Energy sufficiency in products

Concept paper

Edouard Toulouse and Sophie Attali

© eceee and the authors 2018
eceee's energy sufficiency project is funded by the KR Foundation.
It aims at exploring how we can live well, within the limits.
Learn more at energysufficiency.org.
Executive Summary

This paper discusses energy sufficiency in the area of energy-using products, that is ways of reducing energy consumption beyond technical efficiency. It covers moderating product usage, more reasonable sizing, substituting products by intrinsically low-energy alternatives, sharing products, and reducing product ownership. Some of the above might involve different degrees of lifestyle changes.

Products are one area where the EU has been most successful in implementing energy efficiency policies (e.g. Ecodesign and Energy Labelling Regulations on dozens of appliances and electronics). However, despite solid efficiency progress, the energy consumption from products in the domestic and tertiary sectors has at best stabilised, but not taken a steep downward trend. The reasons usually mentioned are the growth in the number of households and tertiary areas, the proliferation of products and gadgets, the inflation in sizes and functionalities, longer usage hours, and constantly new areas of application, some of them possibly due to rebound effects.

Energy sufficiency is therefore an option to consider. It can be both triggered by conscious behaviour change from people and organisations, and potentially driven by product design and policies. The amount of energy savings it can generate in products is not easy to evaluate, as sufficiency actions often relate to behaviours that are influenced by many drivers, and the potentials are not just limited by physical laws but by what people and organisations consider to be individually or collectively reasonable to do. Available estimates however reveal substantial theoretical potentials for an average household, with possible cuts of 50% or more on the energy used by products. A similar level can be guesstimated for an office. Energy modelling approaches at macro-level, such as the French négaWatt scenario, foresee that sufficiency could save as much as new efficiency by 2030 and more by 2050. Sufficiency approaches could also help cutting on embedded energy in products, notably electronics.

Despite these impressive potentials, energy sufficiency in the area of products may look like a lost cause at first sight, considering the substantial barriers: the weight of the ‘anti-sufficiency’ values that the capitalistic consumer society promotes, the conception of modern comfort and dominant social norms, habits and routines in energy use, and socio-technical systems creating path dependencies. Yet, positive and encouraging changes are also emerging: attitudes challenging the traditional consumer society paradigm, the rise of the sharing economy, as well as trends in product convergence, intelligence, and user empowerment technologies.

In the paper, a detailed analysis has been carried out for a list of priority product groups chosen for their weight on the EU energy consumption and sufficiency potential. For each group, relevant trends, opportunities, and specific barriers have been identified and discussed. The list includes:

- Water heating,
- Air-conditioning,
- Household refrigerating appliances,
- Washing machines,
- Tumble driers,
- Lighting,
• Displays,
• Computers,
• Servers (and data centers).

In the last part, the report investigates policies that could support energy sufficiency in products. There are not many examples of existing policies yet, as there is still political resistance towards the concept and its perceived contradiction with liberal values and other policy agendas. Nevertheless, the role of policies can be broader than bluntly prescribing sufficiency. There is a wide range of possible interventions that may not just seek to impose, but encourage, facilitate, enable, and incentivise sufficiency actions.

This variety of potential policies has been investigated in eight sections, in which ideas are discussed, recommendations made, and best practices highlighted, using wherever possible existing literature. These sections cover:

• Official recognition,
• Educational campaigns and tools,
• Incentives to sufficiency actions and behaviours,
• Evolution in comfort standards and prescriptions,
• Regulation of most detrimental habits,
• Product energy requirements and labels,
• System performance requirements that may stimulate sufficiency actions,
• Support to R&D in the area of product sufficiency.
The easiness and likelihood of success in promoting these policy options will vary, but in all instances the question of the political and social acceptability will be central when advocating for energy sufficiency. This social and political acceptability mostly depends on the modalities of implementing sufficiency, and on equity in doing so, at national but also international levels. It will be important to consider it when communicating towards policy-makers.
Table of Contents

Executive Summary ........................................................................................................... 2
1 Introduction .................................................................................................................... 9
  1.1 Scope ......................................................................................................................... 9
  1.2 Definition of ‘energy sufficiency actions’ ................................................................. 9
  1.3 Context ....................................................................................................................... 10
    1. The growth in the number of households and tertiary surfaces, leading to a growth in the total number of products in use ......................................................................... 11
    2. The proliferation of energy-using products and gadgets ........................................... 12
    3. The inflation in sizes and functionalities ..................................................................... 12
    4. Increased usage time ................................................................................................ 12
2 Existing quantifications of sufficiency potentials ............................................................ 13
  2.1 At the micro-level ..................................................................................................... 13
         Household .................................................................................................................. 13
         Other entities ............................................................................................................. 14
  2.2 At the macro-level ................................................................................................... 15
  2.3 Quantification of embedded energy savings ............................................................ 17
  2.4 Conclusion on potentials ......................................................................................... 18
3 Overall barriers and opportunities .................................................................................. 19
  3.1 Is there really a chance for sufficiency in products? ............................................... 19
  3.2 Common barriers .................................................................................................... 19
         Core values that the capitalistic consumer society promotes ................................ 19
         Conceptions of ‘modern comfort’ and some of the dominant social norms .......... 19
         Habits and routines in the field of energy use practices ........................................... 20
         Manufacturer and retailer strategies ...................................................................... 20
         Low energy prices .................................................................................................. 20
  3.3 Positive and encouraging trends ............................................................................ 20
         Values and attitudes challenging the traditional consumer society paradigm ...... 20
         Co-benefits of sufficiency actions ........................................................................... 21
         The rise of the sharing economy ............................................................................ 21
         Product ‘intelligence’ ............................................................................................... 21
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product convergence and miniaturisation</td>
<td>21</td>
</tr>
<tr>
<td>User feedback and empowerment technologies</td>
<td>22</td>
</tr>
<tr>
<td>Detailed analysis for priority product groups</td>
<td>23</td>
</tr>
<tr>
<td>4.1 Water heating</td>
<td>23</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>24</td>
</tr>
<tr>
<td>Main barriers</td>
<td>24</td>
</tr>
<tr>
<td>4.2 Air-conditioning</td>
<td>24</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>24</td>
</tr>
<tr>
<td>Main barriers</td>
<td>25</td>
</tr>
<tr>
<td>4.3 Household refrigerators</td>
<td>25</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>25</td>
</tr>
<tr>
<td>Main barriers</td>
<td>26</td>
</tr>
<tr>
<td>4.4 Washing machines</td>
<td>27</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>27</td>
</tr>
<tr>
<td>Main barriers</td>
<td>27</td>
</tr>
<tr>
<td>4.5 Tumble driers</td>
<td>28</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>28</td>
</tr>
<tr>
<td>Main barriers</td>
<td>28</td>
</tr>
<tr>
<td>4.6 Lighting</td>
<td>29</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>29</td>
</tr>
<tr>
<td>Main barriers</td>
<td>29</td>
</tr>
<tr>
<td>4.7 Displays (TVs, monitors...)</td>
<td>30</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>30</td>
</tr>
<tr>
<td>Main barriers</td>
<td>31</td>
</tr>
<tr>
<td>4.8 Computers</td>
<td>32</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>32</td>
</tr>
<tr>
<td>Main barriers</td>
<td>32</td>
</tr>
<tr>
<td>4.9 Servers</td>
<td>33</td>
</tr>
<tr>
<td>Energy sufficiency opportunities</td>
<td>33</td>
</tr>
<tr>
<td>Main barriers</td>
<td>34</td>
</tr>
<tr>
<td>5 Policies for energy sufficiency in products</td>
<td>35</td>
</tr>
</tbody>
</table>
5.1 What role for policies? ................................................................. 35
5.2 Official recognition ..................................................................... 35
5.3 Educational campaigns and tools ............................................. 36
5.4 Incentives to sufficiency actions and behaviours ..................... 37
  Direct financial support to products and behaviours .................. 37
  Support to projects and programmes ....................................... 37
  Exemplary behaviour from public institutions ....................... 38
5.5 Evolution in comfort standards and prescriptions .................... 38
  Lighting specifications in the non-residential sector ................. 38
  Thermal comfort specifications in private and tertiary buildings .. 38
  Hot water temperature specifications ....................................... 39
5.6 Regulation of most detrimental habits ..................................... 39
  Banning doorless commercial and professional refrigerating appliances ... 40
  Banning non energy-saving taps and showerheads .................. 40
  Forbidding irrelevant lighting waste ......................................... 40
  Regulating the installation of non-residential screens ................ 40
  Fighting planned obsolescence ............................................... 40
5.7 Strengthening product regulations and labels ......................... 41
  Containing the inflation of sizes and capacities ....................... 42
  Avoiding artificial categorisations and feature bonuses ............ 43
  A more prominent visualisation of sufficiency .......................... 44
  Other sufficiency requirements ............................................... 44
5.8 System performance requirements ......................................... 45
5.9 Support to R&D in the area of product sufficiency ................... 46
6 Conclusion .................................................................................... 47
7 References ................................................................................... 48
Figures

Figure 1. Energy use (in standardised conditions) of the market average in 1990 and 2015 for three products (source: VHK 2016) ................................................................. 10

Figure 2. Total electricity consumption trends in the EU residential sector (source: JRC 2016) .................................................................................................................. 11

Figure 3. Total electricity consumption trends in the EU tertiary sector (source: JRC 2016) .................................................................................................................. 11

Figure 4. Growth in the number of EU households (source: JRC 2016) ......................... 12

Figure 5. Saving potentials from applying circular economy principles in the EU (in Baton et al 2017) ................................................................................................. 18

Figure 6. Amount of electrical and electronic products put on the EU market in 1,000 tonnes (Eurostat) ............................................................................................... 22

Figure 7. Left: EU label for washing machines – Right: solution that reduces class overlapping (EEB 2015) ...................................................................................... 43

Figure 8. Solution with curved lines and a reasonable level of class overlap (EEB 2015).... 43

Figure 9. Example of a way to enhance the mention of the absolute energy consumption (BUND 2014) ................................................................................................. 44

Tables

Table 1. Energy sufficiency action categories .................................................................... 9

Table 2. Assumptions in Brischke et al 2015 ................................................................... 14

Table 3. Calculation of the sufficiency potential for the office considered (based on typical power values found in e.g. EU Ecodesign preparatory studies) ...................... 15

Table 4. Electricity saving potentials in Germany from sufficiency actions (Fischer 2015) 16

Table 5. Saving potentials in France from sufficiency actions on products in the négaWatt scenario (own analysis based on the scenario detailed data) ................................. 17
1 Introduction
This paper discusses energy sufficiency in the area of products, that is ways of reducing energy consumption from products beyond technical efficiency.

1.1 Scope
The scope of the paper is energy-using products. Vehicles and space heating in buildings are not covered, as they are treated in other concept papers.

The products covered are not restricted to households. Energy sufficiency can be discussed in other sectors, such as tertiary buildings, offices, etc. This being said, there is a much less abundant literature and case studies in those sectors.

The analysis and recommendations primarily relate to the direct energy consumption of products, during their use phase. However, for some product groups the energy consumed during the manufacturing stage and to extract raw materials (so-called ‘embedded energy’) is becoming increasingly relevant. We consider this aspect where necessary.

The geographical scope of the paper is the EU (although embedded energy is not always consumed in Europe). Potentials, trends and policies are discussed at EU level.

