Energy efficiency of White Goods in Europe: monitoring the market with sales data

Changes and trends regarding energy efficiency, energy consumption, size and price in the markets of refrigerators, washing machines and tumble driers in the EU, France, Germany and Italy, 2004 to 2015

December 2016

Study realised on behalf of ADEME by: *SOWATT and Bush Energie*

ADEME

Agence de l'Environnement et de la Maîtrise de l'Energie

FINAL REPORT

ACKNOWLEDGEMENTS

This study, including the purchase of the data, has been possible thanks to the funding by ADEME.

CITATION OF THIS REPORT

Anette Michel, Sophie Attali, Eric Bush. Topten 2016. Energy efficiency of White Goods in Europe: monitoring the market with sales data – Final report. ADEME, 72 pages.

Content

List of figures

Refrigerators

Washing machines

Tumble driers

1. Summary

This report presents sales data from 2004 to 2015 for domestic refrigerators, washing machines and tumble driers. The data has been purchased from GfK. It includes absolute sales and, for each energy efficiency class, sales-weighed average information on energy consumption (and water consumption for washing machines), size and price. Data is available for the EU-21[1], France, Germany and Italy. Product information is based on declarations according to the Energy Label. Analysis of the data allows tracking changes and on-going trends, discrepancies and differences between national markets.

The **refrigerator** market shows to have constantly improved regarding energy efficiency. The size increase over the past ten years is minimal, while the average declared energy consumption was reduced by 26%. France and Italy have lower sales shares of energy efficient refrigerators than the EU average, in Germany more efficient refrigerators are sold. The average declared energy consumption is highest in Italy, because Italians prefer relatively large and not so efficient (mostly A+) refrigerators. Germans on the other hand prefer smaller and more efficient refrigerators, thus having lower-consuming products.
Despite the continuous improvement, higher energy efficiency standards still have an enormous saving potential in the EU: including freezers, close to 10 TWh could have been saved, had the 2015 sales been replaced with sales of A++ models only. Additionally to more stringent minimum energy performance standards (MEPS), a simplification of the energy efficiency index (EEI) calculation formula can also trigger energy savings.

The picture for **washing machines** is more complex. Good energy efficiency classes have been well taken up by the markets since the introduction of the new Energy Label, but the link to low energy consumption is unclear. The differences in average declared energy consumption between the classes are minimal, average water consumption is even higher for more efficient products. Reasons are small efficiency differences between the classes and the fact that washing machines rated as efficient tend to be bigger. The general trend to larger appliances is on-going. High efficiency in washing machines today means rather large capacity than low energy consumption. Future MEPS that are to lead to energy savings are not possible based on the current Label – a fundamental revision of the Ecodesign and Energy Label regulations is clearly needed.

Sales data for **tumble driers** show a nice surprise: energy efficient heat pump driers (classes A and better) already account for more than 47% of the EU sales in 2015, in Germany already for 75% and in Italy for 93% of all drier sales. Non-heat pump driers meanwhile are still popular in France, where the efficient technology accounts for only 18% of the sales.
The data analysis indicates that ban of class C driers since November 2015 might lead to an unwanted increase in energy consumption, if consumers switch to class B models instead: The average declared energy consumption of B driers is higher than that of class C. Reasons are the small efficiency step between the two classes and the fact that B driers tend to be bigger. The energy saving potential of future MEPS banning non-heat pump driers from the market would amount to 5.8 TWh per year. Over their lifetime, heat pump driers also generate clearly lower total costs to consumers than inefficient driers.

[1] AT, BE, CZ, DE, DK, ES, FI, FR, GB, GR, HR, HU, IE, IT, NL, PL, PT, RO, SE, SI, SK.

2. Introduction

Product market monitoring could bring a lot to Europe

Energy Labels and minimum energy performance standards (MEPS) for energy related products are crucial policy instruments that support continuous market transformation towards higher energy efficiency and lower energy consumption. Appropriate levels for Energy Label classes and their relationship with MEPS levels are key for the effectiveness of these policy instruments: if most models are already in the best Label class and no challenging MEPS are implemented, innovation can stall. This can be seen e.g. in past sales data from Switzerland for dishwashers and ovens published in (S.A.F.E. and FEA, 2015). Label efficiency classes that are still beyond the current market generate market pull, while challenging MEPS levels push poor performing products to a higher level. Together, these instruments ensure that the efficiency of products is improving continuously (e.g. example of refrigerators in last year's market monitoring report (Michel, Attali, Bush, 2015)).
For defining effective policy measures, it is critical to understand the market in terms of what products are sold and which are their attributes (including efficiency). Understanding the market empowers policy makers to make well informed decisions about the optimal level for new MEPS and Energy Label class limits and their timing to achieve maximum effectiveness. If sales data are available over a longer period, it is possible to develop stock models to estimate trends in energy consumption and other attributes (Attali, Bush, 2013) – this can be used for assessing past savings from previous policies as well as projecting future savings from proposed new policies (example from Australia on refrigerators: see (Harrington, Lane, 2010)).

Most economies have a system to monitor the markets of products that are covered by an Energy Label or MEPS, based either on sales data that is purchased from a professional market research company or by manufacturers, or on information on the models that are on the market from mandatory product registration systems (Michel, Attali, Bush, 2014). Australia even combines detail product specifications from the registration database with sales data (Michel, Harrington, 2015). Up to today, Europe has neither mandatory product registration nor does it monitor the markets with sales data (Attali, Bush, 2013). Whenever the European Commission needs market information about products in view of future policy measures, available data is gathered by consultants for preparatory studies or impact assessments. The problem with such data, which is often provided by industry, is that it is incomplete and often out-dated, and cannot be compared over time and between countries. Since little is known about actual market trends, it is difficult for European policy makers to launch revisions on time and to define Label classes and MEPS at optimal levels.

Current European Commission working documents for the revised framework Energy Labelling Directive (EC, 2010) include a new product database, where all models to be put on the market would have to be registered with their product information. This database is a need and would greatly improve the overview on market developments, as well as facilitate the information exchange by market surveillance authorities (Michel, Jones et al., 2015). According to the discussions related to the revision, future Energy Labels should follow the A to G scheme (without A+-classes), with rescales if a certain share of models or sales is in the top classes.

Sales data as presented here can provide a great complement to the information to be offered by the database. The database will take years until it is established, but sales data can be purchased starting now.

Project objectives

In December 2015, at the COP21 meeting in Paris, governments agreed to keep the global temperature rise due to climate change below 2°C, and to reduce CO_2-emissions to zero on the long term. Now the agreement needs to be followed by serious actions. Energy-efficient products save energy – energy that does not need to be produced and hence is carbon-neutral (and the most environmental-friendly).
ADEME[2] (Agence française de l'Environnement et de la Maîtrise de l'Energie) is funding this year (2016) the Topten White Goods market monitoring project. The objective is to demonstrate the value of systematic market monitoring based on sound sales data (recent, complete, consistent over time). The report presents the results of sales data analysis for refrigerators, washing machines and tumble driers, from the EU, France, Germany and Italy. It presents an update of the Topten 2015 market monitoring report (Michel, Attali, Bush, 2015), which analysed sales data for the same product categories for the EU, France and Portugal (no longer covering Portugal, but Germany and Italy instead). The study complements other market monitoring reports such as the ones on TVs (Michel, Attali, Bush 2014) and those on household appliances from Switzerland (S.A.F.E. and FEA, 2015). The data presented here also supports the current revisions of the Ecodesign and Energy Labelling regulations for refrigerators and washing machines. With national sales data from France, Germany and Italy for the 2004-2015 period, these countries can learn how national and European energy efficiency policies and campaigns have impacted the appliances markets. This data also provides a solid basis for these countries' input into the Energy Label and Ecodesign revision process, as well as for defining national strategies and campaigns to support the market transformation towards higher energy efficiency.

Economic situation reflected

Sales of goods and their prices can be strongly influenced by the economic situation. When interpreting the data readers should keep in mind that the period considered in this report, 2004 – 2015, was a period of financial and economic turmoil in Europe. After four relatively normal years, the financial crisis hit the countries in different years and not to the same extent. The purchasing power which is specific to each country has also evolved over time. These variations are not shown in EU averages.

[2] www.ademe.fr/

3. Data and Methodology

Topten purchased sales data on household refrigerators, washing machines and tumble driers from GfK[3]. GfK is a professional market analysis company that operates in many countries around the world. In Europe, GfK covers around 90% of the white goods markets, and all 28 Member States (tumble driers: 24 countries). Sales data, together with many product characteristics, is obtained by GfK from retailers.
For this project, GfK provided for each energy class (A+++ to G) sales, sales weighed average energy consumption, size, and for washing machines additionally water consumption (Table 1). This information is based on the declaration according to the Energy Label regulations. Information about these parameters can also be combined. The data is aggregated and no information on brands or models was included. Data was purchased aggregated for the EU-21[4] (only countries which GfK has been covering since 2004), as well as on country level for France, Germany and Italy. Years covered are 2004 – 2015.

Table 1: Overview: data obtained from GfK

Product categories	• Household refrigerators (including combined refrigerator-freezers, but excluding separate freezers) • Household washing machines (excluding combined washer-driers) • Household tumble driers
Countries	• EU-21[3] • France • Germany • Italy
Years	• 2004 - 2015
Information (according to Energy Label)	For each energy class: • Sales (units) • Average energy consumption (sales-weighed) • Average size (litres / kg capacity; sales-weighed) • Average price (sales-weighed) • Washing machines: water consumption (sales-weighed)

According to Eurostat[5], the population of the covered countries is:

EU-21	500 Mio
France	66.415 Mio
Germany	81.197 Mio
Italy:	60.795 Mio

Additionally, sales data from Switzerland is included in the report. In Switzerland, sales and sales shares of efficiency classes of household appliances is published annually by

[3] www.gfk.com
[4] AT, BE, CZ, DE, DK, ES, FI, FR, GB, GR, HR, HU, IE, IT, NL, PL, PT, RO, SE, SI, SK.

[5] http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tps00001&plugin=1

S.A.F.E.[6] (Schweizerische Agentur für Energieeffizienz) and FEA[7], the Swiss association of the domestic electrical appliances industry (see S.A.F.E. and FEA, 2016).

