# Energy sufficiency as part of climate action

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## Introduction

The concern for sufficiency as part of designing ambitious pathways to reduce greenhouse gas emissions and tackle climate change stems from a broader concern for sustainability. The idea of a growing evidence of some kind of overshoot of planetary boundaries – of which climate change is one major, but not single factor –, although still challenged by some stakeholders, is leading to a growing call for a broad response. While a faster development and deployment of greener technologies is part of this response, the discussion increasingly points to the need for changes in societal organisation and practices.

One of the main questions to be addressed is then to discuss how much such changes are needed, what do they concretely mean, and how much can be achieved. Over recent years, ***sufficiency*** emerged as a proposed term, and concept, to *"encompass such efforts to rethink and redesign collective and individual practices in line with the Earth limits and people aspirations for better lives"*, according to a definition coined by the International Network for Sufficiency Research & Policy (Enough, 2018). This has possible implications in many areas and relates to reflections to be led on such diverse issues as human needs, social equity, economic development, urban structures, social norms, consumption habits, and so on. It therefore also calls for rethinking policies to support the necessary transition in these different areas.

The present note explores the way the concept of sufficiency, when applied to energy, can contribute to building compliance with the Paris Agreement by reinforcing long term scenarios that in turn inform policies. After clarifying the concept and its link to social, economical and ethical concerns, it discusses the reasons why sufficiency should be considered as an important and possibly crucial mitigation option, and how to introduce it in modelling work accordingly, to fully reflect its potential role while taking into account its limitations.

## The concept of energy sufficiency

There is no straightforward and universal definition of the concept of sufficiency, whether as a general approach of consumption or under a specific concept of energy sufficiency. One key component of the latest, however, is the notion of ***energy service***.

The energy services refer to the services to end-users that are provided through energy chains: as a general pattern, primary energy is converted into final energy delivered to industries, tertiary consumers, households, individuals, that in turn use energy converters to provide them with useful forms of energy (mechanical, thermal, light, etc.) that they use to fulfill services.

### Energy services and limits

Shifting to an approach based on energy services, where the whole energy system is considered through the overarching purpose of fulfilling them, starts with emphasizing that energy is not not simply a commodity or theoretical concept. It has social, ecological and strategic values, connected with familiar policy areas: social welfare, climate and air quality protection, security and resource management, and others (eceee, 2018a).

Supported by:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
based on a decision of the German Bundestag
European Climate Initiative EUKI
STIFTUNG MERCATOR

Project partners:
ecologic · IDDRI · Fraunhofer ISI · ENERGIAKLUB Climate Policy Institute Applied Communications · WiseEuropa · Öko-Institut e.V. Institut für angewandte Ökologie Institute for Applied Ecology · Association négaWatt · DTU Technical University of Denmark · ENEA Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

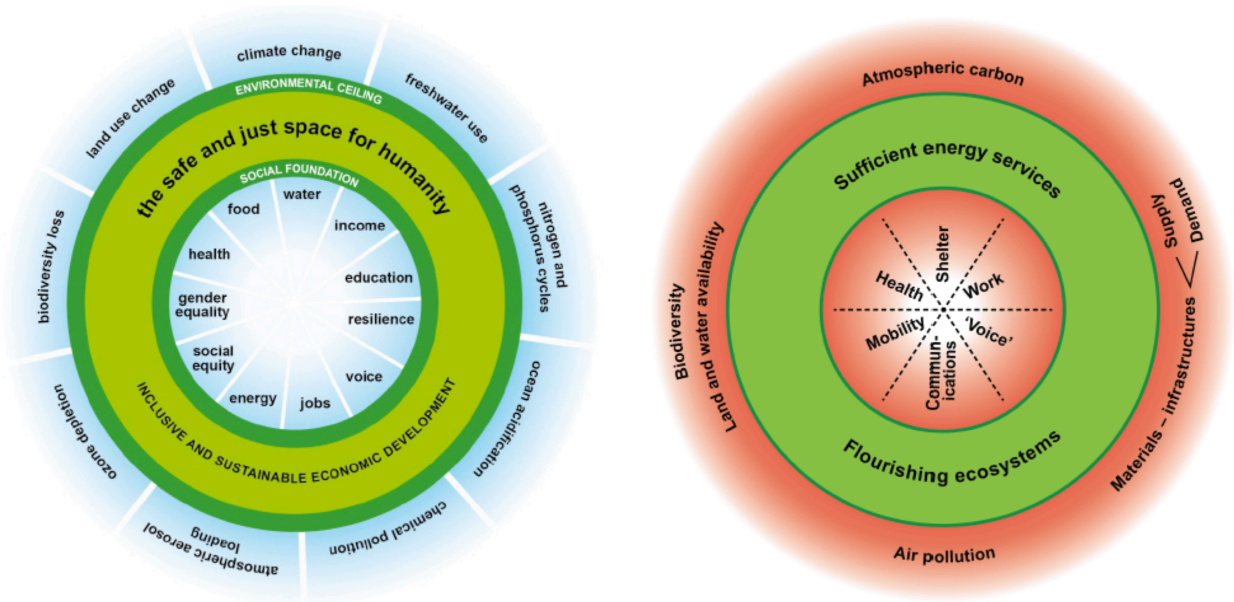
*This project is part of the European Climate Initiative (EUKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).*

Energy services refer to the benefits provided by energy and its use, such as cooking, lighting, cooling, IT-based communication, automotive transport and industrial processes. It is clear that delivering energy services is actually more than making energy available to end users, as it strongly depends on other factors such as the conditions of use of this energy.

