Don't just press the button! – Why appliance settings increasingly matter for efficiency delivery and rulemaking

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Abstract

Appliances and energy-using products are getting more energy efficient, but they also tend to become more and more sophisticated with a multiplication of programmes and auxiliary features. The way they are set and used becomes a critical determinant of their real life energy consumption, which can vary greatly depending on a single initial setting or usage routine.

Irrational or poorly informed behaviour with respect to appliance energy consumption may be a tangible setback in the path towards a lower energy consuming world. This should be an area of interest and concern for those who seek to achieve energy savings. Yet, user behaviour regarding several energy-using appliances is still relatively understudied and overlooked. Experience shows that it is often a weak spot in the preparatory work underpinning energy efficient product policies and programmes, and this can hamper their development and adequacy. The recent controversial dispute over the way people use vacuum cleaners in real life and the energy impact of this, during the preparation of EU's regulations, is an illustration.

One particularly interesting aspect is the growing development of so-called 'eco-modes'. These operating modes are meant to showcase a product's environmental excellence, but are users actually going for them? In some appliances, 'Eco-modes' may be so artificial and far from convenient (e.g. washing machine programmes that last many hours) that in reality they will not be desired and actual energy use will be much higher than claimed.

This can have serious policy implications. For instance, if manufacturers are allowed to use these artificial 'eco-modes' as the basis for assessing their products' energy performance, energy labels may mislead consumers, minimum efficiency requirements may become too easy to meet, and a fair and honest comparison between products and manufacturers would be hindered. Insights on current processes to develop measurement standards for EU efficiency regulations show that this is a real threat.

This paper discusses these issues, and illustrates them with recent examples. It then provides recommendations to better take product use aspects into account, so that product energy efficiency does not just remain on paper but becomes reality.

Introduction

Traditionally, energy efficient technologies and appliance regulations are designed to deliver, provided people behave as expected with the products, that is in accordance with the designer's or decision-maker's vision. The focus is primarily on the technical design phase before products are placed on the market. There has so far been too little interest and research on what happens in real life after the sale is actually made.

With appliances becoming more energy efficient but also more sophisticated and adjustable, the way they are set and used becomes a critical determinant of their real life energy consumption, and an important aspect for policy formulation.

Users, in general, pay little attention to product settings, so real life use of products may diverge widely from what would have been expected by engineers and policymakers. This can lead to energy wastage. There is also a risk that the standard way in which products are tested for energy performance is not

Table 1. Examples of user settings affecting energy consumption.

Product	Impact on energy use	Setting or programme	Data source
PC	70 % increase	Deselecting power management settings and leaving the PC on for long periods	ECW 2010
TV	10 % to 30 % increase	Watching at a high brightness level compared to a reasonable home-mode setting	Based on Horowitz 2013 and Digital Europe 2012
TV	Around 50 % increase	Setting that transitions to a 'quick start' mode for 2 hours before going to normal standby	Based on NRDC et al 2014
Washing machine	30 % to 100 % increase	Washing at temperatures higher than 30 °C or with fast programmes	BIO 2009
Dishwasher	20 % to 30 % increase	Using the automatic programme instead of the energy saving	Stiftung Warentest annual figures[1]
Tumble drier	Average 25 % increase	Drying clothes with a programme by-passing the auto-off sensor-drying	Based on Calwell 2013
Freezer	16 % increase	Lowering the internal temperature setting by 2 °C	Hasanuzzaman et al 2008
Kettle	30 % increase	Heating water at 100 °C compared to 80 °C on a programmable model	Based on BIO 2014
Water heater	6 % to 11 % increase	Setting the tank water temperature at 60 °C instead of 50 °C	US EPA 2015

Note 1: See Figure 1.

representative of what many users are actually doing, hence creating a gap in user information and policy reliability.

Extent of the issue

USER-INDUCED VARIATIONS IN APPLIANCE ENERGY CONSUMPTION

Available evidence suggests that actual user behaviour regarding energy-using products at home is often inconsistent, and varies hugely across households (Moezzi et al 2010). Some energy metering campaigns have confirmed that there were huge disparities from one home to another. Wide ranges exist even for such ubiquitous loads like refrigeration (Nelson et al 2014).

