Discussion Paper No. 09-013

What's Driving Sustainable Energy Consumption? A Survey of the Empirical Literature

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Das Wichtigste in Kürze

Konsumentscheidungen sind ein wichtiger Hebel auf dem Weg zu einer nachhaltigen Entwicklung. Denn nicht-nachhaltige Konsummuster sind eine wesentliche Ursache für globale Umweltbelastungen, einschließlich der Übernutzung von erneuerbaren Ressourcen und der Nutzung von erschöpfbaren Ressourcen mit den damit verbundenen Umweltwirkungen.

Technologische Innovationen haben zwar die Energie- und Materialintensität der meisten Produkte verringert. Aber durch einen insgesamt steigenden Konsum verpuffen diese Einsparungen. Der Energieverbrauch in Haushalten trägt zu fast 30% zum Endenergieverbrauch in Deutschland bei und ist, nach dem Verkehr, der Bereich mit dem zweihöchsten Wachstum beim Energieverbrauch.

Dieses Papier beschäftigt sich mit nachhaltigem Energiekonsum in Wohngebäuden. Es gibt einen Literaturüberblick zu den Treibern individueller Entscheidungen des Energiekonsums. Neben den allgemeinen Determinanten werden auch die Determinanten des Konsums für drei konkrete Energiedienstleistungen bestimmt: Für grünen Strom, Haushaltsgeräte und Micro-Power.

Aus einem Überblick über die empirische Literatur zur Diffusion energieeffizienter Aktivitäten lassen sich die folgenden allgemeinen Hypothesen herleiten:

(1) Charakteristika des Haushalts: Nachhaltige Energienutzung in Wohngebäuden hängt signifikant vom Einkommen ab. Die Evidenz zum Einfluss von Bildung, Alter, Haushaltsgrösse und Besitzverhältnissen ist dagegen gemischt.

(2) Charakteristika des Gebäudes: Die Beziehung zwischen der Wohnfläche und der Nutzung energieeffizienter Maßnahmen ist in den meisten Studien positiv, obwohl nicht immer signifikant. Ebenso wirkt sich das Alter des Wohngebäudes positiv auf die Diffusion energieffizienter Maßnahmen aus, da alte Gebäude über ein höheres Potential zur Energieinsparung verfügen.

(3) Kostentransparenz: Im allgemeinen wird die Hypothese bestätigt, dass Transparenz bezüglich der Kosten der Energienutzung positiv mit einergiesparendem Verhalten korreliert ist. Dies wurde für verschiedene Maßnahmen wie Energierechnungen oder Energielabel gezeigt.

(4) Preise: Energiepreise spielen eine wichtige Rolle und sind positiv mit nachhaltigem Energieverbrauch korreliert. He höher die Preise sind, umso eher sind die Konsumenten zu energiesparendem Verhalten bereit.

(5) Einstellungen/Verhalten zur Umwelt: Obwohl nachhaltiger Konsum nicht möglich zu sein scheint ohne geänderte Rahmenbedingungen (Preise, Infrastruktur etc.), ist es wichtig, das individuelle Verhalten in einem gegebenen Kontext von Angebotsfaktoren und Regulierung zu untersuchen. Bislang konnten aus der Literatur allerdings keine klaren Beziehungen zwischen Einstellungen und Verhalten abgeleitet werden.

Es lässt sich die Schlußfolgerung ziehen, dass bei künftigen Untersuchungen zu nachhaltigem Energiekonsum insbesondere die Einflußfaktoren und der Zusammenhang zwischen Umweltwissen-, -einstellungen und -verhalten sorgfältig untersucht und berücksichtigt werden sollten.

Da nachhaltiger Energiekonsum zu einem gewissen Teil von der betrachteten Energiedienstleistung abhängt, werden zusätzlich Hypothesen zum nachhaltigen Konsum bei konkreten Energiedienstleistungen betrachtet. Als relevante und typsiche Energiedienstleistungen werden grüner Strom, Haushaltsgeräte und Micro-Power ausgewählt.

Grüner Strom: Eine neuere Studie zeigt, dass die Kunden von grüner Elektrizität weniger preissensitiv sind als eine Vergleichsgruppe. Über die Preisdifferenz zwischen grünem und konventionellem Strom herrschen in beiden Gruppen unrealistische Vorstellungen, die Preisdifferenzen werden deutlich überschätzt.

Haushaltsgeräte: Empirische Studien zeigen, dass Energielabel als ein wünschenswertes Produktattribut angesehen werden, obwohl andere Produkteigenschaften von den Konsumenten in den meisten Studien höher geschätzt werden.

Micro-Power: Im Bereich der Heizsysteme zeigen die Resultate aus der Literatur, dass Umwelt- und Sicherheitsaspekte entscheidend für die Konsumentscheidung sind. Die Kunden präferieren den Besitz einer Mikro-KWK Anlage im Vergleich zu Alternativen wie Leasing oder Contracting.

Non-technical summary

Consumption is a key lever to achieving more sustainable development: unsustainable consumption patterns are major causes of global environmental deterioration, including the overexploitation of renewable resources and the use of non-renewable resources with their associated environmental impacts.

Technological innovations have reduced the energy and material intensity of most products. However, the increasing volumes of consumed goods have outweighed these gains: Household energy consumption contributes to almost 30% to the total final energy consumption and is, after transport, the second most rapidly growing area of energy use.

This paper will focus on the area of residential buildings. It will give an overview of the literature regarding the determinants of individual consumer decisions on energy demand. In a first step we will ask for the determinants of sustainable energy consumption in general. In a second step we ask for determinants regarding the following concrete environmental technologies: Green electricity, domestic appliances and micro-power.