For instance, ambient “free” (i.e. available) energy, activities and materials can contribute to the delivery of services. As an example, staying comfortably warm or cool is not only about heating living space, but can be a function of clothing, activity levels, control over one’s living or work space, and other factors that are often not even considered under the heading of “energy”. Conversely, non-energy initiatives or changes can modify the conditions of access to energy services, from creating such an access to denying it. When planners or natural processes alter the “landscape”, for example, they also modify the mobility options.

A focus on services allows for thinking in terms of having enough and not using too much. This brings an idea of higher and lower limitations to individual needs that strongly connects with the “doughnut economy” concept introduced by some economists (Raworth, 2017; Spengler, 2016), as shown in the figure below. The “safe and just space for humanity” is defined by a lower boundary or “social foundation” that corresponds to the satisfaction for all of all basic individual needs (of which energy ones), and an upper boundary or “environmental ceiling” that corresponds to the limitation of global impacts (of which climate change) through keeping mean individual consumption a certain level. The concept has been adapted by the European council for a energy efficient economy to characterize the notion of “sufficient energy service” (eceee, 2018a). This is taking into account the main areas of individual welfare where access to energy services is crucial, such as shelter, mobility or health, as an approach to the lower limit, and the main global environmental concerns which the use of energy impacts, including climate change but also air pollution, erosion of biodiversity, land and water availability, and the use of materials.

**Figure 1 A representation of the concept of boundaries as applied to energy services**




Source: eceee (2018a)

## Lifestyle choices and economy

Although this is not the only way to approach or define what sufficient energy services would mean, this illustrates the strong link between sufficiency and societal and economic choices, which in return often lead to questioning the rationale for sufficiency.

It is obvious that an important part of sufficiency lies in behaviour change, in the sense of lifestyle changes driven by informed actions of individual end users. This is often considered as an add-on to demand side management, or an extension of efforts for improving efficiency to further reduce energy demand.

This is also often raised as an adverse factor to implementing sufficiency, based on perceived limitations to the potential for such informed individual changes.

However, the role of voluntary individual changes needs to be put in a broader and more collective perspective, considering larger issues. An important one is that sufficiency is not necessarily about reducing energy demand: focussing on individual reductions takes attention away from the need to ensure adequate energy services for everyone, including giving access to them to people who do not yet have. Sufficiency encompasses concerns for social wellbeing and equity.

Moreover, pointing to the need for specific, conscious individual decisions and actions to change lifestyle draws attention away from the unconscious, routine nature of many activities associated with energy consumption, where there is also a large area for sufficiency.

Last but not least, framing the issue of sufficiency primarily in terms of lifestyle choices and individual behaviour is too limitative, when infrastructures of supply and demand influence the possibilities open to individuals, sometimes greatly. The way design and construction of the built environment frames behaviour options deserves receiving attention, as it can be crucially important in 'locking in' high or low consumption patterns, for example.

This is actually one of the reasons why strong negative reactions to sufficiency are sometimes witnessed, even before any potential has been discussed and understood. It generally relates to an ideological or political background that goes against questioning the overall economic structures that are at stake in framing current dominant consumption patterns. As US president Georges Bush Senior abruptly put it, aside early climate negociations back in 1992: *"The American way of life is not up for negotiations. Period."*

Against that background, the term "sufficiency" is symbolically strong and can be understood as subversive, morally normative, or carrying negative ideas of curtailment, etc. As a concept, sufficiency often goes against the mainstream worldview and dominant social paradigm based on consumerism and materialism, that pushes for increasing the use of energy-intensive services. In other words, the economic system we live in, and how its growth is achieved, often creates barriers to sufficiency. Social norms and wants poorly compatible with sufficiency are often supported by mainstream media and marketing, in the way they promote certain lifestyles as desirable or even normal (e.g. large luxury flats, big and fast cars, immoderate use of digital technologies, globe-trotting, etc.)

## Social acceptance

This is obviously raising some issues regarding the social acceptance of implementing sufficiency of energy services. Mainy barriers to the perception and positive attitude towards sufficiency potentials are identified (Dufournet, 2019):

- first of all, the relative invisibility and somehow intangibility of energy use, very often as part of daily practices and routines, makes it difficult to realise the saving opportunities;
- when they are better identified, sufficiency potentials can be perceived as encompassing some loss in comfort, welfare or utility compared to maintaining the current levels of consumption;
- even when these potentials are clarified and the need for addressing them is further acknowledged, there is an inherent resistance to change in daily practices;
- there are of course difficulties in reaching advanced levels of implementation due to socio-technical lock-in effects on one hand, and the weight of social norms and imaginaries on the other hand, as discussed above.

Moreover, it can be observed that specific sufficiency options are likely to trigger emotional (and generally negative) reactions, depending on the concerned publics: this is for instance the case with reducing air travel, which one might however deem necessary due to the lack of technical option to readily decarbonise it, lowering speed limits on roads, moderating living space areas per capita, or on a non-energetic but related issue, reducing meat consumption.

