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sustainable energy for everyone

Benefits of Ecodesign for EU households

Final report

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1 About this report

1.1 Background

Ecodesign and Energy Labelling are the EU's flagship policies which address the energy use of appliances by banning the least efficient appliances (Ecodesign) and incentivising more energy efficient appliances (Energy Labelling). The energy savings potential of these policies is estimated at around 13% of EU total energy consumption[1] [Molenbroek et al., 2014a]. These savings are cost-effective, generating benefits for European economies and consumers in terms of financial savings on energy and other resources, improved trade balances, energy security and reduced CO_2 emissions. Yet it is also true that most of the analyses of the impact of these policies focus on their EU-level impact, rather than on what they mean for an average EU household or its individual household members respectively.

For an average household, the EU Energy Label is widely used in shops and is broadly recognisable by most people. Ecodesign is different, it acts invisibly, delivering economic and qualitative benefits to consumers. Consumers certainly appreciate lower energy bills because of these energy savings and the qualitative benefits of less noise, less hassle, better health and comfort, and less water use, but they are not aware that it is the Ecodesign measures that have brought these improvements.

Unfortunately, this leaves the Ecodesign Directive open to criticism. As with any policy, the Directive and its implementation is not perfect and there are some valid criticisms and areas for improvement which will also be addressed in this report which aims at more effective Ecodesign and Energy Labelling regulations. The Ecodesign Directive has also faced what many feel is disproportionate and non-constructive criticism. This is motivated to a large extent not by a desire to hold the European Commission to account and improve the Directive and its benefits for consumers, but rather as part of larger currents of anti-EU political sentiment and an ideological attachment to free markets.

The purpose of this study is to challenge these criticisms and bring clear evidence of the financial and other benefits the Ecodesign and Energy Labelling Directives provide for consumers.

1.2 Project objectives

This study aims to shed light on the financial and other benefits for an average EU household arising from the Ecodesign and Energy Labelling regulations. The objectives are two-fold:

1. To quantify the net economic benefits of Ecodesign (and Energy Labelling) for the average European household – with an additional focus on how these benefits could increase with more ambitious Ecodesign requirements on energy efficiency and/or durability.

[1] Estimated in the Evaluation of the Energy Labelling Directive and aspects of the Ecodesign Directive (2014) at 400 to 460 TWh annually by 2020 compared to BAU (business as usual) for electricity, and 2350 PJ_{prim} for heat, corresponding to around 13% of 2020 BAU electricity and heat consumption in the EU.

2. To identify the qualitative benefits to households and consumers from Ecodesign, such as improved product functionality, less hassle, ease of comparison and reduced maintenance needs.

1.3 Structure

This report presents:

- In chapter 2: the main results of the analysis into the financial savings from Ecodesign and Energy Labelling for an average European household.
- In chapter 3: a narrative story of the savings and benefits for an average European household from the Ecodesign and Energy Labelling regulations.
- In chapter 4: major recommendations from our analysis.
- In chapter 5: the analysis underpinning the narrative presented in chapter 2.
- In Annex A: more detailed explanation of the methodologies employed, for the more interested technical reader.

Product level factsheets of the results presented in this report are provided separately.

2 The financial savings from Ecodesign and Energy Labelling for an average European household

In this chapter we present the financial savings resulting from Ecodesign and Energy Labelling for an average European household.

2.1 Our average European household

The approach is based on our average European family[2] consisting of Lukas and Anna, a young married couple who live with their 4-year-old daughter Sofia. They married 5 years ago and one year after Sofia's birth, they moved into their house, which was built in the 1980s and has 3 bedrooms and a small garden. They have a pet dog, Pip. Lukas and Anna both work full-time, Lukas as a fire fighter, Anna as a claims assessor for an insurance company.

[2] The family composition was based on analysis of EU statistical data, see chapter 5 for further details.

In their house Lukas, Anna and Sofia (and Pip) have the following appliances, each of which is regulated by either or both of the Ecodesign and Energy Labelling regulations:

- A (gas) central heating system.
- A dedicated (gas) hot water heater.
- An electric room heater they use occasionally.
- A combined fridge freezer.
- An electric oven with electric hobs.
- A coffee maker.
- A washing machine.
- A dishwasher.
- A vacuum cleaner.
- Two TVs, one larger screen in the lounge with a set-top box and a smaller screen upstairs in the spare room which they sometimes use when one of them wants to watch something the other does not.
- A desktop PC computer and monitor which they use for occasional jobs at home and Anna occasionally for work.
- A tablet PC which they use for browsing the internet and casual gaming.
- A combined router/Wi-Fi hub for internet access.
- Approximately 45 lightbulbs.

They also own other standard appliances such as mobile telephones, a wireless home phone, an electric toothbrush, electric kettle, toaster, hair-dryer, and shaver/trimmer. As these are not (yet) regulated by Ecodesign these are not analysed here. An analysis of the potential savings and benefits of future regulation of energy use and/or durability requirements of some of these appliances is presented in chapter 5.

2.2 How the financial savings were calculated

Compared to only looking at energy cost savings, the financial savings we present in the following section are based on calculation of the *annualised* total cost of ownership of each appliance (purchase cost + energy costs + other running costs[3]). The calculation methodology for each product and the underlying assumptions and sources are described in more detail in chapter 5 and Annex A of this report.

The results are presented for four scenarios, with scenarios 2, 3 and 4 compared to the reference case to evaluate if a saving is generated.

1. A Reference case: a world without Ecodesign and Energy Labelling in 2016.
2. An Ecodesign case: where each appliance performs at the minimum Ecodesign requirement level valid in 2016.

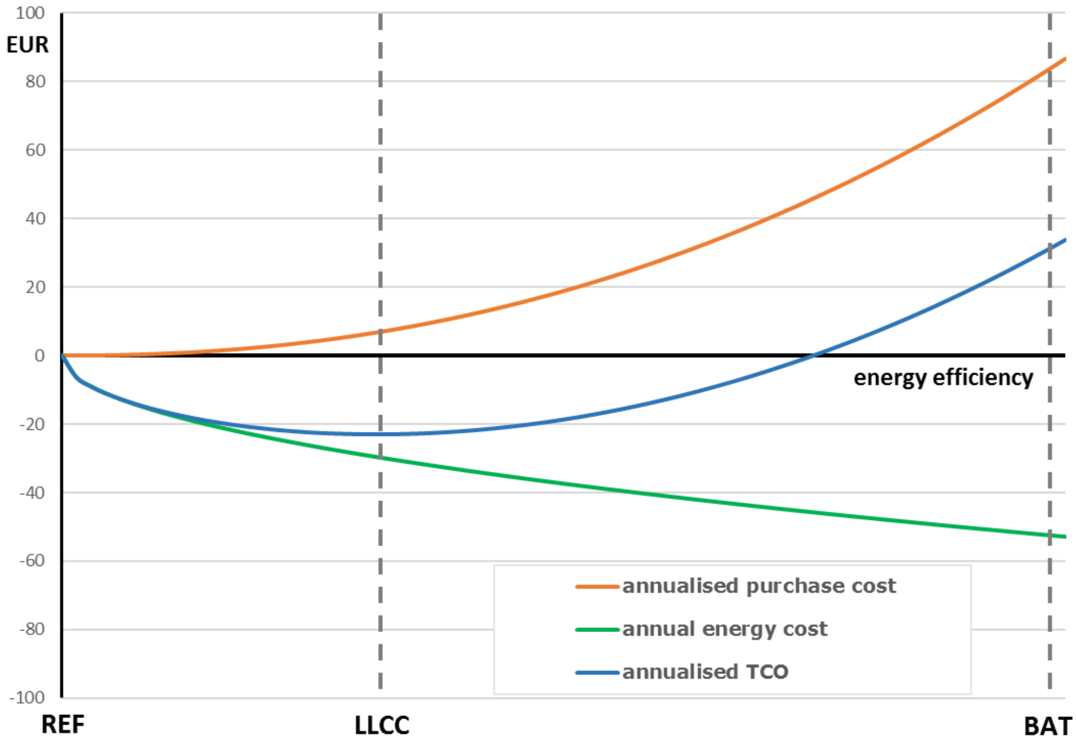
[3] These include estimated maintenance and repair costs (relevant for central heating and water heaters), water costs (relevant for washing machines and dishwashers), and other consumables (washing machines and dishwashers [detergent] and vacuum cleaners [vacuum bags])

3. A Best Available Technology (BAT) Energy Label case: where we take the currently (2016) best performing appliance, typically in the top energy label class.
4. Best of both worlds case: a group of all appliances listed above, but picked from either scenario 2 or 3 based on the criterion "lowest annualised total cost of ownership" per appliance.

Box 1: Least life cycle cost (LLCC): a brief explanation

The Ecodesign regulation is intended to set requirements which result in the least life cycle cost (LLCC) for a product. This represents the point where the energy efficiency requirements result in the lowest total cost of ownership (TCO) for a product, striking the best balance between the reduced spending on energy over the lifetime of the product as energy efficiency increases and the increase in purchase cost of the product as it is made more efficient. The following figure illustrates the concept, highlighting the Reference case (REF), the least life cycle cost case (LLCC), a Best Available Technology case (BAT) and all potential product efficiencies in between. The figure plots on the y-axis the difference in costs relative to the reference case. For simplification the x-axis only represents energy efficiency improvements, but in the case of Ecodesign could also include further design options, e.g. for reducing noise, improving water efficiency or other required functions.

Three lines are plotted: (1) the green line representing annual energy costs which decrease as energy efficiency is improved towards its current maximum (the BAT); (2) an orange line representing the increased purchase cost of the product as it is made more efficient; and, (3) the blue line, which is the sum of (1) + (2) and represents the annualised TCO; all 3 lines are relative to the reference case (REF). The LLCC point is the point where (3) is at its minimum. Ecodesign requirements are aimed to be set at this point. The Energy Label covers the range of higher potential energy efficiency levels up to, and sometimes beyond, BAT.



Source: Ecofys, based on Kemna and Wierda (VHK), 2015; numbers on y-axis only exemplary.

There are a few important lessons that can be drawn from this:

- The greatest financial savings in this analysis should, in theory, come from the Ecodesign scenario, which should represent an aggregate of the LLCC points for each product.
- For some products the actual BAT (Energy Label) scenario offers higher savings than the actual Ecodesign scenario. Demonstrating that the actual regulations are not always set at the LLCC, or if they were, technological improvement and cost reduction has moved the LLCC to the right.
- Regular review and revision of the Ecodesign requirements is needed to maintain these at a level on or close to the LLCC point.

2.3 Results: Financial savings

We calculate financial savings in the three scenarios for the average household of Lukas and Anna as follows:

- **Ecodesign:** in today's "Ecodesign" world, Anna and Lukas save on average **€332 each year** (annualised total cost of ownership, see explanation above), without doing anything additional themselves.
- **BAT (Energy Label):** if they purchased the most efficient currently available products, as rated and encouraged by the Energy Label, the savings could increase to **€454 each year**.
- **Best of both worlds:** if all Ecodesign regulations were set at the least life cycle cost levels (see Box 1 above) identified in this work, i.e. the best of both the Ecodesign and Energy Labelling worlds, Lukas and Anna could save more than **€514 each year**.

These savings compare to the reference case world where the regulations were not implemented and products continued to develop and improve as before, slowly in most cases. The savings also take into account the (sometimes) higher purchase price for more efficient appliances[4]. Figure 1 illustrates the savings and their composition in terms of increased purchase costs and energy cost savings. It is understood that the overall savings may be higher or lower in a real individual household, depending on the actual number of appliances, user behaviour and local variations in climate, energy prices and product purchase prices.

[4] Purchase costs are spread over the full lifetime of the product. The savings calculation is based upon a comparison per product of the total purchase price + (annual running costs + energy costs)*product lifetime, with the total annualised over the assumed lifetime of the product. Only savings compared to the reference case are presented. 'Negative' savings are not included as it is assumed that in the case that the reference product is more efficient than the Ecodesign product that the household would purchase the reference product, not a less efficient Ecodesign product. In these cases savings from Ecodesign are set to zero. Assumptions on future energy prices, inflation and discounting of other running costs and energy costs are also made. Please refer to chapter 5 for full details.

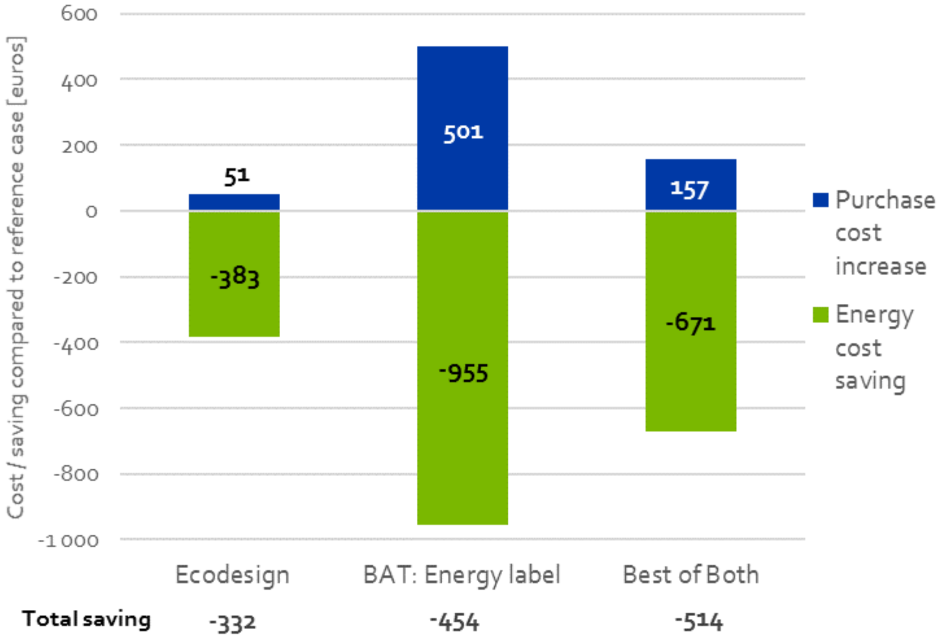


Figure 1: Comparison of annualised savings to reference case, purchase cost increase vs energy cost savings

Figure 1 presents the *difference* (here: savings) in the total annualised cost for the average EU household between the reference case "non-Ecodesign / Energy Labelling" world and three different scenarios of today's world (1) actual Ecodesign; (2) Best Available Technology (Energy Label); and (3) best of both worlds scenarios. Figure 2 presents the total annualised cost of all four scenarios, which is highest in the reference case at more than €3,062 per year, and is progressively lower per scenario for Ecodesign at €2,730 (€332 saving), BAT: Energy Label €2,608 (€454 saving) and best of both worlds €2,548 (€514 saving).