1.2 Definition of ‘energy sufficiency actions’
The paper investigates actions which reduce energy demand by changing the quantity or quality of services that we get from products. They can be split into a number of different categories, described in the table below:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage</td>
<td>Reducing the duration/frequency of usage, and using products differently</td>
<td>Unplugging a product instead of leaving it on standby</td>
</tr>
<tr>
<td>Dimensional</td>
<td>Better sizing of energy-using products to match people’s true needs</td>
<td>Avoiding oversized refrigerators</td>
</tr>
<tr>
<td>Substitution</td>
<td>Choosing a different way (e.g. different type of product or less sophisticated one) to fulfil one’s needs</td>
<td>Using a tablet instead of a computer to surf on the internet</td>
</tr>
<tr>
<td>Collaborative</td>
<td>Increased sharing of products</td>
<td>Sharing a wi-fi access</td>
</tr>
<tr>
<td>Radical change</td>
<td>Substantial cuts in the ownership of products</td>
<td>Dropping the home TV set or the freezer</td>
</tr>
</tbody>
</table>

Each of these types of actions may entail a more or less profound change in lifestyle, depending notably on how far-reaching they are and influence other daily practices.


1.3 **Context**

Products are one area where the EU has been most successful in implementing energy efficiency policies. Energy labels, in place since the 1990’s, and then Ecodesign Regulations since 2007 have contributed to dramatically improving the energy performance of products.

This can be appreciated in the evolution of the average level of energy consumption in standardised conditions of products placed on the market over time.

These Regulations have mostly consisted in requiring higher levels of technical performance from products, so that their energy efficiency is increased.

In the meantime, energy-using products are also pointed at as an illustration of the limits of technical efficiency and efficiency policies to effectively reduce energy demand.

Figures 2 and 3 below show the total EU residential and tertiary electricity consumption in the last years (including all electricity-consuming appliances and equipment). The share of the electricity used by appliances and electronics only is about 40% of the total.

The residential electricity consumption per capita has grown by 5.1% between 2000 and 2014.

---

1 All these Regulations can be found at: https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products
Despite solid efficiency progress, these consumption lines have at best stabilised but not taken a steep downward trend. The reasons for this have already been largely discussed by several authors and for many years (Lorek et al 2017, Fischer 2015, eceee 2010, Granda et al 2008, etc.).

Four main trends are usually blamed:

1. The growth in the number of households and tertiary surfaces, leading to a growth in the total number of products in use

The number of households is steadily increasing in the EU, both due to population growth and trends to smaller household sizes.
The floor area of non-residential buildings is also increasing, by about 1 or 2% per year (according to available statistics\(^2\)).

2. The proliferation of energy-using products and gadgets

Ownership rates as well as the number of appliances per person are steadily increasing, while new products are constantly invented and purchased.

And further trends are expected to add new layers of energy demand, such as networked devices. The International Energy Agency foresees the shocking number of potentially 200 residential and tertiary connected ‘things’ per capita in the long term (IEA 4E 2016).

This proliferation is also sustained by new areas of application where products are increasingly used, e.g. artificial illumination of new spaces, screens in public places, etc.

3. The inflation in sizes and functionalities

Products are not only more abundant, they also become bigger, more sophisticated, and with ever brighter and innovative functionalities.

An analysis has estimated that if current trends in increasing capacities continue as they are, they could possibly eat up a large part of the 2030 energy cuts expected from Ecodesign and Energy Labelling Regulations adopted thus far in the EU, e.g. 100% for washing machines, more than 50% for driers, and 20% for refrigerating appliances (EEB 2015).

At some point, there will be some physical limits to these inflation in sizes and amenities, however they are still far from begin reached for most products.

4. Increased usage time

There are trends in energy-using products staying longer in on mode, or in all sorts of sleep modes that still consume energy.

Some of these trends may be triggered by rebound effects, such as people and organisations increasing lighting points and usage time as lamps become more efficient. Direct and indirect rebound effects have been documented, and are discussed in another concept paper (Sorrell et al 2017), so we are not discussing them in this study.

All these trends are not (or not enough) captured by energy efficiency Regulations. Hence the need to look at ways beyond efficiency to moderate the most detrimental ones, so that efficiency gains are not annihilated.

\(^2\) https://ec.europa.eu/energy/en/eu-buildings-database
2 Existing quantifications of sufficiency potentials

The amount of energy savings in products that can be generated by energy sufficiency actions is not easy to evaluate, for two main reasons.

First, several of these actions relate to behaviours which are influenced by many drivers. Assessing how much behaviours may change in society over the coming years or decades is not as easy as determining how much more technically efficient a product can become.

Second, sufficiency potentials are not only limited by physical laws and infrastructure availability, but also by what people or organisations consider to be individually or collectively acceptable or reasonable to do. Drawing a line between basic needs, wants, and luxury is not self-evident (Lorek 2017), notably in terms of product use. Theoretically, sufficiency could go as far as eradicating most energy-using products from our lives and living with only a tiny amount of energy (which some radical activists try to do in eco-villages). But if we want to reflect a plausible potential, we need to estimate where the acceptability line will be drawn by the majority or the average.

This line is not fixed but may change over time depending on the perceived urgency of saving energy, as illustrated by what Japanese agreed to do after the Fukushima accident and the shutdown of national nuclear reactors (IEA 2011). It also depends on the socio-technical and cultural systems into which our habits and behaviours are embedded at a certain time. It is obviously more difficult to make radical cuts in the use of telecommunication and digital tools today than it used to be decades ago. Last, the willingness to embrace sufficiency actions is also related to the way sufficiency will eventually progress in society, and become or not a core collective value.

Some estimates of energy sufficiency potentials are available in the literature. They are based on a variety of assumptions, thus not fully comparable. However, they can provide orders of magnitude of the savings at stake. It is important to stress that these estimates are rarely assessing in perfect details all the related aspects, such as a comprehensive analysis of all life-cycle impacts, a precise evaluation of socio-technical implementation barriers, the potential implications for gender balance and other social aspects, etc.

2.1 At the micro-level

At the level of a single entity (a household, a company, etc.), it is possible to find some local energy saving field experiments and programs that have assessed the willingness and actual implementation of sufficiency-type actions in a certain existing context. This does not however provide an estimate of the full potential that could be theoretically achieved, should sufficiency become more mainstream. Evaluations of such theoretical potentials also exist, although there are not many.

Household

The Wuppertal Institut and IFEU Heidelberg have evaluated a ‘maximum’ potential for sufficiency for a German home, supposing that no practical restrictions are impeding the sufficiency actions considered (Brischke et al 2015). This means that they supposed that the family managed to adopt a comprehensive and consistent set of sufficiency actions (described in table 2), despite existing social, economic, or legal barriers that could exist to do so.

Covering cold, wash, and cooking appliances, lighting, TV, audio, and ICT devices, the analysis found that sufficiency could potentially cut the specific electricity consumption of an average household by up to 50%, which is twice the potential of efficiency alone.

They warn, however, that this massive potential is a theoretical calculation and ‘is not generalizable to all households. This is because sufficiency approaches are characterized by a high degree of sociocultural boundary conditions, such as care economy duties, comfort requirements, financial capabilities, or attendance times.’
This potential certainly cannot be reaped in all households with one silver bullet, as there are many barriers and conditions. Existing literature shows that no communication campaign, field experiment, or community-based initiative alone could achieve such a level of savings in one go.

Table 2. Assumptions in Brischke et al 2015

<table>
<thead>
<tr>
<th>Product</th>
<th>Average</th>
<th>Sufficiency in Equipment</th>
<th>Sufficiency in Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling + freezing</td>
<td>190(±5)/30L</td>
<td>1 combination unit</td>
<td>2 separate devices</td>
</tr>
<tr>
<td>Efficiency class B</td>
<td>A+++</td>
<td>A+++</td>
<td>A+++</td>
</tr>
<tr>
<td>Temperature</td>
<td>5°C(-12°C)/22°C</td>
<td>7°C(-10°C)/-20°C</td>
<td>1 month off</td>
</tr>
<tr>
<td>Washing machine</td>
<td>7 kg</td>
<td>A+++</td>
<td>1 use/week</td>
</tr>
<tr>
<td>Efficiency class A</td>
<td>6 kg</td>
<td>1 use/week</td>
<td>40°C</td>
</tr>
<tr>
<td>Efficiency class B</td>
<td>2,25 uses/week</td>
<td>12 place setting</td>
<td>A+++</td>
</tr>
<tr>
<td>Efficiency class A</td>
<td>60°C</td>
<td>1 use/week</td>
<td>3 months off</td>
</tr>
<tr>
<td>Tumble dryer</td>
<td>A+++</td>
<td>1 use/week</td>
<td>3 months off</td>
</tr>
<tr>
<td>Efficiency class A</td>
<td>A+++</td>
<td>1 use/week</td>
<td></td>
</tr>
<tr>
<td>Dish washer</td>
<td>A+++</td>
<td>1 use/week</td>
<td></td>
</tr>
<tr>
<td>Efficiency class A</td>
<td>8 place setting</td>
<td>12 place setting</td>
<td></td>
</tr>
<tr>
<td>Efficiency class B</td>
<td>2 uses/week</td>
<td>1 use/week</td>
<td></td>
</tr>
<tr>
<td>Cooker + oven</td>
<td>2,5 h/week</td>
<td>2,5 h/week</td>
<td>1 h/week</td>
</tr>
<tr>
<td>Lighting</td>
<td>LED</td>
<td>LED</td>
<td></td>
</tr>
<tr>
<td>Incandescent bulbs, energy saving bulbs</td>
<td>1,7 h/day 1,5 h/day 1,5 h/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80W</td>
<td>75W</td>
<td>75W</td>
<td></td>
</tr>
<tr>
<td>Television</td>
<td>flatscreen 80 cm + hard disk</td>
<td>flatscreen 80 cm + hard disk</td>
<td></td>
</tr>
<tr>
<td>Efficiency class B</td>
<td>A+</td>
<td>A+</td>
<td></td>
</tr>
<tr>
<td>Tube TV</td>
<td>-</td>
<td>flatscreen 51 cm</td>
<td>A+++</td>
</tr>
<tr>
<td>Efficiency class B</td>
<td>2 h/day</td>
<td>1,5 h/day</td>
<td></td>
</tr>
<tr>
<td>Set-top-box</td>
<td>A+++</td>
<td>0.5 h/day</td>
<td></td>
</tr>
<tr>
<td>Efficiency class B</td>
<td>0.5 h/day</td>
<td>0.5 h/day</td>
<td></td>
</tr>
<tr>
<td>Standby mode</td>
<td>standby mode</td>
<td>standby mode</td>
<td>disconnected</td>
</tr>
<tr>
<td>Audio</td>
<td>stereo system</td>
<td>stereo system</td>
<td></td>
</tr>
<tr>
<td>Efficiency class A</td>
<td>1,5 h/day</td>
<td>1 h/day</td>
<td></td>
</tr>
<tr>
<td>Efficiency class A</td>
<td>standby mode</td>
<td>1 h/day</td>
<td>disconnected</td>
</tr>
<tr>
<td>ICT</td>
<td>1 PC, 1 laptop</td>
<td>1 laptop</td>
<td>1 PC, 1 laptop</td>
</tr>
<tr>
<td>1 monitor</td>
<td>4 h/day</td>
<td>1 monitor</td>
<td></td>
</tr>
<tr>
<td>1 smartphone</td>
<td>2 h/day</td>
<td>1 smartphone</td>
<td></td>
</tr>
<tr>
<td>Efficiency class B</td>
<td>1 monitor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency class B</td>
<td>2 h/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standby mode</td>
<td>standby mode</td>
<td></td>
<td>disconnected</td>
</tr>
</tbody>
</table>

The Öko-Institut published a similar assessment, looking at six household products (fridge-freezer, induction stove, washing machine, tumble drier, TV, gamer notebook) and four levels of sufficiency intensity (Fischer et al 2013). The potential cuts in energy use can be as high as 60% or even 80% in the most extreme scenario for the products considered (e.g. dropping the home refrigerator and TV set altogether). These maximum potentials translate into a 30% saving potential on the total electricity bill (in an energy efficient home).

Other entities

No specific publication has been found on the maximum potential for sufficiency actions in places other than homes. It is unfortunate, since sufficiency actions can also be considered in e.g. offices, shops, public buildings, etc.

