Energy sufficiency policy: how to limit energy consumption and per capita dwelling size in a decent way

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Abstract
Energy sufficiency has recently gained increasing attention as a way to limit and reduce total energy consumption of households and overall.

This paper presents selected results of a research project funded by the German Federal Ministry of Education and Research that examined the potentials and barriers for energy sufficiency with a focus on electricity in households, how household members perceive sufficiency practices, and how policymakers could support and encourage these. Bottom-up calculations for an average 2-person household in Germany yielded a total electricity savings potential from energy efficiency and sufficiency combined of theoretically up to 75 %.

The continuous growth of per capita living space was identified as one important driver for additional energy consumption both for heat and electricity. The paper will present findings of a representative survey of 600 persons responsible for the housework. It revealed that a part of the households is already practicing sufficiency options or are open towards these. Up to 30 % of these households can imagine, given the right conditions and policy support, to move to a smaller dwelling or to share an apartment with others when they are older.

Results of a first comprehensive analysis of an energy sufficiency policy to encourage and support households to sufficiency practices form the second part of the paper, with a focus on the feasibility and potential effectiveness of instruments for limiting the growth in average living space per person. This includes a case study on fostering communal housing projects as a measure to reduce living space. Further, the feasibility of a cap scheme for the total electricity sales of a supplier to its customers was examined. Instruments supporting energy-efficient and sufficient purchase and use of equipment complete the integrated energy sufficiency and efficiency policy package.

The paper will finally present the project's conclusions on an integrated energy sufficiency policy package resulting from this analysis.

Introduction and methodology overview
In the last four decades, energy efficiency increased significantly in OECD countries (IEA 2016). However, only during the most recent years, total energy consumption started to decrease a little in some countries including Germany, and much more slowly than energy efficiency potentials would suggest (IEA 2014). Sufficiency (e.g., Sachs 1993) and particularly energy sufficiency (e.g., Wilhite&Norgard 2003; Darby 2007; Calwell 2010) has therefore gained new attention as a way to limit and eventually reduce total energy consumption of a household or a country overall.

The project "Energiesuffizienz (Energy Sufficiency - strategies and instruments for a technical, systemic and cultural transformation towards sustainable restriction of energy demand in the field of construction and everyday life)" funded by the German Ministry for Education and Research has examined what energy sufficiency actually is, and what householders, household members but also manufacturers and local authorities could do to make electricity use of households more sufficient.

A broad mix of methods was used for the analysis: starting from a definition of energy sufficiency (cf. next section), a criteria-based analysis of options for energy-sufficient practice in the household was performed. This was informed by results of cultural probes and co-creation workshops, qualitative interviews, design criteria for domestic appliances enabling energy sufficiency, an analysis of energy saving potentials from options for energy sufficiency action by households and manufacturers, a focus group on gender issues, and a representative survey. All of this research work formed the basis for the policy analysis.

The focus of this paper is twofold: (1) presenting findings of a representative survey of 600 persons responsible for the housework, and (2) providing an overview of the results of the first comprehensive analysis of an energy sufficiency policy performed in this project. The paper thus builds on two papers for the 2015 eceee Summer Study (Brischke et al. 2015, Thomas et al. 2015), which presented earlier work, e.g. energy saving potentials from energy sufficiency, design criteria for domestic appliances enabling energy sufficiency, and the methodology for the policy analysis in more detail.

This paper is organised as follows: First, we wish to briefly recall the definition of energy sufficiency developed in our project. The next section presents selected results of the representative survey. After a short presentation of the method for policy analysis, the second main part is presenting the resulting integrated energy sufficiency and efficiency policy package, followed by short conclusions.

Energy sufficiency – definition

In terms of its objectives, energy sufficiency is a strategy aiming at a limitation and reduction of the input of technically supplied energy towards a sustainable level. Besides energy consistency (particularly the use of renewable energies) and energy efficiency, it is the third strategy for sustainability in the energy sector. Energy efficiency reduces energy input while keeping the utility/services from energy constant. With energy sufficiency, energy consumption is reduced *while the utility/technical service changes in quantity or quality*. Therefore, energy sufficiency aims at the corresponding changes in energy-relevant consumption and decisions with regard to the use of equipment. It also takes into account fundamental changes of energy-relevant aspects of lifestyles and social practices. Both aspects are linked with changes in the utility aspects of technical appliances (e.g. the cooling capacity) and changes in further utility aspects of consumption goods and services (Fischer et al., 2013). As the concept requires changes in the utility or technical service from equipment, energy sufficiency is not the sole responsibility of the individual: it needs to distinguish between demands and needs created by the caring economy (e.g. provision of clean clothes and food) and personal needs and wishes e.g. for entertainment. And it needs to take into account the necessary infrastructure and equipment design to enable energy-sufficient practices, as well as potential restrictions against such practices or changes in utility.

Energy-relevant decisions of private households can be found on various decision levels:

- Decisions related to the purchase or not of equipment (e.g. purchase of a television)
- Decisions related to the technical utility aspects of equipment such as performance, capacity, technological features (e.g. size of the television screen)
- Decisions related to further utility aspects, such as status symbols, social belonging or differentiation, health and esthetical aspects (e.g. extra big television with special technological features as a status symbol)
- Finally, decisions related to the duration or intensity of use of existing equipment.

The ultimately provided utility of technology depends on a chain of effects that starts with basic needs independently from cultural factors. These are translated into concrete culturally influenced demands, which are translated into required utility aspects. The respective aspects are then translated into the required technical utility, which is influenced by the equipment and the use of technology. Along this chain, cf. Figure 3, the three basic energy sufficiency approaches – **reduction, substitution and adjustment** – can have an effect on the energy demand. A more detailed elaboration of the definition of energy sufficiency was presented elsewhere (Brischke et al. 2015, Thomas et al. 2015).

