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Beyond Economics – A Behavioural Approach to Energy Efficiency in Domestic Buildings

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Abstract

This paper argues that the moderate success of policies aiming to stimulate the uptake of Sustainable Energy Systems (SES) in the domestic sector is grounded in a poor understanding of the ‘consumer’. The predominant economic approach behind most policies assumes that improving the cost-benefit ratio of technologies via grants and subsidies and providing sufficient information will automatically incentivise householders’ to invest into SES. Yet, policymakers often neglect behavioural determinants such as attitudes, social norms or personal capabilities. Drawing on key findings from the economics, technology and behavioural literature, this paper proposes an integrated model to identify behavioural and contextual influences of SES adoption. It further highlights relationships between them and serves as a starting point to empirically research SES adoption, ultimately providing pragmatic answers to complex policy questions.

Keywords: Domestic Buildings, Sustainable Energy Systems, Behaviour, Energy Policy

1. Introduction

The built environment accounts for approximately 40% of the EU’s energy requirements and offers the largest single potential for energy efficiency. According to the European Commission, one-fifth of current energy consumption and up to 45 Mt of CO₂/Y could be saved by 2010 through introducing ambitious energy standards for new houses and, more importantly, refurbishing the existing building stock.

Recent technological developments have made it possible for individual households to generate their own electricity and heat by the use of small-scale (renewable) energy sources. The adoption of so called *sustainable energy systems* (SES) not only allows households to reduce energy costs and increase the level of comfort but is also likely to trigger a change in consumption patterns

towards lower levels of energy consumption. (Sauter and Watson, 2007) Sustainable energy systems encompass all forms of micro-generation technologies (i.e. *Photovoltaic, Small Scale Wind Turbines, Active Solar Water Heating, Biomass, Small Scale Hydroelectric Plants and Fuel Cells*) and what are known as alternative energy systems such as a range of different types of *Combined Heat and Power Generation* (CHP) and *heat pumps*. Various studies on SES show that investments into these technologies are cost effective¹ and that societal benefits are even greater. (Allen et al., 2008) On a national level for example, sustainable energy systems can play a vital role in reducing CO₂ emissions and also to ease fossil fuel dependency and to stabilize energy costs.

¹ Note: the economic potential of sustainable energy systems is largely theoretical, based on discount rates, life-cycle evaluations and current or expected energy prices.

(Energy_Saving_Trust, 2005) Yet, in most European member states the uptake of SES remains low, providing a serious challenge for conservation programme managers, marketers and policy makers.

A wide range of policy instruments for the buildings sector including information, financial incentives, regulations and standards, voluntary measures and R&D have been implemented at a European and national level to encourage householders to retrofit their homes. (Janssen, 2004) The predominant economic approach behind most policies assumes that the abolition of (market-) barriers like the lack of information or limited access to capital will automatically incentivise householders to invest into sustainable energy systems. (Sorrell et al., 2004)

However, empirical research has shown that the uptake of subsidies for weatherization measures has less to do with the size of the subsidy than with the way the programs were marketed and managed. (Stern et al., 1986) Further, information campaigns for residential energy conservation often fail to change behaviour when householders are simply presented with the benefits of pro-environmental behaviour. What makes information effective is the extent to which campaigns capture the attention of the audience, gain their involvement and overcomes possible scepticism. (Stern, 1999) This, however, requires a thorough understanding of the consumer. A growing body of literature around energy conservation contends that investment into energy efficiency measures is often motivated by ‘conviction’ rather than ‘economics’. Behavioural factors, including attitudes and values, explain a great amount of variation in pro-environmental behaviour and provide valuable insights for policy makers and analysts. (Bang et al., 2000, Faiers et al., 2007, Hansla et al., 2008, Jakob, 2007, Paladino and Baggieri, 2007, Pollard et al., 1999, Steg et al., 2005, Stern, 1986, Stern, 1992) Yet, current policies often fail to address the complex interaction between in-

dividuals and their psychological, social and institutional environments.

Environmentally significant behaviour (i.e. adoption of sustainable energy systems) is influenced by both *contextual factors* and by *personal sphere variables*. The latter can be further broken down into *attitudinal factors*, *personal capabilities* and *habits or routines*.² However, research around these four factors has traditionally been confined by disciplinary boundaries and interdisciplinary problems have been widely neglected. (Wagner, 1997) ‘Single-variable studies may demonstrate that a particular theoretical framework has explanatory power but may not contribute much to the comprehensive understanding of particular environmentally significant behaviours that is needed to change them.’ (Stern, 2000) For example, research that only examines the influence of contextual barriers, such as restricted access to capital, limited information or the technical condition of dwellings may find effects but fail to reveal their dependency on peoples’ attitudes or beliefs. Similarly, studies evaluating only attitudinal variables are likely to find effects only inconsistently, because they are depended on personal capabilities and context.