We propose here our own simple calculation of sufficiency potentials for a 10-person office with the following characteristics:
We can estimate the total energy use of this configuration at around 4,700 kWh/year (calculation details are provided in the table 3 below).

If the following sufficiency actions were implemented:

- replacing desktops by laptops,
- using a better-sized server or sharing the existing one with another office,
- keeping only one printer,
- reducing the illumination to 300 lm/m² and installing presence detectors,
- using a coffee machine with auto-power down (requiring a little more time to heat up),

the savings would be in the order of 2,400 kWh/year, that is a 50% cut in electricity use.

This simple theoretical example shows that the impact of sufficiency may potentially be as big in the tertiary sector, especially offices, as it could be in households.

Table 3. Calculation of the sufficiency potential for the office considered (based on typical power values found in e.g. EU Ecodesign preparatory studies)

<table>
<thead>
<tr>
<th></th>
<th>Without sufficiency</th>
<th>Electricity use (kWh/year)</th>
<th>With sufficiency</th>
<th>Electricity use (kWh/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers</td>
<td>Desktops + screens, 50 Watts in total, 8h/day</td>
<td>1,500</td>
<td>Laptops, 25 W, 8h/day</td>
<td>730</td>
</tr>
<tr>
<td>Server</td>
<td>150 W, always on</td>
<td>1,314</td>
<td>Model twice smaller or shared, 75 W</td>
<td>657</td>
</tr>
<tr>
<td>Printers</td>
<td>Laser printers, 5 kWh/week</td>
<td>520</td>
<td>One printer, 5 kWh/week</td>
<td>260</td>
</tr>
<tr>
<td>Lighting points</td>
<td>Tubes, 8 h/day, 50 lumens/W for 20,000 lumens (400 lm/m² over 50 m²)</td>
<td>1,168</td>
<td>Tubes, 6 h/day, 50 lumens/W for 15,000 lumens (300 lm/m² over 50 m²)</td>
<td>657</td>
</tr>
<tr>
<td>Coffee machine</td>
<td>Always-on mode</td>
<td>200</td>
<td>Model with auto-power down after 2 minutes</td>
<td>50</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>4,702</strong></td>
<td></td>
<td><strong>2,354</strong></td>
</tr>
</tbody>
</table>

2.2 At the macro-level

The potential for energy sufficiency actions may also be assessed in the traditional way of energy modelling, that is evaluating how much savings can be generated at the level of a country over a certain timespan. This adds to the picture the consideration of the rate of diffusion of sufficiency actions in society, and how much of the population contributes. It allows to consider possible restraints and caution in the level of sufficiency implementation.
There are not many authoritative energy scenarios explicitly including energy sufficiency actions (Samadi et al. 2016).

Within the German ‘Energiekonzept’ plan, a study has analysed the potential of some sufficiency measures to reduce energy demand by 2020 and 2030 in several sectors of the country, including household appliances (Fischer 2015).

The table below summarises the findings from this modelling on appliances.

**Table 4. Electricity saving potentials in Germany from sufficiency actions (Fischer 2015)**

<table>
<thead>
<tr>
<th>Sufficiency action</th>
<th>Savings by 2020 (TWh/year)</th>
<th>Savings by 2030 (TWh/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of multiple ownership of TV sets and cold appliances</td>
<td>5.4 to 7.3</td>
<td>5.4 to 6.2</td>
</tr>
<tr>
<td>Limitations on appliance energy use</td>
<td>0.2 to 1.1</td>
<td>0.3 to 1.7</td>
</tr>
<tr>
<td>Reduction in the usage of TVs and driers</td>
<td>7.2</td>
<td>5.6</td>
</tr>
<tr>
<td>Investing in building automation systems³</td>
<td>2.1</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14.9 to 17.7</strong></td>
<td><strong>15.3 to 17.5</strong></td>
</tr>
</tbody>
</table>

The total potentials by 2020 and 2030 of this (not necessarily comprehensive) list of sufficiency actions already represent 15 to 20% of the total German household electricity consumption for appliances and lighting.

In France, the négaWatt scenario is an attempt at modelling sufficiency evolutions in all sectors at the level of a country (négaWatt 2017). The core approach of this scenario is to start the analysis from basic human needs (food, housing, mobility...), and systematically investigate how these needs could be fulfilled through services that are intrinsically low-energy consuming (thus involving both sufficiency and efficiency considerations). The scenario then models how this could potentially be achieved over the 2017-2050 period.

As far as products are concerned, more than 40 sufficiency assumptions have been made relating to ownership rates, duty cycles, usage time, and other parameters of all main household and tertiary product categories. The assumptions are based on cautious guesstimates of how sufficiency could ‘reasonably’ diffuse in society over time.

These sufficiency evolutions include among others:

- A moderation on the ownership of some appliances (freezers, driers ...), and capacities/sizes ( Fridges, washing machines, TVs ...)
- A better use of washing appliances (full load, lower temperatures ...)
- A preference for natural light and well-conceived luminaires
- A 25% cut in the amount of hot water used per person by 2050
- The dematerialisation of ICT equipment, and migration of most uses to the cloud.

The scenario still allows for the advent of a digital society and economy (i.e. strong increase in servers and network infrastructures). Against a business-as-usual trend (including existing efficiency progress but no sufficiency), the results of the modelling lead to the following outcome for the electricity consumption:

---

³ Whether installing a home automation system is truly a ‘sufficiency’ action, and its impact on appliances may be discussed. In this table we are presenting the figures from the referred source as they are.
Table 5. Saving potentials in France from sufficiency actions on products in the négaWatt scenario (own analysis based on the scenario detailed data)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Electricity consumption from products (except space and water heating)</th>
<th>2016</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residential sector</strong></td>
<td></td>
<td>90</td>
<td>97</td>
<td>109</td>
</tr>
<tr>
<td>Total in business-as-usual</td>
<td>(TWh/year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New efficiency potential</td>
<td>-18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sufficiency potential</td>
<td>-12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tertiary sector</strong></td>
<td></td>
<td>89</td>
<td>93</td>
<td>98</td>
</tr>
<tr>
<td>Total in business-as-usual</td>
<td>(TWh/year)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New efficiency potential</td>
<td>-12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sufficiency potential</td>
<td>-17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The sufficiency potentials are strikingly high, and compare to or even exceed those achieved by reinforcing efficiency trends. There is a similar conclusion for hot water and air-conditioning of buildings.

2.3 Quantification of embedded energy savings

Sufficiency actions that lead to reducing the number of products in use have not only an impact on cutting direct energy use but also embedded energy and material resource needs. Several of such actions are considered in the previous scenarios (e.g. reduction of multiple ownership, dematerialisation, etc.). But the specific impact on embedded energy is not assessed.

A recent study has estimated the saving potential of applying some circular economy principles on products in the EU (Baton et al. 2017). The portfolio of measures includes improving recyclability, extending product service life, product leasing, and improved refurbishment. These can be seen as part of the ‘collaborative sufficiency’ efforts, as they lead in theory to providing more services to more people with a smaller amount of products (and thus of embedded energy).

The assessment has been made on CO₂ emissions and not energy, although there is a close link. The study found substantial potentials, and in the case of electronics the savings from circular economy principles could even match those expected from energy efficiency measures in the sector (Ecodesign and Energy Labelling Regulations).
2.4 Conclusion on potentials

These examples of quantification of sufficiency potentials suggest that sufficiency could bring substantial energy savings in the coming decades, commensurate to those achieved by new efficiency progress. This highlights the importance of sufficiency in the context of energy conservation strategies.

In addition, a significant part of the sufficiency actions considered in these potentials require little investment or even come at a negative cost. Everything that is related to better sizing, improving product settings and usage, sharing and leasing, or moderating the frenzy for new gadgets, can produce immediate financial benefits.

In the longer run, when technical efficiency gains become smaller and more and more costly to reap, the importance of sufficiency becomes critical to enable substantial cuts in energy consumption levels. It is interesting to note that several EU countries, such as France and Germany, have officially committed to halve their energy consumption by 2050. In the area of products, this is unlikely to happen without a sufficiency wedge.

---

*The graph shows the potential lifecycle CO₂ savings from applying different scenarios to the products sold in the EU in 2020. The ‘service economy’ scenario refers to a new economic model based on leasing and service (rather than product ownership) with leased products that are more energy efficient than average. In the ‘low’ variant, this approach hits 10% of the market, in the ‘high’ version 50%. The ‘no eff’ variant shows the results if leased products are of average efficiency. More details can be found in the referred source.*
3 Overall barriers and opportunities

3.1 Is there really a chance for sufficiency in products?

Despite the impressive potentials estimated above, the likelihood of achieving the bulk of these savings may be questioned. At first thought, energy sufficiency in the area of products may look like a lost cause. Material possession has so much become part of our lives and economy, novelty is so tantalising, and comfort has become such an important value that there doesn’t seem to be much hope that people would compromise on ownership, functionalities, or usage of products.

This would overlook too quickly some more favourable trends, including the fact that many people do not feel so fully satisfied with the material paradigm and consumer society (as revealed in numerous social science studies). An increasing part of the population is eager for more environmental consistency, and alternative ways of finding happiness and fulfilment. Reconsidering the way to purchase and use products may be part of the agenda. Organisations may also be interested in sufficiency strategies to save on costs, or to progress towards a more circular economy.

3.2 Common barriers

The most general obstacles to sufficiency in our societies, pertaining to values, attitudes, and habits, have been investigated and discussed in publications (e.g. Toulouse et al 2017). We briefly summarise here the main items usually put forward:

Core values that the capitalistic consumer society promotes

They include: possession, power, individualism, growth, liberalism, social differentiation through consumption, etc. These values usually contradict those associated with sufficiency: self-restraint, moderation, downsizing, etc.

As there is already ample literature on these values, and the critics to them, we will not further elaborate here.

Just to provide an example in the area of products: buying ever larger TV flat screens is not only motivated by the viewing experience, but also by a certain conception of progress, the constant push for technological novelty, the feeling of grandeur and self-accomplishment it provides, potential social motives to impress relatives or not lag behind dominant trends, etc.

Conceptions of ‘modern comfort’ and some of the dominant social norms

Social norms are rules of behaviour that are considered acceptable/necessary from people and organisations. They cover hygiene standards, expectations from products and services (e.g. instant access, low failure rate...), the need to be digitally accessible 24/7, safety and protection aspects, intimacy rules, etc.

Over the past few generations, expectations of comfort, cleanliness and convenience have altered radically; habits have not just changed, but changed in ways that imply escalating and standardizing patterns of consumption (Shove 2003). These changes in norms, rules and expectations are in turn driven by the development of technology, products and infrastructure. The latter can play an enabling role (for example, the general availability of washing machines has enabled high hygiene standards), but also a restricting one (for example, passive cooling options in buildings have deteriorated with the advent of air-conditioning).
Habits and routines in the field of energy use practices

Many of the mental processes we apply to purchase and use products are routinized, as social scientists point out. This is probably true not only for private but also non-private buyers and users. In addition, there is a poor overall understanding of energy consumption levels, and a frequent underestimation of potentials for energy savings (Cordella-Génin 2014).

Product settings can notably have a substantial impact on energy use (Sivitos et al 2015). Yet, studies have shown that a significant part of the population pay little attention to them. For instance, a survey has shown that half of British TV owners never make any adjustment to their TV settings after purchasing it; another survey in Germany revealed that people commonly use only one programme on their dishwashers, which by the way is rarely the energy saving one (cited in Sivitos et al 2015).

Manufacturer and retailer strategies

Some evolutions in products placed on the market, such as increased average sizes, or new functionalities embedded by default, can be detrimental to energy use and sufficiency behaviours. These evolutions may be driven by many factors, more or less conscious and more or less influenced by consumer preferences (see part 4 for a more detailed analysis). Obviously, they do not facilitate sufficiency when they make it non possible anymore to choose a reasonable product size or configuration.