Empirical results of a representative survey

The research project carried out a representative survey among 600 persons who are responsible for the housework. It built on the analysis of options for more energy-sufficient practices in the household and by individual. Due to time limitations for the telephone interviews, it needed to focus on clothes washing and drying as an example of housework and on entertainment. Facts and perceptions regarding per capita dwelling floor area were another focus.

The research revealed that many German households already carry out energy sufficiency practices. Mostly these options are small changes in daily routines that have for many years been communicated under the labels “energy conservation” or “energy-saving behaviour”. In contrast, more profound changes are practiced more seldom and there is less openness towards these. An example are practices in the process of clothes washing. More than 50 % of the interviewed stated that they already try to wash full machines and with lower temperatures. Including the ones who are open to these practices, about 80 % of interviewees are willing to adopt them. In contrast, the much more profound change of sharing the washing machine, thereby reducing grey energy and the space required, is only practiced by 8 % of those interviewed. However, an additional 14 % of respondents, who live in multi-apartment buildings and could thereby potentially share a washing machine, could imagine doing that in the future. Main reasons for others to reject this option are that they don’t want to be dependent on others and their mistrust in the neighbours. A similar outcome was observed for the option of a washing service. The main reasons for the rejection of this option are the fear that strangers could come into the house, intimacy, the enjoyment of washing clothes, and financial reasons (see Figure 1).

Another important field for energy sufficiency is the constant increase of living space in the past decades. It was found that these increases are related to increasing energy consumption and thereby counteracting the potential energy savings of en-

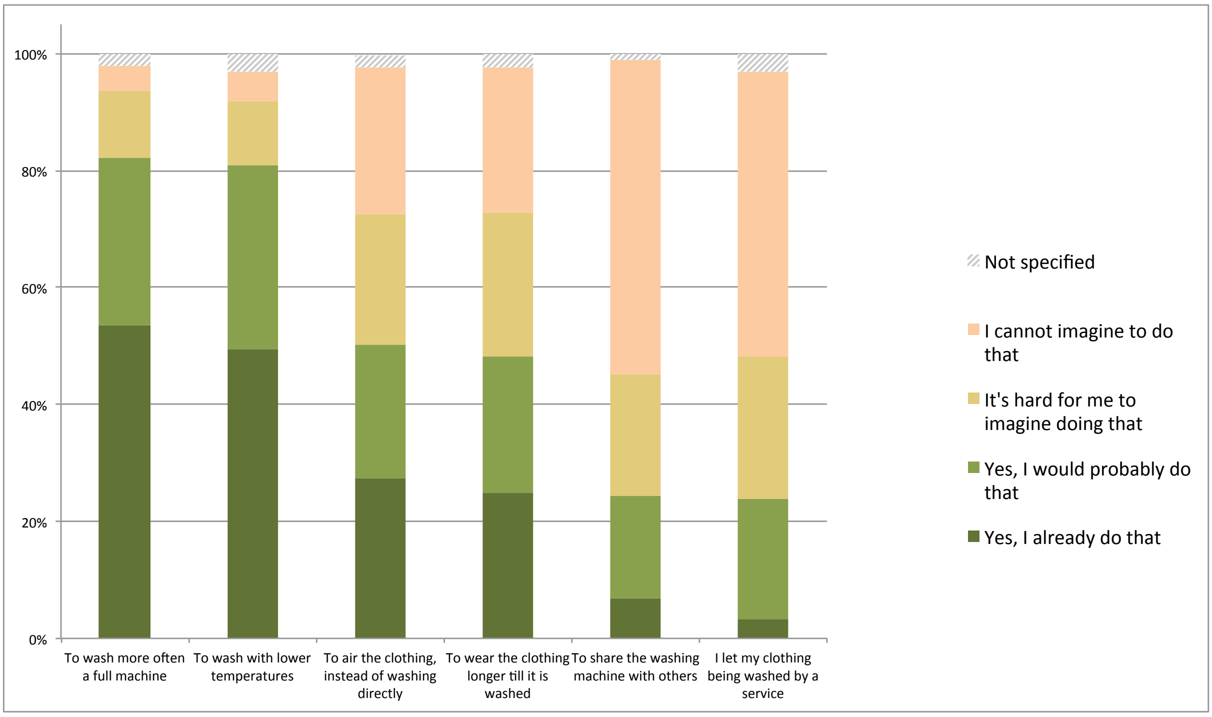

Figure 1. Answers of interviewees with regard to different aspects of the cleaning of clothes (N = 601, except option 5: selection of interviewees living in multi-apartment buildings, N = 378).

ergy efficiency measures. There is a variety of households (for example, pensioners, couples whose children moved out, or after separation of a couple) which could be interested in smaller living spaces. Big living spaces are for some people not only a luxury that is enjoyed but also a burden. This space not only needs to be heated, it also has to be cleaned and cared for.

These households face, however, two main difficulties. First, the rent even for newly rented smaller flats is often higher than the current one for a big flat, in which the tenant may have lived for many years. Secondly, people want to stay in their neighbourhood, where they know the infrastructure and have their friends and social networks. Our policy recommendations to reduce or overcome these obstacles are presented in a later section.

In the survey for this project, 10 % of the interviewed think their flat is "too big" (see Figure 2). Their living space per capita is about 78 m^2. They are typically owning the flat and are older citizens (54.4 % are older than 60) and are single or in couple. 5 % of those who rated their apartment as being right or too large were pleased to say that they would like to move into a smaller apartment, and 34 % can imagine this under certain conditions (including not leaving their present neighbourhood, no increase in rent, and support through policy instruments). These 5 and 34 % are 4 and 27 % of all respondents, respectively.

