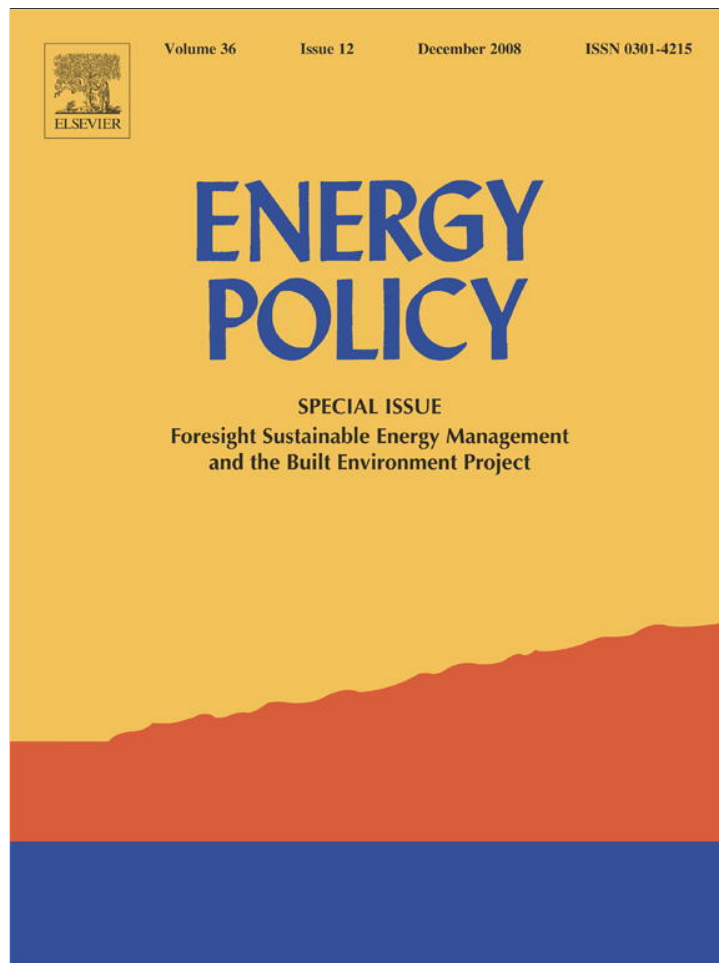


Provided for non-commercial research and education use.
Not for reproduction, distribution or commercial use.



This article appeared in a journal published by Elsevier. The attached copy is furnished to the author for internal non-commercial research and education use, including for instruction at the authors institution and sharing with colleagues.

Other uses, including reproduction and distribution, or selling or licensing copies, or posting to personal, institutional or third party websites are prohibited.

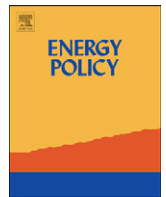
In most cases authors are permitted to post their version of the article (e.g. in Word or Tex form) to their personal website or institutional repository. Authors requiring further information regarding Elsevier's archiving and manuscript policies are encouraged to visit:

<http://www.elsevier.com/copyright>



Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpolPromoting household energy conservation[☆]Linda Steg^{*}

Department of Psychology, Faculty of Behavioural and Social Sciences, University of Groningen, Grote Kruisstraat 2/1, 9712 TS Groningen, The Netherlands

ARTICLE INFO

Available online 18 October 2008

Keywords:

Household energy use
Behavioural change
Energy information

ABSTRACT

It is commonly assumed that households must change their behaviour to reduce the problems caused by increasing levels of fossil energy use. Strategies for behaviour change will be more effective if they target the most important causes of the behaviour in question. Therefore, this paper first discusses the factors influencing household energy use. Three barriers to fossil fuel energy conservation are discussed: insufficient knowledge of effective ways to reduce household energy use, the low priority and high costs of energy savings, and the lack of feasible alternatives. Next, the paper elaborates on the effectiveness and acceptability of strategies aimed to promote household energy savings. Informational strategies aimed at changing individuals' knowledge, perceptions, cognitions, motivations and norms, as well as structural strategies aimed at changing the context in which decisions are made, are discussed. This paper focuses on the psychological literature on household energy conservation, which mostly examined the effects of informational strategies. Finally, this paper lists important topics for future research.

