Monitoring the market based on sales data: Do 2015 white goods consume less energy than ten years ago?

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Abstract

Knowing the market is key for deciding on energy label classes' thresholds, minimum energy performance standards (MEPS) and revisions of these. Up to now, the European Commission has no systematic approach to monitor the market and evaluate policy measures. Our paper demonstrates the potential of systematic market monitoring based on sales data. The results support the revisions of the Ecodesign and Energy Labelling regulations. In a report to be published in March 2017, we have analysed comprehensive sales data from GfK for refrigerators, washing machines and tumble driers. The data covers the years 2004–2015 for the national markets of France, Germany, Italy, and for the whole EU market. It includes information on sales per energy efficiency class, average energy consumption, size and price.

The results show that the efficiency of refrigerators has improved by 37 % since 2004. The energy consumption, however, has decreased less than could be expected from this. For washing machines, the results confirm a strong trend to larger drums. High efficiency is strongly linked to large drums. Considering the low efficiency of small partial loads, this trend lets us question the reported energy savings. Heat pump tumble driers have continued to extend their popularity among consumers: this energy-efficient technology made up nearly half of all drier sales in the EU average in 2015. On certain national markets, their sales share can be even higher. Over their lifetime, heat pump driers are less costly than class B driers. In the revision of the Ecodesign regulation, due in 2017, a ban of driers less efficient than class A+ could save Europe around 5 TWh per year. The results further show large differences between national markets – even though the same regulatory framework applies in all EU Member States, and the same international manufacturers dominate most markets.

Introduction

Energy Labels and Ecodesign requirements can effectively support a market transformation to higher energy efficiency and lower energy consumption. But they need to be well suited to the market: most classes of Energy Labels should cover proportions of the market while still offering an incentive for improvement with "empty" top classes, and Ecodesign requirements should be ambitious enough to push the market. Therefore, it is key that policy makers know the market when defining new or revising existing Labels and minimum energy performance requirements (MEPS). Up to today, Europe does not systematically track its markets, and usually very little is known about market trends. This is bound for change: the revised framework Energy Labelling Directive will introduce mandatory product registration with a public database for all products that have an Energy Label (draft regulations, not published). The database will provide an overview on models on the market, including their technical specifications, and thus greatly improve market transparency for consumers, researchers and policy makers. Sales data as presented in our study can provide a good complement to the information offered by the database. Other than the information in the database, sales data allows giving each model its relevance regarding sales. Also, the database will take

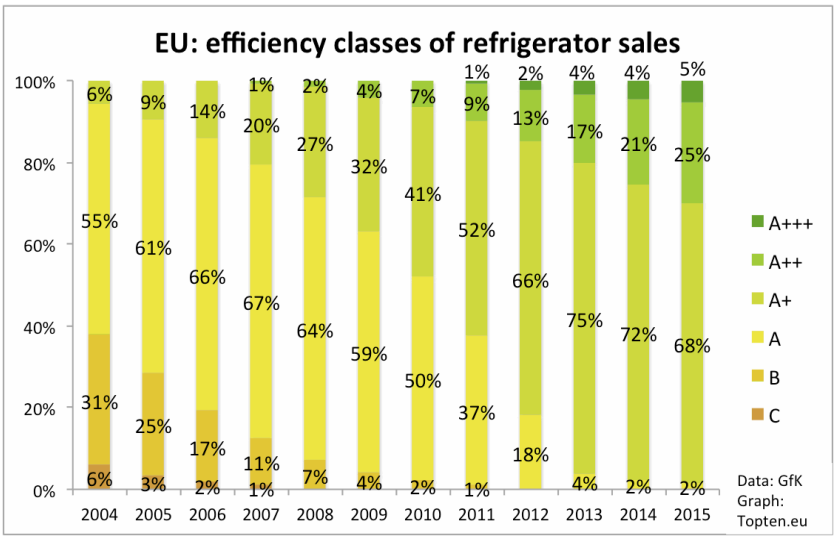

Figure 1. EU: efficiency classes of refrigerator sales.

years to enter into effect and become operational, while sales data exists, can be purchased and analysed today.

The objective of the study is to demonstrate the value that market monitoring based on sound (i.e. recent, complete, consistent over time) sales data can have. It also supports ongoing revisions of Energy Labelling and Ecodesign regulations for refrigerators and washing machines, and the soon-to-start review of the regulations for tumble driers. Since it does not only present data for the whole EU, but also for the national markets of France, Germany and Italy, it can help these member states when providing input to EU product policies or defining national campaigns. The study has been funded by ADEME (Agence française de l'Environnement et de la Maîtrise de l'Energie) and is partly an update, partly an amendement of a previous study that has been published in 2015 (Michel, Attali, Bush, 2015). This paper is focusing on information regarding energy efficiency, energy consumption, and differences between energy label classes. The full report (Michel, Attali, Bush, 2016) contains more data on sales, average size, price and differences between national markets. It is published in March 2017 and is available for download on www.topten.eu.

What kind of data?

Sales data for household refrigerators, washing machines and tumble driers has been purchased from GfK[1]. GfK obtains the data from retailers. For our market monitoring study, GfK provided information on sales (in units), sales-weighed average energy consumption, size and price, for each energy class (A+++ to G) for the three product categories. For refrigerators, the data covers refrigerators with and without freezer compartment, but not separate freezers. All the information is based on declarations on the Energy Label and has been weighted according to sales. The data covers the years 2004 to 2015. Next to the information for the entire EU, our report also covers the national markets of France, Germany and Italy.