If households with at least two people are asked what they would do if their household size shrank in the future: 22 % of them say they would like to move and 37 % under conditions. 22 % of these households with two or more persons (i.e. 13 % of all respondents) can imagine moving to a shared apartment; even 29 % of the households with at least two people (i.e. 17 % of all respondents) can imagine living in a multi-generation house. What is, then, the potential impact of supporting a move through policy instruments? According to the survey results, the potential of those who could already today consider moving in any case or with the support of the instruments is about 10 to 15 percent. With fewer persons per household in the future, this potential will increase to 17 to 23 percent.

Methodology for policy development

The process of analysis we developed and used for the final development of an integrated energy efficiency and sufficiency policy package for electricity use in the household has been described in detail in Thomas et al. (2015). An updated graphical presentation is provided in Figure 3. Any sufficiency action or intervention follows one of the three basic energy sufficiency approaches – reduction, substitution and adjustment – and changes the translation chain from basic needs (left) to the finally supplied technical service. The first three steps of the analysis concern (1) each demand, need, or desire, (2) the current situation, and (3) the potential energy sufficiency actions for changing practices regarding this demand, need, or desire. Steps 4 to 7 of the policy analysis are presented in the four bars to the right of the graph: (4) the analysis of prerequisites and framework conditions needed for households and their members to make the change in practices happen; (5) the sustainability check: is the action reducing energy and resource demand, and socially acceptable? (6) the analysis of the need for energy sufficiency policy and (7) integrating the single policies to a consistent package.

The energy sufficiency and efficiency policy package

In this chapter, we present a summary of the findings of our analysis on the policy package to support energy sufficiency. All instruments target the *micro level* of the individual and/or

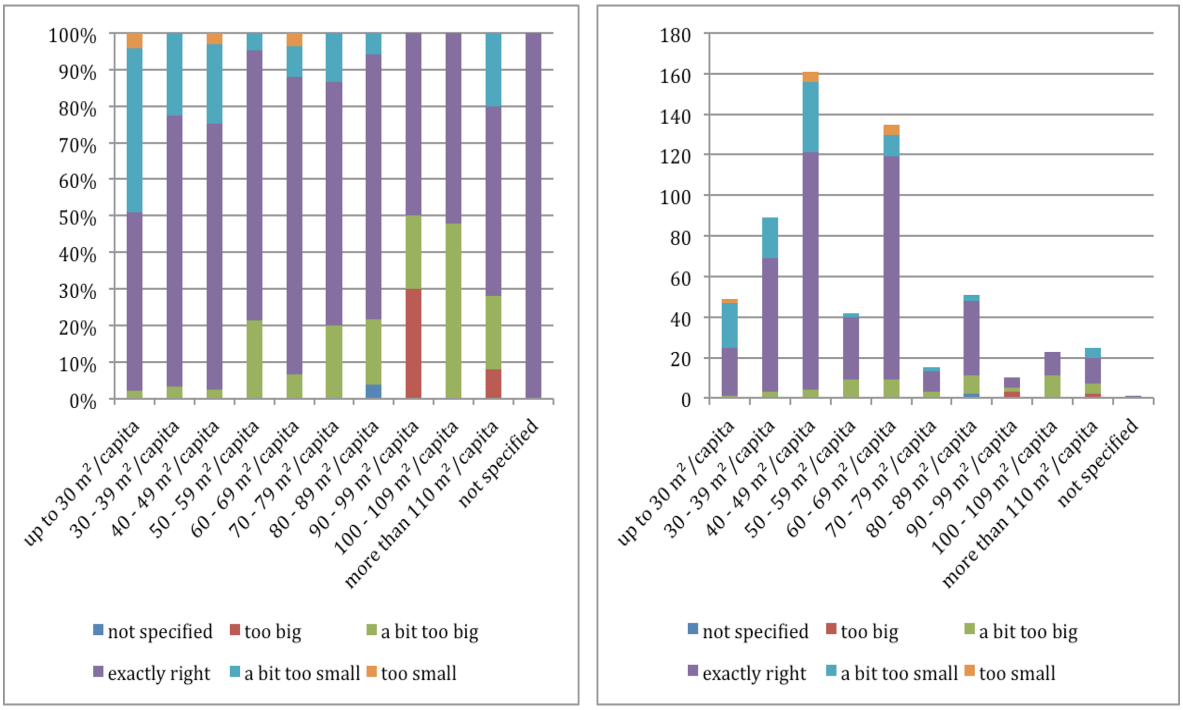

Figure 2. Answers of interviewees to the question of how they would assess their flat with regard to the size in relation to the per capita living space they live on (Left graphic: percentages, right diagram: number of respondents (N = 601)).

