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**Climate protection by reducing the emissions of greenhouse
gases in households and the tertiary sector through
climate-conscious behaviour**

Summary

by

Ulla Böde, Edelgard Gruber

Fraunhofer-Institute for Systems and Innovation Research, Karlsruhe

Bettina Brohmann, Martin Cames, Anke Herold
Öko-Institut (Institute for Applied Ecology e. V.),
Darmstadt, Berlin, Freiburg

Peter Deutscher, Martin Elsberger, Lothar Rouvel
Department of Energy and Applied Technology
at the Technological University of Munich

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Starting point and Objective

The aim of the project was to identify areas in households and the tertiary sector in which changes in behaviour could result in energy conservation and thus a reduction of greenhouse gas emissions. The potentials for reduction are to be quantified. All estimates were based on 2005 and 2020 compared with the reference year 1995. CO₂ emissions in Germany in 1995 totalled 912 million tons of which households accounted for 27 % and the tertiary sector 18 %.

In this study, behavioural measures were understood to be activities by end consumers such as heating, ventilation and use of appliances. Small investments were also included, e. g. energy-saving lights and adapters, but not energy management which is, in its widest sense, a behavioural measure, yet which does not bring about energy conservation on its own, but rather promotes the implementation of concrete measures related to both behaviour and investment.

A second focus of the project was on the analysis and evaluation of possible programmes and instruments to realise the potentials. Programmes are defined as energy policy promotion measures, initiatives etc., such as consultation, further education/training, actions, subsidies and regulations; instruments as individual activities within programmes, e. g. brochures, campaigns, seminars, setting up advice centres.

The project was implementation-oriented. Those affected in practice, for example potential suppliers of programmes of advice and information should be able to work in a very implementation-oriented way with the project's results. For this reason, the results were discussed together with the relevant associations, important multipliers, institutions and initiatives in a workshop.

The measures, programmes and instruments sometimes vary widely between the sectors and the responsibility for households and the tertiary sector was divided between two research institutes. The Öko-Institut was in charge of research in the household sector and the Fraunhofer ISI in the tertiary sector. The Department for Energy and Power Station Technology of the Technological University in Munich was involved in both areas in the extrapolation of the energy conservation potentials for space heating and warm water. The results were presented in two volumes: Volume I "Households" and Volume II "Business, Trade and Services".

Methodology in the Household Sector

To start with, relevant areas of behaviour were identified in several working steps. The following fields of need were distinguished: accommodation, clothing, food,

media/communication and personal hygiene. Within these fields, several applications and groups of appliances were taken into account. In addition, a distinction was made between space heating and warm water on the one hand and between cooking and all other uses of electricity on the other.

The potentials in the individual areas of need were quantified for 1995, 2005 and 2020. The reference development and all other framework data are based on the figures of the Federal Environmental Agency's Project "Policy scenarios for Climate Protection - II". During the course of the study, the results obtained from estimating the potentials were supplemented with empirical primary data on the energy conservation behaviour of households which helped to order the assumptions on the behaviour-induced potentials based on their significance and feasibility. To this end, two interview methods were chosen: a national phone survey of households based on a questionnaire and asking additional questions in the frame of an ongoing general survey.

In a further parallel step, the possibilities of realising the conservation potentials were examined and classified using the research and evaluation of instruments of common programmes which were recommended by "Policy Scenarios for Climate Protection" .