1. www.gfk.com

Key results and discussion

REFRIGERATORS

The Energy Label for household refrigerators was the first such label to be introduced in 1994, with classes A (best) to G (least efficient). In 2004 the Label was amended with classes A+ and A++, in 2011 A+++ was added. The Energy Labelling and Ecodesign regulations for refrigerators are currently being revised; a preparatory study has been published in March 2016 (VHK, 2016).

From 2004 to 2015 the energy efficiency of refrigerators has improved continuously. In this period, the energy efficiency index (EEI) has improved by 37 %. The average EEI in 2015 was 39[2] (in class A+). Figure 1 shows that the MEPS introduced in 2009, banning classes C and B from 2010, was of little effect: these two classes had already almost completely disappeared from the market. The next tier, banning class A from 2012/2014, on the other hand visibly sped up the shift to better classes. So, in 2015, only classes A+, A++ and A+++ are left on the market, with most sales being in A+. In Italy and especially France, a smaller share of A++ and A+++ refrigerators is sold than across the EU (France: 14 % A++, Italy: 20 % A++). The German refrigerators market is clearly more energy-efficient than the EU average: 49 % of the sales were in class A++ in 2015, and 16 % in A+++; A+ accounted for 35 % of the sales.

The average energy consumption of refrigerators sold in the EU was 229 kWh/year in 2015. Since 2004, it has been reduced by 26 %. This is a considerable reduction, but it is less than what could be expected from the efficiency improvement over the same period. The volume has only increased by 3 % (Michel, Attali, Bush, 2016), so the main reason for the difference are likely energy-consuming features that are not reflected in the energy classes (different reference lines for different refrigerator types, 'correction factors' for frost-free, inbuilt and tropic models and chill compartments).

2. Average EEI was calculated by assigning the threshold EEI to each class (e.g. 33 for A++).

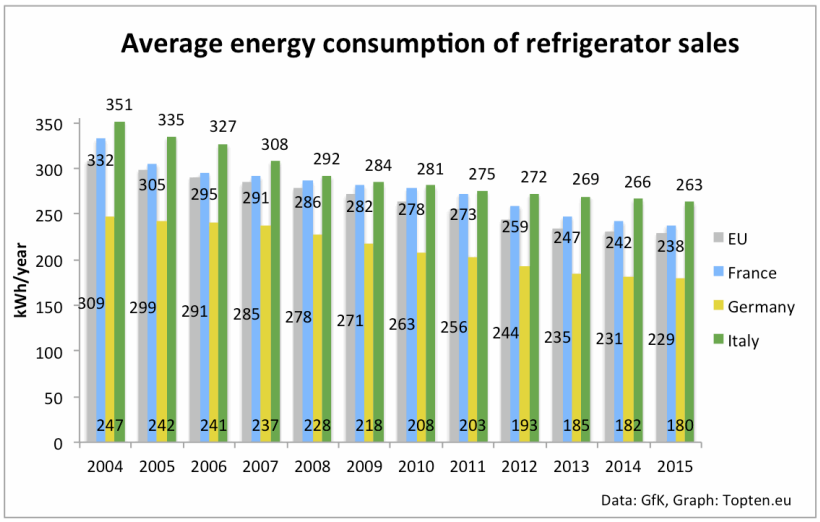

Figure 2. Average energy consumption of refrigerator sales in the EU, France, Germany and Italy.

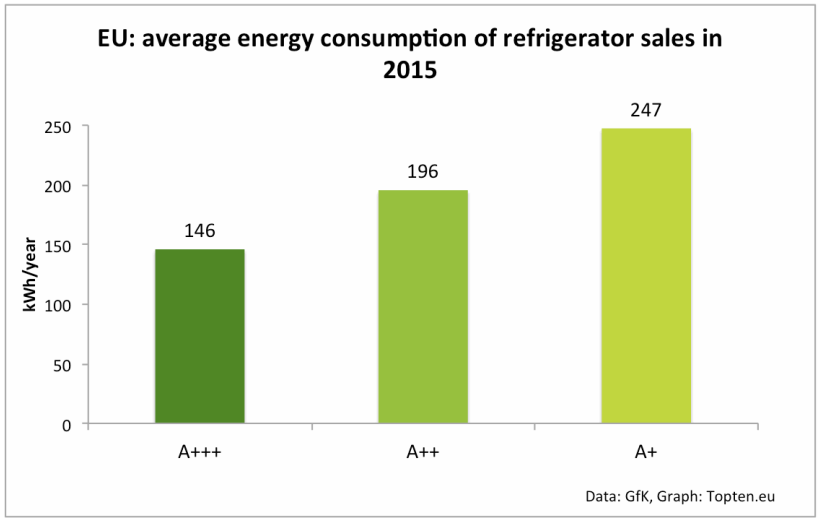

Figure 3. EU: average declared energy consumption of refrigerator sales according to label classes in 2015.

Refrigerators sold in France in 2015 consume 9 kWh/year more than the EU average, in Italy 34 kWh/year more. In Germany, 2015 refrigerators use 59 kWh/year less. The differences can chiefly be explained by efficiency differences, for Italy also by a preference for larger refrigerators (Michel, Attali, Bush, 2016).

Figure 3 shows that A++ refrigerators on average save 21 % electricity over A+ models, while A+++ saves 41 %. This considerable energy reduction with better classes is despite the fact that more efficient refrigerators are larger (Figure 4).

Based on the data on average purchase prices and energy consumption, we have calculated the total lifetime costs of refrigerators of different classes to consumers. Figure 5[3] shows that A+++ refrigerators have lower total costs on average than A++ models, but not lower than A+. The higher purchase costs of A+++ refrigerators do not only reflect more energy-efficient technology, but also the larger volume shown in Figure 4.