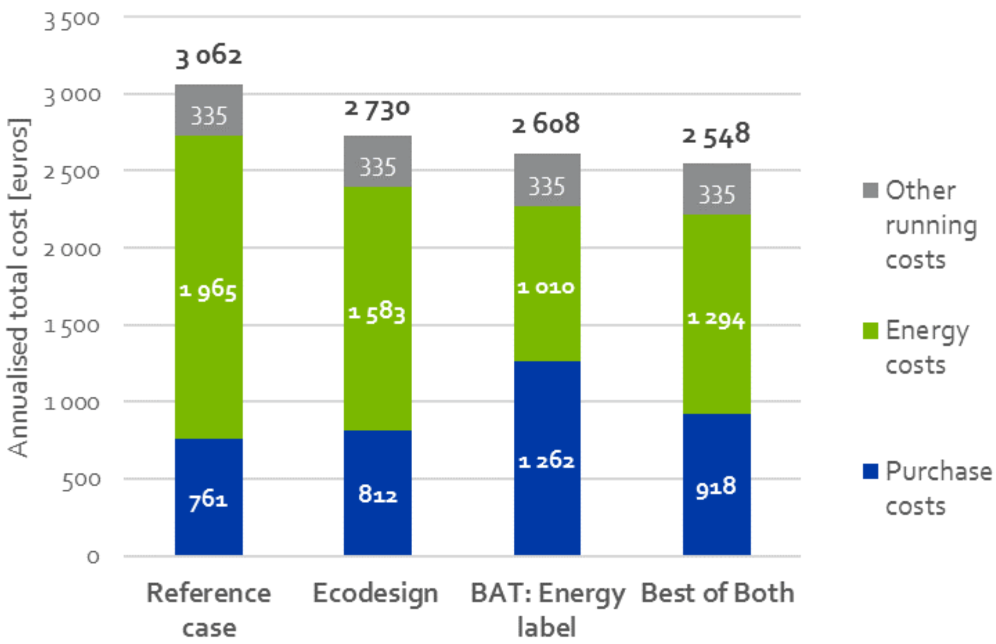


Figure 2: Annualised cost to average household in different scenarios, aggregate of all products

The costs in Figure 2 are also broken down by their type so that the difference in annualised purchase costs and energy costs can be clearly distinguished. As expected, the relative share of purchase and other running costs is significantly higher in the BAT and best of both scenarios, while correspondingly the relative share of the energy cost is much lower. In the reference case around 65% of the total annualised cost is energy costs, while for the Ecodesign case the energy cost share is closer to 60%, and lower again for BAT (~40%) and for best of both worlds (~50%) scenarios.

The range of *potential savings per product* from the Ecodesign and BAT (Energy Label) scenarios is presented below in Figure 3. The range of each bar represents the savings possible between an Ecodesign efficiency level and the BAT level. The best of both worlds scenario would be represented by the highest point of each of these ranges. Noting the different scaling of the y-axis between the left and right part of Figure 3, it is shown clearly that the central heating, water heating, lighting and fridge-freezer appliances deliver the largest range of financial benefits to consumers. From the other products, savings from the BAT scenario for vacuum cleaners, TVs and PC monitors are greatest.

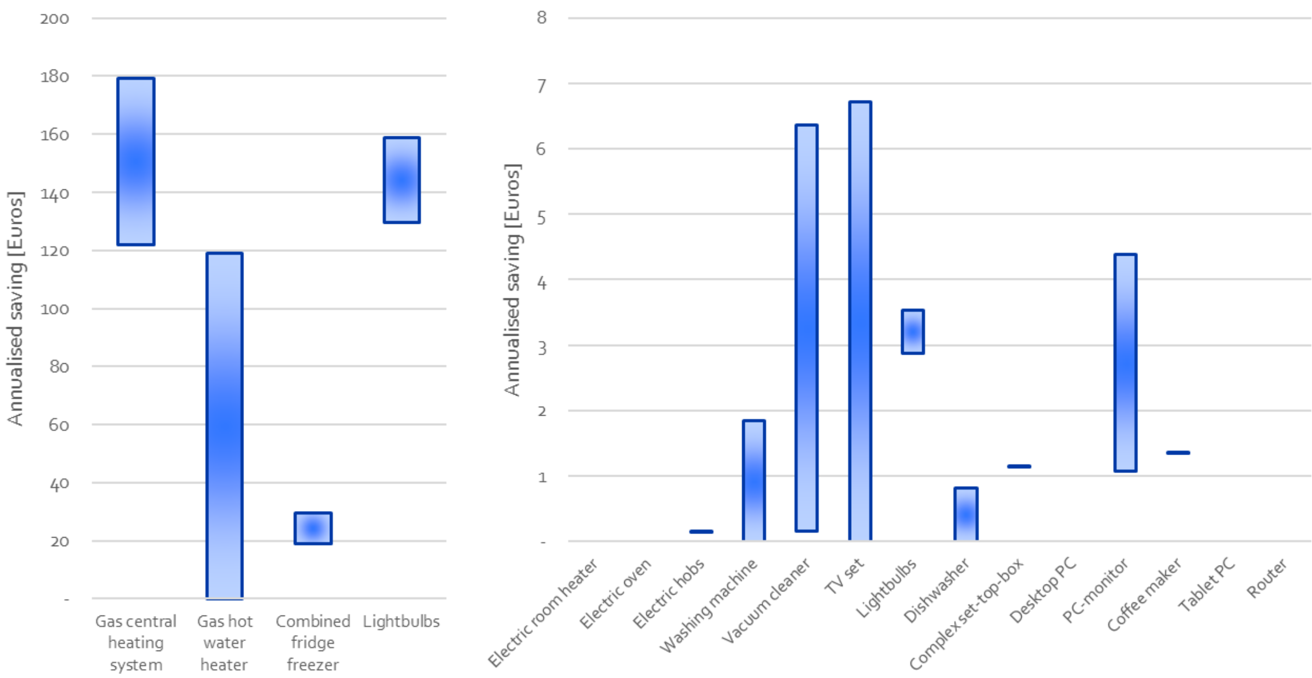


Figure 3: Annualised cost saving ranges compared to reference case due to Ecodesign and Energy Labelling

Concretely Lukas and Anna can save the most on the following appliances each year:

- €122 - €179 on their (gas) central heating boiler.
- €130 - €159 on their lighting.
- €19 - €30 on their fridge-freezer.
- Up to €119 on their hot water heater.
- And from their other appliances, smaller savings individually, but adding up to between €4 - €24 in total.

In addition to the energy savings, Ecodesign measures for reduced water consumption for washing machines can also lead to financial savings for consumers. Taking the washing machine for the average household of Lukas and Anna, the estimated water savings could be worth around €9.70 per year. While Ecodesign does not directly impose water efficiency requirements for dishwashers, it is one of the criteria presented on the energy label, therefore encouraging greater efficiency from manufacturers. Comparing best available technologies from 2010 and 2015 shows that water efficiency has improved, with savings equivalent to an additional €2.70 per year. See section 5.3 for further elaboration of these water saving calculations.

The full aggregated annualised savings per product are presented below in Table 1 which allows comparison of the savings per scenario. It is notable that for central heating systems the Ecodesign scenario offers the greatest saving. This is due to the fact that the additional purchase costs of a BAT system, i.e. a highly efficient heat pump, outweigh the achievable energy savings. This result is also consistent with Ecodesign being closer to the least life cycle cost point for central heating systems.

It is also notable that for some products, such as the electric room heater, electric oven, desktop PC, tablet PC and router there are no additional savings from Ecodesign or Energy Labelling. One of the most striking results is the lack of savings for gas hot water heaters from Ecodesign requirements, although the savings from the Energy Label BAT can be significant.

Table 1: Summary of overall annualised (life-cycle) savings per product compared to the reference case

# in HH	Product	Ecodesign [€/year]	BAT: Energy Label [€/year]	Best of both [€/year]
1	Gas central heating system	179.23	121.91	179.23
1	Gas hot water heater	-	119.10	119.10
1	Electric room heater	-	No label	-
1	Combined fridge freezer	18.99	29.66	29.66
1	Electric oven	-	-	-
1	Electric hobs	0.14	No label	0.14
1	Washing machine	-	1.84	1.84
1	Vacuum cleaner	0.15	6.36	6.36
1.625*	TV set	-	10.92	10.92
45	Lightbulbs	129.60	158.85	158.85
1	Dishwasher	-	0.82	0.82
1	Complex set-top-box	1.13	No label	1.13
1	Desktop PC	-	No label	-
1	PC-monitor	1.08	4.39	4.39
1	Coffee maker	1.35	No label	1.35
1	Tablet PC	-	No label	-
1	Router	-	No label	-
	Total	331.67	453.85	513.79

* This represents two TV sets, one 32” TV set and one 20” set

Durability requirements such as extended product lifetimes could potentially also result in significant savings for consumers. We examined the potential impact if these were applied to vacuum cleaners (a review of the existing durability requirements is already underway), smartphones, fridge-freezers, washing machines, and coffee machines. The variations and uncertainties in the savings are high, but additional potential savings of tens of euros each year are possible. See section 5.4.1 for further details.

Future requirements for Ecodesign on electric kettles, toasters and hairdryers offer potential for up to €14 euros of annual *energy* cost savings. As more efficient products are typically more expensive, the actual net savings for consumers would be lower. There is insufficient data to make a reliable estimate of the additional product costs, but a rule of thumb of 25% of the energy cost savings can be used, which would result in total net annual savings of around €10-11 per year. See section 5.4.2 for further details.

3 A day in the life of an average European household in 2016

In this chapter we tell a story of the day in the life of our average European household of Lukas, Anna, Sofia and Pip. We do this to more fully illustrate the positive impacts of the Ecodesign and Energy Labelling regulations, highlighting not only the financial savings[5], but the other benefits such as reduced noise and hassle, and improved functionality and health.

We use box texts in the story to: (1 – Green boxes) highlight the main benefits to the average household; and, (2 – Blue boxes) highlight other concerns for these products or future benefits that could be delivered through future use of the regulation.

The day begins …

It is 7 o'clock on a Saturday morning. Time for Lukas and Anna to get up. Anna switches on the light. As in most rooms in their house the major light sources are LED lightbulbs and lamps:

Lighting – benefits from Ecodesign and Energy Labelling
LED lightbulbs, as incentivised by the Ecodesign and Energy Labelling Directives, instead of inefficient incandescent lightbulbs, bring benefits such as: • €3.53 net financial savings each year per lightbulb, driven by lower energy use. • €159 total net financial savings each year, across all 45 lightbulbs in the house. • Low probability of premature failure. • High probability of lamp survival > 6,000 hours. • Information on the energy label for luminaires on whether the LED bulb is sealed into the device or if it is replaceable.

Lighting – consumer concerns and potential additional (future) benefits
Some luminaires are equipped with LED bulbs which are sealed in and are not replaceable which means a consumer has to replace the whole luminaire when just the LED bulb is defective. • Ecodesign regulations could be used to address this issue, requiring that bulbs should be always replaceable.

Right after getting up Anna puts on her bathrobe for warmth. They do not live in a cold house, in fact they bought almost all their appliances new when they moved into their house. This included

[5] All financial savings in this chapter represent savings on an annualised total cost of ownership (TCO) basis, as described in the previous chapter.

replacing the 30-year-old central gas heating boiler and the hot water heater. Yet their household budget is still a bit tight, so they turn their thermostats down at night to save money.

Heating and hot water – benefits from Ecodesign and Energy Labelling

An A class condensing gas central heating boiler brings benefits such as:

- €179 net financial savings each year compared to a low-temperature (non-condensing) boiler which would have been standard in a non-Ecodesign world.
- Less noise – as the Ecodesign directive restricts the maximum noise from boilers, and this information is displayed on the energy label that comes with the product.

And an efficient instantaneous gas water heater, with the regulations bringing benefits such as:

- Less noise – as the Ecodesign directive restricts the maximum noise, and this information is displayed on the energy label that comes with the product.

Heating and hot water – consumer concerns and potential additional (future) benefits

The Ecodesign regulation for space heating boilers has requirements scheduled to come into force in 2018, which will reduce nitrogen oxide emissions, resulting in:

- Cleaner, less polluted air – which can lead to better health.

It is important to note that the current Ecodesign requirements do not yield economic benefits based on the total costs of ownership for water heaters. If Anna and Lukas would purchase a high efficiency gas hot water heater (BAT: energy label) they could save up to €119 each year.

Anna enters the bathroom and enjoys a warm shower. Meanwhile Lukas prepares coffee with the new coffee maker they got from his parents-in-law last Christmas because the old one was broken. In the meantime, Anna has stopped showering. Sofia is still asleep and there is almost complete silence in their home. Lukas opens the fridge to start preparing breakfast. He does not notice the energy label sticker which is still there from when they bought it a year ago, when their local retailer offered a special discount for "A+++" fridge-freezers.

Fridge-freezers – benefits from Ecodesign and Energy Labelling

Their A+++ class fridge-freezer brings benefits such as:

- €30 net financial savings each year.
- Less noise – as the Ecodesign directive restricts the maximum noise. This information is displayed on the energy label.

Fridge-freezers – consumer concerns and potential additional future benefits

Some components of fridges may not be replaceable, e.g. door seals. Failure of these relatively small and cheap components could mean that an expensive whole door replacement is required or in some cases that it is better to buy a new fridge-freezer.

- Improved durability and reparability requirements within the Ecodesign regulation could avoid relatively small and repairable problems requiring expensive replacements of much larger components or the whole appliance.

Anna enters the kitchen; her hair is still wet. She will use the noisy hair dryer only after breakfast, when everybody is awake and there is no risk that Pip starts barking at the noise from the hair dryer and wakes Sofia up. Last time, when she replaced the old broken one, which only had lasted for two years, she intentionally looked for an energy label also featuring sound levels like with the heater and fridge. Yet she could not find any hair dryer with low wattage or an energy label with the sound level on it[6]. Now Lukas moves to the shower. Anna pours some water into the kettle to prepare some tea[7]. It is Saturday and so there is time to put some bread into the toaster, too[8].