© 2008 Queen's Printer and Controller of HMSO. Published by Elsevier Ltd. All rights reserved.

1. The current state of science

1.1. Household energy use

In the search for behaviour changes to reduce fossil energy use, households are an important target group because they are responsible for approximately 15–20% of total energy requirements in OECD countries (OECD, 2001). Households use energy in a direct and in an indirect way (e.g. Vringer and Blok, 1995). Direct energy use is the use of electricity, natural gas and other fossil fuels. Indirect energy use refers to the energy used in the production, transportation and disposal of goods and services. In European countries, about half of total household energy use can be defined as direct energy use, and in the UK about 40% (Kok et al., 2003; Reinders et al., 2003). Studies typically focus on direct energy use, while indirect energy use has been addressed in only a few studies (Abrahamse et al., 2007; Gatersleben et al., 2002).

Households use energy for many different purposes and different household activities vary widely in the amount of energy they use. In 2005, in the UK, about 53% of domestic energy use was related to space heating, 20% to water heating, 16% to the use of household appliances, 6% to lighting and 5% to

cooking (Maslin et al., 2007). These data can help practitioners decide which sort of household energy conservation would be most worthwhile.

1.2. Factors influencing household energy use and energy conservation

Many factors influence household energy conservation. Firstly, individuals need to be aware of the need for and possible ways to reduce household energy use. Secondly, they need to be motivated to conserve energy. Thirdly, they should be able to adopt the relevant behaviours. Each of these factors will be discussed briefly below.

1.2.1. Knowledge

In general, people are well aware of the problems related to household energy use, and are concerned about these problems (Abrahamse, 2007), although there is still confusion about the causal processes involved (e.g. Bord et al., 2000). For example, many people think global warming is caused by the depleting of ozone in the upper atmosphere (which is not true), while only a limited number of people think global warming is caused by heating and cooling homes (which is true; Bord et al., 2000). As climate change communication has intensified in the last few years, public understanding may have improved. However, given the complex processes involved, some confusion is still likely. Moreover, people know little about the energy use related to their behaviour. For example, when assessing the energy use of

[☆] While the Government Office for Science commissioned this review, the views are those of the author(s), are independent of Government, and do not constitute Government policy.

^{*} Tel.: +31 50 363 6482.

E-mail address: e.m.steg@rug.nl

appliances, people tend to rely on a simple heuristic: they think that energy use is related to the size of appliances. The larger the appliance, the more energy it is believed to use (Baird and Brier, 1981; Schuitema and Steg, 2005b). Obviously, this heuristic is not always accurate. Moreover, people underestimate the energy use involved in heating water, which suggests that people are not well aware of the fact that energy sources are needed to do this (Schuitema and Steg, 2005b).

1.2.2. Motivations for energy conservation

In many Western countries concern with environmental and energy problems is generally high (Abrahamse, 2007; Poortinga et al., 2002; Schultz and Zelezny, 1999). Yet people often do not act in line with their concerns, and total household energy use is still rising. As well as lacking knowledge of the energy use related to various behaviours (see above), many people attach only a low priority to saving energy. Energy use is not only driven by concerns about environmental and energy problems. Many other factors play a role, such as status, comfort and effort (Stern, 2000). People are less likely to reduce their energy use when saving energy involves high behavioural costs in terms of money, effort or convenience. People are far more likely to carry out pro-environment activities such as recycling, which has a low cost in money and effort, than others such as reducing car use which have higher financial and lifestyle costs (see Lindenberg and Steg, 2007, for a review). This does not imply that environmental and normative concerns do not affect high-cost behaviour. Some people do reduce their energy use even at the cost of personal disadvantage.