WASHING MACHINES

The first Energy Label for washing machines was introduced in 1995. The regulation defined energy efficiency as specific energy consumption of the 60 °C programme per kg capacity. The Energy Label was revised in 2011/2012, and the scale was amended with classes A+, A++ and A+++. Since then, the energy classes are based on an energy efficiency index (EEI), which is based on annual energy consumption. This annual energy consumption includes low power modes (Left-On and Off mode) and the formula assumes 220 wash cycles per year. The energy measurement is performed with the 60 °C and the 40 °C cotton programmes, and includes full load as well as half load cycles. This means that the declared energy consumption before and after 2011/2012 cannot be strictly compared.

As for refrigerators, also the Energy Label and Ecodesign regulations for washing machines are currently being revised. The Joint Research Centre (JRC) should soon publish the final preparatory study[4].

3. Total costs include purchase price and electricity costs over the product lifetime. Assumed refrigerator lifetime is 15 years, electricity price 0.2 Euros/kWh.

4. http://susproc.jrc.ec.europa.eu/Washing_machines_and_washer_dryers/index.html

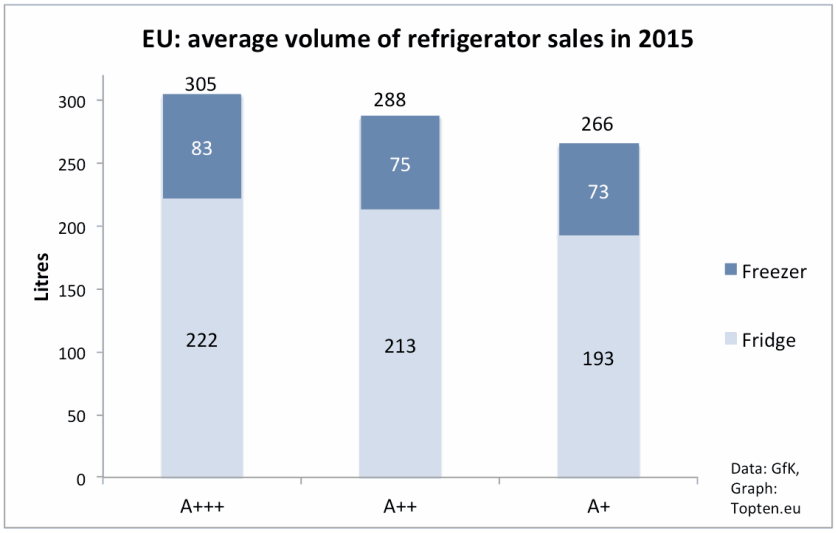

Figure 4. EU: average volume of refrigerator sales according to classes in 2015.

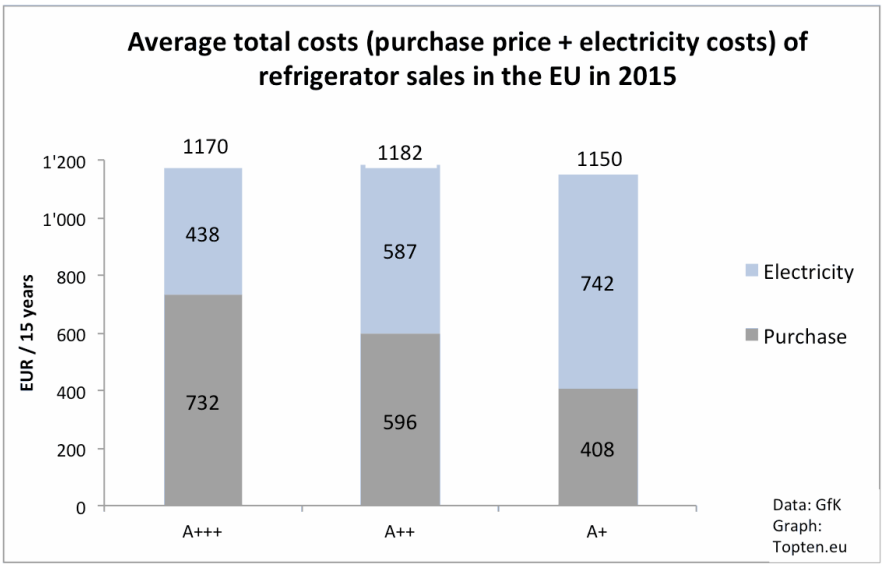

Figure 5. Total costs (purchase price + electricity costs) of refrigerator classes.

Figure 6 shows that the 2011/2012 revision was long overdue. Already in 2004 more than 80 % of the sales were in class A, by 2011 this share had risen to 100 % and many models clearly exceeded the threshold. Please note that the classes A+ and A++ were only official from 2011. Before, manufacturers marked their models with stickers such as 'A-10%' to show their superior efficiency. The official classes A+ and A++ were not exactly in line with manufacturers' unofficial self-declaration, therefore some models moved back to class A in 2011. Tier 1 of the Ecodesign regulation banned washing machines in classes B and less efficient starting in December 2011. Figure 6 shows that this measure was implemented too late to be of any effect. Tier 2, banning class A from 2013, was of some effect. Since 2013, only classes A+, A++ and A+++ are left on the market – as for refrigerators. Class A washing machine models that have entered the market before can still be sold, therefore their market share has not yet dropped to zero. The 'plus'-classes are very popular, and in 2015, only four years after the introduction, the majority of all sold models was already in the top class A+++. The outcomes of the current revision are needed. Also, today, best products are clearly exceeding the threshold of the top class: the most energy-efficient washing machine[5] is 50 % more efficient than required for A+++.

As for refrigerators, also for washing machines there are clear differences between the national markets regarding energy efficiency. National data in the full report (Michel, Attali, Bush, 2016) shows that A+++ washing machines are less popular in France than in the EU average. Italy is in-between, and in Germany A+++ washing machines already accounted for 81 % of the sales in 2015.