For each product category, the results are presented in the following order:
1. Total average figures (energy efficiency, energy, (water), size, price) and total sales
2. Analysis of differences between energy classes: energy (water), size, price and total costs. Apart from the price, this analysis is limited to EU data.

4. Results and discussion

4.1 Household refrigerators

Regulatory context

The energy label for household refrigerators and freezers was the first such label to be introduced in 1994, effective from 1995 (European Commission (EC), 1994). Class D stood for an EEI of 100% and was at the presumed average efficiency level. In 1996 first minimum energy efficiency requirements were announced and came into force in 1999 (EU Parliament and Council, 1996), banning the majority of classes D, E and F from the market. By 2004 55% of the sold products were in class A (Figure 1), and the Label was amended with classes A+ and A++ (EC, 2003).
In 2009 more ambitious requirements were introduced (EC, 2009): products less efficient than class A were banned from the EU market in 2010. In 2011, the new Energy Label including class A+++ has been introduced (EC, 2010). In 2012 / 2014, class A has been banned from the market in two steps (Energy Efficiency Index < 44 since July 2012, EEI < 42 since July 2014), considering the measurement tolerances that were tightened.
These measures are summarised in Table 2.
Since July 2014, new models can only be in the classes A+, A++ and A+++. Models that have entered the market before can still be sold. Both the Labelling and the Ecodesign regulation are currently being reviewed. A preparatory study has been published[8]. A Consultation Forum meeting will take place once the Energy Labelling Directive revision is completed – in spring 2017 at the earliest.
Refrigerators have improved a lot in the 20 years since the first Energy Label was introduced: the least efficient refrigerators on today's market are nearly 60% more efficient than the 1994 average.

Table 2: EU energy policies covering household refrigerators and freezers

Year of application	Measure
1995	Energy Label A-G
1999	Ban of classes D, E and F
2004	Label classes A+ and A++ added
2010	Ban of classes B and C
2011	Label class A+++ added
2012/2014	Ban of class A

[6] www.energieeffizienz.ch
[7] www.fea.ch
[8] www.ecodesign-fridges.eu

Table 3: Energy Efficiency Index (EEI) of cold appliances Label classes

Class	Max. EEI 2004 - 2011	Max. EEI since 2012
A+++		22
A++	30	33
A+	42	42*
A	55	55
B	75	75
C	90	95

Label classes according to the Label Directives from 1995, 2003 and the regulation from 2010. *The A+ EEI was temporarily increased to 44 from December 2011 until July 2014. This was related to the measurement tolerance being lowered at the same time.

Switzerland, where basically the same products are sold as in the EU, is implementing the EU Energy Labelling scheme, but has introduced own, more ambitious MEPS: since January 2013, only A++ and A+++ refrigerators are allowed on the Swiss market.

Results

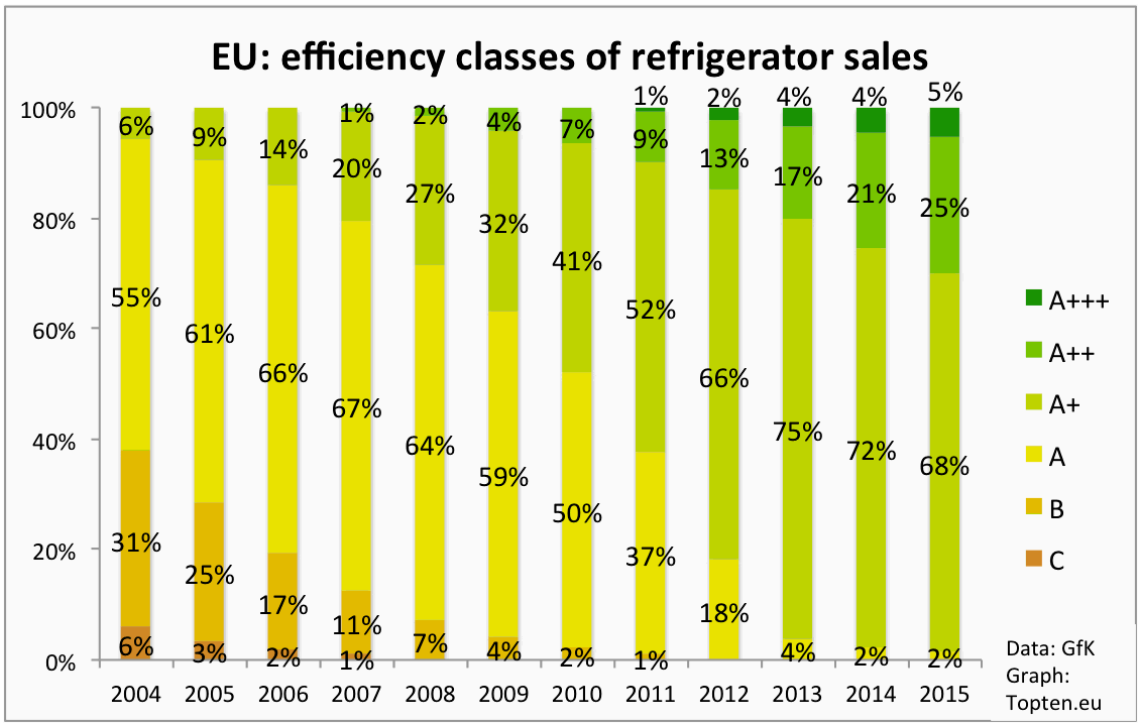

Figure 1: EU: efficiency classes of refrigerator sales

Figure 1 shows continuous improvements in refrigerator efficiency from 2004 to 2015. The average efficiency index has improved by 37% in this period (Average EEI 2015: 39)[9].
In 2004 classes A and B were dominating the market. New, better classes were a need, and class A+ was taken up quickly after its introduction in 2004. Ten years later this class is dominating the market. Classes B and C both were nearly gone from the market already before their ban in 2010. The second tier of the Ecodesign regulation from 2009 had a stronger effect: the disappearance of class A was visibly sped up by the Ecodesign requirements. A++ is slowly gaining market share, A+++sales are still low.