This paper follows Stern’s (2000) call and proposes an integrated model that incorporates variables from the four categories, drawing on key findings from the economic, technological and behavioural literature. The main challenge is to incorporate personal and contextual variables while retaining the necessary diversity and flexibility required to provide pragmatic answers to complex policy questions.

The proposed framework builds on Icek Ajzen’s (1985) *Theory of Planned Behaviour* (TPB) which provides a good theoretical account to identify personal-sphere determinants of peoples’ decision to adopt sustainable energy systems. According to the the-

² For a discussion, see: STERN, P. C. (2005) Understanding Individuals’ Environmentally Significant Behavior. IN 10785, E. (Ed.).

ory, SES adoption can be explained by peoples' *attitudes*, *social norms* and *perceived behavioural control* (PBC). Whereas the former two variables evaluate the (inner and social) motivational factors, the last variable evaluates householders' (perceived) personal capabilities, such as financial resources or informational constraints. However, TPB is only a partial theory and does not include the impact of external influences on behaviour. Generally speaking, the stronger the contextual limitations are, the weaker the personal-sphere effects and vice versa. For example, situations in which householders are faced with strong institutional or regulatory barriers to adopt SES leave little room for (e.g.) attitudes to affect behaviour. Examining 'boundary conditions' and their influence on personal sphere factors is therefore vital to gain a comprehensive understanding of SES adoption in the domestic sector and can ultimately inform interventions that will more effectively stimulate the uptake of sustainable energy systems.

This paper is structured as follows. Section two will briefly explore SES adoption in the wider context of environmentally significant behaviour. Drawing on findings from the economic and behavioural science it will discuss key contextual and personal factors that are likely to prevent and motivate householders from investing into sustainable energy systems. Based on the discussion the final section proposes an integrated framework to empirically identify context-specific determinants of SES adoption. The paper will conclude with implications for further research

2. Environmentally Significant Behaviour: Adopting Sustainable Energy Systems

Environmentally significant behaviour can take many forms from actively engaging into pro-environmental movements, voting green to recycling. The relevant literature broadly distinguishes between various

types of environmentally significant behaviour which are different both in how they effect the environment and the combination of causal factors that shape them.³ The adoption of sustainable energy systems can be defined as *personal or private sphere behaviour*, which includes the purchase, use and disposal of personal and household products that have an environmental impact. (Stern, 2005) The purchase of sustainable energy systems and their usage has a *direct* environmental impact (as opposed to e.g. voting 'green') as it cuts CO₂ emissions and is likely to trigger behavioural change and reduce energy consumption. However, the effects are only noticeable in the aggregate, i.e. when a great number of people adopt sustainable energy systems.

The social sciences offer many different models of (environmentally significant) behaviour. These models vary widely in their basic assumptions, independent variables, structure and scale.⁴ Generally speaking, by simplifying the complexity of human decision making models can help to identify key influences on (e.g.) the decision to invest into sustainable energy systems and are therefore vital for the design of interventions aimed at promoting behavioural change.

2.1 Adopting Sustainable Energy Systems – An Economic Perspective

Purchasing or investment decisions have traditionally been located in the discipline of economics and follow the process of rational choice. Microeconomic theory assumes that the so called *Homo Economicus*

³ For a discussion, see: STERN, P. C. (2000) Toward a coherent theory of environmentally significant behaviour. *Journal of Social Issues* 56, 523-30

⁴ For an overview of decision making models in relation to residential energy use, see: WILSON, C. & DOWLATABADI, H. (2007) Models of Decision Making and Residential Energy Use. *Annual Review of Environment and Resources*, 32, 169-203.

seeks to maximise utility⁵ within given budget constraints. Individuals rationally weigh up alternatives based on the evaluation of cost and benefits in relation to available information, quality or value. A decision outcome with higher utility will be consistently preferred to an alternative outcome with lower utility. (Faiers et al., 2007) The basic economic model of human decision making also assumes that consumers' preferences are complete, pre-existing, invariant and transitive. In general, individuals' evaluation of outcomes is assumed to be purely self-interested and instrumental. However, it is important to recognise that the rational actor model can incorporate utility from different sources other than money.