Determining Behavioural Potentials in the Household Sector

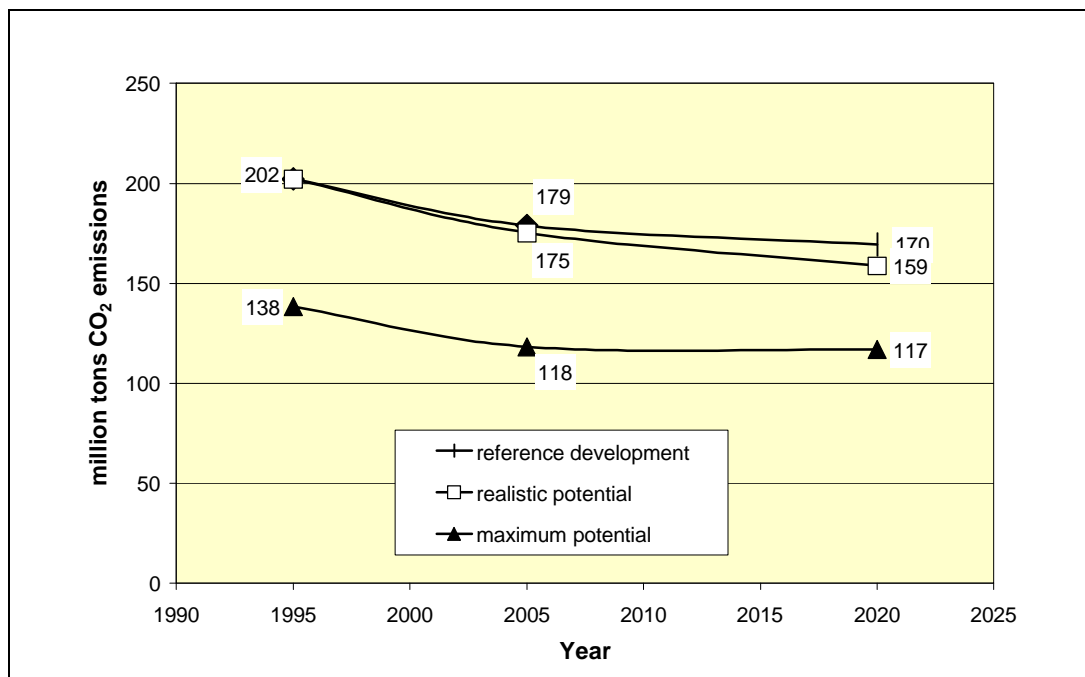
Based on the reference development, behavioural measures were defined and illustrated by behavioural assumptions which are supported by figures and results of literature research as well as plausibility considerations. With the help of these assumptions, the change in energy consumption in private households could be calculated. These results represented the initial figures for estimating the absolute and relative behavioural potentials in relation to CO₂ emissions.

The behavioural potential in the area of space heating can be illustrated by the influences on room temperature, ventilation behaviour and extent of heating. For warm water production, the daily amount of warm water required and the number of persons were varied. The calculations of the potentials in both areas is based on the results of the IKARUS-Project for the Federal Ministry of Education and Research ("Instruments for Greenhouse Gas Reduction Strategies"), Subproject 5, Households and Tertiary Sector. The 51 types of building depicted there which vary according to age, building type and location (old/new Federal States) were summarised in 4 aggregate buildings which represent the average state of small buildings with one or two accommodation units as well as large buildings with three or more accommodation units in the old and new Federal states. In this way, the total existing living space can be described energetically. The actual average consumer behaviour was applied as standard case.

Conservation potential in the Household Sector

Assuming that, through campaigns and programmes, 1% of the not yet implemented potential can be tapped each year, the contribution of behavioural changes in private households could be increased to almost 11 million tons CO₂ by the year 2020. By 2020, a good 20 % of the behavioural potential would have been realised (Figure 1).

Figure 1: CO₂ reduction potential due to behavioural measures in the household sector



Based on the reference development, the reduction potential achievable due to behaviour corresponds to a share of 6.4 % of the CO₂ emissions in the household sector and a share of 1.4 % of the total CO₂ emissions in Germany in 2020.

Programmes and Instruments in the Household sector

In the analysis of programmes and instruments - with the view to a perspective further development - particular attention was paid to innovative, self-organised and not yet widely known programmes and instruments. The working hypothesis is that these could give practical and well-suited indications of new forms and constellations for promising advice and information proposals.

On the other hand, the experience of implementation documented here also served to estimate the realisable behavioural potentials outlined above. The programmes were differentiated according to actions and campaigns, programmes of public utilities for households, lighting programmes, feedback programmes and social marketing approaches were regarded. Alongside programme design, the conditions for success were to be shown under which the programmes offered were accepted by the consumers.

Recommendations for Action in the Household Sector

Measures and programme proposals were developed from the analysis of these existing approaches which seem particularly suited to address the aspect of behaviour.

As an example from various studies and the survey conducted here, it could be shown that the existing form of energy consumption invoice does not give households a clear overall picture of their consumption situation. This information deficiency can be improved, according to the programme organisers, by a more transparent form of feedback to the customers on additional information, a different billing form, including graphics, comparative prior year figures or competitive elements (bonus).

When supplying information, the trend should be observed that very few households actively try to obtain further information on energy conservation: the majority consider themselves to be energy conscious and sufficiently informed. In contrast, households composed of pensioners with low income are more aware of conservation possibilities and necessities.

There are differences in the awareness and assessment of the significance of each conservation potential between the areas of space heating and electricity: the heating possibilities not yet utilised by households are systematically underestimated. Most answers to the question about energy conservation possibilities are to do with replacing old "white goods" appliances and lighting.

Against this background, possible solutions for the area of behaviour should differentiate according to age and size of household as well as field of application. Package offers and new communication channels should be developed for specific target groups. This requires greater networking and strategic co-ordination with regard to content of programme and information suppliers.