It is useful, in the face of such limitations to the acceptance of sufficiency, to point to some co-benefits associated to its implementation and their potential to foster further acceptability of this option. Alongside the obvious benefit of contributing to saving energy and reducing the associated costs and impacts, sufficiency options often come with other benefits that may be even more desirable and felt positively. For example, perceived benefits of low-meat diet include the prevention of disease or the pleasure to diversify the food that one eats. Health benefits, when they can be characterized, are particularly interesting to highlight.

Indirect benefits on conditions of living can also be emphasized in many cases. This is for instance the case with an increased share and reduced use of cars, that besides reducing pollution, leaves mor space for other uses and activities in cities. Other and broader benefits on life quality, such as more fulfilling social interactions or an happier life, etc. can also be identified.

More collective benefits can also be discussed, such as the potential role of sufficiency, either at a regional or national level or even worldwide, in reducing inequalities and contributing to social justice. Sufficiency is part of the ongoing conversation about “prosperity without growth” (Jackson, 2017), the contributes to informing the recurrent question about the impact of sufficiency on the economy. Some studies show how sufficiency can promote new forms of economic wealth and create jobs, for instance in areas such as local tourism, alternative transports, repairing activities, etc.

One very interesting way to consider the potential benefits of sufficiency options, as compared to other greenhouse gas mitigation options, is to consider its impact on the series of 17 sustainable development goals (SDG) defined by the United Nations (or 16 of them, excluding the one about climate action).

## Figure 2 Options for climate action and sustainable development goals

| Options for climate action (reduction of net GHG emissions) | United Nations sustainable development goals | Social | | | | Social 2 | | | | Environmental | | | | Economic | | | | | | Cumulative score | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 10 | 16 | 17 | 6 | 12 | 14 | 15 | 7 | 8 | 9 | 11 | 13 | | | | |
| | | No Poverty | Zero hunger | Good health and well-being | Quality education | Gender equality | Reduced inequalities | Peace, justice and strong institutions | Partnerships for the goals | Clean water and sanitation | Responsable consumption / production | Life below water | Life on land | Affordable and clean energy | Decent work and economic growth | Industry, innovation and infrastructure | Substainable cities and communities | Climate action | Number of valued criteria | Maximum | **Total (mean value)** | Minimum |
| Industry | Accelerating energy efficiency improvement | +2 | | +2 | +1 | | +1 | | +2 | +2 -1 | +1 | | | +2 | +1 | +1 | +2 | n.d. | 11 | 17 | **15,5** | 14 |
| | Low-carbon fuel switch | | | +2 | +1 | | | | +2 | +2 -2 | +2 | | +1 -1 | +2 | +2 | +2 | +2 | n.d. | 10 | 18 | **15** | 12 |
| | Decarbonisation/CCS/CCU | | | -1 | | | | | +2 | +1 -1 | +2 | -1 | | +2 -2 | +2 | +2 | | n.d. | 8 | 9 | **6** | 3 |
| Buildings | Behaviorial response | +2 | | +2 | | | | +2 | | +2 | +2 | | | +2 | +2 | +2 | +2 | n.d. | 9 | 18 | **18** | 18 |
| | Accelerating energy efficiency improvement | +2 -1 | +2 | +2 | +2 | +1 | +1 -1 | +2 | +2 | +2 | +1 | | +2 | +2 | +2 -1 | +2 | +2 | n.d. | 15 | 27 | **23** | 19 |
| | Improved access & fuel switch to modern low-carbon energy | +2 | 0 -1 | +2 | +1 | +1 | | +2 | +2 | +2 -1 | +2 -1 | | +2 | +2 | +2 | +2 | +3 | n.d. | 14 | 25 | **21,5** | 18 |
| Transport | Behavioural response | +2 -1 | +2 | +2 -1 | +1 | +1 | +2 | +1 -1 | +2 | +2 | +2 | | | +2 | -2 | +2 -2 | +2 | n.d. | 14 | 21 | **15** | 9 |
| | Accelerating energy efficiency improvement | +2 -1 | | +2 | | | | +2 | +2 | +2 | +2 | | | +2 | +2 -2 | +2 -2 | +2 | n.d. | 10 | 20 | **14,5** | 9 |
| | Improved access & fuel switch to modern low-carbon energy | +2 -1 | 0 | +2 | | | +2 | +1 -1 | +2 | +2 -1 | +2 | | | +2 | +2 -2 | +2 | +2 | n.d. | 4 | 21 | **15** | 9 |
| Replacing coal | Non-biomass renewables | +2 | | +2 | +1 | +1 | +1 | +2 | +2 0 | +2 -2 | +2 | +2 -1 | -1 | +3 | 0 | 0 -1 | +2 | n.d. | 15 | 21 | **16** | 11 |
| | Increased use of biomass | +2 -2 | +2 -2 | +2 | | | | | | +1 -2 | +2 | | +1 -2 | +3 | +1 | +1 | | n.d. | 9 | 15 | **8** | 1 |
| | Nuclear/Advanced Nuclear | | | -1 | | | | -1 | | +2 -1 | | | -1 | +1 | +1 | -1 | | n.d. | 6 | 0 | **-1,5** | -3 |
| | CCS: Bio energy | +2 -2 | +1 -2 | +2 -1 | | | | | | +1 -2 | +1 | | +1 -2 | +2 | +1 | +1 | | n.d. | 9 | 12 | **4** | -4 |
| Advanced coal | CCS: Fossil | | | -1 | | | | | | +1 -2 | | | | +2 | -1 | +1 | | n.d. | 5 | 2 | **0,5** | -1 |
| Agriculture & livestock | Sustainable healthy diets and reduced food waste | 0 -1 | +2 | +1 | | | | +1 -1 | +1 -1 | +2 -1 | +2 | | +1 | +1 | +1 | +1 | | n.d. | 11 | 13 | **9** | 5 |
| | Land based GHG reduction and soil carbon sequestration | +2 | +2 | +2 -2 | +2 -2 | +2 0 | +1 0 | 0 -1 | +2 | +1 -1 | +1 | | +1 -1 | +1 | +2 -1 | +2 -2 | | n.d. | 14 | 21 | **9,5** | -2 |
| | Improved livestock production and manure management systems | +2 | +2 | +2 -2 | | +2 0 | +1 0 | +1 | +2 | +2 -1 | +1 | | +1 | +1 | +1 | +2 | | n.d. | 13 | 20 | **15** | 10 |
| Forest | Reduced deforestation, REDD+ | +2 | +1 -2 | | +1 | +1 -1 | +2 | +2 | +1 -1 | +1 -1 | +1 | | +1 | +1 -1 | +1 | +1 -1 | | n.d. | 13 | 16 | **9,5** | 3 |
| | Afforestation and reforestation | +2 -2 | +1 -1 | +1 | -1 | +1 | +1 | +1 | +2 | +2 -1 | | +2 | +2 | +1 | +2 | | +2 | n.d. | 14 | 18 | **14** | 10 |
| | Behavioural responsible sourcing | | | | | 0 | 0 | +1 | +1 | +2 -1 | +1 | | +1 -1 | +1 | +2 | +2 | +2 | n.d. | 11 | 13 | **10,5** | 8 |
| Oceans | Ocean iron fertilization | | +1 -1 | | | | | | | | | +1 -2 | | | | | | n.d. | 2 | 2 | **-0,5** | -3 |
| | Blue carbon | +3 | +3 | | | | | | | +2 | | +2 0 | +3 | | | | | n.d. | 5 | 13 | **12** | 11 |
| | Enhanced Weathering | | | | | | | | | | | +2 -1 | -1 | | | | | n.d. | 2 | 1 | **-0,5** | -2 |