Normative and environmental concerns are important in promoting energy conservation, because they provide the most solid basis for it (Lindenberg and Steg, 2007). If people only conserve energy for hedonic or cost reasons, they will stop doing so as soon as the behaviour is no longer attractive or cost-effective. When energy conservation results from normative concerns, it is more robust against such changes.

Normative and environmental concerns also play an important role in the acceptability of energy saving policies. Energy policies are more acceptable when individuals value the environment, are aware of the problems resulting from energy use and feel responsible for it, and when they feel morally obliged to do their bit to help reduce these problems (De Groot and Steg, 2008; Steg et al., 2005). Other important factors increasing the acceptability of energy policies are their perceived fairness and the extent to which these policies are expected to actually reduce energy problems (Bamberg and Rölle, 2003; Jakobsson et al., 2000; Rienstra et al., 1999; Schuitema and Steg, 2005a). The acceptability of energy policies also depends on their characteristics. In general, policies are more acceptable when they increase rather than restrict freedom of choice, when they target efficiency behaviour rather than curtailment behaviour (e.g. when they stress purchasing energy-efficient appliances rather than showering less or turning down the thermostat), and when they are aimed at reducing energy use at home rather than for transport (Poortinga et al., 2003; Steg et al., 2006).

1.2.3. Ability to engage in energy conservation

In some cases, people indicate that they are not able to reduce their energy use. Energy-efficient equipment may not be available, it may be very expensive, or feasible alternatives may be lacking. This ability is highly dependent on contextual factors, such as the availability of products and services, the available infrastructure, cultural norms and economic factors. When these factors strongly inhibit or facilitate pro-environmental actions, psychological motivations are relatively unimportant (Guagnano et al., 1995).

These contextual factors are beyond the scope of the present paper.

1.3. Strategies to promote household energy conservation

On the basis of the barriers to fossil energy conservation discussed in the previous section, it may be suggested that energy conservation can be promoted via increasing people's knowledge, strengthening their concern with energy problems, or facilitating behaviour changes by contextual changes. This section discusses possible strategies to promote household energy conservation, targeting these factors.

In general, two types of strategies may be employed to promote household energy conservation. Psychological strategies are aimed at changing people's knowledge, perceptions, motivation, cognitions and norms related to energy use and conservation. The assumption is that such changes will be followed by changes in behaviour, and, consequently, by energy savings. Examples are the provision of information, education and modelling. Structural strategies are aimed at changing the context in which decisions are made so as to make energy conservation more attractive. Examples are new or better products and services, changes in infrastructure, pricing policies and legal measures.

Most studies in the psychology of energy use have focused on the effectiveness of informational strategies (see Abrahamse et al., 2005, for a review). Generally, information campaigns result in only modest behavioural changes. But there are some informational strategies that appear to be successful in promoting household energy conservation. They include prompts (Luyben, 1982), individualised social marketing approaches in which information is tailored to the needs, wants and perceived barriers of individual segments of consumers (e.g. Abrahamse et al., 2007; Daamen et al., 2001; Thøgersen, 2007), commitment strategies (Katzev and Johnson, 1983, 1984), eliciting implementation intentions in which people indicate how they plan to reduce their energy use (e.g. Bamberg, 2002; Jakobsson et al., 2002), and modelling and providing information about the behaviour of others (Schultz et al., 2007; see also Abrahamse et al., 2005). Informational strategies are especially effective when pro-environmental behaviour is relatively convenient and not very costly in terms of money, time, effort or social disapproval, and when individuals do not face severe constraints on behaviour. Besides, informational strategies may be an important element in the implementation of structural strategies intended to force individuals to change their behaviour.