Between 2006 and 2010, average energy consumption of washing machines in the EU remained more or less stable at around 225 kWh/year. After the introduction of the revised energy label, average energy consumption declined to reach

5. V-Zug Adora SLQ-WP with integrated heat pump; EEI= 22.8, 8 kg. Source: www.topten.eu.

179 kWh/year in 2015. A part of this reduction will simply be due to less energy-consuming programmes being tested since the revision (40 °C, half load) and other changes, but also these programmes have clearly been better optimised regarding energy efficiency.

The differences in average declared energy consumption between countries are much smaller for washing machines than for refrigerators. In 2015, French and Italian washing machines consumed a little more energy than the EU average (7 and 5 kWh/year, respectively), German washing machines consumed on average 15 kWh/year less.

The strong trend to larger washing machines is on-going. In 2004, nearly all washing machines were designed for 6 kg of laundry and less. By 2015, 65 % of all sold washing machines had capacities for more than 6 kg.

Figure 9 and Figure 10 show differences between energy classes regarding average energy consumption and capacity. Differences in average declared energy consumption between A+, A++ and A+++ washing machines are small (A++ / A+++: 23 kWh/year) to nearly inexistent (A+/ A++: 1 kWh/year).

One reason is the small efficiency improvement needed to jump to the next class. Less than 12 % improvement is sufficient to go from A+ to A++ and from there to A+++ again. E.g. for refrigerators these efficiency improvements from one class to another are much larger. Another reason is revealed by Figure 10: washing machines in better energy classes are larg-

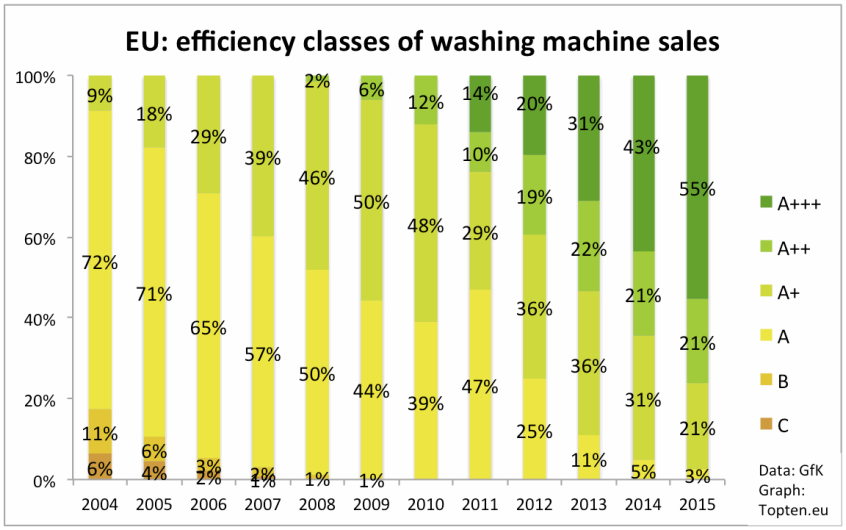

Figure 6. EU: efficiency classes of washing machine sales. Note: Classes A+, A++ and A+++ were only 'official' starting in 2011: before 2011, GfK categorized as A+ whatever was in principle declared as 'A-10 %' (or A+), and 'A-20 %' as A++. Sales share of these classes before 2011 has to be read with caution.

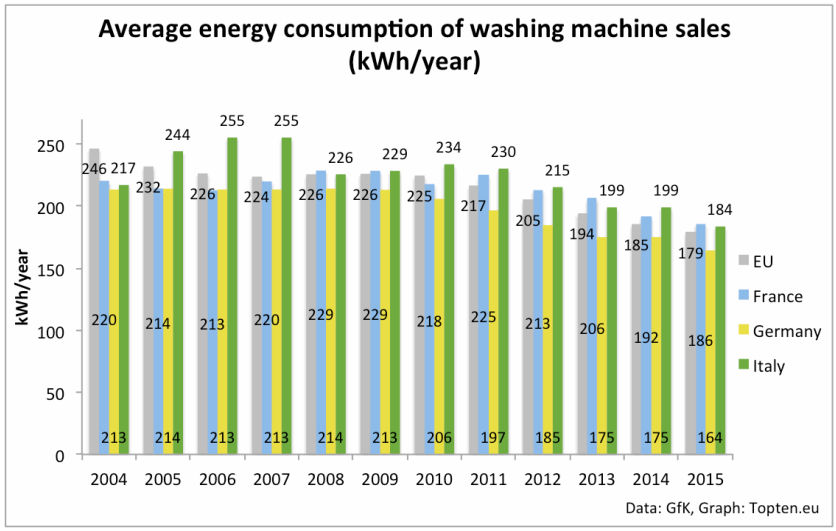

Figure 7. Average energy consumption of washing machine sales in the EU, France, Germany and Italy. Note: Before 2011/12 the energy consumption was declared in kWh/cycle. These values have been multiplied by 220 by GfK. This is the number of annual cycles assumed for the declaration on the 2010 Energy Label which applied from December 2011. Since the new declaration also includes part load, 40 °C cycles and low power modes consumption, the values are not 100 % comparable. While the exact values have to be read with caution, this chart can show trends before 2011 and after.