These differences stem not only from differences in appliances, but also from differences in using them. Hence the importance of assessing the extent of the issue, so looking at how much energy may not be saved as expected due to real-life behaviour.

When a product is so basic as to have only one operating mode, the risk is relatively limited. Yet, energy-using products and appliances are becoming more and more sophisticated due to the penetration of electronics and smart functionalities. The trend is developing towards more and more programmes and menu settings. While this improves flexibility and programmability if used correctly, it also increases the range of possible sustained deviations from an efficient use.

Table 1 provides cases found in the literature, of the impact on energy consumption of choices regarding user-settings or programmes for several appliance types.

These examples of variation are sometimes very large – more than the width of one or two classes on energy labels (!), often for little or no visible additional comfort. More concretely, a EU household equipped with average-performing appliances used with the aforementioned settings examples can already consume 500 extra kWh/year, meaning €100 more on annual energy bills[1].

WHY WOULD PEOPLE FAIL TO USE THE MOST SENSIBLE SETTINGS?

Appliances set and used in energy-intensive ways are not just isolated cases. An illustration is the seemingly impressive number of home PCs used without power management on: a very large share of machines according to IVF (2007); confirmed in more recent research (ECW, 2010) that found the issue in 50 % of the 50 homes they studied.

Another illustration is a survey of consumer behaviour in Germany on dishwashers showing 80 % of respondents not using primarily the energy saving programme (Bichler, 2015). Consumers commonly use just one programme (Bichler 2014, Richter 2010b); however this programme is different from consumer to consumer, as shown in Table 2.

This contrasts with usual consumer statements, where a majority declare energy and water saving as their top priority (Presutto et al 2007, Schmitz and Stamminger 2014). There may be several reasons for this mismatch, including difficulty to identify the best/eco programme, perceived cleaning or drying result, doubts about the programme length, confusion about the energy impact of the various programmes (in particular the performance of the short vs. 'eco' programme), etc.

1. Based on own calculations using average-performing products found in houses (2013) and the 2012 average EU electricity price.

Stiftung Warentest, the German consumer testing organisation, has been running tests on dishwashers for years. They show that the eco/energy saving programme has the lowest energy consumption, while the automatic and short programmes consume more energy (20 to 30 %) (see Figure 1, which also shows that the reduction of energy consumption in the energy saving programme is followed by reductions in the other programmes).

Generally, it is probable that some users decide to use non energy efficient or sub-optimal settings or programmes for very deliberate reasons. But for many others it is likely the result of more routine-type behaviour and lack of attention or understanding on the consequences and alternatives. The knowledge about the energy use of appliances and saving opportunities is relatively poor in the general public (Attari et al, 2010); energy-using activities at home are mostly inconspicuous and habitual, engrained by social structures, personal histories, and cultural interpretation, and resulting in sustained habits that can impede more rationale behaviour in terms of avoiding unnecessary energy consumption (Moezzi et al, 2010).

Contrary to a common misconception, users do seem to read product instruction manuals -according to available surveys such as Pistochini et al (2013), however a large share may miss the point about energy use in relation to settings (36 % of respondents found user manuals incomplete or complex in Pistochini et al (2013), an Italian survey related to white appliances). Another study revealed that more than half of British TV owners never make any adjustment to their TV picture after purchasing the set, potentially using more energy than necessary (Morris, 2012).

Table 2. Overview of dishwashing programmes chosen as the main programme.