Structural strategies have been studied less frequently in psychology. Typically, the study is confined to the perceived effectiveness of such strategies, and most focus on the effects of transport pricing (see Steg and Schuitema, 2007, for a review). These studies reveal that people generally think transport pricing will not be very effective in reducing car use (e.g. Jakobsson et al., 2000) or the problems of car use (e.g. Schlag and Teubel, 1997; Schuitema and Steg, 2005a), especially because they think car use reductions are hardly feasible (Jakobsson et al., 2002). But studies of the actual effect of transport pricing policies revealed that transport pricing may have substantial effects on car use. Prominent examples are the Singapore area licence scheme and the London congestion charge (see Santos, 2004; Santos et al., 2004; Verhoef et al., 2004). This suggests that pricing strategies may be effective in reducing household energy use and that the effects can be larger than initially expected.

One obvious way to reduce household energy use is to promote the adoption of energy-efficient appliances. Various psychological factors are important in this respect (see Midden et al., 2007, for a

review). Energy-efficient appliances will be more readily adopted when they meet important needs, wants and preferences. It is important to consider possible side effects of energy-efficient appliances as rebound effects may occur. This happens when people use efficient appliances more often, because they are energy efficient (Hertwich, 2005). Midden and colleagues illustrate that technology and behaviour are closely interwoven in many respects, and indicate various ways in which technological and behavioural factors can be integrated in interactive approaches to effectively promote energy conservation.

Politicians are often reluctant to implement stringent policies, because they believe that these policies can threaten individual quality of life. Tough policies such as substantial price increases for energy may reduce individual quality of life in some respects (e.g. less freedom, money). But they may also increase individual quality of life in other respects (e.g. improved environmental quality and health), and overall quality of life may not be harmed much (De Groot and Steg, 2008; see Steg and Gifford, 2005, for a review).

2. Future advances to 2050 and beyond

It is clear that some important questions have been effectively addressed in various psychological studies on household energy use and conservation. However, various issues need to be further addressed. Some important topics for future research are listed below.

2.1. Indirect energy use

As indicated earlier, most studies consider direct energy use only. This is regrettable, as about half of total household energy use involves indirect energy. It is important to consider indirect energy use and ways to reduce it more systematically. Indirect energy use may be reduced by changing the behaviour and decisions of producers and distributors, but also by changing consumer behaviour. This might be done by promoting the purchase of energy-efficient products and services, and by reducing the amount of household waste. Quantifying the energy requirements of different products is a substantial challenge and requires interdisciplinary research.

2.2. Individual and contextual factors

When studying energy use, personal factors such as attitudes, values, norms and habits should be considered alongside contextual factors. These can include the physical infrastructure, technical facilities, the availability (or not) of products, special product characteristics, advertising and shared socio-cultural objectives such as income and material growth. These latter may have a substantial impact on behaviour. Individual and contextual factors should be studied in combination, as they are likely to interact. This implies that interdisciplinary approaches are needed to get a full understanding of energy use, the factors influencing it and ways to reduce it. Most studies to date have followed a monodisciplinary approach, and provide a limited view at most as they consider only a selective set of factors influencing energy use and energy conservation.

2.3. Provision of tailored information

Tailored information is more effective in changing behaviour than general information targeting a broad public. However, little is known about how information can best be tailored to the needs,

circumstances and behaviour of specific populations. Information can be tailored on the basis of different criteria, such as current behaviour (e.g. one could provide information on energy saving options that are relevant to a particular person or household), motivations (e.g. stress the environmental benefits when people value the environment more, and focus on cost savings when people are more worried about money), or stages of change (e.g. one could stress the need for energy conservation for those who have not yet considered the need to reduce their energy use, but focus on actual ways to reduce household energy use when people are willing and planning to conserve energy).

2.4. Psychological and structural strategies for behaviour change

Thus far, most psychological studies have examined the effects of informational strategies on behaviour and energy conservation. Structural strategies have received much less attention. Studies examining the effects of structural strategies mostly examine intentions to change behaviour, not actual behavioural changes.