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

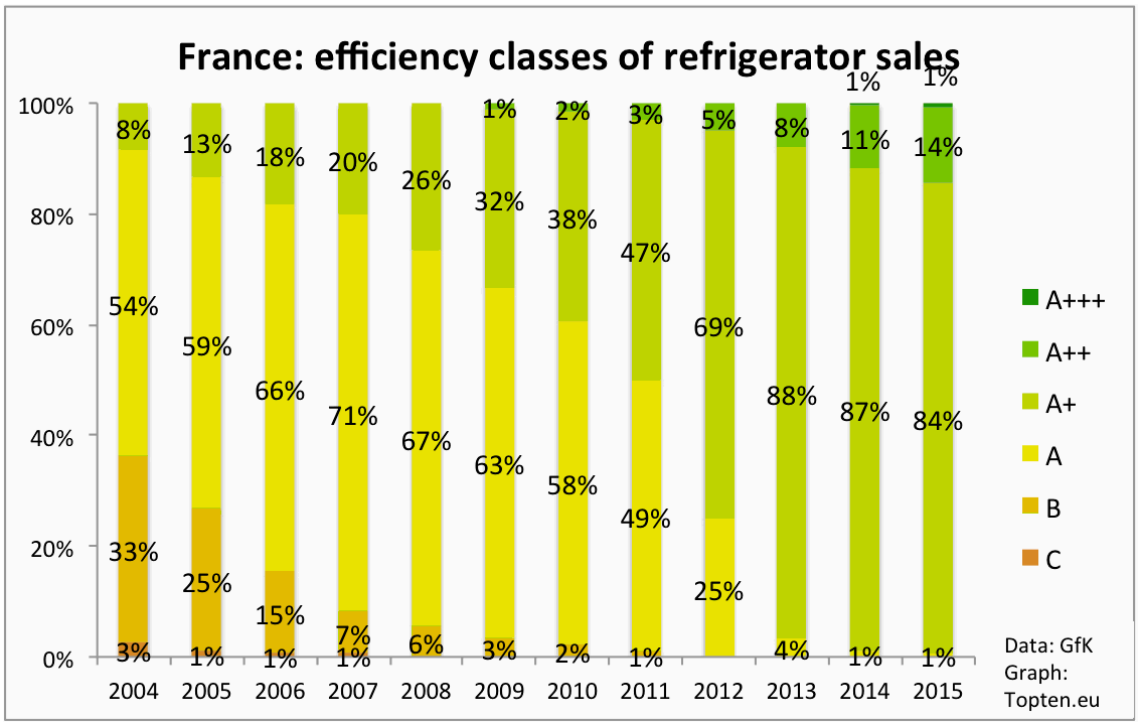

Figure 2: France: efficiency classes of refrigerator sales

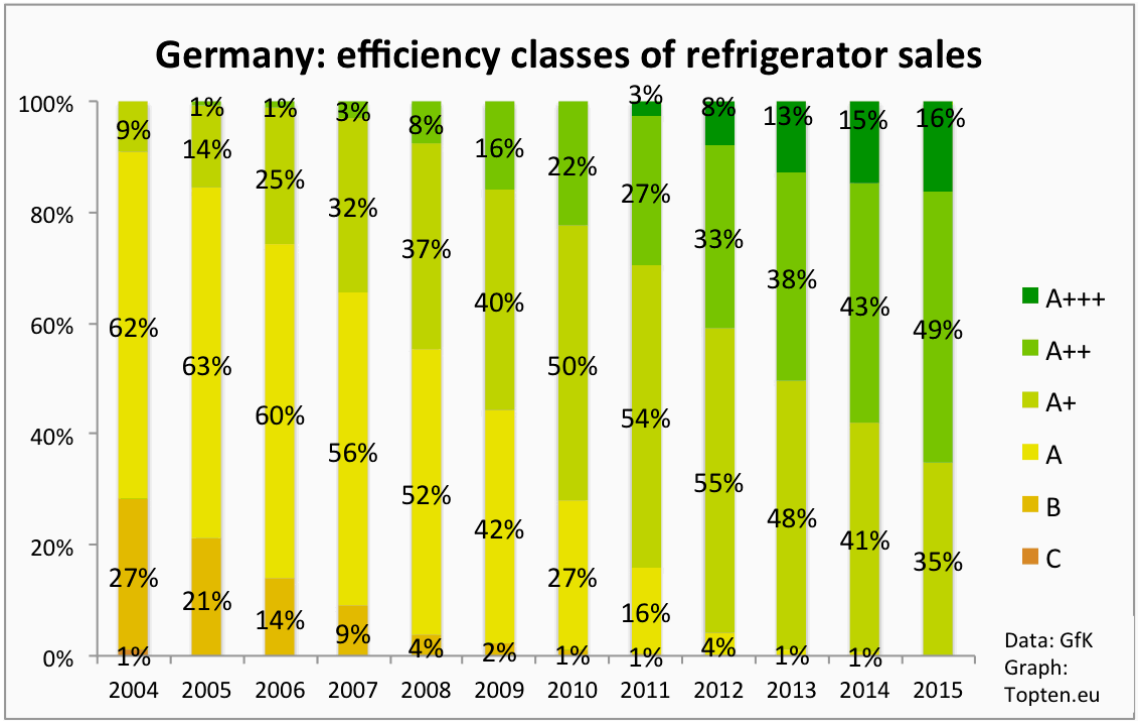

Figure 3: Germany: efficiency classes of refrigerator sales

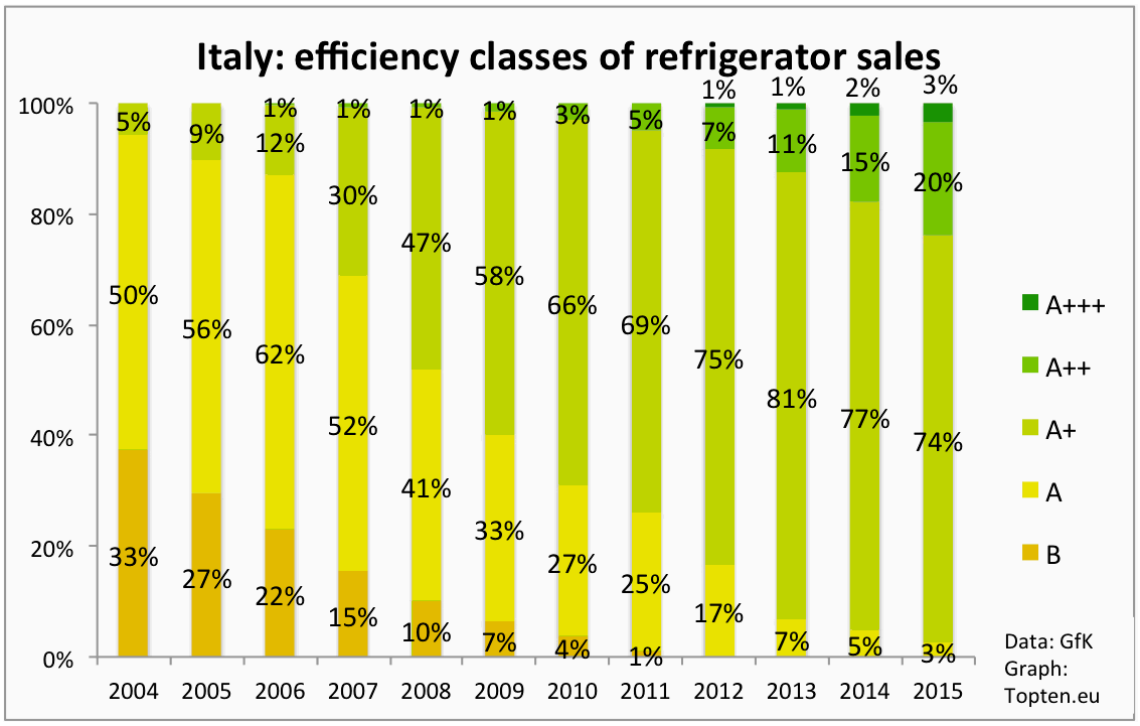

Figure 4: Italy: efficiency classes of refrigerator sales

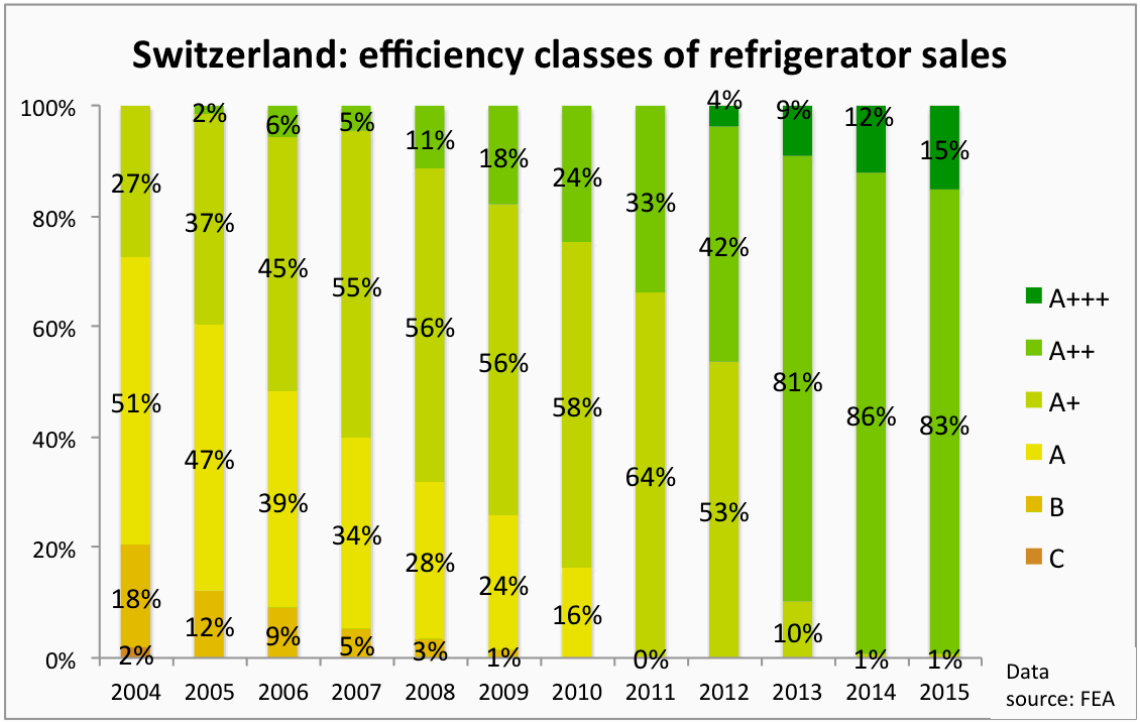

Figure 5: Switzerland: efficiency classes of refrigerator sales. Source: S.A.F.E. and FEA, 2016

Data from France (Figure 2), Germany (Figure 3) and Italy (Figure 4) shows that these trends can vary between EU countries – despite identical legislation and the same manufacturers being present on national markets: in 2015 in France and Italy the least efficient class A+ accounted for 84% (France) and 74% (Italy) market share - clearly more than the EU average of 68%. The market share of good efficiency classes (A++ and A+++) is smaller in those two countries. The contrary is true for Germany: A++ and A+++ classes together accounted for 65% of the sales in 2015, only 35% of sold refrigerators

were in the low class A+. The average 2015 EEI was 40% (France and Italy), and 34% in Germany.
Data from Switzerland (S.A.F.E. and FEA, 2016, see Figure 5) shows a more efficient refrigerator market: here A++ refrigerators accounted for almost 80% of the 2013 sales. Clearly the Swiss ban of A+ models starting in 2013 was of big impact.

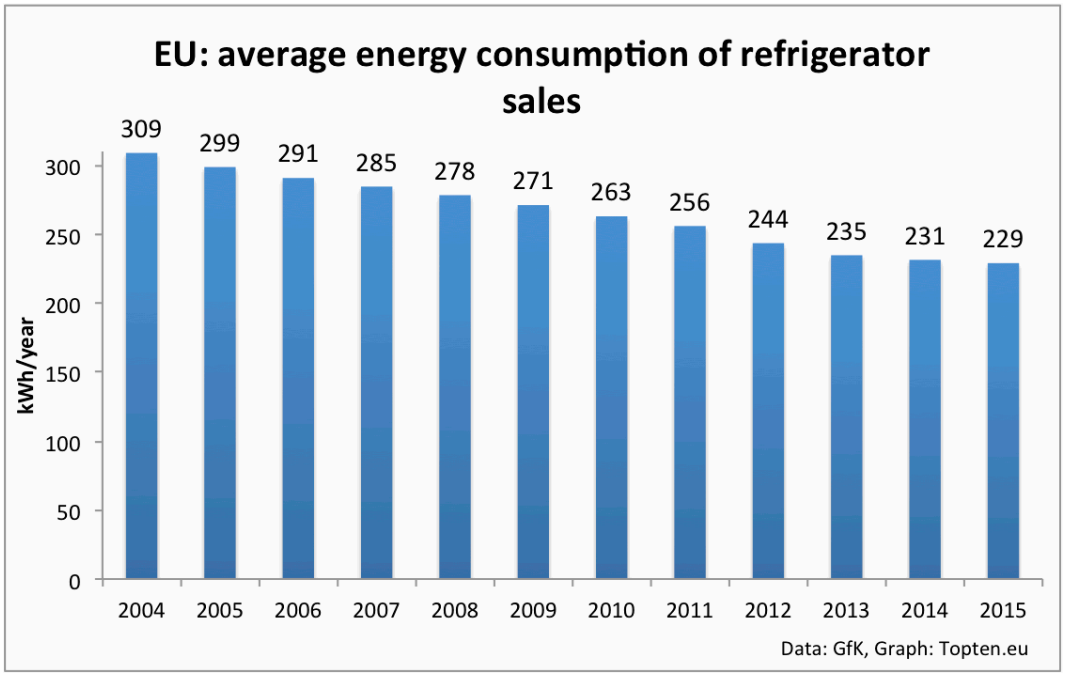

Figure 6: Average energy consumption of refrigerator sales in the EU

In 2015, the average declared energy consumption of sold EU refrigerators was 229 kWh/year. This corresponds to a reduction of 26% since 2004. This is a significant reduction – but it is clearly below the 37% efficiency improvement that occurred over the same time span.