Source: based on IPCC (2018)

The special report by the International Panel on Climate Change on 1.5°C trajectories presents a global review of what the existing scientific litterature says about these impacts, that is summarized in the figure above (IPCC, 2018). For each of the main greenhouse gases mitigation option that it considers in that review, and each of the 16 SDGs other than climate action, when there is an indication of an interaction, the IPCC provides a score, sometimes with a range, which caracterizes the likely positive or negative impact of implementing this option, and its intensity[1].

Although it is not directly provided in the report, the summation of goal-by-goal scores for each option, without any pondering of the goals, gives a very informative indication about the potential for boosting or hampering global sustainability of implementing various mitigation options. Four of the twenty-three options considered directly relate to sufficiency, whether it's on energy consumption through behavioural response in building and transports or agriculture through sustainable healthy diets and reduced food waste, and forest through behavioural responsible sourcing. All show mostly positive impacts on a large range of SDGs and rate rather well in the overall results compared to other options.

## The challenge of modelling energy sufficiency

Like for any option that is to be considered in low or zero carbon strategies, the potential for sufficiency needs to be addressed both in scenarios, which are neededto quantify the possible need and role of sufficiency, and policy making. However, one can point to a self-sustained loop that feeds lack of support to sufficiency options, due to the relative absence of sufficiency in policy making, and even in discussions about concrete policies and measures and the weaknesses and discrepancies of energy scenarios regarding the role of energy sufficiency leads to a self-sustained lack of support.

### Status of sufficiency in scenarios

Action on energy demand plays a major role in mitigating greenhouse gas emissions and meeting ambitious goals for climate action (Duscha, 2018). Energy sufficiency is an important part of the potential for action on energy demand, and should therefore be further integrated in the design of strategies in that area.

It is however quite obvious that in order to be better integrated in policy-making, energy sufficiency needs to be formally more visible in usual decision-making tools, including potential assessments and policy scenarios (Toulouse, 2017). One can only witness that so far the contribution of sufficiency to sustainability goals has been mostly overlooked and remains a blindspot in most mainstream energy scenarios.

Most prominent global energy scenarios only take marginal account of the potential for lifestyle changes to reduce energy demand and GHG emissions, at least in the assumptions and changes they explicitely descrive (IEA, 2018; Greenpeace, 2015; European Commission, 2018), although they are prominent exceptions (Grübler, 2018). Similarly, the vast majority of existing national or infra-national scenarios, including in Member States, does not specifically address sufficiency potentials, although sufficiency items are punctually included.