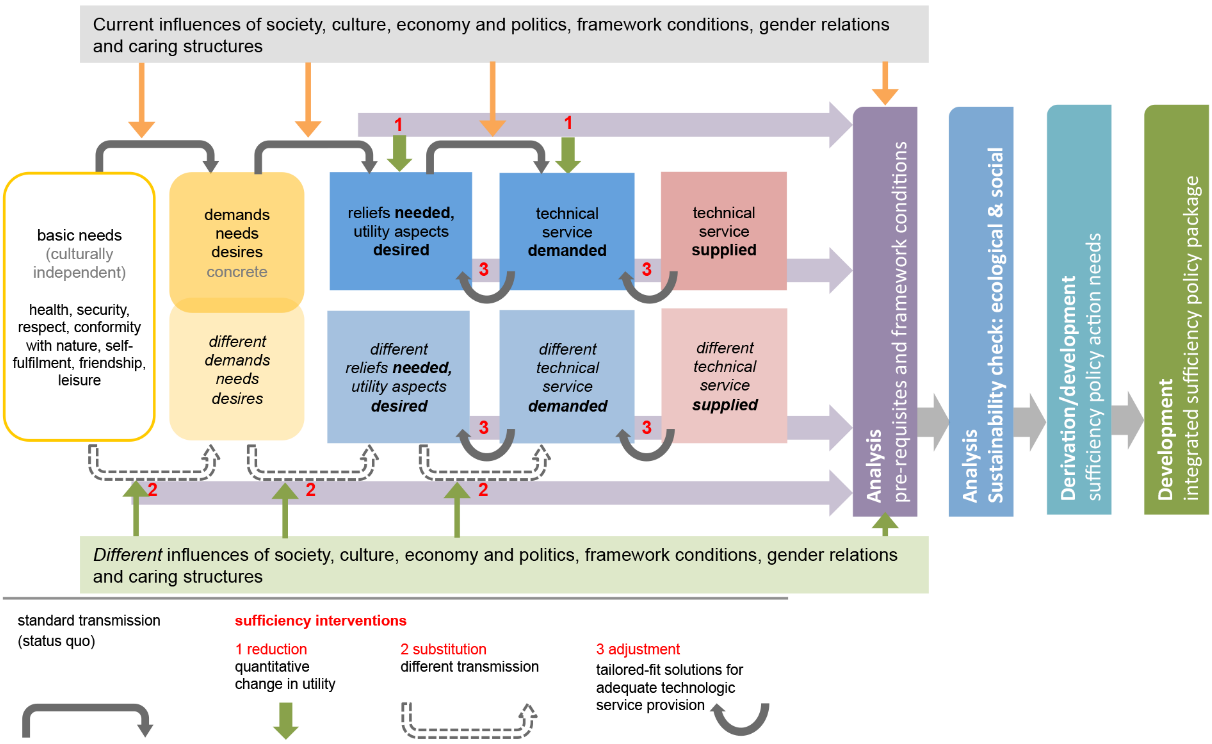

Figure 3. Standard transformation chain of the determinants of household energy consumption and methodological approach towards developing integrated energy sufficiency policy packages.

the *meso level* of the household and its environment (building and neighbourhood). For a fully integrated policy package, an analysis of instruments to control the macro drivers of energy consumption would need to be added (Thomas et al. 2015). However, this was not possible in this project. Therefore, we aimed at an integrated policy package for energy sufficiency and efficiency at the micro and meso levels, which also addresses average per capita dwelling floor area.

INSTRUMENTS FOR LIMITING AVERAGE DWELLING FLOOR AREA PER PERSON

For many end uses of electricity in the home, demand depends on the dwelling floor area per person, although usually not in a linear fashion, e.g. lighting, refrigeration and freezing, or TVs. More room space, which is mostly available to higher-income households, allows for more and bigger appliances—also easier to afford purchasing for the wealthier. Therefore, instruments for limiting average dwelling floor area per person will be an important part of the energy sufficiency policy package. They will address one important driver of energy consumption and non-sufficiency.

Events in life such as children moving out to their own household, divorce or separation of partners, or the death of a partner will create phases, during which routines and practices may change dramatically. Usually, this will also have a financial impact. Such phases are, therefore, also a window of opportunity for policy instruments supporting the move to a smaller apartment or the (sub-)letting of a part of the house or flat. In principle, the macro drivers for the growth of per capita dwelling space, such as increasing income and wealth, should also be addressed by policy. However, it is at present unclear how this could be done.

In this project, we therefore analysed concrete instruments to support the move to a smaller dwelling, forms of communal housing, or (sub)letting a part of the home or flat. We see a major role in implementation for the municipal administrations, which however will need law-making and financial support from the federal and state governments. Three particular instruments were analysed in our project:

- Municipal living space agencies, offering a combination of living space advice, practical support for moving, and the provision of financial support
- Financial incentives for alternative forms of housing and the dwelling space needed for them
- A cap on dwelling floor area per person as an overarching instrument.

Municipal living space agencies: living space advice, practical support for moving, and the provision of financial support

In addition to two barriers mentioned above, moving to another home requires a lot of effort and money for the search, the renovation, and the actual moving. When moving to a smaller dwelling, there may be excess furniture. Municipal living space agencies providing living space advice, practical support for moving (e.g. for the search of a smaller dwelling and for the organisation of the moving; swapping dwellings between young families growing and elderly declining in numbers could be of interest too), and the provision of financial support could be a combination able to overcome these barriers for many more households than each of these instruments alone. For example, the effectiveness of information platforms for dwelling exchange is very limited, as the survey confirmed, with less than 5 % saying this would be enough. Especially for households moving into a dwelling they own, the advice should be coupled with an individual energy efficiency and sufficiency advice.

The financial incentives should be funded by the central government but handed out or allowed through the municipal agencies. They could take several forms, from waiving a tax for the acquisition of real estate, or property taxes for some time. Bonus payments to older couples who sell their houses in favour of bigger families might be possible as well. Tenants could receive direct payments or an aid to the new rent for some time, all could receive a grant on the costs of moving. Incentives could also be given to those sharing their dwellings.

Potential: What is the potential impact of supporting a move through policy instruments? For example, 7 TWh of heating energy could be saved a year if by 2030, 20 % of the 4 million pensioner households in Germany decided to move into smaller flats or share the flat with others. This corresponds to 1.81 million t CO_2/yr (cf. Fischer et al 2016). According to the survey results, the potential of those who could already today consider a move in any case or with the support of the instruments is 10 to 15 percent. With fewer persons per household in the future, this potential will increase to 17 to 23 percent. This is about ten times the number of households on which the energy saving potential cited above as calculated by Fischer et al (2016) is based.