Low energy prices

This barrier is not specific to energy sufficiency, but to energy savings in general. As it is very broad and covered by a huge literature, we are not discussing it in detail here.

Financial motivations are of course an important driver of people and business behaviour. More attention is paid to energy use and energy conservation if it has a strong impact on finances.

Yet, energy prices in Europe, although varied between Member States, are (still) often relatively affordable for middle-class populations, and thus not encouraging saving actions.

3.3 Positive and encouraging trends

In the meantime, there are also reasons to hope. Sufficiency values, often associated to a pro-environmental attitude, are already considered by a part of the population. Also, several sufficiency actions may progress in society without being attached to a negative feeling of self-restraint or compromising. They may also develop indirectly, not only for the benefits of saving energy.

We list here some of the general social and technical evolutions that increase the chance for sufficiency actions to be implemented.

Values and attitudes challenging the traditional consumer society paradigm

There is a vast literature about how a share of the European population has developed a sceptic or critic approach to the values and conceptions listed in the previous paragraphs, and is revisiting them to move (more or less quickly and consistently) to more pro-environmental behaviours and lifestyles. Energy sufficiency may be an increasing part of their agenda.

Just to provide an illustration: a recent paper called ‘A study of regretted appliance purchases’ (Roberts et al 2017) reveals from a survey that 53% of adults report regretting purchasing an electrical device at some point, and 23% regretted making such a purchase

---

5 As an example, many computers are left on without power management enabled, probably without the users realising or bothering about it (cf. paragraph 4.8).
within the past year. Reasons include e.g. the resentment at built-in obsolescence, or the frustration at the pace of technological change.

**Co-benefits of sufficiency actions**

If not purely for energy saving or environmental protection, a number of energy sufficiency actions have the potential to bring other benefits. This convergence increases the likelihood of seeing these actions discussed, considered, and adopted more widely.

Examples in the area of products include reducing discomfort and diseases through more reasonable indoor cooling, reducing nightlight pollution through more moderate and better optimised outdoor lighting, etc.

**The rise of the sharing economy**

By changing the way to own and use products, the collaborative or sharing economy explores new behaviours and business models that could support the sufficiency agenda. For instance, the switch from possession to leasing could enhance product repairing and upgrading, and reduce the turnover for some of the electronics. Social services for sharing appliances and occasional products may also decrease ownership rates and better optimise product use. New trends such as ‘repair cafes’ for small electronics are also noticeable.

Obviously, there might also be detrimental effects (e.g. people starting to use a shared appliance that they were not using at all before). A careful look at the sharing economy implementation is therefore necessary, and initiatives analysed case by case.

**Product ‘intelligence’**

As energy-using products tend to become more and more sophisticated, smart, and configurable, they usually become better at detecting user’s needs and habits and optimising their functioning. This ‘hidden sufficiency’ helps people and organisations being more rational and avoiding a part of the current energy waste due to poor product usage or settings. Examples include advanced auto-power down functionalities, products with sensors, and maybe in the future artificial intelligence-based products that reduce the energy use from products to the very strict minimum for each individual user.

**Product convergence and miniaturisation**

Another example of ‘hidden sufficiency’ in the electronics sector is the development of mobile products. Because of battery constraints, they are intrinsically less energy-demanding than fixed devices. And as convergence progresses (e.g. smartphones replacing phones, computers, cameras, video recorders, music players, etc.), less products are manufactured and some savings on embedded energy should be generated. This doesn’t show clearly yet, as people and organisations continue accumulating electronic devices, but the trend might reverse at some point.

A step further would be in modular mobile devices that can be adjusted to the user exact needs. The idea of a ‘Fab labtop’ computer of that kind has been for instance developed in a sufficiency open experiment in Germany (Brischke et al 2015).
The drawback is that miniaturisation also allows new electronic technologies to be developed and to add energy use where there was none before. The expected mushrooming of various small or large networked products in the ‘Internet of Things’ is one illustration (IEA 4E 2016), and it is important to avoid as much as possible additional power sucking (e.g. through the development of ambient energy harvesting technologies).

**User feedback and empowerment technologies**

Various home or office automation systems can report on the levels of energy use of the different appliances and products. This feedback can raise awareness among users, and include features such as alerts in case of excessive consumption.

There is a wide literature on the evaluation of such systems and how much savings they may actually generate. A recent global meta-data analysis reports an average 5% to 10% saving potential at household level for energy feedback systems (Bertoldi 2017). However, there are barriers and conditions to fully achieve this potential. A detailed assessment of the outcomes of various user feedback projects in the US can also be found in ACEEE 2016.
4 Detailed analysis for priority product groups

It is not possible to provide an exhaustive analysis of the specific barriers and opportunities for all possible sufficiency actions in the area of products, as there are too many types of products consuming energy.

Based on the available literature and our own evaluation, we propose to focus on a list of priority product groups. They have been selected for their weight on the EU total energy consumption, the relevance and potential of sufficiency actions, and the perceived likelihood of success in promoting these actions. For each of them, a detailed analysis is provided in the following, including an overview of the product group weight and relevant trends with respect to sufficiency, a list of identified opportunities related to sufficiency, and a discussion of specific barriers.

The analysis covers:

- Water heating
- Air-conditioning
- Household refrigerating appliances
- Washing machines
- Tumble driers
- Lighting
- Displays
- Computers
- Servers (and data centers)

Where not mentioned, the sources used are:

- For total energy consumption figures: VHK 2016, EU Ecodesign preparatory studies
- For ownership rates: VHK 2016, Ecodesign preparatory studies
- For quantified technical trends: Michel et al 2016, and Ecodesign preparatory studies
- For usage trends: Ecodesign preparatory studies
- For the calculation of sufficiency opportunities: VHK 2016, Ecodesign preparatory studies

4.1 Water heating

<table>
<thead>
<tr>
<th>Primary energy use in the EU in 2015</th>
<th>64.3 Mtoe (748 TWh\text{primary}) per year in the residential sector and 30.4 Mtoe (354 TWh\text{primary}) per year in the tertiary sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership trends</td>
<td>Most dwellings are already equipped.</td>
</tr>
<tr>
<td>Technical trends</td>
<td>Some models claim to be “smart” and able to adjust to the user’s needs and habits.</td>
</tr>
<tr>
<td>Usage trends</td>
<td>Water-saving taps and showerheads are available, but not implemented everywhere.</td>
</tr>
</tbody>
</table>

---

6 Ecodesign preparatory studies are accessible on: https://circabc.europa.eu/w/browse/f27f80a1-0cb3-4bb3-b75d-d75fa23c0b54
Energy sufficiency opportunities

- Avoiding over-sizing of water heaters would reduce energy use. Carefully setting the temperature of a storage heater is also an instant sufficiency trick, that can reduce the consumption by up to 10% (Sivitos et al 2015). Heating time can also be limited through a timer socket plug, or more automatically through models with smart controls.

- There is an estimated potential of 25% savings on total energy use through the generalisation of water-saving taps and showerheads (JRC 2014).

- Many Europeans shower or bath every day, while it is not considered necessary or even healthy by dermatologists. Avoiding one or two showers per week could probably save about 10% to 20% on total energy use.

- Showering time could also be reduced, should people be aware of how long they shower and that only armpits and groin release odours and require to be washed often. User information has proven effective: in a large-scale experiment, shower water consumption was reduced by 22% on average through real-time feedback systems (Tiefenbeck et al 2016). Shower timers are another way of encouraging people to be reasonable. An average cut of 10% of the time spent would translate into a 5 to 10% cut in energy use.

In total, it seems reasonable to assume that up to 50% of the total energy use could be cut through these sufficiency actions.

Main barriers

- Over-sizing may result from a lack of awareness/consideration when installing the equipment, as well as the wish to be able to offer sufficient hot water to any guests.

- Social norms related to hygiene influence the perceived necessity to shower and wash daily. Bathing is considered by some as part of standard comfort.

- Showering time is probably highly routinized, and most people are actually not aware of how long they shower (and how much hot water it requires) (Tiefenbeck et al 2016).

- People do not seem easily ready to compromise on the perceived pleasure of the morning shower (as revealed for instance in the evaluation of an energy saving programme in French families, mentioned in Martin et al 2016).

4.2 Air-conditioning

**Electricity consumption in the EU in 2015**

| Ownership trends | 50 TWh/year in the residential sector and 165 TWh/year in the tertiary sector |
| Usage trends | Room AC are steadily increasing (by 6%/year). An 80% further growth is expected by 2030. Central air cooling systems have been multiplied by 5 in the last 25 years. A 30% growth is still excepted by 2030. Usage is very much dependant on the climate. |

Energy sufficiency opportunities

- There are several alternatives to air-conditioning (automatic shades, comfort fans, green roofs, Provence well, etc.). There are also ways of promoting passive cooling during the conception of buildings. A part of the foreseen growth in AC installations could be avoided.
Energy sufficiency in products

• Installations are sometimes oversized, as illustrated by examples reported by field experts in the commercial and industrial sectors. It is difficult to assess and quantify the extent of the problem at EU level though.

• More reasonable levels of indoor temperature are possible. Air-conditioned areas are often so chilled that they create a feeling of discomfort, especially in tertiary buildings. In addition, there seems to be evidence that productivity increases in offices with more reasonable levels of air-conditioning\(^7\). It is usually estimated that increasing the AC thermostat by 1°C decreases the electricity use by up to 5% (although the exact saving depends on several parameters).

• Although a small share of the market, portable single ducts are intrinsically inefficient products, and sometimes used in poor conditions (e.g. in small shops or apartments with a window or door opened to the outside warm air). Discouraging their procurement could save 1 to 2 TWh/year.

Main barriers

• Indoor temperature standards and habits are often based on old empirical prescriptions from several decades ago. For instance, they are usually based on masculine dress codes and physiology, thus unfit for women in offices who suffer from too cold temperature settings (Kingma et al 2015). Habits are also influenced by the technologies themselves (e.g. the advent of air-conditioning has decreased the tolerance for hot temperatures, and made it seem ‘normal’ to experience huge temperature differences between outside and inside). This leads to discomfort for some users and overconsumption of energy. Changing these habits often requires a long and difficult process.

• Building systems, especially in the tertiary sector, are often not programmed well and maintain the same indoor temperature all season long.

• The Energy Label for air-conditioners adopted in 2011 has a specific and very favourable scale for single ducts that allows them to be well ranked while being much less efficient than wall-mounted products. This is a detrimental tool to discourage their use.

4.3 Household refrigerators

<table>
<thead>
<tr>
<th>Electricity consumption in the EU in 2015</th>
<th>86 TWh/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership trends</td>
<td>1.3 refrigerating appliance per EU dwelling (stable)</td>
</tr>
<tr>
<td>Technical trends</td>
<td>Slight increase in volumes. Inflation of new functionalities (frost free, networked fridges...). Because of them, the average energy use of sold models has only decreased by 26% since 2004 compared to the 37% improvement in efficiency over the period.</td>
</tr>
<tr>
<td>Usage trends</td>
<td>Products are on 24/7</td>
</tr>
</tbody>
</table>

Energy sufficiency opportunities

• Better optimising refrigerating appliances in homes (e.g. using one instead of two) would reduce the multiple ownership and the average number of appliances per

\(^7\) http://news.cornell.edu/stories/2004/10/warm-offices-linked-fewer-typing-errors-higher-productivity
Energy sufficiency in products

dwelling. Cautiously extrapolating the calculations in Fischer (2015) leads to a potential saving in the EU of 5 to 10 TWh/year by 2030.

- Having a big standalone freezer may be indispensable in some cases (e.g. in rural areas), but could sometimes be avoided by using less frozen and more fresh food. This requires some evolution in food preparation and diet habits. A 10 point reduction in ownership rates (currently at around 40% in the EU) would translate into about 4 TWh/year of savings.

