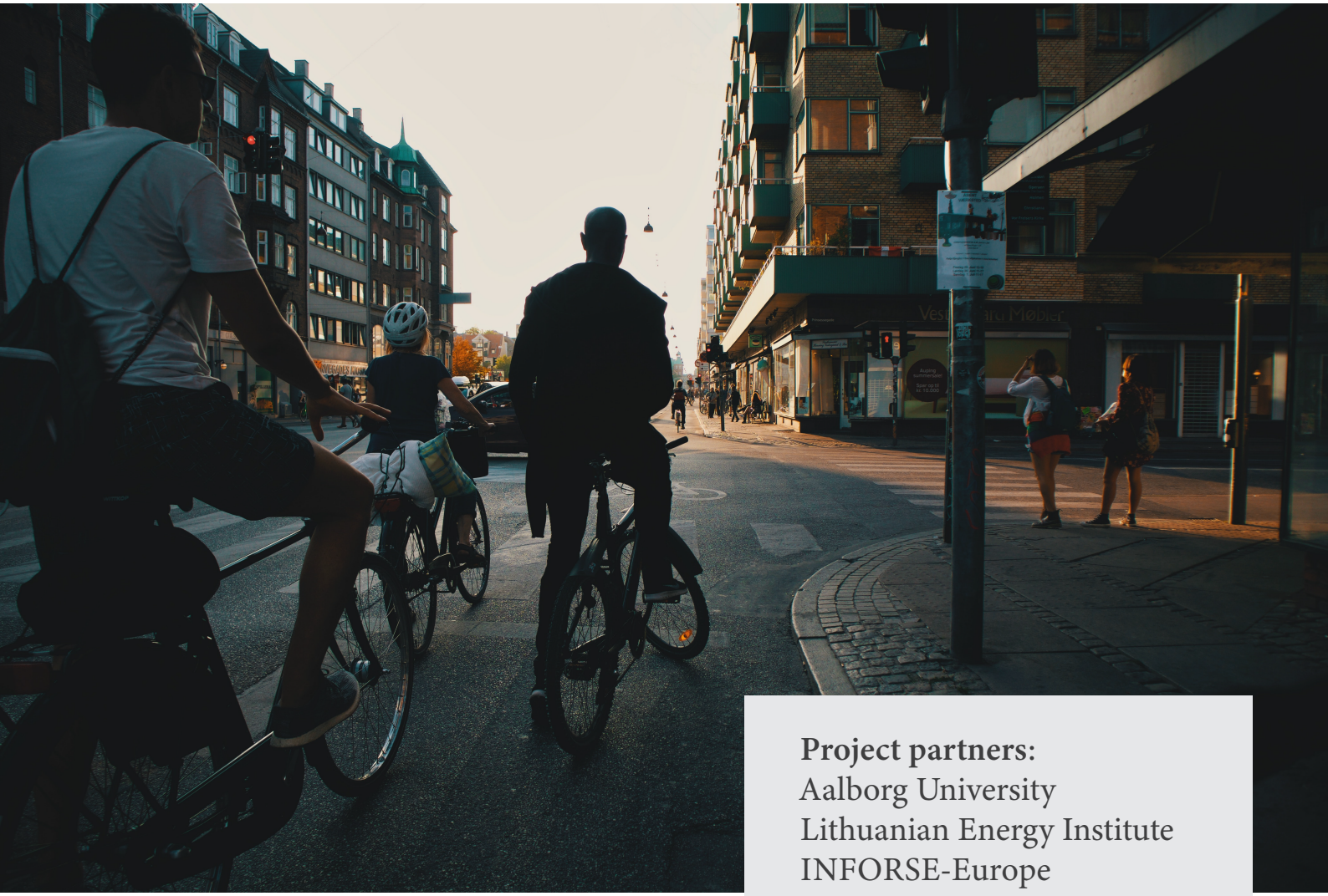
Systematisation of experiences with energy sufficiency initiatives



Project partners:
Aalborg University
Lithuanian Energy Institute
INFORSE-Europe
Green Liberty Latvia

Integrating Energy Sufficiency into Modelling of Sustainable Energy Scenarios
- A project funded by the Baltic Nordic Energy Research Programme

Systematisation of experiences with energy sufficiency initiatives

Project Acronym	IESIMOSES
Title	Integrating Energy Sufficiency into Modelling of Sustainable Energy Scenarios
Deliverable	Work package 2 “Systematisation of experiences with energy sufficiency initiatives”
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Funded by	The Baltic Nordic Energy Research Programme
Date of deliverable	31.03.2022
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Citation (APA):

Jørgensen, M. S., Brizga, J., Lekavičius, V., Olesen, G. B., Jensen, C. L., Røpke, I., Rasmussen, R. V., Vikkelsø, A., & Kronby, H. (2022). Systematisation of experiences with energy sufficiency initiatives. WP2 report from “Integrating Energy Sufficiency into Modelling of Sustainable Energy Scenarios”.

Project overview:
Integrating energy sufficiency into modelling of sustainable energy scenarios

The project was funded by the Baltic-Nordic Energy Research Program and took place 2020-2022. The project partners were Green Liberty (Latvia), INFORSE Europe (Denmark), Lithuanian Energy Institute (Lithuania) and Aalborg University (Denmark). The project was coordinated by Aalborg University. The project had an observer group with members from AirClim (Sweden), Finnish Nature Conservation Society (Finland), Naturvernforbundet (Norway), Association négawatt (France), and Stockholm Environmental Institute (Tallinn Office, Estonia).

The project objectives were:

1. Integrate sufficiency aspects into energy modelling tools applied for development of sustainable energy scenarios
2. Develop modified Danish, Latvian and Lithuanian national sustainable energy scenarios, which build upon the combination of sufficiency, efficiency and renewable energy
3. Create national policy dialogues among public and private actors in the Nordic and Baltic countries about energy scenarios that include energy demand changes from a sufficiency perspective and discuss the feasibility of these scenarios and the possibilities and limitations for socio-economic and regulatory changes enabling transition towards these scenarios
4. Disseminate the methodology for integration of sufficiency into energy modelling tools and development of scenarios, and disseminate the experiences with developing and applying these tools and scenarios to Nordic and Baltic stakeholders and to scientific journals

The following reports are available from the project:

Systematisation of experiences with energy sufficiency initiatives (Work package 2):
The report presents the applied understanding of energy sufficiency in the project and gives a literature-based overview of energy sufficiency actions within energy consumption in households and within mobility respectively. Furthermore, the report presents data, which enables integration of sufficiency actions into energy modelling.

Integration of sufficiency into energy modelling tools (Work package 3):
The report describes how sufficiency-based changes in energy demand within energy consumption in households and within mobility can be quantified at national level and can be included through exogenous and endogenous modelling approaches in EnergyPlan and MESSAGE modelling tools.

Development of adjusted national sustainable energy scenarios (Work package 4):
The report analyses how much energy sufficiency measures can contribute to the reduction of national greenhouse gas emissions. The report presents revised national sustainable energy scenarios for Denmark, Latvia and Lithuania based on the EnergyPlan and MESSAGE modelling tools with the integration of energy sufficiency.

National policy dialogues (Work package 5):
The report presents the developed concepts for national policy workshops aiming at exploring how policy measures can influence preferences for sufficiency-based reductions of energy consumption. Furthermore, the report presents the experiences from the national policy dialogues organised in Denmark, Latvia and Lithuania.

Dissemination to other Nordic and Baltic countries (Work package 6):
The report presents the experiences from a two-day workshop with dissemination of perspectives on and methods within energy sufficiency to Baltic and Nordic countries that were developed in the project. Furthermore, the report presents the joint cross-national discussions and experience sharing among the participants at the workshop. Finally, the report presents ideas for further research and knowledge development within energy sufficiency.

The reports can be requested by sending an email to the project coordinator Michael Søgaard Jørgensen, Department of Planning, Aalborg University, Denmark at msjo@plan.aau.dk

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1.0 Introduction

The report has been written as part of the project “Integrating energy sufficiency into modelling of sustainable energy scenarios”, which is funded by The Baltic Nordic Energy Research Programme. The project is coordinated by Aalborg University and conducted in collaboration between Aalborg University, INFORSE-Europe, Lithuanian Energy Institute and Green Liberty Latvia. The aim of the project is to contribute to the development of more advanced strategies for systemic, sustainable transition of energy production and use, based on new social practices that reduce energy consumption. This contribution is met through developing new, improved national 2030 energy and climate scenarios based on the feasibility of reaching a net-zero emission and 100% renewable energy system by 2050. Besides building upon existing national sustainable energy scenarios, the new scenarios developed in the project integrate experiences from recent national sustainable energy practice initiatives within the categories; household energy consumption and mobility.

This report is a deliverable of work package 2 “Systematisation of experiences with energy sufficiency initiatives” and presents the applied understanding of energy sufficiency in the project and gives a literature-based overview of energy sufficiency actions within energy consumption in households and within mobility respectively. Furthermore, the report presents data which enables integration of sufficiency actions into energy modelling.
In pursuit of this contribution, the report systemically analyses literature on experiences from sustainable energy experiments and initiatives, identified in research reports and scientific articles, with the purpose of identifying possibilities for changes in social practices toward sufficient energy usage. The concept of energy sufficiency is discussed through the report and means, in short, changes in social practices that reduce energy consumption without exceeding lower social limits.

The aim of integrating energy sufficiency in the modelling of future energy scenarios, stems from the need for more actions to reduce greenhouse gas emissions to reach a net-zero emission and 100% renewable energy system by 2050. New climate targets have been and are being agreed upon and promoted in attempts to reduce greenhouse gas emissions (GHG-emissions) and aim at decarbonisation. However, the current scale and approaches to achieve these targets are insufficient to achieve the necessary scale of changes for a sustainable transition in energy systems. Increased integration of renewable energy sources contributes to the decarbonization of the energy supply and on the demand side, technological energy efficiency developments provide a reduction in energy consumption. However, current energy efficiency policies are not appropriately dealing with the complex aspects of final energy consumption, and the social and cultural aspects of energy use - a realisation which is asserted and argued by Jensen et al. (2019). Hence, a decarbonised energy supply (particularly via renewable energies), along with energy efficiency are necessary, and energy sufficiency is thus an additional and the third strategy for sustainability in the energy sector.

This project (IESIMOSES) builds on the conviction that all three approaches will need to be employed to provide the necessary reductions in GHG-emissions with both sufficiency and efficiency initiatives to reduce energy consumption. Thus, combining these perspectives and approaches create new demands for both energy modelling and policies. The project is a contribution to the efforts of integrating changes in energy related social practices in the development of consumption-based energy scenarios. Additionally, the project contributes to considerations about new policy measures and instruments concerning sustainable energy transitions.

The findings of this report have been applied in the further development of two energy modelling tools (EnergyPlan and MESSAGE) with the integration of sufficiency measures (reported in work package 3 “Integration of sufficiency into energy modelling tools”) and the subsequent development of new energy policy scenarios, which integrate such measures (reported in work package 4 “Development of revised national sustainable energy scenarios for Denmark, Latvia and Lithuania”). Such scenarios have in the project been applied at policy workshops with the aim of identifying policy measures that can influence and increase the role of energy sufficiency in sustainable energy transitions (descriptions hereof can be found in work package 5 “National policy dialogues in Denmark, Latvia and Lithuania” and work package 6 “Development of Nordic-Baltic competence and experience sharing of energy sufficiency”).

1.1 Reading guide

The report is structured as follows:

- Chapter 1.0 is an introduction to the report and establishes the project foundation and objectives.
- Chapter 2.0 explores definitions and understandings of energy sufficiency and the concept of rebound effects.
- Chapter 3.0 establishes the methodological and theoretical foundation of the report and certain aspects of the project. The project approach to data collection and categorisation is presented, followed by considerations of policy problem framings and a brief introduction to social practice theory.
- Chapter 4.0 presents the ENERGISE project approach identifying and analysing Sustainable Energy Consumption Initiatives (SECIs)
- Chapters 5.0 and 6.0 present energy sufficiency actions within households and mobility respectively, collected through the literature search and review, of which some provide enough data to be integrated into energy modelling and scenarios in ensuing work packages of the IESIMOSES project.

2.0 Energy sufficiency

This chapter serves as a base to define energy sufficiency for this project as well as keeping an overview of the different approaches to energy sufficiency and its components. The term has been discussed based on internal discussions in the IESIMOSES project team, as well as considerations outlined in literature reviews in relation to this project. The many interpretations and definitions of the complex term, which overlap to varying degrees, have resulted in a more general discussion rather than a fixed definition. A table of different definitions is presented towards the end of this chapter.

Additionally, the role of rebound effects is reflected on and discussed in relation to reductions in energy consumption. Thus how energy efficiency and energy sufficiency initiatives might cause direct or indirect rebound effects, and moreover how we might deal with that complexity.

2.1 Energy sufficiency definition in this project

In this section, different definitions of the term sufficiency will be explored and discussed. Since sufficiency is an idea recently introduced into energy debates, it has not yet been commonly stabilised as a term. Therefore, we begin the discussion by presenting existing concepts with considerable overlaps with the concept of sufficiency. These are e.g.:

- **Energy conservation** (Fawcett and Darby 2019) - reducing energy consumption to save money or protect the environment;
- **Frugalism** (Lastovicka et al. 1999) – focuses on maximizing available resources over the long term (Fujii 2006);
- **Voluntary simplicity** (Elgin and Mitchell 1977, Gregg 2009, Rebouças and Soares 2021) – “freely reduced consumption involving a conscious effort to live a simple life” (McDonald et al. 2006);
- **Minimalism** (Kang et al. 2021) – reductions to the essential and the simple, simplicity and beauty as important aesthetics parameters.

These existing concepts all include elements of sufficiency. Some of them include not only sufficiency but also efficiency actions, some are focussed only on voluntary actions, etc. Nevertheless, all these concepts, including energy sufficiency are strongly influenced by regulation, infrastructure and technology, consumer behaviour and lifestyle and cultural changes.

Although there is no single agreed definition of energy sufficiency, essentially the sufficiency concept focuses on two aspects:

- keeping consumption within planetary boundaries by limiting the amount of consumption (avoid excessive over-consumption),
- securing an amount of consumption that covers basic needs for all (avoid under-consumption).

Thus, the concept is concerned with consuming energy on a sufficient level, neither too high nor too low. Energy must be consumed to a degree where it sufficiently ensures basic needs and yet is sufficiently low to keep the consumption within the planetary boundary.

This double meaning is reflected in concepts such as doughnut economics (Raworth, 2017) and consumption corridors (Di Giulio & Fuchs, 2014). However, not all authors recognize this and some consider energy sufficiency to be only related to efforts reducing **energy service consumption** that leads to a reduction in the associated environmental impacts (first aspect of sufficiency), e.g. "Energy sufficiency refers to changes in **individual behaviours** that lead to lower demand for energy services [emphasis added]" (Moser et al., 2015) or "Energy sufficiency involves reducing (**voluntary or compulsory**) consumption of **energy services** in order to **minimise** the associated **environmental impacts** [emphasis added]" (Sorrell, Gatersleben, & Druckman, 2020).
These definitions can be characterised as being about **energy sufficiency actions** only. Both individuals and organisations may reduce their consumption of energy services for a variety of reasons and those actions may be enabled or discouraged by policies, technologies and other system elements that provide those services (Sorrell, Gatersleben, & Druckman, 2020). Some areas that offer the particular potential for energy sufficiency actions are transport, heating, cooling, lighting and cooking. Several authors have been trying to classify these different energy sufficiency actions, e.g. Karlin et al. (2014) identifies 3 types of energy sufficiency actions: behaviour, usage and practices. They also identify other attributes of energy sufficiency actions, e.g. frequency (repetitive, daily, habitual), costs (no or low costs), performance (reversible, non-durable), cognition (subconscious, little effort, continuous, reliant on volitation).

Others define energy sufficiency more broadly, integrating environmental limits as well as concepts like equity, basic needs (second aspect of sufficiency), e.g. the European Council for an Energy Efficient Economy (ECEEE) theme on sufficiency has defined energy sufficiency as "a state in which people's basic needs for energy services are met equitably and ecological limits are respected". Darby and Fawcett (2018) and Vadovics and Živčič (2019) (ENERGISE project) discusses 'energy sufficiency within limits', which they define as "a consumption that ensures that everyone has access to a sufficient amount of energy to satisfy their basic needs in a way that respects the ecological limits of the planet". The Enough Network defines sufficiency as the (proposed) term that "encompasses efforts to rethink and redesign collective and individual practices in line with the planetary limits and people's aspirations for better lives". Thus, energy sufficiency is understood as connecting the need to limit energy consumption and individual practices with the need to make consumption and distribution more just to avoid energy poverty.

These energy sufficiency definitions take the possible **rebound effects** (when savings due to increased efficiency or reduced consumption leads to an increase or shift in production or consumption that eats part of, or all of the resource or energy savings gained, see section 2.3 Rebound Effects) and social practices into account and therefore talk about the ecological limits or **sustainability corridors**, which assume upper and lower limits for consumption. Thus, general reduction (or indeed increase) in energy use cannot be defined as a sufficiency approach unless it is anchored to a reference point. However, quantifying such a reference point of sustainable energy consumption by defining the appropriate sizing of dwellings, indoor

temperature, the number of km travelled etc is challenging (Sahakian et al., 2021). Building on the ENERGISE project, this challenge is adressed as follow:

> "Without such a reference point, the outcome of the energy reduction becomes somewhat arbitrary. This is because a reduction of, for example, 10% in energy use is not the same for all households, [as the baselines can be rather different]. If we consider two identical households (in terms of composition and infrastructure) A and B, where A uses double the amount of energy as B, a reduction of 10% in energy use across the two households is not equal. Nor can we conclude that both households have limited energy use to a level that could be considered 'sufficient', as energy use in household A remains far higher than the otherwise identical household B. In this case, one of three scenarios are likely to be at play: household A consumes more energy than what is sufficient to live a good life; household B uses less energy than what is sufficient to live a good life; households A and B have different interpretations of what constitutes a 'good life' and the amount of energy use that this required to support it" (ENERGISE D2.4, p. 24).

The second scenario can be regarded as an instance of hidden energy poverty, which underlines the problems in dealing with averages (e.g. a change in the average of heated area). This example stresses the need to work in relation to reference points to ensure that reductions are fair.

There is an ongoing debate as to what level of energy and resource use is sufficient to live a 'good life' and whether it is possible to achieve this for all within planetary boundaries, and who should be involved in decisions on the subject. Several scholars (e.g. O'Neill et al., 2018; Figge et al., 2014; Hickel, 2019; Spengler, 2016) have raised this question. O'Neill et al. (2018) concluded that the universal achievement of more qualitative goals (e.g. high life satisfaction) would require a level of resource use that is 2–6 times the sustainable level, based on current consumption and production patterns. Hickel (2019) concludes more optimistically that it is theoretically possible to achieve a good life for all within planetary boundaries in poor nations by building on existing exemplary models and by adopting fairer distributive policies. However, the additional biophysical pressure that this entails at a global level requires that rich nations reduce their biophysical footprints by half and to fit within the safe and just operating space, abandon economic growth as a policy objective and shift to post-capitalist economic models. For more affluent societies this would mean avoiding certain kinds and levels of consumption - not consuming certain goods and services, e.g. excessive living space (overly large homes, secondary residences of the wealthy), oversized vehicles, environmentally damaging and wasteful foods, leisure and work patterns involving driving and flying (Alexander, 2015; Wiedmann et al., 2020).