2.1.1 The Energy Efficiency Gap

In relation to energy efficiency investments, the decision context has been repeatedly identified in economic-engineering studies as the *energy efficiency gap*. (Sorrell et al., 2004) By that economist describe the under-utilisation of energy-efficiency investments that appear cost-effective on an estimated life-cycle basis. 'Specifically, the empirical pattern is of customers appearing to require returns to these investments that exceed – in some cases very substantially – market interest rates for borrowing or saving.' (Sanstad, 2006) In orthodox economics market outcomes contrary to rational expectations have been explained through the existence of barriers that prevent individuals from making decisions that are both energy- and economically efficient. The classification of barriers varies across the literature but generally includes factors such as risk, high initial costs for technologies, split incentives (the so-called 'landlord-tenant' dilemma), imperfect information, hidden costs and

bounded rationality.^{6,7} Again, the underlying argument implies that consumers act rationally and that (market) barriers prevent them from doing so, adversely impacting on decisions to invest in sustainable energy systems.

Energy efficiency investments often represent a high technical or financial *risk* and uncertainty associated with the returns from investments may be a prohibiting factor. (Schleich and Gruber, 2006) Uncertainty stems from the stochastic future of energy prices. With increasing energy prices, the investment into energy efficiency yields higher returns in the form of energy cost savings. On the other hand, investing in a more energy-efficient technology may turn out to be unprofitable if energy prices fall after the new technology has been implemented. There is also a risk that new, more efficient technologies, might be introduced shortly after an irreversible investment was made, providing another rational for households to postpone investments.

Further, if *information* is not available or are costly to acquire individuals are not likely to make rational decisions. The cost, quality, and accuracy of information can vary widely between different technologies and might even lead to the crowding out of relatively more efficient products. Many households might also be unaware of the level and pattern of their energy consumption and saving potentials might remain unknown, also causing an underutilisation of energy efficient technologies.

Householders also face so called *hidden costs* when searching for potential suppliers, or consultants and the negotiation of contracts with, for example, installers. These

⁵ Utility is a construct in economics that measures an individual's expressed preference for different decision alternatives

⁶ These barriers can further be categorised into market and non-market failures. See for example: JAFFE, A. B. & STAVINS, R. N. (1994) The Energy Efficiency Gap: What does it Mean? *Energy Policy*, 22, 804-810.

⁷ For a discussion, see: SORRELL, S., O'MALLEY, E., SCHLEICH, J. & SCOTT, S. (2004) *The Economics of Energy Efficiency—Barriers to Cost-Effective Investment*, Cheltenham, Edward Elgar.

costs might prevent individuals from gathering sufficient information and, again, energy saving potentials from SES might remain unknown. The actual technologies, once installed, might also provide costs in the form of unexpected maintenance or low reliability. If hidden costs are high an investment into energy saving items might not be profitable in the long term. Banfi et al (2006), for example, showed that the lack of information (e.g. due to hidden costs) was a main reason for underinvestment into energy efficiency such as insulation measures in Swiss households. These findings were confirmed by similar studies in Irish households and the service and commerce sector in Germany (Scott, 1997, Schleich and Gruber, 2006)

One of the most obvious and often addressed barriers is householders' limited *access to capital*. Most sustainable energy systems require high one-off investments and have relatively long payback periods. This particularly affects low-income households who often have only limited access to credit and can only borrow at high interest rates. (Sorrell et al., 2004) In fact, investments may not be profitable anymore due to high interest rates for capital and, as a result, only investments yielding in energy savings that exceed this high rate will be realised. Other households might be in the process of redeeming a mortgage and might not be able to take up another loan. Moreover, savings or loans might be required for investments which are higher on the decision makers' list of priority, like a new car or a family holiday. (Schleich and Gruber, 2006)

In a situation where a dwelling is rented, neither the landlord, nor the tenant may have an incentive to invest in energy efficiency (i.e. *Landlord-tenant dilemma*). Landlords are unlikely to invest in energy saving items if the costs cannot be passed on to the tenants. The tenant, however, is the true beneficiary of an investment as it will result in lower energy bills. Yet, tenants might not be willing to invest or partly share the invest-

ment costs as they tend to underestimate the monthly energy-savings and might move out before benefiting from the energy cost savings.

Other factors include *regulatory or legal barriers*. Many of these institutional factors are related to the structure of the energy markets. Householders' might for example be faced with problems such as negative attitudes of energy providers, restricted access to the main grid, unfair charges for back-up power or overly complicated permitting procedures. (Janssen, 2004) Moreover, householders might face *technical restrictions* related to the physical condition of their dwelling. For example, many technologies, like Photovoltaic, have certain space requirements which simply might not be available.