Financial incentives for alternative forms of housing with smaller per capita area and the dwelling space needed for them

For Germany, Fischer et al. (2016) found that the number of small apartments is too small to allow a big exchange of dwellings, unless the number of people in the household changes. One solution could be to provide incentives for separation of large homes or flats to smaller ones. Our survey, however, suggests that what people want is rather to move back into bigger communities, such as shared flats or multi-generation housing. Large potential therefore seems to rest in the support for such projects. If, for example, older people leave their houses they will look for barrier-free apartments. If the apartment is small and the children come for a visit, it will be necessary to have guest rooms. In cities with shortage of dwelling floor space, such approaches are occasionally already applied today. In addition to shared flats or multi-generation houses they include other communal housing projects with shared rooms for fitness, hobbies, festivities, guests, but also the re-use of already existing buildings, including non-residential buildings. Some examples were presented in Thomas et al. (2015).

In addition to financial incentives, policy may also support such approaches e.g. through public architectural competitions or requiring that any such competitions should include guidelines and requirements for less living space per person.

Potential: If households with at least two people are asked what they would do if their household size shrank in the future, 22 % of these households (13 % of all respondents) can imagine to move to a shared apartment, and even 29% of the households with at least two people (17 % of all respondents) can imagine to live in a multi-generation house. This is likely to be the case for many of those living as a single-person household too. It will probably take many years to enhance the supply of buildings for multi-generation housing to the level needed to satisfy such a high demand even with a financial incentive programme, whereas the reconstruction of dwellings supporting shared households may be possible much more quickly. Still, we expanded on communal housing and how it could be supported by municipalities in a case study.

Communal housing – a high-quality and climate-friendly role model?

Can communal housing enable individuals to lead a more energy sufficient lifestyle? Is it possible to reduce energy consumption by sharing infrastructures and living spaces? Which barriers and chances do communal housing projects face? These and more questions lead to an investigation of other, new forms of housing within the research project.

Two important insights that are closely tied to energy sufficiency stood at the beginning of this investigation. First, several studies show decreasing electricity consumption per capita the more people live within the household. In a single household in Germany, the average electricity consumption is about 1900 kWh/yr/capita. This figure decreases to ca. 1200 kWh/yr/capita in a four person household (Frondel et al. 2013; Lehmann 2013). Whether this reduction is because today four-person-households are often families with children that use less energy or if it holds for communal housing projects was not possible to clarify due to a lack of studies. However, an argument for a potential is that in communal housing projects habitants can more easily share some appliances like freezers or even fridges with their co-habitants. Secondly, decreasing household size is strongly linked with an increase of living space per capita. In Germany, a continuous increase in living space per capita can be observed from 34.9 m² in 1991 to 40.7 m² today with a projection of about 45 m² per capita in 2030 (Matthes et al. 2013). This development does not only counteract efforts of increasing energy efficiency but also reduces the absolute energy saving potential in the heating sector. With an average of 68.3 m² the per capita living space of single households is the highest, while four-person households only have a per capita living space of 30,7 m² (Umweltbundesamt, 2016). Communal housing projects can help to reduce per capita living space with comparable amenities and comfort by a combination of reduced private living space plus communal or shared living spaces.

But what is meant with the term communal housing projects? These forms of living are characterized by three main criteria:

1. The people living together share a part of the living space between each other. Shared living space means more than for example common hallways in apartment buildings, but also common kitchen, living room or bathrooms.
2. Living together is self-organized. Thereby monasteries, boarding schools, orphanages, nursing homes and others similar to these are excluded from this definition.
3. The people living together are not linked through family ties. Families can be part of a communal housing project, but a family living in a single-family apartment is clearly not such a project.

With this definition, we find two main forms of communal living. One is the well-known flat share that is widely practiced particularly among students in Germany. Another one is a special communal housing project. This form is not yet well known but its popularity is growing in Germany. Future residents are engaging in such projects with different aspects of motivation:

- Some potential residents are searching for living in a community instead of today's anonymity of big cities.
- For others, communal housing is a political project to create low-cost housing by excluding the buildings from the real estate market and thereby minimizing the influence of speculation on the rents.
- In intergenerational projects, people search for housing in comfort and with the help and community of co-habitants.

But all of these projects are characterized by the criteria mentioned above which also bring about ecological, social and economic benefits and co-benefits (depending on the motivation) (Duscha, 2015). A popular and – with regard to energy sufficiency – particularly interesting project is Kalkbreite in Zürich. Some of many aspects of this project are: the per capita living space is limited to 30 m² on average; residents cannot own a personal car; there are common infrastructures for residents such as a room for washing clothes, and a library.

Because of the identified benefits that communal housing possibly brings about, we investigated governance options to support and foster these projects. A case study on existing and possible improvements of governance measures in Heidelberg, including a literature review of measures in other municipalities, was carried out. Among the identified governance measures supporting communal housing are the following:

- Including a reduced or at least not an increasing average per capita living space as conditions for financial support schemes
- Including additional benefits or separate financial support schemes for shared spaces in communal housing and multi-apartment buildings, under the condition that they replace a larger area of individual space
- Creating informational offers like leaflets or advising services (help desks) for interested people
- Integrating communal housing in the urban development plans of municipalities
- Creating lighthouse projects to inform the broader public of these modern, multi-benefit forms of living.

Nevertheless, communal housing is not the only means by which per capita living space can be stabilized or decreased. The co-benefits include other services that can be organised together, social live, shared maintenance and social benefits through a less anonymous environment.