However, there are still no clear thresholds for possible safe and equitable energy services. In the ENERGISE Resource Consumption Typology, sufficiency is understood as efforts to reduce energy use to a determined maximum level or to limit energy use to a defined amount (e.g. as in Figge et al., 2014; Spengler, 2016). However, the amount of energy considered sufficient to live a good life is subject to different interpretations depending on the actors involved in determining the measure, and the methods of calculation applied. It also remains extremely context-dependent and can vary, for example, according to location, climate,

number and socio-demographic composition of occupants, building type, culture, etc (ENERGISE, D2.4). Sahakian et al. (2019) propose a definition of sufficiency which relates both to resource consumption as well as challenging habitual practices, which requires accounting for both maximum limits to consumption and the collective conventions (e.g. what is the comfortable indoor temperature or size of a house? What does it mean to live without a car?), which hold together practices as performances. **Social practices** (see section 3.2.3), e.g. setting indoor temperature, size of homes, or driving speed, are linked to the various practices carried out by the individual but shared socially in time and space. This paper therefore explicitly deals with the role that collective conventions play in the way people understand and perform 'good lives'.

2.1.1 Energy services

Energy sufficiency is closely linked to the concept of **energy services** - 'benefits' energy provides ("Energy services are the benefits that energy carriers produce for human well being" (Modi et al., 2005), for more definitions of energy services see Fell (2017)). Nevertheless, these are services that require direct energy consumption for their provision, e.g. areas heated or cooled, areas or functions lighted, volume of food cooked, volume of communication, volume of transport and volume of industrial processes and products. Delivering energy services is more than making energy available to end-users (Marignac, 2019):

- Energy services have a subjective dimension depending on the context, e.g. indoor air comfort temperatures are different for different people;
- Ambient 'free' energy, human power and nature-based solutions can contribute to the delivery of services, e.g. instead of driving the car, mobility can be provided by using a bicycle; instead of artificial light, daylight can be used during the day, etc.
- Non-energy initiatives can create or deny access to energy services, e.g. limited income can lead to decreased energy services and to energy poverty, urban planning can increase or reduce the need for transport.

More detailed definitions have been identified for particular areas of action. A project which focused on **household appliances** (Brischke et al., 2015) defined energy sufficiency as an approach to reducing energy consumption (thus lacking the basic needs element) by three strategies:

- **quantitative reduction** of sizes, features, usage times of devices, etc.;
- **substitution** of technical equipment in households;
- **adjustment** of services delivered to meet user needs.

Sufficiency in **heating** can also combine several different aspects:

- **appropriate sizing** of dwellings and other buildings for their use, for instance, sizing of dwelling to the need of inhabitants. This can be realised in several ways; in the construction phase as well as with movements of people in existing housing stock;
- **heating of needed parts** of the buildings only, reduced heating of unused spaces and during unused hours;

- **lower indoor temperatures**;
- **communal living** by sharing parts of the floor space.

Similar approaches can be defined for other consumption areas, e.g. in the **transport sector** some of the possible energy sufficiency actions are:

- **slowing down mobility**, e.g. speed limits;
- **decreasing need for mobility**, e.g. better spatial planning;
- **discouraging motorised mobility** and encouraging non-motorized mobility, e.g. public space given to non-motorized transport like bicycles;
- **sharing** cars and using public transport. .

Energy use for bathing can be reduced by changing the bathing practice through:

- having fewer baths/showers per week,
- having shorter baths/showers,
- having colder baths/showers,
- showering instead of bathing, or
- more people having baths/showers together.

2.1.2 Types of sufficiency changes

Another approach to classification could be to distinguish between sufficiency changes that take place under different conditions. Distinctions could be made between different kinds of changes in the level and character of services:

1) Changes that take place in households **at the households' own initiative**. The initiatives can be inspired from outside (campaigns, taxes, labelling, etc.), but they are not related to any changes in the material or organisational framework of everyday life. This sort of sufficiency can involve changes in the level or character of a service, where the user gets a different experience in the use situation. This can be related to changes in either behaviour or equipment or both. For instance:

- A reduced amount of the service (fewer baths, lower temperature in the home, less residential space, fewer kilometres, less meat, less laundry, smaller refrigerator, smaller car);
- Reduced convenience or time use (colder showers, shorter showers, reduced speed while driving a car, remembering to turn off lights, avoiding standby of ICT equipment);
- Replacing the service with another one (showering instead of bathing, public transport instead of the car, using a clothesline instead of a tumble dryer).
- Doing without the service.

2) Changes in households that involve some **changes in the material or organisational framework**, but do not change the traditional way of living. For instance:

- Reduced amount of the service or reduced convenience supported by sharing the service (several people sharing flat, driving together with others);
- Reduced convenience that reduces indirect energy consumption through the sharing of equipment (shared washing machines, lawn mowers, cars, clothes). The reduced convenience might also reduce the direct energy consumption - when you do not have your own car, you might drive less;
- Replacing the service with another one supported by public infrastructure (less car driving supported by better public transport, bike lanes);
- Replacing a service based on capital equipment in the household with a service bought from outside (take-away, laundry services, using taxi instead of driving) (it is not always obvious what is best from an energy sufficiency perspective).

3) **Changes in the configuration of everyday life** that can reduce the amount of traditional services needed or even change what sort of services are needed. The experiences from eco-communities and conscious urban planning can illustrate such changes (in addition to the changes mentioned above, which are also relevant here):

- Reduced residential area because of shared facilities (e.g. guest rooms);
- Reduced need for transport because more everyday activities take place locally;
- Shared procurement and cooking reduce energy consumption, driving, packaging, food waste;
- Cultural impact through debates on norms influences travelling practices, food consumption, etc.;
- Relatively more work takes place in the informal economy of the community and less work in the formal economy. Reduced monetary income impacts of many kinds of consumption. Typically less transport reduces total energy, but producing food at home might not be more efficient than at factories (bread baking, producing marmalade, beer, etc.).

2.1.3 Sufficiency Leverages

Similarly to the previous section, the négaWatt association (a non-profit french think tank on energy) summarises energy sufficiency approaches in 3 energy sufficiency leverages (Marignac, 2019):

- **Servicial** sufficiency relates to the level of use, mainly characterised by the intensity and duration of use of buildings and equipment. Speed limits on roads or motorways, turning off unused appliances, increasing the average load factor of trucks, or extending the lifetime of goods to reduce the need for manufacturing new ones illustrate the diversity of actions belonging to this category. Deeper changes such as shifting mode from car to bike also relate to some change in the level of service.
- **Dimensional** sufficiency deals with the dimensional factor of energy consumption, which encompasses the size and the nominal capacity of equipment and buildings, the use of which requires consuming energy. Housing size is a very important factor that strongly influences the need for energy, especially for heating and cooling.

- **Organisational** sufficiency encompasses any kind of sharing of equipment (sharing goods or appliances) or buildings (from co-working spaces to shared laundering areas in collective housing), as well as the development of public transport. It also deals with organisational changes that reduce e.g. the distances to be covered by goods, for instance through a shift of supply chains towards more local products, or by people, for instance through dedicated urban planning to densify spreading areas or better mix of houses, workplaces and service sites. These more integrated approaches are evident in community-level sustainability approaches such as eco-communities and transition towns where energy use is considered as part of a broader shift toward more sustainable lifestyles.

2.1.4 Energy efficiency

A distinction also has to be made between energy sufficiency and **energy efficiency.** Energy efficiency is about improving input-output relationships, with the goal of maximising the value created in relation to the resources used. Energy efficiency strategies can increase outputs while maintaining existing impacts, or maintain outputs while decreasing impacts, or a combination thereof (ENERGISE, D2.4). By the definition from Brischke et al. (2015), "energy sufficiency at the household level differs from energy efficiency in one central aspect: Energy efficiency reduces energy input while keeping the utility/ services constant. With energy sufficiency, energy input is reduced while the utility/technical service changes in quantity or quality" (Thomas et al., 2019, p 1125). Energy efficiency is thus understood as delivering the same energy service with less use of energy. While efficiency improvements can deliver considerable savings in household energy use and related CO2 emissions, they have thus far been insufficient to offset increases in overall resource use and environmental impacts associated with growing global demand (Thomas et al., 2015; Shove, 2017). There can be several reasons for this, of which the most important are rebound effects (see section 2.2 Rebound Effects) and continued growth of energy services (ENERGISE D2.4).

Most of these definitions take as their point of departure that energy consumption should be reduced. However, the same definitions could be formulated with the aim to reduce energy poverty and ensure sufficient energy services. Then the level of an energy service can be increased either by increasing efficiency in provisioning or by increasing energy service consumption, which would then be termed sufficiency.

Though this project focuses on sufficiency, in practice there is a **grey area** between efficiency and sufficiency, which is also included. For instance, waste can be reduced by avoiding the delivery of an energy service that is not really used. Immediately, this would be considered *efficiency*, but in practice, the initiative may imply reduced convenience, because it can take more time to start the service (as a computer operating system) when it is needed. Such a loss of convenience can be seen as *sufficiency*. Relating to the showering example, a water-saving showerhead may be in the grey area, improving efficiency, but also influencing the experience of the service.

An integrated view of energy efficiency and sufficiency is unavoidable from a modelling point of view: focusing on one of the aspects alone would overestimate their possible impact. For example, indoor temperature reduction in an inefficient building would have much more impact on energy consumption than indoor temperature reduction in a building that has undergone energy retrofit. The energy sufficiency concept is mostly used in relation to private household consumption. In principle, the distinction between efficiency and sufficiency could also be relevant in relation to public consumption and to the use of final energy services in production, but this project sticks to the traditional focus on household consumption.

2.2 Rebound effects

The term **rebound effects** typically describes the situation where savings due to increased efficiency leads to an increase in production and consumption that eats part of - or all of - the resource or energy savings gained by the efficiency increase. They can also describe the situation where such savings reduce the cost of products and services and make them more accessible to a greater number of people, leading to overall increases in energy use (Chitnis et al., 2013; Figge et al., 2014 in ENERGISE D2.4). Indirect rebound effects can materialise if savings realised through more efficient energy use are subsequently offset by increased energy demand in the wider system. For example, this can manifest in terms of monetary savings that are later spent on high-energy demand services (e.g. air travel), or energy efficiencies that are negated by changes in living conditions (e.g. higher room temperatures) (ENERGISE D2.4, p 27). Another term for these is "spillovers" (Sorrell, Gatersleben, & Druckman, 2020). Rebound effects are part of the explanation why consumption in high-income countries tends to be more efficient in relative terms, but much higher in absolute terms than consumption in low-income countries, or why the "more efficient nations tend to have higher rates of growth in electricity and overall energy consumption and carbon dioxide emissions" (York & McGee, 2016, p. 77).

Though it should be logical that efficiency improvements would help curb resource use (because improved efficiency reduces resource use per unit of production or consumption), there is significant and growing evidence that this is not generally the case. Istead, increased efficiency is often correlated with increased resource use at various scales and in various contexts, due to its connection to growth of production and consumption (York and McGee, 2015).

Additionally, since energy efficiency approaches are in many cases associated with rebound effects, a growing number of authors see profound changes in ways of consumption in affluent societies as necessary for a long-term reduction in energy demand to be within planetary boundaries and in this context, highlight the need for change towards more frugal lifestyles or "sufficiency" (Princen, 2005; Girod & De Haan, 2009; Stengel, 2011). However, sufficiency actions themselves might cause rebound effects by making resources available for other uses and user groups (Alcott, 2008). If energy sufficiency actions reduce the consumption

of energy services with a low carbon intensity and if the associated rebounds increase the consumption of energy services with a higher carbon intensity, the net result may be to increase aggregate emissions.

There are, however, certain differences between rebound effects associated with efficiency and sufficiency, respectively. Since energy efficiency improvements reduce the price of a given energy service, it impacts both purchasing power and consumption as affected by changes in relative prices. Sufficiency actions, on the other hand, are only associated with income effects. Additionally, since the motivation behind efficiency measures (e.g. saving money) and sufficiency measures (e.g. reducing emissions) often differ, this can translate into differences in the type and extent of associated effects (Sorrell, Gatersleben & Druckman, 2020). Though it is often assumed that energy sufficiency actions translate directly into lower energy use and GHG-emissions, this is not necessarily the case; "Energy sufficiency actions may [...] 'free-up' *financial, moral* and *temporal* resources that can subsequently be 'spent' on other goods, services and activities that also involve energy use and emissions - either directly or indirectly along the relevant supply chains" (Sorrell, Gatersleben & Druckman, 2020, p. 2). Moral resources, part of what Freire-Gonzalez (2021) also refers to as cultural and psychological factors, include the idea of a 'moral licence' that legitimises engaging in additional consumption, due to an achieved (or perceived) reduction in resource consumption - i.e. individuals may feel they have done something good for the environment, giving them a moral surplus to then spend time and money on other energy or emissions intensive goods or activities.
Therefore, if one type of energy consumption is reduced and then substituted by indirect energy consumption (e.g. when reducing driving for food shopping by receiving food deliveries), the specific type of household energy consumption targeted might be reduced, but not necessarily the total energy consumption. These types of unintended consequences and rebound effects should be considered, though it might be impossible to fully account for them.

With regards to the second aspect of sufficiency, i.e. ensuring basic needs, rebound effects may be considered a positive outcome in some contexts where energy efficiency implementation allows for increased energy consumption in certain areas in order to ensure basic needs of energy services, especially in vulnerable households and demographics. Freire-Gonzalez (2021) points to the link between rebound effects and inequality:

> "we know that at microeconomic level, poor households can afford higher levels of the services affected by productivity improvements, which they could not before [e.g. higher indoor temperatures or goods that are produced at lower cost due to efficiency gains]. A short-term microeconomic perspective shows that direct rebound effects improve lives in the poorest households or regions. However, we struggle to discern the effects on inequality from a long-term macroeconomic perspective" (Freire-Gonzalez, 2021, p. 4).

However, ensuring basic needs or reducing energy poverty does not necessarily mean increased total energy consumption in households if sufficiency actions are implemented broadly. Energy poverty is

context-dependent and a consequence of inequality. Thus, parts of society are able to reduce energy consumption to the level that is still socially acceptable while people under energy poverty increase their consumption of energy services, making it possible for the combined impact to be a reduction in total energy consumption.

The prevalence of rebound effects is one important reason why it is relevant to claim that a general reduction (or increase) in energy consumption cannot be defined as a sufficiency approach unless it is anchored to a reference point, accounting for both social lower limits and environmental upper limits. Furthermore, the extent of the issue of rebound effects is highly dependent on the level at which sufficiency is considered. At household or national scales, changes in energy consumption practices can mean reductions in certain areas and subsequent increases in other areas. However, at the planetary level, it can be argued that inherent in a sufficiency definition that sufficiency also describes a level of global consumption that ensures social needs for all within planetary boundaries, and thus rules out rebound effects. At lower than planetary levels, however, the pervasiveness of rebound effects ultimately stresses the need for deeper cultural shifts in consumption and more comprehensive policy approaches to climate change mitigation.

2.2.1 Dealing with rebound effects

Freire-Gonzalez (2021) explores the complex global and systemic factors that trigger and expand rebound effects and discusses different means of dealing with rebounds. There is a significant lack of knowledge and awareness of the rebound effects and unintended consequences of energy conservation actions and policies. "Resources productivity, conservation, and sufficiency can lead to the same consequence: expansion of production and consumption capabilities" (Freire-Gonzalez, 2021, p. 6). Rebound effects can be seen as being tied to the notion of insatiability. The assumption of insatiability is at the heart of economics, and informs the idea that human wants and desires for new commodities are essentially insatiable. However, Freire-Gonzalez (2021), reframes rebound effects as a global systemic problem, by referring to the notion of systemic insatiability, rather than individual insatiability. If satiation is never reached, efficiency gains and savings will ultimately create rebounds somewhere in the system, if adequate limits are not set, which is why systemic insatiability is a more adequate explanation.

Resource conservation actions and policies, and voluntary individual actions can generate rebound effects in the absence of physical and price constraints on behaviour, but Freire-Gonzalez (2021) argues it is possible to counteract these effects, and explores two different paths in this regard: 1) policy instruments within current capitalist systems (e.g. resources taxation, cap-and-trade systems, regulation, voluntary actions, and changing lifestyles) and 2) implementation of most prominent systemic post-growth alternatives (including systemic alternatives such as steady-state economy, degrowth, agrowth, and post-development)[1]. Both

[1] Steady-state economy: "Steady-state economics promotes non-growing societies based on a stable material and energy throughput" (Freire-Gonzalez, 2021, p 7); Degrowth: "[...] proposes a deep change in socioeconomic systems

categories present possibilities and limitations that are relevant to consider when dealing with sufficiency and efficiency actions in global socio-economic contexts. The second category assumes that the problem cannot be dealt with under current conditions, but that profound changes in socio-economic systems are necessary. However, such changes can be limited in the sense that they encounter issues of feasibility in socio-economic, institutional, and cultural terms. Collective changes in lifestyles are powerful means of avoiding rebound effects and achieving overall sustainable societies. However, this necessitates profound changes in cultural values, e.g. that highlight the value of non-material ways of providing good and meaningful lives.

2.3 Energy sufficiency definitions overview

Table 2.1 presents an overview of the different energy sufficiency definitions presented and used in this project (IESIMOSES):

Source	**Energy sufficiency definition**	**Focus points**
Darby and Fawcett (2018) and Vadovics and Živčič (2019)	The ENERGISE project defines energy sufficiency as "a consumption that ensures that everyone has access to a sufficient amount of energy to satisfy their basic needs in a way that respects the ecological limits of the planet".	- Social and environmental factors - Basic needs as well as ecological limits - A global level of consumption ensuring sufficiency
Sahakian et al. (2019)	"Energy sufficiency which accounts not only for absolute reductions in resource usage, but also changes in everyday and habitual practices – which implies challenging collective conventions around energy usage in the home, as well as setting upper limits to consumption."	- Social and environmental factors - Action / practice oriented
The Enough network [2]	The Enough network defines sufficiency as a term that "encompasses efforts to rethink and redesign collective and individual practices in line with the planetary limits and people's aspirations for better lives".	- Social and environmental factors - Better lives as well as ecological limits - Action oriented

toward not only a smaller but also a different societal metabolism, serving new functions [...], with an understanding of metabolism as the flow of materials and energy between nature and society, among societies, and within societies" (p 7), Steady-state and Degrowth are seen as complementary in many ways. Agrowth: "The agrowth perspective, as an alternative to degrowth postulates, considers that economic growth should not be a primary societal objective. Welfare and sustainable targets should be central, and whether these targets require economic growth is irrelevant" (p 7); Post-development: "[...] post-development theory argues that the concept of "development" is a Western-Northern imposition over the other countries of the world to maintain influence and hegemony" (p. 7).

[2] The Enough Network site for researchers: https://www.researchgate.net/project/ENOUGH-International-network-for-sufficiency-research-policy

Moser et al. (2015)	"Energy sufficiency refers to changes in individual behaviors that lead to lower demand for energy services [emphasis added]"	- Upper limits (environmental) and reductions - Action oriented
Sorrell, Gatersleben and Druckman, 2020	"Energy sufficiency involves reducing (voluntary or compulsory) consumption of energy services in order to minimize the associated environmental impacts [emphasis added]"	- Upper limits (environmental) and reductions - Action oriented
The European Council for an Energy Efficient Economy (ECEEE)	Energy sufficiency as "a state in which people's basic needs for energy services are met equitably and ecological limits are respected".	- Social and environmental factors - Basic needs as well as ecological limits - A state of affairs
The négaWatt association, (Marignac, 2019)	"Energy sufficiency, as a means to rethink and redesign individual and collective practices to favour activities and services that are intrinsically low on energy use, can be a key further leverage to enable deeper decarbonisation pathways" - Focus on ensuring adequate energy services for everyone - Focus on unconscious, routine nature of many activities associated with energy consumption; - Focus on lifestyle changes and macro level / system changes	- Social and environmental factors - Basic needs as well as ecological limits - Action / practice oriented - Systemic changes

Table 2.1 - Energy sufficiency definitions

As the table demonstrates, there are several definitions, some with varying focus areas. For the project, no single definition has been formulated or chosen, and the above table along with perspectives presented throughout chapter 2, thus serve as a discussion and overview of factors to take into consideration in relation to energy sufficiency.