% of households using mainly this programme	Intensive	Energy saving / Eco	Automatic	Glass/Care	Short	Normal 50-55 °C	Normal 60-65 °C	Other programmes
Richter (2010a) *(n = 1,209)*	12.4	17.0	14.8	7.8	11.3	29.1		7.7
Stamminger and Streichardt (2009) *(n = 2,599)*	8.9	17.7	7.8	–	8.7	27.7	29.1	6.0
Bichler (2015) – Online-study *(n = 3,836)*	14.5	18.7	14.3	6.4	12.2	17.0	16.9	–
Bichler (2015) – Usage diary study *(n = 202)*	13.7	22.4	25.7	0.5	11.5	8.2	16.9	1.0

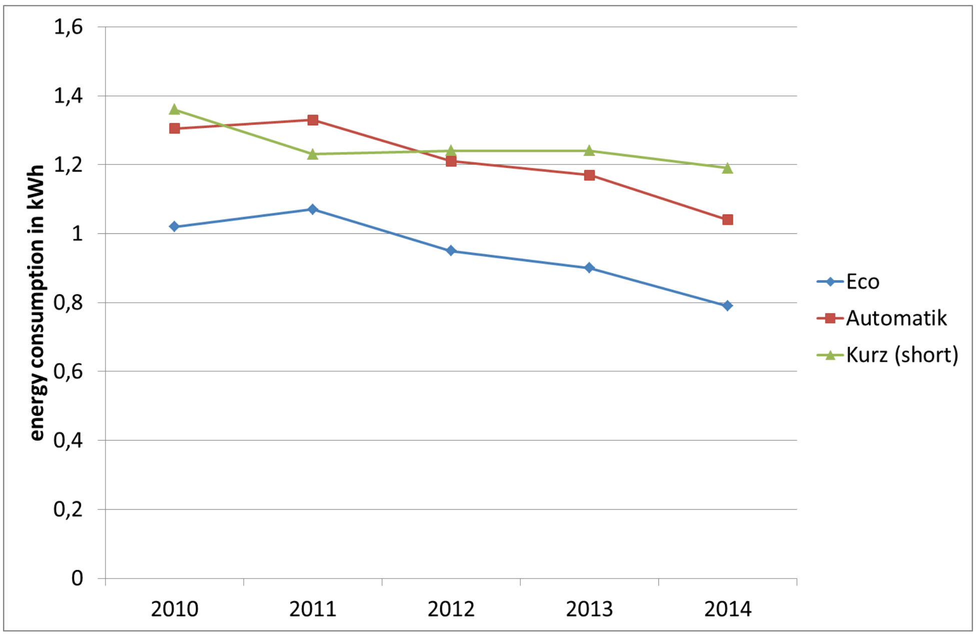

Figure 1. Dishwashers' average energy consumption of different programmes in Germany. (Stiftung Warentest, graphics: University Bonn.)

AN UNDERSTUDIED PROBLEM

Market statistics and rulemaking on appliance efficiency are traditionally based on averages, hiding the disparities and complexities of the use of products in real life. The practice of assuming an 'average behaviour' saves time and simplifies calculations. User behaviour is often considered to be a given and stable fact, and not influenced and produced by the design of the appliance itself or its interface (Prignot, 2009). The problem is that assumptions about behaviour are often based on overall optimism concerning the energy benefits of pure technological change (Moezzi et al, 2010).

The way in which these 'average behaviours' are constructed in EU policy reveals weaknesses and oversimplification, due to a lack of data and research. As an illustration, in the preparation of Ecodesign and Energy Labelling regulations the analysis about user behaviour has often proven to be too rudimentary or unsatisfactory. The diversity of practices is not sufficiently acknowledged (Prignot, 2009). A statement confirmed in some of the EU preparatory studies prior to Ecodesign regulations, such as the one on TVs (Fraunhofer, 2007), recognising that the variety of TV use patterns is growing, making it "very difficult" for them to determine averages. Another example has been the controversial discussions about vacuum cleaner usage patterns that revealed major disagreements between stakeholders and a lack of robust knowledge in relation to actual user behaviour (AEA, 2009)[2].

There have been attempts outside the EU at better understanding and characterising the subtleties of appliance use behaviour, such as the Energy Efficient Use Index concept for standby (Shuma-Iwisi, 2011) or research on the usability of thermostats (Meier et al, 2011), yet we think this is still a relatively unexplored area, especially when it comes to user motivations for selecting settings and programmes.