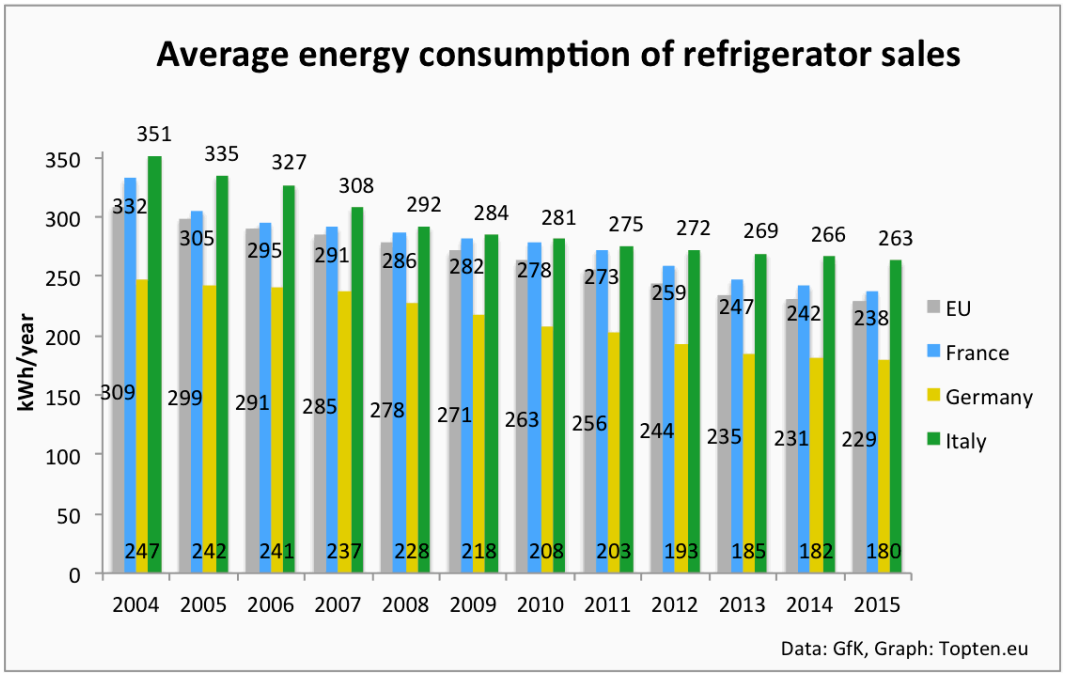

Figure 7: Average energy consumption of refrigerator sales in the EU, France, Germany and Italy

In France, 2015 refrigerators consume 9 kWh/year more than the EU average, in Italy 34 kWh/year more. German 2015 refrigerators use 59 kWh/year less than the EU average.
Even though the consumption levels are different in 2015 (France: 238 kWh/year, Germany: 180, Italy: 263 kWh/year), the reduction rates since 2004 are similar across the countries (France: -28%, Germany: -27%, Italy: -25%).
The higher declared energy consumption of Italian refrigerators compared to the rest of Europe is likely to be due to the below-average efficiency combined with a preference for larger volume refrigerators (see Figure 11).

Comparing the EU energy reduction with what would be expected from the efficiency development in the EU, the savings are smaller than the 37% improvement in efficiency index shown in Figure 1. The difference cannot be fully explained by increased volume (only + 3%, see Figure 8). Instead, the deviation is likely to be caused by factors that are not shown explicitly on the Energy Label: the current efficiency definition grants credits for certain special features such as a Frost Free function, built-in appliances, compressors that are optimised for tropical climates, or a chill compartment. Since the European EEI formula rewards these features, it is probable that they have become more common. Enertech, who performed a measurement campaign in 100 French households in 2015 funded by ADEME (Enertech 2016), also observed that inbuilt and frost-free refrigerators, even if smaller and rated as equally energy-efficient than comparable models without these functions, are consuming more energy. Another misleading aspect of the EEI formula for refrigerators is that different reference lines are used for different product categories, making it much more difficult for refrigerators without freezer compartment to reach good efficiency levels than for refrigerator-freezers. A shift to a higher share of refrigerator-freezers is also likely to have contributed to the energy consumption reduction being lower than the gains in the label efficiency index.

For France, the average declared consumption can be compared with the findings of a recent study funded by ADEME that actually measured appliance energy consumption in households (Enertech 2016). Enertech measured an average annual consumption of 386 kWh/year for combined refrigerator-freezers (sample size n = 68). Refrigerator-freezers are the most popular refrigerator type (VHK 2016). The 6 US style refrigerator-freezers ('side-by-side') were treated separately. These used 976 kWh/year on average. For normal refrigerator-freezer models, Enertech measured an average annual energy consumption of 386 kWh - nearly 150 kWh/year (63%) more than the 238 kWh/year that are declared for refrigerators sold in 2015 in France. One reason for this big difference is that the models measured in French homes are old models, while those sold in 2015 are more energy-efficient. Indeed Enertech found that the better models were the younger ones, while the average age of the models in their sample was seven years.
However, seven years ago the declared consumption was also lower than what Enertech now measured in refrigerator-freezers of this age. French refrigerators that were sold in 2008 had an average declared annual consumption of 286 kWh – 100 kWh (26%) less than Enertech's results. Possible reasons for this difference:

- User behaviour can have a big impact on refrigerator energy consumption. Aspects such as the location of the appliance (in a warm place), temperature setting, door openings (number and length), habits to put in hot food etc. can increase a refrigerator's energy consumption considerably. A study in the mid-nineties (Sidler, 1997) showed that the very same refrigerator model can have a very different energy consumption, depending on the household it is operated in. Sidler also found that for

better insulated and thus more energy-efficient models, user behaviour had a greater impact. With refrigerators being much more energy-efficient than in the nineties, user behaviour will be of even higher importance.

- Refrigerators might become less efficient with age, e.g. due to loss of insulating effect of the insulation material.
- The refrigerators measured by Enertech in fact were older than seven years on average: many study participants did not know the age of their refrigerator. Most of these will be 10 years or older. The average age has been calculated from those age indications that were remembered – the rather younger ones. This means that the real refrigerator average age in Enertech's sample was beyond seven years.
- Our sales data also includes refrigerators without freezer, which have a lower consumption. Enertech measured an average annual consumption of only 202 kWh for this type.

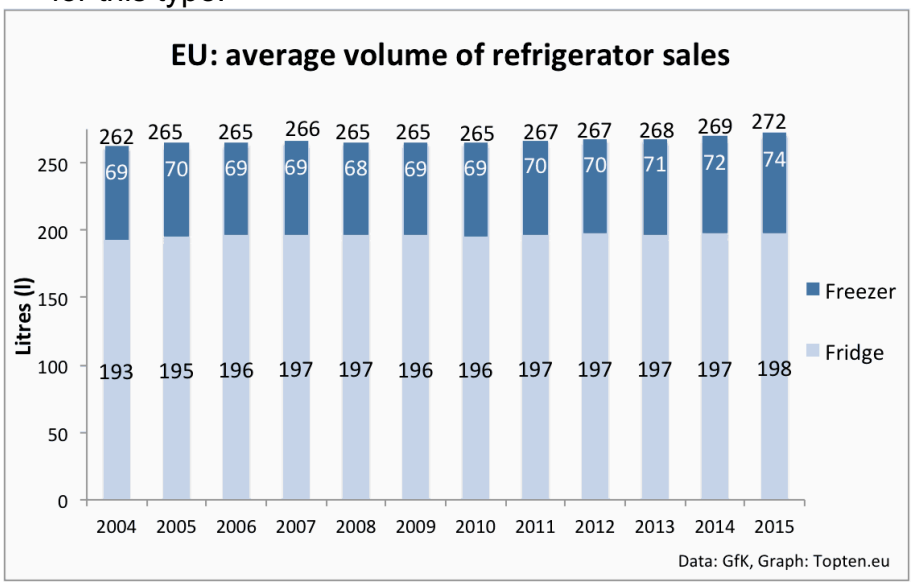

Figure 8: EU: average volume of refrigerator sales

Average declared volume of refrigerators has not increased a lot in the EU in the past 11 years: only by 10 litres (+4%) (freezer compartment: +7%, refrigerator compartment: +2%; + 5 litres each).

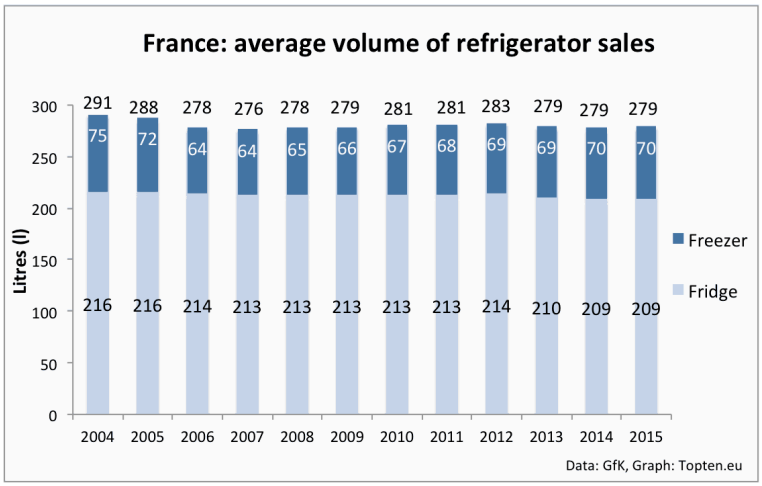

Figure 9: France: average volume of refrigerator sales

French consumers choose a larger cooling compartment than the EU average consumers, but French refrigerators have become smaller since 2004. The average volume has decreased by 13 l (total: -12l / -4%, freezer: -7l / -7%, refrigerator: -5l / -3%).