Lukas has finished in the shower and wakes Sofia up for breakfast, they go downstairs and sit at the table. When breakfast is finished Anna and Sofia get ready to go outside in the cold to build a snowman, their first of the winter, whilst Lukas clears the table, and fills and starts the dishwasher. For the dishwasher they also bought an "A+++" energy efficiency device as there was a good deal on these appliances and the energy label information on noise and drying efficiency also helped.

Dishwashers – benefits from Ecodesign and Energy Labelling

Their A+++ class dishwasher brings benefits such as:

- Less noise – as the Ecodesign directive restricts the maximum noise, and this information is displayed on the energy label.
- Better cleaning – as the Ecodesign directive requires a minimum cleaning effectiveness.
- Better drying – as the energy label rates the drying efficiency of dishwashers.
- Better information – as the Ecodesign directive requires better information on the cleaning cycles and the Energy Label displays an approximation of the dishwasher washing capacity (in place settings).
- All previous qualitative benefits create more flexibility for when to use the appliance and they save time, as less re-washing or drying by hand is required compared to before.
- €0.82 net financial savings each year.

[6] So far hairdryers are not regulated by Ecodesign. Given their typically high power and noise level, Ecodesign requirements could yield improvements similar to vacuum cleaners. Moreover, durability requirements could be set.

[7] So far kettles are not regulated by Ecodesign. Yet, better insulation, better information (e.g. as to boiling just the needed amount of water rather than filling up the whole kettle), the possibility to boil very little amounts of water (e.g. just a cup of tea) and respective variable power could all be achieved by Ecodesign requirements.

[8] So far toasters are not regulated by Ecodesign. Lower energy consumption through better insulation and better information on optimal usage could be achieved by adequate Ecodesign requirements.

Lukas joins the snowman builders together with Pip, and after a fun snowball fight they go back inside. Anna brings in the electric heater to add some extra warmth to their living room where Sofia plays on the floor with her toys. Meanwhile Lukas starts preparing lunch, spaghetti bolognese, which Sofia likes very much. The wireless home phone rings: it is Auntie Prunella, Lukas' sister. She is ringing to let them know she will be there at around 5 pm. Lukas and Anna look at each other with an embarrassed smile, they had completely forgotten about it!

After a quick lunch they soon swing into action. Prunella has very high standards for cleanliness, and they have just 4 hours to clean the house and bake a cake before she arrives.

Anna, Sofia and Lukas make the cake together. Little Sofia is happy as she likes these kind of family events. After the cake goes into the oven it is time for Sofia's nap. When she is asleep upstairs Lukas starts vacuuming downstairs. In the past this could have caused quite a family headache, trying to vacuum around Sofia's naptime, as the vacuum was so noisy and re-emitted too much dust to allow Sofia, who has a dust allergy, to have a peaceful sleep.

When buying their new vacuum cleaner they had explicitly asked the shop assistant for a quiet model for moments just like this. They remembered feeling a bit uneasy when they went to the shop, as in some newspapers they had read about politicians in Brussels who wanted to ban powerful vacuum cleaners for the sake of tiny energy savings. They were surprised to hear from the shop assistant that all these frightening news stories were far from reality. Admittedly, he told them, he had also had some reservations whether a 900 W model could remove dust as effectively as their previous 1,500 W model. However, the information given on the energy label and reviews he read in consumer magazines had convinced him that this really was the case. In fact, the information on the label provided Lukas and Anna with exactly the information they were looking for: capability to pick-up dust and hair, because Pip sheds a lot, dust retention which is important due to Sofia's allergy, the noise level and last but not least, better energy efficiency and thus lower running costs.

Vacuum cleaners – benefits from Ecodesign and Energy Labelling

They bought an A class vacuum cleaner which brings benefits such as:

- €6.36 net financial savings each year.
- Better cleaning – the Ecodesign directive sets minimum requirements for dust pick-up which is also rated (from A-G) on the Energy Label.
- Cleaner air, better health – the Energy Label displays a rating (from A-G) of the dust re-emission of a vacuum cleaner. From 2017 the Ecodesign Directive will also require minimum levels of dust re-emission.
- Less noise – the Energy Label displays the noise of the cleaner (in Decibels) and from 2017 the Ecodesign Directive will also require minimum noise levels.

Vacuum cleaners – consumer concerns and potential additional future benefits

From 2017 onwards, vacuum cleaners will have to fulfil durability requirements for the hose and motor. An ongoing review process may bring additional future benefits.

Prunella arrives at 5 pm sharp. She enjoys the cake and everybody has fun together. Sofia is at her best, introducing Prunella to "Ice Tea – the snowman". When Prunella leaves they are relieved that she did not make any comment like "kids shouldn't play on dirty floors with pet hair!" as she has sometimes in the past. Indeed, they all wish she could have stayed a bit longer.

Outside it is dark again and time for Sofia to go to bed. Anna is happy that singing a lullaby helps Sofia to fall asleep almost immediately.

Now it is time to tidy up the kitchen. Lukas does not notice the coffee machine. Although they used it in the morning and forgot to switch it off, the coffee maker has switched itself off automatically[9].

Anna sets off the washing machine, content that it will not wake Sofia up. Thanks to the kind advice they got from the shop assistant and the information on the energy label they were able to select a washing machine that not only has much lower energy and water costs but also featured comparatively low noise levels in both in the wash and spin cycle. Being sensitive to Sofia's skin allergy, Anna regrets that there is no information about rinsing efficiency, which would have been helpful to judge whether detergent is thoroughly removed from the clothes[10].

Washing machines – benefits from Ecodesign and Energy Labelling

They bought an A+ washing machine which brings benefits such as:

- Better cleaning – earlier versions of the Energy Label rated the washing performance of machines, leading to overall improvement in machine wash performance.
- Dryer clothes – the Energy Label displays a rating (from A-G) of the spin-drying efficiency of a washing machine.
- Less water use – the Ecodesign directive sets maximum water use requirements for washing machines, with an estimated €9.70 annual saving on water bills.
- Less noise in operation – the Energy Label rates and displays the noise the machine makes in both the wash and spin cycles.
- Better product information and functionality – the Energy Label requires the capacity of the machine to be displayed on the label and the Ecodesign directive requires that a low temperature (energy) cycle is available.

In the evening Lukas reads the news of the day and looks at the next day's operational schedule at the fire station on their tablet PC. Although Lukas forgot to switch off the device after Sofia had finished playing her kids games earlier, the tablet automatically went into standby mode[11]. The battery level is still at 80% and the tablet ready for use. No need to move upstairs to use the desktop PC. Anna sits next to him on the sofa and watches TV.

[9] Auto-switch off of coffee makers happens thanks to Ecodesign-regulations.

[10] Allergic reactions both depend from the detergent used and how much remains in the clothes after rinsing. The European Centre for Allergy Research Foundation certifies both detergents and washing machines.

[11] Tablets are required to have the option of a standby-mode that kicks in after a certain idle time. This is thanks to Ecodesign.

Televisions – benefits from Ecodesign and Energy Labelling

They bought an A+ television which brings benefits such as:

- €6.72 net financial savings each year – savings may increase in future as higher Energy Label classes are added in 2017 (A++) and 2020 (A+++).
- Lower energy consumption in stand-by mode – through Ecodesign requirements.

Anna leaves the TV on but decides to read a consumer magazine. She very much likes the tips on how to save money and she feels it has already helped her in making better purchase decisions for some of their appliances. Tonight she finds an interesting article about how much a family could save from small appliances that use a surprisingly high amount of energy such as kettles, toasters and hair dryers. While she is impressed that they could still save some €10 per year she finds it even more interesting that a longer lifetime of these products and better reparability could add significant savings too, without mentioning the benefits for the environment. This is quite in line with her concerns about devices for which she cannot replace the battery, and is forced to replace the whole device, like with her previous mobile phone.

Small appliances – consumer concerns and potential additional future benefits

Many smaller devices such as hair-dryers, kettles, toasters and mobile phones are not regulated by Ecodesign or Energy Labelling, some of these devices are noisier, more inefficient, less durable and harder to repair than they could or should be.

- Around €10 annual savings could result from regulation of these small devices.
- Other potential benefits for consumers could include better functioning, longer lasting, more easily reparable products.
- Benefits for the EU – although the individual savings and benefits are small, they are significant at EU level. This can be particularly relevant for energy savings and resource use, i.e. critical raw materials in mobile phones.

A little later, the TV switches off automatically as Lukas has set the auto-power down function to 2 hours[12], as they almost never watch TV for longer and they often forget to switch it off. Lukas and Anna notice when the TV switches off and check the clock. It is getting late and they decide to go to bed.

It is snowing again. What a nice day!

[12] TVs are required to have an auto-power down function. This is thanks to Ecodesign regulations.

4 Conclusions and policy recommendations

Our story about Lukas, Anna, Sofia and Pip reveals the significant economic and qualitative benefits that Ecodesign and Energy Labelling already exert on our daily life in the EU. The story and the detailed analysis underpinning it (see chapter 5) allows us to draw some major conclusions and formulate policy recommendations aiming at:

- Higher energy savings at the EU level – with benefits for energy security, trade balances and competitiveness.
- Higher financial savings for consumers – of more than €500 per household per year by fully exploiting Ecodesign's savings potential[13].
- More useful and incentivising energy labels – encouraging innovation in EU industry and continuing leadership in the global market for many of these products.
- Enhanced sustainability and reduced environmental impacts – reduced energy use leads to reduced greenhouse gas emissions and other forms of pollution. Reduced resource use, water use and noise also have important benefits on health and the local and global environment.
- Last but not least – a more realistic and balanced perception of what Ecodesign and Energy Labelling regulations actually deliver for the benefit of Europe, European households and individuals.

4.1 Conclusions

There are significant financial benefits for the average European household from Ecodesign and Energy Labelling.

- Ecodesign (and Energy Labelling) are providing significant financial benefits to consumers.
- The financial benefits of current Ecodesign regulations are estimated at €332 each year for an average household, annualised over each appliance's lifetime. This represents a total cost saving of around 11% for the household on the annualised total costs of ownership.
- If the household purchased best available technologies, (as incentivised by the Energy Label) which provide savings over a non-Ecodesign/Label world, then the financial savings would be higher at around €454 each year for an average household, representing a saving of 15% on the annualised total costs of ownership.
- If the average household were to take the best of both worlds scenario across the Ecodesign and Best Available Technology products, then these savings could increase to €514 euros per year, representing a saving of 17% on the annualised total costs of ownership.

[13] The financial benefits stated in this study were calculated using a conservative approach. Data on which the calculations are based already includes the beneficial impacts of Energy Labelling measures dating back to the early 1990's in the reference case. This is particularly relevant for washing machines, refrigerators and dishwashers, for which the benefits of labelling have been significant since the Directives were first introduced. This means, taking a less conservative approach, energy efficiency in the reference case would have been worse than assumed here, and consequently benefits attributable to the Ecodesign and Energy Labelling Directives of today would have been even higher.

- The biggest savings for consumers are delivered by the Ecodesign regulations on heating appliances, lighting, and fridge-freezers, with these accounting for a large majority (>90%) of the savings potential.
- Ecodesign requirements do not only yield energy but also water savings, which can deliver further financial benefits of up to 10 euros per year for the average household from savings on water use by washing machines and dishwashers.

Financial savings could increase if Ecodesign requirements were closer to LLCC.

- In theory the Ecodesign scenario should deliver the maximum savings for the average household as it is intended to represent the least life-cycle cost (LLCC) point, i.e. requiring the efficiency level, where the sum of a product's purchase price and its lifetime energy cost are at their lowest level (see also Box 1 in section 2.2). It is a major finding of our research, that in a number of our calculations this is not the case, which means that current minimum requirements set by Ecodesign regulations are in many cases outdated and could be more ambitious.
- Outdated Ecodesign requirements and energy labels make it impossible for consumers to make an informed choice.
  - Ideally the energy label would provide guidance on which products have the least life-cycle cost. As pointed out before, these should be the products just fulfilling Ecodesign minimum requirements and thus be allocated in the lowest energy efficiency class available.
  - All other products having even lower energy consumption (and costs) but due to their higher purchase price also having a higher life cycle cost would still be rated in better performing energy label classes.

Ecodesign and Energy Labelling have a number of non-financial benefits that facilitate Europeans' daily life, improve their well-being and increase their independence.

- Improved product information for consumers:
  - Allowing easier, better informed purchase decisions, comparability of other functionalities across products (e.g. dust pick-up, drying efficiency) and maximising the product's usefulness during operation. This information was not there to the same degree before the regulations.
- Environmental benefits:
  - Energy savings and the related avoided greenhouse gas emissions and reduced air pollution from power plants.
  - Water savings from advanced washing machines and dishwashers.
- Health effects:
  - For example, as labels now include dust pick-up and re-emission information, consumers can choose better performing products, reducing the incidence and severity of dust related health problems.
  - Reduced noise (e.g. vacuum cleaners, dishwashers, heating systems) – which can have important quality of life and health benefits.
- Reduced hassle:
  - Standby mode rules take care of small decisions for consumers to save energy and requirements for higher durability.

- Greater flexibility for when to use the appliance, e.g. through less noise allowing for usage when others sleep.
- Higher quality of how well functions are performed (e.g. drying efficiency of dishwashers) reduces the amount of time needed for rework (e.g. for manually re-cleaning or re-drying dishes taken from the dishwasher).

Extending Ecodesign and/or labelling to other products could yield additional benefits.

- Ecodesign/Energy Labelling could potentially be usefully extended to electric kettles, hair dryers and toasters, with estimated *energy* savings of around €14 per year possible. Although it remains unclear if a net saving could be achieved once increased product prices are taken into account, it seems likely that there is scope for improvement. Even without any individual savings, it would still be beneficial from an environmental perspective at EU level.
- Addressing energy use of chargers in 'no-load condition' could deliver energy savings significant at the EU level for small, battery powered appliances for which individual savings are small. Furthermore, for these small appliances Ecodesign could simultaneously address durability (longer lifetime), reparability (replaceable battery) and resource use (easy recyclability). These types of benefits become more and more important as the impacts associated with the use phase of appliances decline relative to the impacts associated with their manufacture and disposal, i.e. that it becomes increasingly beneficial to not need to manufacture a new device even if it is (marginally) more energy efficient in its use phase.
- In consideration of durability requirements, the existing data on the financial costs and benefits is quite limited. Our analysis suggests that there can be financial benefits for consumers from extended product lifetimes, although these estimates come with significant uncertainties. Further work, particularly in establishing the additional product cost incurred by improved durability, is needed to better evaluate the financial impact on consumers.