From a review of the empirical literature on the diffusion of energy-efficient activities we derive the following general hypotheses:

(1) Characteristics of the household (occupants): Sustainable energy use in residential buildings is significantly influenced by income. However, the evidence on the role of education, age, household size and ownership is mixed. The general message is “it depends”.

(2) Characteristics of the residence: The relation between housing size and the take-up of energy-efficient measures is expected to be positive. This is confirmed by most studies, although it is not significant in all studies. The age of a residential building is also expected to be positively related to the diffusion of energy-efficient measures since old buildings have a higher potential for improving energy efficiency.

(3) Characteristics of measures (technology): In general, the hypothesis is confirmed in the literature that transparency regarding the costs of energy use is positively correlated with energy-saving behaviour. This has been shown for different measures such as energy bills or energy labels.

(4) Economic factors: Energy prices play an important role and are positively correlated with sustainable energy use. The higher energy prices, the more responsive are households with regard to energy savings.

(5) Attitudes/preferences towards the environment: Although sustainable consumption seems not to be possible without changing framework conditions (prices, infrastructure etc.), it is decisive to analyse the individual behaviour assuming a given context in terms of supply factors and regulation. Up to now, however, no clear hypotheses can be derived from the literature.

The conclusion can be drawn that research is especially necessary in the area of (5), i.e. a careful integration on environmental attitudes and environmental behaviour into empirical studies.

Finally, we derived some hypotheses from the literature regarding three specific technologies of sustainable energy consumption in residential buildings: Domestic appliances, micro-power and green electricity.

Domestic appliances: Results from the literature show that respondents viewed environmental certification as a favourable product attribute, although, for the typical respondent, the importance of other product attributes outweighed that of environmental certification.

Micro-power: In the field of heating systems, results from the literature survey showed that environmental and safety aspects are decisive in customer's product judgments. An interesting result was the preference of respondents for ownership of their combined heat and power plant, rather than using other financing models such as contracting or leasing.

Green electricity: A recent study shows that green electricity buyers are less price-sensitive than a comparable group of non-buyers. When asked about the price difference between conventional and green electricity, none of the surveyed groups could estimate it accurately.

What's driving sustainable energy consumption? A survey of the empirical literature

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Abstract:

The focus of the paper is on the individual decision of energy consumers, and it's relation to sustainable consumption. Consumer behavior is based on individual decisions, but it depends largely on supply-side measures and an appropriate infrastructure (e.g. the availability of energy-efficient household equipment) and on socio-political factors (e.g. if systems of emissions trading or eco-labels exist). We derive some hypotheses on the determinants of sustainable energy consumption in residential buildings from a review of the empirical literature on the diffusion of energy efficient activities. While there is agreement on a lot of factors, the role of environmental attitudes and environmental behavior remains uncertain. Thus research needs are derived respectively. Finally, we specify these hypotheses for three specific technologies of sustainable energy consumption: Domestic appliances, micro-power and green electricity.

Keywords: Sustainable consumption, consumer behaviour, domestic appliances, micro-power, green electricity.

JEL Classification: Q01, Q41

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I Introduction

Consumption is a key lever to achieving more sustainable development: unsustainable consumption patterns are major causes of global environmental deterioration, including the overexploitation of renewable resources and the use of non-renewable resources with their associated environmental impacts. In environmental terms, the European Environmental Agency report on 'Household consumption and the environment' (EEA, 2005) identifies the need areas of food, housing, personal travel/mobility as well as tourism to be the four major areas of household consumption with the highest negative environmental impacts.

With regard to development trends, household consumption expenditure per capita in the EU-15 Member States has increased by approximately one third in the last fifteen years (EEA, 2005). For the period until 2020, consumption growth is expected to continue approximately at the same rate as GDP growth, i.e. 2-3% annually. Technological innovations have reduced the energy and material intensity of most products. However, the increasing volumes of consumed goods have outweighed these gains: Household energy consumption contributes to almost 30% to the total final energy consumption in Germany and is, after transport, the second most rapidly growing area of energy use.

This paper will focus on the area of residential buildings. It will give an overview of the literature regarding individual consumer decisions on energy demand in the context of sustainable consumption. Although we focus on the economic literature, we will, however, explicitly consider contributions from other socio-economic literature. We will particularly ask for the determinants of sustainable energy consumption regarding the following concrete environmental technologies: Green electricity, domestic appliances and micro-power.

We are aware that the individual consumer is embedded in a specific institutional setting that already determines a certain part of his energy consumption. He may be a tenant and his landlord may not be interested in energy saving investments, energy costs may even not be in the focus of his own interest. However, any energy consumption requires an individual decision, may it be aware or unaware. And this is exactly the decision process in the centre of our interests, which we hopefully make more transparent.

The paper is structured as follows: We will start with a definition of sustainable consumption. In the next step, we will review the general socio-economic literature regarding individual decisions on energy demand and on general factors influencing sustainable energy use. On this basis, section 3 will derive hypotheses from the existing literature. Since these hypotheses depend largely on the specific technology analysed, we also review the literature with regard to three concrete energy services in residential buildings (green electricity, domestic appliances, micro-power). Finally we will draw some conclusions with hypotheses regarding the three concrete services.

II Sustainable energy consumption

II.1 Definitions of sustainable consumption

“Over the last decade or so, there has been a wealth of social and natural scientific debate about the environmental consequences of contemporary consumption and there is, by now, something of a consensus. It is clear that lifestyles, especially in the West, will have to change if there is to be any chance of averting the long-term consequences of resource depletion, global warming, the loss of biodiversity, the production of waste or the pollution and destruction of valued 'natural' environments” (Shove. 2003: 1).