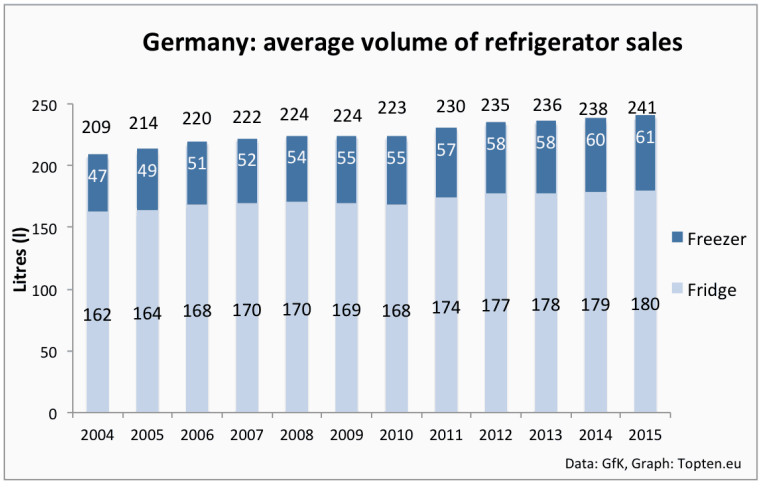

Figure 10: Germany: average volume of refrigerator sales

German refrigerators have clearly increased over the past ten years (Total volume: +32l / 15%, Cooling compartment: + 17l / 11%, Freezer compartment: + 14l / 31%), but at a low level: with 241 litres in total in 2015, German refrigerators are still 11% smaller than the EU average (272l).

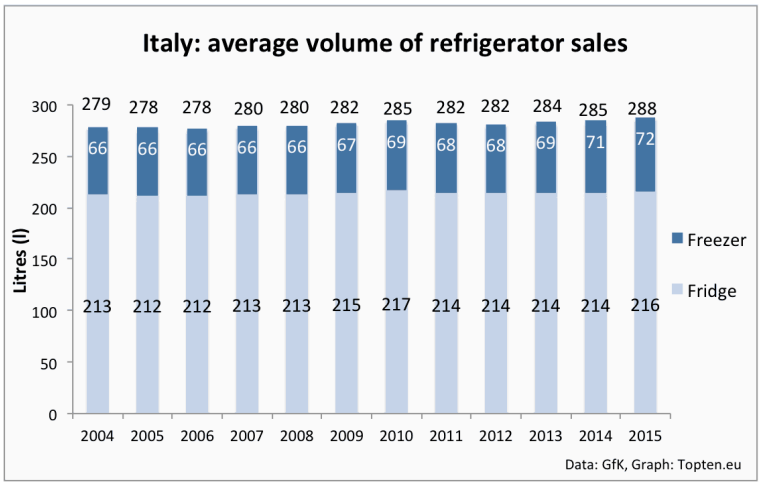

Figure 11: Italy: average volume of refrigerator sales

Similar to the French, Italian consumers tend to prefer larger cooling compartments than the EU average. Already in 2004 there was a preference for comparably large cooling compartments, since then also the average freezer compartment has become larger (total volume: + 9l / 3% since 2004, cooling: + 3l / 1%, freezing: + 6l / 10%).

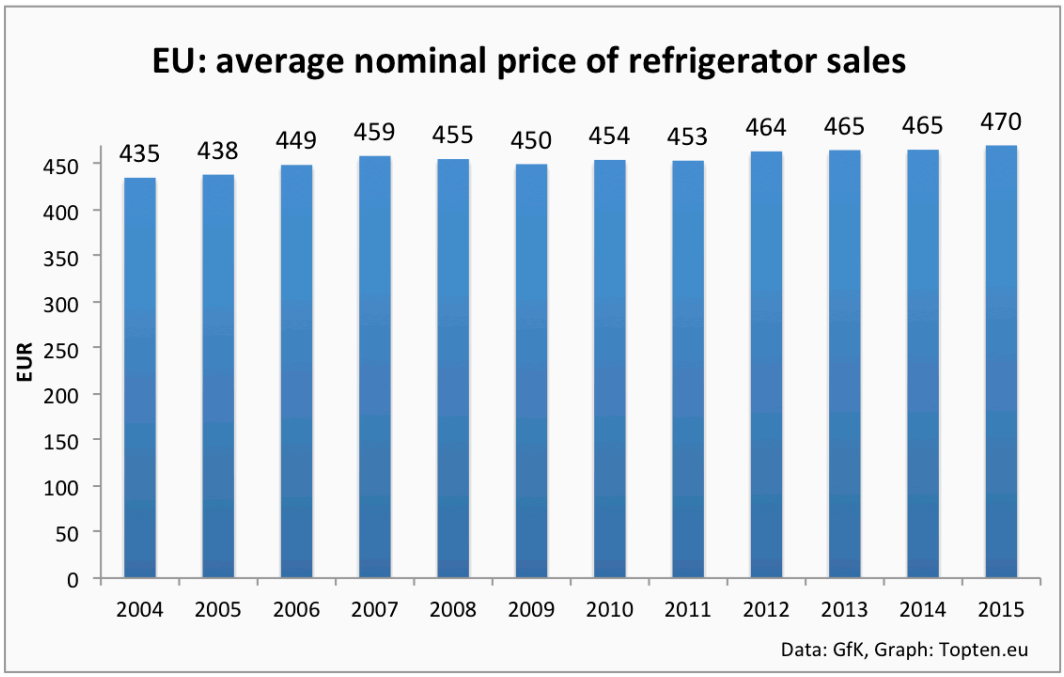

Figure 12: Average nominal price of refrigerator sales in the EU

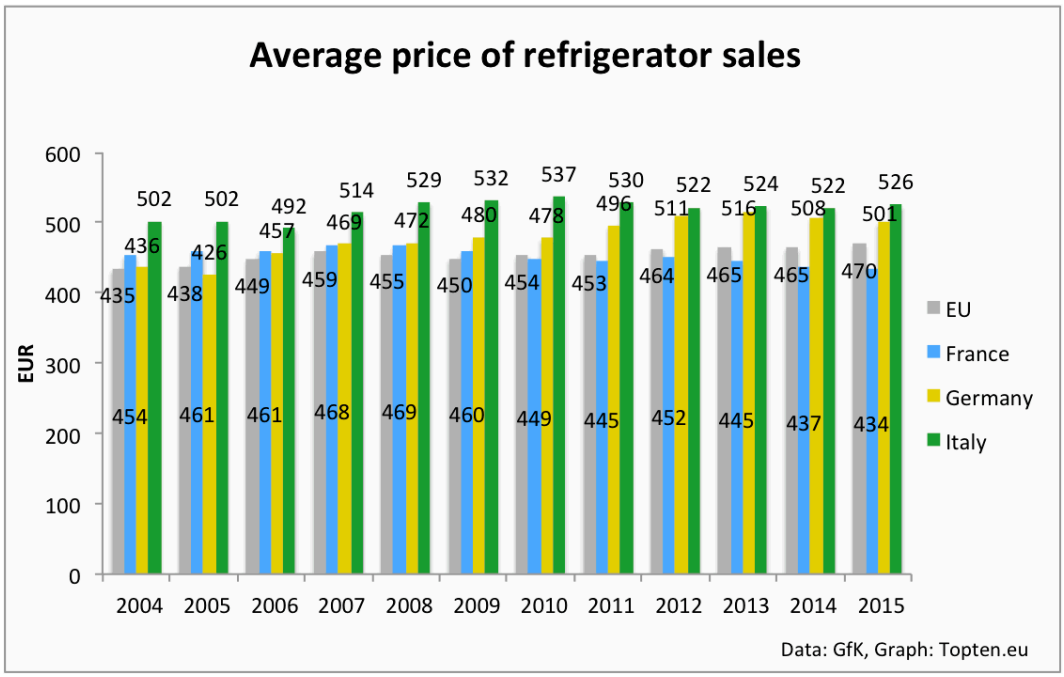

Figure 13: Average nominal price of refrigerator sales in the EU, France, Germany and Italy

Since 2004 average EU nominal prices have increased by 8%. German refrigerator prices have increased by 15%, Italian prices by 5%. French prices for refrigerators have decreased by 4% since 2004. In 2015 the average EU refrigerator cost EUR 470. French consumers paid on average less than that (EUR 434), while German (EUR 501) and Italian (EUR 526) consumers paid more than the EU average.

While efficiency improved by 37% in the EU, the average nominal price paid for refrigerators only increased by 8% over the same period. Total costs for consumers (purchase price plus electricity costs) were reduced from EUR 1362 in 2004 to EUR 1157

in 2015[10]. In France, they fell from EUR 1450 to EUR 1148, in Germany from EUR 1177 to EUR 1040, and in Italy from EUR 1556 to EUR 1315. Were real prices considered, the cost reduction would be even larger.

Italian refrigerator prices are clearly higher than the EU average prices. Possible explanations may be:

- Italians have a preference for large refrigerators. In Germany for instance, the average refrigerator sold in 2015 was 20% smaller than in Italy.
- According to oral information from GfK, the retail structure is strongly fragmented in Italy, meaning that refrigerators are bought in many (very) small retailers. Compared to other countries, only a small share of the home appliances are sold by large discounters or online shops.
- Since 2007, Italy has had a programme allowing consumers to subtract around 50% of the price for new refrigerators and other appliances (classes A+ and better) from their tax bill. Possibly this rebate programme supports Italians in choosing larger and more expensive refrigerators (however without pushing them to choosing higher efficiency models).

Total sales (numbers of units) are shown below in Figure 14 to Figure 17, displaying different patterns for the countries.
EU refrigerator sales fluctuate between 14 and 16 Million units per year, reaching a maximum of 15.7 million in 2015 (+7% since 2004). Sales in France and Germany have increased at higher rates (France: +20%, Germany: + 31%), while Italian sales are at the same level in 2004 and 2015, after reaching a peak in 2007.