A cap on dwelling floor area per person as an overarching instrument

A centralized cap for existing and new living space would make the incentive and conversion programmes discussed above even more attractive to municipalities: Cities e.g. in Germany are in competition to each other. They are also competing for inhabitants. Interesting new building projects in the housing market are created to attract young families. Each additional taxpayer will increase the income of the city. Thus, it is difficult for the cities to restrict any new build activities: they fear the advantage for neighbour cities. This problem may only be solved by establishing a common target for floor space consumption applicable to all German cities and towns.

A more radical approach for such a regulation might be to allow the building of new, additional houses only in cities with a growing number of inhabitants. Such a regulation would potentially be the most powerful, but certainly a very contentious instrument. As required, they may be allowed to buy or sell rights of dwelling space form shrinking cities. This would satisfy the needs of growing cities but also give an incentive to all municipal authorities to limit new build of dwellings.

In practice, the cap can only be kept through the kind of financial incentive programmes and services for reconstruction and moving by municipalities to their citizens as discussed above. Only with such programmes will it be possible to avoid shortages and excessive rents or purchase prices, and make the cap scheme acceptable. Therefore, the central government will also need to accompany the cap by adequate funding to local authorities. An alternative may be to give the task of implementation and/or funding to energy companies (cf. next section of this paper).

Still, the political resistance against such a legal cap could be too high. In this case, the cap could be set as a strategic but non-binding policy target. The federal and Länder governments would need to monitor compliance with the target and support meeting it through the other instruments discussed above, in connection to regional planning that aims at a balanced development between municipalities in a region.

There are several options for funding the whole housing policy package. They include using revenues from property (acquisition) taxes or energy taxes. Municipalities will save on costs for preparing land for construction. In addition, a luxury tax could be levied for dwelling above a certain size. This would avoid the social problems that came along with a general dwelling space tax (cf. Fischer et al. 2016), which are the reason why we do not propose such a general tax.

Potential: In principle, the cap on dwelling floor area could fully implement the potential for limiting the growth of floor area, in conjunction with the other instruments aiding compliance with the cap. For example, Matthes et al. (2013, p. 25) expect total dwelling floor area in Germany to grow by 6.4 % between 2015 and 2030. Per capita, this means an increase of 10,8 %, from 40.7 to 45.1 m^2. The latter is just a little higher than the existing dwelling stock in 2015, which was 44.2 m^2 per capita, including 8 % of empty dwellings. If Germany succeeds in avoiding the net addition to the stock of 0.21 bn. m^2, and assuming an average energy consumption for heating and hot water of 70 kWh/(m^2*a) and a greenhouse gas intensity of 0.23 kg/kWh (natural gas), the cap will save almost 15 TWh/yr of energy and around 3.4 mn. tons of CO_{2eq}/yr of greenhouse gas emissions. If residential electricity consumption is proportional to dwelling size too, electricity savings of 8.4 TWh/yr and greenhouse gas emissions reductions of 4.2 mn. tons CO_{2eq}/yr may be added.

For 2050, current projections already foresee a stabilisation of total residential floor area, so a cap on this total would not bring any further savings.

ELECTRICITY SALES CAPS AND TRADE

Another innovative instrument was proposed by the German Advisory Council on the Environment (Sachverständigenrat für Umweltfragen, SRU) in 2011. It is a cap-and-trade scheme for the electricity sales to private households of all suppliers in the country. Its basic way of functioning is as follows:

In the beginning, certificates are produced for the total amount of allowed electricity sales in the starting year and allocated to suppliers based on their number and type of customers. This total amount of certificates will be reduced in subsequent years, following a pre-determined path. Suppliers will have to hand in the exact amount of certificates matching their sales each year. If a supplier meets its target, i.e., the number of certificates allocated is the same as its electricity sales in kWh, there will be no need for further action. If the customers saved more energy than targeted, the supplier may sell surplus certificates or bank them. If a supplier cannot motivate its customers to realise enough savings, it will need to purchase the missing certificates from other suppliers with a surplus. This trading element can therefore create flexibility and improve economic efficiency.

This scheme provides a strong incentive for suppliers to support their customers in reducing their electricity consumption through energy efficiency, energy sufficiency, or fuel switching. They have complete freedom as to the ways and services they use to support their customers in reducing their electricity consumption. This is, hence, a policy addressing another important driver of energy consumption and non-sufficiency: the incentive that energy companies have had to increase energy sales. However, a number of details need to be clarified, and its consequences better analysed before such a scheme could be started. The "Energiesuffizienz" project was the first to delve into such more detailed analysis. For lack of space, we can only present the results here.

We found that such an electricity cap and trade scheme is legally feasible in Germany and is likely to be highly effective in reducing the electricity consumption of the customers included. It will need both energy sufficiency *and* energy efficiency to stay within the sales caps, if these are set ambitious enough. In order to implement most of the potential for energy sufficiency and efficiency in Germany that is additional to recent baseline trends, the *sales cap would need to be reduced by around 3 per cent each year*. The scheme will be easy to combine with almost all policy instruments and programmes recommended following the analysis at the micro and meso level, possibly including those aiming at the limitation of average dwelling floor space – financial incentives, information and advice would be offered by the obligated energy companies to their customers – and likely also with existing policies and measures, if interactions are sufficiently analysed and addressed.

However, there are *still many questions in detail* that need to be resolved before implementing such a scheme. These include the sectors covered (only residential or others too?); or whether it should be a mere *electricity* sales cap (carrying the risk of fake savings through fuel-switching away from electricity) or a full *energy* sales cap, which will create a lot of further questions. When adding other fuels than electricity, the unit for the cap needs to be analysed: primary or final (sold) energy, or even emissions, when taking renewable energies and the fuels used for power generation into account. In detailed design, there are questions such as the stochastic fluctuations of consumption between years and between households, and how to avoid undesired effects such as adverse selection – there may be an incentive for obligated energy companies to acquire customers with high or low energy consumption, depending on the rules of setting the baseline.