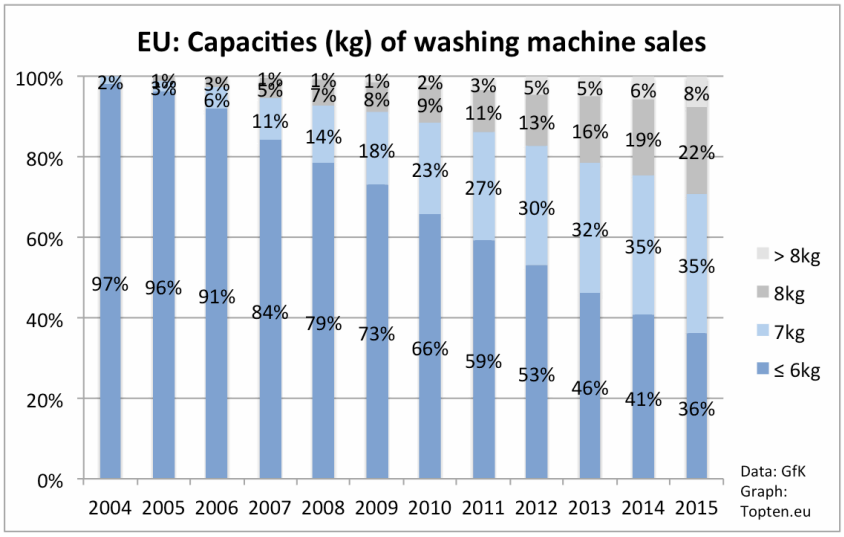

Figure 8. EU: capacities of washing machine sales.

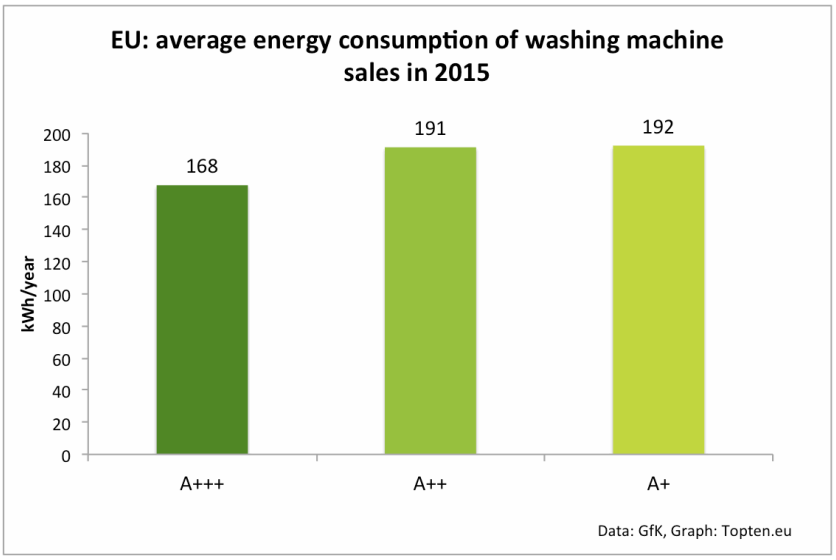

Figure 9. EU: average energy consumption of washing machine sales according to energy classes, 2015.

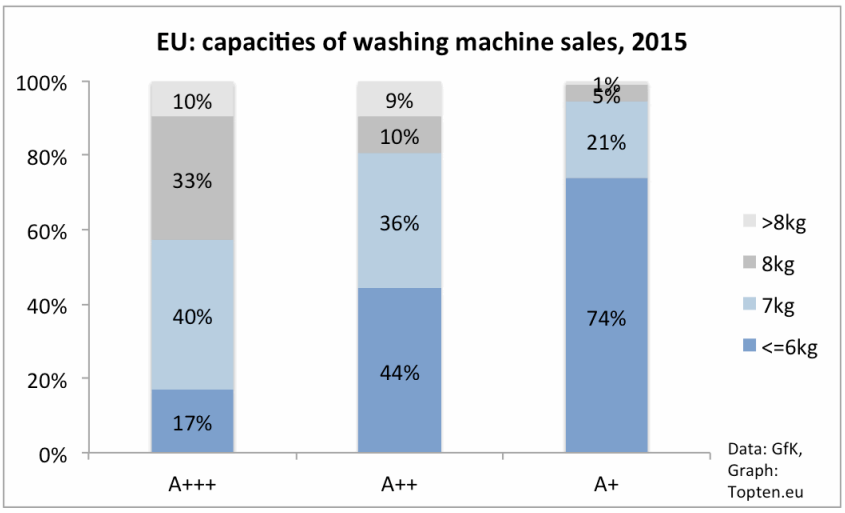

Figure 10. EU: capacities of washing machine sales according to energy classes, 2015.

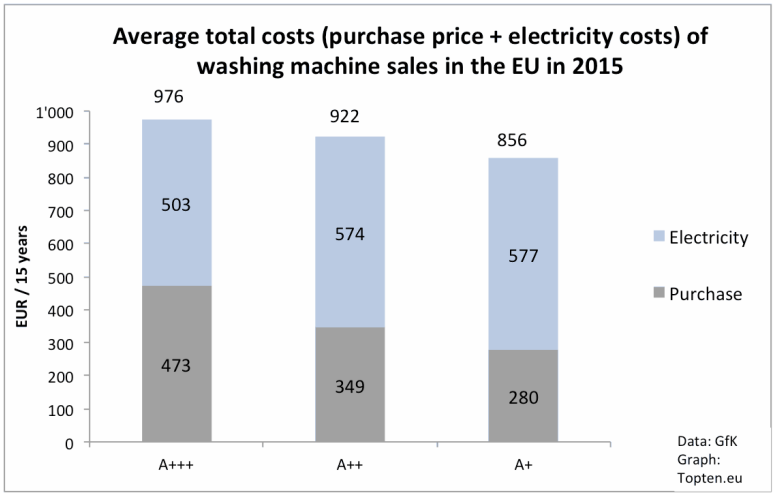

Figure 11. EU: Total costs (purchase price + electricity costs) of washing machine sales in 2015.

er. The strictly linear reference line used for the definition of the washing machines EEI seems to make it easier for larger machines to reach good efficiency levels than for smaller ones. Therefore, most A+++ washing machines are designed for 7 kg of laundry and more. They may have a relatively low specific energy consumption (kWh/kg laundry), but their absolute energy consumption is comparable or only marginally lower than that of less 'efficient' washing machines.

