes affect individual behaviour in all fields of everyday life. However, regarding empirical research, similar to the general concept of environmental awareness (cf. Section 3.1) holistic lifestyle concepts are afflicted by a particular problem: they often lack correlation between the abstract, general attributes, i.e., values or life goals, and actual

behaviour (Hunecke, 2002). Specific lifestyle concepts, in turn, use attributes that focus on a specific area of everyday life (e.g., mobility, nutrition, perception of environment). Holistic as well as specific lifestyle concepts usually show a multi-dimensional structure. Most concepts embrace the following three dimensions (Georg, 1998; Hartmann, 1999; Reusswig, 2002; Scholl & Hage, 2004):

Social structure / social situation: this refers to socio-demographic variables, like income, education, age, marital status, religion, sex, number of children etc. These socio-demographic variables are part of classical social class models and are included in most lifestyle concepts as well.

Mentality: this dimension embraces the socio-psychological concepts of values[6] and attitudes[7]. Values guide behaviour and provide criteria for the selection and justification of behaviour (Grunert & Juhl, 1995; Rokeach, 1973; Stern & Dietz, 1994). Therefore the mentality dimension constitutes the motivational element of lifestyles. Values are a broad concept from which individuals derive attitudes and preferences (cf. Section 3.2). Due to this mediation, values are a central but more distant determinant of human behaviour (Gutman, 1982; Olson, 1989; Rokeach, 1973). This dimension is most closely linked to the concepts analyzed by psychological models (cf. Section 3.2).

Performance: this dimension forms the expressive element of lifestyles, which translates the mentality dimension into behavioural patterns (or more specific: consumption patterns). Some scholars, namely economists, argue that psychological categories like values or needs can be stated but not observed. Therefore, empirical research should focus on “revealed preferences” (Samuelson, 1938) that can be derived from actual behaviour (Hartmann, 1999). In that case, the performance dimension would replace the mentality dimension. However, such an approach is not common, as it provides only little information. In particular, the performance dimension, especially as a component of specific lifestyle concepts entails the risk of tautology when it encompasses behavioural aspects that actually should be explained by the lifestyle concept (Otte, 2008). The performance dimension should therefore be handled with care.

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6 "A value is an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence" (Rokeach 1973: 5).

7 The term attitude can be defined as “[…] a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor” (Eagly &Chaiken 1993: 1). This corresponds to Ajzen’s (1991) definition of an attitude towards a behaviour defined as an overall evaluation of its possible consequences (cf. Section 3.2).

4.4 Lifestyle concepts and energy-relevant behaviour

With regard to the explanation of rebound effects, lifestyle concepts which include structural and socio-psychological aspects – such as material resources or value orientations – correlating with energy consumption behaviour may be useful to identify lifestyle groups in which efficiency improvements of products or services would induce increased demand or usage. Based on a comprehensive review of a broad variety of lifestyle concepts, this section gives an exemplary overview of different lifestyle concepts which were applied to energy consumption behaviour, especially in the areas of mobility and housing which are in the focus of this paper.

Regarding specific lifestyle concepts, the Institute for Socio-Ecological Research (ISOE) developed a couple of lifestyle typologies focusing on different fields of everyday life: mobility (Götz et al., 2002), nutrition (Empacher & Hayn, 2005) and consumption in general (Empacher et al., 2002; Schultz et al., 2000). In the field of mobility, socio-demographic variables, mobility-related behavioural variables, and general value orientations were used to distinguish between nine different mobility styles. Götz et al. (2002) showed that the identified mobility styles vary a great deal with regard to their reliance on private car use in leisure traffic. For instance, whereas the “modern-exclusives” manifest the highest level of car use in leisure traffic (46.7%), the “traditional-domestics” display a much lower level (25.8%).

The WELSKO[8] types (Prose & Wortmann, 1991; Wortmann et al., 1996) were developed in a study focusing on the issue of energy consumption. Prose and Wortmann (1991) identified seven household types that diverged regarding variables like sex, education, profession, value orientations, income and behaviour. On that basis, they were able to identify household types that differ regarding energy-saving behaviour, for example, on the one hand, the “alternative environmentally conscious” (mean 32 years, highly educated), who focus on environmentally friendly consumption and therefore on low energy use, and, on the other hand, the “uninterested materialists” (mean 40 years, poorly or moderately educated), who are not interested in their energy use.