4.2 Policy recommendations

Ecodesign minimum requirements for energy performance should always be as close as possible to the least life-cycle cost (LLCC) point.

- To actually deliver cost-optimality and maximum benefits to consumers it is vital that requirements stay relevant and that Ecodesign in particular is targeted as close to, and remains close to, the least life cycle cost (LLCC) level over time. This is also a pre-condition for not lagging behind with banning inefficient products from the market which have an energy performance worse than the LLCC (see also Box 1 in section 2.2).
- Only up-to-date minimum requirements that remove the most inefficient products from the market allow consumers to easily distinguish between products with least life cycle cost and more efficient products with a higher life cycle cost but lower energy costs. This would be the case when the worst available energy efficiency class that can be found on the energy label would always be close to the current LLCC product.
- In the past the market sometimes developed faster than Ecodesign – for example for TVs & LEDs – additional review steps at the end of the Ecodesign process may help to set more realistic requirements closer to the sometimes rapidly moving LLCC point. For products where a high innovation rate can be expected, shorter review cycles for corresponding Ecodesign regulations should be foreseen.

Energy Labels for different products should use the same scale, which needs to stay relevant.

- Consumers need clear signals as to the energy efficiency of products. The intended market pull effect of the energy label will only work to its full potential, when the "A" class as often as possible represents the best available class across all products. It creates confusion when "A" represents the best class only for some products (e.g. vacuum cleaners) while for others at the same time "A" does not even exist as it has been banned already (e.g. washing machines).
- We recommend a return to A-G energy efficiency classes for all products, where the "upper labels classes should be set at a level that encourages the development of more efficient products than are currently on the market unless it is unambiguously demonstrated that this is not technically feasible" [Molenbroek et al., 2014b]. This proposal has been taken up by the European Commission [European Commission, 2015b] and is waiting for final approval.
- In any case, a more regular review and update of the labels within the easier to understand A-G framework would be beneficial. Updates are needed to improve accountability of technological progress and to continue to provide relevant and useful information to consumers that wish to purchase more efficient products. This would also help to avoid the case where manufacturers and retailers offer their own labels in addition to energy labels, i.e. creating A+++ minus 10/20/30/40/50% etc.; to differentiate the best performing products.

Communication about financial benefits of Ecodesign and Energy Labelling should also address the household and individual level to make benefits more tangible.

- This study has shown that for an average European household annual savings of more than €500 could be achieved compared to a world without Ecodesign and Energy Labelling when Ecodesign requirements would always be close to the LLCC point.
- The complexity for consumers to compare the financial benefits of energy savings across appliances, and in particular with old appliances, is a barrier to understanding the benefits of the regulations and achieving greater savings. Surprisingly, there is a lack of accessible online calculator tools for consumers to quickly estimate the financial benefits of different appliances – while there are some applications and websites attempting to provide such a service, these are quite limited and could be significantly better developed. There are several "energy efficiency top product" databases, yet they do not provide the possibility to directly retrieve product prices and thus compare *total* cost. Such tools also would help to highlight the difference between total life-cycle costs of a product and its energy cost.

With ever decreasing energy use during operation, Ecodesign needs a stronger focus on the total environmental impact of products and on how this can be reduced.

- As energy use in the use-phase of a product's lifetime decreases, the energy (and other resource) use in the manufacturing and disposal phase becomes more important to the overall environmental impact of the product. Durability requirements therefore can become particularly relevant once Ecodesign and Energy Labelling have successfully achieved the most significant energy efficiency improvements. This may be starting to become the case for some products, i.e. fridge-freezers, washing machines, which have significant impacts from their manufacture and for which energy consumption in their use phase has been significantly reduced by Ecodesign. The broader lifecycle perspective should be taken into account in consideration of future durability requirements.

- In the context of durability, the issues of reparability and recyclability gain relevance, too. It must be ensured that (premature) failure of small but essential parts of a product does not render the whole product obsolete, i.e. such parts should be replaceable (e.g. built-in mobile phone batteries or sealed-in LEDs). If they are not, and a whole new substitute needs to be bought, this negatively impacts the overall environmental performance but also the financial performance from the consumer's perspective.
- Currently it is hard to quantify the financial benefits of more durable products, lower failure rates and better reparability. To date, the valuation and review of durability requirements has typically been carried out from a societal perspective, in terms of energy use, materials and environmental impacts with only limited consideration of the financial impacts on consumers. Therefore, future work should:
    - Pay further attention to the potential financial benefits for consumers of increased product lifetimes.
    - Particularly focus on the additional purchase costs of more durable products as these are the key missing components in better assessing the overall costs and benefits for consumers.
    - Further investigate the potential benefits from reduced failure rates and associated repair costs. This can include applying Ecodesign requirements to products where consumers cannot replace vital parts of a product themselves, e.g. in the cases of sealed-in LEDs or mobile phone batteries, and are likely to throw the product away rather than repair it.

Purchase decisions are strongly influenced by non-energy/non-financial aspects. That is why the potential of Ecodesign and Energy Labelling to improve individual comfort, well-being, health and independence should receive greater focus in research and communication.

- Most consumers do not buy appliances regulated under Ecodesign or Energy Labelling primarily for saving energy but for making their life more comfortable and increase their health, well-being and independence, e.g. through letting the appliance do what used to be manual work like dishwashing and thus freeing up time. By looking at a typical day in the life of a family this study reveals a number of important non-financial and/or non-energy benefits Ecodesign and Energy Labelling bring along: less noise, less dust, better cleaning and drying efficiencies, better illumination, higher durability, etc.

  There may be scope to improve labelling to better communicate these non-energy and non-financial aspects. For example, the meaning of "kWh per annum" can be confusing as "annum" is not universally understood as being equivalent to "year". A very good example where consumer information has facilitated understanding is lightbulbs where CFL or LED power is often indicated with the equivalent value for an incandescent light bulb, a unit with which many consumers remain familiar and use as a reference (such as for example 5W ≈ 40W). Similar shortcuts could be useful for other products to address common misconceptions about their power and effectiveness.

5 Analysis underpinning the story

Chapter 2 and 3 provide a concise narrative description of the benefits of Ecodesign and Energy Labelling to the average EU household. In this chapter we explain the approach used, the key assumptions, calculation steps and inputs. More detailed methodological explanations are also provided in Annex A.

5.1 The average European Household

The average household is based on data and analysis of statistics at EU level.

Household size analysis

The typical household size of a European household is 2.4 people [Eurostat, 2016][14]. In this analysis we have assumed the typical European household composition to be two adults and one dependent child[15], which is the case in 9.3% of European households. Although also other household compositions are very common, e.g. around 60% of all European households are single or two person households, it was felt that assuming two adults plus one child was both reasonable and would make a storyline that reflects a very common reality in the course of the life of an average European.

Appliances analysis

The household appliance outfit described above in Chapter 2 is based on analysis of stock data from the VHK IA studies [VHK, 2016] and the number of European households from Eurostat[16] [Eurostat, 2016], which show the following estimated ownership of devices per household [Kemna and Wierda, 2015]. These were also cross-referenced against data from the Odyssey-Mure dataset [ENERDATA, 2016].

Table 2: Overview of appliances' stock data

Product	EU27 2015 stock ('000 units)	Average number per household	Assumed no. of devices in average household	Expanded definition / comment
WH dedicated Water Heater	161 740	0.75	1	It still remains more common to have separate devices than a combi space heat/hot water boiler (av. no. per HH = 0.46)
CH Central Heating boiler, space heat	119 737	0.56	1	

[14] From dataset: Distribution of households by household type from 2003 onwards

[15] All persons aged less than 18 are considered as dependent children, plus those economically inactive aged 18-24 living with at least one of their parents.

[16] EU27 total households estimated at 214.6 million in 2014, EU27 used for consistency with VHK data, Croatia not yet added to dataset.

Product	EU27 2015 stock ('000 units)	Average number per household	Assumed no. of devices in average household	Expanded definition / comment
LH Local Heaters	282 097	1.31	1	From this sub-category the most common appliance is the electric convection heater, therefore the electric portable space heater was selected.
RAC Room Air Conditioner	65 115	0.30	0	As a result, air-conditioners were not included as part of the average household.
LS Light Sources	11 796 000	54.96	See below	
LFL	*2 220 000*	*10.35*	*0*	*Linear fluorescent (tube)*
CFL	*4 737 000*	*22.07*	*45 (Ecodesign)*	
Tungsten	*2 484 000*	*11.58*	*0*	
GLS	*2 057 000*	*9.59*	*45 (no-Ecodesign)*	
HID	*89 000*	*0.41*	*0*	*High intensity discharge*
LED	*208 000*	*0.97*	*45 (BAT)*	
Lighting excluding LFL and HID	***9 487 000***	***44.20***	***45***	***Rounded to 45. Excluded LFL and HID as these are primarily for commercial uses***
TVs	474 920	2.21	2	
DP Monitor PC	130 000	0.61	1	
STB set-top boxes (Complex & Simple)	271 033	1.26	1	Assumed complex set-top box.
VIDEO DVD players/recorders	25 294	0.12	0	Not common enough for average household.
VIDEO game consoles	82 119	0.38	0	Not common enough for average household.
PC Desktop	97 110	0.45	1	In combination, an average household will have a computer, we selected for a desktop computer in the average household.
PC Notebook	94 500	0.44	0	
PC Tablet/slate	157 500	0.73	1	
SB (networked) Stand-By (rest)	453 500	2.11	0	Includes (fixed) phones, network attached storage, not modelled due to data gaps
			1	home gateways (routers)
BC Battery Charged devices	1 000 000	4.66	0	Mobile phones, electric toothbrushes, other. Not yet modelled
RF household	303 200	1.41	1	Combined fridge-freezer

Product	EU27 2015 stock ('000 units)	Average number per household	Assumed no. of devices in average household	Expanded definition / comment
Refrigerators & freezers				
CA Electric Hobs	149 114	0.69	1	Electric hobs, as the most common, selected for the average household.
CA Gas Hobs	93 516	0.44	0	
Total hobs	***242 630***	***1.13***	***0***	
CA Electric Ovens	199 332	0.93	1	Electric ovens, as the most common, selected for the average household.
CA Gas Ovens	42 390	0.20	0	
Total ovens	***241 722***	***1.13***	***0***	
CA Range Hoods	97 111	0.45	0	Not average in EU households.
CM household Coffee Makers	158 518	0.74	1	
WM household Washing Machine	196 821	0.92	1	
DW Household Dishwashers	98 345	0.46	1	Although borderline, it was decided to include dishwashers in the average household.
LD household Laundry Drier	68 018	0.32	0	Laundry driers are not included
VC household Vacuum Cleaner	380 966	1.78	1	Despite high stock it was decided more appropriate to model only one vacuum cleaner in the average household.

5.2 Quantification of current net economic benefits

5.2.1 Benefits for the average EU household

As far as possible we have quantified the net economic savings of Ecodesign and Energy Labelling based on a bottom-up approach, i.e. from the perspective of the average household described previously.

By defining the appliances used in the average household we had a starting point for the analysis. It was then necessary to decide on the characteristics of the appliance being used. Based on inception discussions and for consistency in demonstrating the savings of Ecodesign we use four scenarios, namely:

1. **Reference scenario** – with no Ecodesign or Energy Labelling measures for the appliance, this scenario is intended to represent a base case of the sales-weighted average product sold on the market today. It is derived from a previous analysis of the various preparatory studies [Kemna and Wierda, 2015], adopting from the previous analysis an assumed autonomous (in the absence of any Ecodesign or Labelling measures) efficiency improvement applied to the appliance efficiency to bring it to 2015 values.

2. **Ecodesign scenario** – where it is assumed the appliance conforms to the minimum requirements specified in the current regulation. We used these requirements to model the energy performance of a product that just meets the requirements. It should be noted that in some cases the required Ecodesign energy efficiency level can be lower than the energy efficiency level of the reference scenario. As the Ecodesign requirements typically operate to exclude products only at the bottom of the market in terms of energy efficiency, the sales-weighted average efficiency of the reference scenario may be higher than the Ecodesign value, particularly given the assumed autonomous efficiency improvements.
3. **BAT (Energy Labelling) scenario** – where we select a high performance appliance, typically a known (current) best performing product, which will usually perform at the top or second highest Energy Labelling class available. The rationale being that Energy Labelling has been a major driver for manufacturers to make more efficient products – this is an important assumption. It is possible, very likely even, that in future for some product groups the savings will be higher as new, more efficient products become available in higher label classes than currently possible.
4. **Best of both world's scenario** – a combined scenario picked from either scenario 2 or 3 based on the criterion "lowest annualised total cost of ownership" per appliance.

The savings for the average household per appliance will therefore fall within a range from scenario 2 to scenario 3 in the majority of cases. As noted above, it is possible in either of these cases that the regulation delivers no net savings. The annual energy savings resulting from each of the scenarios are presented below in Table 3, the indexed values provide a clear comparison to the reference case. It can be seen that for water heaters, electric room heaters, washing machines, TVs, dishwashers and PCs that the Ecodesign scenario values are higher than the reference case, signalling no energy use savings from Ecodesign efficiency requirements. Where Energy Labels are used, the BAT scenario always uses less energy than the reference scenario.

Table 3: Annual energy savings in the three key scenarios

Product	Annual energy use [kWh]			Annual energy use, index to reference = 100		
	Reference	Ecodesign	Label / BAT	Reference	Ecodesign	Label / BAT
Central heating (gas/electricity*)	15 273	12 094	2 774*	100	79	18*
Water heating (gas)	5 084	5 253	2 425	100	103	48
Electric room heater	423	878	No label	100	208	No label
Fridge-freezer	424	229	119	100	54	28
Electric oven	102	110	56	100	112	57
Electric hobs	251	246	No label	100	98	No label
Washing machine	189	229	139	100	121	74
Vacuum cleaner	63	62	26	100	99	41
TV	95	169	37	100	179	39
Lightbulbs	23	8	4	100	34	19
Dishwasher	262	324	134	100	124	51
Complex set-top-box	88	68	No label	100	77	No label
PC	103	112	No label	100	109	No label
PC-monitor	49	39	9	100	80	18
Coffee maker	37	30	No label	100	81	No label
Tablet PC	14	8	No label	100	61	No label
Router	56	56	No label	100	100	No label

* The Label/BAT central heating appliance is an electric heat pump. While energy savings are around 80% in kWh, the actual cost savings will be lower as electricity is more expensive than gas per kWh.