Furthermore, the overview has factored into the energy scenario modelling of the project, where the focus has been on how many of the factors can be included. The quantification of lower and upper limits pose a significant challenge which varies according to the level at which the model operates (e.g. national, global etc.). A factor such as 'better lives' or 'basic needs' are philosophical and somewhat context dependent. Both sets of limits (environmental upper limits and social lower limits) are, however, immensely important. Even in areas or nations with low rates of energy poverty, with rising energy prices and economic inequality, the issue of insufficiency can become more significant. Lastly, the limited amount of research on sufficiency actions and the quantification herof also poses challenges in energy sufficiency modelling.

3.0 Theoretical Framework

This chapter presents the empirical scope of the project and accounts for the theoretical perspective adopted in the project. The first section of the chapter presents the empirical foundation and data collection, including limitations in data that can be used and delimitation of data used within the scope of the project. Following this, the theoretical foundation of the project is established. This is initiated with a notion of (policy) problem framings, inspired by the ENERGISE project, followed by a brief introduction to social practice theory.

3.1 Empirical scope of the project

For the analysis of experiences from sustainable energy experiments and initiatives, the IESIMOSES project team has reviewed empirical sources using the EU H2020 project ENERGISE, findings from the French négaWatt association and the German project EnSu (Energie-Suffizienz) as starting points and empirical foundation for literature search and review. The three projects are briefly introduced in the following.

The ENERGISE project provides insights into the identification of sustainable energy sufficiency initiatives and experiments and the collection of data, through their definition of sustainable energy consumption initiatives (SECIs) and grid template for SECI categorisation. ENERGISE is an innovative pan-European research initiative that has contributed to a greater scientific understanding of the social, material and cultural aspects of energy consumption. It was funded under the EU Horizon 2020 Research and Innovation program (GA 727642) for three years (2016-2019). It explored options for a bottom-up transformation of energy use in households and communities across Europe and developed Living Labs (ELLs) for the direct observation and challenging of existing practices. This report draws on deliverables produced by the ENERGISE consortium, and links and references to the original reports and materials are given throughout the report.

The négaWatt association[3] is a non-governmental French think tank of experts who provides solutions and recommendations for the national energy system of France. Their approach to energy systems is based on the three pillars of renewable energy, energy efficiency and energy sufficiency. Based on these, the négaWatt association has developed an energy transition scenario for France, with the aim of supporting long-term solutions and supporting policy dialogues. As previously presented in section 2.1.3, they have proposed a categorisation of energy sufficiency into three leverages; the servicial, dimensional and organisational. For every sufficiency leverage, they furthermore suggests different policies that can be applied. The IESIMOSES project draws on knowledge from négaWatt in terms of empirical material produced and in dialogues as members of the négaWatt association engage in the IESIMOSES project observer group.

[3] The négaWatt association website: https://www.negawatt.org/en

The German EnSu (Energie-Suffizienz) project analyses barriers, potentials and policies for energy sufficiency in Germany. They approach energy sufficiency as one of the three energy sustainability strategies (with the other being energy efficiency and renewable energies). They analyse how the European government follows this strategy, by “conducting a systematic document analysis of all available European National Energy and Climate Plans (NECPs) and Long-Term Strategies (LTSs)” (Zell-Ziegler et al., 2021, p. 1). From the analysis they have collected 230 sufficiency-related policy measures, whereas differences between countries become evident. The energy sufficiency strategy is by EnSu determined as “the strategy of achieving absolute reductions of the amount of energy-based services consumed, notably through promoting intrinsically low-energy activities, to reach a level of enoughness that ensures sustainability” (Zell-Ziegler, 2021, p. 2).

3.1.1 Data limitations

Generally, examples of sufficiency actions, at household or community levels or in national climate policies, are not plentiful. The ENERGISE project found that the number of initiatives analysed which could be categorised as sufficiency-oriented or that exhibit a more complex understanding of energy use are few in number, and that the vast majority of initiatives analysed could be categorised as efficiency-oriented, with a focus on technological developments and individual behaviour. The analysis of initiatives was furthermore challenged by a general lack of reporting on outputs in a quantitative manner. Many projects were unspecific about the changes and types of changes achieved, e.g. the unit of outputs, or the reference point from which changes were achieved. This makes it difficult to compare and assess the potentials of the projects and initiatives.

Research by Zell-Ziegler et al. (2021) in which it was analysed to what extent European governments follow sufficiency strategies, found that “sufficiency is seldom mentioned explicitly and rarely seen as a key field for policy action in the climate plans and strategies of European countries, and is often limited to a future hypothetical prospect of personal behavioural change” (Zell-Ziegler, 2021, p. 9). The analysis was conducted by systematically reviewing all available European National Energy and Climate Plans (NECPs) and Long-Term Strategies (LTSs). The analysis found that relatively few policy measures can be regarded as policies to reduce energy service, aimed at lowering energy demand levels, but rather aimed at shifting demand towards less energy-intensive services. Furthermore, the authors found that regulatory instruments so far play a minor role for sufficiency policy in the NECPs. Sufficiency is largely treated as micro-level individual behaviour change or as exogenous trends that will need to take place (similarly to energy efficiency in recent decades), and not yet as a genuine field of policy action to provide the necessary framework for enabling societal change (Zell-Ziegler, 2021).

3.1.2 Delimitation of data within the project scope

This report will present a number of sufficiency initiatives and experiments that have been identified through the previously described analytical approach and have been highlighted due to the changes achieved by the initiatives and/or due to sufficient amounts of quantifiable empirical data and quantifiable characteristics. Delimitations are determined on the basis of the overall scope of the project.

In general, a number of articles are dealing with the physical potentials for energy sufficiency, analysing the demand for energy services that is needed to maintain a normal life in an industrialised country. However, without defining the path to move the industrialised societies in this direction nor the policies that could enable such a change. While it is useful to see the potential that could be reached with additional policies, we will in this study focus on sufficiency actions, where we have policy options that can be used in Nordic and Baltic countries and where we have reasonable documentation of their effects.

Empirically, through the experiments and initiatives chosen, this project primarily deals with *direct energy use* in households and the reduction hereof. Indirect and embodied energy use and emissions might be brought into considerations of rebound effects and other unintended consequences, but for this stage of the project the primary focus is direct energy use. Taking indirect and embodied energy and emissions and the reduction of these more explicitly into consideration will be a relevant next step. Direct household energy use typically makes up less than half of the total domestic energy use, while indirect household energy use often makes up more than half, in Western households (Biesiot & Noorman 1999; Chatterton et al., 2016, and Druckman & Jackson, 2008 in ENERGISE D1.3, pp 18-19). Thus, indirect energy use is at least equally important to consider, but often more challenging to address, and the distinction raises additional questions regarding delimitation and placing of responsibilities. However, it is worth noting that in the case of indirect energy consumption, energy might not even be the largest issue. In the production of many commodities, a variety of inputs are used and, depending on the production process, they may have an even larger environmental impact than the related energy production. This is one reason why, in this project, a distinction has been made between sufficiency in (direct) energy consumption and sufficiency in overall consumption, of which the former is the focus of this project.

With an established scope of empirical data built upon in this project, the initiatives and experiments are divided into two categories for clarification and for modelling purposes. The categories are:

- Household energy consumption, by which is meant electricity and heat consumed in the house
- Mobility, by which is meant direct energy usage in transportation by/of household members

These categories are chosen since they represent direct energy consumption that people have control over in their private life and therefore can change, at least in principle, though societal structures and social practices cause certain lock-ins. Moreover, the focus on addressing households is determined because households are considered the unit of social practice organisation. According to the ENERGISE project, households present a relevant alternative to conventional focus on energy consumption at the level of

individuals or nations. They also serve as a relevant unit of practice analysis, since they "frequently display their own practice cultures, that is, unique combinations of practices that meet individual members' needs and that emerge from their social interactions and joint practices both within the household and outside" (ENERGISE D1.3, p 17). Thus, household energy consumption also reflects social and material conditions outside the home, such as norms, infrastructure and policy.

3.2 Theoretical approach

With regards to the theoretical approach, this project takes its point of departure in the approach and theoretical standpoint taken by the ENERGISE project[4]:

> "Energy use in the EU continues to be stubbornly high, a fact that poses major challenges for energy research and policy. [...] [The ENERGISE project] notes the prevalence and persistence of traditional market and technology based efforts to reduce household energy use, despite clear evidence of their limited long-term impacts due to rebound effects. Recognising that initial efficiency savings are often eaten up by changes in routines and habits such as increases in the use/number of domestic appliances or material changes such as trends towards larger homes, ENERGISE adopts a sufficiency-focused approach to household energy use that revolves around the dynamics of every[-day, red.] practices. Moving beyond conventional approaches such as the promotion of energy-saving technology or efforts to increase energy efficiency by redirecting individuals' behaviour and consumer choices, ENERGISE explicitly recognises the hitherto untapped potential of sufficiency thinking and practice. To this end, it explores opportunities for recrafting and substituting energy-intensive practices in ways that work with people's needs and everyday routines." (ENERGISE D1.3, p. 5)

As indicated by the theoretical standpoint of the ENERGISE project, conventional approaches to reducing household energy use have significant limitations. This is partially a question of the ways in which energy use and related issues are generally framed and understood. Problem framings are important since the way in which a problem is understood affects the proposed solutions to that problem, which can be more or less beneficial. This section draws on the Problem Framing Typology (PFT) of the ENERGISE project and social practice theory, to provide a foundation for policy discussions.

3.2.1 Problem framing

A problem framing denotes the theoretical understanding of change as well as the methodological approach for how to create change. Thus, the way that the potential for change as well as the delegation of responsibility for change is conceived, is dependent on the *problem framing* that is utilised. Sustainable consumption initiatives and related policies, often rely on an ecological modernization rationality, where the

[4] Deliverable 1.3 can be found via the following link:
http://energise-project.eu/sites/default/files/content/ENERGISE_D1.3_22112019_Final.pdf

focus is usually on making current consumption patterns more sustainable in such a way that the status quo (ideas about the quality of life and economic growth) is not challenged. As a result, energy policies for sustainability tend to black box the demand-side, often resulting in abstracting *efficiency* strategies from the social organisation within which the strategies and resulting solutions unfold. Rebound effects and other unintended consequences are often not adequately considered in these types of efficiency strategies.

A large part of the efforts that went into the ENERGISE review was to learn from, as well as assess, European Sustainable Energy Consumption Initiatives (SECIs) in order to understand how *SECIs frame the potential, realms and responsibility for change*. If a particular SECI is launched based on the assumption that the possibility (and responsibility) for change lies with the individual, the SECI will draw on methods accordingly. The ENERGISE PFT introduces alternative problem framings that may offer a way to mitigate rebound effects by addressing and challenging a wider set of socio-material, cultural and institutional aspects of energy demand. These considerations are relevant with regards to policy dialogues, since they raise questions of problem framings and approaches in the policies that need to be implemented in order to foster energy sufficient consumption practices and avoid unintended consequences.

3.2.2 Problem framing typology - ENERGISE

The ENERGISE PFT[5] is inspired by the definition of various kinds of problem framings (of the sustainability challenge), as presented by Spurling et al. (2013), and by recommendations for behaviour change initiatives as proposed by Southerton et al. (2011).

The ENERGISE PFT consists of four different categories under which a sustainable energy consumption initiative or energy sufficiency initiative can be classified, depending on the seemingly predominant problem framing approach that the initiative (re)produces.

- **Changes in technology:** This framing assumes that changing levels in energy consumption associated with particular products, devices, or facilities is primarily a matter of technological change, and not about changing the organisation of daily life. The methods for intervention prevalent in this framing are: information, sometimes monetary incentives and legislation, some forms of technological experimentation. The social organisation of everyday life is never (or rarely) included in the objectives of interventions (ENERGISE D2.4; Fahy, Goggins & Jensen, 2019; Jensen et al., 2019).
- **Changes in individuals' behaviour**: This framing primarily assumes that changing levels of energy consumption is a matter of changing individuals' behaviour in terms of their (personal) energy consumption. Typical methods for intervention are: information, campaigns, nudging, training and

[5] The PFT was used to classify SECIs according to their main approach to the challenge of attaining sustainable energy consumption. A thorough presentation of the ENERGISE PFT can be found in Fahy, Goggins and Jensen (2019, chp. 2) via: http://energise-project.eu/sites/default/files/content/2019_Book_EnergyDemandChallengesInEurope.pdf and Jensen et al. (2019) via: https://www.sciencedirect.com/science/article/pii/S0301421519305142.

education in a knowledge-oriented sense, as opposed to the development of new competencies or changing meanings. Methods are rooted in the idea that people can be incited to become 'better consumers', by appealing to individual choice in a 'marketplace of possibilities'. Often, the change objective is somewhat unspecified, often with behaviour change seen as a matter of energy awareness (ENERGISE D2.4; Fahy, Goggins & Jensen, 2019; Jensen et al., 2019).

- **Changes in everyday life situations**[6]: This framing is a very practice oriented understanding of changes in energy use. Energy usage is understood and targeted not as an entity in itself, but as a result of everyday life situations, which are seen as situated and collective in nature. Change is therefore understood as changes in consumption patterns related to energy use. This framing assumes that changing levels of energy consumption is a matter of changing material components, images/norms and competences related to specific areas of daily life. Everyday life situations are targeted and experimented with, in terms of their social, material and habitual aspects. People are seen as 'change-agents', and there is often acknowledgement and deliberation on the historical aspects of the practice. Methods for intervention are often a broad mix, usually with an emphasis on the social or collective aspects, e.g. including participatory methods, such as some forms of peer-to-peer learning, collaboration, living labs, training, experiments and a community focus. Here, information campaigns are very often combined with other forms of intervention. Responsibility for change is seen as shared amongst groups of people and technology (ENERGISE D2.4; Fahy, Goggins and Jensen, 2019; Jensen et al., 2019).
- **Changes in complex interactions**[7]: Within this framing, energy use is seen as a matter of complex interactions between household activities as well as professions and sectors and most importantly, the social organisations of these areas. It is this organisation and these interactions that energy use depends on. It therefore goes beyond the home and into systems of provision, and changing energy use is thus seen as a matter of changing complex interactions between several areas - often expressed as changes across supply and demand, and as development in both professional and everyday life practices. This makes the intervention opportunities bigger, but also more complex. Multiple actors in and across several sectors and practices are involved and the responsibility for change is shared between multiple actors from different domains of society. Several methods of interventions are often included: e.g. training, education, new business models, experimentation, community building and community based action. Change is seen as a process of emergence and knowledge production that happens between all actors involved in the initiative or change process, as changes in several types of consumption patterns and in how practices interact with each other (ENERGISE D2.4; Fahy, Goggins & Jensen, 2019; Jensen et al., 2019) (see section 5.5 for elaboration in relation to policy approaches).

[6] These framings are often comparable to conceptualizations like 'substituting practices' or 'recrafting practices' in Spurling et al. (2013), and draw on several of the mechanisms put forward within and across 'contexts' as defined by Southerton et al. (2011) (Jensen et al., 2019)

[7] These framings are often comparable with conceptualizations such as 'changing the way practices interlock' in Spurling et al. (2013) and draws on several of the mechanisms put forward within and across 'contexts' as defined by Southerton et al. (2011) (Jensen et al., 2019)

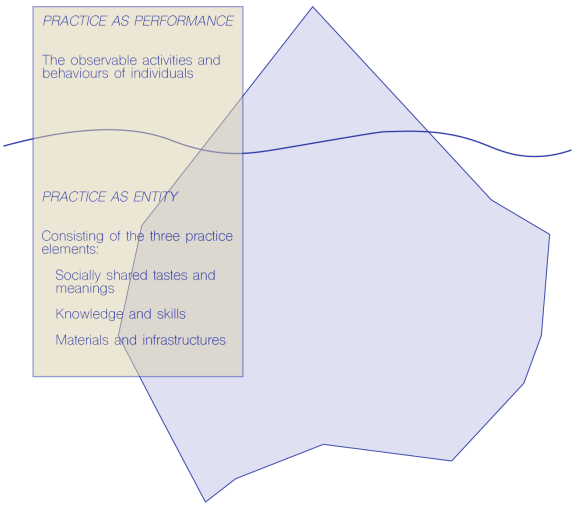
The project found, similarly to the classification according to the RCT (see section 2.3 *Energy sufficiency definitions overview*), that the majority of the identified SECIs could be categorised within more conventional problem framings that either understands change as a matter of technological change or individual behavioural change. Only a few SECIs treated change as a matter of systemic change, or at least changes to everyday life situations and particular practices.

3.2.3 Social practice theory

An ENERGISE review on key publications in the area of social-scientific and interdisciplinary energy research identified a multitude of different influences on household energy consumption[8]. The review demonstrates the need for a better understanding of the dynamics of everyday practices. In the growing body of practice-theoretical literature on energy use, energy use is generally treated as an enabler of everyday practices. The temporal and spatial dynamics of practices that take place in the home play a role in the use of appliances (e.g. for cooking and washing), the movement between the home and place of work, when and how the home is heated, what rooms are heated, the use and maintenance of technologies etc.

Working definition of practices (extracted from Spurling et al., 2013 in ENERGISE D2.2, p. 20):

"Individual behaviors are, primarily, performances of social practices. Rather than being the expression of an individual's values and attitudes, behavior is the observable expression of social phenomenon (socially shared tastes and meanings, knowledge and skills, and materials and infrastructure). As such 'behavior' is just the tip of the iceberg, and the effects of intervening in behavior are limited accordingly. It is the practice entity— the socially embedded underpinning of behavior—which forms a better target for sustainability policy. Socially acceptable individual behavior—or the successful performance of a social practice—thus rests upon the use of objects, tools and infrastructures, of knowledge and skills and of cultural conventions, expectations, and socially shared tastes and meanings. These are the elements that compose social practices."



Adapted from Spurling et al (2013), p. 8

[8] "These range from personal factors to household dynamics and their connections with wider social, political and material conditions (e.g. media coverage of energy issues, energy use patterns in workplaces, technological innovation concerning energy generation, economic incentives for micro-generation of energy at household level)" (ENERGISE D1.3, p 8)

The tip of the iceberg features directly observable behaviour and material objects that are part of the performance of a practice. Below the surface is a combination of elements that are not available to direct observation and assessment in the same way:

> "These include taken-for-granted cultural norms and conventions concerning the desirability of certain practices, prevailing political and economic conditions and institutions, and the availability, presence and prevalence of particular technologies and infrastructures. Importantly, people's engagement in a particular practice both shapes and reflects the social environment that they are embedded in, ranging from family relations and household structures to wider societal conditions." (ENERGISE, D1.3, p. 10).