A critical aspect that cannot be investigated with declared values is part load washing: several consumer surveys have indicated that most wash cycles are run only partly filled, and that bigger drums are not filled with more laundry (e.g. Schmitz, Alborzi, Stamminger, 2016). Only partly filled washing machines do not use water and energy efficiently. The larger the drum, the higher the risk that energy and water is wasted.

Washing machines in better energy classes save only little energy, but have higher purchase prices – partly due to their bigger drum capacity (Michel, Attali, Bush, 2016) – see Figure 11[6]. Therefore, total costs to consumers are lowest for the least efficient (smallest and least costly) washing machines in class A+. This constellation implies, based on the current EEI formula, it is not viable to introduce more ambitious MEPS, as EU MEPS levels must not go beyond the lowest total costs to consumers.

TUMBLE DRIERS

The tumble drier energy label is in place since 1996. As for washing machines, the label's energy classes were based on a kWh/kg capacity efficiency definition. Class A could only be reached by condensing driers with integrated heat pump – the first such models emerging on the EU market in 2006. These driers exceeded the class A limit by far – but the label could not communicate their vast superiority regarding energy-efficiency. First heat pump tumble driers consumed around 50 % less energy than driers without heat pump, by today they have been further improved. The Energy Label was revised in 2012, and Ecodesign requirements were introduced. Classes A+, A++ and A+++ were added and remained, including class A, reserved for efficiency levels that can only be reached by heat pump driers until today.

6. Total costs include purchase price and electricity costs over the product lifetime. Assumed washing machine lifetime is 15 years, electricity price 0.2 Euros/kWh.

As for washing machines, the labelling scale is now based on an EEI classification and annual energy consumption, assuming 160 cycles per year and including low power modes. The test runs include half load cycles. The Energy Labelling and Ecodesign regulations for tumble driers are due for review in 2017.

Figure 12 shows that in 2006 not only heat pump driers (class A) appeared on the market, but also class B driers. Class B quickly gained market share and replaced class C. Heat pump driers gained market share more slowly, but in 2015 47 % of all driers sold across the EU were heat pump driers (classes A to A+++). With the current Label that is in place since 2013, class A is nearly empty – being placed at the 'technology gap' between heat pump and non-heat pump driers. Similar as for refrigerators and washing machines, Ecodesign tier one, banning classes D and less efficient from November 2013, was of little impact. Tier two has banned class C since November 2015. This has been of bigger impact, affecting the least efficient 20 % of the market.

Also for tumble driers the full report (Michel, Attali, Bush, 2016) shows big differences between national markets. In France, heat pump driers accounted for only 18 % of the sales. In Germany, on the other hand, already 75 % were energy-efficient heat pump driers, and in Italy even 93 %! Switzerland has introduced own MEPS in 2012 – since then only heat pump driers are allowed.

The EU average tumble drier sold in 2015 consumed around 27 % less energy than in 2004, and 36 % less than in 2008, when average energy consumption peaked. Average declared energy consumption of driers sold in 2015 was 362 kWh/year. The big differences in average energy consumption between the countries are basically reflecting the efficiency differences shown in Figure 12.

Figure 14 illustrates the big saving potential of promoting efficient heat pump tumble driers. Heat pump tumble driers of class A+ (270 kWh/year) consume nearly 50 % less energy than class B driers (500 kWh/year) without heat pump. Also the differences between heat pump driers of different efficiency levels are much bigger than for instance for washing machines: A++ saves 42 kWh/year over A+, A+++ saves even 93 kWh/year.

Surprisingly, class C driers on average consume less energy than this of class B. Reasons are likely the small efficiency dif-

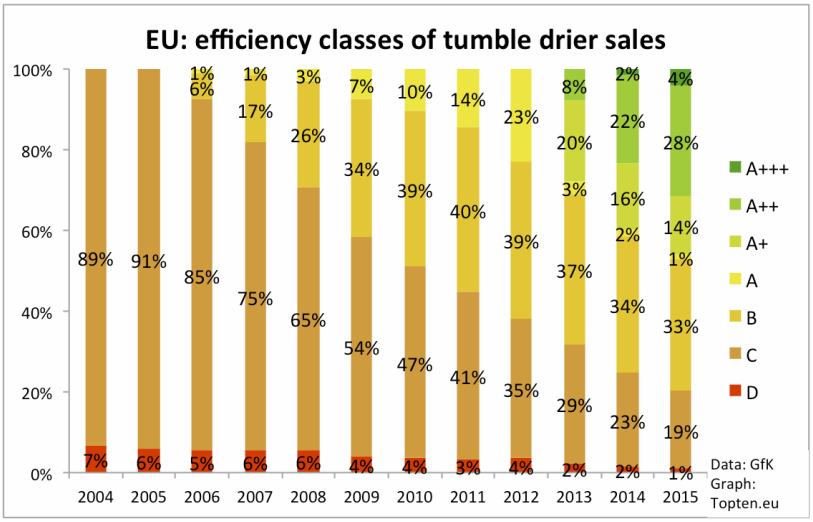

Figure 12. EU: efficiency classes of tumble drier sales.