Regarding holistic lifestyle concepts, the SINUS milieus are one of the most well-established concepts in German lifestyle research. Borgstedt et al. (2010) applied them in a study on environmental awareness in Germany, showing dif-

[8] The German acronym WELSKO stands for values, lifestyles and consumer behaviour.

ferences in environmental awareness across the milieus. For example, environmental awareness and purchasing green energy is widely spread in the "socio-ecological milieu". However, its eco-balance is corrupted by a preference for long distance travel. In contrast to the "socio-ecological milieu", the "traditional milieu" shows little or no environmental awareness. However, due to financial restrictions and anti-consumerist values (e.g., frugality), this milieu exhibits quite a positive eco-balance.

Another holistic lifestyle concept which was also applied to the issue of domestic energy consumption, amongst others, was developed by Schulze (1995). It comprises five lifestyles ("experience milieus") that are mainly based on aesthetic preferences. Bohunovsky et al. (2011) showed that total energy consumption hardly varies across the different lifestyles defined by this concept. Indeed, ownership as well as modernity and thus energy efficiency of electronic devices varies to such an extent across the different types that nearly the same amount of overall energy is consumed in all the different lifestyle groups independent from differences in energy-relevant behaviour.

The integrative lifestyle typology by Otte (2005b, 2008) also belongs to the holistic approaches. It was already applied to several fields of everyday life, amongst others to the issue of energy consumption[9]. Otte's (2008) typology is based on the two dimensions *resource level* and *modernity / biographical perspective*. Whereas *resource level* refers to educational (respectively cultural) and economic resources, *modernity / biographical perspective* refers to modern or hedonistic value orientations, at the one end of the continuum and traditional or religious value orientations at the other end. Otte (2008) assumes that individual value orientations are closely linked to the biographical development level. This means that older people are more likely to have a traditional or religious value orientation than younger people, who, in turn, are more likely to have a modern or hedonistic value orientation (Otte, 2008).

With regard to analyzing rebound effects in combination with psychological action theories (cf. Section 3), a holistic lifestyle approach would enable comparisons across different behavioural areas, namely mobility and housing, and would cover aspects which are not yet integrated by psychological models. These psychological models, in turn, could effectively integrate specific deter-

9 For further information, please refer to the website of the research project "Analysis of lifestyle aspects influencing the energy demand in the residential sector in France and Germany": http://www.zirn-info.de/projects_e/lebensstil.htm.

minants to explain rebound effects. Thus, a combination would enable different dimensions and factors which seem relevant for rebound effects to be effectively covered.

Otte's (2008) typology is, on the one hand, a holistic concept and can thus be applied to different behavioural areas. On the other hand, it includes dimensions and characteristics which we consider relevant for rebound effects, based on the previous discussion of rebound effects in this paper. For example, satiation of needs may vary along the dimension of resource level across the various lifestyle groups. Furthermore, a stronger orientation to traditional values, such as frugality, could be linked to a lower level of satiation of specific needs or to a voluntary self-restraint in the satiation of existing needs, irrespective of available resources. Thus, Otte's (2008) integrative lifestyle typology may be an approach which could be fruitfully combined with psychological models in order to study rebound effects.

5 Combining psychological action theories and the lifestyle concept to analyze rebound effects

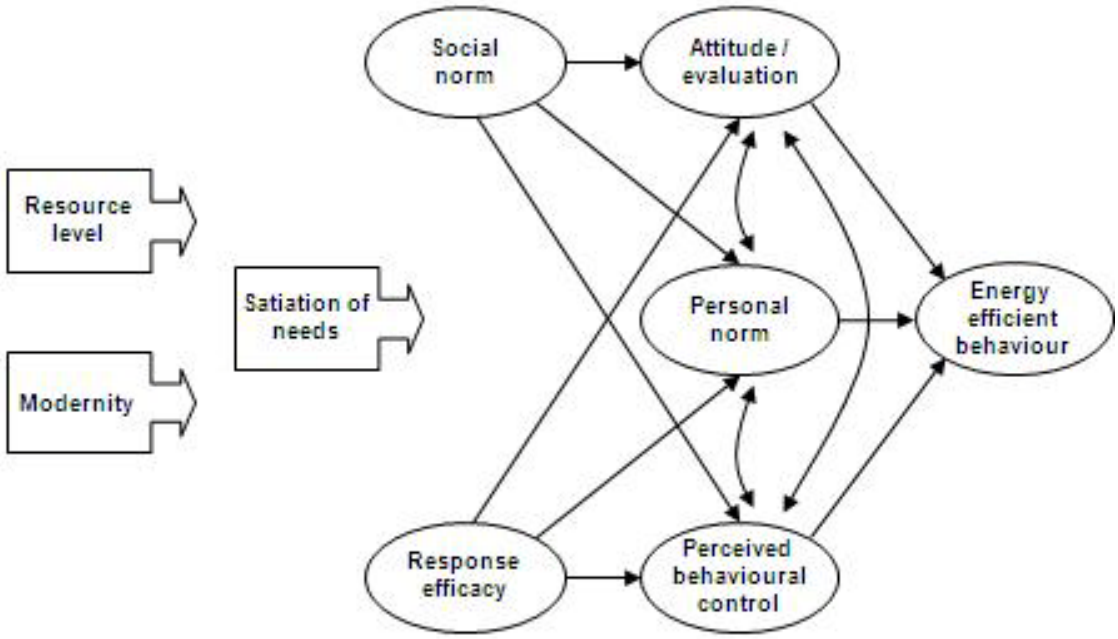
Rebound effects have been identified as a problem counteracting the aim of reducing or containing energy consumption. However, knowledge about the forces driving rebound effects is scarce, in particular with regard to sociological and psychological aspects. Psychological action theories facilitate a detailed analysis of the reasons for specific individual behaviour. However, they only partly account for its social context. Lifestyle concepts are a feasible means to broaden the micro focus of psychological models to the meso level of social groups and milieus (Hunecke, 2002). With regard to rebound effects, lifestyle concepts can help to identify sub-groups which are more likely to show rebound effects, be it due to material resources or sociological and psychological factors.