CONSEQUENCES

If real life product use is overlooked or averaged in too simplistic ways, policies and measures directed at cutting energy use may miss important aspects and therefore not deliver the expected results. Besides, standard energy performance ratings for consumer information may be artificial or misleading, if they are done in a way that diverges too much from what a large share of people really experience at home (Calwell, 2013). An actual example may be the washing machine energy label where machines reach declared values of A+++ minus 50 % and above, but the programmes behind the label classification are taking so much time that hardly any consumer will use them. The shorter programmes in contrary use much more energy.

Can we trust 'eco-modes'?

One particular mode/setting that is increasingly available on appliances and energy-using equipment is the so-called 'eco' mode/button. It is supposed to help users reduce their environmental impact easily and to some extent showcase the manufacturer's green consciousness. It is therefore of particular interest to have a look at this particular mode and understand how relevant and successful it can be at mitigating the issues addressed in the previous part.

NO CLEAR DEFINITION

Although the concept of 'eco mode' can be understood as an alternative combination of settings under which a lower (or the lowest) environmental impact/energy consumption is achieved by the product, neither a general nor specific standardised definition nor specifications are available for most product categories. Using an 'eco-mode' can affect the operation of a product in different ways:

- In some water heaters, the eco-button deactivates pre-heating, meaning that the equipment no longer keeps an amount of water constantly hot for use anytime, but would only start heating water when the tap is turned on (Worcester Bosch, 2015). The main consequence is a few-second delay in the delivery of hot water.
- In some refrigerators, pressing the 'eco-button' adjusts the temperature of the refrigerator and freezer compartments for reduced energy consumption (Samsung, 2015; Hotpoint, 2015).
- More confusingly, the absence of a clear definition allows sometimes for a variable use of the term 'eco' for different functions and combination of settings even amongst products of the same category. For instance, different car models have eco-buttons that do different things (smooth throttle response, change the transmission programme, adjust the HVAC system, reduce the load for air-conditioning) according to manufacturer and model (Ramsey, 2011).

DO ECO-MODES REALLY SAVE ENERGY?

A few examples of doubts about questionable 'eco-modes' have been reported. We can mention two of them:

- Tests on an internet gateway model in 2011 have revealed that the eco-modes were not saving more than 1 W power overall (N9ws, 2011), where these eco-modes have been qualified as an '*inefficient gadget*').
- Figure 2 (from a relatively old model as far as we can tell) shows a washing machine for which the so-called 'energy saving' programme was probably a more energy-efficient alternative than the 95 °C normal programme, but still at a temperature higher than 60 °C and (thus by far not the least consuming option).

From our experience, this however remains limited. In most cases eco-modes can deliver significant energy savings, especially when they are framed by clear definitions and safeguards to limit potential fraud.

An illuminating example is that of washing machines in the EU. Eco-modes are now defined in regulation (Commission Regulation No 1015/2010). They shall be named as 'standard 60 °C cotton programme' and 'standard 40 °C cotton programme' (to encourage users to use them by default) and shall be clearly identifiable on the programme selection device. They shall be '*the most efficient programmes in terms of combined energy and water consumptions for washing cotton laundry*'. In addition, manufacturers have to declare the energy consumption

2. Unresolved questions such as 'do people vacuum longer when the cleaning or sucking performance is decreased?' are important because they have consequences on annual energy use.

of the different programmes in instruction manuals. Figure 3 shows an example of declared values found in the manual of an A+++ washing machine model (AEG L 89495 FL). Comparing the consumption for the non-eco cotton 60 °C programme ('cottons 60 °C' versus 'Standard 60 °C cotton'), we see an energy consumption that can be more than twice that of the eco-programme for the same amount of load. This factor varies even more for the cotton programmes at 40 °C: almost by a factor of three. In this case, selecting the eco-mode does make a huge difference in terms of energy consumption.

Unfortunately, eco-mode definitions and (minimum) specifications have not been included in most EU product regulations adopted thus far.