2.5. Acceptability and adoption of sustainable energy sources

Various alternatives to fossil energy sources are being developed, including renewable energy sources and decentralised energy. Effective ways to introduce these alternatives are an important topic for future research. We need to examine the factors that affect the acceptability and adoption of such alternatives. This is not an easy task to accomplish, because many people know little about alternative energy sources. Asking for people's opinions on sustainable energy sources 'out of the blue' will reveal knowledge deficits and misperceptions, but does not provide a stable basis for policy making. The findings of such studies will depend on descriptions provided by the researchers and on what people have learned from the media. Public perceptions and preferences will be more robust when detailed information is provided about the merits and possible drawbacks of such energy sources.

2.6. Feedback on energy use

People generally know little about how much energy their behaviours use. They usually find out about their household energy use from meter readings, and even these are not always possible, for example in master-metered apartments. In any case, meter readings reflect total gas or electricity use only. The recently introduced smart meters provide interesting opportunities to provide detailed feedback about energy use. As yet, little is known about effects of smart metering on knowledge and behaviour, but some field trials are being conducted in the UK that will give initial insights into the possible effects. How to enhance the use and effectiveness of this technology is another important topic for future research.

Recently, environmental scientists have developed sophisticated tools to provide people with detailed information about the energy use associated with specific behaviours (Benders et al., 2006). These tools can be used to provide people with tailored advice about ways to reduce their energy use, and feedback about the extent to which behaviour changes resulted in actual energy savings (see Abrahamse et al., 2007). Such instruments are an important tool to educate people about energy use. However, as of yet, little is known about the extent to which people are willing to use such tools, and change their behaviour based on the advice given.

2.7. Systematic evaluation of intervention programmes

Many interesting projects have been implemented to support energy conservation. Unfortunately, these are not always systematically evaluated, and consequently no firm conclusions can be drawn on how successful they have been. Clear theories and sophisticated research designs are needed to allow firm conclusions about the effects of interventions, especially when testing interventions for the first time. Ideally, clear theoretical predictions should be made. Moreover, the target behaviour, its antecedents and its associated energy use should be measured before and after an intervention has been implemented, and the effects of the 'treatment' should be compared to those in a control group which has not been exposed to the intervention. This makes it possible to conclude whether the behaviour and the factors influencing it changed in the expected way, and to what extent these changes are due to the intervention, and not to some naturally occurring event. For example, this approach makes it possible to determine whether households that did not participate in the project also reduced their energy use, perhaps because of price increases or higher temperatures. Systematic evaluations not only reveal to what extent an intervention has been successful in changing behaviour and reducing energy use, but also why it succeeded or failed, how an intervention might be adapted to increase its effects and how theories should be adapted to better understand and predict household energy use.

2.8. Interdisciplinary research

This paper has discussed many factors influencing household energy use. They encompass a range of disciplines. Moreover, various strategies can be applied to reduce household energy use, and these, again, are studied by researchers with various disciplinary backgrounds. This implies that any single discipline will provide a limited view of the topic at most. Interdisciplinary studies allow us to get a broader and more comprehensive view of the issues involved and of successful ways to reduce household energy use.