Above all the social integration of channels of and access to information should become increasingly important. Campaigns which allow self-organised processes within a clear time and subject framework (Models "Northern Light" or "Round

Tables") show high success rates in the implementation of concrete measures. However, these results refer mostly to investments. In the field of behaviour, it is much harder to evaluate successes and to assign these to a measure.

Incentive systems represent an important aspect when designing information offers. Different promotional measures can influence how highly individuals rate climate protection activities. However, it has been shown that financial incentives alone do not bring about long-term changes in behaviour although they can make it easier to gain access to households.

The conception of consultation proposals in the household sector must take prioritisation into account if the conditions for a strategic exploitation of the behaviour potential are to be considered. Programmes, which aim at changing behaviour can only play a supplementary role - with the exception of only a few applications.

This study shows that, with a view to tapping behavioural potential, the following five application fields are relevant for programme design:

- Lighting: use of energy saving lamps
- Space heating: correct heating and ventilation
- Warm water production
- Food: cooking (pressure cookers)
- Dish washers, tumble dryers due to an increasing number of appliances fitted.

The study showed that, when including information programmes in package offers, the selection of the relevant channels of information, the networking of the actors involved to utilise synergies and the strengthening of social relations is of critical importance.

Methodology in the Tertiary sector

Several areas were selected in the very heterogeneous sector "Business, Trade and Services" which are significant with regard to total energy consumption: trade with the emphasis on the electricity-intensive grocery retailing industry, hotels and restaurants, banks and insurance brokers, non-profit organisations (offices, hostels), public administrations (national, regional, local authorities) and schools. The analyses thus cover about two-thirds of those employed in the tertiary sector and approx. 60 % of the energy consumption. In the sectors selected, cross-cutting measures, e. g. heating, lighting and office equipment were examined as well as sector-specific measures. In the other sectors, the special features of process technology were not considered due to the variety of process-related behavioural measures, but the statements made about cross-cutting measures remain valid here.

Behavioural measures and their individual potentials for energy conservation were researched in the literature and in discussions with experts. In addition, frame conditions, e. g. development trends in technology and in equipment were identified which influence the potentials of behaviour-related measures.

Energy savings related to behaviour in the areas of space heating, warm water and electricity consumption were quantified with the help of the IKARUS database and the figures of the Federal Environmental Agency's project "Policy scenarios". Calculations were made for 1995, 2005 and 2020.

With regard to implementation activities, experience with programmes and instruments was researched and analysed which aim mainly or at least in part at changes in behaviour. The study concentrated in particular on innovative considerations and contributions.

Individual potentials in cross-cutting areas and selected branches

Five cross-cutting areas were identified for energy conservation related to behaviour which are relevant for all sectors: heating, cooling and air conditioning, warm water production, lighting, and using electrical appliances. Sector-specific energy consumption segments were examined in addition to this. The individual potentials were derived from the literature; to supplement this experts were interviewed and own measurements carried out. The individual measures were described in detail in a similar manner to manuals with regard to the expected technological development as well as practicability and degree of difficulty in implementing the measures. A distinction was made here between end-users, e. g. staff, and "organisers", e. g. caretakers, managers or computer personnel.

Recommendable and not always applied measures without any investment costs include, e. g. the correct selection of flow and room temperature with intermittent drops in temperature, regular maintenance of systems and appliances, correct ventilation, partial disconnection of heating pumps, operation of ventilation and air conditioning systems on demand, limiting the temperature of warm water, demand-oriented lighting, cleaning reflectors and lamps, avoiding no-load operation of electrical appliances, targeted disconnection of certain appliances and using power management systems.

Insulating pipes or time switch clocks in warm water production, energy-saving bulbs, brightness control and energy-saving appliances for monitors, printers, photocopiers etc. were all identified as important small investments.

In grocery retailing, the largest conservation potential is to be found in an energy-saving usage of domestic refrigerators. Refrigeration is also a main point of con-

sumption in hotels and restaurants; there are additional conservation possibilities here in cooking, baking, washing, the dining-room, the guest rooms and, if applicable, the hotel laundry. Other than the cross-cutting areas, no other conservation potentials could be found in sectors of an office nature.

Particular attention has been paid to schools for some years with regard to energy-saving activities. Numerous studies have been conducted and actions implemented, therefore schools were examined in detail in this project. Measures in schools are also important because this is the place where future generations can learn how to use energy in an economical and sustainable manner. The cross-cutting areas are significant in schools as are special measures in sports halls.