Problem framings that utilise a practice theory perspective takes as its unit of analysis the socially and collectively shared underpinnings of behaviour and "moves beyond individual behaviour on the one hand and its context on the other - whether material infrastructure or social norms - to a unit of analysis that integrates both behaviours and their material, social and cultural contexts" (Spurling et al., 2013, p. 19). It is these wider societal conditions (e.g. norms, conventions, infrastructures) that influence people's everyday practices and the related consumption of energy and resources.

The lack of understanding of or regard for underlying influences is often evident in efficiency strategies, where socio-material contexts are often neglected (ENERGISE D2.4). "Simple replacement of less efficient products does not challenge existing conceptions and norms around energy use and can inadvertently reinforce already unsustainable practices, black boxing existing patterns of use by seeking to make them more efficient instead of challenging them more fundamentally (Thomas et al., 2015; Shove, 2017)" (ENERGISE D2.4, p. 28).

3.2.4 Policy considerations

Practice theory seeks to break with conventions of conceptualising society and societal change as an aggregate of rational individuals and their choices and behaviours (see Shove (2010) for an account of the shortcomings of this policy perspective). Shifting the focus away from methodological individualism, by making socially shared practices the unit of analysis, presents challenges as well as possibilities with regards to both empirical research and policy/change initiatives. This is true for example with regards to defining the boundaries of a practice or identifying the more invisible and indirect influences. Spurling et al. (2013) seek to explicitly move the focus away from dominant framings in research and policy (ones that focus on technological development and/or individual behavioural) as the primary 'solutions' to sustainability challenges. The following table 3.1 presents the policy problem framings that the ENERGISE PFT draws on, as they were presented by Spurling et al. (2013, p. 15) - the conventional as well as the proposed alternative, practice oriented problem framings:

Problem framings	
Common framings in current policy	*Framings drawing on a practice perspective*
1. Innovating Technology *Target of intervention:* reduce the resource intensity of existing patterns of consumption through technical innovation and optimisation	**4. Re-crafting Practices** *Target of intervention:* reduce the resource intensity of existing practices through changing the components which make up those practices (meanings, skills and materials)
2. Shifting Consumer Choices *Target of intervention:* encourage consumers to choose more sustainable or energy efficient products	**5. Substituting Practices** *Target of intervention:* replace less sustainable practices with more sustainable alternatives, with an eye to how alternative practices can fulfil similar purposes
3. Changing Behaviour *Target of intervention:* more broadly, encourage individuals to adopt more sustainable behaviours and discourage them from less sustainable behaviours	**6. Changing how practices interlock** *Target of intervention:* social practices interlock with each other - for example: mobility, shopping and eating. Changing the way they interlock means exploring and harnessing the complex interactions between practices, so that change ripples through interconnected practices

Table 3.1 - *Problem framings, by Spurling et al. (2013, p. 15)*

Practice theory tends to see change and stability, not as mutually exclusive opposites, but as coexisting phenomena on a spectrum. Practices, as entities, are stable enough in time and space that they are recognisable as a practice - i.e. a practice that is similarly performed and shared by people through time and/or space. At the same time, practices are constantly changing, and as such, exist on a trajectory of change where they are picked up or dropped by people. The notion that practices are picked up or dropped relates to practices being in competition with one another, competing for people's time and resources. Additionally, the notion of practices existing on a trajectory presents the opportunity for policies to guide said trajectory in a more sustainable direction by harnessing or challenging the trends, tendencies and trajectories already occurring. These theoretical conceptions of household practices along with the practice-oriented problem framings, provide foundations for comprehensive policy approaches to changing household practices and related energy consumption. Efforts have been made, e.g. in the ENERGISE project and by Spurling et al. (2013) to identify sustainability initiatives (as both experiments and implemented policy initiatives) that apply, whether explicitly or implicitly, practice-oriented approaches.

The empirical data limitations which challenged the ENERGISE analysis made it difficult to compare and assess the potentials of the projects and initiatives in a quantitative manner. However, general learnings and inspiration can still be extracted from these.

- Some of the SECIs that were categorised as exhibiting a practice-oriented problem framing or a complex systems interaction framing in fact draw on some of the same mechanisms that are also employed in SECIs with more conventional problem framings. Examples include information sharing and regulatory measures. However, they draw on such mechanisms "with *a different purpose*"[9] (Jensen et al., 2019, p. 11).
- In SECIs that are underpinned by problem framings of systems interactions, i.e. that fall under the category of "Changes in Complex Interactions" (see section 3.2.2), a broad variety of actors are included in the process, and ideas about what constitutes good and appropriate lifes and consumption levels, may be discussed rather than black-boxed (Jensen et al., 2019).
- For policy purposes, economic aspects and dominant economic thinking play a crucial role in what types of initiatives and projects are seen as measurable and valuable, and thus relevant to promote and fund. These considerations, such as vested interests, economic systems, sunk investments and obstinate infrastructural conditions are, however, not ones that initiatives and projects can confront and change on their own, but must be part of a greater challenging of and changes in dominant political and economic perspectives (Jensen et al., 2019).

These insights support the understanding that "policy neither can nor should aspire to 'silver bullet solutions'. Society and 'everyday life' is different across countries and even within countries. Therefore, policies need to consider socio-material constitutions of energy demand and energy systems, as well as cultural contexts" (Jensen et al., 2019, p. 11). In addition to the considerations of this section, more specific implications for energy sufficiency policy approaches will be explored throughout the report, in relation to household energy consumption as well as mobility.

[9] Here, Grøn Forskel is used as an example (a project that showcases how everyday life situations, such as cooking or shopping for clothes can be more sustainable (e.g. vegetarian alternatives, shopping second-hand); beyond that of energy use itself). The project is categorised under the problem framing "Changes in Everyday Life Situations". Here, experiments and reflections are shared between several actors, instead of being regarded as a mechanism through which top-down advice can simply be transferred - information sharing is thus facilitated from within the changes that occur.

4.0 ENERGISE collection of energy sufficiency actions

ENERGISE developed a Living Labs approach to directly observe and challenge existing practices related to energy consumption together with 300+ households and tested both household and community-level initiatives to reduce energy consumption. A comprehensive review and classification of 1000+ household and community SECIs from 30 European countries provided the foundation for the development of two prototype 'ENERGISE Living Labs' (ELLs) designed to capture dynamics of (changes in) individual and collective energy consumption.

ENERGISE carried out the review of 1000+ SECIs, with the purpose of 1) learning from existing energy consumption initiatives in order to inspire the design of future practice-oriented energy consumption interventions and 2) to categorise existing energy consumption initiatives. The review was carried out according to the problem framing (see section 3.2.2 for the ENERGISE PFT) that each SECI builds upon and the way in which they consider energy and resource consumption reduction as a matter of sufficiency or efficiency or a mix hereof (see section 2.3 for the ENERGISE RCT).

4.1 The ENERGISE definition of Sustainable Energy Consumption Initiatives (SECIs)

This section summarises main approaches related to the review and classification of the 1000+ SECIs collected in the ENERGISE project, with a particular focus on what role sufficiency played in the SECIs, as well as in the process of classifying the SECIs. In ENERGISE, SECIs are defined as activities that deal with reducing energy related CO2 emissions from households. This can either be in terms of:

1) Reducing the actual energy consumption, or
2) Reducing the emissions intensity of energy consumption (e.g. by substituting fossil fuels with renewable energy sources)

The SECIs included in the ENERGISE review generally feature an element of active involvement of households because the data collected had to inspire the development of Living Lab approaches involving households. The definition of a SECI was intentionally kept broad in order to make room for empirical enquiry, such as a large variety in empirical examples seeking to achieve the same goals. The review and resulting database only include initiatives that target households and these households' energy consumption[10]. ENERGISE included SECIs that viewed households as *actors* in a number of different ways.

[10] This means that initiatives *only targeting food or mobility* are not included (e.g. initiatives that primarily/solely promote vegetarianism or walking without relating this to related energy aspects). Initiatives that target energy consumption *as well as* mobility or food-related issues might be included (e.g. switching to electric cars). If initiatives targeting energy consumption have resulted in *unintended changes in mobility patterns or food consumption*, these might be included as well.

The households might be viewed as consumers (by buying products and services); prosumers (for instance by (co-)producing renewable energy); innovators (by using products in innovative ways creating other/new kinds of energy demand), and/or they were viewed as active participants in various groups relating to sustainable energy consumption (e.g. Facebook groups or NGOs). Households could also be investors in sustainable consumption initiatives and renewable energy schemes.

Generally households play different roles depending on the different practices they engage in, and a number of different roles were relevant for ENERGISE. Examples of these roles are to what extent and how participants of households (or households as entities) reproduce certain practices such as heating, cooking or showering. If there are variations in these practices, it was relevant for ENERGISE to capture these variations. Equally, for the general aims of the ENERGISE project, the differences between individual and collective aspects of initiatives were particularly important. In looking for examples of collective agency in SECIs, initiatives that have been promoted as part of a spatial community or a community of interest were of importance.

4.2 Identifying and collecting data on SECIs

In ENERGISE, assessment and review of SECIs was conducted by adhering to the abovementioned, intentionally broad, definition of SECIs. The data collection in ENERGISE was based on Modified Grounded Theory, which Jaeger-Erben et al. (2015) describe as follows: "main dimensions for data analysis are derived from theory and complemented and further developed inductively on the basis of empirical data" (p. 786). When reviewing SECIs, knowledge regarding the national context of the SECI is important, since it makes it easier to identify venues to locate relevant SECIs and eases the contextual analysis.

ENERGISE developed a grid template, through which data on the SECIs were collected and reported, including 30 categories, which enables the analysis of identified SECIs. The grid was based on instrumental as well as theoretically inspired categories that enable a broad, but also focused exploration of the SECIs. A full list of categories with a detailed description of each category and the rationale behind them, can be found in ENERGISE D2.2[11]. In short, the 30 categories enable exploration of factors and dynamics related to the scope, content, methods and outputs of each SECI. Explanatory examples of categories and their rationale follow below (categories 13 and 15 are used as examples):

Cat 13. Outputs

The outputs of the SECI and the way that the outputs are described by the initiator and other involved actors, and potentially the ways in which the outputs are measured or sought verified is interesting to explore. There can be a variety of outputs: more energy efficient buildings; an increase in energy efficient

[11] ENERGISE Deliverable 2.2 can be found via: http://energise-project.eu/sites/default/files/content/WP2%20Deliverable%202%202%20FINAL.pdf (see pp 10-17 for the Grid Template)

appliances; more energy-efficient use of appliances; changes in consumption patterns etc. Exploring what kinds of outputs are promoted and reported on may provide insights into the SECIs, the involved actors' and – importantly - the funders' theories of change (problem framings).

Cat 15. Indication of type of output

If the outputs are measured, it is interesting to explore the ways in which they are reported. If the outputs are measured in monetary values it may suggest that people are generally understood by the SECI initiator as rational decision makers driven by monetary incentives. If the outputs are measured as changes in use, it may suggest that the initiator values changes in routines and habits as crucial for sustainable transition. Enquiries about type of output are directly related to category 13 and 14 and may offer insight into the way in which the initiator frames the SECI and understands changes in energy demand**.**

The 1000+ European SECIs identified and assessed in ENERGISE provide a broad and extensive picture of SECIs across Europe, including a vast variety in scope, methods and goals. A selection of the identified SECIs have been explored and assessed in more detail. 80 SECIs were selected for further exploration, based on a number of different aspects.

SECIs that in particular seemed to employ a type of intervention that represents what Spurling et al. (2013) have characterised as Re-Crafting Practices, Substituting Practices and Changing how Practices Interlock (see section 3.2.4), were included for further description. SECIs that (seemingly) employ these types of interventions were of particular interest to the ENERGISE project. The SECIs that have been selected thus include aspects of these three types of interventions. The SECI initiator and/or funder may not themselves frame methods-, types-and targets of intervention in this way. Nevertheless, it was important to learn from SECIs that seem to have promoted certain kinds of changes in practices, or that seem to have employed a certain understanding of the social, material, infrastructural and cultural aspects of energy consumption. See appendix 1 for a guideline of how to explore relevant SECIs in more detail.

While the SECIs are diverse and inspiring, the limited amount of data collected for the majority of the SECIs with regards to consumption levels prior to the experiments as well as resulting reductions and assessments of scalability, poses a challenge for incorporating them in this project. Due to the lack of quantitative data from the experiments and initiatives, only a very limited number of these were relevant to explore further and bring into the energy modelling undertakings of this project. Outputs of SECIs, measured in monetary values would be some of the most straightforward ones to integrate into energy modelling, since it would not require changing the models' logics. Unfortunately the online database does not enable filtering by such attributes. Furthermore, an assessment of the SECIs indicate that initiatives working with monetary measures and incentives are rarely sufficiency oriented (at least according to the ENERGISE categorisation).

5.0 Energy sufficiency actions in households

As mentioned in section 3.2.1, initiatives and experiments explored in this project are divided into two categories: household energy usage and mobility. Chapter 5 and 6 will present some highlighted initiatives and experiments that have been identified throughout the project within the two categories respectively. The integration of measures into two energy models (EnergyPlan and MESSAGE) is, as mentioned, part of the IESIMOSES project and is reported in work package 3 "Integration of sufficiency into energy modelling tools".

This chapter presents energy sufficiency actions in households that have been identified through literature showing experiments and initiatives of different countries. From the ENERGISE project, section 5.1 presents two identified energy sufficiency actions of changes in laundry practices and changes in thermal comfort practices. Section 5.2 follows with experiences from German and Danish literature on sufficiency actions of reduced living space, and section 5.3 presents sufficiency actions in relation to water savings in terms of european labelling for water taps as well as lifestyle changes. The chapter ends with two sections covering an overview of the potential electricity savings in households and policy recommendations for supporting household energy sufficiency actions.

5.1 ENERGISE Living Labs

Based on SECIs developed in the ENERGISE project, this section presents in more detail the learnings from SECIs with sufficient quantitative data to allow for integration in sufficiency-oriented energy policy scenarios through the development of energy models. As is evident from chapter 2.0 *Energy sufficeincy*, various ways of defining energy sufficiency have been discussed across the two projects, ENERGISE and IESIMOSES. The RCT is the 'official' way that ENERGISE has worked with sufficiency, and this definition primarily orients itself towards absolute reductions. SECIs that have been characterised as sufficiency SECIs according to the RCT, are SECIs that to some extent deal with absolute reductions in energy consumption. The sufficiency SECIs have been categorised into a list of 95 SECIs - meaning that the SECI seemingly include elements of sufficiency[12].

ENERGISE operates particularly with two different ways of approaching sufficiency measures: setting up limits to introduce *absolute reductions*, where everyone involved should keep below the same maximum level, or introducing *relative reductions*, where everyone involved reduces by a particular percentage. In the ENERGISE Living Labs (ELLs), households were asked to engage in two different challenges, one that dealt with absolute reductions related to heating the home (reducing indoor temperatures to a common level), and one that dealt with relative reductions related to laundry (halving the number of weekly laundry cycles). In the following the ENERGISE Laundry Challenge and the Thermal Comfort case are briefly

[12] The list can be cross-referenced with the online database, if needed http://energise-project.eu/projects

introduced[13][14]. It is important to note that the social underpinnings of the participants' practices were analysed and included in the cases, but have been left out of this report and brief description due to the modelling focus of this project. However, they are essential aspects of the practices and therefore of the understanding of how such practices can change. Quantitatively, the changes achieved through the ELLs were relatively small, but it is highlighted in the reports that the quantitative perspective says little about the reactions, changes in mindsets and practices that occured in the participants. For an overview of the deterrends and enablers for the participants in the challenges see ENERGISE D5.2, pp 28-31.

In the Danish ENERGISE Living Labs (ELLs), 20 households from Trekroner and 17 households from Viby Sj, both towns located in Roskilde Municipality in Denmark, were recruited. The participating households ranged in size from one person to more than four persons. In the following, the Viby Sj case is called ELL1 and the Trekroner case is called ELL2.

5.1.1 Changes in laundry practices - ENERGISE

The participants were asked to halve their number of weekly laundry cycles. The households' additional practices for keeping clothes clean were examined, as were the parameters they used to determine when clothes were in need of washing. These aspects were examined prior to, during and after the challenge. The number of weekly cycles washed by households in ELL1 varied from 1-8, with an average of 3,5 cycles per week, and for ELL2 participants, the number of weekly cycles varied from 1-8, with an average of 4 cycles per week. The number of weekly cycles is to some extent connected to the size of the household, however not linearly.

According to the baseline survey (see table 5.1), most of the ELL1 and ELL2 participants determined when items need to be washed on the basis of length of wear (47% and 75% respectively), although smell (23% and 20% respectively) also were a common criteria. Less than 6% and 5%, respectively, mentioned stains to be a criterion. From the focus groups it was clear that several participants in both groups struggled with wearing their clothes for several days in a row. Participants would determine the need to wash primarily on the idea of having worn a piece of clothes 'long enough', but it is not, from this data, evident how long 'long enough' is. Based on the interviews, it seems to be one day for inner clothes and shirts, and a few/several days for pants and sweaters.

[13] For more information about the Danish ENERGISE Living Lab background, process and results, please see Jensen and Friis (2019) via: https://zenodo.org/record/3384613

[14] "While heating homes was seen as the most significant domain in terms of energy use, there was agreement on selecting domains that would represent different types of challenges. Laundry was selected because it tends to be a 'sticky' practice, in that it may be harder to change – tied up, as it often is, with routinized household activities, as well as shared meanings and collective conventions around cleanliness and hygiene. Heating and laundry were thus chosen as the two consumption domains because they are relevant in terms of energy and resource uses, but also because they appear to vary in their degree of malleability from a practice perspective (ENERGISE D5.2, pp 25-26)

Number of ELL1 household members (n=17)	1 (n=4)	2 (n=8)	3 (n=1)	4+ (n=4)
Average laundry cycles/week	2,4[15]	2,2	6	5,8
Number of ELL2 household members (n=20)	1 (n=1)	2 (n=3)	3 (n=4)	4+ (n=12)
Average laundry cycles/week	2	2	3,6[16]	4,9[17]

Table 5.1 - Laundry practices in different types of households before participating in the ENERGISE challenges (n=37) Source: baseline survey.

A notable difference between ELL1 and ELL2 is that in ELL1, a larger share of participants (40%) do not do anything apart from washing, than in ELL2 (20%). In ELL2 a larger share of participants (55%) claim to air out their clothes than in ELL1 (35%).

The similarities and differences between and within the two groups, highlight the importance of recognising the context in which the (sufficiency) initiative is introduced. People/households may engage in different configurations of practices which results in different levels of consumption. Therefore, results of the challenge need to be understood in relation to the context and baseline in which the challenge was carried out.

The process of designing and implementing experiments like the ENERGISE ELLs is rather 'resource-intensive', since it requires a lot of time and resources, amongst other things in order to convince and commit people to follow the project's rules and purposes. At the same time, ENERGISE endorses the standpoint that "community based sustainable transition processes need to be driven and pushed forward by the citizens' strong engagement and commitment in order to anchor the sustainable practices over a longer term" (Jensen and Friis, 2019, p. 48).

Effects and results

Participants did not manage to reduce their number of laundry cycles entirely by half (nor had all agreed to this commitment). However, participants did reduce their number of laundry cycles by 35-39% during the challenge period (Figure 5.1).

[15] The single households average washing number was respectively; 240: 2, 241:4, 242:1,5 and 246:3. So there are quite significant differences between the amount of washing.
[16] (household size:3) A significant variation in the amount of washing: From 1.5 to 7 average cycles pr. week.
[17] (households 4+) A significant variation in the amount of washing: From 1.5 to 8 average cycles pr. week. The household who has noted 1.5 may have misjudged. In the interviews she said that she often washed one piece, and the weekly surveys indicate slightly more cycles.