However, an increasing number of authors propose that scenarios develop a greater focus on energy services and discuss explicitly sufficiency strategies, which in turn stirs further research and assessment work about sufficiency leverages and their potential. An increasing number of existing scenarios, models and studies have now quantified sufficiency potentials one way or another (Allen, 2018). They generally concur on the significance of the sufficiency wedge, with cuts on final energy demand ranging from 20 to 40% by 2050 and commensurate to those achievable through efficiency, as exemplified on a national level, for France by the négaWatt 2017-2050 scenario, as shown in the figure below, which meets by 2050 a 100% supply by renewables and net zero greenhouse gas emissions (Ass. négaWatt, 2018a)

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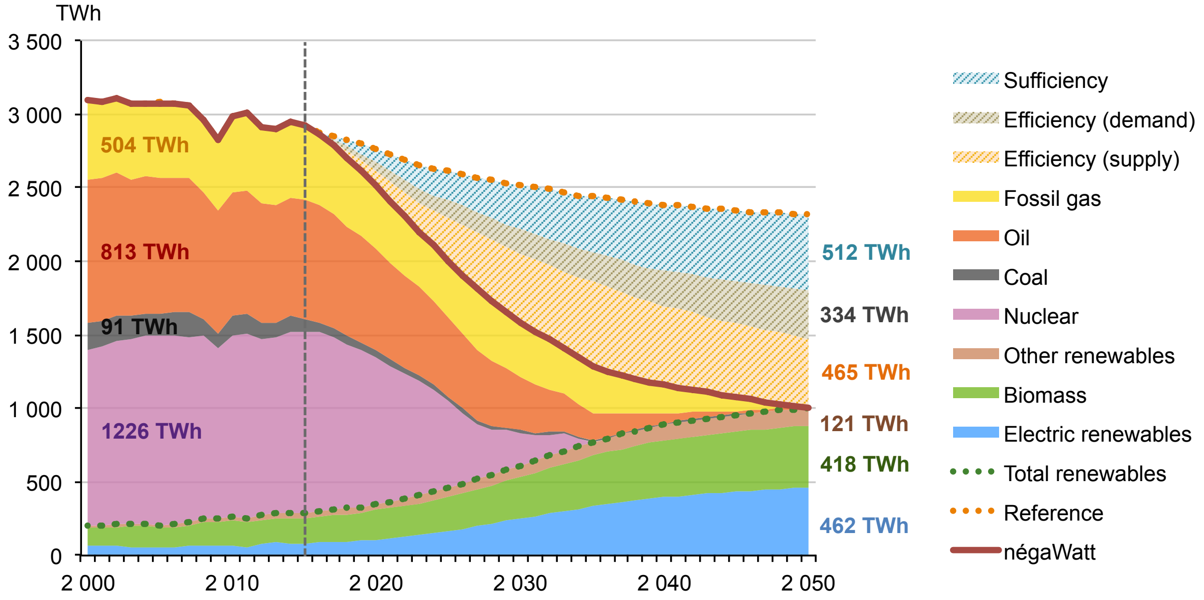
[1] The score provided by IPCC ranges for each option and each goal, when there is an interaction, between -3 and +3. The report also provides additional information regarding the level of consensus and the level of evidence that scientific litterature shows.

**Figure 3 Evolution of primary energy and the role of sufficiency in a net-zero scenario for France**




Source: Association négaWatt, 2018.

## Assessment of sufficiency potentials

While modelling is a crucial tool for assessing the potential that can be mobilised through action, this is even more true regarding sufficiency, as assumptions need to be made on the enabling conditions rather than on the behaviour or practice itself (Toulouse, 2017). Such an approach can only be developed in a robust way through a capacity to make assumptions to relate the enabling conditions to the realisation of the projected changes of behaviour that would be deemed required.

Although this has been less enhanced until recently than the corresponding capacity to relate enabling conditions and projected realisations regarding other options (energy efficiency, shift to decarbonised energy supply…), there doesn't seem to be any specific reason why such a capacity could not be achieved. Sufficiency aspects should be possible to address through modelling like any other mitigation option.

More decisively, it is likely that many energy models that have not been used so far with sufficiency-oriented input should be able to do so one way or another by adjusting modelling parameters to better reflect the potential for sufficiency in assumptions about changes on demand side of the energy system they describe. To this end, identifying what these relevant modelling parameters are is a prerequisite. However, complex organisational and behavioural aspects may not be easy to illustrate through existing modelling, thus requiring the development of more sophisticated tools. Nevertheless, sufficiency assumptions can to some extent be translated into simplified proxies to be used in existing models (e.g. a reduction or stabilisation in the demand of specific energy services).

The robustness of the assessment of a given sufficiency potential does not only depends on the quality of the modelling itself. The robustness of the underlying assumptions about the sufficiency aspect and its diffusion are obviously key to ensure realism of the projected potentials. Weaknesses in such potential assessments have been spotted, though, due to different factors (Toulouse, 2017):

- due to insufficient backing, the potentials considered often remain quite normative in that they fail to display and quantify the causal chains to concretise them;
- there are biases in terms of sectors covered: households and personal mobility are preponderant, whereas very scarce research is available on other sectors, although they can be of great importance, such as sufficiency in business strategies;

- last, sufficiency-based scenarios are still quite divergent in terms of methodology and assumptions, to the point where they sometimes seem to contradict rather than reinforce each other.