References

- Abrahamse, W., 2007. Energy conservation through behavioral change: examining the effectiveness of a tailor-made approach. PhD thesis, University of Groningen, The Netherlands.
- Abrahamse, W., Steg, L., Vlek, Ch., Rothengatter, J.A., 2005. A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology* 25, 273–291.
- Abrahamse, W., Steg, L., Vlek, Ch., Rothengatter, J.A., 2007. The effect of tailored information, goal setting and tailored feedback on household energy use, energy-related behaviors and behavioral antecedents. *Journal of Environmental Psychology* 27, 265–276.
- Baird, J.C., Brier, J.M., 1981. Perceptual awareness of energy requirements of familiar objects. *Journal of Applied Psychology* 66, 90–96.
- Bamberg, S., 2002. Effects of implementation intentions on the actual performance of new environmentally friendly behaviours—results of two field experiments. *Journal of Environmental Psychology* 22 (4), 399–411.
- Bamberg, S., Rölle, D., 2003. Determinants of people's acceptability of pricing measures—replication and extension of a causal model. In: Schade, J., Schlag, B. (Eds.), *Acceptability of Transport Pricing Strategies*. Elsevier Science, Oxford, pp. 235–248.
- Benders, R.M.J., Kok, R., Moll, H.C., Wiersma, G., 2006. New approaches for household energy conservation—in search of personal household energy budgets and energy reduction options. *Energy Policy* 34, 3612–3622.
- Bord, R.J., O'Connor, R.E., Fischer, A., 2000. In what sense does the public need to understand global climate change? *Public Understanding of Science* 9, 205–218.
- Daamen, D.L., Staats, H., Wilke, H., Engelen, M., 2001. Improving environmental behavior in companies: the effectiveness of tailored versus nontailored interventions. *Environment and Behavior* 33 (2), 229–248.
- De Groot, J.I.M., Steg, L., 2008. Morality and prosocial behaviour: the role of awareness, responsibility and norms in the norm activation model. *Journal of Social Psychology*, in press.
- Gatersleben, B., Steg, L., Vlek, C., 2002. Measurement and determinants of environmentally significant consumer behaviour. *Environment and Behavior* 34 (3), 335–362.
- Guagnano, G.A., Stern, P.C., Dietz, T., 1995. Contextualizing attitude—behavior relationships: a natural experiment with curbside recycling. *Environment and Behavior* 27, 699–718.
- Hertwich, E.G., 2005. Consumption and the rebound effect: an industrial ecology perspective. *Journal of Industrial Ecology* 9, 85–98.
- Jakobsson, C., Fujii, S., Gärling, T., 2000. Determinants of private car users' acceptance of road pricing. *Transport Policy* 7, 153–158.
- Jakobsson, C., Fujii, S., Gärling, T., 2002. Effects of economic disincentives on private car use. *Transportation* 29 (4), 349–370.
- Katzev, R.D., Johnson, T.R., 1983. A social—psychological analysis of residential electricity consumption: the impact of minimal justification techniques. *Journal of Economic Psychology* 3, 267–284.
- Katzev, R.D., Johnson, T.R., 1984. Comparing the effects of monetary incentives and foot-in-the-door strategies in promoting residential electricity conservation. *Journal of Applied Social Psychology* 14 (1), 12–27.
- Kok, R., Falkena, H.J., Benders, R., Moll, H.C., Noorman, K.J., 2003. Household metabolism in European countries and cities: comparing and evaluating the results of the cities Fredrikstad (Norway), Groningen (The Netherlands), Guildford (UK), and Stockholm (Sweden). Integration Report of WP2 (Toolsust Deliverable No. 9), Groningen, The Netherlands: IVEM, University of Groningen <<http://www.toolsust.org/documents/D-9%20European%20report.pdf>> (accessed at 10 October 2007).
- Lindenberg, S., Steg, L., 2007. Normative, gain and hedonic goal-frames guiding environmental behavior. *Journal of Social Issues* 63 (1), 117–137.
- Luyben, P.D., 1982. Prompting thermostat setting behavior: public response to a presidential appeal for conservation. *Environment and Behavior* 14 (1), 113–128.
- Maslin, M., Austin, P., Dickson, A., Murlis, J., Owen, M., Panizzo, V., 2007. UK Greenhouse Emissions: Are We on Target? University College London, Environment Institute, London.