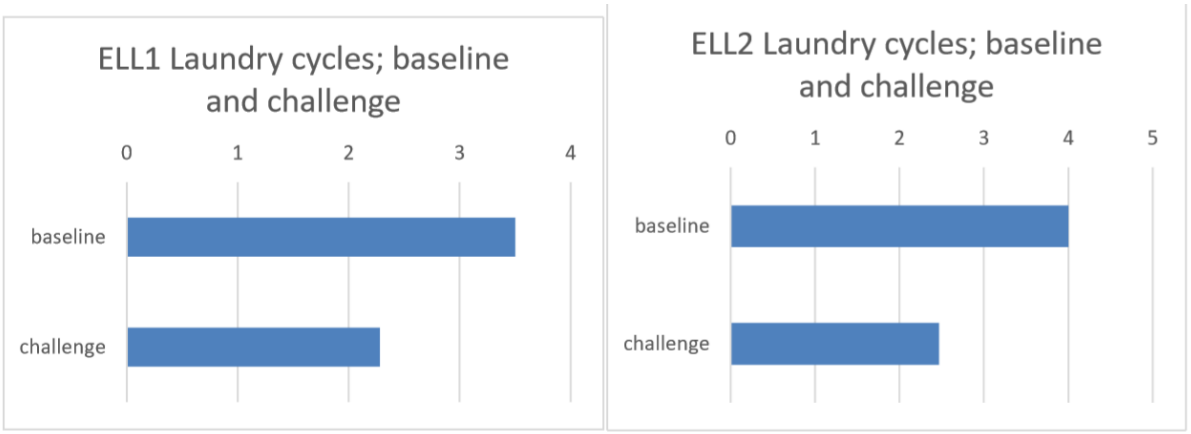


Figure 5.1 - Number of laundry cycles washed during baseline and challenge period (week 5, 6, 7 and 8). For ELL1 the laundry cycles have been reduced by 35%, and for ELL2 the laundry cycles have been reduced by almost 39%. Source: weekly surveys

In comparison to the ELLs showed, as described by Jensen and Friis (2019) that "many of the participants started doing fuller loads [...]. Further, several participants developed new/extended ways of keeping used clothes in circulation – so the 'in-between-use' pile of clothes got bigger and slightly more organised. This was combined with the uptake of airing out clothes. Some participants challenged the social norms (or at least their own experiences of these) around wearing the same clothes for two days running. Those who tried [...] found this challenging. [...] In general, it seemed like the participants became more sensorial (using senses like seeing and smelling) in order to judge when their clothes were dirty enough to be put into the laundry basket. Thus, the participant's consciousness about the social norms around laundry 'needs' seem to some degree to have challenged or broken down certain taboos [...] related to smelling the clothes instead of just automatically putting it in the laundry basket" (Jensen and Friis, 2019, p 27)[18]. Figure 5.2 and figure 5.3 shows data on the changes in ways of keeping clothes clean and changes in ways of determining when clothes need to be cleaned.

[18] According to responses in the Exit survey about other ways of keeping clothes clean rather than washing, about 19% and 12% (in ELL1 and ELL2, respectively) state that they had no other ways of keeping clothes clean. 37% and 76% state that they washed stains off by hand. 19% and 41% state that they brushed off stains. 57% and 88% state that they had aired the clothes, and about 63% and 47% state that they prevented stains e.g. by wearing aprons. One participant comments that they would change clothes when they got home, and another participant comments that they used odour remover.

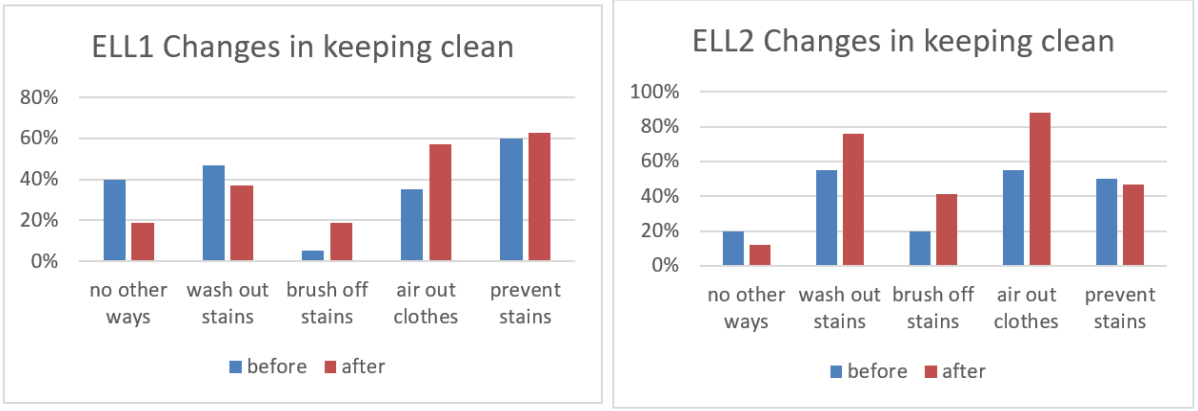


Figure 5.2 - overview of changes in ways of keeping clothes clean other than washing it; before and after the challenge. Source: Baseline- and Exit Surveys.

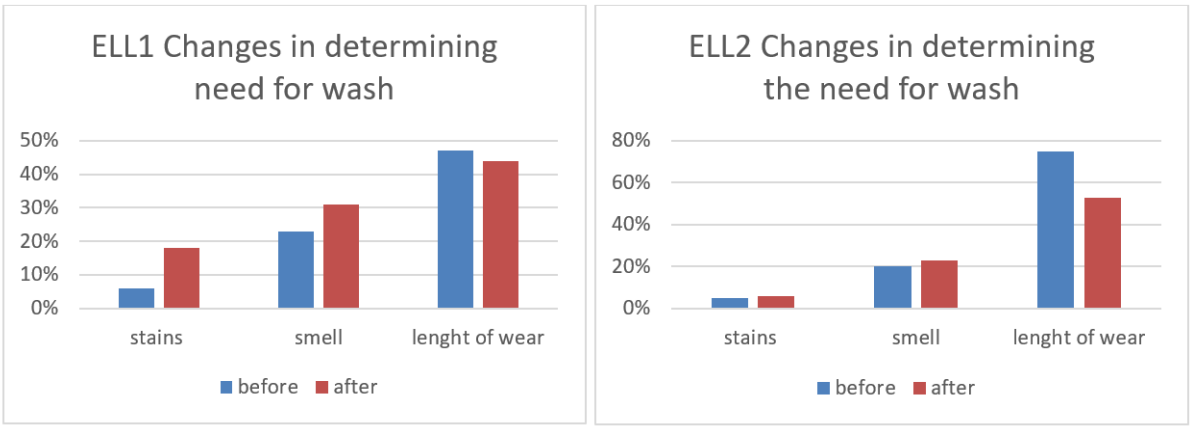


Figure 5.3 - changes in ways of determining when clothes need to be washed, before and after the challenge. Source: Baseline- and Exit Survey.

Concludingly, a slight change towards a more sensorial approach has happened, but 'length of wear' is still the most determining factor. Yet, it is unclear what exactly 'length of wear' implies, and the definition may also have changed along with the challenges progressing. The project provided enough data that it is possible to integrate the results into modelling of the IESIMOSES project, as presented in work package 3 report "Integration of sufficiency into energy modelling tools".

Policy recommendations for supporting energy sufficiency in laundry practices

In order to exemplify policy approaches targeting sufficiency practices, this section will draw on illustrative examples developed by Jensen et al. (2019) and Thomas et al. (2019) regarding laundry practices. As noted in section 3.2.2 *Problem framing typology - ENERGISE*, Jensen et al. (2019) operate with the four problem framings from the ENERGISE PFT. With regards to policy, actions will be structured and implemented differently depending on the framings by which initiatiaters understand the 'problem'. For example, problem framings with point of departure in an understanding of social and structural dynamics of everyday

life and the complex system interactions in which every day practices are embedded, tend to have a more comprehensive approach to policy design (see section 3.2.2 *Problem framing typology - ENERGISE*). This section therefore draws on policy suggestions made by Jensen et al. (2019) based on these problem framings, along with the policy package suggested by Thomas et al. (2019). In both cases, emphasis is put on the need for a comprehensive approach with a combination of different types of actions that interact and reinforce each other appropriately (e.g. information, campaigns, advice, changes in regulations, changes in social norms and meanings, financial measures, material and infrastructural facilitation). Furthermore, the complexity of interactions between energy production and consumption systems is stressed, along with the need for collaboration and initiatives across sectors.

Understanding that everyday life situations influence the way and frequency of laundry practices, means that initiatives aiming at changing laundry practices should also address the situations that generate laundry. The situations of everyday life that influence the way, and the frequency, with which practices are performed, as well as the specific practice itself, would be the 'unit' of intervention. This might especially relate to norms around laundry practices (frequency and methods). Addressing the norms and social meanings around cleanliness might not be straightforward, but can be part of campaigning, and alternative ways of keeping clothes clean and presentable, can be facilitated (Jensen et al., 2019). Norms around cleanliness and freshness highly influence laundry frequencies, so policy actions that aim to support and promote longer usage periods of clothes is an important focus. Relevant policy instruments include information, campaigns, sufficiency advice and incentives or promotion of clothes of material qualities that can be worn relatively long without smelling or looking unclean. Airing out clothes can be another way of supporting longer use periods. Here, space for airing is essential, and is therefore a concern of e.g. landlords or the building sector (e.g. making balconies and outdoor airing facilities available and allowing for airing out clothes) (Thomas et al., 2019).

Information, campaigns and advice can also support more sufficient utilisation of appliances; e.g. washing only full drums, reducing the water temperature or number of spin cycles. Additionally, EU energy labelling could be changed for washing machines to promote sufficiency rather than efficiency by focusing on low absolute energy consumption per wash rather than per kilo per load, and requiring washing machines to inform users of loading level (Thomas et al., 2019). Targeting complex system interactions of energy production and consumption related to laundry, means challenging norms and social meanings, in combination with targeting political and legislative changes in terms of how clothes and laundry machines are produced and challenging the ways in which buying, wearing and washing clothes are organised and connected. This can include legislative changes in relation to machine design and production (Jensen et al., 2019). For example, reduced spinning cycles is a relevant change if a tumble dryer is not used, and as long as adequate drying space is available. To promote this, regulations should require that washing machines provide low spin cycle and low temperature programmes, with intuitive labels that are easy to understand. Reducing the use of tumble dryers, discarding or never acquiring a tumble dryer is beneficial for limiting

laundry related energy use, and therefore requirements and financial support for providing drying space in buildings is important (Thomas et al., 2019).

In the pursuit of downsizing individual household laundry equipment, community facilities should be established. Policy instruments such as financial incentive programmes and investment can support public laundries and local laundry services, in combination with information, campaigns, energy sufficiency advice and legal frameworks ensuring local availability. Laundry cost should also be included in social benefits, and financial access of low-income households should generally be ensured (Thomas et al., 2019). Supporting different ways of organising the systems that are part of acquiring, wearing, washing and maintaining clothes could mean there is a need for new networks or business models and for experimentation in community based initiatives that enable people to engage in alternative laundry and clothing maintenance practices (Jensen et al., 2019).

5.1.2 Changes in thermal comfort practices - ENERGISE

In this second Living Lab, regarding thermal comfort, the participants were asked to reduce the indoor temperature of their houses to a fixed level (18ºC), regardless of prior preferences. In both ELLs, 21-22ºC were the preferred temperatures for the living room area (with slight variations). Participants in both ELLs shared a preference for colder temperatures in bedrooms, though with a range of stated temperatures varying from 15 to 23ºc. Participants were generally confident that they could easily reduce indoor temperatures by one degree, but all found it unacceptable to feel cold in their own home, or invite guests into a cold house. It is clear that participants carry with them learned ideas and memories about appropriate (or inappropriate) ways of heating the home (or related issues).

“A large share of the participants [...] highlighted that a steady state temperature (at 21-22ºC) was better for the building (health wise), “or so they had heard” (often referring to official advice, however rarely with a specific reference attached to the statement)” (Jensen and Friis, 2019, p. 15). Having guests over has been a challenge for several participants – since they felt they had to tell guests to bring extra clothes, which felt uncomfortable. Some participants turned up the heat when having guests over. Others reported reduced opportunity for having guests due to the cold. Generally speaking, comfort usually trumped economic and/or environmental considerations when it came to the heating challenge.

Generally, the heating system seems to be ‘out of sight, out of mind’ as long as it is working. Only a few, mostly elderly male participants, seem to have a more detailed knowledge about their heating systems. Participants gave somewhat contradicting signals; on the one hand, heating systems were considered unproblematic, and on the other hand, there were several concerns about heating and cooling situations, which suggests that there is a level of ‘detachment’ between systems and services.

Practices and activities related to temperature settings were often male dominated (in contrast to the laundry practices which were female dominated), but the decisions and norms around the level of temperature and thermal comfort were female dominated. Female participants/female partners often preferred a higher temperature than the male participants/male partners, particularly in the living room areas. The male participants/male partners were the primary controllers of the heating systems in the home, and therefore also had the knowledge and experiences with regulation.

Effects and results

The heating challenge, which started on November 5th and ended on December 2nd, had participants aiming to lower their indoor temperatures. In both participant groups, the exit surveys indicated preferred temperatures for living rooms of about 0.5ºC lower than what temperatures indicated in the baseline surveys[19](Jensen and Friis, 2019). This relatively small variation between baseline and exit survey responses reflects the challenging nature of the experiment. Participants had stated during exit interviews and focus groups that the heating challenge was too difficult, some had given up, some found the colder temperatures unbearable, and some had not been able to reduce their temperatures significantly due to infrastructural/material reasons[20]. "Most participants did however say that they could probably live with a 1-degree reduction in general, but not a lot more" (Jensen and Friis, 2019, p. 24). Participants generally seemed to be less flexible when it came to heating, rather than keeping clothes clean.

Participants were asked during the interviews whether they had made any changes in how they used rooms or things in order to keep warm, to which most replied "no". However, during interviews, small anecdotes would come up, about staying a little longer in the warm bathroom and baking a little more than usual (using the oven as a secondary heat-source). The stories could be seen as examples of how people adapt and find ways to make use of what is available, when challenged (Jensen and Friis, 2019). They can also be seen as unintended negative environmental impacts if added oven use, or use of other additional ways of staying warm, ultimately cause more energy to be consumed than what is saved by lowering indoor temperatures.

Though some rebound-effects occurred, Shakaian et al. (2021) note that such instances were not common. Contrastingly, some indirect effects were of a climate and energy conscious nature. Participating in the challenge made participants more aware of reducing energy consumption from other appliances, reducing water consumption or changing their shopping habits to reduce food packaging or the need for doing laundry. Some participants were interested in committing to new and different challenges, and a significant number of participants shared their experiences with their network.

[19] "It is important to note that 0.5 degrees is based on averages, and that some participant answers may show bigger variations between baseline and exit answers, and some may show a smaller variation. Also, it is important to note that the sample size is smaller for the exit survey responses than for the baseline survey responses" (Jensen and Friis, 2019, p 24)

[20] (e.g. heating systems that did not work or reacted unexpectedly, and/or too well insulated houses)

Almost all participants found that they would be okay with about 1-2ºC lower than what they were used to before the challenge. Several participants stated in exit interviews, that when they turned up the heat after the challenge, they did not turn it all the way up to the pre-challenge level, though some did. "It seems to be a shared understanding that cold temperatures are not suitable for having guests over, as most participants turned up the heating when guests came to visit, or they felt bad about subjecting their guests to the colder temperatures. Although there seemed to be a general appreciation of ENERGISE's aim and idea, participants did not want to feel cold or subject others to cold temperatures. There seems to be a great connection between feeling cozy/feeling at home and feeling warm" (Jensen and Friis, 2019, p 26). 5 out of 15 participants from ELL1 and 4 out of 12 from ELL2 had changed the temperature when they had guests during the ELLs.

The following observations are based on a comparison between the baseline and closing surveys as well as a follow-up survey administered approximately three months after the end of the challenges[21]. Table 5.2 explores the persistence of indoor temperatures, by showcasing the change in actual, measured temperatures.

ELL1	**Average (actual) temperatures before and after the challenge**			
	T1: Before (week 7)	T2: Directly after (Week 11)	T3: Three months after	Difference T3-T1
Living area, °C	20,74	20,4	20,6	
Bedroom 1, °C	19,14	18,98	18,3	
Bedroom 2, °C	Too few entries	Too few entries	To few entries	

Table 5.2A - Indoor temperatures before and after the challenge. Source: weekly surveys and follow-up surveys (Jensen and Friis, 2019, p. 35)

ELL2	**Average (actual) temperatures before and after the challenge**			
	T1: Before (week 7)	T2: Directly after (week 11)	T3: Three months after	Difference T3-T1
Living area, °C	21,69	21,26	20,9	
Bedroom 1, °C	20,27	19,89	18,08	
Bedroom 2, °C	21,53	21,48	20,5	

Table 5.2B - Indoor temperatures before and after the challenge. Source: weekly surveys and follow-up surveys (Jensen and Friis, 2019, p. 36)

[21] Some of the changes that came around during the challenges persisted and continued. It is also important to note that some participants had started the heating challenge earlier than the official start of the challenge in order to ease into the challenge, particularly in ELL1, which means that T1 does not necessarily represent temperatures that participants would have had at the same time of the year, if they had not been involved in the project.

It became evident from the experiment that in order to obtain substantial savings in relation to home-heating, the home size, in terms of (heated) square metres, needed to be targeted. Furthermore, the access (or lack thereof) to regulating different heating systems as well as translating different buttons on the washing and tumble machines also play a significant impact on the households commitment to reduce everyday consumption. "Therefore, the material and infrastructural settings around the houses seem to play a pivotal role in changing towards less resource-intensive practices" (Jensen and Friis, 2019, p. 3). The experiment provides enough data that it is possible to integrate it into energy modelling of the IESIMOSES project, as presented in work package 3 report "Integration of sufficiency into energy modelling tools". However, the considerations regarding heated square metres should also be accounted for, and in an attempt to do so, the example following below is also included.

Experimentation and upscaling

Based on the extensive experiences with practice experimentation and Living Labs of ENERGISE (ENERGISE, Policy Brief, January 2019)[22] and research by Dijk, de Kraker and Hommels (2018), it is possible to identify certain recommendations with regards to experimentation as a policy approach, along with the upscaling of experimental projects.

Definition of upscaling (extracted from Dijk, Kraker and Hommels, 2018, p 3):
"They [studies of socio-technical transition] generally refer to upscaling from innovation experiments or projects as not only the growing level of adoption (as in diffusion studies), but also the changing social and institutional context, or, in their words, the growing alignment of technologies, actors and institutions [...] [different definitions of upscaling:] Kemp & Grin [...], *the emergence of a set of new practices learned from practical experiments, with corresponding new structure and culture elements;* Van den Bosch [...], *all activities aimed at embedding the experiment in the structure, culture and practices at a higher scale level (the regime),* or Naber et al. [...], *four types of upscaling: (1) growing (i.e., the experiment continues with more actors), (2) replication (on other locations), (3) accumulation (i.e., linking to other experiments), (4) transformation (i.e., the experiment shapes wider institutional change in the regime)*)."