The further characteristics of each appliance and the specific prices, energy consumption, running costs, lifetime and usage are summarised and presented in the accompanying product factsheets. Among the benefits of this approach is the possibility to further customise the average household, i.e. if we would also like to look at a single person household we would then only need to characterise the appliances they use to re-calculate their savings range.

One of the key characteristics to assume is the current product age. The purpose of this work is to present an estimate of the current situation. For the reference scenario, we represent a counterfactual of the estimated sales-weighted average efficiency of products sold in 2015 and estimated purchase prices in 2015 in the absence of regulations. This is used for comparison with the other scenarios, which model the savings from products that comply with the current Ecodesign and Energy Labelling regulations. While current regulations may have only been recently introduced or changed, they may also have already been in place for many years. In this latter case, the benefits of the regulations are more likely to be low, as innovation will have led to autonomous improvements in the reference case since the requirements were introduced. This explains in some cases the relatively low or no savings from Ecodesign.

Our approach implies that all appliances are purchased new in 2015. This approach was selected to avoid potential inconsistencies in comparing years and lifetimes with the alternative approach, i.e. calculating savings in 2010 on one product, 2012 on another, 2007 on another, and so forth, based on an assumed product age. It is recognised that this is somewhat artificial but this is consistent with comparing the differences between scenarios and also a plausible case for the narrative, i.e. moving from a furnished apartment which already had (almost) all appliances to an own house and needing to buy all new appliances.

Financial outcomes are calculated in broad terms for each scenario as:

- Total financial cost = Product purchase price + (Annual energy cost + Annual other running cost) * lifetime of the product.

The total financial cost is annualised over the lifetime of the product. This requires a few adjustments and assumptions, namely:

- Current and future energy prices: these have a major influence on the value of any energy efficiency improvements. Current 2015 energy prices of 18.7 cents/kWh for electricity and 6.7 cents/kWh for natural gas were assumed. These values are residential average prices in the EU, weighted by the number of households, and were sourced from an assessment of the EU Energy Performance of Buildings Directive (EPBD) by Ecofys for the European Commission's impact assessment of the EPBD. Energy price increase values were sourced from the EU Ecodesign Impact Accounting study [Kemna and Wierda, 2015], with a real price increase rate of 4% per year assumed for both electricity and natural gas prices.
- Inflation rate for other running costs (i.e. water, consumables [vacuum bags, washing powder, etc.], standard maintenance and repair): this was set to 4%, consistent with the rates used for electricity and gas.
- Discount rates: Discounting is a standard approach used in cost benefit analysis to take into account the time preference for money of consumers, i.e. that we would rather save 10 euros now than 10 euros in 5 years' time, meaning that savings are effectively less valuable to a consumer the further into the future they are expected. Discount rates are used to account for this effect, being used to reduce the valuation of future costs (and therefore savings) in the calculation. A discount rate of 4% was assumed in this study, consistent with EU Impact Assessment guidance and the rates used in the EU Ecodesign Impact Accounting study [Kemna and Wierda, 2015]. It is also broadly consistent with previous research in this area [Hermelink and Jager, 2015] which observed rates of 3-6% across the EU. The 4% rate was applied to both future energy and other running costs.
- Product lifetime: over which to spread all costs. The assumed product lifetimes are provided in the factsheets and also based on the EU Ecodesign Impact Accounting study [Kemna and Wierda, 2015].

As a result of this adjustment we calculate as our primary result:

- Annualised cost of a product = (product purchase price + discounted and adjusted annual energy and other running costs over whole product lifetime) / product lifetime.

This result shows what the annual cost of the average household would be when all costs are taken together and spread over the lifetime of the product. By comparing the values generated by the products in each of the three scenarios we are able to calculate the level of any financial benefit from the Ecodesign or Energy Labelling regulation.

5.2.2 EU aggregate net economic benefits

The savings of the average household can be scaled up to EU level. By using estimations of the total stock of the products in the EU28 [Kemna and Wierda, 2015], multiplied by the savings per appliance as experienced by the average household, we can estimate savings for the EU28 as a whole. This provides financial savings of €54-96 billion euros each year, with the highest savings from more efficient boilers (€25-37 billion), lightbulbs (€27-33 billion) and water heaters (up to €19 billion).

Clearly, there are significant limitations to this approach, not least the varying household sizes in reality and therefore the different loads placed on the appliances. Also the different energy carriers for the central heating technology, gas for the reference and Ecodesign scenario, and electricity (heat pump) for the BAT/Energy Label scenario complicate the natural gas savings estimate. Nevertheless, the estimates provide a clear indication that the savings resulting from the regulation are likely to be highly significant.

5.3 Other benefits of Ecodesign and Energy Labelling

Product energy efficiency policies such as Ecodesign and Energy Labelling can have numerous co-benefits linked to the energy efficiency and other improvements required by the regulation. While many of these co-benefits are not financial, or easily monetised, they remain an important benefit to the average household. We briefly summarise the key co-benefits for the average household below.

Energy savings

While the Ecodesign and Energy Labelling regulations focus on promoting higher efficiency and energy savings to the consumer, it can be that a more efficient product is more expensive. In some cases, the higher purchase price cannot be compensated for through energy savings within the lifetime of the product. Nevertheless, the energy savings remain important, particularly from an environmental perspective, and it can also be something that a household sees as a benefit, even if there is no overall financial benefit. From a societal perspective, demand for the most efficient products helps to encourage investment in innovation by manufacturers. This helps to reduce the cost of newer, more efficient technologies over time due to learning and scale effects. Indeed these learning effects are visible in product purchase prices reducing over time, sometimes faster than estimated in the original Ecodesign preparatory studies [coolproducts, 2015].

When the calculated savings are aggregated across all of the products, the estimated energy savings for the average EU household are compared to the reference scenario total electricity consumption of around 3,200 kWh per year. Savings of approximately 220 kWh are achieved in the Ecodesign scenario and of 1,500 kWh in the BAT-Energy Label scenario. Similarly, significant savings are possible for gas fuelled heating appliances, with savings of 3,000-15,000 kWh (300-1,550 m^3) less natural gas each year compared to the reference scenario consumption of around 20,000 kWh per year. The ranges of these savings for the electricity using products are provided in Figure 4 below.

It is important to note that for some products there are no savings. This is because Ecodesign requirements are sometimes lower than the reference scenario and therefore no energy and cost savings are delivered. One conclusion that can be drawn is that consumers tend to experience greater benefits when Ecodesign requirements are set at more ambitious levels.

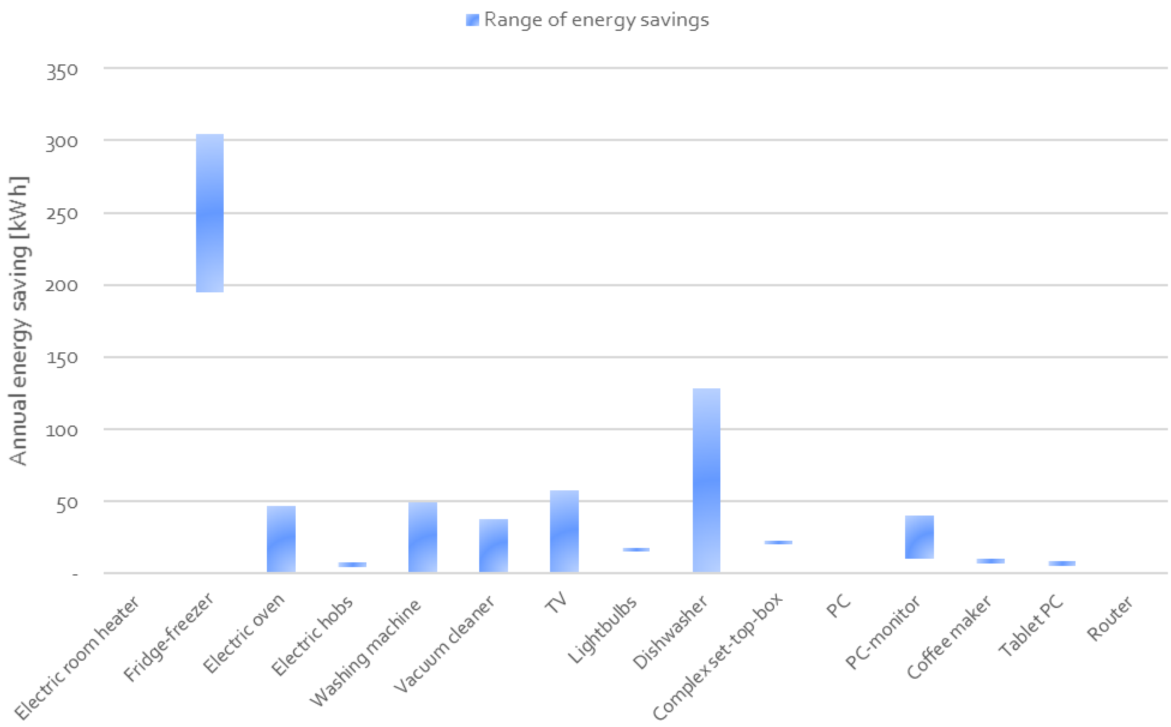


Figure 4: Range of energy savings for the average EU household compared to reference case, as a result of the Ecodesign and Energy Labelling regulations, single products, kWh per year.

A further note is that for some products energy savings are possible but financial savings are not. For example comparing with Table 1 it is evident that this is the case for electric ovens and Tablet PCs. This demonstrates examples of products where the additional purchase cost of a more energy efficient product is not fully compensated by the energy cost savings.

Noise impacts

Noise pollution may be defined as undesirable sound in the (local) environment that can be detrimental to human activity. Unwanted sound can create discomfort and contribute to a general deterioration of environmental quality within indoor environments. Household appliances are sources of various levels of noise. Among the most common sources of household noise are domestic appliances such as washing machines, tumble dryers, dishwashers, air conditioners and vacuum cleaners.

One of the ways to control noise is to reduce noise levels at the source. The Ecodesign Directive and its implementing measures set out requirements limiting the noise levels of household appliances such as washing machines, dryers, air conditioners, heat pumps and vacuum cleaners. Whichever the case, it is clear that the Ecodesign Directive by regulating noise levels of appliances puts limits on some important sources of indoor noise, therefore increasing the comfort for the household. In addition, the presence of a sound level on the energy label enables consumers to take the noise level of an appliance into account in their purchase decision. The importance of noise reduction will vary from person to person and will also depend on the house they live in and the location of the appliance. Clearly in apartment buildings with multiple flats, in small houses where living, kitchen, and sleeping areas are close-by, and/or households with young children easily disturbed by noise, the impact of noisy appliances is much greater on the quality of life of the household and those around them. Therefore the co-benefit of noise reduction is also greater.

Reduced hassle

Ecodesign requirements can lead to reduced energy bills without consumers needing to act. The requirements on energy use in stand-by mode is particularly valuable in this case. For example, since January 2015 coffee machines are required to turn off automatically after brewing which reduces the energy consumption of the appliance without the user needing to take action. Furthermore, it increases the safety as users no longer have to worry if they turned off the coffee machine [UBA Umweltbundesamt, 2015]. This applies to a variety of other appliances, such as complex set-top boxes, computers and networked equipment, where automatic standby requirements save energy for consumers without requiring action, reducing the hassle and pressure on the user.

Health and comfort effects

Health and comfort can increase with an improved indoor climate. Increased thermal comfort, less noise and improved indoor air quality all contribute to enhanced well-being and reduced health risks [bigEE, 2013] [Feifer et al., 2016].

Ecodesign requirements contribute towards health and improved comfort in households. For example, in the case of vacuum cleaners the requirements extend beyond the energy consumption of the appliance to also include dust pick up, dust re-emission and noise. This is important as the concentration and composition of dust in the indoor environment is associated with a variety of medical complaints including increased incidence of allergies, asthma and skin conditions. Controlling dust is particularly important for households with young children as they are more susceptible to these conditions [Roberts et al., 2009]. Efficient elimination of dust due to increased requirements by the implementing measure would considerably increase the wellbeing and comfort of the inhabitants of the indoor environment. DENA findings [DENA, 2014] support this and suggest that the EU regulation on vacuum cleaners has led to a burst of innovation by manufacturers to not only optimise energy efficiency, but also the throughput, dust and noise emissions. As a result, this has improved the health and comfort of inhabitants.

Water impacts

Water consumption and sewage output can be considerably reduced through the use of devices that are not only energy efficient but also water efficient such as low-flow showerheads or washing machines.

In the implementing measure covering domestic washing machines there are requirements on water consumption [Bundgaard et al., 2015]. After entering into force in December 2010, further improvements on the requirements for domestic washing machines have been implemented via a staged approach in 2011, 2012, and 2013. These include limits on the overall energy and washing efficiency, and on water consumption.

This leads to financial benefits for households through reduced water bills. Ecodesign requirements for washing machines were introduced in 2011 and tightened in 2013[17]. Assuming the 7.1 kg machine we use in the average household, the change in requirements reduces the maximum water usage from 71 litres of water to 53 litres of water per wash cycle. Over the course of a year (and an average 182 wash cycles) this change results in at least 3.25m^3 (3,250 litres) less water being used. At a weighted average EU water price of €2.98m^3 this leads to savings of €9.70 per year[18] [Eurostat, 2016].

The water use of dishwashers has not been regulated by Ecodesign although a review is currently underway. Draft documents indicate that minimum water use requirements may not be appropriate as further reductions are technically difficult without reducing product cleaning functionality. The Energy Label for dishwashers does include an indication of the total annual water consumption based on the consumption of a standard cycle, multiplied by 280 annual cycles. Best available technologies in the original Ecodesign directive in 2010 were identified as having water consumption of approximately 10 litres/cycle, or approximately 2,800 litres per year. The best available products identified by Topten have water consumption rated at around 1,900 litres per year. This saving of 0.9m^3 (900 litres) per year for the best available technologies would be equivalent to a saving of €2.7 euros/year for the average household.

Reduced water consumption will also have benefits for local water availability which is especially important in water stressed areas in Southern Europe.