Assessment of Behavioural Effects in the Tertiary Sector

The behavioural measures and small investments identified were not able to be illustrated in detail using the IKARUS database. In the field of heating and ventilation, the calculation possibilities were restricted to the amount of heating, the room temperature and ventilation. Existing parameters for the buildings, the heating technology and the distribution system were applied in four model buildings of the sectors under investigation: grocery retailer, hotel/restaurant, administration building and school.

To determine the space heating demand, a standard case was assumed, e. g. with a room temperature of 21 °C and a ventilation of 0.7 h⁻¹ in the administration building. By combining different patterns of heating and ventilating behaviour within a realistic range from "wasteful" to "reasonable", 18 variants were obtained. The difference between the "best" and the "worst" case is 2.5 to 3 times the specific heating consumption per m².

If the behavioural influence is calculated assuming an average reduction of ventilation by one third and a room temperature reduction of 2 K, the specific heating consumption in old buildings falls by 30 % and by 25 % in new buildings under the more stringent energy conservation regulations; this would total 64 TWh for the reference year 1995; by 2020 the potential would drop to 51 TWh due to the increasing proportion of new buildings.

When calculating the potential for saving electricity, the tertiary sector's entire stock of appliances and systems were included. The calculations based on the data on number of appliances, power and extent of use from the IKARUS database as well as estimates of measures already implemented showed that electricity consumption can also be significantly reduced through changes in behaviour. The potential in lighting is by far the greatest at 10.4 TWh compared with about 1.8 TWh for office equipment and 1.9 TWh for air conditioning and ventilation systems. It is clearly

higher than the energy conservation possible due to forced exploitation of progress in technology up to 2020. The electricity demand for lighting constitutes the largest share of the total electricity consumption in the tertiary sector and in absolute terms also offers the largest saving potentials. The biggest behaviour-related potential for saving in office equipment lies in minimising no-load operation. Sector-specific examinations also showed large potentials, some of which may continue to grow up to 2020 with the trend towards ever more electrotechnical equipment.

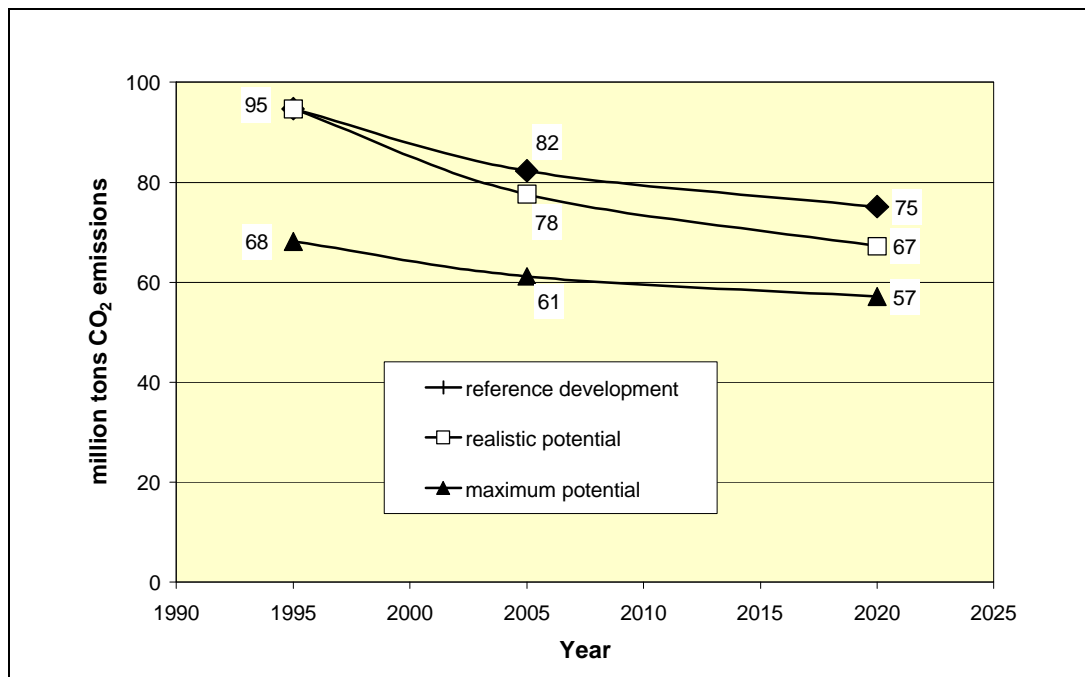
A conservation potential of about 47 % can be determined for warm water based on the demand level of 1995, i.e. about 10 TWh. This potential will drop by about 10 % by 2020 corresponding to the drop in demand for warm water.