Based on the classic description and definition of the Brundtland Report (WCED, 1987: 43), sustainable consumption is now defined as: “[T]he use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations” (OECD, 2002a: 9).

Sustainable consumption is seen as a process involving negotiation and the building of consensus – in some areas this process competes with conventional market operations. This means that if new consumption strategies are to be achieved, all actors must be willing to engage in discourse. Hansen and Schrader, 1997 point out that the normative judgement of sustainable development and the corresponding sustainable consumption “has to be given additional legitimacy by a societal discourse” and *practice (*Hansen and Schrader, 1997: 455).

Sustainable consumption has to be understood as a societal field of action, which could be characterised by three interacting areas of action:

- the individual area of action (divided in two sub-areas): demand-side area, which includes consumption activities in the context of households as well as of professional procurement activities (of both large-scale private-sector companies and the public sector) and the informal area, in which private consumers undertake informal activities (e.g. unpaid household work), which are not market-oriented and are thus not visible on the level of demand;
- the supply-side and structural area of action, which includes the activities of companies and also governmental bodies to provide sustainable products, services and information;
- the socio-political area of action, which includes the activities of governmental bodies but also of organisations and associations to form the general framework for governance in both the individual and supply-side or structural area of action. Furthermore, in this area of action societal factors of consumption behaviour such as visions and moral concepts will be formed.

The three areas are interrelated: Consumer behaviour is based on individual decisions, individual behaviour, however, largely depends on supply-side measures, an appropriate infrastructure (e.g. the availability of energy-efficient household equipment) and socio-political factors (e.g. if systems of emissions trading or eco-labels exist).

There is consensus among experts that the implementation of more sustainable consumption behaviour requires not only awareness among consumers, but also changed social and economic structures: Consumption is a “socially constructed historically changing process” (Bocock, 1993: 45). Several authors (e.g. Fichter, 2005; van Vliet, 2002) underline the need and notion of new product policies and the important role of consumers in this regard: “people are not simply end-consumers entirely isolated from the production process” (van Vliet et al., 2005: 17) but “they participate in the organisation of production-consumption cycles” (van Vliet, 2002: 53).

Eberle et al., 2004 look at sustainable consumption as a more ecological but also socially … way of buying and using goods and services. Individual and societal consumption behaviour is embedded in daily routines and influenced by a variety of contextual factors such as specific lifestyles, social environment (neighbourhood,

favoured peer groups), systems of infrastructure, habits and routines (Shove and Warde, 1998; Empacher et al., 2003; Shove, 2003): with this in mind, sustainable consumption encompasses a range of very diverse fields of action and needs of change.

On the one hand, every decision of purchase is also a vote for or against certain production conditions (with environmental effects as well as social conditions); on the other hand, “the existence of a suitable supply” (Hansen and Schrader, 1997: 463) is crucial for the transition to more sustainable consumption. “The creation of an awareness that an ignorant ’business as usual’ attitude does not only promote inaction but constitutes an active immoral act is hence a necessary prerequisite for a change towards sustainable consumption” (Hansen and Schrader, 1997: 459). Empirical data show that this awareness already exists (in western societies): 75% of German consumers agree with the opinion that users are able to put considerable pressure on producers.

In that regard, consumers follow the concept of a “co-producer” (Hansen and Hennig, 1995). The comprehensive (economic) debate during the first years of the 2000s on the function of consumption as utility production – among other areas in the field of behavioural economics (Belz and Egger, 2001; Belz, 2001; Scherhorn, 1994) – reveals numerous points of contact which have to be considered in a strategy for change. When taking all these aspects into account it becomes clear and was stated by Jackson (1995) that sustainable behaviour is “a function of partly attitudes and intentions, partly of habitual responses, and partly of the situational constraints and conditions under which people operate.”

II.2 Approaches to explain sustainable energy consumption

Three different psychological schools are the main contributors to the field of energy: behavioural psychology, cognitive psychology, and social psychology (especially attitude-behaviour models). While there are many differences among these approaches, they share a focus on individual behaviour. In the case of social psychology, this is modified by the inclusion of ‘social norms’.

Psychologists involved in evaluating energy-related behaviour increasingly stress the role of participation, social context and peer-to-peer networks as well as macro-level factors contributing to energy use, such as technology, economy or institutions and culture (Abrahamse et al., 2005).

There is also an increasing debate about the “social dilemmas” related to energy conservation or/and the use of green electricity: in both cases it is the cumulative impact of the behaviour of all consumers that counts. Meanwhile, psychologists and social psychologists are extending their models beyond the traditional individualistic focus and follow the ideas of a more holistic social-ecological framework (in detail see Kurz, 2002).

As regards the use of energy, sociologists have stated that people do not actively *consume* energy, but use energy services to raise their family, or run a business, for example (Wilhite et al., 2000). Due to the historically centralised system of supply, users often have little involvement and responsibility. Energy use in the home is mostly invisible, and our energy consuming behaviour is based on habits and routines.

In this context, the sociological and socio-technical research is very critical towards existing – single-issue – instruments and measures which only focus on individual behaviour. It is obvious that single-issue interventions have not led to much change in actual energy use in the past. They also argue against the notion of ordinary energy users (and their irrational behaviour) as ‘barriers’ to energy efficiency (Guy and Shove, 2000; Shove, 2003).