THE PRICE TO PAY FOR SAVING ENERGY

'Eco' modes and programmes save energy by optimising the functioning of the product and limiting the use of the most energy intensive components and processes. This may come at a certain price in terms of user comfort or services. In 'eco' conditions, the product usually takes some more time to produce the desired output and may not have all side functionalities available at the same time. For instance, a product in 'eco-standby' mode may require a few more seconds to warm up compared to normal standby. This may be annoying for some users, but also largely acceptable for others.

But there is always a possibility that in order to always show better performance, some eco-modes become so artificial that their use may be considered by users as impractical or troublesome (especially when they are not aware of the savings and benefits at stake). The significant energy consumption reduction achieved in washing machine eco-programmes is not at the cost of a decrease in washing performance (as regulation sets a high level of washing performance in all programmes) but through longer duration to undertake the wash cycle; the energy saving programme often takes one hour more than the non-eco cotton programme. Users who want a quick wash may be surprised and upset by this longer delay.

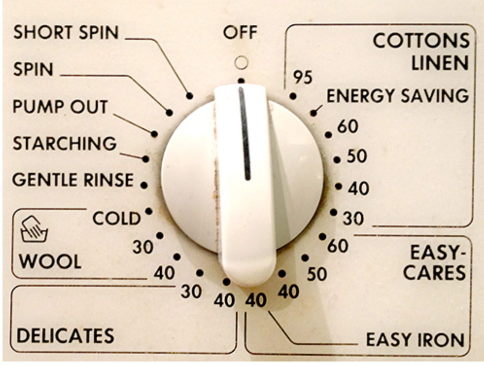

Figure 2. Washing machine example. (Chadwick Mal, 2013.)

Regrettably, consumers are rarely informed about the rationale for these consequences and these may come as an unfortunate surprise. Regarding washing machines, few people realise that low energy consumption and good performance require increasing the time of the wash (at a given washing technology). A probable reason for this is that the information concerning programme duration is not easily accessible to consumers prior to purchase. Consequently, consumers do not pay sufficient attention to programme durations at the time of purchase, and manufacturers are not encouraged to make progress on this parameter.

It has to be noted, however, that increased energy efficiency does not necessarily come with a significant sacrifice. For example, a tumble drier that runs in an eco-mode using a sensor to stop the cycle when the load is sufficiently dry will not only save energy but also potentially time, compared to a programme with a pre-fixed duration.

Although it is not possible to draw firm conclusions from the anecdotal evidence we have presented, it is reasonable to assume that eco-modes in general can save a significant amount of energy (based on e.g. the values presented in Table 1) at a performance level that may often seem acceptable,

Programmes	Load (Kg)	Energy consumption (kWh)	Water consumption (litre)	Approximate programme duration (minutes)	Remaining moisture (%)[1)]
Cottons 60 °C	9	1.55	79	170	52
Cottons 40 °C	9	0.97	79	164	52
Synthetics 40 °C	3	0.55	54	109	35
Delicates 40 °C	3	0.60	59	89	35
Wool/Hand wash 30 °C	2	0.35	58	60	30
Standard cotton programmes					
Standard 60 °C cotton	9	0.64	58	226	52
Standard 60 °C cotton	4.5	0.35	40	185	52
Standard 40 °C cotton	4.5	0.35	40	199	52

Figure 3. Extract of an instruction manual for a washing machine (AEG L89495FL).

provided the impact on other aspects (such as programme duration) remains reasonable and users are well-informed of the gains.

Policy implications

As we have seen, the energy performance of a product can vary greatly depending on the way it is set and used. This variation has three major implications for policies aimed at increasing energy efficiency:

- It is an important issue to consider when deciding how the energy performance of a product is to be assessed in order to underpin fair and effective energy labels and minimum energy performance requirements.
- It suggests that product regulations should not only address product technical efficiency, but also ways to better ensure that products are used in the most efficient ways.
- It can have an influence on policy delivery and evaluation, because if people do not use products in the way expected, the final amount of energy savings can be quite different.

In the following part, we particularly elaborate on the first point.