5.4 Potential additional benefits in future

5.4.1 Potential benefits from expanded durability requirements

A product's sustainability is characterised to a large extent by its durability – namely its lifetime, reliability, and reparability. Durability measures the length of a product's life and gives information on how long it maintains its quality over this period. The reasons to replace a product can be split into four different types of obsolescence patterns. First of all, *technical obsolescence* usually occurs when a new product with a new technology completely replaces the old, for example CD's replacing cassette tapes. Secondly, and similarly, *functional obsolescence* describes the action of replacing an obsolete product when it can no longer adequately fulfil the functions it was created for. Thirdly, the style of a product can be a reason to replace a still adequately performing product. If the device has gone out of fashion or the style is no longer desirable in the eyes of the user, the process of replacing the old product is referred to as *style obsolescence*. Fourthly, the reason that a product requires replacement by a new one is not always based on consumer behaviour or technical evolution but can also be a result of manufacturers design decisions with some believing that they use (shorter) product life as a way to optimise their product strategy and increase sales. This is called *planned*

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[17] The requirements are stipulated in relation to the capacity of the machine by the formula c * 5 +35, where c = the capacity (in kg) of the machine. This formula was used from 2011-2013, since 2013 the formula has been 1/2c *5 +35, therefore halving the capacity allowance for water consumption in a standard wash cycle.

[18] Water prices calculated on basis of Eurostat household data and water price data from 24 Member States from Global Water Intelligence and Eurostat.

obsolescence and results from designing the product in a way that ensures it will be unfashionable or no longer functional after a certain period of time thereby limiting its useful life to the consumer.

The environmental impacts resulting from a short product service life can be highly significant. Firstly, contributing to the high volume of waste from electrical and electronic equipment. Short product lifetimes can also be highly dissatisfying for consumers. A study published by the German Federal Environment Agency [Prakash et al., 2016] underlines the importance of the durability of products through an economic and ecological comparison calculation between short- and long-life product variants. The research shows that long-lasting products despite higher manufacturing costs do better than short-life devices in all analysed environmental categories. In addition, it was found that the cumulative energy demand and the greenhouse gas emissions of less durable washing machines, televisions and laptops is significantly above the same from more durable, longer-life product variants [Prakash et al., 2016; Monier et al., 2016]. In some cases, e.g. refrigerators, increased energy efficiency has gone hand-in-hand with increased product durability [Waide, 2016].

Addressing the issue of reparability could also have socio-economic benefits for the EU as repair services are most often nationally or regionally-based. This is in contrast to product replacement where the economic benefits are concentrated in the country of manufacture which is likely to be more often outside of the EU than repair [Monier et al., 2016]. Moving to greater durability and reparability also creates opportunities for manufacturers such as expanding their business model towards service provision. Some manufacturers are already doing so [Cooper, 2016].

Regulatory instruments are one strategy to increase the durability of products which can help to achieve reductions in costs, energy expenses, greenhouse gas emissions, and other environmental impacts over the full product life cycle. It is possible that increased product durability may also deliver financial benefits to consumers, and this is part of what we assess in this study as the Ecodesign Directive contains provisions for the inclusion of durability criteria. Ecodesign-based durability requirements could include regulation of minimum product lifetime requirements, improved reparability and the improvement of consumer information in relation to the environmental benefits of more durable products [Prakash et al., 2016].

Current durability requirements for Ecodesign include the following:

- Non-directional household lamps (CFL and LED) – Durability requirements for lifetime and switching cycles.
- Directional lamps, light emitting diode (LED) lamps and related equipment - Durability requirements for lifetime and switching cycles.
- Vacuum cleaners (From Sep 2017) – "The hose shall be considered useable after 40 000 oscillations under strain if it is not visibly damaged after those oscillations. Strain shall be applied by means of a weight of 2.5 kilogrammes". The motor should also have a lifetime at least 500 hours. The specific requirements are currently under review.

The voluntary agreement on imaging equipment also includes some durability provisions relating to the upgradability of key components, e.g. processors, memory, cards or drives, and that this can be carried out using commonly available tools. Moreover, spare parts and maintenance services should be available for at least 5 years after a product is no longer produced. Additionally, the regulation on domestic ovens, hobs and range hoods has a provision that durability requirements will be considered when the regulation is reviewed in 2021.

Notably the requirements for lamps (lightbulbs) cover such long timescales that it is difficult to actually test the reliability of these. For example, if a lamp is required to function for more than 6,000 hours, testing will take over a year which leads to time delays and excessive costs for testing. This problem increases for LEDs which have estimated lifetimes of 20,000 hours or more.

Taking these existing requirements into account we carried out a further review to select five product groups for which extended durability requirements could have significant potential benefits for consumers. In doing so we applied three main criteria to products, namely that they should (1) have a relatively long lifetime; (2) show a significant number of break downs in the first 5 years of their lifetime; and, (3) typically be replaced only when they break down. Following discussions with ANEC-BEUC we agreed on the following products:

- Vacuum cleaners – utilising information from the ongoing special review of durability requirements [European Commission 2016].
- Smartphones – while the lifetime of this product is relatively short and reasons for replacement vary, there is increasing evidence that obsolescence is common to these products and that addressing this could be beneficial for consumers.
- Refrigerators.
- Washing machines.
- Coffee machines.

We operationalised and assessed the potential benefits of durability requirements for these products as follows:

Vacuum cleaners

Durability requirements for vacuum cleaners are due to enter into force from September 2017. As described previously these require a minimum of 500 hours of motor operation. The special review study interim report [VHK, 2016] carried out to specifically review durability requirements for vacuum cleaners proposes a potential increase in the requirement to 600 hours to accommodate an issue around the load of the vacuum bag or receptacle. The interim report references tests carried out by the German Consumer association (*Stiftung Warentest*) on the 600 hours' motor lifetime which found that approximately 87-90% of all cleaners met this level, regardless of price. We use the 600-hour assumption and therefore an increase in lifetime of 20% is modelled to simulate the potential benefit for the consumer. The purchase price difference of this change is set at 3%, corresponding to the price difference stated in the Interim report of the Special review p.18 (€227 minus €221) for average and 600hr compliant cleaners [VHK, 2016].

Assuming that a vacuum cleaner conforms to the minimum requirement of the current Ecodesign regulation and holding all other variables (efficiency, load) the same, the following calculation can be made for the impact of increased durability:

- Ecodesign product purchase price: €229, lifetime 6 years.
- More durable product purchase price: €236 (€229 * 1.03), lifetime 7.2 years.
- Equivalent Ecodesign product purchase price for 7.2 years lifetime: €275 (€229 * [7.2/6]).
- Total saving to consumer: €39, annualised saving of €5.40.

This is a relatively simple representation but provides an indication of the potential savings for the consumer. The actual saving could be more or less for many reasons, including that: the price and performance of the replacement product after 6 years is assumed to be the same; and, it is not clear if increased durability requirements would also reduce the incidence of early product failure and/or repair/maintenance costs, but any advantage here would also increase the savings for consumers.

Smartphones

Even though many consumers feel they cannot live without their smartphones, the market is still very young and the pace of change in the market is extremely rapid. Mobile telephones have become small computers, where parameters like storage capacity and speed of the processor are important features. It is not just about calling, it is also about taking pictures and videos and being able to use an increasing number of more and more sophisticated apps.

Mobile phones do not enjoy long lifetimes in practice. Several reasons can be mentioned for this. One reason can be that a consumer wants to obtain a newer model with more capabilities as the market is evolving so rapidly. However, there are also many instances where consumers are forced to discard their device because of a malfunction within the first 1-2 years of use. Common examples of hardware malfunctions are broken screens or cameras, dead batteries and damaged buttons. It is suspected that devices are designed to have rather limited lifetimes. Consumer organisations have collected a number of examples of expensive products that failed soon after the end of the guarantee period and could not be repaired [Maurer and Pachl, 2015]. Problems can also be encountered with telephone software, in some instances caused by manufacturers / developers who fail to provide security updates, especially for models in the lower market segment [Consumentenbond, 2016]. In other cases, repair activities have been obstructed. The Australian Competition and Consumer Commission found instances of Apple software disabling handsets if it detected repairs by non-Apple technicians [The Guardian, 2016]. An issue not directly related to failure or lifetime is demonstrated by tests that showed storage capacity to be more than 30% lower than according to the specifications [Test-Achats, 2016]. It is likely that hardware innovation will slow, and there are already some signs of this. As the focus of development moves towards software, this potentially opens the door for more modular smart phone design [Cooper, 2016]. This could support more durable basic components and replacement of only necessary parts as they become obsolete or fail, i.e. only a CPU, or camera needs to be replaced, not the whole phone.

The Preparatory Study to establish the Ecodesign Working Plan 2015-2017 estimates that resource consumption can be reduced by 10% and energy use by 12.6 PJ (3.5 TWh) for every 3 months by which the lifetime of smartphones is extended. While these numbers are very significant, there is limited incentive for manufacturers to actually increase product lifetimes, as this may reduce the frequency with which consumers replace their smartphones and therefore sales.

An increased device lifetime could save consumers significant amounts of money, in reduced purchase costs. Taking a simple indicative example, with assumed price differences:

- Assumed smartphone purchase price: €250, lifetime 2 years.
- More durable product purchase price: €275, lifetime 2.5 years.
- Equivalent Ecodesign product purchase price for 2.5 years' lifetime: €312.50 (€250 * [2.5/2]).
- Total saving to consumer: €62.50, annualised saving of €25.00.

These prices are simple estimates and not based on real examples, as data of this type is scarce, but they serve to illustrate the point that a 6-month increase in product lifetime could deliver significant savings to consumers, assuming that this extended lifetime can be achieved at reasonable cost.

The Ecodesign Directive is a very suitable instrument to tackle a number of aspects that would increase longevity of mobile phones. For example:

- An Ecodesign information requirement could be formulated to provide lifetime information.
- France has already introduced a legal requirement which requires information about the time for which spare parts will be available. This could be considered to increase reparability.
- To provide design requirements enabling easy battery exchange and the possibility for saving or erasing personal information (enabling a second life). Further study might identify further specific and verifiable design requirements. In Austria, a technical standard has been developed to set labelling criteria for electrical and electronic appliances designed to be more durable and repair-friendly. To obtain this label, key design criteria have to be met such as accessibility of components in a machine to allow for easy repair and use of standardised interfaces and marketing designs which simplifies repair and widens the range of spare parts.
- Prohibition of built-in software or software-updates that disable the phone if third parties attempt repair.
- Improved recycling through easy end-of-life removal of batteries.

A thorough preparatory study should clarify feasibility and urgency of these and other issues. Ecodesign will not be the only instrument with which it is possible to improve the situation around lifetime of mobile phones. Improved guarantees of mobile phones and improved quality of repair shops, better price/quality ratio of repairs are also issues that could be addressed.

Refrigerators

There are currently no durability requirements in place, but evidence shows that refrigerators are being replaced sooner due to defects, and that defects in the first 5 years of operation have significantly increased over the same period [VHK, 2016; Prakash et al., 2016]. The recently published review study [VHK, 2016] concludes that in energy and emissions terms there is unlikely to be any benefit from extended lifetimes for refrigerators due to improvements in the energy efficiency of the average refrigerator during the operational lifetime of the product. Reparability is also increasingly a concern as failure of relatively small but important components, such as door seals, can require expensive replacement of larger components such as a whole door, which in some cases can mean that purchasing a new refrigerator is cheaper than repairing what in itself is a relatively minor fault.

In respect of durability, further calculations by the study team suggest that there could be benefits from the financial perspective of the consumer. We compare two scenarios over 20 years, as an example period for extended lifetime where: (1) a current Ecodesign product with lifetime of 16 years is replaced by an assumed standard product after this period; and (2) a scenario where the current product is more durable and has a lifetime of 20 years, but is otherwise unchanged.

This requires a few assumptions on energy use, energy prices and purchase prices for the respective products. For scenario 1 we start from the Ecodesign case for combined fridge-freezers used in this study, with 229 kWh annual energy use and a purchase price of 708 euros, we use the review study efficiency of 150 kWh annual energy use for the replacement product after 16 years. The purchase price we assume for the replacement is based on the same ratio used in the study to derive purchase prices (see annex A), and of which a quarter (4 of 16 years' lifetime) is used. For scenario 2, we assume the same energy use as today, 229 kWh per year, over the full 20-year period, but with an increase of 3.75% in the purchase price for this 25% more durable product – this is based on an assumption of price increase proportional to the observed 3% increase in product purchase price for 20% more durable vacuum cleaners presented above. Clearly this price increase assumption is somewhat arbitrary, as it is based on an actual case for vacuum cleaners not refrigerators. With the lack of refrigerator specific data of this type, this simple assumption allows for an estimate to be made, but should be taken into account when considering the results. The results of this simple calculation are presented below:

Table 4: Estimated economic impact of improved durability requirements for refrigerators

	1. Without durability	2. With durability
Purchase price current (euro)	708	734
Purchase price future (euro)	205	0
Kwh cost	798	857
Total cost (euro)	**1711**	**1591**
Saving		120
Annual saving		6

The results show a benefit for consumers, with the durability (extended lifetime) scenario offering an advantage (6 euros/year saving) compared to the without durability scenario.

There are sensitivities to the calculation. For example, if increased durability could only be achieved at a higher cost, the outcome could change, i.e. if the proposed 25% lifetime improvement could only be achieved at 21% rather than 3.75% cost increase then this would lead to the without durability scenario becoming more attractive (with other factors remaining the same). It is also the case that, for simplicity, energy prices have been held constant over time, and no discounting has been performed on future costs and benefits. If future price changes were to be modelled and discounting applied, the results could change. These issues and sensitivities are common to work of this kind – see also [Ardente and Mathieux, 2014]. As a result, although we show a potential benefit for consumers, we are unable to conclude strongly in favour or against consumer benefits from extended lifetime requirements for fridge-freezers. It is feasible that there could be financial benefits for consumers, but it is not possible to say with any certainty how large these could be because of a lack of data on the (likely higher) cost of producing more durable products.

Durability requirements have the potential to offer consumers financial savings if they address the significant financial costs that arise from premature failure and reparability. We recommend these as the focus of any Ecodesign requirements in this area.

Washing machines

There are currently no durability requirements in place but in the context of Ecodesign durability and reparability of washing machines might become more relevant in the future. The main reason for this is an increasing failure rate of key components. Incorrect use or insufficient maintenance also contribute to early appliance failure.

While repair may prolong the lifetime, washing machines are most likely to be replaced if a defect appears because the repair costs are typically too high or the necessary spare parts are unavailable. The tendency of replacing a product can also be identified due to changes in consumer preferences and needs, which could be the satisfaction of having a larger or more modern product with new features. While this may be expected for consumer electronics such as mobile phones, TVs and computers, it is also increasingly the case for consumer durables such as washing machines [European Commission Joint Research Centre - Institute for Prospective Technological Studies (JRC/IPTS), 2015] [Prakash et al., 2016]. At the same time, there is also an increasing trend towards product digitisation and it can become easier, and cheaper, to diagnose and address product faults digitally by communicating with the device, or simply updating its software [Attali, 2016].