The energy efficiency gap provides the predominant motivation for most government interventions in the residential sector. The central implications for interventions are 'to improve the instrumental outcome (i.e., net benefits) of the desirable alternative and to ensure sufficient information is available for reasoning-based decisions.' (Wilson and Dowlatabadi, 2007) However, besides numerous information campaigns and the provision of government loans, subsidies or tax exemptions the uptake of sustainable energy systems remains relatively low, indicating that the underlying normative assumptions in utility theory might not hold in reality and that the above discussed external conditions are not the only determinants of decision making. Behavioural economists have therefore tried to integrate more robust psychological understanding of decision making into microeconomics.

2.1.2 A Behavioural Economic Perspective

A different type of barrier often quoted in the economic literature is *bounded rationality*, which implies that human cognition and judgment is subject to biases and errors, and systematically deviates from the

expected utility model. The recognition of psychological factors rather than contextual barriers as key determinants of decision making has led to the development of behavioural economics. Contrary to the orthodox utility model, 'behavioural economists argue that the biases in human decision making need to be taken seriously if a fully explanatory account of economic organization and behaviour is to be provided, and if the predictive capability of economic models is to be improved.' (Sorrell et al., 2004) Behavioural economists have tried to integrate more robust psychological concepts into rational choice theory, some of which are discussed below, but a generalized theory has yet to emerge.

In the context of residential energy use, households' preferences for energy-efficient appliances have been revealed through empirically estimating individual discount rates. (Train, 1985) Discount rates measure a person's willingness to invest into energy-saving measures, hence sacrificing present consumption for future energy cost savings. According to rational choice theory discount rates are expected to be consistent across appliances and different contexts. Yet, the findings indicate that people use different discount rates for different types of goods and in different situations. Revealed discount rates for domestic energy technologies, for example, stretched from 25 to 300 percent, with higher rates for refrigerators than for weatherization measures, indicating that people's choices are influenced by factors other than rational cost benefit evaluations. (Sanstad, 2006)

Empirical and experimental research has also revealed that preferences are not fixed or invariant but that the decision reference can influence the decision outcome. Known as *framing effects*, researchers have shown that the way alternatives, attributes and probabilities are presented can influence people's decisions. Householders' willingness to invest earned income, windfall income or saved in-

come, for example, is unlikely to be the same even though the money in each case is fully interchangeable. Householders might also focus excessively on high initial costs rather than considering future energy cost savings when intending to invest in sustainable energy systems. This phenomenon has been described in economics as *anchoring* and means the tendency to rely too heavily or 'anchor' on one trait or piece of information when making decisions. (Kahneman and Tversky, 1974)

However, even technically accurate information on the costs and benefits of energy saving measures do not necessarily improve the quality of decision making. Instead of maximising utility, individuals often use *heuristics* or rules of thumb to make decisions. For example, people use *recognition' heuristics* (e.g. choose the option that was chosen last time) or *elimination heuristics* (e.g. exclude certain alternative categorically) in order to reduce the complexity of decisions.

In other words, even in the absence of contextual constraints consumers often do not behave according to the standard model of rational choice. But although economists begin to account for individuals' limited cognitive abilities they still fail to question the (non-economic) *personal influences* consumers have to invest into energy efficiency in the first place. Households' willingness-to-pay (WTP) for sustainable energy systems is likely to vary significantly depending on their attitudes. Attitudes in turn are likely to be influenced by, for example, the level of knowledge or people's environmental concern. (Batley et al., 2000) Other explanatory factors might be the experienced social pressure through family, friends or neighbours. Although widely recognised in disciplines such as social psychology or marketing, these factors appear to be neglected by economists and policy makers. The following section takes a closer look at the personal sphere and argues that the *theory of planned behaviour* (TPB) provides a useful model to

identify and evaluate important personal influences of sustainable energy systems uptake in the residential sector.