Van Vliet, 2002 exemplifies this critique: [Social-psychological models] “lack a proper scheme for analysing the interplay between ‘action’ and ‘structure’ or between ‘micro’ and ‘macro’ levels. Economic models […] do not pay attention to the ‘motives’ or ‘reasons’ of citizen-consumers behind a certain pattern of behaviour. Within the economic theory of ‘revealed preferences’, everything judged an ‘irrational’ factor is excluded from conceptual schemes” (Van Vliet, 2002: 11).

Wilhite et al., 2000 point to the drivers of increasing energy use: how new ‘needs’ are constructed and how expectations of comfort and convenience evolve. These expectations are not created by energy users alone: they are also co-constructed by producers of energy-using equipment and systems of provision (Shove, 2003; Spaargaren, 2003; van Vliet, 2002).

Beyond the often discussed rebound effects (e.g. Sorrel, 2007), Wilhite goes even further in arguing that new technologies themselves serve as change agents: the introduction of these technologies may on the one hand increase efficiency “but at the same time create potentials for new energy intensive practices” (Wilhite, 2007: 23). In developing his “concept of distributed agency” in consumption, he points to

the need of overcoming the separate view on technology on the one hand and the socio-cultural contexts of behaviour on the other hand.

With respect to resource consumption in particular (such as energy and water), sociologists of technology argue that effective means to change energy-related social behaviour can only be found by examining the socio-technical networks that build up around new solutions, the way in which tacit knowledge about energy efficiency develops, and the way in which the adoption of new solutions starts to 'make sense' in a specific context (Guy and Shove, 2000).

In the energy-related context two groups of behaviour were differentiated (see Martiskainen, 2007):

- Different types of curtailment (saving) behaviour (which include conservation efforts such as turning appliances off – addressing the use phase), and
- Different types of efficiency behaviour (which include buying decisions – addressing the investment phase).

Talking about the purchasing behaviour we have to consider the (symbolic) meaning of different products and the different purchasing situations as well as lifestyles and life events. In this context Schäfer and Bamberg, 2008 underline the importance of different events in life as "windows of opportunities" for behavioural change and the chance to intervene successfully towards a more efficient behaviour.

Poortinga et al., 2002 evaluate the adoption of different energy-saving measures. As a result they discuss the preference of technical instruments[2]. Having the choice between behavioural measures and technical instruments, consumers prefer technical improvements, especially to shifts in consumption. While people with a high income find technical measures more acceptable than people with low or average income, this is explained by the fact that technical measures require initial investment. Furthermore it is mentioned that consumers consider other factors than the effectiveness of practical energy saving.

Studies conducted in the early 2000s (Gram-Hanssen, 2002 and Bartiaux, 2002b) have shown that consumers often do not justify their decisions by environmental concerns – even if they decrease negative impacts (Bartiaux, 2003). On the other hand, Sammer and Wüstenhagen, 2006a, 2006b demonstrate that consumers pay

[2] Poortinga et al. distinguish between technical improvements, different use of products and shifts in consumption

more for environmentally sound products. Against the backdrop of the concept of lifestyles, studies indicate that consumer behaviour differentiates between different need areas – due to the symbolic meaning of the given product. Kaenzig and Wüstenhagen, 2006 refer to Pedersen, 2000 and Bilharz, 2005, who point out that "purchasing behaviour is not predictable" between different "green" consumption and need areas. Kaenzig and Wüstenhagen, 2006 conclude that different products and systems "have to be considered separately and that findings for one system can not be transferred without careful checking for differences" (Kaenzig and Wüstenhagen, 2006: 297).

III Overview of empirical findings for the determinants of sustainable energy consumption

Existing studies on the adoption of energy-efficient measures in households are typically based on different, partially over-lapping, concepts from economics (including behavioural economics), psychology (including the marketing-related literature on consumer behaviour) and sociology. Such analyses on the diffusion of energy-efficient activities typically include factors related to the following categories (e.g. Dillman et al., 1983; Olsen, 1983; Walsh, 1989; Fergusen, 1993; Long, 1993; Scott, 1997; Brandon & Lewis, 1999; Barr et al., 2005; Carlsson-Kanyama & Linden, 2007; or, in particular, Sardianou, 2007): (1) *characteristics of the household* (occupants), (2) *characteristics of the residence, (3) characteristics of the measure* (technology), (4) *economic factors, (5) weather* and *climate factors, (6) information diffusion, (7) attitudes/preferences towards the environment.* In light of the interdependencies among factors (and categories), causal impact of individual variables (or concepts) cannot always be clearly identified or distinguished.

Among others, Curtis et al., 1984 point out that energy-saving measures may be divided in (i) low-cost or no-cost measures which do not involve capital investment but rather behavioural change (e.g. switching off lights, substituting compact fluorescent lamps for incandescent light bulbs) and (ii) measures which require capital investment and involve technical changes in the house (thermal insulation of built environment, windows with double- or triple-glazing). Purchasing a new appliance usually does not require technical changes in the house, but purchasing expenditures may be high.