Due to these open questions, we cannot recommend to implement this new instrument right away but to test it in a pilot scheme. In the short run, governments should implement the micro-/meso-level instruments themselves. In Germany, e.g., the energy efficiency fund of the federal government could be given the additional task of promoting energy sufficiency, along with the necessary funding (Thomas et al. 2013).

INSTRUMENTS SUPPORTING ENERGY-EFFICIENT AND SUFFICIENT PURCHASE AND USE OF EQUIPMENT

Energy efficiency and energy sufficiency should not be seen as opposed to each other but work in the same direction. The ultimate goal is to reduce energy consumption in absolute terms, at least in Germany. More specifically, the German government set the target to reduce electricity consumption by 10 % until 2020 and by 25 % until 2050, compared to the 2008 value (BMWi 2012).

Therefore, some instruments of the energy sufficiency policy package may be the same as for energy efficiency—such as energy taxation, and linear or progressive energy prices. Some may simply adapt technology-specific energy efficiency policy instruments. Examples are progressive appliance efficiency standards, standards based on absolute consumption, or providing energy advice. However, sufficiency may also require radical new approaches, often linked either to substitution routes strongly different from the current technology and practice, or to addressing the drivers of non-sufficiency. They may hence range from promotion of completely different services for food and clothes cleaning, to instruments for limiting average dwelling floor area per person, or to a cap-and-trade system for the total electricity sales of a supplier to its customers, instead of an energy efficiency obligation. In the following subchapters, we expand on a number of these policy instruments.

Energy pricing instruments

Energy taxation is an instrument to internalise external costs of energy supply into energy prices. It thereby increases the energy prices and hence the economic motivation to save energy. This motivation supports both energy efficiency and energy sufficiency alike. Some have observed that energy taxation and the signal for energy sufficiency it sends can also be a measure to counterbalance the rebound effect from energy efficiency action and policy. However, energy taxation alone will not be sufficient to overcome barriers that are not related to the energy price and will therefore not realise anywhere near the full potential, for both energy efficiency and sufficiency.

The same holds true for linear or progressive energy prices. They both improve the price signal for saving energy, including through energy sufficiency. However, currently the energy policy debate is rather for more fixed price elements to cover network and reserve costs also for those who self-generate with solar PV, hence even more degressive energy prices. Maybe energy sufficiency can provide an argument against such trends.

Sufficiency-oriented product policy

For appliance energy labels and standards, a sufficiency-oriented product policy implies a move from specific to absolute metrics (e.g. kWh/cycle not kWh/kg/cycle) and from linear to progressive requirements. In our example of clothing hygiene, the current EU energy label has energy efficiency defined in relation to a baseline calculated in terms of kWh/kg/cycle, i.e. per kg of full load capacity of the washing machine. Even though an intercept value was introduced, it probably still is easier for manufacturers to achieve the highest efficiency label classes A+++ and A++ with larger machines, so this is a clear signal to increase capacity. This may well have been a driving force behind the observation that currently clothes washers with 7 or 8 kg of capacity dominate the market, while 20 years ago, 5 kg of capacity was most common (Ecofys 2014). This trend is a barrier to energy sufficiency, which would call for smaller appliances. Defining the energy efficiency baseline in kWh/cycle may be able to revert this trend and hence support energy sufficiency in the purchasing decisions of EU households. Similar changes may be required for other types of appliances. For refrigerators or TV sets, e.g., progressive standards with a maximum absolute level would be appropriate (Calwell 2010), for other product groups an absolute maximum energy consumption alone may be sufficient, as is already the case for vacuum cleaners.

Labelling and ecodesign requirements should also oblige manufacturers to install an automatic switch-off after a time to be determined for appropriate types of equipment. All programmes and settings should directly display the data on their electricity consumption (such as for washing and drying cycles, filling level of kettles, refrigerator settings, radiator thermostats). ICT appliances should carry clear information on multicompatibility.

Brischke et al. (2015) present more detailed conclusions for the future development of energy labelling and ecodesign.

Energy sufficiency advice

As for energy efficiency, lack of information and motivation can be an important barrier to implement energy sufficiency actions in the purchase and use of appliances or the alternatives. Personalised energy sufficiency advice can be much more effective than general publicity and information campaigns in making people aware of their own options and in convincing them of advantages or that e.g. perceived health risks are not a problem. For cost and effectiveness reasons, such advice should be integrated with advice on energy efficiency options.

In our example of clothing hygiene, advice would particularly concern actions such as wearing clothes longer, airing instead of washing, washing at full loads only, and reducing wash temperatures and spin speeds, unless a drier is used. It could also relate to actions that need external infrastructures and services if these were available in the building or neighbourhood, such as communal laundry facilities in multifamily houses, laundries in the quarter, or laundry services in combination with an additional refreshing cabinet in the home, and to financial incentive programmes for any of these.

Financial incentives

Financial incentives, such as grants or tax deductions, may be justified for the purchase of energy-sufficient products, e.g., smaller washers, refrigerators, or TV sets. Vice versa, higher taxes could be levied on less sufficient products. Waiving the scrapping costs for old but still working appliances would be an incentive for scrapping instead of keeping them, when a new one is bought anyway, and thereby also promote energy sufficiency. Promoting and facilitating repair instead of purchasing new appliances may not always reduce energy consumption but be a sufficient practice saving resources too.

Promotion of energy-sufficient services

In some cases, energy-sufficient services can be substitutes for appliances we use today in the home. Their market breakthrough may require promotion through public awareness, information, and motivation programmes, but their establishment may also need financial incentive programmes and/or public investment, at least for some initial demonstration facilities and businesses.