2.2 Adopting Sustainable Energy Systems – An Attitude-Based Perspective

Energy efficient behaviour and technology adoption has been widely researched in disciplines like marketing and consumer research, as well as social- and environmental psychology.⁸ Research in these areas focuses mainly on the influence of personal factors, like attitudes, values or norms on environmentally significant behaviour. But ‘despite the diversity of the specific applications of its models and despite the heterogeneity of the scientific endeavours, attitude-related theorising has converged into 2 frameworks for the understanding of conservation behaviour: (a) the value-belief-norm theory (e.g. Stern, 1999b); and (b) the theory of planned behaviour (e.g., Ajzen, 1991). While the former focuses on values and moral norms, the latter is grounded in self-interest-based and rational-choice-based deliberation.’ (Kaiser et al., 2005)

According to *value-belief-norm theory*, (VBN) moral and general altruistic considerations are the key explanatory variables of conservation behaviour. VBN builds upon earlier work of Schwartz’s (1977) moral norm-activation theory. It presumes altruistic values and that these, together with other values, underlie an individual’s personal norm (i.e. sense of obligation). The theory further emphasises peoples’ awareness of adverse consequences (AC) and threats to whatever objects are the focus of the values that underlie the norm (e.g. people, species or biosphere). Finally, the theory suggests that a person’s sense of obligation depends on the attribution of responsibility (AR) to self for

the undesirable consequences to others or the environment; in other words, the belief that personal actions have contributed or can alleviate those consequences. For example, people who believe climate change is caused by human action (AR) might feel that they ought to reduce energy consumption to prevent CO₂ from adversely impacting on the environment (AC), because they value the environment.

However, the explanatory power of (altruistic) values might decline in situations where individuals are faced with great external constraints (e.g., financial, informational or regulatory). Research has shown that attitudinal decision models that do not explicitly include external conditions have relatively low explanatory power when behavioural change requires high-effort, high-cost, and high-involvement decisions. (Gatersleben et al., 2002) However, the adoption of sustainable energy systems by households fulfils all these criteria: Most SES are very costly, high-involvement products, and gathering relevant information can be very time consuming for individuals. Also, people might feel they are lacking the necessary capabilities (i.e. time, money, skills) to adopt SES. Hence, householders’ might experience low self-efficacy, restraining psychological antecedents of behaviour.

2.2.1 The Theory of Planned Behaviour

Contrary to VBN, the theory of planned behaviour (indirectly) includes the impact of external conditions on decision making through measuring a persons’ perceived behavioural control (PBC). According to Kaiser et al (2005), ‘the inclusion of perceived behavioural control leads to a more fully explained behaviour, especially behaviour that is difficult to engage in.’ TPB received considerable support in the relevant literature and appears to be a useful framework to describe personal influences on the decision to adopt sustainable energy systems.

⁸ For an overview see for example: WILSON, C. & DOWLATABADI, H. (2007) Models of Decision Making and Residential Energy Use. *Annual Review of Environment and Resources*, 32, 169-203.

The theory of planned behaviour was developed by Icek Ajzen (1991) and has its roots in social psychology and research around attitude formation. A class of theories commonly referred to as expectancy-value models (Fishbein, 1963, Rosenberg, 1956) provide a theoretical link between evaluative criteria and the concept of attitude. ‘These models formalized the widely held view that consumers’ anticipated satisfaction with a product (and hence the purchase of that product) is determined by their beliefs that the product fulfils certain functions and that it satisfies some of their needs.’ (Pollard et al., 1999) Based on these findings the theory of reasoned action (TRA) was developed by Martin Fishbein and Icek Ajzen (1975) as a predecessor to TPB.

The theory of reasoned action suggests that people evaluate the consequences of alternative behaviours before engaging in them, and that they choose to engage in behaviours they associate with desirable outcomes. (Bang et al., 2000) In the model, *behavioural intentions* are determinates of actual behaviour and can be used as a proximal measure of behaviour. The TRA further suggests that behavioural intentions depend on a persons’ *attitude* (A_{ac}) towards performing the behaviour and their *subjective norms* (SN) (i.e. the perceived expectations of relevant others).

Attitudes to behaviour can be understood as rational-choice-based evaluation of the outcomes (e_i) of a behaviour (i.e., a behaviours’ subjective utility), as well as an estimate of the likelihood (b_i) of these outcomes. Thus, the sum of the expected values determines

attitudes; $A_{act} = \sum_{i=1}^n b_i e_i$. For example, some-

one who believes that CO₂ reduction is something desirable that can be achieved through the adoption of SES is likely to form a positive attitude towards SES. Paladino and Baggiere (2007), for example, used a TPB framework to assess the relative impact of

attitudes on peoples’ decision to buy ‘green’ electricity in Australia. Their findings show that environmental knowledge and concern has a positive impact on peoples’ attitudes towards green electricity, explaining variance in the actual purchase behaviour

Subjective norms provide a second motivation and reflect a person’s desire to act as others think he or she should act. Significant others can for example be friends, family, neighbours, political parties or religious organisation. Like attitudes, subjective norms also refer to the strength of salient beliefs, called normative beliefs, and the motivation to comply with these. Like expected values social norms are covered by two measures: the likelihood that a significant other (referent) holds the normative belief (NB_i) and the motivation to comply (MC_i) with the views

of the referent: $SN = \sum_{j=1}^n NB_j MC_j$. For exam-

ple, purchases of SES might be influenced by NGO’s who claim that renewable energies are a cost effective way to save energy.