As for the impact of income, results from most studies imply that higher income is positively related with energy-saving activities/expenditures, e.g. Dillman et al., 1983 and Long, 1993 for the US; Walsh, 1989 and Ferguson, 1993 for Canada; Sardianou, 2007 for Greece; and Schleich and Mills, 2008 for Germany.[3] Thus, richer households are less likely to face income or credit constraints for investments in energy efficiency. In additions, empirical findings for Canada by Young, 2008 suggest that richer households also tend to be associated with a higher turnover rate for household appliances, providing greater chances for energy-efficient appliances to replace older, less energy-efficient appliances. With regard to the impact of education levels on energy-saving activities, empirical evidence is rather mixed. In particular, the econometric analyses by Hirst and Goeltz, 1982 for the US, by Brechling and Smith, 1994 for the UK and by Scott, 1997 for Ireland confirm that higher levels of education are associated with greater energy-saving activities. Reasons include, for example, that a higher education level reduces the costs of information acquisition (Schultz, 1975). Likewise, education, which may be seen as a long term investment, may be correlated with a low household discount rate and, thus, be positively associated with energy-saving measures. Such measures often require higher up front cost for investment, while savings in energy costs materialise in the future. Attitudes towards the environment as well as social status, lifestyle (Lutzenhiser, 1992, 1993; Weber & Perrels, 2000) belonging to a particular social milieu group (Reusswig et al., 2004) approving environmentally friendly behaviour tend to be positively related with education. In contrast, the analyses by Ferguson, 1993 for the take-up of conservation measures in Canadian households and by Mills and Schleich, 2008 for the diffusion of energy efficient light bulbs in Germany do not imply a statistically significant impact of education levels.

As expected from economic theory, most existing studies find that higher energy prices accelerate the diffusion of energy-efficient technologies or are associated with higher expenditure for energy saving measures (e.g. Walsh, 1989; Long, 1993; Sardianou, 2007; Schleich and Mills, 2008; Mills and Schleich, 2008).

According to Walsh, 1989, who finds that older household heads are less likely to carry out energy efficiency improvements, such investments yield a higher expected rate of return for younger investors. For household appliances (and light bulbs) this argument may be less relevant than for measures improving thermal insulation of the

[3] However, Curtis et al., 1984 find no statistically significant correlation of energy saving activities and income in Canada (Province of Saskatchewan).

built environment, which tend to have a longer lifetime. Further, as suggested by Carlsson-Kanyama et al., 2005, younger households tend to prefer up-to-date technology, which is usually also more energy efficient. Lower take-up of energy-efficient technologies by elder households may also interact with older people's fewer years of formal education, and less information on energy-saving measures. For example, survey results by Linden et al., 2006 for Sweden indicate that younger people have better knowledge about energy-efficient measures than older people. Clustering individuals into different types, findings by Barr et al., 2005 for the UK and by Ritchie et al., 1981 and Painter et al., 1983 for the US suggest that "energy savers" are older. In general, although - depending on the timing of the survey - age may turn out to have varying effects on the take-up of energy-efficient measures, the impact of age may not be linear and depends on the actual measure considered.

Household size and the number of children are expected be positively related to the adoption of energy-efficient appliances because more intense use would lead to faster replacement (e.g. Young, 2008). Similarly, the more persons there are in a household, the more profitable it is to acquire information on the energy performance of appliances and to purchase energy-cost saving appliances. For other energy-saving measures such as insulation of walls or roof, household size and composition may be less relevant. In terms of empirics, the literature provides mixed results. For example, results by Curtis et al.,1984 imply higher energy-saving activity for households with two to four members than for other household sizes, while the impact of household size on energy-saving expenditures in the study by Long, 1993 is negative.

Renting, rather than owning a residence has been found to inhibit the adoption of energy-saving technologies in a number of previous studies (e.g. Curtis et al., 1984; Walsh, 1989; Painter et al., 1983; Scott, 1997; Barr et al., 2005), as it is difficult for residence owners to appropriate the savings from investments in energy-saving technologies from tenants (Jaffe and Stavins, 1994; Sutherland, 1996). As Black et al., 1985 emphasise, this user-investor dilemma holds in particular for energy-saving measures requiring large capital investment such as thermal insulation of the outer walls, roofs, or attics.

Since larger residences have, on average, more appliances and higher levels of energy consumption, they are likely to have greater interest in, and knowledge of, household energy consumption and consumption-saving technologies, particularly if

the cost of gathering information is relatively fixed. Larger residences may also have greater economic incentives to invest in energy-saving technologies if appliance use is greater. Some studies, among them Walsh, 1983 or Schleich and Mills, 2008, find the expected positive relation between housing size and the take-up of energy-efficient measures, while others, such as Sardianou, 2007 find no statistically significant correlation.

Unless recently refurbished, older houses should have higher potentials for (profitable) energy-saving measures. Thus, the age of a dwelling is expected to be positively related to the diffusion of energy-efficient measures. This argument holds in particular for measures improving energy efficiency in the build environment. Because of shorter lifetimes it is presumably less relevant for household appliances, which typically last for around ten years or less (OECD, 2002b).

Location may also affect the take-up of energy-efficient measures. In particular, urban households may have easier access to information and markets and thus lower transaction costs than rural households. Likewise, larger cities (or utilities in larger cities) tend to be more active in terms of implementing and promoting environmental policies, including policies to raise awareness. The econometric analyses by Scott, 1997 for the observed diffusion of several energy-efficient technologies in Ireland also suggest a positive relation. However, since citizens in smaller cities and hence more rural areas may have stronger preferences towards the environment, the direction of the relation is likely to be ambiguous.

In general, information diffusion relates to the level and quality of knowledge about (i) energy efficiency measures, of (ii) energy consumption (patterns) and costs for existing and new technologies as well as (iii) knowledge about the environmental impact of the particular technology alternatives. From an economic perspective rational household behaviour presumes that households are well informed about the technological alternatives and their costs (including energy costs). For example, information on energy operating costs is typically transmitted via energy bills, where frequency, design and other marketing elements may be relevant. For Norway, Wilhite and Ling, 1995 report that more frequent and more informative billing led to energy savings of around 10% (cited by Sardianou, 2007). Information on the energy performance of technologies (in particular appliances) is typically transferred via energy-consumption labels. Information about energy-efficient technologies is often transmitted via campaigns by local, regional, national and international

administrations or institutions, by energy agencies, consumer associations, technology providers and their associations, or by utilities. Scott, 1997 finds lack of adequate information on energy saving potential to be a barrier to several energy efficiency technologies in Irish households.