- Midden, C., Kaiser, F., McCalley, T., 2007. Technology's four roles in understanding individuals' conservation of natural resources. *Journal of Social Issues* 63 (1), 155–174.
- OECD, 2001. Environmental Outlook. Organisation for Economic Co-operation and Development, Paris.
- Poortinga, W., Steg, L., Vlek, C., 2002. Environmental risk concern and preferences for energy-saving measures. *Environment and Behavior* 34 (4), 455–478.
- Poortinga, W., Steg, L., Vlek, C., Wiersma, G., 2003. Household preferences for energy-saving measures. A conjoint analysis. *Journal of Economic Psychology* 24 (1), 49–64.
- Reinders, A.H.M.E., Vringer, K., Blok, K., 2003. The direct and indirect energy requirement of households in the European Union. *Energy Policy* 31, 139–153.
- Rienstra, S.A., Rietveld, P., Verhoef, E.T., 1999. The social support for policy measures in passenger transport. A statistical analysis for the Netherlands. *Transportation Research D* 4 (3), 181–200.
- Santos, G., 2004. Urban road pricing in the UK. In: Santos, G. (Ed.), *Road Pricing: Theory and Evidence*. Elsevier, Amsterdam, pp. 251–282.
- Santos, G., Li, W.W., Koh, T.H., 2004. Transport policies in Singapore. In: Santos, G. (Ed.), *Road Pricing: Theory and Evidence*. Elsevier, Amsterdam, pp. 251–282.
- Schlag, B., Teubel, U., 1997. Public acceptability of transport pricing. *IATSS Research* 21 (2), 134–142.
- Schuitema, G., Steg, L., 2005a. Factors that affect the acceptability of pricing policies in transport. Paper presented at the 7th Nordic Environmental Social Science (NESS) Research Conference, Göteborg, Sweden, 15–17 June 2005.
- Schuitema, G., Steg, L., 2005b. Percepties van energieverbruik van huishoudelijke apparaten (Perception of energy use of domestic appliances). In: Bronner, A.E., Dekker, P., de Leeuw, E., de Ruyter, K., Smidts, A., Wieringa, J.E. (Eds.), *Ontwikkelingen in het marktonderzoek. Jaarboek 2005 (Developments in Marketing Research. Yearbook 2005)*. De Vrieseborch, Haarlem, The Netherlands, pp. 165–180.
- Schultz, P.W., Zelezny, L., 1999. Values as predictors of environmental attitudes: evidence for consistency across 14 countries. *Journal of Environmental Psychology* 19 (3), 255–265.
- Schultz, P.W., Nolan, J., Cialdini, R., Goldstein, N., Griskevicius, V., 2007. The constructive, destructive, and reconstructive power of social norms. *Psychological Science* 18 (5), 429–434.
- Steg, L., Gifford, R., 2005. Sustainable transport and quality of life. *Journal of Transport Geography* 13 (1), 59–69.
- Steg, L., Schuitema, G., 2007. Behavioural responses to transport pricing: a theoretical analysis. In: Gärling, T., Steg, L. (Eds.), *Threats to the Quality of Urban Life from Car Traffic: Problems, Causes, and Solutions*. Elsevier, Amsterdam, pp. 347–366.
- Steg, L., Dreijerink, L., Abrahamse, W., 2005. Factors influencing the acceptability of energy policies: testing VBN theory. *Journal of Environmental Psychology* 25 (4), 415–425.
- Steg, L., Dreijerink, L., Abrahamse, W., 2006. Why are energy policies acceptable and effective? *Environment and Behavior* 38 (1), 92–111.
- Stern, P.C., 2000. Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues* 56 (3), 407–424.
- Thøgersen, J., 2007. Social marketing of alternative transportation modes. In: Gärling, T., Steg, L. (Eds.), *Threats to the Quality of Urban Life from Car Traffic: Problems, Causes, and Solutions*. Elsevier, Amsterdam, pp. 367–381.

- Verhoef, E., Koopmans, C., Bliemer, M., Bovy, P., Steg, L., Van Wee, B., 2004. Vormgeving en effecten van prijsbeleid op de weg. Effectiviteit, efficiëntie en acceptatie vanuit een multidisciplinair perspectief (Design and Effects of Road Pricing. Effectiveness, Efficiency and Acceptability from a Multidisciplinary Perspective). Vrije Universiteit Amsterdam/SEO, Technische Universiteit Delft, Rijksuniversiteit Groningen, The Netherlands (in Dutch).
- Vringer, K., Blok, K., 1995. The direct and indirect energy requirements of households in the Netherlands. *Energy Policy* 23 (10), 893–910.