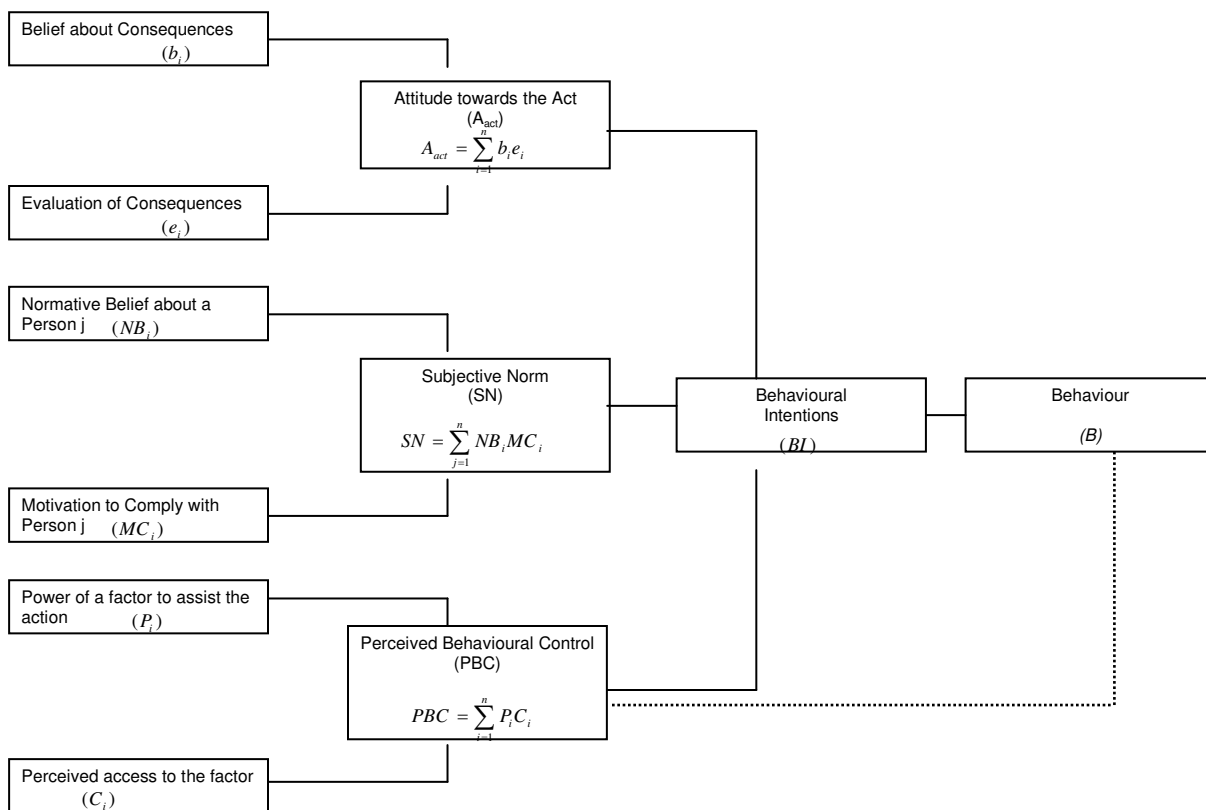
However, as discussed above, behaviour is not always under a person’s full volitional control. In other words, ‘the performance of many behaviours depends not only on motivations but also on non-motivational factors like a person’s ability to actually perform the behaviour.’ (Sanhi, 1994) So whenever control over behaviour is limited by external factors or personal capabilities, intentions (i.e. attitudes and social norms) do not provide a sufficient prediction of behaviour.

To overcome these problems Icek Ajzen (1991) proposed the theory of planned behaviour as an extension of the theory of reasoned action. The new theory includes a third construct called *perceived behavioural control* (PBC) to capture non-motivational factors such as availability of recourses, ability or environmental constraints to predict be-

haviour more accurately.⁹ PBC is defined as ‘the person’s belief as to how difficult or easy performance of the behaviour is likely to be. (Ajzen and Madden, 1986) Beliefs that underlie a person’s PBC are called control beliefs and reflect the power of a factor (P_i) to assist the action and perceived access to the factor (C_i). Thus, $PBC = \sum_{i=1}^n P_i C_i$ is posited to measure PBC.