From a behavioural and transaction cost perspective, what matters is not only the availability of information but also the *credibility* of the source (Stern and Aronson, 1984: 43). For example, Craig and McCann, 1978 find that the response of New York households to information on energy-saving measures was stronger if the information was provided by the state regulatory agency rather than by the utility. Along similar lines, Curtis et al., 1984 find that a greater variety of sources is positively correlated with energy-efficient activities. While information may improve the level and the quality of knowledge, improved information need not necessarily result in sustained energy savings. In particular, energy savings resulting from technology choices tend to have long-term effects, but behaviour-related savings may only be transitory (e.g. Abrahamse et al., 2005).

Most studies do not allow for a distinction between the relative contribution of factors related to cost savings and attitudes towards the environment. Brandon and Lewis, 1999, however, find that environmental attitudes and beliefs are relevant but financial considerations are at least as important.

IV Determinants for the choice of selected energy services

It may be argued that the determinants of energy consumption in households depend highly on the analysed energy services, i.e. on the question if it is a service dealing with electricity or heating, or if the service is washing or lighting. Thus we look in this section on empirical evidence regarding three specific technologies of sustainable energy consumption in residential buildings: Domestic appliances, micro-power and green electricity.

Stated preference surveys analysing the choice between different product alternatives, such as the choice between different means of transportation (see e.g. Bhat and Castelar, 2002), have existed for a relatively long time. Energy-related stated-preference surveys predominantly referred to issues related to transport, in particular to the choice between cars with sustainable or less sustainable energy sources. By empirically analysing Swiss automotive customers, Wüstenhagen and Sammer, 2007 analysed the effects of the energy label which has been introduced in

Switzerland in 2003 on the purchasing decisions for energy-efficient vehicles. Their research based on a conjoint analysis has shown that the energy label does have a measurable influence on the buying decision of Swiss automotive customers (for other energy-related preference surveys related to transportation see Brownstone and Train, 1998; Brownstone et al., 2000; Sándor & Train, 2004; Horne et al., 2005).

IV.1 Empirical studies in the field of household appliances

Some conjoint analyses have been conducted in the field of energy-related household decisions and are closely connected to the present study. Regarding the energy efficiency of domestic appliances, Sammer and Wüstenhagen, 2006a, 2006b examined the impact of the EU energy labels on the choice among different washing machines and light bulbs with different degrees of energy efficiency. Their study investigated the relative importance of eco-labels compared to other product features in consumers' purchasing decisions and showed a significant willingness of customers to pay for A-labeled energy-efficient products. Anderson and Hansen, 2004 also analysed the impact of environmental certification on preferences, in their case for wood furniture, by applying a conjoint analysis. Their results showed that respondents viewed environmental certification as a favourable product attribute, although, for the typical respondent, the importance of other product attributes outweighed that of environmental certification. Moxnes, 2004 also applied a conjoint analysis in the field of domestic appliances and estimated individual utility functions for customers who recently bought a refrigerator. In their paper they present a frequent argument against efficiency standards, maintaining that they prohibit products that represent optimal choices for customer and thus lead to reduced customer utility. They found out, however, that efficiency standards for refrigerators can lead to increased utility for the average consumer. Another study on refrigerators by Revelt and Train, 1998 focused more on the impact of incentive payments such as rebates and loans on residential customers' choice of efficiency level for refrigerators. They studied the relative importance of rebates or loans for the adoption of high-efficiency appliances such as refrigerators by households in the US. To study the potential effect of loans they used stated-preference data to estimate the effect of loans relative to the effects of rebates. They concluded that loans have a larger impact than rebates. A study explicitly related to air conditioners has been conducted by Matsukawa and Ito, 1998, who measured the effects of the purchasing price on the household's choice of the number of all air-conditioned units in the household.

Their empirical findings showed that the price of an air conditioner does have a great impact on the actual number purchased (for another study related to residential electric appliances see Dubin and McFadden, 1984). Table 1 gives an overview of conjoint studies conducted in the field of energy-related household appliances.

Table 1: Empirical studies in the field of household appliances

Authors	Year	Title	Country
Sammer and Wüstenhagen	2006a	The influence of Eco-Labeling on Consumer Behavior – Results of a Discrete Choice Analysis for Washing Machines	Switzer-land
Sammer and Wüstenhagen	2006b	Der Einfluss von Öko-Labelling auf das Konsumentenverhalten – ein Discrete Choice Experiment zum Kauf von Glühlampen	Switzer-land
Anderson and Hansen	2004	The impact of environmental certification on preferences for wood furniture: a conjoint analysis approach	United States
Moxnes	2004	Estimating Customer Utility of Energy Efficiency Standards for Refrigerators	Norway
Revelt and Train	1998	Mixed logit with repeated choices	United States
Matsukawa and Ito	1998	Household ownership of electric room air conditioners	Japan
Dubin and McFadden	1984	An econometric analysis of residential electric appliance holdings and consumption	United States

IV.2 Empirical studies in the field of heating systems

In the field of heating systems, Karrer, 2006 evaluated the most relevant product attributes of combined heat and power (CHP) plants from a customer's point of view by evaluating the attributes generating customer value by a conjoint method. The results showed that environmental and safety aspects are predominant in a customer's product judgments. An interesting result was the preference of respondents for ownership of their CHP plant, rather than using other financing models such as contracting or leasing. Vetere, 2008 explicitly investigated

preferences for solar thermal installations in Swiss hospitals. Vaage, 2002 described the structure of the energy demand in a household as a discrete/continuous choice and, on this basis, established an econometric model suitable for the data available in the Norwegian Energy Surveys. This study was based on the work of Nesbakken and Strøm, 1993, who applied the 1990 Energy Survey in a discrete/continuous model for the energy demand in Norwegian households. Table 2 gives an overview of conjoint studies conducted in the field of heating systems.