Dijk, de Kraker and Hommels (2018) note that if Living Labs and experimental approaches are to deliver significant contributions to sustainability, it is important to take their constraints, as well as their potentials, into consideration. Living Lab approaches often run the risk of ignoring the wider socio-institutional context and the constraints herein, with expectations that upscaling is a relatively straight-forward "roll-out". The constraints that such niche innovations often face are described as "a context of interconnected and

[22] The policy recommendations are accompanied by a list of best practice categories for facilitation of experiments - both can be accessed here: http://energise-project.eu/sites/default/files/content/Laakso%20et%20al%20(2019)%20ENERGISE_WP3_PolicyBrief_3.pdf

'obdurate' urban socio-technical networks" (Dijk, Kraker and Hommels, 2018, p. 2). In response to these concerns, the authors make recommendations on how to strengthen anticipation of such constraints and ways to overcome them. The following draw on these, along with recommendations from ENERGISE[23,24] regarding the facilitation of household energy sufficiency experiments and approaches to engaging households in changing their energy practices.

Four types of typical constraints that experimentations face when aiming to upscale, are identified by Dijk, de Kraker and Hommels (2018): 1) "Fragmented established institutional arrangements with expert driven ways of thinking, and powerful lobbies"; 2) "Obdurate urban assemblage (infrastructural/technical, legal, financial; spatial, social etc.)"; 3) "No consensus on the merits of the outcomes of the innovation experiment beyond those involved" and 4) "Limited representativeness: results of innovation experiment are only limited applicable to large scale".

To anticipate and overcome these, several efforts are relevant, such as:

- *Integrating multiple perspectives by taking a multi-actor/stakeholder approach*. Including and engaging diverse groups of actors, cross institutionally, as well as future users and policy makers is beneficial and critical to understanding the diversity of participants along with the (social) context of experimentation, the conditions and limitations. By only including a particular set of actors, the lack of representativeness lowers the likeliness of using the project outcomes in new situations. Being aware of and explicit about what is contextual in the experiment and what is not, is also important in this regard;
- *Developing participatory visions* through co-creation with heterogeneous stakeholders through Transitions Management methods;
- *Carrying out successful and convincing pilot projects*, and framing the experiment in ways that avoid immediate dismissal. E.g. framing the issue with a focus on health as well as climate;
- *Focusing on behavioural measures that trigger structural change* - i.e. the new and innovative practices should be embedded in daily lives of existing communities (e.g. schools, places of work etc.), since community engagement with collective 'sense making' makes the move beyond individual behaviour change to structural behaviour change more likely. Community based experimentation can have a positive impact on the ambition level of interventions, and allows for opportunities for questioning social norms, meanings and conventions (e.g. around comfort, cleanliness and convenience). To further expound the potential of community experimentation, meetings and forums for participants to share experiences and reflections can be facilitated.

[23] For a comprehensive summary of implications for public policy and practice, along with limitations of a practice oriented approach and opportunities for amplification, see ENERGISE D5.2, pp 60-65: http://energise-project.eu/sites/default/files/content/ENERGISE_D5%202_260919_Final.pdf

[24] ENERGISE, European Policy Brief, May 2019 with recommendations for experimentation based on experiences with Living Labs can be accessed here along with further argumentation: http://energise-project.eu/sites/default/files/content/Laakso%20et%20al%20(2019)%20ENERGISE_D3%206_PolicyBrief%20(2).pdf

- *Scale jumping* - i.e. when social groups move to higher organisational levels, by linking up with actors in other areas and at other scales, in order to achieve their interests.

It is worth noting that, "[w]hich constraints on upscaling are the major ones is to a significant extent case or city specific and thus needs to be identified through a specific analysis of each local situation" (Dijk, de Kraker and Hommels, 2018, p. 13).

5.2 Reduced living space

This section presents initiatives in regard to reduced living space as energy sufficiency actions identified in German and Danish literature. It covers possibilities and limitations of moving to smaller dwellings, proposed measures for such and furthermore explores the potentials of tiny houses in a Danish context.

5.2.1 Space saving - German analysis

The German Umwelt Bundes Amt (Federal Environmental Agency) has commissioned a number of studies on integrating energy sufficiency in energy planning and strategies. Six reports were published from 2018-2020. For more on these read Kenkmann et al. (2019) in German.

The living space in Germany increases significantly every year and leads to growing living space consumption per capita, even though the population is stagnating, and further increases are expected in long-term scenarios. This trend causes a growing use of space, energy and resources, making sustainability and climate targets in the building sector very difficult to reach. The space saving project builds on a growing awareness of the problem and explores and estimates the large potential of a reduced living space per capita.

The study (Kenkmann et al., 2019) examines the roles of policymakers, associations, and the housing sector, and their specific obstacles and motivations to address the problem. The study also identifies relevant policy instruments to support households in reducing their living space, such as informational and financial instruments and combinations hereof. The instruments are analysed with regards to costs/benefits and distributional effects relating to households. The study identifies the most relevant target groups, with living spaces far above average and analyses possibilities and barriers for reducing living space. Retirees and households facing a break in their routine of life (e.g. reaching retirement age or families whose children are moving out) are among the target groups. For these target groups specific barriers to reducing living space are analysed.

To support households to reduce their living space, a mix of policy instruments are found to be necessary, consisting of both informational and financial instruments. Existing approaches are analysed and a set of novel instruments to support households of the target groups to reduce their living space is created. The

impact of these instruments (for energy consumption and emissions) is then calculated. Furthermore it is analysed whether or not these measures are attractive from the point of view of a household taking into account costs and benefits and show likely distributional effects.

The analysed sufficiency actions are:

- Reducing electricity consumption through sufficiency policies (Stromverbrauch senken)
- Space-saving living through sufficiency policies (Flächensparend Wohnen)
- Shorten work - is it good for the Climate? (Arbeitszeitverkürzung – gut fürs Klima?)
- The interaction of macro- and micro-instruments to reduce energy consumption by behavioural change (Das Zusammenspiel von Makro- und Mikro-Instrumenten zur Energieverbrauchsreduktion durch verbrauchsarmes Verhalten)
- Improving climate protection modelling with sufficiency (Mit Suffizienz mehr Klimaschutz modellieren), analysing how sufficiency is included in existing models (status: end of 2019)
- Overview report on options for reducing energy consumption through behaviour change (Möglichkeiten der Instrumentierung von Energieverbrauchsreduktion durch Verhaltensänderung)

Effects and estimations

The study proposes a number of measures to realise lower living space (Kenkmann et al., 2019):

- *Financial instruments to stimulate the division of single-family houses into more dwellings*. One of the target groups for this measure is retiring people that want to stay in their house. The financing needs identified are for planning and constructing the division of the dwelling into two. The study finds that out of target groups of 2.57 mill. families combined in Germany, 11% could divide their house until 2030 (from 2020) and reduce the average living space per person from 90 m2 to 54m2.
- *Municipal advice centres for efficient use of dwelling space.* The target groups are seniors/retired people and others living with large dwelling space per person. The study finds that out of target groups of 0.38 mill. families, 11% could move to smaller houses and flats 2020-2030, reducing their average size of dwelling from 87m2 to 43 m2. It is important to acknowledge the significant challenges of moving to a new home. It is financially costly, most often even when moving to smaller dwellings, and residents might not want to leave their neighbourhoods, but only change dwelling (Thomas et al., 2019). Municipal administrations can support the move to a smaller dwelling (or different forms of communal housing, or (sub)letting part of a dwelling) through municipal advice centres. These should assist people with large dwellings per person to find smaller dwellings, financial support or practical support in organising the move or clarify legal issues. Furthermore, alternative forms of housing can be promoted and supported, by ensuring the dwelling space needed for these options and providing financial incentives (Thomas et al., 2019).
- Fitnescheck for political and commercial changes. Based on the finding that German housing policies have no focus on limiting living space per person, the proposal is to integrate sufficiency of

living space in German housing policies including advice services. The study has not been able to quantify the effect of this measure.

These proposals and estimations have been integrated into energy modelling in work package report 3 “Integration of sufficiency into energy modelling tools”.

According to Thomas et al. (2019), nationwide cap to municipalities for existing and for new living space, on the average dwelling floor area per person as an overarching instrument, would make the above mentioned incentive and conversion programmes more attractive to municipalities. The first step would be to halt the growth in average dwelling size per capita, before aiming to reduce it, or more radically, to only allow the building of new, additional houses in cities with a growing number of inhabitants. For municipalities to stay within this cap, it would be necessary for them to aid their inhabitants in moving to smaller dwellings, through the measures discussed above. Central governments thus need to provide adequate support and funding to local authorities. However, as a legally enforced cap, the political resistance to this might be too high, and might therefore be better implemented as a strategic and non-binding cap where compliance is regularly monitored (Thomas et al., 2019).

Putting an upper cap on the allowed size of dwellings would be in sharp contrast to municipal priorities in some areas such as Copenhagen. In recent history, larger dwellings have been a dedicated priority in the municipality, in order to attract families with children. Until recently, the demand was that 75% of dwellings had an average size of 95 m2 with a lower limit of 65 m2. The remaining 25% also had a lower limit of 50-65 m2 but did not have the requirement of an average of 95 m2 (Kjærulff, 2017).

The regulations meant that the size of new dwellings increased (in the decade prior to the regulation, 1 out of 10 new dwellings were larger than 100 m2, and in the following decade this number rose to 1 in 4) (Herby, 2018). The regulation has been relaxed in recent times and the focus on families with children has been supplemented by a focus on singles and couples. The average size requirement of 95 m2 still counts for 50% of new dwellings but not for the remaining 50%. The lower limit is now 50 m2 (40 in urban development areas). However, the regulation does not affect student and youth dwellings, communal dwellings or dwellings for citizens with specific needs (Retningslinjer for Boligstørrelser Københavns Kommuneplan 2019, n.d.).

5.2.2 Tiny houses

While the general trend among detached houses in Denmark is increasing in size, there is a simultaneous growing trend for smaller houses, mostly centred around the upcoming concept of *tiny houses*. While tiny houses are not defined in Denmark, many international sources define them as houses (dwellings) with less

than 37 m^2 floor area[25], but many of them are smaller. That there is a trend for tiny houses in Denmark can be illustrated with google searches in Denmark for "tiny house". The following graph (figure 5.4) shows this trend[26].

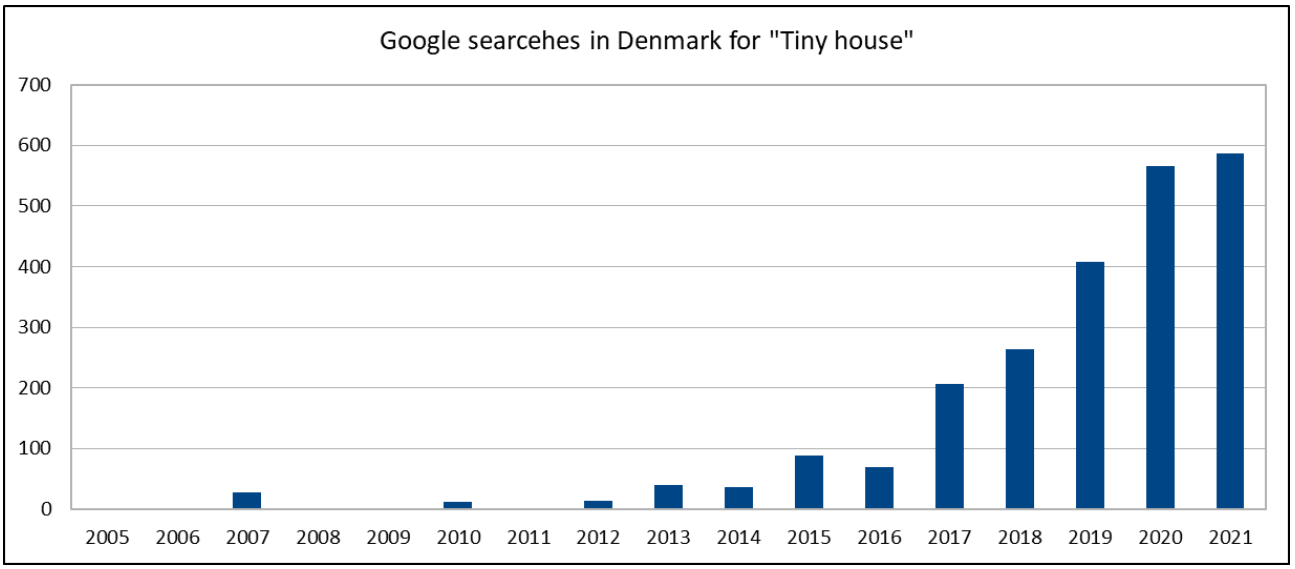


Figure 5.4 Google searches in Denmark for "Tiny house" 2005-2021.

The trend clearly shows that the concept has been growing over the last 5 years. It is now searched for as frequently as "energibesparelse" (energy conservation). There is no official information or rules for tiny houses, but the concept is known via media, organisations, and in particular social media, where Facebook groups are gathering people interested in tiny houses. The two main Facebook groups are "Dansk tiny house" with 7600 members and "Dansk Tiny House Gruppe" with 6300 members and each with near daily posts[27].

There are local groups for tiny houses in at least 10 municipalities and in three municipalities (Tønder, Haderslev, and Rebild) the municipality is starting to include tiny houses in their subdivisions for new houses.

In spite of the large interest, the number of families that move to a tiny house is quite small. One reason is that there are many barriers. Among the barriers are:

- The new Danish building code, BR18, requires that both materials and the entire houses are pre-accepted before a building permission is given. This requires a quite expensive process to get a house design pre-accepted, but once a design is pre-accepted, it is possible to build many similar

[25] Defined in the International Residential Code (IRC) published by International Code Council INC., USA, see https://codes.iccsafe.org/content/IRC2018P4/appendix-q-tiny-houses

[26] Data from google trends, https://trends.google.com/trends/explore?q=tiny%20house&geo=DK accessed 9/12 2021, the month ly data from google trends are summed up to annual data

[27] https://www.facebook.com/groups/309736869641559 and https://www.facebook.com/groups/718885828490183, accessed 17/12 2021

houses. This is not a big issue for large construction companies that build many houses of the same types; but it is a barrier for pioneers, including tiny house pioneers, of which many are not wealthy.
- Land for new detached houses is subdivided in plots for larger houses, not suitable for tiny houses.
- The Danish building code requires high energy efficiency per square metre, which requires relatively thick walls. This is a limitation for movable tiny houses as the size limit for buildings that can be moved on roads is relatively small due to traffic safety. Even though such tiny houses consume much less energy in total than larger houses, they need to be equally well insulated as larger houses.
- The municipal requirements for average and minimum sizes of new dwellings is a barrier to establishing very small dwellings (see section 5.2.1).
- The Danish building code recommends 2 parking places per family, which is much beyond the need of typical tiny house dwellers that often want a simpler living without a car, or maybe with one car. Municipalities can allow deviations from the national recommendations, but that is another issue that prospective tiny house dwellers need to overcome.

In addition to the above-mentioned barriers for tiny houses, the process of obtaining a building permit for any dwelling includes substantial work, and the requirements for a small dwelling are similar to requirements for larger dwellings. This surprises some prospective tiny house dwellers that hope to be able to place a tiny house without too much hassle. In Germany and Norway there are simpler requirements for small houses, also when they are used for dwellings. Thus, there is a possibility to reduce this barrier in Denmark.

While we do not know how many tiny houses are constructed in Denmark, it seems to be less than 100 per year. This is to be compared with the construction of 32,363 dwellings in the last year, of which 5,645 were detached houses and 12,019 were single family houses (detached house, double houses, row houses)[28], thus the current development of tiny houses is insignificant.

If a substantial part of new dwellings were made as tiny houses, it could make a difference in the energy and climate impacts of new, Danish dwellings. Today, the average new, Danish detached house is 205 m2 and with the construction of 5645 of them in 2020, this adds 1.16 mill m^2 to the Danish living space. If half of them would be tiny houses of 25 m^2 each, it would reduce the addition to 0.65 mill m^2. This would mean 2,822 tiny houses per year to replace other detached houses. This is well below the number of people in the Danish tiny house facebook groups. It has, however, not been possible to find any information about the actual interest of Danish families to live in a tiny house, and about how many of the families that move into new detached houses would consider a tiny house instead.

[28]Finished dwellings in 2020, according to Danmarks Statistik, Statistikbanken, tabel BYGV02, see https://www.statistikbanken.dk/BYGV02

Because of the lack of information on the potential to reduce expansion of dwellings with reduced barriers and improved conditions for tiny houses, we have not included tiny houses as a sufficiency option that can be included in national energy models (further descriptions on how the identified energy sufficiency measures can be integrated into modelling, can be read in work package 3 “Integration of sufficiency into energy modelling tools”). While replacing new detached houses of average size with tiny houses will reduce the climate impact of the dwelling use substantially on a personal level, it will require further research to determine if this can significantly influence energy use and climate impacts on a national level. Furthermore, it is relevant to investigate whether tiny houses are considered as an alternative for flats in multi-apartment buildings. This shift might entail greater energy use, due to losses of efficiency gains because an apartment would consume less energy than small detached houses. Hence, aspects must be investigated further in order to determine the potentials for reducing living space by moving to tiny houses.

5.3 Water savings

This section presents energy sufficiency actions on water savings in the sense of changes in the level of service and experience, informed by water consumption labelling for taps, showerheads etc. Moreover it is presented how changes in lifestyle towards sufficiency practices of water consumption can have an impact in a danish context.

5.3.1 Water savings via consumer information with labelling

The EU Commission is considering introducing labels that inform consumers of the water consumption levels of taps and showerheads. The EU Joint Research Center has evaluated the effect of a proposed labelling scheme for taps, showerheads etc. (Cordella et al., 2019). The evaluation shows that the labels will make consumers save 27% hot water and cold water on average, simply because many consumers and designers will use the labels when they select new appliances. Thus it is considered a sufficient practice in the sense that practitioners get a different experience in the use situation (considered the first type of change presented in section 2.1.2). The savings will only be realised with the change of taps and showers; therefore the effect will appear gradually. With the assumption that the label will be agreed in 2021, 75% of the 27% savings will be realised by 2030, equal to 20% savings in energy use for hot water. We have used the 20% saving in 2030 and 27% in 2040 for national scenarios in the work package 3 report “Integration of sufficiency into energy modelling tools”.

5.3.2 Water saving with lifestyle changes

A major part of hot water use is for hygiene, primarily for showers. The average Danish person showers every day and/or takes long showers, though it is healthier for the skin to shower less frequently or take shorter showers. Several sources support this assessment, though it is hard to get scientific evidence for

precisely how much we should shower[29]. Differences in needs for showers after work or sport activities are also a consideration.

While there are health reasons for showering less for many people, as well as time saving benefits, the benefits of showering less are not generally considered. Among the reasons that keep the habits in place are that the health benefits for showering less is a minor health issue for most people, and for some people it does not seem like an option as they need to shower after dirty work, sport activities etc. Also a long shower can be a wellness issue on a cold winter day, if you are having a cold, etc. The change of habits to take fewer baths and showers is most likely to occur if there is a convincing combination of reasons, such as health, energy savings, and water savings, and that each of these reasons are known and understood. Reducing baths/showers can be part of sufficiency information; but to have large-scale effects, it will need to be driven by a national campaign for some years.

Experience has shown that Danish people are willing and able to save water. Increased concern for water use resulted in a reduction of residential water use in Denmark due to increased information on water as a scarce resource and information campaigns on how to save water. Residential water consumption was reduced from 60 m3/person annually in 1987 to 40 m3/person in 2012, a 33% reduction over 25 years equal to 1.3% per year. The reduction was most significant in the first 15 years (1987-2002), where it was 1.7% per year (DANVA, 2020)[30]. For some people, the increased cost of water was a reason to save water, but the water bill is a small part of the costs of living for most people. Therefore, it may be said that environmentally friendly attitude is a more likely reason for water savings.