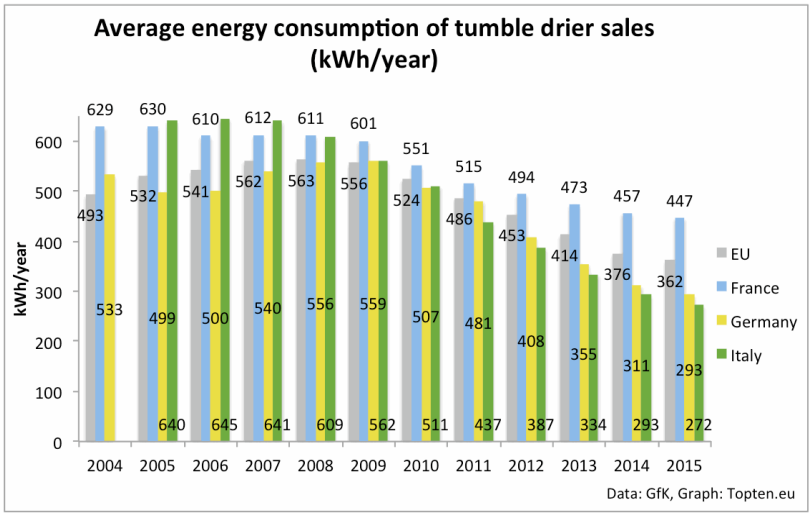

Figure 13. Average energy consumption of tumble drier sales in the EU, France, Germany and Italy. Note: Declared energy consumption according to the old Label (2004–2012, in kWh/cycle) has been multiplied by 160 (cycles/year). It is however not completely comparable with the declaration on the new Label, because this includes part load drying and low power modes consumption.

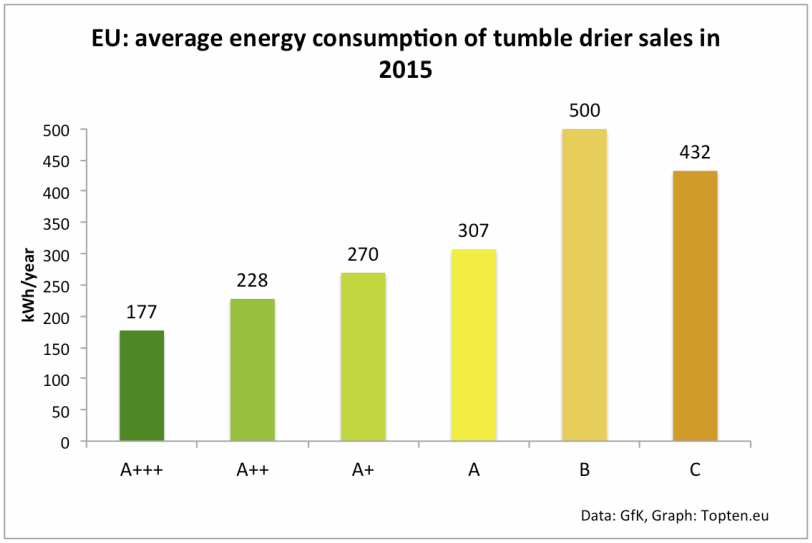

Figure 14. EU: average energy consumption of tumble drier sales, 2015. Class A has a very low sales share and nearly no models exist in this class, therefore this result is not statistically significant.

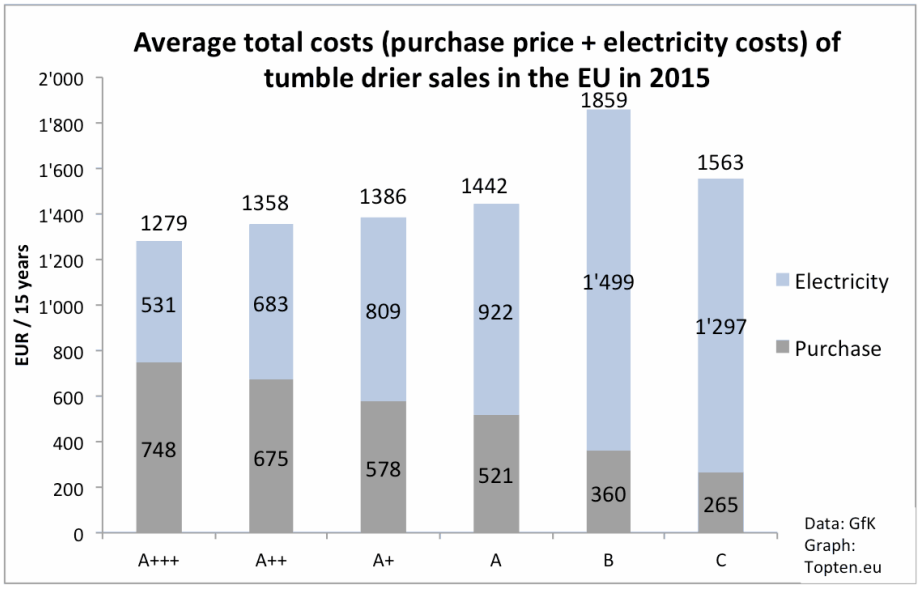

Figure 15. EU: average total costs (purchase price and electricity costs) of 2015 tumble drier sales.

ferences between the two classes, and the fact that class B driers have larger capacities than those in class C (Michel, Attali, Bush, 2016). To go from class C to B, drier efficiency needs to be improved by only 11 %. For other 'class jumps', much stronger improvements are required: up to 25 % for classes A++ and A+++, and even 35 % to go from A to A+. Tier 2 is prohibiting class C drier models from entering the EU market since November 2015. If potential class C buyers choose class B driers instead, this measure risks contributing to a higher, not a lower energy consumption! Therefore, it is key that heat pump driers are strongly promoted, so that most consumers choose an energy-efficient drier and do not end up with higher energy bills than needed.