Thus, this paper suggests a theoretical framework to study the forces driving rebound effects by combining a holistic lifestyle approach such as the lifestyle typology of Otte (2008) with a psychological framework of variables which could be influenced, i.e., changed, by improved energy efficiency of a technology in such a way that they contribute to inducing direct rebound effects (cf. Figure 3). The degree to which needs are already satiated is included as a relevant predictor for rebound effect. Satiation of needs as well as the psychological factors of the suggested model are supposed to differ between the various lifestyle groups, due to different value orientations and resource levels. We proceed from the following assumptions with regard to their interplay and influence on rebound effects.

In general, we expect that rebound effects will mainly occur in behavioural areas in which needs related to the specific technology are not yet satiated. Specific levels of satiation for each need may exist, though they can also change in the course of time due to learning processes. In addition, individuals from different lifestyle groups may differ in the degree of need satiation and, thus, in the occurrence or magnitude of rebound effects due to different resource levels and values. However, the relevance of needs which are not yet satiated may differ, depending on whether individuals are constrained by external restrictions, i.e., by their resources or whether they voluntarily choose to constrain satiation of their needs due to values such as preserving resources for environmental reasons, or due to values such as frugality and modesty. Referring to the lifestyle typology of Otte (2008), we expect more or larger rebound effects for lifestyle groups with a lower resource level, due to a lower degree of need satiation. With regard to value orientation, we assume that a more traditional value orien-

tation is related to a stronger orientation towards intrinsic values of frugality and modesty, while lifestyle groups with a more modern value orientation may be more oriented towards hedonism and satiation of their needs. Therefore, we expect rebound effects to be less likely in groups with a more traditional value orientation, even if their needs are not yet satiated.

Figure 3 Theoretical framework to study socio-psychological drivers of rebound effects



With regard to the psychological framework introduced in this paper, we hypothesize that rebound effects can be explained by changes in personal norms, attitudes, perceived behavioural control, response efficacy and social norms related to a specific behaviour. These changes may again be more likely for individuals or lifestyle groups with needs which are not yet satiated. If individuals or lifestyle groups, on the other hand, hold a strong environmental value orientation, their norms and attitudes towards using energy-consuming technology may be more stable.

An empirical study of both the developed framework and the derived assumptions promises to shed more light on the driving forces of rebound effects. This will be necessary in order to effectively point out in which areas, social groups and under which circumstances significant rebound effects are likely to occur and to draw conclusions about relevant measures to contain rebound effects.

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Authors' affiliations

Anja Peters, Elisabeth Dütschke

Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI)
Competence Center Sustainability and Infrastructure and
Competence Center Energy Policy and Energy Systems

Marco Sonnberger, Jürgen Deuschle

University of Stuttgart
ZIRN – Interdisciplinary Research Unit on Risk Governance and Sustainable Technology Development

Contact: Anja Peters

Fraunhofer Institute for Systems
and Innovation Research (Fraunhofer ISI)
Breslauer Strasse 48
76139 Karlsruhe
Germany
Phone: +49 / 721 / 6809-421
Fax: +49 / 721 / 6809-135
E-mail: anja.peters@isi.fraunhofer.de
URL: www.isi.fraunhofer.de

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