- There is still a share of very big sized ('American style') models. A measurement campaign in French households found 6% of them in their sample, consuming on average 2.5 times more than standard fridge-freezers (Dupret et al 2017). Discouraging such models could ultimately save several TWh/year.

- The risk of increasing volumes seems to be relatively limited at present. However, the inflation in functionalities (frost free, built-in appliances, compressors optimised for tropical climates, chill compartment, networked functions...) constitutes a worrying trend. Some moderation on these functions would avoid additional energy use.

- Carefully setting the internal thermostat of refrigerating appliances to avoid excessively cold temperatures, i.e. 4 or 5°C in the fridge and not below -18°C in the freezer, can yield substantial savings. Recommendations on optimal internal temperatures seem to vary culturally, and people may get confused by contradicting messages. There is evidence from metering studies that many freezer compartments operate at too cold temperatures; besides, they do not need to be at -18°C all the time, and some simulations have revealed 15% to 30% energy saving potentials (Waide et al 2015). In total, a 20 to 40% cut in the electricity use of refrigerating appliances would seem achievable through energy sufficiency actions.

Main barriers

- Some people prefer to keep old (even poorly functioning) fridges to put them in the basement or garage instead of scrapping them.

- Owning a standalone freezer is considered part of modern comfort by a fraction of the population (especially those who like to freeze their own food preparations for later).

- The EU Energy Label allows giant side-by-side fridges to get very good energy ratings if they are efficient, as there is no progressiveness with size in the efficiency formulae.

- The EU Energy Label formula also currently ‘rewards’ additional features by giving them a bonus on the energy rating. This has contributed to easily popularising them. Sometimes inbuilt and frost-free models are consuming more than larger ones with the same energy class but without these functions. In addition, the label reference lines for ranking models makes it more difficult for refrigerators without freezers to reach high classes than for refrigerator-freezers. This may partly explain the observed shift towards refrigerator-freezers in the last years.

- Refrigerator controls do not always allow the user to set an exact internal temperature, and/or lack a precise feedback information on the temperature.
4.4 Washing machines

<table>
<thead>
<tr>
<th>Electricity consumption in the EU in 2015</th>
<th>28 TWh/year in the residential sector, and 3.3 TWh/year in the non-residential (2009 figure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership trends</td>
<td>&gt; 90% ownership in households (stable)</td>
</tr>
<tr>
<td>Technical trends</td>
<td>Models become more sophisticated, smarter, but also bigger in capacity (from 4.8 kg on average in 1997 to 7.04 kg in 2013 for sold machines).</td>
</tr>
<tr>
<td>Usage trends</td>
<td>Studies report a continuous decrease in yearly cycles, e.g. -5% between 2006 and 2011 in Europe, or -28% between 2008 and 2015 in France (Dupret et al 2017).</td>
</tr>
</tbody>
</table>

Average wash temperatures are also decreasing; by 1 to 3°C in most EU countries between 2006 and 2011.

Energy sufficiency opportunities

- Models placed on the market in the recent years tend to have bigger and bigger capacities (up to 10 or 11 kg), but average loads do not necessarily increase with the same magnitude, they may even remain below 4 kg (Michel et al 2016). This causes an oversizing issue, responsible for a potential 4 TWh/year of electricity waste by 2030 (EEB 2015). A sufficiency approach could avoid some of this waste.

- There is already a trend for sufficiency in the reduction of the number of cycles (also allowed by the bigger capacities). This is good news, and could be further enhanced by proper user education, as well as future technological innovations (e.g. no-wash and no-iron clothes). Other ideas could be developed, such as replacing washing machines by ‘cloth refreshing cabinets’ combined with a local laundry service (Brischke et al 2015).

- There is also a positive trend in the reduction of average wash temperatures, stimulated by efficient detergents and cold wash programmes. This could be further encouraged, notably by replicating best-in-class approaches (there was still a 16°C difference between the average wash temperature in Poland and Spain in 2011).

Combining a further 10% reduction in yearly cycles and a 5°C reduction in wash temperatures could save about 25% of the electricity consumed by washing machines in the residential sector (own calculation).

Main barriers

- According to experts, the trend to larger capacities has been largely driven by manufacturer strategies. For long, the EU Energy Label has favoured this capacity growth through a formula making it easier for big capacities to reach the highest classes (Michel et al 2016). The new formula introduced in 2011 has partly reduced the bonus, but the strict linear approach still supports the trend (an A+++ 8kg machine can consume nearly 30% more than a lower-ranked 6kg model).

- The positive trend to less cycles is hindered by the fact that a fraction of people wash at part or even smaller load. The social norm of always wearing immaculate and neat clothes, and the habit of wishing to wear different ones every day both limit the time that people are ready to wait before running the next cycle.
The trend for low wash temperatures, notably by selecting 'eco'/standard programmes, is currently endangered by a trend to increased programme durations. As programme time is not regulated, some manufacturers place on the market machines that require more than 3 hours to wash at the standard programme. This reduces the amount of energy used, but can be a concern for users (Stamminger et al 2017).

### 4.5 Tumble driers

| Electricity consumption in the EU in 2015 | 28 TWh/year in the residential sector, and 6.6 TWh/year in the non-residential (2009 figure) |
| Ownership trends | The stock has grown by 8% in 5 years. It is expected to grow by a further 14% by 2030. |
| Technical trends | Models become more sophisticated (with e.g. heat pumps), but also bigger in capacity (from 5 or 6 kg in 2004 to mostly 7 or 8 kg in 2015 for sold machines). |
| Usage trends | There is no evidence that the usage has dramatically changed, but the development of sensor dry (using moisture sensors) can help optimising the energy use to the exact need. |

**Energy sufficiency opportunities**

- The most radical sufficiency action in drying is obviously to use line drying instead of a tumble drier. Promoting line drying wherever possible could slash a substantial part of the total electricity consumption.

- Tumble driers placed on the market in the recent years tend to have bigger and bigger capacities (up to 10 kg or more), but average loads do not necessarily increase with the same magnitude. This causes an oversizing issue. The potential electricity waste from this has been estimated at 4 TWh/year by 2030 (EEB 2015). A sufficiency approach could avoid some of this waste.

- Sensor dry programmes could be further promoted or made mandatory.

A total estimate of the potential of these sufficiency opportunities is difficult to assess, as it largely depends on how much the use of driers could be discouraged and replaced by line drying. There was no sufficient literature related to available space, habits, etc. to draw firm conclusions at EU level.

**Main barriers**

- Line drying is not always practical in apartments. Building codes and prescriptions could make sure that solutions are always provided (such as collective laundry rooms for line drying in small apartment flats). This also requires that people are comfortable with having (at least some of) their clothes in a shared space.

- Manufacturer marketing strategies tend to push people to purchase driers. For instance, the French federation of appliance manufacturers suggests that driers are ‘responsible products’ that make you save 6 hours per week on line drying. This is not going in the sense of energy sufficiency.

- The growth in capacities logically follows that of washing machines. EU Energy Labelling Regulations have thus been indirectly supporting the trend.

---

8 [http://www.gifam.fr/page/les-produits.html](http://www.gifam.fr/page/les-produits.html)
4.6 Lighting

<table>
<thead>
<tr>
<th>Energy sufficiency in products</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electricity consumption in the EU in 2015</strong></td>
</tr>
<tr>
<td><strong>Ownership trends</strong></td>
</tr>
<tr>
<td><strong>Technical trends</strong></td>
</tr>
<tr>
<td><strong>Usage trends</strong></td>
</tr>
</tbody>
</table>

Energy sufficiency opportunities

- Artificial light is spreading in all types of buildings and environment. Better promoting natural light in building codes and people’s habits could reduce a part of the energy use. And there is evidence that it is better for health, for instance in offices (Boubekri et al 2014). The total potential of natural light is difficult to assess though.

- Illumination levels may be fine in households, but they are sometimes high in offices, public buildings, shops and streets. Excessive artificial light levels have been reported in measurement campaigns in classrooms or offices\(^9\). Some retailers have been caught up in the arms race of lighting, with illuminance levels exceeding 1,200 lux\(^10\). Over-illumination leads not only to energy waste, but also to documented health issues. Some moderation would help. Also, the flexibility of LED products allows in theory to better optimise lighting solutions (e.g. more directional street lighting that avoids light pollution).

- Lighting controls such as presence detectors, daylight control, etc. can help reducing wasteful lighting. This can be supported through the development and promotion of ‘lighting system’ approaches, instead of focusing only on light sources. An evaluation at EU level suggests that improving tertiary luminaires and enforcing controls could save 55 to 65 TWh/year (cited in Borg 2014).

- It is too early to know whether there is a real future for networked lamps, but some models are apparently of poor quality with high standby losses (IEA 4E 2016). A sufficiency approach would consist in limiting these technologies, and focusing them where they can really help (e.g. coupled with presence detection, used for on-demand street lighting, etc.).

In total, a substantial part of the energy used for lighting could be avoided.

Main barriers

- With the development of LEDs, there is a common conception that lighting becomes super-efficient and adding new lighting points is not a problem. Although there might

---

10: http://archive.luxmagazine.co.uk/2011/01/britain%E2%80%99s-brightest-store%E2%80%A6/
not be a strong direct rebound effect when replacing an old lamp by an LED equivalent (Schleich 2014), anyone can witness the multiplication of new LED sources in the public space and tertiary buildings, often for decoration purposes that did not exist before.

- Standards and common design practices prescribing illumination levels in non-residential buildings are not always optimised to avoid energy waste. There are also preconceptions that higher illuminance levels will increase productivity, sales, or safety.
- The interoperability and understandability of lighting controls remains an issue. There is a lack of standardisation, notably of user interfaces (Nordman 2011).

### 4.7 Displays (TVs, monitors...)

<table>
<thead>
<tr>
<th>Energy sufficiency opportunities</th>
</tr>
</thead>
<tbody>
<tr>
<td>It seems difficult to envisage a moderation in the purchase of TV screens in the short term, although some product substitution could take place (e.g. tablets and smartphones reducing the use of bigger displays). Extrapolating the estimates from Fischer 2015, a reduction of 2 points in residential TV ownership rates could yield a 4 TWh/year savings on EU electricity consumption.</td>
</tr>
<tr>
<td>Encouraging the use of laptops instead of desktops could incidentally reduce the need for some computer monitors (although laptops are sometimes still used in combination with monitors and docking stations). Halving the stock of monitors this way would save about 4 TWh/year of electricity in the EU by 2030.</td>
</tr>
<tr>
<td>A more reasonable approach to sizes could be considered, although also difficult to implement in practice. If current trends continue, the average TV screen diagonal would reach 120 cm by 2030. Keeping it at 100 cm instead would save around 4 TWh/year of electricity by 2030 (own estimate).</td>
</tr>
</tbody>
</table>
| A moderation in picture enhancement and networking functionalities is conceivable, through more explicit settings and better user education. In some existing models, energy-saving settings are difficult to control and are sometimes deactivated without user warning (CLASP et al 2017). A fraction of the power use is the result of unawareness rather than conscious choice. The simple fact of setting a high brightness
Energy sufficiency in products

may result in a 10% to 30% increase in energy use (Sivitos et al 2015). Also, a TV with auto-brightness control inadvertently disabled can consume as much as 57% more than when it is on (Horowitz et al 2015).

- Excessive screen viewing from children has been linked to a plethora of psychological and health problems. They are a key target to try and implement moderation behaviours. If we assume that children are responsible of 20% of average viewing time (own theoretical estimate), and this time is halved, this would trigger a 2 to 3 TWh/year electricity saving in the EU by 2020.