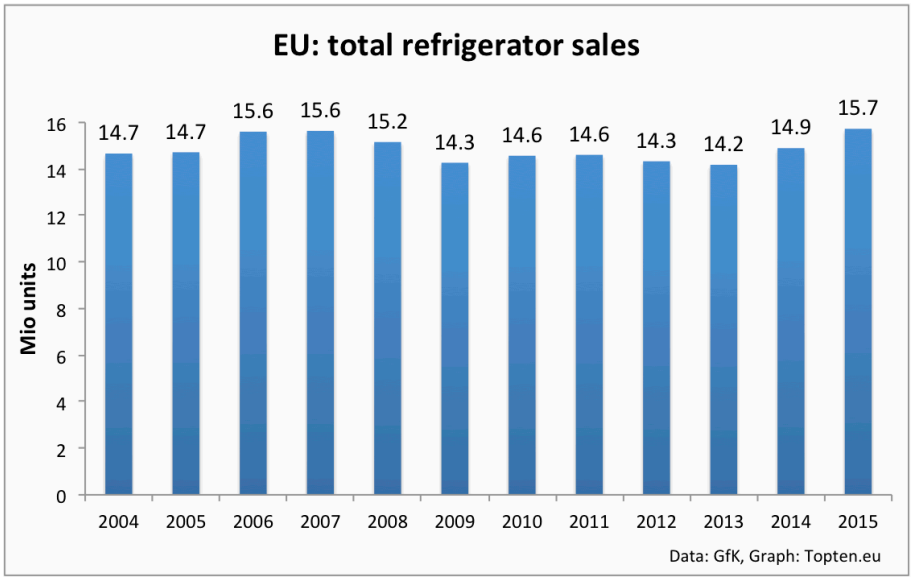

Figure 14: EU: total refrigerator sales

[10] Assumptions: 15 years of lifetime, 0.2 Euro/kWh.

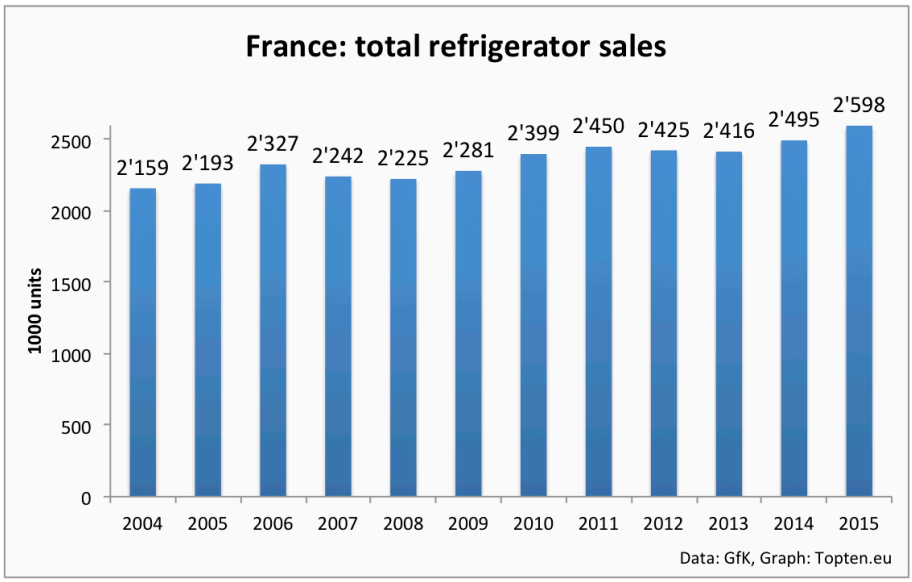

Figure 15: France: total refrigerator sales

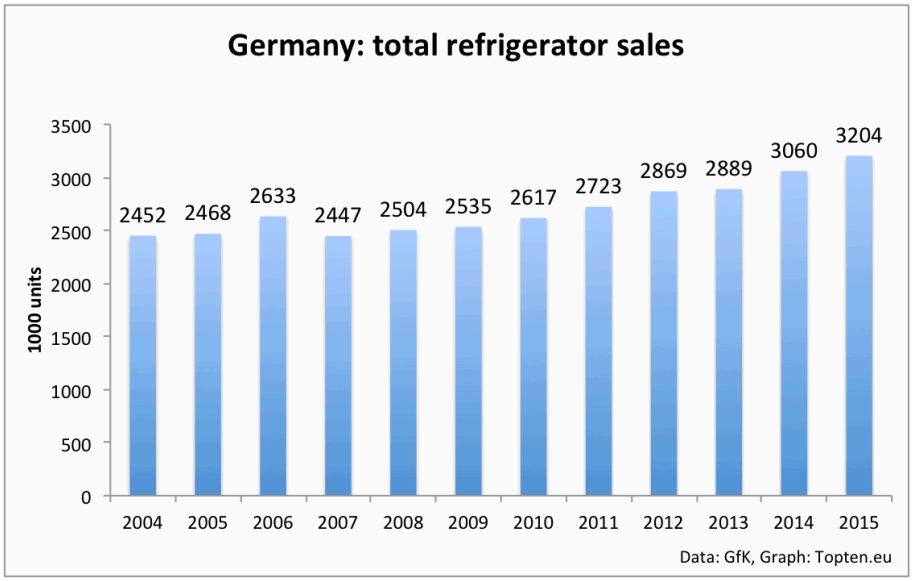

Figure 16: Germany: total refrigerator sales

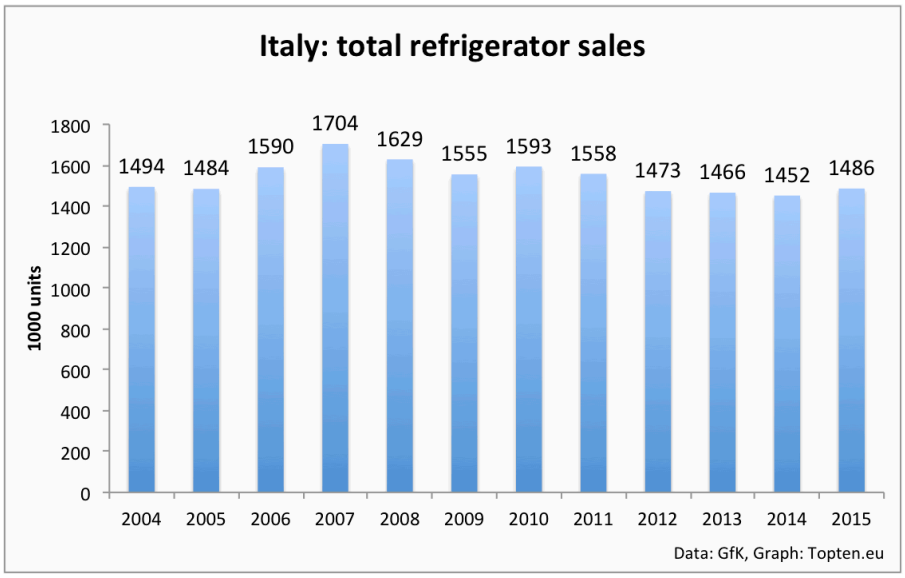

Figure 17: Italy: total refrigerator sales

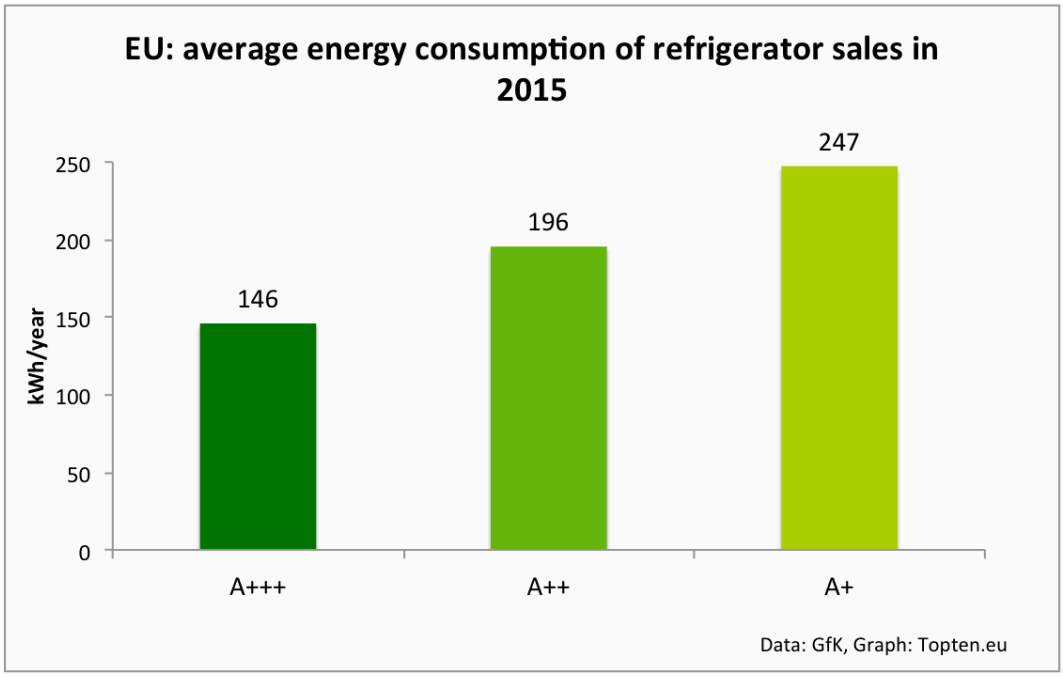

Figure 18: EU: average declared energy consumption of refrigerator sales according to label classes in 2015

Energy consumption differences between efficiency classes are large for refrigerators: a move from A+ to A++ saves 21% electricity, a move from A+ to A+++ is a 41% reduction (Figure 18). While the consumption difference between A+ and A++ reflects exactly the EEI difference between the two classes, the EEI difference is a bit larger (48%) from A+ to A+++ than the reduction in average energy consumption. Analysis of the average volume per class shows that the reason for this difference is likely to be the larger volume of A+++ refrigerators: total average volume of A+++ refrigerators was 15% larger than of A+ models (Figure 19). Still, the gains in efficiency clearly outweigh the effect of the larger volume on energy consumption, and A+++ refrigerators on average consume clearly less energy than less efficient models.