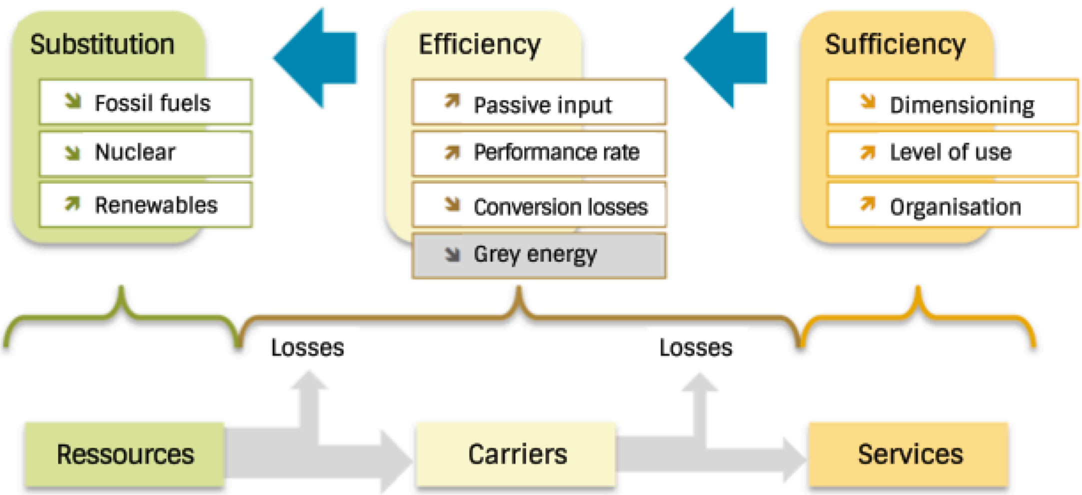
Together with a growing attention for the whole issue of sufficiency, discussions emerge on how to overcome these barriers to a better and better shared identification of sufficiency leverages and potentials, as well as recommendations to increase the quality and credibility of sufficiency potential quantifications.

## Sufficiency leverages

One key issue for integrating sufficiency in modelling is the way it articulates, in terms of how the model describes the energy system and how it accounts for changes in that system, with other options such as the more traditional energy efficiency, and substitution between energy resources.

Modelling approaches range from considering sufficiency as the primary stage of action, so as to play on the level of energy services upfront, then considering the most efficient way to deliver those energy services and the most relevant resources to mobilise for that; this approach has notably been developed as a basis for its successive scenarios by Association négaWatt, as illustrated in the figure below. This ambitious vision for energy sufficiency contrasts with other modelling approaches, where on the contrary sufficiency is considered as an additional option that needs to be activated once some limits of the potential for efficiency and decarbonised energy supply seem to be reached.

**Figure 4 Sufficiency leverages as a possible part of a global strategy**



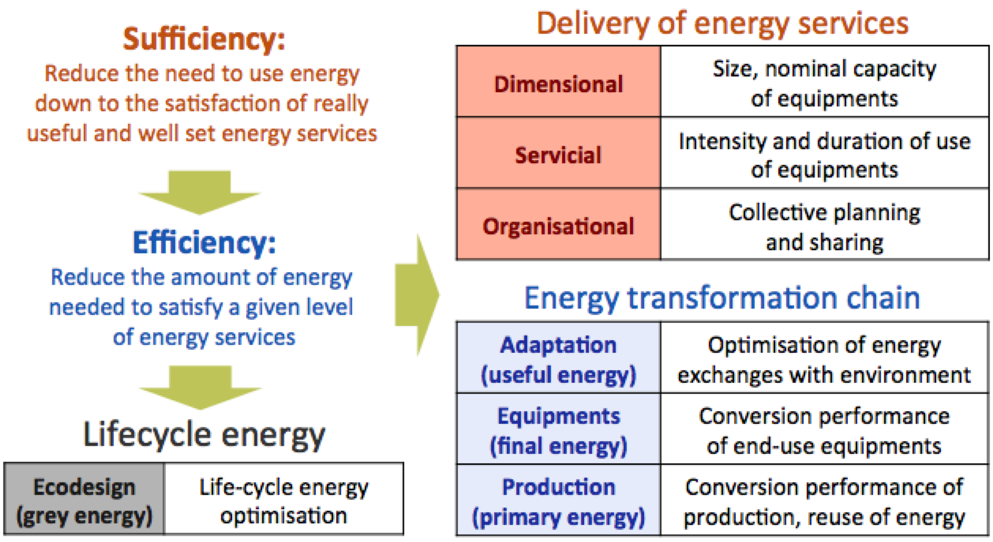

Source: Association négaWatt, 2018.

The way sufficiency is integrated into a global strategy in different models strongly influence the way the corresponding scenarios inform the vision of sufficiency and its role, in a self-sustaining way: the more it is activated upstream of the overall set of actions, the more its potential is important and its role can be significant; conversely, the more it comes downstream and the more it will feed the idea that it has only a limited potential and minor role to play. One way to overcome that difficulty is to further focus on sufficiency leverages by themselves in different areas of energy services fulfilled by the system, and discuss specifically the potential to activate them.

Sufficiency needs to be considered as a separate dimension of energy conservation that articulates with energy efficiency, using criteria to clearly distinguish between those actions that play on technologies or behaviour to change the level of energy service, and those that play on technologies or behaviour to reduce the losses in supplying a certain level of energy service. This is not always simple: using automatic devices to turn lights on and off depending on presence is an example of a technology that delivers sufficiency, while sharing a car could be regarded as a change of behaviour that delivers efficiency…

One can nevertheless differentiate three main leverages in the field of sufficiency, as illustrated in the figure below, which shows how they can combine with efficiency leverages to form a comprehensive strategy for reducing energy demand (Ass. négaWatt, 2018b).