The sum of CO₂ emissions for space heating, electricity and warm water in the tertiary sector is seen as an overall result. The autonomous development of CO₂ emissions in the tertiary sector, i.e. without forced technical developments or conservation measures, is referred to as the reference scenario (Figure 2). The maximum amount of emissions which could be avoided solely through changes in behaviour equals 26.5 million tons CO₂ for the base year 1995. This maximum potential is, however, reduced to 18 million tons due to the predicted overall drop in CO₂ emissions and the continued autonomous development of technology up to 2020.

The potential which can actually be achieved is much lower and is dependent on the success of programmes which mobilise and motivate climate-conscious behaviour. Regarding the area of space heating, it is assumed that the not yet implemented potential can be tapped at 1 % per year. A faster exploitation of 4 % per year up to 2005 and then 2 % per year until 2020 is assumed for the areas of electricity and warm water. The reason for assuming this faster development is that, when estimating the potential of individual measures, the obstacles to their implementation had already been taken into account. That the achievable factor then drops to 2 % by 2020 is based on the assumption that, initially, lots of easily realised behavioural measures are implemented and that, in time the remaining potential can only be tapped via more complicated measures or ones which may even adversely affect perceived comfort. The result is that, up to 2005, 22 % of the conservation potential due to behaviour can be tapped (4.7 million tons CO₂); up to 2020, about 44 % is achievable (7.9 million tons CO₂).

Strictly speaking, the potential in the tertiary sector is even greater as sector-specific behavioural measures can also be added. For the sector "supermarkets", e. g., the additional saving potential amounts to between 0.9 million (1995) and 0.7 million tons CO₂ (2020), for "Hotels and restaurants" between 1.1 (1995) and 1.2 million tons (2020). Process heat measures were also taken into account in this sector due to their significance for energy consumption which were not dealt with in the other sectors because of their heterogeneity.

Figure 2: CO₂ reduction potential due to behavioural measures in the tertiary sector



Programmes and Instruments

Programmes and instruments in the fields of information, motivation, advice and further training are fundamental for the promotion of energy-saving behaviour. Research was conducted into relevant experience on a national and international level.

There is no lack of written information of every kind from leaflets to manuals, although some individual branches of the tertiary sector are not yet covered. Their contents usually focus on investments, measures dealing with changes in behaviour are usually only mentioned in passing. References to energy-saving behaviour should receive greater attention in brochures in future, although this alone is not sufficient to motivate energy-saving behaviour. Relevant recommendations should also be addressed in the frame of advice on energy issues and in further training classes. Separate brochures or seminars on behaviour are not recommended for the tertiary sector as too little attention is paid to this area. Financial incentives for small investments are not thought to be necessary as the measures in question are profitable. There is a need for central co-ordination of the information, advice and further training activities on the subject of energy conservation in Germany.

Recently, positive experience has been made with different action programmes which lead to a sensitisation of the user for energy consumption and conservation. Such actions in companies, administrations or local authorities cover information, consumption measurements and feedback, competitions etc.. "Energy models" - joint actions of companies in a particular region or sector to discuss and set energy conservation targets - can also produce short-term successes mainly in changes in behaviour and small investments. However, reminders are necessary to constantly re-activate this behaviour.

In recent years, lots of programmes on energy saving in schools have been developed and implemented with great success. Teaching materials were developed, and information events and competitions were held in order to raise the energy consciousness of school children. One incentive to participate is the "Fifty-fifty model" which allows the schools themselves to decide how to use half of the energy costs saved.

Recommendations for action in the tertiary sector

Motivation has to be the focus of activities to promote the implementation of energy-saving behaviour. Many companies believe they have already exploited all the saving potentials. Simple indices which can be determined quite easily in the company and which can be compared with those of other firms in the same sector would be very helpful. Branch associations have to take an active role here as initiators and multipliers.

A whole set of serious prejudices concerning behavioural measures has to be eliminated, (equipment durability, forfeiting comfort etc.). Energy efficiency should be linked to positive characteristics where possible, e. g. improving overall efficiency or organisational advantages. Cost savings are not the only incentive. For many companies, the "environmentally friendly" image plays an important role. Feedback about the impacts of behaviour on energy consumption are an important motivation to continue conservation, especially for company employees.

Conservation possibilities through behaviour, e. g. "turning off equipment" must be broadcast in a suitable way. It is not recommended to make behaviour a main topic. The information must be specific to the target group involved and integrated in brochures, further training seminars, manuals, advice guidelines etc. Any actions such as, for example, "energy week", "energy models" or competitions within and between companies should be specifically promoted. It should be examined whether the "Fifty-fifty" model of schools can be adapted for administrations and if the staff could profit from energy conservation.