Table 2: Empirical studies in the field of heating systems

Authors	Year	Title	Country
Karrer	2006	Customer Value dezentraler Energieversorgung - Relevante Leistungsattribute von BHKW und deren Implikationen fürs Marketing.	Switzerland
Vetere	2008	Conjointanalytische Untersuchung der Kundenpräferenzen im Business-to-Business Marketing für Solarthermie	Switzerland
Jaccard and Dennis	2006	Estimating home energy decision parameters for a hybrid energy-economy policy model	Canada
Vaage, K.	2002	Heating technology and energy use: a discrete / continuous choice approach to Norwegian household energy demand	Norway
Nesbakken and Strom	1993	Energy Use for Heating Purposes in the Household	Norway

Research in UK households (Martiskainen, 2007; Dobbson & Thomas, 2005) indicates that micro-power may initiate behavioural change since people who install micro-generating technologies are more likely to be and become more aware of their overall energy use.

IV.3 Empirical studies in the field of green electricity

Why does the diffusion of sustainable consumption patterns fail? – This is the research question of the WENKE2 project (Clausen, 2008): Within this BMBF-funded project two consumer groups of RE (solar thermal and green electricity) and

randomly chosen pedestrians were asked about their motivation for buying and using these specific technologies.

The results regarding green electricity indicate a broad environmentally sound motivation as the most important reason for buying GE, followed by a great political concern and involvement.

Green electricity buyers are less price-sensitive than a comparable group of non-buyers. When asked about the price difference between conventional and green electricity, none of the surveyed groups could estimate it accurately.

Clausen (Clausen, 2008: 28) concludes that the weakest point in the marketing of green electricity may be that the public has still not been successfully provided with information as to what prices can realistically be expected. Whilst green electricity buyers overestimate the price four-fold, non-buyers assume on average a ten-fold higher price for green electricity.

Alongside information from newspapers, “friends and acquaintances” are given as the most important source of information, supporting the importance of social components in the dissemination and stabilisation of sustainable consumption (social marketing, see, for example, Martiskainen, 2007; Mc Kenzie-Mohr, 2000; Eberle et al., 2004).

A recent conjoint analysis of the preferences of electricity customers – conducted in Switzerland – backs the findings of Clausen, 2008. Burkhalter et al., 2007 have shown that customers pay special attention to the criteria of energy mix, cost and location of electricity production, whereas other attributes, such as electricity supplier, the pricing model, an eco-certification or the duration of the contract play a subordinate role for the average private client. Goett, 1998 examined the type of pricing, length of contract and type of supplier. His main findings were that a fixed price was preferred over time-of-day and seasonal rates and that consumers prefer not being locked into a long-term contract. Cai et al., 1998 analysed price, outages, integration of renewable sources, support of conservation programmes, and customer services. Their findings showed that the number of outages was by far the most important service attribute. Blass et al., 2008 also estimated consumer valuation of residential electricity reliability in Israel. They found out that knowledge of consumer willingness to pay for reliability is an important component of a rational planning strategy for capacity investment in the generation and transportation of electricity, as well as a key factor in determining an optimal electricity pricing

schedule. Goett et al., 2000 extended the conjoint-type research of Cai et al., 1998 based on these previous studies by examining more attributes, including sign-up bonuses, amount and type of renewable, billing options, bundling with other services, reductions in voltage fluctuations, and charitable contributions. Their main result is that customers are vitally concerned about renewable energies offered by suppliers. Their estimates suggest that customers are willing to pay, on average, 2.0 cents per kWh more for a supplier that uses 100% hydro than for a supplier with no renewable sources, and 1.45c more for 100% wind than for no renewables (for other energy-related preference surveys related to electricity see Beenstock et al., 1998; Dubin & McFadden, 1984; Dagsvik et al., 1987). Table 3 gives an overview of conjoint studies conducted in the field of electricity.

Table 3: Empirical studies in the field of electricity

Authors	Year	Title	Country
Burkhalter, Känzig and Wüstenhagen	2007	Kundenpräferenzen für Stromprodukte – Ergebnisse einer Choice-Based Conjoint-Analyse	Switzerland
Goett, A.	1998	Estimating Customer Preferences for New Pricing Products	United States
Cai et al.	1998	Customer retention in a competitive power market: Analysis of a Double-Bounded plus follow-ups Questionnaire	United States
Goett, Hudson and Train	2000	Customer Choice Among Retail Energy Suppliers: The Willingness-to-Pay for Service Attributes	United States
Blass, Lach and Manski	2008	Using Elicited Choice Probabilities to Estimate Random Utility Models: Preferences for Electricity Reliability	Israel
Beenstock et al.	1998	Response bias in a conjoint analysis of power outages	Israel
Dagsvik et al.	1987	Residential Demand for Natural Gas	Netherlands

The social dilemma as a debate of (potential) green electricity buyers is mentioned by Truffer et al., 2002. People are willing to pay more for green electricity, but on the

condition that everybody is involved and committed. Furthermore the survey shows that in general only few people are familiar with the green power system and infrastructure. So, the importance of labelling and independent verification that Truffer et al., 2001 underlined as one result of a previous focus group research becomes evident.