**Figure 5 Main sufficiency leverages to be adressed in modelling**




Source: Association négaWatt, 2018.

The first leverage deals with the dimensional factor of energy consumption, which encompasses the size and the nominal capacity of equipments and buildings, the use of which is requiring to use energy. The global surface of tertiary buildings and housing is a very important factor that strongly influences the need for energy, especially for heating and cooling them. Another very important matter is the size and number of cars, when the current dominant model for mobility, based on the proprietary use of individual cars, leads to them not being used most of the time, and being used in a very desoptimised way when they are[2].

This example illustrates the link with the second leverage that can be pointed to, which could be described as servicial sufficiency. This relates to the level of use, mainly characterized by the intensity and duration of use of buildings and equipments. Speed limits on roads or motorways, turning unused appliances off, increasing the average load factor of trucks, or extending the lifetime of some goods to reduce the need for manufacturing new ones illustrate the diversity of actions belonging to that category. Deeper changes such as shifting mode from car to bike also relate to some change in the level of service.

The third sufficiency leverage to be potentially applied refers to organisational matters. It encompasses any kind of mutualisation of equipments (sharing goods or appliances) or buildings (from co-working spaces to shared laundering areas in collective housing), as well as the development of collective transport. It also deals with organisational changes that reduce for instances 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 houses, workplaces and services sitings.

The scope of sufficiency as a possible contributor to a low or zero-carbon strategy must also extend to related non-energetic consumptions, as some of them rely on industrial activities using specific processes or agricultural activities that generate significant greenhouse gases emissions too. This calls for a

[2] Typically, the car of an average household might be left unused in a parking space more than 90% of the time, and be driven most of the time by a person alone, in urban areas, at 30-50 km/h when it is designed to carry up to 5 people at 130 km/h.

reduced consumption of certain goods, which has also a significant impact on the use of raw materials in industry, another pressing issue. The need to reduce emissions in the agriculture sector points to a change in diet, to reduce the share of meat and animal proteins and increase that of vegetal proteins instead.

Many of the examples that illustrate the way these identified leverages could be used in different sectors also show why sufficiency is not only about changes on the individual level, but also implies changes on a more structural level.

## Sufficiency in modelling

The development of sufficiency in modelling builds on the capacity to project the implementation of the different leverages in the different sectors.

As shown in the figure below, the approach will there mostly consists in identifying in the different areas of need for energy services some parameters that could change as a result of sufficiency (Förster, 2018). Indicators need then to be found that allow for describing the corresponding changes in the model, such as the average square meters of floor space per person if the models allow for describing changes in the stock of buildings. Last but not least, some sufficiency measures can be considered and assumptions made in the model about their impact on the related indicators.

**Figure 6 Examples of sufficiency items to be modelled**

| Sector | Area of need | Parameter | Example of units | Sufficiency measure |
|---|---|---|---|---|
| **Transport** | Mobility | Registered cars | Number per year; Number of cars per household | Less demand for individual transportation; More use of public transport |
| | Mobility | Size of cars | Cubic capacity; Car model | Use of smaller cars |
| | Mobility | Distance travelled | Kilometres per person | Reduction of kilometres travelled by car (through urban planning, etc.) |
| | Mobility | Air travel | Number of short/medium/long haul flights per year; number of person kilometres per year | Reduction of private and business air-travel |
| **Buildings** | Dwelling & construction | Heating temperature | °C room temperature | Heat rooms less strongly |
| | Dwelling & construction | Floor space | $m^2$ per person; $m^2$ per unit of tertiary activity | Reduction of floor space per person; sharing of space (coworking…) |
| | Dwelling & construction | Warm water use | Liter per household and year | Reduction of warm water temperature |
| | Dwelling & construction | Electric appliances | Number per household; Size of appliances; Usage rate per hour / day | Reduction of multiple equipment; sharing of appliances; size reduction of appliances; reduction of usage rate |
| | Dwelling & construction | Electricity consumption | Kilowatt hours per household and year | Reduction of most consuming activities (e.g. electric drying) |
| **Agriculture** | Nutrition | Animal stock | Number of animals per hectare; Kg meat consumption per person and year | Reduction of meat consumption |
| | Nutrition | Food waste | Kg per household and year | Reduction of food waste; better meal planning and adapted shopping |

Source: Öko-Institute (Förster, 2018)

Although this approach allows for an increasing account for sufficiency in modelling, further issues are still to be addressed (eceee, 2018a). One is for instance related to the scale of action to consider: on one hand, the “climate change” limit is global, and while greenhouse gases emissions limits are generally set on a national basis, the action needs to be consistent on a worldwide level; on the other hand, action on a more local level can deliver better identified social, economic and environmental benefits. The way these levels articulate is quite crucial to discuss assumptions on sufficiency, since what seems an appropriate level of energy services will depend on the level actually delivered to the populations considered.