Unlike attitudes and social norms, PBC has both a direct effect on behaviour and an indirect effect on behaviour through intentions. This is based on the assumption that the implementation of an intention into action is at least partially determined by personal and external constraints. In other words, no matter how favourable a person’s attitude and regardless how great the social pressure, individuals who believe they are lacking the necessary capabilities are unlikely to perform

Figure 1: Theory of Planned Behaviour



Source: From (Ajzen, 1991)

⁹ The idea that behavioural achievement depends jointly on motivation (intention) and ability is by no means new. PBC was referred to in the relevant literature as ‘barriers’ or ‘facilitating factors’. Yet, the interaction of these factors has received little empirical attention. For a discussion, see: AJZEN, I. (2002) Perceived Behavioural Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behaviour *Journal of Applied Social Psychology*, 32, 1-20.

the behaviour. At the same time the perceived lack of recourses or opportunities is likely to negatively impact on the formation of behavioural intentions, indirectly affecting behaviour. Again, this implies that the addition of PBC should become increasingly useful as volitional control over behaviour decreases. Figure 1 provides a graphical overview of the TPB, its’ three predictors and

their underlying belief structure. Generally the theory predicts that the stronger each factor, the stronger a person's intention to perform the behaviour. However, attitudes, social norms and PBC are not always weighted equally in predicting a person's volitional (voluntary) behaviour. Including the weighting factors [w_i], the final model can be expressed as:

$B \sim I = (A_{act})w_1 + (SN)w_2 + (PBC)w_3$. This indicates that depending on the individual and the context, these three factors might have very different effects on behavioural intention. (Miller, 2005) For example, a person might have a generally positive attitude towards SES, but might feel they are lacking the necessary financial resources to perform the behaviour. If this is the case, PBC would be expected to provide the greatest explanatory power. However, in order to get a comprehensive picture, specific contextual factors such as policies, regulations or physical conditions of the dwellings which are likely to constrain and facilitate peoples' decisions need to be evaluated simultaneously.

3. Towards an Integrated Approach

Based on Stern's (2000) classification of causal variables of environmentally significant behaviour and Ajzen's (1991) theory of planned behaviour, this paper proposes an integrated framework to systematically research the adoption of sustainable energy systems, illustrated in Figure 2. This paper argues that the theory of planned behaviour provides a good theoretical grounding to capture the *personal sphere* influences of SES adoption. Its three predictors reflect Stern's causal variables and include attitudes, social norms and peoples' capabilities i.e. perceived behavioural control. Habits are not included, as the adoption of sustainable energy systems appears to be a 'one-off-event', and unlike (e.g.) recycling behaviour, does not interfere with peoples' daily routines. TPB assumes that householders' anticipated satisfaction

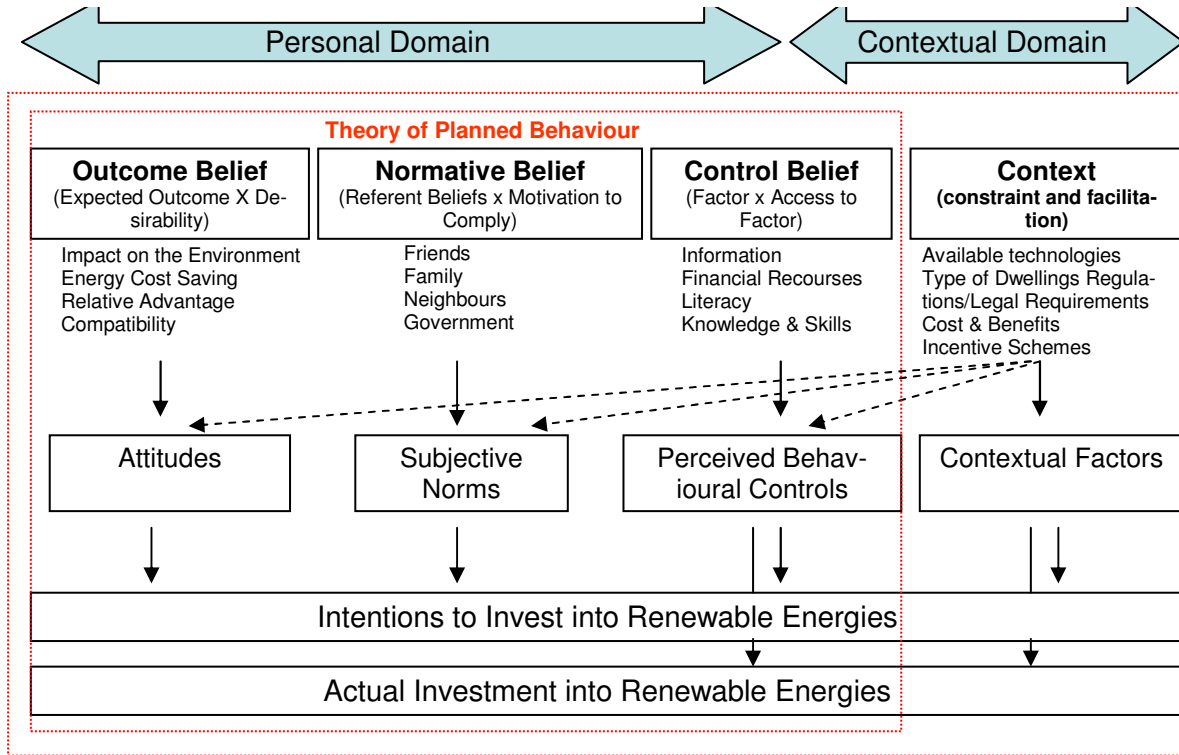
with a technology is determined by their beliefs that the technology fulfils certain functions and that it satisfies some of their needs.¹⁰ This 'utility based approach' appears to be suitable to explain *attitude formation* in relation to green technologies, as householders' are likely to expect certain benefits (i.e. outcome beliefs) from adopting SES. The benefits can include environmental (e.g. saving the environment, reducing CO₂ emission) and non-environmental impacts (e.g. energy-cost savings, level of comforts or increased social status). The identification of peoples' beliefs and attitudes towards SES is vital for policy makers and marketers as it allows the design of more effective policies and information campaigns which successfully capture the attention of the audience gain their involvement and overcomes possible scepticism.