- In the non-residential sector, displays are mushrooming in the public space. Their sales are rapidly increasing (Diga et al 2015). It is generating some resistance, e.g. by groups and NGOs calling for more regulation. It would be beneficial that some rules are discussed to avoid an excessive or uncontrolled development. A 25% instead of 50% growth in the number of these products by 2030 would translate into about 1 TWh/year of electricity savings.

Main barriers

- The current use and growth of display products are clearly driven by powerful trends in society (the digital age, the entertainment economy, etc.) as well as addiction-type behaviours (Alter 2017). As long as they persist, it will be difficult to infuse a sufficiency approach in this sector. Education of children to distance them from these products and increase their self-control is likely a necessary step.

- The screen market is largely driven by innovation, and manufacturers tend to multiply efforts to offer new technological developments and user experiences in size and picture quality, brightness, etc. At some point though, this adds new energy consumption for questionable benefits (ultra-high definition is only worth if one has the space to install a very large screen).

- The EU energy label for TVs has been so far linear with screen surface, meaning that very large displays can get the highest energy ratings even if they actually consume much more than smaller screens. There is no enticement whatsoever for a moderation on sizes.
4.8 Computers

<table>
<thead>
<tr>
<th>Electricity consumption in the EU in 2015</th>
<th>19 TWh/year</th>
</tr>
</thead>
</table>

**Ownership trends**

The number of computing devices in use (PCs, tablets...) is strongly increasing, with an annual growth still reaching 9% over 2010-2015. Their number is expected to double by 2030.

**Technical trends**

Computers become more powerful, with enhanced networking functionalities. There is a trend for mobile devices though, supporting a form of energy sufficiency.

Obsolescence is fast, and upgradability and reusability still weak.

**Usage trends**

Home usage of computing devices is probably increasing (although no recent study could be identified).

There is evidence that power management functionalities are poorly used (enabling rate of only 20% in the most recent study identified).\


Energy sufficiency opportunities

- Although it is hardly conceivable that Europeans would easily become less attracted by computing devices, some substitution/convergence trends could take place. Should tablets become more comparable in functionality to PCs, people and tertiary organisations could naturally reduce the number of devices they use. The trend for cloud computing and increased use of networks could also translate in lighter final user devices, such as thin clients (simplified interfaces with all the computing functionalities migrated in networks). Traditional PCs and workstations are expected to still use 4 TWh/year of electricity in the EU by 2030, but this consumption could be slashed.

- As computers become more energy efficient, the weight of the embedded energy becomes all the more critical. For laptops, it has become the number 1 source of greenhouse gas emissions (Prakash et al 2012). In this context, prolonging the lifetime of computers through better upgradability, repairability, and reusability would yield benefits (not only for energy but also other material resource conservation).

- In terms of usage sufficiency, a simple and relevant improvement would be to generalise a responsible implementation of all power management features. By increasing the enabling rate from 20% today to 80%, a significant waste of electricity would be avoided. If we make the conservative assumption that people are not in front of their (private or professional) computer 30% of the time it is on, this sufficiency action would generate about 3.5 TWh/year of savings (own calculation).

Main barriers

- As for displays, the current use and growth of computing products are driven by powerful societal trends (the digital age, the entertainment economy, etc.) as well as

---
addiction-type behaviours (Alter 2017). As long as they persist, it will be difficult to infuse a sufficiency approach in this sector. Education of children to distance them from computers and tablets, and increase their self-control is likely a necessary step.

- Hardware obsolescence is strongly influenced by software obsolescence. Both need to be tackled together.
- The ‘throw-away society’ trend is a major general barrier to prolonging product lifetime. Some people find it more convenient to replace a product instead of alternatives.
- Marketing strategies from manufacturers are not supportive of product upgrading and repairing. Some models cannot be easily opened and customised. Spare parts are often expensive. This is a general trend across the electronics sector.

### 4.9 Servers

| **Electricity consumption in the EU in 2015** | 28 TWh/year for servers, between 14 and 28 TWh/year for the auxiliary devices and cooling of server room and data center buildings |
| **Ownership trends** | The number of enterprise servers and data centers is quickly inflating. A +60% increase is still foreseen by 2030. |
| **Technical trends** | Product obsolescence is quick, and lifetimes are short (3 to 5 years). |
| **Usage trends** | Servers are on 24/7. The strong growth in data traffics and cloud computing explains the fast increase in need for servers and storage capacities. |

#### Energy sufficiency opportunities

- Firstly, professional servers and storage devices are installed because of the way we use networks and cloud computing. Digital habits are amongst the least reasonable and responsible. Many people pay no attention to limiting e-mails to the necessary, reducing attachment sizes, avoiding unnecessary downloads and constant synchronisations, etc. A more moderate use would avoid a number of servers being installed. The potential is clearly significant, as revealed by studies quantifying the carbon footprint of digital activities.

- According to various studies, servers are far from being used in an optimal way and at their adequate load: oversizing, low utilisation rates, ‘comatose servers’ that remain plugged without providing any service, under-employment of power management solutions, etc. Taking into account market barriers, a potential energy saving of 40% has been identified in US data centers (NRDC 2014). The same probably exists in Europe. Reaping it would mean 11 TWh/year in electricity.

- Data center buildings are also far from being energy sufficient. A recent survey in 87 French centers has revealed an average PUE (Power Usage Effectiveness) of 1.8, which is not that great\(^\text{12}\). Sufficiency solutions exist, such as increasing the operating temperature, using free cooling, etc. An 0.2 decrease in average PUE in the EU translates into 5 TWh/year of savings.

---

\(^{12}\) A PUE of 1.8 means that for each kWh consumed by servers, another 0.8 kWh is consumed for auxiliary devices and cooling.
• Prolonging the lifetime of servers and storage units through better upgradability, reparability, and reusability would also yield benefits (not only for embedded energy but also other material resource conservation).

Main barriers
• Moderation in the use of digital tools and communication seems a tough challenge. There is a sense of immateriality, immediateness, easiness, as well as a lack of awareness about the energy/environmental impacts. Besides, the energy used by servers is not directly consumed by final users.
• The current fast technological development pace in servers makes it difficult to promote lifetime prolongation, reuse, and other approaches to reduce electronic waste.
• There is an incentive split challenge in the sector, with data center owners usually paying the power bill, while IT purchasers specify equipment separately. The disparate parties have misaligned motivations resulting in under-consideration of energy saving solutions (NRDC 2014).
5 Policies for energy sufficiency in products

5.1 What role for policies?

There are not many examples of policies in the EU directly prescribing or enforcing energy sufficiency actions in products yet. The concept of sufficiency is still poorly known and understood by a part of policy-makers. It is sometimes caricatured as an attempt at eco-dictatorship, or unacceptable intrusiveness in people’s lifestyles and personal freedom.

Main reasons for this reluctance include a lack of understanding of the concept and its potential, a perceived contradiction with the traditional growth and liberal motto, or a disinclination to challenge behaviours through policy intervention. These barriers, as well as the issue of the compatibility between sufficiency, liberal societies, and market economy, have been discussed in the literature (e.g. Heyen et al 2013, Muller et al 2016, Schneidewind et al 2014, etc.).

Nevertheless, the role of policies can be broader than bluntly prescribing or prohibiting something. There is a wide range of possible interventions that may not just seek to impose, but encourage, facilitate, enable, or incentivise sufficiency actions. There are also existing policies doing the exact opposite and constituting barriers to sufficiency action diffusion; mitigating them would then be a part of the solution to let sufficiency and sufficiency actions better flourish by themselves.

The literature includes a number of publications where the contribution of policies to energy sufficiency has been discussed, and various policy instruments considered (Bertoldi 2017, EEA 2013, Heyen et al 2013, Toulouse et al 2017, etc.). In particular, the German project Energiesuffizienz has elaborated a set of detailed energy sufficiency policy options (Thomas et al 2017), based on a thorough background analysis of the barriers and drivers (Thema et al 2017), as well as surveys in Germany about the social acceptability of some of these options (Leuser et al 2016).

Some authors suggest that policy packages towards sufficiency need to combine both interventions aimed at supporting social innovations and building supportive frameworks for them, and others destabilising currently dominant regimes (i.e. the overall drivers of non-sufficiency) (Thomas et al 2015).

In the development of policies supporting energy sufficiency, there seems to be a common understanding that attention should be paid not only to market barriers, but also to the social and political acceptability of the measures. This includes for instance paying attention to who will be affected, and potentially driven to spend more time or effort on certain daily activities (Thomas et al 2015 & 2017).

In the following, we discuss a number of possible policy options specifically in the area of products, covering various types of intervention. We do not cover the broadest and cross-sectoral policies to save energy, such as energy targets, energy taxes, carbon allowances, caps on energy supply, etc. They may of course be relevant to indirectly influence sufficiency in the field of products, but they have been analysed elsewhere (e.g. Bertoldi 2017, Thomas et al 2017, etc.), and our aim here is to primarily focus on the product area.

We classify these policies into different categories. For each, we introduce existing and potential policy ideas to tackle the barriers identified in the previous chapters, and we share best practices from various countries.

5.2 Official recognition

A first emblematic step that policies can take is to acknowledge the importance and relevance of energy sufficiency, that is of strategies for saving energy beyond pure technical efficiency.

In the area of products at EU level, a place where sufficiency (or equivalent concepts) could be acknowledged is within the framework of policy interventions covering products placed
on the common market, that is essentially Ecodesign and Energy Labelling Regulations\textsuperscript{13}. The Ecodesign Directive (2009/125/EC) does indeed include in its recitals notable sentences:

- ‘A significant reduction in energy consumption (...) is possible’
- ‘Therefore, substantial demand-side measures and targets should be adopted’
- ‘It may be necessary to inform consumers about the environmental characteristics and performance of energy-related products and to advise them on how to use products in a manner which is environmentally friendly.’

However, in the meantime, the Directive also insists several times on the fact that its scope is merely ‘energy efficiency’ of products. And it doesn’t say a word afterwards about dimensional, usage, or collaborative aspects of products.

The Energy Labelling Directive (2010/30/EU) is straightforward in defining its purpose (‘Improving the efficiency of energy-related products’ and ‘stimulating end-users to purchase more efficient products’). Yet, a recital also hints at the fact that ‘the total energy consumed by products is expected to continue to rise in the longer term’, justifying that the ‘high total energy consumption of a product’ could be sometimes highlighted. Another one suggests that the Directive ‘should also, indirectly, encourage the efficient use of products’.

However, as for the Ecodesign Directive, there is then no further reference to dimensional, usage, or collaborative aspects of products. Realising that, the authors in charge of the 2014 official evaluation of the Energy Labelling Directive prepared for the European Commission have expressed the view that ‘labels should ensure that promotion of low absolute energy consumption remains a guiding principle (...) Higher energy using appliances should not be unfairly favoured and rather the efficiency metrics should err towards scales that favour lower energy solutions’, thus making a clear plea for energy sufficiency (Ecofys 2014).

\textit{Note: beyond these general remarks about recognition aspects, we come back in paragraph 5.7 to these Directives to discuss their more practical content and implementation.}

\section*{5.3 Educational campaigns and tools}

As many energy sufficiency actions are about altering common attitudes and social norms, information and education play a central role. Public communication material can be focused on promoting sufficiency-based behaviours.

This includes sound advice on how to carefully choose products, and how to use them in a reasonable way. Public communication may not go as far as prescribing certain lifestyles, however it can already address many of the behavioural aspects that were identified in the previous parts. Additionally, communication could highlight the benefits of more sufficiency-based lifestyles, through case studies and personal stories.

There are varied publications analysing public communication in the area of sustainability, and providing recommendations on how to make it as effective as possible. They include for instance engaging the target audience in narratives and learning stories (Lorek et al 2017), or using active communication and gamification techniques (Toulouse et al 2017).