A second issue is time. Sufficiency in our relation to time and the way it can evolve is a significant matter for two very different reasons. One is the “time of use”, that is the time when we make use of energy services and therefore expect for the required energy to be available. This is a growing consideration, especially regarding power, but also an area where there's a growing potential for action. Shifting electric demand to coïncide with preferred times of consumption brings no sufficiency regarding energy demand, but it means some kind of sufficiency regarding peak power demand. Another reason is the “use of time”, or the pace of human activity and how it affects energy demand, ranging from the evolution of working hours to public holidays or daylight saving.

Another issue to discuss in modelling is demography, since the number of people is of couse directly linked to the global need of energy services. Demography also plays in through different factors such as the average number of people per household, or the age distribution and its impact on the number of people working, the need for health services, etc.

On a related note, sufficiency assumptions must address equity issues, that is how energy services are distributed throughout the population considered in the modelling exercise. In principle, as discussed in the “doughnut” approach above, sufficiency requires that everyone has access to a socially-agreed minimum set of energy services. Furthermore, one could aim for access to energy services to be equitable.

Sufficiency assumptions must also be discussed in the light of a clear vision of their relationship with technological development. On the negative side, one can underline that technology is, in general, a very significant driver of the increase of both energy services and their ecological impact. Moreover, much new technology is ICT-enabled (in line with increasing concern with system flexibility), which is consuming energy and materials and calls for caution regarding sufficiency. However, the use of technology can be part of significant progress in sufficiency, for example in creating the continuity of service between modes that allows for a shift from the “one car for all travels” scheme to more flexible and service-based mobility practices. Altogether, the combination of technological and lifestyle changes need to be optimised, on individual and collective levels, and through time.

Last but not least, the modelling of sufficiency needs to deal with the so-called “rebound effect”. This describes a process of re-spending the cost savings from sufficiency actions, leading to new spendings that come with an additional energy consumption, partly offsetting the initial savings. Secondary rebound effects that might occur are estimated to remain generally modests (e.g. less than 10% of the saving) for sufficiency actions affecting electricity use and heating, larger (e.g 20 to 40%) for those affecting transport fuels and possibly very large (e.g. between 60 and 100%) for those affecting food products (eceee, 2018b). However, this is not a purely mechanical effect, and consistent sufficiency policies and measures might aim for minimising this rebound.

Besides this micro-economic effect on end-users spending, questions also arise on a macro-economic level. At first glance, downshifting reduces aggregate consumption and hence its environmental impact. But that might also have non proportional effects on the costs of the energy system as a whole. Therefore, sufficiency might bear complex impacts on macro-economy that are still difficult to reflect in corresponding models.

## Recommendations

Sufficiency offers an important potential to contribute to ambitious low and zero-carbon strategies, that is not clearly reflected yet in policies and measures for a series of reasons, among which, together with some reluctance that the concept is still bearing with some players, the weakness of its representation in a large majority of existing ambitious scenarios. However, progress in assessing sufficiency potentials and understanding the underlying drivers allows for a better account of sufficiency in future modelling, which leads to some recommendations (Förster, 2018; Samadi, 2017).

Clearly, the lack of analysis of the potential of sufficiency to contribute to a reduction in energy demand and GHG emissions has been a weakness in energy scenario studies, and therefore a bias in the advise they provide to policy makers. The quantitative potential of lifestyle and behavioural changes need to be highlighted more prominently in these scenarios. One way to better achieve this is to clearly separate in modelling the changes in lifestyle assumptions and those about changes in energy efficiency or energy supply. Especially, leverages should be explicited so as to not blurring the respective roles of energy sufficiency and efficiency in a global, combined, action on the demand side.

Also, sufficiency of energy services and changes in lifestyle should preferably be embedded, discussed and quantified in modelling exercices as independently as possible of technology decisions. Sufficiency should be considered as a mitigation option by itself, which needs to be balanced with more technology-driven options, rather than an additional thought to bridge the residual gap between the limits found with technological options and ambitious objectives.

Efforts of modellers towards a better and more systematic explicitation of sufficiency would reinforce its integration in stringent climate protection scenarios. At least, it should be considered that for those modelling exercices that aim for producing a set of constrasted scenarios, sufficiency should be an important part of the storyline, and if provided set of political and societal course of actions, of at least one of them. Global efforts to better account for sufficiency would also create more demand for the weakness or even omission of sufficiency in some scenarios to be clearly and soundly justified.

One key area for progress, considering the importance of economic concerns in policy making and the dominant pre-conceptions of the relationship between sufficiency and growth, is the increased robustness of the modelling of the impact on economic activity of energy-sufficient lifestyles.

Finally, it is up for the energy modelling community to foster appropriate practices and shared understanding of methodological issues, so as to better assess and justify the potential for sufficiency and for corresponding policies to deliver. This includes:

- the need to formulate and document justification and derivation for sufficiency in all areas considered;
- the identification of relevant parameters for each sufficiency measure considered, and the need to document the reason why it is considered relevant or necessary;
- the explanation of how sufficiency measures are integrated in the model by calibration when the necessary parameters already exist, or by addition of parameters or functionalities when needed;
- the description, as much as possible, of the triggers for sufficiency when touching upon lifestyle changes, or the impact chains per measure including their temporal development;
- the discussion of the limits of predictability and modelability of sufficiency options in the same way, and on the same level, as should be the case for other changes considered;
- the development of narratives underlying the quantitative assumptions for sufficiency potentials, to further illustrate the plausibility of the envisaged development and provide a representation of sufficiency-oriented lifestyles.

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