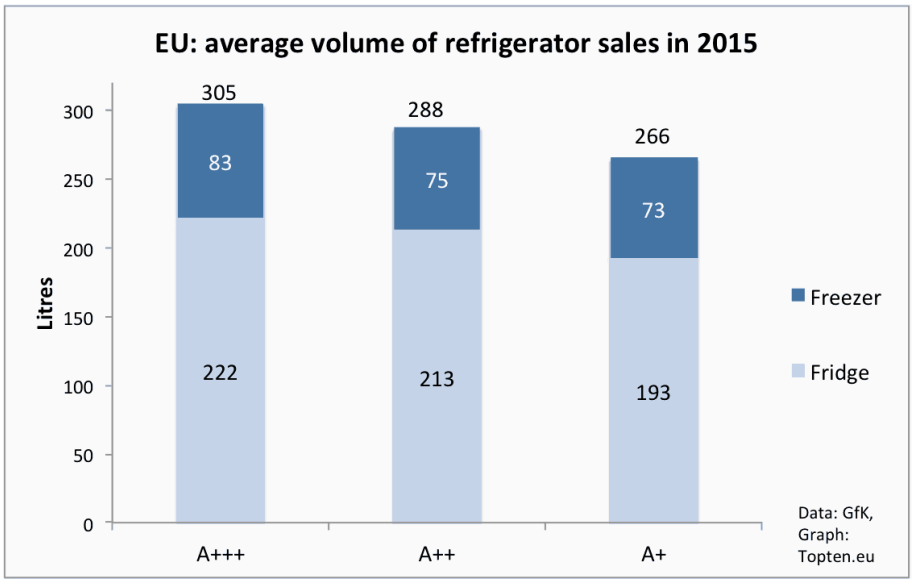

Figure 19: EU: average volume of refrigerator sales according to classes in 2015

A+++ refrigerators consume less energy than less efficient ones, but they are also the largest models. The larger volume in A+++ refrigerators, especially the freezer volume, might be responsible for the below-expectation energy consumption reduction (see above). Total and freezer volume is 12% larger in A+++ refrigerators than average.

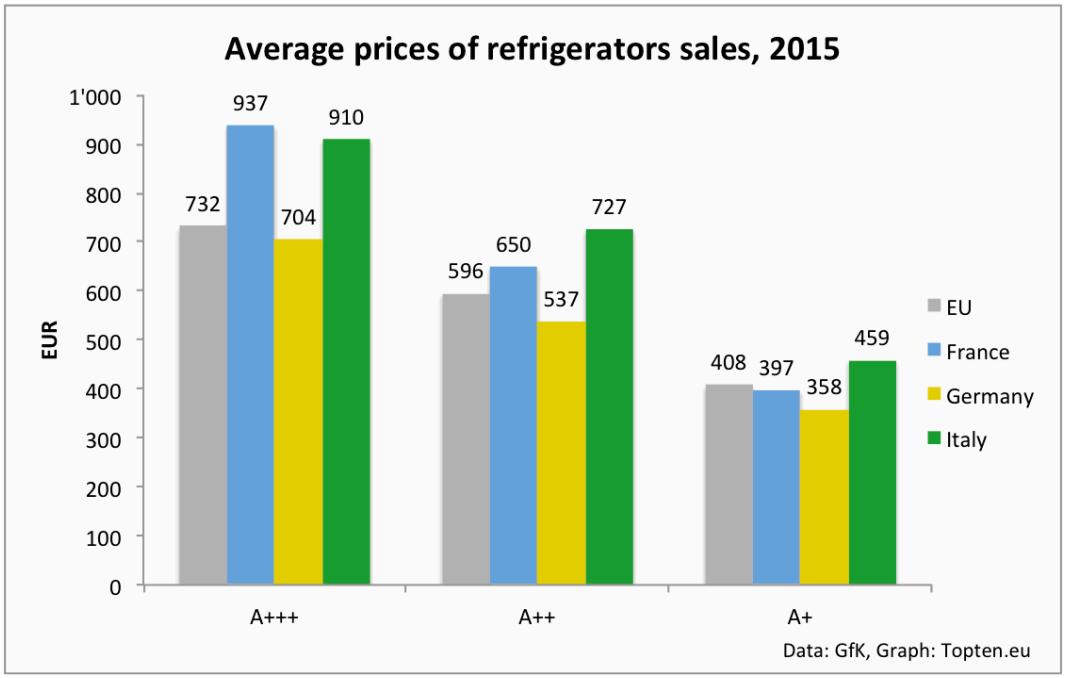

Figure 20: Average prices of refrigerator sales according to classes in EU, France, Germany and Italy, 2015

In the EU, average price increase from A+ to A++ is 46%, and 23% from A++ to A+++. Quite striking are the high Italian prices for all efficiency classes – as also shown on Figure 13 for the average prices. For possible explanations, see page 19. For A+++ refrigerators, French prices are even higher than in Italy, and also A++ prices are clearly above the EU average. There could be an interrelation with the low sales shares of these classes in France (A++: 14%, A+++: 1%). However, the sales share of A+++ is not much higher in Italy (3%) and across the EU (5%). Germany has the highest A+++ sales share

(16%), and the lowest average prices for this class. Also the German prices for A++ and A+ refrigerators are below the EU average. This may be linked to the German preference for rather small refrigerators (Figure 10) and the retail market structure with popular discounters and online stores.

Price differences between efficiency classes do not only reflect higher energy efficiency, but also larger size of more energy efficient refrigerators. The same applies to Figure 21 below, showing that the total costs for EU consumers (purchase price plus electricity costs during the product lifetime)[11] in 2014 are the lowest for A+ refrigerators. While A+++ refrigerators are the best choice from an energy saving and climate friendly point of view due to their low energy consumption (Figure 18), they are not (yet) the most economical choice for consumers. Even though A+++ refrigerators save a lot of energy compared to A+ and A++ models, the average price premium is still higher than electricity cost savings that can be accumulated over the product's lifetime.

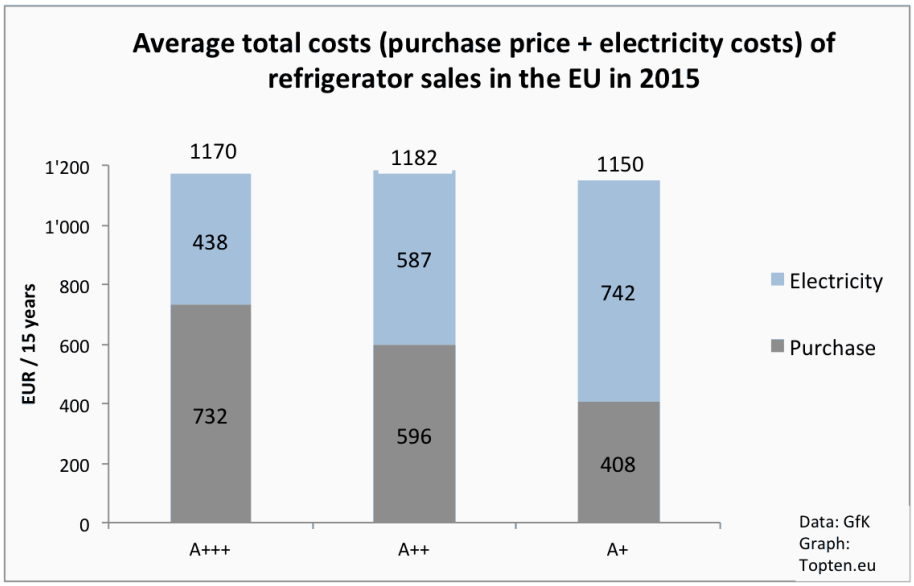

Figure 21: Total costs[12] (purchase price + electricity costs) of refrigerator classes

Conclusions

A+ refrigerators, i.e. the least efficient energy class still allowed on the EU market, have been dominating the 2015 sales across the EU (but not in all countries). The ban of class A in 2012/2014 by the Ecodesign regulation clearly sped up the efficiency development. There are large differences between national markets: considering the efficiency development, Germany is nearly four years ahead of France and Italy. Even more efficient is the Swiss market: here, the ban of A+ refrigerators has clearly shifted the market to higher efficiency.

EU average declared energy consumption was 229 kWh/year in 2015. French and Italian refrigerators consume more than this (France: 238 kWh/year, Italy: 263 kWh/year), German refrigerators consume less (180 kWh/year). Reasons for the differences in energy consumption are lower efficiency and bigger size in France and Italy, and vice

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

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

versa in Germany. Comparison with the results of Enertech's measurement campaign in France (Enertech 2016) implies that especially user behaviour can lead to refrigerators consuming more in reality than according to the Label declaration.
The average price French consumers pay for an A+ refrigerator is lower than the EU average. Average prices for A++ and especially A+++ refrigerators however are clearly higher in France. High prices and possible low availability of energy efficient refrigerators might be reasons for the low sales share of these in France.

In the EU, average declared energy consumption of refrigerators has been reduced by 26% in the last 11 years. While this is good news, it is less than the 37% efficiency improvement that can be observed over the same period. This deviation cannot be explained by an increase in volume (which is only 4%), but likely by the non-transparent calculation formula of the EEI, which is favouring more complex and energy-consuming refrigerators models: 1. Combi models have a much steeper reference line than refrigerators without freezer compartment and can consume much more energy to reach a specific efficiency level, 2. 'Correction factors' hide the extra energy consumption of extra features like frost-free function, inbuilt models, compressors dimensioned for tropical climates, and chill compartments. The effect of these bonuses is also reflected in Enertech's study (Enertech 2016).

Higher efficiency of refrigerators holds large electricity saving potentials for Europe, even though the total costs to consumers are still lowest for A+ refrigerators. A move from the 2015 average efficiency (EEI=39) to A++ (EEI = 33) would lead to 15% energy savings – over the entire lifetime of the appliances that are sold in a specific year. Based on annual sales and average annual energy consumption, these savings amount to 7.9 TWh for one year of sales (or annual stock savings if the entire stock was replaced)[13]. (The potential savings are not lower than in our last year's monitoring report (Michel, Attali, Bush, June 2015), because the total sales have been substantially higher in 2015 than 2014.) An estimate, which includes separate freezers in this calculation, results in nearly 10 TWh of annual savings. These savings could have been hypothetically obtained with the 2015 sales, if the minimum efficiency requirement had been moved to A++ (the Swiss MEPS level since 2013). This figure does not contradict the savings estimations of the CLASP scenarios (CLASP, 2013): CLASP scenario 2 (Tier 1: EEI = 36 from 2016, tier 2: EEI= 28 from 2019) saves 11.4 TWh/year in 2030, scenario 3 (tier 1: EEI = 33 from 2016, tier 2: EEI = 22 from 2019) 18 TWh/year in 2030.[14]
For France, the saving potential of A++ in 2015 was 18% (average EEI: 40.3). 1670 GWh could have been saved over the lifetime of refrigerators sold in 2015 had they all been A++ models (without separate freezers). Italy, with an average EEI of 39.8, could have saved 17% or 997 GWh, had only refrigerators of A++ been sold in 2015.
Due to the high sales share of energy efficiency refrigerators, Germany's average EEI (34) is already close to the A++ efficiency. Germany could have saved 3.5% or 303 GWh, had only A++ refrigerators been sold in 2015.
These saving potentials are based on declared consumption values. Since user behaviour can impact the real energy consumption (mainly by increasing it), real savings can be lower than projected.