\textsuperscript{13} See https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products for an introduction to these EU policy frameworks.
Best practice

ADEME (The French environment and energy management agency) regularly publishes eco-guides for consumers on various topics. Its guide on office behaviour provides advice to moderate the use of digital technologies in order to save energy. Recommendations include:

- Using power management tools
- Deactivating Bluetooth, Wi-Fi … functions where not used
- Limiting the number of software opened at the same time
- Lightening e-mails and attachments
- Focusing web searches
- Prolonging the lifetime of office equipment
- Etc.

Policy-makers also have the power to enforce restrictions on the communication by private bodies, notably when it poses a threat to public policies.

An example would be to restrict ads and marketing campaigns for certain types of energy-intensive products or behaviours (e.g. aggressive promotion of air-conditioners in temperate regions), potentially using inspiration from ad regulations in some countries after the oil crisis in the 70’s. Specific audiences, such as children, could be particularly considered for such restrictions.

Another possibility would be to require all promotion campaigns for energy-related products to indicate prominently the absolute annual energy consumption of the model (and not only its energy efficiency class).

5.4 Incentives to sufficiency actions and behaviours

A number of targeted incentives and governmental interventions can support energy sufficiency and the development of social innovations enabling sufficiency behaviours. They can be of varied nature and level of implementation (e.g. EU, national, local). They can be classified into three main groups:

Direct financial support to products and behaviours

Governments can stimulate sufficiency actions by financially rewarding their uptake, and/or penalising the most anti-sufficiency ones. Options include:

- Tax rebates and other discount mechanisms to intrinsically low-energy products and energy-saving solutions, such as hot water-saving/reusing devices, intelligent thermostats, lighting controls, collective laundry projects, etc.;
- Progressive taxes or financial maluses on products such as giant screens, terrace heaters, non-repairable electronics, etc.;
- Scrappage programmes to encourage people and organisations to get rid of superfluous appliances and products they might keep (e.g. the old fridge in the basement or garage).

Support to projects and programmes

National and local governments may also provide help to stimulate and disseminate projects showing how sufficiency actions can be implemented in practice and generalised. Examples are:

- Funding of demonstration projects that analyse and implement solutions to increase the diffusion of sufficiency practices and overcome existing barriers;
• Contribution to the development of programmes of personalised sufficiency advice (Thomas et al 2015), such as the German ‘Stromsparcheck’\(^\text{14}\);

• Support by local authorities to community-based initiatives that promote energy sufficiency and responsible sharing practices.

**Exemplary behaviour from public institutions**

State-owned bodies and administration can be requested to adopt energy sufficiency actions and behave in an exemplary way. This may be done through:

• Public procurement rules that include energy sufficiency criteria, such as moderation on sizes, functionalities, etc.;

• Implementation of best behaviours (reasonable temperature setting, lights and screens off outside working hours, product sharing platforms, etc.) in public institutions.

---

**Best practice**

Faced with severe droughts, the Spanish city of Zaragosa has implemented since 1997 a comprehensive water saving programme involving a wide range of public and private bodies. Activities included the implementation of 50 showcases of good technologies and practices in various places, and the support to the marketing of water-saving products. As a result, the sales of water-saving taps increased sixfold.\(^\text{15}\)

---

### 5.5 Evolution in comfort standards and prescriptions

As seen previously, several of the barriers to reducing energy use from products relate to habits and customs that influence the level or intensity of their use. Some of these habits have their roots in prescriptions and norms decided by public or authorised bodies. Sometimes, they have not been revisited in years, or have been but without sufficiently considering energy consumption issues. Examples include:

**Lighting specifications in the non-residential sector**

Varied standards and specifications set recommended illuminance levels in various areas (working planes, corridors, etc.). They are usually not set by governments but by standardisation bodies. However, policy-makers are entitled to request these bodies to develop new or adjust existing standards to implement public policies (e.g. through the ‘mandating’ process towards CEN and CENELEC in the EU).

A global comparison showed that minimum values of illuminance on work planes for office work, drawing and conference rooms greatly vary in the world from 200 to 500 lux. Also, minimum work plane illuminances in offices set by countries are usually higher than those recommended in international ISO standards (Halonen et al 2010). Optimising these values to the lowest acceptable level, taking also natural light into account, could help spreading more reasonable lighting practices.

**Thermal comfort specifications in private and tertiary buildings**

Specifications and recommendations also exist for indoor temperatures, although it is often not simply the results of official prescriptions, but of a collection of more or less old standards, habits, and preconceptions.

---


\(^{15}\) http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search dspPage&n_proj id=1123&docType=pdf
In this matter, it would be useful that governmental authorities take a firm stance and make it clearer what levels should be considered acceptable, taking into account not only comfort perception but also energy sufficiency. For instance, a reference temperature of 25°C in Summertime could be prescribed.

**Hot water temperature specifications**

Optimal levels of water heater temperature settings have been long debated, notably with respect to the balance to find between Legionella risks, scalding risks, and energy savings. Some still recommend going as high as 60°C, while others consider feasible to drop to 55°C without significant risks. A 5% energy saving is at stake, which is significant considering the weight of water heating energy use. It would be useful that relevant authorities at EU level commission research and draw on it to send a clearer conclusion on this topic.

**Best practice**

In Japan, the government has decided to save energy through the ‘Cool Biz’ campaign (2005), and then ‘Super Cool Biz’ campaign (after the Fukushima disaster). The prescribed indoor temperature in administration buildings has been raised to 28°C in Summer, and a liberal summer dress code introduced and encouraged.

The governmental intervention notably included newspaper ads and photos of ministry workers wearing light shirts. The campaigns also spread to the private sector. According to official evaluations, the Cool Biz campaign has saved 2.2 million tons of carbon emissions in 2012, and has become inspirational worldwide.

**5.6 Regulation of most detrimental habits**

In cases where the lack of sufficiency is such that it leads to outrageous energy waste, policy-makers may consider ‘tough’ intervention, and making some of the most detrimental behaviours or product types outlaw.

It has the double benefit of generating quick and instant energy savings, while constituting an example and a sign that energy waste needs to be generally considered.

It is not easy to draw a comprehensive list of such habits, as there may be a cultural dimension that ought to be considered. Anyway, the following examples could in theory be valid across the EU. (Note: some of these regulations could potentially be enforced through product policy instruments such as the Ecodesign Directive – see paragraph 5.7).
Banning doorless commercial and professional refrigerating appliances

Studies have shown that sales and consumer experience are not significantly affected by doors (Lindberg et al 2008), while it is an obvious way of conserving the cold and reducing energy use.

Banning non energy-saving taps and showerheads

Products that reduce water flows while maintaining a decent rising efficiency should become the default norm.

For instance, there could be a maximum flow value of 6 litre/ min set on these products.

Forbidding irrelevant lighting waste

There are countless examples of lighting installations that serve no clear purpose, or are operated when nobody needs them. Prescriptions can be enforced, such as light bans at certain times and in certain areas. Banning of the most light-wasting luminaires could also be an option to consider.

Regulating the installation of non-residential screens

Faced with a wild mushrooming of displays in public spaces, notably ad screens, authorities could decide to frame this development to keep it under reasonable limits. Restrictions and obligations for more consistency between installations could be enforced at national or local levels.

Fighting planned obsolescence

Marketing and technological business strategies increasing the need to change products often should be targeted, and could be outlawed in cases where they are done just to impose product renewal. Additionally, legal warranties could be made longer, more information provided on product lifetime, and the availability of spare parts made mandatory.
Best practice

France has issued in 2013 a decree that forbids to leave lighting on in non-residential buildings after 1 am if they are unoccupied. It notably covers offices buildings and shop windows. This rule has been explicitly enforced to reduce energy consumption (and light pollution). There is a possible derogation for highly touristic and cultural areas.

When introducing this measure, the then Minister of Environment has referred to a ‘logic of energy sufficiency’ and announced an estimated 2 TWh/year of electricity saving for the country.

Independent assessments have however revealed that the rule was insufficiently applied and monitored\(^\text{16}\).

Cool Biz campaign has saved 2.2 million tons of carbon emissions in 2012, and has become inspirational worldwide.

5.7 Strengthening product regulations and labels

The Ecodesign and Energy Labelling Directives on energy-related products have become central pieces of EU energy saving policies on products. The two instruments have led to dozens of Regulations that apply across the common market. The strengths and weaknesses of these two policy instruments have been discussed in official evaluations (e.g. Ecofys 2014). In paragraph 5.2, we have seen that energy sufficiency was not clearly part of the overall objective, although some recitals have interesting wording.

In terms of implementation, observers usually agree that, while these Directives do the job for promoting technical energy efficiency, sufficiency aspects are hardly considered in practical provisions (BUND 2014, eceee 2010...):

- Reference lines for setting minimum requirements and labelling classes are often linear with size and capacity, sometimes even favouring the biggest products;
- Usage patterns are taken for granted;
- Substitution opportunities are overlooked;
- Sharing and lifetime extension aspects have been poorly addressed.

In addition, some opportunities offered by the Directives have not been significantly exploited, for instance Article 14 of the Ecodesign Directive that states that consumers of products shall be provided with ‘the requisite information on the role that they can play in the sustainable use of the product.’

It is fair to acknowledge though, that there have been sometimes attempts at going a bit further than the traditional narrow approach. These should be highlighted:

- Energy labels include not only a scale with the energy class but also an absolute energy consumption figure - although the meaning of the indicated mention ‘kWh/annum’ seems to generate comprehension issues (Waide et al 2013).
- Auto-power down requirements have been enforced by default for some electronics, e.g. TVs after 4 hours, or and set top boxes after 3 hours (but users remain free to deactivate them).
- TV sets shall have a ‘home mode’ setting (tailored for a living room application) that shall be the default choice at set up.
- The possibility for users to deactivate networked connexions on products with networked functionalities has been secured.
- Washing machines shall include a cold wash programme.

\(^\text{16}\) An example (in French) is: https://www.anpcen.fr/docs/20141030145337_63764_doc126.pdf
- Water heaters have been granted a bonus on the energy label when they include smart controls that automatically adjust to individual usage conditions to reduce energy consumption.

- Minimum requirements on lamp lifetime and survival factors have been adopted.

- Minimum hose and motor lifetimes have been set for vacuum cleaners.

These examples remain relatively limited, and the focus on technical efficiency is repeatedly reaffirmed all along the policy process.

In the following, we investigate several options that would constitute further steps in promoting sufficiency within these policy instruments.

**Containing the inflation of sizes and capacities**

In order to tackle dimensional sufficiency aspects, there have been discussions about how to make energy efficiency requirements for products more progressive in nature (i.e. with increasing size, capacity, speed, etc.).

This has been summarised and analysed in a previous report prepared for eceee by Chris Calwell (eceee 2010). Progressiveness can be achieved through curved (asymptotical) reference lines, or even a cap on energy use after a certain level. This implies that it becomes more and more difficult, and at some point eventually impossible, for a product model to fulfil minimum requirements or reach the highest energy grades when size, capacity, and amenity increase. Building on this work, other reports have further investigated the topic (e.g. BUND 2014). One of them has specifically analysed size increase issues for white appliances, and further elaborated solutions to the current limits to EU energy labels (EEB 2015). Three options are distinguished:

- Capacity-independent lines: this is the most radical approach, where minimum requirement or label class boundaries are based on absolute energy use limits. Examples do exist, such as the French energy/CO₂ car label;

- Curved lines (this is the approach discussed in eceee 2010);

- Less overlapping classes: An additional fix for the energy label would be to limit situations in which a good energy rated product can consume more than a smaller product in a lower energy class. This can be done by adjusting the steepness and levels of the formulas, so that there is less risks of overlaps.
These different approaches can also be combined, to design the most fitting solution depending on the product group.

Implementing such solutions is still facing political resistance. There are not many examples of a full consideration of these sufficiency approaches yet. Curved reference lines have been considered in a review of Ecodesign and Energy Labelling Regulations for TVs, however the shape of the proposed lines has more to do with the fact that they are better representing the market average than to sufficiency considerations.