IMPORTANCE OF SETTINGS IN MEASUREMENTS

Product energy efficiency regulations need to be underpinned by accurate measurement and test methods. Designing measurement methods is a crucial – yet often overlooked – part of the rulemaking process (Toulouse, 2014). With respect to EU Ecodesign and Energy Labelling regulations, the European Commission issues standardisation requests to European Standardisation Organisations (CEN and CENELEC) in order to develop harmonised European standards (EN)[3] for measurement methods. The purpose of these standards is to describe an agreed methodology to measure the energy performance of the products and support the regulations in question. These standards are then published as 'harmonised', meaning that they are recognised in all EU Member States as providing presumption of conformity with EU regulations. Measurement standards are crucial in order to have clearly defined, repeatable, reproducible and accurate methodologies, which allow for the fair assessment and comparison of products, as well as ensuring that effective regulations with adequate results can be adopted.

The conditions in which products are tested usually matter, sometimes very much. Particularly as different modes or settings (and their multiple combinations) may significantly impact the energy consumption. As an example, the decision in the EU to test TV sets in a home mode instead of (brighter) out of the box mode has resulted in a 30 % improvement of the apparent energy performance (Digital Europe, 2012). Therefore, an agreed and well-specified definition of the settings under which the performance of products is tested, declared and verified, appears as an essential condition for the standards to deliver their aforementioned purposes.

3. The International Organisation for Standardization (ISO) defines a standard as "a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose" (ISO; 2015).

RISKS OF GREY AREAS: THE WATER HEATER EXAMPLE

Yet, this condition is not always fulfilled, or not sufficiently. In this case, each manufacturer or market surveillance authority may conduct tests under random or most favourable settings, each time impeding fair or accurate comparison. A representative example of such a situation is water heaters in the EU (Spiliotopoulos, 2014). As described earlier, some water heaters provide an 'eco-button' deactivating the function of constantly keeping an amount of water hot. The measurement standards currently under development and candidate for harmonisation do not specify clearly the mode that products should be tested under. Manufacturers would be free to test their products under any mode. It is logical to assume that they would choose the one demonstrating the best energy performance, i.e. the one using the eco-button. This would give their products a much higher energy rating and ease the compliance with minimum performance requirements adopted in 2013. However, as mentioned earlier, the 'eco-button' mode may not be the most frequently used in real life, especially if it stretches energy performance artificially at a too high cost for user comfort. The consequences of this would be threefold:

- For the environment, as energy savings initially expected by the product regulations would be hindered by the way products are tested,
- For consumers, who would be kept unaware of the mode their appliance was tested in to achieve the efficiency rating on energy labels, and potentially surprised to receive higher than expected energy bills,
- For the industry, a fair and honest comparison of products would be jeopardised.

In the absence of harmonised standards to support the EU regulations on water heaters at the time of publication (in August 2013), the European Commission issued a Communication (Official Journal of the European Union, 2014) with '*transitional*' methods to be used until harmonised standards are completed. These methods did not specify the testing mode/settings either. Having recognised the problem and need to specify the mode under which the tests should be conducted (and in the absence of sufficient user behaviour research in the area of water heaters to characterise the most representative of real-life mode), the European Commission specified that each water heater shall be tested in the "out of the box-mode". This mode has been defined as "the standard operating condition, setting or mode set by the manufacturer at factory level, to be active immediately after the appliance installation, suitable for normal use by the end-user according to the water tapping pattern for which the product has been designed and placed on the market" (Official Journal of the European Union, 2014).

The rationale behind this specification lies on the fact that if a consumer does not intervene on the product by changing the settings after it is installed, it will run according to the energy class specified on the energy label. However, this solution only partly resolves the issue, as the product could be set by the manufacturer in an eco-mode by default, though later on switched by the consumer to another mode with higher energy consumption, without the user knowing the energy consumption impact of this change.

MAKING 'ECO' THE DEFAULT OPTION?

It would not necessarily be a bad thing if products are tested in their eco-mode, provided this mode is really efficient, convenient, clear to consumers, and most importantly, largely used by default.