In our example of clothing hygiene: To the extent that communal laundry facilities in multifamily houses, laundries in the quarter, or laundry services and refreshing cabinets in the home will actually save energy, financial incentive programmes and/or public investment for such infrastructures and services could be justified. In addition, public awareness, information, and motivation programmes for households to use these alternatives to an own washing machine could be essential to support them.

Securing and creating the energy-sufficient infrastructure

Households will only be able to perform some types of energy-sufficient practices, if the necessary infrastructure is available to them at all. Examples are places for hanging clothes to dry outside or in the loft, or cool storage rooms that may partially substitute refrigerators. The legal requirements should be created in tenant or building (refurbishment) legislation to allow external drying and to at least safeguard existing drying or food storage rooms in residential buildings. New build of such rooms may not reduce the overall energy consumption, given the 'grey energy' of the materials needed.

General requirements

A number of energy-sufficient practices may not need financial investment, but additional coordination efforts or time. This requires to safeguard sufficient time budgets and windows for housework. And it creates the need for changes in the professional economy in order to take the caring economy into account too.

It is also important that energy sufficiency policy is designed and implemented in a way sensitive to the individual vulnerabilities, restrictions (e.g. financial shortages or lack of the necessary infrastructure), and particularly to the demands from caring and being cared for, as well as for the needs of those doing the caring or being cared for. This is equally relevant for the instruments on the micro and meso level discussed above as for the overarching instruments for limiting average dwelling floor area per person or electricity sales. Detail can be found in the criteria-based analysis of energy sufficient practices (Thema et al. 2015) and in Spitzner und Buchmüller (2016). A professional training corresponding to these sensitivity requirements for businesses, administrations, policy, and particularly for consultants is a necessity too.

In addition, both the caring economy and energy sufficiency should be defined as tasks of consumer protection, along with the necessary rights and funding. This includes representation of the rights of households vis-a-vis the relevant infrastructure and service providers.

AN INTEGRATED ENERGY SUFFICIENCY AND EFFICIENCY POLICY PACKAGE

An integrated policy to advance energy sufficiency and efficiency needs to address the manifold preconditions, barriers, and situations faced by households and market actors, if it is to succeed. Figure 4 provides the overall picture of the micro- and meso-level approaches and instruments for supporting energy sufficiency that we analysed. On the one hand, they promote more energy-sufficient and energy-efficient practices and decisions for energy-related products in an integrated way. On the other hand, they aim at limiting the increase in per capita dwelling space, which has been an important driving factor increasing household energy consumption so far.

Both for product and dwelling space policy, a *combination of an instrument creating a binding overarching target with concrete instruments of financial incentives, advice, and regulation* appears most promising and successful. For target setting, an electricity sales cap – if the open issues for this instrument can be solved – or an energy efficiency and sufficiency fund can provide this function for the energy-related products, while a cap could be put on average dwelling floor area too. The latter needs clarification of whether it could be legally binding or just serve as a policy target.

In addition, we found that there is the need to develop instruments that *limit the macro drivers of energy consumption* (cf. Thomas et al. 2015), but did not have the resources to analyse what these could be in this project nor any other project so far.

Conclusions

What did we learn from our analysis of guiding principles, methodologies, concrete policies and measures, and a comprehensive policy package for energy sufficiency? On the one hand, energy sufficiency actions and the policy support they need are

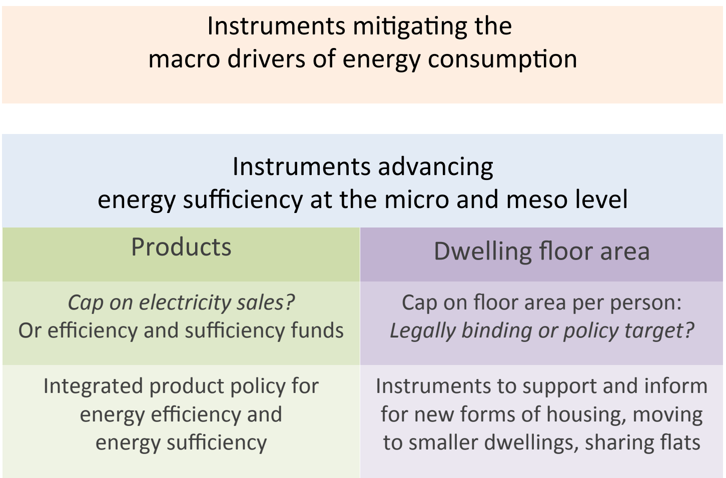

Figure 4. Overview of approaches in the integrated energy sufficiency policy package; instruments with a question mark need further research.

more different from energy efficiency than we thought at the outset of the work: With sufficiency actions, utility aspects are reduced or change qualitatively; and because of substitution options, the analytical approach cannot follow a single product type (as with efficiency) but has to follow rather a field of needs/ care economy domains. On the other hand, the resulting policy package for energy-related products looks quite similar overall to well-known energy efficiency policy package. However, energy sufficiency policy has to deal with all the gendered aspects of the care economy and more generally with norms and social practices determining the demand for technical services, which are not as relevant for energy efficiency, because the latter does not imply a change in the demand for technical services. Taking these preconditions on board, it has been possible to modify the energy efficiency policy package to include sufficiency, and to develop a first set of policies for limiting the growth of average dwelling floor space. Implementation of the latter, however, will also need to avoid increasing needs for transport.

As some services and practices that need to be developed as well as some instruments in the policy package are quite new, policy experimenting may be needed to create good practice case studies before broad implementation. Future work will need to test, evaluate, and refine the micro and meso level policies in this sense, but also to take a closer look at the macro drivers of energy demand, and how policy could contain them.

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