In addition, a revision of the EU Energy Labelling policy instrument adopted in end of 2017 has only made a shy step, through requesting that implementing Regulations should specify ‘whether for larger appliances a higher level of energy efficiency is required to reach a given energy class’. This provision looks good; however, it is not systematic and will need to be debated and specified during each product group discussion.

Avoiding artificial categorisations and feature bonuses

In order to accommodate all types of products with varying features, minimum requirement and energy labelling equations sometimes split product groups into several subcategories with their own reference lines and calculation factors. This leads to unexpected situations where subcategories may have an easier life reaching certain efficiency levels than others, based on some of their technical characteristics rather than their absolute energy consumption. For instance, the split of domestic refrigerating appliances into 10 subcategories in the EU Energy Labelling scheme has generated a form of penalisation of single fridges over fridge-freezers (Michel et al 2016).

---

17 When a product is situated in a grey hatch area, it is technically possible that a product in a better energy class consumes more energy than it. On the right graph, the extent of the grey areas is more reduced to avoid this issue.


To avoid these issues, it sounds relevant to limit such sub-categorisations and calculation sophistications, so that the energy efficiency rating within a product group remains as purely as possible based on energy consumption levels assessed in the same way.

Similarly, energy efficiency calculations sometimes include correction factors or bonuses to account for secondary features that product models may have. In Ecodesign and Energy Labelling, these bonuses have often been generous and induced an incentive to include them, thus increasing absolute energy consumption. The illustration of household fridges is again well-known (Topten 2015; Ecofys 2014).

A systematic rule could be to suppress or strictly reduce bonuses for auxiliary energy-consuming features, and reserve them only for features that help users save energy (such as ‘intelligent’ functions able to optimise the functioning and energy use of a product to the exact user’s needs or habits).

**A more prominent visualisation of sufficiency**

In order to infuse a sense of sufficiency in buyers’ mind, energy labels could more prominently highlight the absolute energy use of a product, in contrast to its technical efficiency. There have already been discussions about this when the EU energy labelling framework policy was evaluated in 2014. Options with continuous scales based on absolute consumption have even been tested on consumers, with mixed results (BUND 2014). A main reluctance being that the current famous categorical layout of the EU label from A to G is considered by many as something that should not be lightly dropped.

Less radical options could keep the efficiency letter classification, while enhancing the display of the absolute energy consumption. Currently, consumers understand how the absolute energy consumption figure on the label may be used to compare two models, but they have trouble making something of it in itself, as the kWh unit is poorly understood (Waide et al 2013).

![Figure 9. Example of a way to enhance the mention of the absolute energy consumption (BUND 2014)](image)

**Other sufficiency requirements**

Apart quantitative energy requirements, the Ecodesign Directive also allows to set requirements of a more generic nature. This option has been modestly used so far to
influence aspects of product designs that could support sufficiency: existing provisions have been listed in the beginning of paragraph 5.7.

Based on the literature (Brischke et al 2015), examples of requirements set in other instruments such as voluntary green labels (BUND 2014), and our own inspiration, here is a list of potential ideas for generic requirements supporting sufficiency:

- Better prescribing how product interfaces should work, inform consumers on the product energy use, and drive them to reasonable usage patterns; as an example, temperature settings in fridges and freezers should be explicit and not just based on an abstract scales (Brischke et al 2015);
- Imposing a standardisation of control and energy-saving pictograms when the market fails to achieve it (e.g. on thermostats, programme selection, etc.);
- Restricting the use of and better framing what ‘eco-modes’, ‘holiday modes’, ‘night modes’, and the like should be and do, to avoid user confusion;
- Prescribing how products should be delivered by default, i.e. with responsible settings that only activate core functionalities and all energy-saving features on, and requesting that the user is warned about overconsumption of energy if changes are triggered on these initial settings;
- Forcing manufacturers/service providers to clearly inform the user about the energy consequences of software updates that may be installed during the product lifetime, especially if they have an impact on energy-saving modes and features;
- Generalising wherever possible the implementation of energy-saving sensors and functionalities (e.g. moisture sensors in tumble driers, auto-brightness controls in displays, presence detection features, etc.)

Some requirements can also address aspects of product design that help prolonging product lifetime and avoiding embedded energy waste. Such requirements, traditionally falling in the ‘resource efficiency requirements’ category, include:

- Prescribing ways for products to be more easily dismantled, customised, and repaired;
- Enforcing the removability of batteries;
- Requesting from manufacturers to keep spare parts for a certain period of time;
- Informing consumers about product lifetime aspects (e.g. on labels).

As resource efficiency is a very broad field in itself, we can’t further elaborate here, but more information and inspiration may be found in existing studies and initiatives about potential resource efficiency requirements for Ecodesign and Energy Labelling (e.g. Dalhammar et al 2014, Ardente et al 2014).

5.8 System performance requirements

In some cases, products are part of larger systems that influence the way they function and the way they can be more or less easily operated to save energy. Examples are home and tertiary building systems (controlling ventilation, air-conditioning or heating), tertiary lighting systems (including controls and sensors), office IT systems, data centers, etc.

Requirements are necessary to ensure that such systems are optimised to save energy and allow their components to be operated in a sufficient way.

The EU Energy Performance of Buildings Directive covers heating, ventilation, and air-conditioning systems, and lighting should follow suite. Potentials for energy savings in these systems are huge, but the ‘sleeping giant’ has not been really waken up yet due to insufficient ambition, as well as incomplete implementation and compliance at national level (Ecofys 2017).

---

20 There is evidence for instance that some fridge models have ‘holiday modes’ that in reality do not achieve any significant energy saving (EEB et al 2017).
A number of specifications could be considered in national building codes or other laws, such as:

- Authorising certain energy-using equipment and installations only if there is proof that no other solution is applicable;
- Systematising presence detectors and daylight sensors in all lighting applications where this is relevant;
- Ensuring in all new and refurbished buildings that a space is available for a shared laundry/line dying space.

Office IT systems could be requested to upgrade to protocols that are compatible with energy management functionalities of products, to enforce auto-power down at night on all equipment, etc.

In addition, authorities could specify that training programmes of system installers and maintenance experts (of heating systems, building automation systems, etc.) should include a strong component about sufficiency and energy saving aspects.

**Best practice**

In the Swiss Geneva Canton, an energy law specifies that tertiary air-conditioning installations for comfort are only possible if:

- The need for it has been duly demonstrated,
- A part of the heat generated by the equipment is reused,
- And the cooling water in the system is reused.

The law also stipulates that alternative to air-conditioning, such as solar protections, passive cooling, geo-cooling, etc. should be prioritised.

### 5.9 Support to R&D in the area of product sufficiency

A significant number of possible energy sufficiency actions in products relate to behaviours, that are influenced by socio-technical contexts, available technologies, product interface designs, as well as the successful diffusion of social innovations.

In all these areas, there are needs for more research and development in social sciences, behavioural sciences, and technologies, to better understand and improve these behaviours. Governments can increase research budget in those fields, notably where the needs and potentials are highest.

**Best practice**

The German Energie Suffizienz (‘Energy Sufficiency’) project, funded by the German Ministry for research over 2013-2016, has investigated various aspects of energy sufficiency and developed comprehensive sets of policy actions for reducing energy use in buildings at the micro and meso levels.

It notably included a part on appliances, where sufficiency potentials have been modelled, innovative approaches for user adequate products and services discussed in open innovation workshops using the Design thinking method, and recommendations for product regulations drafted (Thomas et al 2017).

The project involved IFEU Heidelberg, the Wuppertal Institut, and the Berlin University.

[https://energiesuffizienz.wordpress.com/](https://energiesuffizienz.wordpress.com/)
6 Conclusion

The analysis has shown that energy sufficiency in products has a significant potential that can match that of efficiency. And without it, there is a substantial risk that the total energy use from products will not deflate to the level that energy transition goals require.

Without going as far as radical attitudes (such as not owning or hardly using the most common appliances and electronics), there is a myriad of sufficiency actions that are possible, and policy interventions that can stimulate and encourage them. This is true in the residential sector, as well as in other sectors although there is much less references and quantifications available. Additional research on non-domestic products would be welcome (e.g. on industrial systems, office equipment, etc.).

Despite a number of best practices and success stories, sufficiency in products has not been largely and seriously considered by policy-makers so far. The reasons and barriers are known, and it raises the question of the best approach and strategy to promote energy sufficiency.

- Should it be implemented ‘insidiously’, by small incremental and independent steps in various existing policies that would remain unnoticeable (i.e. curving reference lines in energy efficiency regulations, requiring that product interfaces and default settings ‘nudge’ users into more optimised behaviours, etc.)?

- Or is it indispensable to stand for sufficiency more openly and aggressively, so that its overall relevance is acknowledged, and dedicated policy packages developed consistently?

The answer is very much tied to the possibility of progressing on the political and social acceptability of sufficiency, which are core aspects. It probably goes through involving and educating politicians, consumer organisations, and opinion leaders, considering their views and convincing them that sufficiency is not just about inflicting arbitrary constraints and imposing a dull frugality, but rather saving energy by being smarter in our relation to technologies and less addicted to them.
7 References


Bertoldi Paolo, 2017, Are current policies promoting a change in behaviour, conservation and sufficiency? An analysis of existing policies and recommendations for new and effective policies. Presented at the 2017 eceee Summer Study.


Cordella-Génin Robin, 2014, Freins et motivations à une plus grande efficacité et sobriété énergétiques - L'exemple d'une campagne de sensibilisation aux économies d'énergie basée sur le suivi des consommations. IEP Grenoble.


Dupret Muriel, Zimmermann Jean-Paul, 2017, Electricity consumption of cold appliances, washing machines, dish washers, tumble driers and air conditioners. On-site monitoring campaign in 100 households. Analysis of the evolution of the consumption over the last 20 years. Presented at the 2017 eceee Summer Study.


Ecofys, 2017, Optimising the energy use of technical building systems – unleashing the power of the EPBD’s Article 8.

EEA (European Environmental Agency), 2013, Achieving energy efficiency through behaviour change: what does it take?.

EEB (European Environmental Bureau), 2015, White goods in a dangerous spin-cycle - Spiralling capacities, impacts and practical solutions. Prepared by Edouard Toulouse.


EU Ecodesign preparatory studies and Impact Assessment Studies on energy-related products. Available on: https://circabc.europa.eu/w/browse/f27f80a1-0cb3-4bb3-b73d-d75fa230b54

Fischer Corinna, Grießhammer Rainer, 2013, Working Paper: When less is more - Sufficiency: terminology, rationale and potentials. Published by the Öko-Institut.

Fischer Corinna, 2015, Absolute energy savings in the household sector – a case for public policy.
Energy sufficiency in products


Horowitz Noah, Cadier David, Calwell Chris, Hardy Gregg, 2015, How Much More Energy do Ultra High Definition and Smart TVs Use?. Presented at the 2015 EEDAL Conference.


Leuser Leon, Lehmann Franziska, Duscha Markus, Thema Johannes, Spitzner Meike, 2016, Akzeptanz von Energiesuffizienzpraktiken im Haushalt. Published by the Wuppertal Institut and IFEU.

Lorek Sylvia, Spangenberg Joachim, 2017, Stocktaking of social innovation for energy sufficiency. EUFORIE - European Futures for Energy Efficiency Deliverable 5.3.

Martin Solange, Gaspard Albane, 2016, Changer les Comportements, l’apport des sciences humaines et sociales pour comprendre et agir. Published by ADEME.


Nordman Bruce, 2011, Lighting Control User Interface Standards. Presented at the 2011 EEDAL Conference.

NRDC, 2014, Data Center Efficiency Assessment.


Topten, 2015, Household refrigeration: What is the good EEI formula? Prepared by Anette Michel for Topten and ECOS.