Coming back to the example of washing machines, it has been shown earlier that the eco programmes are those, which use the least amount of energy with a satisfying level of washing performance. However, users are not sufficiently aware of the longer programme duration: as an illustration, the EU energy label misses information regarding the duration of the programme in which the product was tested. This is unfortunate, as some consumer surveys have shown a higher level of acceptance of longer programme durations if the relevant information (e.g. that such programmes can save energy) has been communicated to users (Schmitz and Stamminger, 2014). In addition, when policies fail to sufficiently address important aspects, it leaves room for manufacturers to optimise one visible performance criteria (e.g. energy use) at the cost of another (such as longer programme duration). Communicating more on programme durations, as well as foreseeing relevant provisions during the revision of the related regulations, would urge manufacturers to address and compete on this aspect.

Recommendations for policymakers and related stakeholders

Based on the previous discussion and findings, there appears to be room for improvement in the way settings and 'eco-modes' are considered in product policies, and the repercussions this can have from an environmental, financial and competitiveness perspective. We provide hereunder a non-exhaustive list of recommendations:

- With regards to measurement methods used for energy labels and minimum performance requirements, the conditions in which a product is measured should always be crystal clear and representative of real life use, while being proportionate to related cost and time considerations. If a product is only tested in an 'eco-mode' with reduced functionalities, it is important to guarantee that this mode is reasonable and not only designed to lower the product environmental or energy impact in an artificial way that would hardly take place in real homes. To achieve this in the EU, a safeguard principle could be added to the framework Ecodesign and Energy Labelling Directives (such as: 'The conditions in which products are tested for conformity shall be realistic and correspond to a normal or common usage pattern. Where products have different operating modes or programmes, the testing conditions shall be made sufficiently precise in the implementing measure. In particular, it should be avoided that a product is only tested in an eco-mode with reduced functionalities specifically designed to lower the product's environmental impact if it is not the default mode.')
- For all relevant product categories, definitions or minimum specifications for 'eco-modes' could be agreed and specified, to make sure that these modes really save energy and are appealing for users. A harmonised way across appliances of depicting the eco-mode (wording, pictogram …) could have a positive learning effect on consumers; it could motivate users not using eco modes to switch to these, while facilitating use for existing users.
- When eco-modes are well-framed and have clear benefits, consumers should be encouraged to use them as a normal practice. Legislation can play a role, through enforcing generic requirements such as: obligation to deliver products with energy management features enabled by default, mandatory sensors to stop programmes when the expected result is achieved, displaying the eco-mode in a clear way on the control panel, etc.
- In addition, it would be fair to better inform consumers about the modes/settings in which a product has been rated, to avoid gaps between the perceived energy performance at the time of purchase and the real life one afterwards, but also motivate sustainable behaviour. This could be added in some way to the energy labels, particularly in a future digitalised version, as well as information about the important parameters that are relevant to users in relation to settings, such as programme duration for white appliances or reactivation time for eco-standby modes.
- Other means of user information and awareness raising on the benefits of eco-modes and eco-settings should be reinforced; not only provided in instruction manuals, as those may not be read and/or be understood but through additional means, such as communication tools (e.g. 'I try 30 °C' campaign from the International Association for Soaps, Detergents and Maintenance Products in 2013 on low temperature wash [AISE, 2013])[4], as well as education/information on energy saving behaviours through education as well as consumer organisations.
- Finally, more research should be undertaken on real life user behaviour of energy using and energy related products, especially the motivations and practices related to settings and mode selection. Such investigations would in particular be very useful for new – or the revisions of existing – EU Ecodesign and Energy Labelling regulations. In concrete terms, it means that the academic world should be more stimulated to look into these topics, and authors of technical studies prior to regulations should spend more time on these as well, with a view to identifying a representative group of settings to base regulatory requirements on; if not possible, adjust the requirements to make sure the performance of products is improved in all major modes (and not just one).

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4. Mottos could include: *longer washing times save real energy!*

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