As with refrigerators, further calculations by the study team suggest that there may be a financial benefit for consumers. We compare two scenarios over 19 years, as an example period for extended lifetime where: (1) a current Ecodesign product with lifetime of 15 years' lifetime is replaced by a product assumed to be standard after this period; and (2) a scenario where the current product is more durable and has a lifetime of 19 years (4 years longer) but is otherwise unchanged. This requires a few assumptions on energy use, energy prices and purchase prices. For scenario 1 we start from the Ecodesign case used in this study with 229 kWh annual energy use[19] and a purchase price of 332 euros. In the absence of an alternative estimate we use an estimated future efficiency of 150 kWh annual energy use for the replacement product after 15 years, this is consistent with the approach for refrigerators which have the same starting energy use. The purchase price we assume for the replacement is based on the same ratio used in the study to derive purchase prices (see annex A) which is proportionally included (4 of 15 years' lifetime). For scenario 2, we assume the same energy use as today, 229 kWh per year, over the full 19-year period but with an increase of 4% in the purchase price for this 27% more durable product. Again, based on an assumption of price increase proportional to the observed 3% increase in product purchase price for 20% more durable vacuum cleaners presented above. The results of this simple calculation are presented below:

[19] Although this is the same value as for refrigerators the values were arrived at independently and are the same by coincidence.

Table 5: Estimated economic impact of improved durability requirements for washing machines

	1. Without durability	2. With durability
Purchase price current	333	346
Purchase price future	136	0
Kwh cost	755	814
Total cost	**1224**	**1160**
Saving		64
Annual saving		3.4

The results show a benefit for consumers in the durability (extended lifetime) scenario as it offers an advantage of 3.4 euros/year saving compared to the without durability scenario. There are sensitivities to the calculation. For example, if increased durability could only be achieved at a higher cost the outcome could change, i.e. if the proposed 27% lifetime improvement could only be achieved at 22% rather than 4% cost increase then this would lead to the without durability scenario becoming more attractive (with other factors remaining the same). Energy prices have been held constant and no discounting has been performed on future costs and benefits to keep the method simple. These issues and sensitivities are common to work of this kind – see also [Ardente and Mathieux, 2014]. As a result, although we show a potential benefit for consumers, we are unable to conclude strongly in favour or against consumer benefits from extended lifetime requirements for washing machines. It is feasible that there could be financial benefits for consumers but it is not possible to say with any certainty how large these could be because of a lack of data on the (likely higher) cost of producing more durable products.

Durability requirements have the potential to offer consumers financial savings if they address the significant financial costs that arise from premature failure and reparability. We recommend these as the focus of any Ecodesign requirements in this area.

Coffee machines

A desk-review of durability requirements for coffee machines was carried out. This found no significant evidence relating to extended lifetimes of these appliances, although there was reference to the relatively high cost of replacing defective water tanks leading to replacement of the whole appliance rather than repair.

A simple estimate can be made, using a similar approach to vacuum cleaners and estimating the benefit of 20% longer lifetime, on the basis of the standard lifetime of a coffee machine which is assumed to be 6 years in the VHK IA study, therefore:

- Ecodesign product purchase price: €162, lifetime 6 years.
- More durable product purchase price: €167 (€162 * 1.03), lifetime 7.2 years.
- Equivalent Ecodesign product purchase price for 7.2 years' lifetime: €194 (€162 * [7.2/6]).
- Total saving to consumer: €27.60, annualised saving of €3.83.

As before, this is a relatively simple representation, but provides an indication of the potential savings to the consumer. The actual saving could be more or less for many reasons, including that the price and performance of the replacement product after 6 years is assumed to be the same – if this was significantly improved it would reduce the savings potential, i.e. lower energy costs from the replacement product. Also it is not clear if increased durability requirements would also reduce the incidence of early product failure and/or repair/maintenance costs, but any advantage here would also increase the saving for consumers. In any case, as discussed previously, the reasons for changing an appliance remain complex and are as much due to consumer preference for a new product rather than the existing product being defective. Therefore, the savings estimated above cannot be predicted with any certainty to be achieved if durability requirements were introduced.

Conclusions on durability requirements

This section reviews, describes and explains some of the key factors relevant for durability requirements for five products. It also makes some simple estimates of the potential financial benefits. Among the key conclusions are:

- There is increasing evidence of reducing product lifetimes, although the drivers of this are unclear with planned obsolescence, consumer preferences, and difficulties in repair among the key drivers.
- Repair costs are important. In some cases these are higher than the cost of purchasing a new device, leading to consumers replacing devices which only have minor faults.
- Making products more reparable could bring socio-economic benefits for the EU in comparison to product replacement, as repair firms are more likely to be EU-based than product manufacturers. At the same time there can also be opportunities for manufacturers to expand their business model into offering these services.
- It is difficult to estimate the financial benefits for consumers of increased durability as, in many cases, it is unclear how much more expensive a more durable product would be. Further work is needed to better clarify this point. Yet, using simple assumptions, estimates can be made which point towards financial savings for consumers. In any case, the financial impact of any changes through Ecodesign should be communicated to consumers.
- Environmental impacts of increased durability are important and have been shown to be clear and positive in almost all environmental categories, but especially in terms of resource use and related impacts.

5.4.2 Potential benefits from additional product coverage

Extending Ecodesign and Energy Labelling to other product groups can potentially deliver further financial savings to consumers. A number of products are being considered for regulation in the draft Working Plan for Task 4 report 2015 – 2017 [BIO by Deloitte et al., 2014]. We carry out a simple review based on the (limited) available data to reflect on the potential further savings an average EU household could gain if the regulations were extended to a selection of other common household products.

Based on the Working Plan study we have made simple estimates of the energy and financial savings for electric kettles, toasters, hair-dryers, and inverters for solar photovoltaic (PV) systems if these were to be regulated under Ecodesign in the future. An overview table of results is given below. This shows estimated gross savings of energy costs of approximately €25 per year. The estimates in the table do not take account of potential increases in product purchase prices, as data is unavailable. A rule of thumb for a ratio of extra purchase costs to energy savings of 25% was used in previous work [Molenbroek et al., 2012]. **Net savings can therefore be estimated at €19 per year for an average household,** with a high uncertainty attached to this estimate.

Table 6: Overview of potential savings from the extension of Ecodesign to other products

Product	Estimated annual electricity use	Estimated saving potential	Value of saving [euros/year]	Other areas for potential Ecodesign action
Kettle	167 kWh/year	Up to 24% (40 kWh)	€7.5	Durability
Toaster	40 kWh/year	35% (14 kWh)	€2.6	Durability
Hair-dryer	70 kWh/year	30% (21 kWh)	€3.9	Durability, Noise
Inverters for PV systems	Assuming a 3kW system, generating approximately 3,000 kWh/year, each inverter conversion efficiency % point is worth 30 kWh/year	Based on 2% improvement potential (60 kWh)	€11.2	
Total			**€25.2**	

We also searched for relevant information on mobile (smart) phones, (wireless) home telephones, electric toothbrushes, and shaver/trimmers, but either found little data or data that suggested that annual energy use is very low as these devices typically have a low wattage and are usually battery driven[20]. The total battery energy cost may be less than €1 per year per device. Therefore, both energy and financial savings potential is also very limited at the individual product level.

At the same time energy savings from these devices may still be substantial at the EU level and therefore it remains worthwhile to consider these products for Ecodesign and Energy Labelling measures. It would be most important to reduce consumption of the chargers in "no-load condition" to a maximum of 0.075 W, which the draft working document for the review of regulation 278/2009 already foresees as from January 2018 on [European Commission, 2015a]. At the current limit of 0.5 W, the annual energy consumption of a charger while in "no load condition" may easily be higher than what is needed for the actual operation of the device.

It can be of particular interest to adopt Ecodesign to simultaneously address durability, reparability, and resource use which can be of relatively high importance for these products, i.e. important resources contained with smart phones.

[20] For example around 2 kWh per year for smartphones, less than 20 kWh per year for home telephones, less than 3 kWh per year for electric toothbrushes, electric shaver less than 1 kWh per year.

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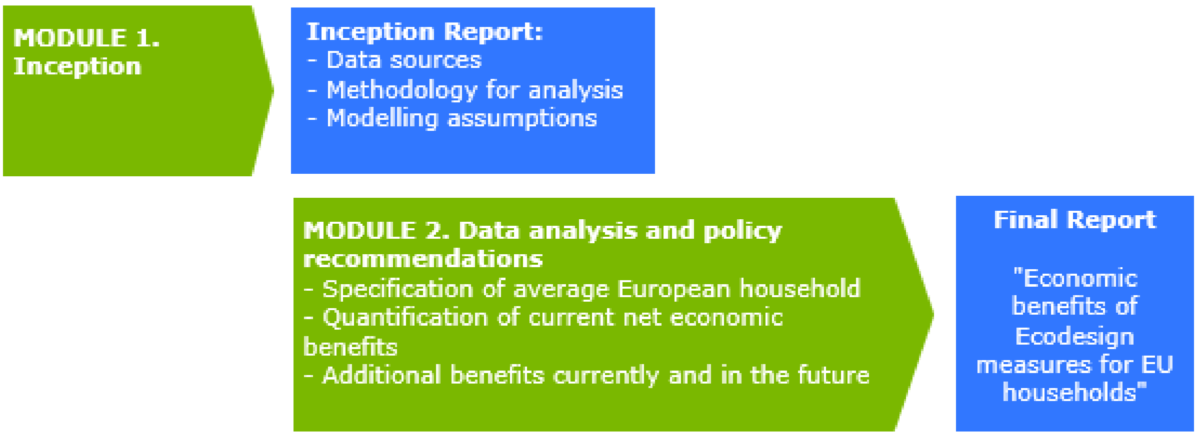
Annex A: Approach and methodology

Overview of the approach

Figure 5 below provides an overview of our approach to this work. This follows the module structure proposed in the original terms of reference.

- Module 1 represented an extended inception phase with two key tasks, firstly an inception meeting, and secondly development of the inception report. The inception report enabled an informed choice to be made regarding the further work in module 2, including on data purchase costs and expectations.
- Module 2 represented the key data gathering and analysis steps to work towards the final report with policy recommendations. This was split into four tasks, first defining the average household; second, quantifying the current benefits conferred on this average household by Ecodesign (and Energy Labelling); third, identifying additional benefits in future, from increased durability and more qualitative benefits; and, fourth, producing the final report with recommendations.

Figure 5: General approach



A more detailed description of our approach, key sources, assumptions and modelling is provided in the following sections.

Product scope and data availability

The products selected in this study were selected based on the original terms of reference for the work, data review and discussion with ANEC-BEUC. The initial data review looked at key data sources including:

- **VHK Ecodesign Impact Accounting reports 2014 & 2015** – these contain for the majority of product groups modelled estimates of stock, efficiency, energy use and cost data. This data was agreed to be the primary baseline for this work.

- **Odyssey-Mure dataset** – a large and detailed dataset but with only partially relevant information and coverage at EU level. This would primarily be of use to cross-reference data from other sources, i.e. on number of appliances in average household.
- **Topten** – provides a database on energy efficient products and a range of reports analysing trends in product energy use, efficiency, price, size and market share over time.

The table below highlights the coverage of the product groups by these data sources.

Table 7: List of products covered in study, data availability and sources

Product	ED	ELD	# per household	Available data sources		
				VHK IA report	Odyssey-Mure dataset	Topten
Gas central heating system (lot 1)*	X	X	1	x		
Dedicated (gas) hot water heater (lot 2)*	X	X	1	x		
Electric room heater (lot 1)	X	X	1	x		
Combined fridge freezer (lot 13)	X	X	1	x	x	x
Electric oven with electric hobs (lot 22, 23)	X	X	1	x		
Coffee maker (lot 25)	X		1	x		
Washing machine (lot 14)	X	X	1	x	x	x
Vacuum cleaner (lot 17)	X	X	1	x		x
Televisions (lot 5)	X	X	1.625	x	x	x
Desktop PC computer and monitor or laptop (lot 3)	X		1	x		
Tablet PC (lot 3)	X		1	x		
Complex set-top box (lot 18)			1			
Combined router/Wi-Fi hub			1	x		
Wireless home phone			1	x		
Mobile phone			2	x		
Electric toothbrush			1	x		
Lighting (lot 19)	X	X	45	x		X
Dishwashers (lot 14)	X	X	0	x	x	x
Standby modes (lot 6, 26)	X		-	x		
Solar Panel inverters						

*For these heating technologies we also applied the BEAM model, an Ecofys in-house tool for estimating and quantifying building energy use and impacts. This was used to check and in some cases overwrite the VHK IA report data.

Excluded from the analysis were:

- Clothes dryers (lot 16) – not a typical household appliance.
- Sound and imaging equipment – games consoles (lot 3 ENTR) – no significant Ecodesign or Energy Labelling requirements.
- Air conditioning and related equipment (lot 10, 11) – not used by a majority of households.

Modelling assumptions and methodological development

Per product the following assumptions are made:

Efficiency and/or load values are taken from the VHK IA study [Kemna and Wierda, 2015] PRICE, EFBAU and LOAD sheets – please see page 1 of Annex A of the VHK study for definitions of these capitalised tables. In some cases (see below), further calculations, conversions and/or assumptions are required to make these comparable to the Ecodesign and Energy Label/BAT efficiency metrics.

Purchase price and efficiency values are based on the PRICE table from the VHK IA study [Kemna and Wierda, 2015]. These provide for 2010 for a base case, mid-case, and best available technology:

- Purchase price.
- Efficiency / load level.
- Change in product purchase price per change in efficiency level.
- Autonomous annual price decrease.

By analysing the change in weighted average new product efficiency between 2010 and 2015 from the EFBAU (efficiency of new products in business as usual [no Ecodesign/Energy Label] scenario) sheet of the IA study [Kemna and Wierda, 2015], we assume a proportionally equal change in the average efficiency for the base case between 2010 and 2015.

Using the autonomous annual price decrease, the percentage efficiency change, and the change in product purchase price per change in efficiency level variables, we update the purchase price of the base case product. We also use the change in product purchase price per change in efficiency level to calculate the purchase price of the Ecodesigned and Energy Labelled / BAT products.

All prices are adjusted from 2010 to 2015 euros by applying the historic annual inflation rate for this period of 1.72%, which is derived from observed Euro-zone inflation rates as reported by the European Central Bank.