Given the historically positive response to water savings, we assume that a new campaign with water savings, with a strong focus on health reasons for bathing and showering less, can further reduce water use, in particular the use of hot water. Assuming that ⅔ of the population can reduce bathing or showering to half, the potential is a ⅓ reduction in hot water use. Given experience with a maximum of 1.7% water savings per year, we assume that the maximum saving until 2030 is 17% equal to half of the theoretical potential. We will not include further reductions after 2030. While we will use this estimate in the modelling of a national scenario (see work package 3 "Integration of sufficiency into energy modelling tools"), further work is needed to determine with more precision the fraction of the people that are able and willing to change habits, for instance via living labs with this focus.

5.4 Electricity Savings in Households

This section will present an analysis of options to live a normal modern life with much less electricity use than in the average Danish family, and how sufficiency initiatives based on this could reduce power demands. Electricity is used for a large number of different purposes in households, and to achieve

[29] https://www.theguardian.com/lifeandstyle/2016/jun/14/why-we-should-shower-less-hygiene-water-preservation and https://www.medicalnewstoday.com/articles/324682#can-you-shower-too-much

[30] Annual consumptions are read from graph on page 4 in DANVA annual report (2020)

significant energy savings in electricity use, it is important to address a number of the main uses of electricity.

According to Danish Energy Statistics, the Danish annual electricity demand in households was 37 PJ = 10.30 TWh including electricity for heating. With 2.76 million Danish households, it is equivalent to 3736 kWh/household or 1770 kWh/person for each of the 5.8 million persons in Denmark. The electricity demand for appliances and lighting was 3234 kWh/household[31]. In multi-storey buildings part of the electricity consumption is used for shared facilities: lighting (outdoors, staircases, etc), elevators, laundry, pumps, ventilation, heating (2%) and antenna, internet, etc. This consumption is approximately 11 kWh per square metre[32]. The total area of flats is approximately 79 mio. square metres, thus in average for all households (flats and detached houses) 310 kWh/year is used for shared lighting and appliances.

Many families are using as little as 500 kWh/person, even when they still use electricity for cooking and other normal household functions[33]. If all citizens changed to using 500 kWh/person this could in theory reduce electricity demand by 64%, but it would require large changes in lifestyle, such as quitting the dishwasher and cloth dryer, having only one smaller TV Set, and other changes.

Instead of expecting that the average can be reduced to the same level as those in flats with the lowest 5% consumption, we will base the proposals on possible reductions in some of the electricity uses in typical households. The sufficiency changes proposed are chosen based on compatibility with typical Danish lifestyles, but they are not tested for general acceptance, except for a few.

The national energy statistics from the Danish Energy Agency includes average use and average consumption of major appliances. This is based on ElmodelBolig (ElectricityModelHousing) which is statistics based on a questionnaire sent to approximately 2,000 households every second year. It includes information about the stock of appliances and usage. The latest annual report from 2018[34] includes more detailed information about stock and usage than the national energy statistics. We have used this to determine the possible sufficiency actions. For example 47% never turn off their stereo therefore we estimate that 30% of the electricity consumption can be saved by changed use.

[31] Energy Statistics 2019, p. 35. The Danish Energy Agency.
https://ens.dk/en/our-services/statistics-data-key-figures-and-energy-maps/annual-and-monthly-statistics
[32] Based on a study made for social housing. The average consumption is 13 kWh/m2/year for buildings with laundry and 10 kWh/m2/year for buildings without laundry. Byggeri og Energi: Vurdering af besparelsespotentialet for etageejendomme. Denmark, 2014.
https://byggeriogenergi.dk/media/1247/vurdering_af_besparelsespotentialet_for_elforbrug_i_etageejendomme.pdf.
[33] The families living in flats that have the lowest 5% of electricity consumption consume annually 500 kWh/year for two person families falling gradually to 350 kWh/ person for six-person families, according to fig. 2 in SBI report 2005:12, "Husholdningers elforbrug - hvem bruger hvor meget, til hvad og hvorfor? by Kirsten Gram-Hansen. Published by Statens Byggeforskningsinstitut, Denmark, 2005
[34] ElmodelBolig: Nyhedsrapport 2018 and Bestandens elforbrug 2018. https://statistic.electric-demand.dk/.

The average energy use of these appliances are given in the table 5.3 below together with possible sufficiency actions. For some actions, there are co-benefits, which are important arguments for having larger take-up of the proposals. The resulting savings, with sufficiency actions in 10 different types of electricity consumption, gives average electricity savings of 20% of the household demand for appliances and lighting.

Household electricity demand	Consumption 2019	Action	Saving	Consumption with sufficiency
Per HH 2019, kWh/year	3234		20%	2590
Heat circulation pumps and boilers	81	No action	0%	81
Cooking	278	Optimise	20%	222
Kitchen hood	49	No action	0%	49
Fridge, combined fridge/freezer	281	Half HH with two fridges	16%	236
Freezer	130	No action	0%	130
Dishwasher	166	No action	0%	: 166
Washing machine[35]	176	Wash less	37%	111
Dryer[36]	228	Dry outside every second time, dry less	68%	73
Lighting	260	Turn off when not in use	30%	182
TV, DVD a.o.	442	Turn of when not in use, see more TV together	20%	354
Stereos, game consoles	105	Turn of when not in use	30%	74

[35] The consumption from ElmodelBolig is increased by 25% to include use of common laundry in multi-storey buildings. 24% of all Danish households do not have their own washing machine. Also, the consumption for dryers is increased by 25%.

[36] We estimate that usage of the dryer will be reduced by 37%, when washing is reduced by 37%. When further every second drying is outside instead of using the dryer, the total saving is 68%.

PC, printer, a.o.	269	Turn of when not in use	20%	215
Network (router, modem, TV boxes)	105	Turn off at night and during work hours	35%	68
Standby - TV, PC, Stereo, Washing m, Dishwasher, Dryer	70	Turn totally of when not in use	50%	35
Standby - cooking, fridge, freezer	80	No action	0%	80
Other (ventilation, vacuum cleaner, hobby, shared consumption in multi-storey buildings)	514	No action	0%	514

Table 5.3 Electricity consumption in Danish households excl. Heating (2019), electricity savings from various sufficiency measures and electricity consumption in 2030 after sufficiency measures.

5.5 Policy recommendations for supporting household energy sufficiency actions

The following will add to the policy recommendations noted throughout the chapter, regarding what types of policy approaches can promote and support energy sufficiency in households. Typically, policies for energy transition build on an understanding of changes in energy consumption depending on a mix of energy efficiency improvements that build on behavioural, economical or technological factors (Jensen et al., 2019). Contrastingly, research on energy sufficiency policy highlight the need for multidimensional approaches taking into account complex systems interactions, social and mental aspects such as norms, the economic system and the collective aspects of social practices (Jensen et al., 2019; Thomas et al., 2019; Zell-Ziegler et al., 2021).

Policies can be understood in a broad sense in this context - as instruments set up by various actors from the organised society as a political entity, at various governance levels. Meanwhile, energy sufficiency actions also concern domains in and close to the households, requiring a markedly different type of policies than those aiming to encourage individual behaviour change. Identifying relevant policies and measures for addressing the needs and wants of households, overcoming restrictions in the household (or its environment) in order to enable sufficiency action will "require the analysis of barriers and incentives, but more than for energy efficiency also on acceptabilities of actions, drivers of energy consumption, and framework conditions that shape action in purchasing and using equipment" (Thomas et al., 2019, p. 1131).

Thomas et al. (2019) highlight that energy sufficiency actions and policies differ significantly from those of energy efficiency. These cannot follow a single product type, as is possible with efficiency, but need to follow a whole range of needs and wants. Sufficiency policy also needs to deal with and understand the social norms and practices that determine energy service demands. One important social consideration is that of imbalances (especially gender imbalance) in the care economy, which is one particular area where energy sufficiency actions can be promoted (Thomas et al., 2019). It is thus important that the promotion of energy sufficiency does not put inappropriate and additional burdens on those household members performing care practices such as cooking, washing and cleaning. In the ENERGISE Living Labs, as is often generally the case, it was primarily women who were in charge of laundry activities (Jensen and Friis, 2019). For these women, the reduction in laundry cycles meant reduced time spent doing laundry. However, since laundry time was also perceived as a ‘mental break’ in a busy schedule by many women, it is worth noting that decrease in one area of care work could potentially mean an increase in other types of (care) work. Rebound effects (see section 2.2) are another important consideration. In the context of policy measures, rebound effects need to be understood and acknowledged with the aim of avoiding (direct or indirect) unintended negative environmental impacts.

Thomas et al. (2019) present a policy package for how policy can support households and household members, along with manufacturers and local authorities in practising energy sufficiency actions. They primarily focus on the micro (individual) and meso levels (household and surrounding environment including e.g. suppliers), However, similarly to Freire-Gonzalez (2021) (see section 2.2) and to the political considerations of complex interactions from the ENERGISE PFT (see section 3.2.2), they note that macro drivers such as increasing wealth also need to be addressed by policy. How to do this, however, is largely left out of the analysis. Sufficiency is in this case regarded as a field of concrete action, and the analysis aims to operationalise energy sufficiency actions and their implementation. Energy use is seen as deeply embedded in daily routines and practices, as well as in infrastructures, appliances and technological contexts.

As suggestions for a micro and meso-level energy sufficiency policy package, they present a list of broad types of instruments, to be regarded as a combined approach with instruments reinforcing each other. Such instruments would furthermore need to be backed by an overarching framework instrument, such as an electricity sales cap for suppliers or an energy efficiency and sufficiency fund (by the federal government) and possibly a cap on average dwelling floor area. Thus, the suggestions stress the common thread in the literature, that policy approaches must be comprehensive in their designs, utilising well-designed combinations of instruments. Furthermore, new, uncertain and radical instruments which are characterised by open questions, including some of the recommendations made by the authors themselves, should be put to tests in pilot schemes (Thomas et al., 2019).

Overview of policy recommendations by Thomas et al. (2019):

<table>
<tr><th>Information, knowledge and competency oriented instruments</th><th>Financial / economic instruments</th><th>Material instruments (appliances, infrastructure etc.)</th></tr>
<tr><td>Energy sufficiency advice: a lack of information and motivation can present barriers to the consideration of energy sufficiency actions when appliances are used or purchased. Though information alone will not be enough, it is still necessary. It could be presented in e.g. personalised, motivating and intriguing ways that allows the recipient to see what savings they could achieve or contribute to.</td><td>Energy pricing instruments: energy taxation is used in order to internalise external costs of energy supply into energy prices, thus increasing the energy prices and the economic motivation to save energy, supporting both energy efficiency and energy sufficiency.</td><td>Sufficiency-oriented product policy: a sufficiency-oriented product policy for appliance energy labels and standards, would mean moving from specific to absolute metrics (e.g. kWh/cycle not kWh/kg/cycle for washing machines) and from linear to progressive requirements. For e.g. refrigerators or TV sets, this could mean setting progressive standards with a maximum absolute level. For other product groups, an absolute maximum energy consumption alone might be sufficient.</td></tr>
<tr><td>General requirements: policies are part of producing and reproducing the social 'meanings' of such things as services, needs, comfort, convenience etc. It is important to take into account what 'meanings' policies are taking part in producing and reproducing.</td><td>Financial incentives: financial incentives (e.g. grants, tax deductions etc.) can be used for promoting the purchasing of energy sufficient products. (e.g. smaller refrigerators, or TV sets). In the same sense, higher taxes can be levied on less sufficient products.</td><td rowspan="2">Securing and creating energy sufficient infrastructure: some types of energy sufficiency actions will require the availability of the necessary enabling infrastructure to households. The embodied energy of materials should be taken into account when establishing new infrastructure with the aim of reducing overall energy consumption.</td></tr>
<tr><td colspan="2">Promotion of energy sufficient services: Energy sufficient services can sometimes substitute the appliances used in households. It can require public promotion, information and motivation programmes along with some financial incentive or investment programmes to</td></tr>
</table>

demonstrate such services to support their market breakthroughs and establishment.	

Table 5.4 *Broad types of policy instruments adapted from Thomas et al. (2019, pp 1142-1143)*[37]

Policy approaches for energy sufficiency, as an addition to energy efficiency, require markedly different strategies than those of efficiency. Approaches must be more multidimensional and comprehensive, and to a higher degree deal with social aspects and issues of acceptability. The suggestions by Thomas et al. (2019) can supplement the identified sufficiency practices and considerations for how to support these through policy.

[37] As an overarching and supporting framework, the authors suggest a nationwide electricity sales cap and trade for suppliers, concerning sales to private households (Thomas et al., 2019, p 1141). This recommendation has, however, not been explored further in this project.

6.0 Energy sufficiency actions in mobility

This chapter will explore initiatives for energy sufficiency in mobility within a Danish context. Transport emissions, especially personal transport with an emphasis on the personal car, constitute a very large amount of total Danish emissions. Denmark has set a goal of a 70% reduction of GHG-emissions (compared to 1990 levels) by 2030, and climate-neutrality by 2050 (at the latest). The reduction demands significant changes in transport practices and habits, not only technological solutions such as switching to electric personal cars or waiting for new fuel technologies. The chapter primarily draws on a plan presented by The Danish Association of Engineers (IDA), for how Denmark can achieve the 70% GHG-emissions reduction. The plan is the result of a collaboration between three societies within IDA (IDA Rail, IDA Green Technology, IDA Transport and Urban Planning) during the fall of 2020 (Hartmann, Jørgensen & Wellendorf, 2021), and is an addition to IDAs Klimasvar 2.0 (Lund et al., 2021), with suggestions for how to reduce emissions via transport measures to move transport from cars to bicycles and public transport, and reduce transport in general.

6.1 Sustainable mobility measures - IDA Mobility plan

The report "Omstilling til Bæredygtig Mobilitet" (in english: "Transition to Sustainable Mobility") by Hartmann, Jørgensen and Wellendorf (2021) makes a contribution to sustainable mobility transition by indicating new ways of achieving climate goals. The primary focus is on changing behaviours and the ways in which we move and transport ourselves, followed by how to achieve remaining emissions from cars as a secondary focus. The first approach, shifting mobility from cars to walking, biking and public transport, can lead to a 43% reduction in emissions from personal transport. The remaining reductions, up to the goal of 70%, can be achieved through car sharing, carpooling and electric cars. Furthermore, as a society and with regards to policy, the ability to comprehend mobility as a whole, rather than dividing it into categories, needs to be strengthened. The combined approaches are a stark contrast to the business as usual development of a continued growth in car transport of 2% per year from 2020-2030.

Policy recommendations for supporting sustainable mobility measures

The report divides the proposed initiatives into the following six categories:

1) National mobility plan: there is a need for a coherent and long-term national mobility plan.
2) New mobility agency: a new mobility agency should take over the overarching mobility planning and contracting from the Ministry of Transportation, the Transport Authority, Rail Net Denmark and the Road Directorate.
3) Promote collective transportation: the railway should be a green pulse in and between larger cities. Faster trains, more departures and expanded infrastructure will ensure transition from personal cars to collective transportation.

4) Strategic city/rural mobility: walking, biking and collective transportation in the city centres, high frequency transportation between city centres. Major upgrade of biking infrastructure - also on main roads.
5) Reformation of collective transportation tariffs: short distances should be relatively more expensive and longer distances relatively less expensive, in order to support CO_2- reducing mobility practices.
6) Dynamic use of taxes and fees: taxes and fees should promote collective transportation and biking, rather than personal car mobility as is currently the case.

Since the two first suggestion categories (National mobility plan and New mobility agency) are of strategic character, they will not have a direct effect on CO_2-reduction if they are not combined with the actual actions and specific measures proposed in the plan. The remaining suggestions contain measures that the authors estimate will lead to immediate CO_2-reductions.

Some specific measures proposed in the plan are:

- Promoting public transportation
    - Improved railways with frequent trains on most lines, frequency of trains ranging from every 30 min. to every 10 min. depending on lines. This is more or less a doubling of current train frequency. To realise this, additional tracks are needed for crossings at single track railways and others.
    - Collective transportation time tables should be coupled so as to ensure easy modal shifts. High frequency and high speed trains between larger cities should be implemented, along with an efficient "railway-H" as a counterpart to the motorway-H.
    - Electrification of collective transportation must be sped up.
    - New investments in an S-train tunnel and a light rail grid.
    - In larger cities, bus routes should be established as Bus Rapid Transit (BRT) lines, where they can drive independently from car traffic in dedicated lanes.
- Reformation of collective transportation tariffs
    - The tariffs need reformation so that shorter trips, that compete with biking or walking, become relatively more expensive, and longer trips, that compete with cars, relatively less expensive with prices as low as 0.5-1 DKK/km.
    - The ticket system needs to support flexibility and multi-modal trips.
    - Generally tariffs should be reformed to ensure competitive advantage for collective transportation on all trip distances and purposes.
- Dynamic use of taxes and fees
    - A special focus on reducing the share of people commuting by car (30% of the total car traffic), since the large number of cars during rush hours creates high pressure on roads, leading to stress, accidents and increased need for road maintenance. The many combined

effects make for a broad as well as deep sustainability potential (social, environmental, climate, economic).

- Suggestions for fees with positive socio-economic effects:
  - Road pricing - a km based charge for road use.
  - Parking fees - higher charges for residential parking licences and taxation on parking at place of work.
  - Commuter tax deduction - move the lower limit to 35 km, or differentiate so it applies at 0km for biking, at 12 km for collective transportation and 35 km for cars.
  - Fossil fueled car fees - of 2500-5000 DKK a year.
  - Allowing employers to give bicycles to employees without taxation.

The suggestions from the IDA Mobility Plan can be supplemented with the findings from the project 'Give up your car' (Laakso, 2017) in which households with cars were encouraged to reduce their driving by replacing car transportation with bus transportation. In the project, 11 participants were chosen based on applications (of which 22 were received) in which they proved that they had sold their car or one of their cars - a precondition for participating in the project. The households were then, in return, offered free travel cards to local buses for six months. Before the experiment, the household members drove, on average, 210 kilometres per person per week (varying between 35 to 850 kilometres due to differences in distances to work and other locations and activities). "At the end of the experiment, the average kilometres driven had been reduced to 100 (per person per week). The total GHG emissions of participants reduced significantly during the experiment (as all the households had one car less), the average reduction being 43 % [...]. The reduction varied between 8 to 69% among households" (Laakso, 2017, p. 9). In Denmark, 474,465 families had two cars in 2021, and 1,375,116 families had one car (Statistics Denmark[38]).

The car use was mostly replaced by buses, but also by cycling and walking as the weather improved with the season. The fact that participants applied based on a preexisting interest in giving up one of their cars helped the success of the experiment. Furthermore, the project was relatively successful due to the precondition of participants giving up one car, since previous projects had shown that results of experiments with free bus pases were often only temporary, since cars are expensive to own and therefore economical to use as long as you own it (Laakso, 2017, p 14).
Six months after the experiment, only one of the participants had bought a new car. Some participants continued using buses regularly, but generally, bus use was reduced after the experiment. In households with two cars, emissions increased to some degree after the experiment, since bus use was replaced by more intensive use of the remaining car. Laakso (2017) furthermore stresses the need to understand mobility practices in order to ensure long term effects of such initiatives and what she calls *re-routinisation* (Laakso, 2017).