Figure 15[7] shows that consumers who are ready to pay a higher purchase price for an energy-efficient heat pump tumble drier are better off regarding total costs. Even though driers in better energy classes have higher purchase prices (Michel, Attali, Bush, 2016), the lower energy costs can compensate for this price premium over the products' lifetime.

Since Ecodesign MEPS should be set at the Least Lifecycle Cost (LLC) point for consumers, obviously the next MEPS tier, to be defined in the review process that should be launched in 2017, will have to aim at an ambitious efficiency level, certainly banning non-heat pump driers (as already implemented in Switzerland).

Conclusions and Recommendations

Household **refrigerators** have a history of more than 20 years with an Energy Label. The Energy Label, in combination with Ecodesign requirements, has successfully supported a continuous improvement of refrigerators towards higher energy efficiency. But there is still a considerable saving potential, even with today's technologies. A shift from the 2015 average efficiency (EEI = 39) to A++ (EEI = 33) would save 15 % energy. Had all refrigerators sold in 2015 been in class A++, Europe could have saved 7.9 TWh over the lifetime of these models sold in one year.

New, more ambitious MEPS are one of the key recommendations. Because there are big differences between national markets, new MEPS should be announced sufficient time before being implemented.

A second recommendation is a new A to G labelling scale, in line with the working document for the revised framework energy-labelling Directive. Today, only 'plus'-classes are left on the market. Best products exceed the A+++ threshold by 20 %. Clearly, new classes are needed, with the top classes empty initially, to allow and to incentivise future improvements.

Third, the EEI formula should be simplified, and misleading features be removed. Results presented here show that energy consumption has been reduced only by 26 %, while efficiency has improved by 37 %. 30 % of savings are missed, because refrigerator energy consumption is not directly linked to energy efficiency. Factors that are de-coupling energy from efficiency in the refrigerators EEI formula are the system with several reference lines (with the steepest and thus least ambitious line for combi refrigerator-freezers, which have become much more popular (VHK, 2016)), and the 'correction factors' that are in fact incentivising energy-consuming extra features like frost-free function, inbuilt models, tropic compressors or chill compartments by hiding their higher energy consumption. These correction factors should be removed, and one or two reference lines for cooling and freezing compartments (e.g. what has been proposed by VHK, 2016) are sufficient.

The Energy Label for **washing machines** had clearly supported a shift to higher energy efficiency. From 2004 to 2011 class A was dominating the market, the 2011 revision was long overdue. Manufacturers helped themselves by using 'unofficial' declarations such as 'A-10 %' to show that their products were better than A. By 2015, the majority of sold washing machines is already in the new best class A+++, and most energy efficient products already exceed the A+++ threshold by 50 %. Clearly, the new classes had not been designed ambitiously enough.

7. Total costs include purchase price and electricity costs over the product lifetime. Assumed drier lifetime is 15 years, electricity price 0.2 Euros/kWh.

The small efficiency steps between classes are one of the reasons for the very small differences in average energy consumption between the classes. The other reason is the fact that washing machines in good energy classes are usually large washing machines: it seems that it is easier for manufacturers to reach good energy classes by increasing the drum size instead of lowering the energy consumption. The trend to larger drums is continuing. Large drums however have little to do with energy efficiency: a high share of part load washing can waste energy and water.

A new Energy Label with classes A to G with ambitious class thresholds is needed: The vast efficiency differences that are on the market would also justify new MEPS at more ambitious levels. However, based on the current EEI formula, it is not possible to set more ambitious MEPS without banning small, low-consuming washing machines from the market. A revision of the EEI formula is urgently needed. First of all, the misleading incentive towards larger drums must be removed. This could be achieved by introducing a digressive reference line to the EEI calculation formula, and a fixed-amount small test load (e.g. 2 kg) to the test runs. The revision should also aim at making the label declarations more consumer-relevant. A consumer survey from 2015 showed that the two standard programmes cotton 40 °C and 60 °C are used for less than 17 % of all wash cycles (Alborzi, Schmitz, Stamminger, 2015). The label programmes should be user-friendly (not taking too long) and easy to select (no presence of a second, less efficient version of the label programmes).

In 2015, almost every second **tumble drier** sold in Europe was an energy-efficient heat pump drier. The situation on national markets differs a lot, however. Choosing a heat pump drier is paying off for consumers: thanks to their low energy consumption, energy-efficient heat pump driers save consumers money over their lifetime of 15 years – despite higher purchase prices. The differences in energy consumption between heat pump driers (classes A to A+++) and driers without heat pump (classes C and B) are huge: heat pump driers save around 50% energy. This also means that even a relatively small share of non-heat pump driers holds a big energy saving potential: Had all driers sold in 2015 been in class A+, Europe could have saved 5.8 TWh over the lifetime of these driers.

On the other hand, Class B driers consume on average more energy than driers of class C. Reasons are the small efficiency improvement from class C to B, and that B driers are on average larger than C driers. The ban of class C from November 2015 therefore risks of leading to higher, not lower energy consumption – if consumers switch from class C to B. In order to avoid this, heat pump driers must be promoted even more. Campaigns could communicate that they're saving money over their lifetime, or rebate programmes could lower their purchase price.

For the review due in 2017, a ban of non-heat pump driers is clearly a need. Non-heat pump driers result in unnecessarily high electricity and total costs to consumers.

This paper demonstrates the potential of **sales-based market monitoring**. Recent, comprehensive sales data allow analyzing market trends, evaluating policies, discovering strengths and weaknesses of past and current policies.

The future European database will contain information on each model that is on the market. Sales data can well complement this information in the future. E.g. Australia combines these two types of information to analyse its products market in a comprehensive way (Michel, Harrington, et al. 2015). Sales data are available today – there is no need to wait for the products database to be established.

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