V Conclusions

The focus of this paper is on the individual decision of consumers, and its relation to sustainable consumption. Consumer behaviour is based on individual decisions, but it depends largely on economic incentives, supply-side measures and an appropriate infrastructure (e.g. whether the consumer benefits from investments into energy efficient equipment, or the availability of energy-efficient household equipment) and on socio-political factors (e.g. if systems of emissions trading or eco-labels exist). It consists of daily “micro-decisions” which construct our self-identity or, in other words, our lifestyle. Thus behaviour can only be understood in a specific context. The context of beliefs, norms and values has to be analysed to understand sustainable consumption.

From a review of the empirical literature on the diffusion of energy-efficient activities we derive the following general hypotheses:

(1) Characteristics of the household (occupants):
It is confirmed by the literature review that sustainable energy use (including purchase) in residential buildings is significantly influenced by income. However, the evidence on the role of education, age, household size and ownership is mixed. The general message is “it depends”. For example, the causal relation largely depends on a specific regulatory framework (e.g. ownership in Germany has a positive effect on sustainable energy use while it is negative in the US), or on particular circumstances (education may increase awareness of environmental problems but also unsustainable behaviour such as travelling, old people may be less interested in environmental problems but may have more time to spend on purchasing new equipment, for big families energy saving is more profitable but they have less money to invest in energy efficiency equipment).

(2) Characteristics of the residence:

The relation between housing size and the take-up of energy-efficient measures is expected to be positive. This is confirmed by most studies, although it is not significant in all studies. The age of a residential building is also expected to be positively related to the diffusion of energy-efficient measures since old buildings have a higher potential for improving energy efficiency. In other words: While new building are better equipped with energy-saving technologies, the number of planned measures is higher in older buildings. An econometric study also confirms that urban households have easier access to information and markets and thus lower transaction costs than rural households.

(3) Characteristics of measures (technology):

In general, the hypothesis is confirmed in the literature that transparency regarding the costs of energy use is positively correlated with energy-saving behaviour. This has been shown for different measures such as energy bills or energy labels. The effect of information also depends on the credibility of the source: the response of households to information on energy-saving measures is stronger if the information is provided by the state regulatory agency rather than by the utility.

(4) Economic factors:

Energy prices play an important role and are positively correlated with sustainable energy use. The higher energy prices, the more responsive are households with regard to energy savings.

(5) Attitudes/preferences towards the environment:

Although sustainable consumption seems not to be possible without changing framework conditions (prices, infrastructure etc.), it is decisive to analyse the individual behaviour assuming a given context in terms of supply factors and regulation. Up to now, however, no clear hypotheses can be derived from the literature. Although there is some agreement that attitudes and lifestyles are relevant, it has not yet been shown that these factors are significant determinants of energy consumption.

Finally, we derived some hypotheses from the literature regarding three specific technologies of sustainable energy consumption in residential buildings: Domestic appliances, micro-power and green electricity.

Some conjoint analyses have been conducted in the field of household energy-related decisions, which are closely connected to the present study. For example, significant willingness of customers to pay for A-labeled energy efficient products have been shown in studies on the impact of the EU energy labels on the choice among different washing machines and light bulbs with different degreesof energy efficiency. Other results from the literature show that respondents viewed environmental certification as a favourable product attribute, although, for the typical respondent, the importance of other product attributes outweighed that of environmental certification. Another study analysed the impact of incentive payments such as rebates and loans on residential customers' choice of efficiency level for refrigerators. It concluded that loans have a larger impact than rebates. A study explicitly related to air conditioners showed that the price of an air conditioner has a great impact on the actual number of air conditioners purchased.

In the field of heating systems, results from the literature survey showed that environmental and safety aspects are decisive in customer's product judgments. An interesting result was the preference of respondents for ownership of their CHP plant, rather than using other financing models such as contracting or leasing.

Regarding green electricity, a recent study shows that green electricity buyers are less price-sensitive than a comparable group of non-buyers. When asked about the price difference between conventional and green electricity, none of the surveyed groups could estimate it accurately. Alongside information from newspapers, "friends and acquaintances" are given as the most important source of information, supporting the importance of social components in the dissemination and stabilisation of sustainable consumption.

A recent conjoint analysis on the preferences of electricity customers backs these findings. It shows that customers pay special attention to the criteria of energy mix, cost and location of electricity production whereas other attributes, such as electricity supplier, the pricing model, an eco-certification or the duration of the contract play a subordinate role for the average private client. Generally, an important role of concern about renewable energies can be derived from the literature.

Another study found that a fixed price was preferred over time-of-day and seasonal rates and consumers prefer not being locked into a long-term contract. Further results from the literature survey are: The number of outages may be the most important service attribute. Knowledge of consumer willingness to pay for reliability is an important component of a rational planning strategy for capacity investment in the generation and transportation of electricity, as well as a key factor in determining an optimal electricity pricing schedule.

However, the social dilemma as a debate of (potential) green electricity buyers is also mentioned in the literature. People are willing to pay more for green electricity, but only on the condition that everybody is involved and committed. The problem of higher fees for green electricity is that they allow free-riding. The importance of labelling and independent verification is underlined as one result of the literature survey.

Summing up: While there is agreement on several determinants in the literature, research needs can especially be identified with regard to (5), i.e. the role of attitudes/preferences towards the environment, and the role of environmental behavior. While these aspects are more or less ignored in revealed preferences studies, stated preference analyses take them into account, but did not come up with general results up to now. Thus, these factors should be carefully considered in future studies.

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