[38] Statistics Denmark, tabel BIL82
https://www.dst.dk/en/Statistik/emner/transport/transportmidler/familiernes-bilraadighed

6.2 Sustainable mobility through planning - IDA Mobility Plan

The suggested measures to promote sustainable mobility through planning is a significant part of the strategy and includes the development of a national mobility plan as a means of ensuring strategic and cohesive development of mobility in and between cities and rural areas. These should not be regarded as two disconnected areas, as is the case today, especially with regards to biking and collective transportation.

The overarching ideas fall under the following categories:

- Less space and less parking for cars in cities.
- The principle of having most functions available within 15 min by bicycle from dwellings, as recommended by the C40 city network.
- "Traffic islands" in cities, where local districts are only accessible for cars via one route while bicyclists and pedestrians can enter it from all sides.

Policy recommendations for supporting sustainable mobility through planning

Some of the proposed actions with regards to urban planning are as follows:

Strategic urban planning in municipal and local plans - placement of companies and institutions.

- The basic principles of such strategic planning should be sustainability and CO_2-emissions reduction by prioritising accordingly: soft mobility > collective transportation > cars, e.g. by setting standards and norms for parking of bikes and (electric) cars.
- Rethinking local city centres with necessary daily functions such as stations. Inspiration could be drawn from the concept of 15 minute cities, where most functions are available within 15 minutes, as recommended by C40 Cities. This will also require investments in speed reducing initiatives, biking paths and sidewalks.

Traffic islands

- At the municipal level, setting speed limits in city centres and creating traffic islands and/or environmental zones where fossil fuel vehicles are excluded. These can be accompanied by parking prohibition and/or car free zones around institutions such as schools and a general reduction of speed limits to 30 km/h (as recently introduced in the Netherlands, Belgium and Spain).
- Such measures are essential in changing short distance mobility behaviour and reducing traffic. They also lead to increases in the urban space quality - reducing noise and air pollution, making the space more attractive to spend time in.
- There are both international and Danish experiences to draw from (e.g. Nørrebrogade) - applicable in any larger or medium sized city.

Cohesive and connective collective transportation

- Cohesive connections should be created between larger cities and between large and medium sized cities. Trips of 10-99 km accounts for 65% of CO2-emissions from personal transportation which calls for a regional perspective on collective transportation.

- Combining biking with collective transportation and using the bicycle to reach the station, provides interesting opportunities in terms of making collective transportation competitive from a time optimising perspective, studies show.

Improved mobility around stations

- Stations need to ensure advantageous modal shift opportunities, with multiple access points and connections between platforms and the stations' immediate surroundings as well as the surrounding city. Optimal connective stations also require sufficient parking spaces for (electric) cars and bicycles, with charging options.
- Additionally, new stations should be established in new residential or workplace areas.

Expansion of biking infrastructure between cities

- A special focus should be on creating a country wide web of super bicycle paths for the trips of 4-20 km in rural areas that can be carried out on electric bikes with the infrastructure is safe and appropriate. It is also important to create super bicycle paths of sufficient quality to accommodate new developments in bicycle technologies such as speed pedelecs, electric cargo bikes and velomobiles.
- A complete web of countrywide super bicycle paths will cost an estimated 11 billion DKK. Based on experiences in the Capitol Region, these super bicycle paths significantly change mobility behaviour patterns. A 10 year period showed a 23% increase in bicyclists on these paths, of which 14% used to drive cars.

Options to bring bikes on trains and buses

- This enables and eases the "combination trip", ensuring competitive advantages against cars and enabling a cohesive trip from A to B, even if one's destination is not located at a station.
- This requires reliable and comfortable trains and buses with good service, preferably with facilities for working or having meetings.
- Experiences from the S-train grid in Copenhagen show that allowing free onboarding of bikes generates many new passengers who previously drove cars - an increase in passengers of up to 10%.

Lower speeds for road traffic

- Lowering speed limits to 90, 70 and 30 km/h respectively, presents an easy-to-implement environmental initiative. This only requires new signs and can be quickly implemented.
- This would make biking and collective transportation advantages and would reduce accidents, noise and CO2-emissions immediately.

6.3 Estimations and potential

Some of the suggestions by IDA include estimated effects of the measures, based on the Danish National Travel Survey[39] (Transportvaneundersøgelsen (TU) ved DTU Center for Transport Analytics via:

[39] The data in this survey is calculated based on the transport distribution in terms of length of trips (straight line distance) and the measures and their potentials are therefore specified according to different trip distance intervals.

www.tudata.dk) and national and international experiences, along with considerations on implementation and scalability. Other initiatives and measures are not individually commented or estimated, but figure as part of combined efforts. An overview of the estimated distribution of different transport modes before and after the proposed measures is shown in figure 6.1. The complete overview of estimations based on the proposed measures, can be found in the expert contribution "Omstilling til Bæredygtig Mobilitet" (in english: "Transition to Sustainable Mobility") by Hartmann, Jørgensen and Wellendorf (2021). However, the publication only includes qualified assessments and estimations, and actual calculations would require further analysis.

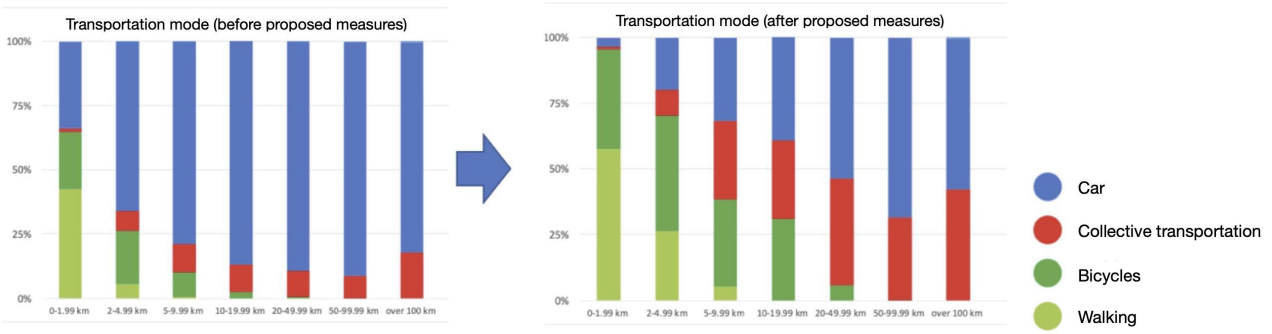


Figure 6.1 An estimation of the distribution of different transportation modes before and after the proposed measures. Adapted from (Hartmann, Jørgensen and Wellendorf, 2021, p. 31)

For an overview of the specific measures that provide the primary changes in each travel distance interval, see the expert contribution (pp 33-36). To exemplify these changes in one of the trip distance intervals, we highlight the interval of 0-2 km. This is one area where urban planning has particularly significant potential. For the short distance trips, a potential car presence reduction of 90% is estimated, and the CO_2-emissions from the remaining car traffic will be reduced by 75% through car sharing and electric cars. This leads to an estimated 98% reduction in CO_2-emissions on trips of 0-2 km. Some of the proposed measures to obtain these reductions are:

- All city centres in large and medium sized cities are free of fossil fueled cars approximately 2 km from the centre/station.
- Speed limits in all city centres (small and large) are reduced to 30 km/h.
- Bicycle paths and bicycle parking in stations' surroundings are prioritised.

The combined effects of the measures in all six proposal categories are estimated for the different trip distance intervals for the target year 2030. These estimations are given in the table 6.1 below:

Trip of distance	0-2 km	2-5 km	5-10 km	10-20 km	20-50 km	50-100 km	+100 km	**All trips**
Reduction of car transport	90%	70%	60%	55%	40%	25%	30%	**43%**

Reduction of CO_2*	98%	91%	87%	82%	70%	55%	33%	**70%**

Table 6.1 Estimations of reductions of car transport and CO2 per distance travelled. Numbers adapted from *(Hartmann, Jørgensen and Wellendorf, 2021, p. 33-36)*

*Reduction of CO_2 includes that half of remaining fossil cars are replaced with electric cars. In the input data for EnergyPlan, the reduction of car use will reduce transport fuel demands. The effect of the measures for input data for EnergyPlan is shown in the table below for Danish transport energy demands

6.4 Actions for shorter daily transport

Daily transport is determined by the need to travel between the places we need to go on a daily basis, such as travelling between home, work, shops, leisure facilities etc. We can reduce this travel by living closer to the places we need to go, and by going there less often, as when working from home. Often the distances between places we need to go is determined by the structures we live in, as the city structure, the distribution of workplaces etc. Another factor is our ability and willingness to move nearer to, for instance, a workplace. Thus, our daily transport can be reduced by:

- Urban planning with better location of functions
- Easiness of moving closer to the workplace etc.
- More work from home.

Each of these actions can be promoted with policies. For urban planning, cities have started to plan their city with functions closer to each other. One specific example is the Paris 15-min. city. The metropol has since 2020 worked for a city in which citizens' basic needs, such as work, shopping, health, or culture, should be available within 15 min of their home, using walking, bicycling and public transport. This will reduce the demand for commuting and other daily transport to a level, where it will be possible to meet it with no other energy input than muscle power. The concept is strongly promoted by the Paris Mayor and it is not only for environmental and climate reasons. The Mayor's advisor Moreno states "there are six things that make an urbanite happy: dwelling in dignity, working in proper conditions, [being able to gain] provisions, well-being, education and leisure. To improve quality of life, you need to reduce the access radius for these functions".

The 15-min. city is under development, and to realise it is needed to improve diversity in the city and to lower the unbalanced distribution of facilities between districts. So far, improved bicycle infrastructure has been put in place as well as limits to car access.

While urban planning combined with the other measures to reduce daily transport has huge potential for reducing mobility demand in a sustainable way, it has not been able to quantify them and include them in modelling. Some aspects of urban planning are included in the plans described in this chapter; but with the 15-min. city plans and similar, much stronger reductions are possible, when they gradually get realised.

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Appendix 1

The Description Template for describing SECIs

The Description Template is meant to provide the basis for further qualitative descriptions of inspirational initiatives, from which we can learn about social, material, institutional, cultural and geographical dimensions of energy consumption and sustainable energy consumption initiatives. The Descriptions should allow us to assess and possibly compare these dimensions across countries, so we need to explore these dimensions and their interdependency for each initiative we include in this 2nd phase of WP2 Data Collection.

The Description Template has two parts, where the first part is mainly descriptive (including a contextualizing introduction, methods, steps of implementations and results) and the second part allow us to reflect about the initiative in terms of discourses, levels of shared understandings, material conditions, aspects of locality and intervention targets. The second part is theoretically inspired, drawing on theories of practice. This structure allow us to gather information about the initiatives, which we can use for designing our ELL's (such as methods, the role of the householder, steps of implementations and methods) and it allows us to explore practice theoretical aspects of the initiatives, which are interesting in terms of assessing and comparing initiatives in terms of what is 'good practice', and it allows us to explore practice-theoretical aspects of interventions, which can inspire our ELLs as well.

Below is a working definition of the concept of (social) practice that we draw on when filling in the Description Templates:

Working definition of practices (extracted from Spurling et al 2013).

Individual behaviors are, primarily, performances of social practices. Rather than being the expression of an individual's values and attitudes, behavior is the observable expression of social phenomenon (socially shared tastes and meanings, knowledge and skills, and materials and infrastructure). As such 'behavior' is just the tip of the iceberg, and the effects of intervening in behavior are limited accordingly. It is the practice entity— the socially embedded underpinning of behavior—which forms a better target for sustainability policy.

Socially acceptable individual behavior—or the successful performance of a social practice—thus rests upon the use of objects, tools and infrastructures, of knowledge and skills and of cultural conventions, expectations, and socially shared tastes and meanings. These are the elements that compose social practices.

Introductory paragraph

- ***Brief Description:*** Describe the initiative briefly: what, where, when, how and who.
- ***Brief Contextualization:*** Please briefly contextualize the initiative, particularly in terms of historical and local conditions underpinning the initiative. How are national trends in terms of addressing energy consumption *reflected* in the initiative: Is it an unusual, almost one-of-a-kind example, or is it an exemplary case for a larger program that was implemented in various places or is it a follow-up from something else? What are the local conditions for the initiative, if any? For example, is there a local 'awareness' of problems with energy or water? Is there a local water scarcity that is reflected in the focus of the initiative? Long term energy problems like blackouts? Or is there a strong sense of community in terms of exploring different ways of living?
- ***Aims and objectives***: Please include details of the aims and objectives of the initiative. What specific problem(s) is the initiative addressing, and what seems to be the success criteria? What do the people responsible for the initiative hope to obtain, and were they successful? .

Methods for intervention

Describe the methods of intervention, e.g. information, competition, visioning process, subsidy, co-creation. For each method employed, briefly explain what it consisted of and how it tied into other methods used. Are the methods utilized in this initiative inspired from nationally popular approaches that are repeated in various places/situations, but with variations and maybe with varying results? *As an example, in Denmark, refurbishment schemes are popular, and widespread. A lot of initiatives take their point of departure in framing the problem of energy consumption as a matter of issues with inefficient buildings, and not what people do inside of the buildings*.

Or are the methods utilized in this initiative part of a research project (and therefore relatively unique/new)? Or are the methods utilized in this initiative inspired by what other countries do? (eg. some Irish initiatives about community energy are inspired from Danish approaches).

Steps of implementation:

Briefly describe what has happened and when? Please detail the initiative in terms of steps of implementation. How did it start, how were householders enrolled, what happened and when? What kinds of events were organized when, in relation to the initiative? When did changes in energy consumption start happening (if they did)? What seemed to have led to these changes? What did the intervention and implementation cost (if known/info available)? Please sketch a small timeline, if possible.

Results/outcomes:

Please detail what kind of results and outputs have come out of the initiative? Have there been any measured reductions in energy consumption or emission reductions? What has been done to obtain these reductions? What are the norms of reporting/what is reported on? Can you detect any examples of changes in representations of everyday life, e.g. are householders doing things differently? Do they shower differently (less often or in different ways?) Do they cook differently? What has changed in the householders' everyday lives that have led to lower energy consumption?

The role of the households

How have householders been involved in the initiative? Have they been part of designing the initiative? Have they engaged in several activities, and if so, which? Has the initiative developed based on feedback from householders? Or have the householders mainly been receiving information and asked to act on that?

Did householders contribute financially to the initiative?

Are there any interesting details about the participation? Think in terms of what could inspire our living lab design. Are there any examples of experiments? Or examples of householders that stop doing certain things that generate energy consumption (e.g. driving, using the tumble dryer)? From this initiative, what do you think could be useful for the design of the Energise Living Labs?

Location

Are there any significant features about the locality of the initiative? Where does the initiative take place? Why has the initiative been introduced to this particular area and to these particular people/householders? Are the households in this initiative selected because of a certain sense of community, or because they are located in the same place (purely geographical reasons)? Are there spillover effects of the initiative into wider (local) society? As an example, did the initiative focus on lowering energy consumption in relation to washing and dishwashing, but did then also result in changes in the way people cook, or drive or share things with each other locally?

Was/is the initiative successful?

Was/is the initiative considered successful by the initiator? Why? Why not?

Do you think the initiative was/is successful? Why? Why not?

Textual and communicative aspects of initiative:

What seems to be the general framing of the initiative; how is energy consumption framed as a problem? What do initiators say or write about the problems they aim to solve with the initiative? Does it correspond to the way that householders talk about the problem? As changes in energy consumption is normally (politically) and narrowly assigned to changes in individual actions, it is interesting if the initiative reflects any other ways of addressing energy consumption. Is there any indication that the initiative differs from the norm, and treats energy consumption as a result of social organization rather than as a result of individual actions? With what words are the outcomes/results (if any) described? In what way is the role of the householder framed and communicated? (e.g. as people living everyday lives, or as rational consumers who like to save money, placing responsibility on either individuals, groups, or society?)

The physical/technological aspects of the initiative:

What kinds of activities are made possible/not made possible in the physical conditions of the initiative? Are technologies introduced to households, which enable different ways of using energy or different ways of cooking, showering, cleaning, etc.? Are householders asked to stop using certain technologies/products or to start sharing certain technologies/products? Is the size of the houses targeted? Is the amount of products that householders used targeted? Is there a certain physical layout that enables, for instance, sharing and repairing of products? *As an example, the physical layout of a Danish Ecological community enables a certain sense of community, ways of living,*

growing own crops, repairing and sharing. It also limits the use of cars, due to the low number of car-parking spaces.

Can you find examples of whether certain material components are regarded as i*nfrastructural* (something that is perceived as unchangeable – e.g. how energy supply is often treated), as *devices* (something that can be altered with, that you can use differently – e.g. things and products such as kitchen appliances) or as *resources* (something that is used up, in order to obtain something particular, e.g. water, energy)? Has any product, technology or supply changed role over the duration of the initiative? Has, for example, energy supply changed its role from 'infrastructural' to a 'device' that you can alter and change?

Shared understandings related to initiative:

Is there a shared understanding of what energy is used for between initiators/initiative and householders? Is there a shared understanding of the role of consumption between householders/people involved in initiative? *E.g., in several of the Danish ecological communities, there is a shared understanding that material consumption should have less priority than spending time together, spirituality, eating together, etc. In some of the more technically oriented initiatives, the underlying reasons for consuming are not targeted or challenged, rather the initiatives seek to optimize or make efficient existing ways of living and using energy*. What is perceived to be the 'normal' or 'appropriate' way to save energy? How are shared understandings reached and agreed upon (e.g. through energy charters, communal dinners, sharing events etc.)?

Problem Framing and Target of Intervention:

In what way does the initiative frame the problem of energy consumption, and what becomes the target of intervention? *(Please read the Executives Summary 'Interventions in Practice: Re-framing policy approaches to consumer behavior' by Spurling et al 2013). Where on the table (below) does the initiative belong?*

Table 3 adapted from Spurling et al 2013

Problem Framing	Target of Intervention
Common framings in current policy interventions	
1. Innovating technology	E.g. initiatives that focus in optimizing products that people use and/or solely technical aspects of retrofitting
2. Shifting Consumer Choices	E.g. Initiatives that focus on informing householders about choosing energy efficient products.
3. Changing Behavior	E.g. Initiatives that focus on *nudging* householders to do something differently (primarily optimizing existing patterns of everyday life).
Framings drawing on a practice perspective	
4. re-crafting Practices	E.g. Initiatives that introduce interventions in several elements of practice be it in terms of material changes, changes in competences or changes in socially shared images and meanings. It can be initiatives that uses various outlets for promoting change, like the New Nordic Diet that challenges the material element of a diet (food), the competences required to

	prepare certain meals (new cook-books) as well as socially shared meanings attached to 'good food' (making Nordic meals trendy).
5. Substituting Practices	E.g. Initiatives that recognize that performances of practices requires space and time, and therefore practices compete for time and space. Practices of commuter driving and commuter cycling compete. If a practice of commuter cycling is to disperse, interventions should focus on making time and room for such a practice; e.g. making more room for bikes on the road, create facilities for showering at destinations, maintenance possibilities, and help advocating for a socially shared acceptance of biking to work (including spending the time needed to bike rather than driving. The aim would be for people to defect from a practice of commuter driving and to be recruited to a practice of commuter cycling.
6. Changing how Practices Interlock	E.g. Initiatives that challenge the sequence of practices or the organization and institutionalization of everyday live. It could be initiatives that promote working closer to home and maybe in hub-offices that would encourage people to meet across lines of work (decreasing the need for mobility, and maybe encouraging people to socialize differently and eat together, changing configurations or practices of eating, working and socializing)