Subjective norms provide another personal motivation for householders to adopt sustainable energy systems. The perceived pressure (i.e. normative beliefs) from significant others like friends, family or neighbours can encourage or prevent people from investing in more energy efficient technologies. Again, policy makers and conservation programme managers can utilise this knowledge and appeal to householders' social consciousness.

However, the discussion above has shown that personal motivation to invest in SES also depends on householders' *perceived behavioural control*. Socio-demographic variables such as age, educational attainment or income can serve as proxies for personal capabilities. However, TPB allows to directly evaluate peoples' perceived behavioural control by measuring the subjective importance and availability of factors like time, money or skills (i.e. control beliefs). This variable is expected to have great explanatory power

¹⁰ This view is also held by the diffusion of innovation theory. For a discussion, see: WILSON, C. & DOW-LATABADI, H. (2007) Models of Decision Making and Residential Energy Use. *Annual Review of Environment and Resources*, 32, 169-203.

Figure 2: Integrated model to evaluate determinants of energy efficient technology uptake



Source: Adopted from Ajzen (1991) and Stern (2000, 2005)

as many householders' are likely to have positive attitudes towards SES, yet feel they are lacking the necessary recourses to act.

External or *contextual forces* provide the forth causal variable and can either constrain or facilitate personal factors. The economic literature around the energy-efficiency gap provides a good starting point to identify relevant contextual variables. External factors can for example include government regulations and legal factors; institutional constraints; availability of information; monetary incentives; availability of public policies to support behaviour; capabilities and constraints provided by technology and the built environment (e.g., building design, availability of technologies) and broad features of the social, economic and political context (e.g., the price of oil, the sensitivity of government to public and interest group pressures, interest rates) Understanding the influence of these factors on peoples' behav-

our is crucial. Information campaigns trying to change peoples' attitudes might be worth less if contextual constraints leave no room for personal factors to affect behaviour.

The model suggests the stronger the contextual influences (i.e. effective regulations or strong financial incentives) the less likely are the personal factors to explain the behaviour in question. However, in situations where policies cannot change the context, personal factors may provide the only levers to encourage behavioural change. It is also worth noting that a contextual factor may have different meanings to people with different attitudes or beliefs (Stern, 2000) For example, for some people a high price of solar panels may be an economic barrier to purchase, whereas for others it is a marker of social status.

4. Conclusion

The design of effective policies aiming to encourage the uptake of sustainable

energy systems needs an improved understanding of behavioural factors that influence householders' decisions to invest into SES. As suggested by the discussion above, determinants of SES adoption and interdependencies between personal and contextual factors are likely to vary across countries and even regions. The proposed conceptual framework, however, can serve as a starting point to identify context specific (personal and external) variables, postulate relationships among them and test their relative significance empirically.

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