Running costs are assumed based on the RUNBAU (total running costs of product stock in business as usual [no Ecodesign/Energy Label] scenario) sheet, which provides the total EU27 (Croatia not yet included in the dataset) running costs (energy costs + maintenance + resources [water, detergent, etc.;]) for all appliances in the EU27 in 2015. These are divided by the number of units operational in the EU from the STOCK sheet of the IA study to arrive at an average unit running cost. The NRGCOSTBAU (total energy costs of product stock in business as usual [no Ecodesign/Energy Label] scenario) sheet is used in the same way to determine the energy specific element of the total running costs. In doing so the non-energy running costs per unit are also calculated.

Appliances are defined in terms of their efficiency values. As noted above, the base case efficiency value is updated from the values provided in the PRICE sheet of the IA study. The Ecodesign and Energy Labelling / BAT values are derived from the regulations or other data (see below). In each case the values either directly provide for kWh/year energy consumption, or indirectly allow calculation of the same through a known (and assumed constant) load placed on the appliance (from the LOAD sheet of the IA study) and the efficiency values.

The relationship between the efficiency values in the three scenarios is used for the remaining calculation steps.

For the unit purchase price, the base case price is used as a starting point to which we add a value equal to the proportional difference between the Ecodesign or Energy Label / BAT efficiency multiplied by the price change per efficiency unit change factor.

Annual energy use (in kWh) is used to calculate the value of the energy savings over the lifetime of the product. Annual energy use is assumed to be the same each year of the product lifetime. The energy prices used are presented in section 5.2.1 and are increased by 4% each year. Other running costs are also increased by 4% each year.

Future energy savings are discounted by an annual factor of 4% to represent the time preference of consumers for benefits now rather than in future. Other non-energy running costs are also similarly discounted. These are assumed to be the same across all products, regardless of efficiency.

Purchase costs are added to the total discounted energy costs and other running costs to reach a total lifetime cost for the consumer. This is divided by the lifetime of the appliance to arrive at an annualised cost value which is then compared to calculate potential savings for consumers.

All euro values from different years are deflated to the reference year of 2015.

Purchase price assumptions

The purchase price of the product across the scenarios has a crucial impact on the financial outcomes. The VHK IA study was used as the primary source for purchase prices. The IA study base case was used for the reference scenario. This was then updated from 2010 to 2015 euros and values, taking into account observed inflation, autonomous efficiency improvements, and the increased cost of the product resulting from these autonomous efficiency improvements. The price increase of the autonomous efficiency improvements was modelled using the approach described in the previous section. The following table presents the purchase prices per product and scenario. It also highlights the source for the best available technology. Large price differences are evident for the central heating technology; this represents the currently high cost of renewable energy heating systems such as heat pumps. In a handful of cases, such as electric room heaters and dishwashers, the Ecodesign scenario price is lower than the reference scenario, as the price is linked to the product efficiency. As the Ecodesign efficiency is lower than the reference case the purchase prices are consequently also lower.

Table 8: Product purchase prices used in calculations

Product	Reference scenario	Ecodesign scenario	Label / BAT scenario	BAT value derived from
Central heating (gas/electric*)	2288.1	2 889.5	9 137.1*	BAT (Ecofys)
Water heating (gas)	522.6	496.6	1 404.2	BAT (Ecofys)
Electric room heater	28.1	23.0		None
Fridge-freezer	427.4	707.8	865.3	BAT (Topten)
Electric oven	561.9	573.7	756.0	BAT (Topten)
Electric hobs	147.0	158.4		None
Washing machine	423.6	332.5	535.4	BAT (Topten)
Vacuum cleaner	228.5	228.5	232.3	BAT (Topten)
TV	466.0	425.3	497.2	BAT (Topten)
Lightbulbs	0.9	4.0	6.5	BAT (VHK)
Dishwasher	560.3	390.9	907.6	BAT (Topten)
Complex set-top-box	155.3	168.4		None
PC	465.5	458.2		None
PC-monitor	176.1	181.5	197.9	BAT (Topten)
Coffee maker	161.6	161.6		None
Tablet PC	466.0	495.1		None
Router	86.7	86.7		None

* The Label/BAT central heating appliance is an electric heat pump, the Reference and Ecodesign products are gas-fired boilers.

Product specific assumptions

The approach per product generally followed the approach and assumptions presented above or detailed in the product factsheets attached as Annex B. It was necessary for some product groups to modify or deviate from the general approach because of different efficiency metrics, technology and price developments and different load profiles to the average assumed in the source materials. The following section details these cases.

Gas central heating boiler

Prices of the heating boilers in the VHK 2015 base case and BAT case were checked against the in-house Ecofys BEAM model. The BEAM model contains data of boiler characteristics including price, and with price variations across Europe. These were weighted by the number of households to arrive at a household weighted European average product purchase price. It was chosen to use the BEAM data as this model is completely focussed on heating and cooling applications. The base case price was assumed to scale proportional to the efficiency of the Ecodesign requirement efficiency.

In addition, the energy savings for the boilers were calculated slightly differently as the energy carrier in the base case (gas) differed from the BAT case (electricity), where an electric heat pump was modelled. Therefore, the savings are based on the electricity price.

Gas hot water heater

For the Energy Labelling/BAT scenario the BAT represents a high-efficiency natural gas water heater.

Electric room heater

We assumed an [1 kW] electric portable local space heater. All types of electric heaters are covered by the Ecodesign regulation, with a large range in base efficiencies between the different types of local space heaters that are regulated. This explains the large divergence of the reference scenario and Ecodesign efficiency values, as portable electric heaters are relatively efficient, in comparison to an open fireplace or gas heater.

Electric ovens

The Ecodesign and Energy Labelling requirements are listed in terms of the EEI for electric ovens. The formula for the EEI is a factor of the energy consumption required to heat a standardised load divided by a standard energy consumption (SEC) for heating the same load according to the formula SEC = 0.0042 * volume (litres) of the oven + 0.55 kWh. It is critical then to make an assumption regarding oven volume. We have assumed an oven volume of 65 litres, based on review of available ovens, and an annual load of 110 oven cycles per year assumed from the VHK 2015 study.

An oven of volume of 65 litres with an EEI of 100 is equivalent to 0.82 kWh per cycle and 90.5 kWh/year. The Ecodesign standard, set at an EEI of <121 translates into a per cycle energy use of 1.0 kWh per cycle and 109.5 kWh/year.

For the Energy Labelling maximum label class of A+++ an oven must have an EEI <45, which would translate into energy use of 0.37 kWh per cycle and 40.7 kWh/year. A review of the current market found no products currently operating at this level, the highest ranking product, had an EEI of 61.3 (A++), which at a volume of 65 litres would translate to energy use of 0.50 kWh per cycle and 55.5 kWh/year. The latter value is therefore used in the calculations.

Electric hobs

The Ecodesign requirements for electric hobs are listed in terms of the kWh required to heat a litre of water to boiling and to keep it at this temperature for 20 minutes, with an assumed load of 1,229 litres based on VHK.

As no Energy Labelling regulation applies to hobs, the Best Available Technology as presented by Topten is used as the high savings estimate.

Washing machine

The washing machine efficiency is based on an assumed 182 wash cycle per year load and a wash capacity of 7.1 kg. The energy efficiency index for the average machine is calculated assuming this capacity value.

The Energy Labelling/BAT scenario is selected on the basis of BAT and the top performing product as assessed by Topten (topten.eu). The reason for this is that many products have now exceeded the A+++ threshold for washing machines. To the extent that some retailers and manufacturers have begun to create their own label categories, i.e. A+++ -10/20/30/40/50% to differentiate products more efficient than the A+++ class. This demonstrates that energy efficiency is a key point of product competition and differentiation but that the Energy Label is judged by some retailers and industry to be unfit for purpose at the top end of the market.

Vacuum cleaners

The energy use calculations are based on an assumed cleaning load of 31.2 hours/year across all scenarios.

The allowed annual energy use under Ecodesign is directly stated in the regulation (62 kWh/year). The highest Energy Label class (A) is equivalent to a maximum energy use of 10 kWh/year. The current best performing vacuum cleaner as listed on Topten uses 25.5 kWh/year. The latter, as BAT, is used for the calculations.

Televisions

The VHK base case was based on a viewable screen area of 36.8 decimeters^2, or equivalent, assuming a standard 16:9 aspect ratio, an approximate screen size of 36.5" or 93.5cm. As this is not a standard screen size, the base case values were adjusted to reflect a standard screen size of 32", or 81.25cm, based on a recent market report (Topten, 2013). Price, efficiency, and energy consumption values from the base case were adjusted accordingly.

No price change per efficiency unit change factor was provided in the VHK study. Based on Ecofys' expert judgement it was decided to set this factor to 0.5 euros / kWh annual energy use improvement. This relatively low value was selected as efficiency is yet to be a major point of competitiveness or selling point for TVs. Price, quality, and other features and functionality are dominant in consumer choices and product price variations. It is not possible therefore to derive an actual efficiency premium for TVs.

For the BAT scenario the product in the assumed size category has an EEI that falls within the current highest available label class (A+). In larger size categories products are already available performing at the A++ level, although this category does not become available until 2017.

Energy use for each scenario was calculated bottom-up. This included a modified assumption for daily usage compared to VHK, with a daily on-mode usage of 4 hours assumed. Standby energy use was calculated from the VHK 2015 study for the base case, for Ecodesign it was set to 0.5W and for Energy Label/BAT it was set to 0.3W.

For the 2nd smaller TV set assumed to be owned by the average household, assumed to be a TV set of around 20", which in the base case has an energy use of approximately 62.5% of the 32" TV. This multiplier is used to calculate aggregate savings for the TV sets in the average household.

Lightbulbs

For lightbulbs three different bulb types were selected to represent the three scenarios, namely:

- Non-Ecodesign: Standard incandescent (GLS) bulb.
- Ecodesign: CFL bulb.
- Energy Label/BAT: LED bulb.

The characteristics of each, in price, lumens, efficiency (lumens/watt), and hours of usage, were taken directly from the VHK IA study (2015) [Kemna and Wierda, 2015].

In reality LED lamps are rapidly improving in price, efficiency and overall performance. It is likely the actual savings that can be achieved are even higher than those modelled in our BAT case.

Complex set-top boxes
The Ecodesign regulation applies only to the stand-by mode of this product, although a voluntary agreement on efficiency is in place.

The calculation for efficiency assumes for Ecodesign the efficiency value from the ECOEFN table of VHK 2015, and therefore reflects the projected sales-weighted average energy use of products sold in 2015. The BAT is also taken from the VHK study, from the BAT value presented on the PRICE table. The rest of the approach is standard.

Desktop-PC
The Ecodesign value for efficiency in kWh/year is taken directly from the regulation. As no Energy Labelling regulation applies, this is not modelled.

No price change per efficiency unit change factor was provided in the VHK study. Based on literature review and expert judgement it was decided to set this factor to 0.75 euros / kWh annual energy use improvement. This relatively low value was selected as efficiency is yet to be a major point of competitiveness or selling point for Desktop PCs, but some cost increase is to be expected for more efficient hardware. Price, quality, and other features and functionality are dominant in consumer choices and product price variations. It is not possible, therefore, to derive an actual efficiency premium for PCs.

PC-monitors
These fall under the TV product group for Ecodesign and Energy Labelling, therefore a similar approach was used. The VHK base case was based on a viewable screen area of 13.5 decimeters^2, or equivalent, assuming a standard 16:9 aspect ratio, an approximate screen size of 22” or 56cm. This screen size was thought to be higher than standard, therefore the base case values were adjusted to reflect a standard screen size of 19”, or 49cm. Price, efficiency, and energy consumption values from the base case were adjusted accordingly.

No price change per efficiency unit change factor was provided in the VHK study. Based on literature review and expert judgement it was decided to set this factor to 0.5 euros / kWh annual energy use improvement. This relatively low value was selected as efficiency is yet to be a major point of competitiveness or selling point for Monitors. Price, picture quality, and other features and functionality are dominant in consumer choices and product price variations. It is not possible, therefore, to derive an actual efficiency premium for Monitors.

For the high scenario a BAT example was used from Topten. The BAT in the assumed size category has an EEI that would fall under the A++ level, although this category does not become available until 2017.

Energy use for each scenario was calculated bottom-up. This included a modified assumption for daily usage compared to VHK, with an assumed daily on-mode usage of 2 hours. Standby energy use was calculated from the VHK 2015 for the base case, for Ecodesign it was set to 0.5W and for Energy Label/BAT it was set to 0.3W.

Coffee maker

The Ecodesign regulation on networked standby-by losses regulates the energy use of coffee machines. The efficiency value for the Ecodesign scenario was taken from the VHK study EFN ECO table for 2015, which demonstrates a reduction in the stand-by energy use for these appliances.

A BAT appliance was also included, on the basis that the Ecodesign regulation may have stimulated further reductions in power usage.

A price change per efficiency unit change factor of zero was provided in the VHK study. This was not changed.

Tablet

Tablets are regulated under the networked stand-by loss Ecodesign regulations. It was assumed that tablets are 'without High Network Availability' and therefore required to have energy use of less than 6W as of 2017. This was used to calculate the maximum energy usage for the Ecodesign scenario, based on an assumed daily usage in on-mode of 2 hours. Stand-by/idle energy use for the remaining 22 hours of 0.5W, consistent with the broader regulation, was also assumed.

No price change per efficiency unit change factor was provided in the VHK study. Based on expert judgement it was decided to set this factor to 5 euros / kWh annual energy use improvement. This relatively high value was selected as the size constraints in such devices tend to lead to higher cost individual components. It also remains true that efficiency is yet to be a major point of competitiveness or selling point for tablets. Price, screen quality, operating system, speed, and other features and functionality are dominant in consumer choices and product price variations. It is not possible therefore to derive an actual efficiency premium for tablets.

Router

Internet routers or gateways are also subject to networked stand-by loss regulations. This product group was one of the product groups covered by the draft Preparatory Study to establish the Working Plan 2015-2017. Values from this study were used in some cases to over-ride the values used from the VHK standard approach. These include the purchase price which was set to 100 euros.

No price change per efficiency unit change factor was provided in the VHK study. Based on expert judgement it was decided to set this factor to 1 euro / kWh annual energy use improvement. This relatively low value was selected as efficiency is yet to be a major point of interest or competitiveness for routers. Price, size, and functionality are important to the extent that consumers have any influence in the purchase of these products. It was not possible therefore to derive an actual efficiency premium for routers.

Annex B: Product factsheets

Provided separately.

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