[13] We project the lifetime savings of the appliances to their year of sale. It is a simpler approach than estimating the savings if the entire stock was replaced, but this is an approximation of the figure of annual stock savings (after full replacement). Assumed lifetime is 15 years. Freezer sales were estimated at 25% of refrigerator sales, based on (S.A.F.E. and FEA, 2016).
[14] CLASP savings are calculated by summing up the increasing effect of the different tiers until 2030. Based on the staged introduction according to the scenarios ,Topten A+ scenario corresponds to CLASP scenario 3 tier 1, or close to full scenario 2.

Recommendations

1. New A to G Label with empty top classes

For refrigerators, only classes A+ to A+++ remain on the market. It is known that the 'Plus'-classes are of limited effect on consumer decisions (e.g. London Economics, 2014), while the original A to G-Label is clearest for consumers (e.g. Molenbroek et al., 2014). The opportunity of the current Label revision should be used to go back to an A-G scheme, with the two top classes empty initially to account for future innovations. Next to market data, also the Best Available Technology (BAT) must be considered when designing a new Labelling scale: product lists on www.topten.eu show that there are many A+++ models on the market, and that the best model exceeds the A+++ threshold by 20% (EEI = 17.7). This clearly shows that further improvement potential exists, and a challenging Energy Label can help to realise energy savings.

2. Announce future MEPS

The opportunity of the review of the EU Ecodesign regulation must be taken to realise energy savings: New MEPS in Europe can cut off the lower end of the market to realize the 10 TWh of potential savings per year quantified in this paper: Future MEPS should be announced for 2018, at the level of today's A++ class.

3. Simplify the EEI calculation formula to remove misleading features

The EEI calculation formula must allow a direct comparison of different products by removing the current rewards for special features. One reference line for all cooling / freezing compartments (independently of their category) is sufficient. The misleading correction factors for tropic compressors, Frost Free function, built-in models and chill compartment should be removed. With the formula simplified, the Energy Label will allow consumers to compare models across categories, bring more transparency and do more to support the most energy-saving models. Higher efficiency will more directly translate into saved electricity.

4.2 Household washing machines

Regulatory context

The first A to G EU Energy Label for household washing machines was introduced in 1995 (EC, 1995). The Label was based on a kWh/kg capacity efficiency definition, with 0.19 kWh/kg being the threshold of class A. The energy consumption was defined based on a full load test at 60°C. In 2010, the Energy Label was amended with classes A+ to A+++ (EC, September 2010). At the same time, the efficiency definition was changed: the Label classes are now based on an Energy Efficiency Index (EEI), the calculation of which is based on annual energy consumption including low power modes and does also consider tests at 40°C and with part load, additionally to the full load 60°C programme. The measurement standard was also amended at the same time to include these wash cycles, but also additional features were changed (e.g. different detergent and type of soil). As a result, declarations before and after 2011 have to be compared very cautiously. The new Label was compulsory for new products put on the market from 20th December 2011, while both Energy Label versions could be used in the period from December 2010.
Also from December 2011 the Ecodesign regulation applied, banning washing machine models not reaching energy efficiency class A from the market (EC, November 2010). Other requirements concerned washing efficiency (min. former washing performance class A) and maximum water consumption. In December 2013 this MEPS level was lifted to class A+ energy efficiency and more stringent water consumption values. Since then, all washing machine models also must offer a 20°C programme.
Before the new Label officially introduced the 'plus'-classes, manufacturers had already marketed their machines that were exceeding class A efficiency as 'A-10%' or 'A-20%'. Based on a voluntary agreement between the Commission and CECED, some manufacturers officially labelled these products as 'A+' before December 2010.
The Ecodesign and Energy Labelling regulations are both being revised at the moment. A preparatory study will soon be published, and will make suggestions for new Label and Ecodesign requirements[15]. As for refrigerators, the policy process is expected to continue in 2017.

Table 4: EU energy policies related to household washing machines

Year of application	Policy measure
1996	A to G Energy Label
End of Dec. 2011	- A+++ to D Energy Label - Ecodesign tier 1: o ban of classes B and less efficient o max. water consumption depending on capacity (W≤ 5* c + 35) o washing efficiency > 1.03 (old washing performance class A)
End of Dec 2013	Ecodesign tier 2: o ban of class A o max water consumption tightened (W≤ 5* c1/2 + 35)[16] o 20°C programme mandatory

[15] http://susproc.jrc.ec.europa.eu/Washing_machines_and_washer_dryers/index.html
[16] 6kg machines: 11'000 litres/per year, 7kg: 11'550, 8kg: 12'100, 9kg: 12'650 litres/year.

Table 5: Classifications of the old and current Energy Label

Energy efficiency class	Old Label efficiency (in kWh/kg, until Dec 2011)	Current Label efficiency (EEI, since end of Dec 2011)
A+++		EEI < 46
A++		EEI < 52
A+		EEI < 59
A	≤ 0.19	EEI < 68 (banned since Dec, 2013)
B	≤ 0.23	EEI < 77 (banned since Dec. 2011)
C	≤ 0.27	EEI < 87 (banned since Dec. 2011)
D	≤ 0.31	EEI ≥ 87 (banned since Dec. 2011)
E	≤ 0.35	
F	≤ 0.39	
G	> 0.39	

Results

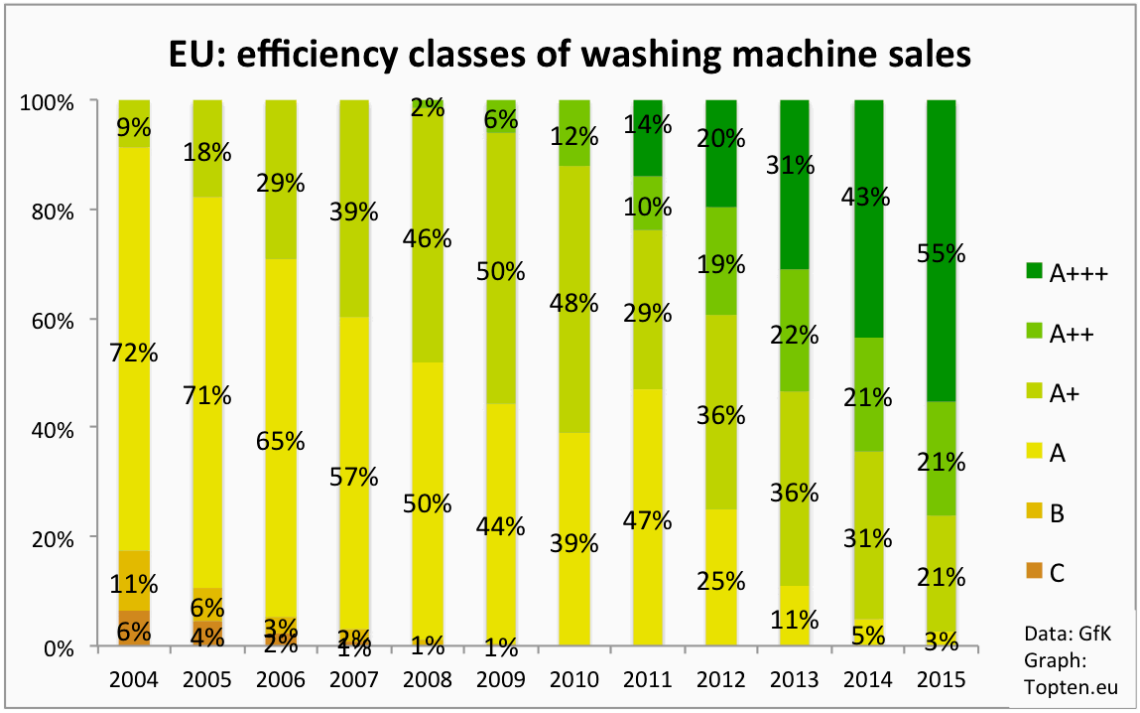

Figure 22: EU: efficiency classes of washing machine sales
Note: Classes A+, A++ and A+++ were only 'official' starting in 2011: before 2011, GfK categorized as A+ whatever was in principle declared as 'A-10%' (or A+), and 'A-20%' as A++. Sales share of these classes before 2011 has to be read with caution.

The efficiency development of washing machines happened much faster than expected by the European Commission. Already in 2004 the Energy Label was out-dated, with more than 80% of the sales in the official top class A. By 2010, when in December the new Energy Labelling regulation entered into force, 60% of the sales exceeded the class A threshold by 10% or more. The Label revision was much too late, and there was little incentive for innovations for many years. There was an increase in class A sales share from 2010 to 2011 – most likely due to the change of Label classification and test measurements that happened at the same time. Already 14% of the sales were in the

new top class A+++ in 2011, the transition year of the new Label. Tier 1 of the Ecodesign regulation, banning class B and less efficient from December 2011, was obsolete from its entry into force. These classes had been virtually gone from the market several years earlier. Tier 2, banning class A from December 2013, was of minor effect – 11% of the sales still occurred in this class in 2013. In 2015, 55% of the sales across the EU were in the top class A+++, meaning that, four years after the current Label became compulsory, the majority of all sold washing machines were in the top class.
These results show that classes A+ to A+++ were introduced too late, and that class thresholds were not defined ambitiously and wide enough. Indeed with 13% (A+) and 12% (A++, A+++) the relative efficiency improvements between the classes are smaller than in other Labels (e.g. refrigerators & freezers: A++ 21%, A+++ 33%; TVs: A+ 23%, A++ 30%), and actually only slightly larger than the measurement tolerance. The current revision of the Label is overdue. A new Label will not be in place before 2018, until then manufacturers have no possibility to market energy efficient innovations. However, these have been on the market for several years already: the best washing machine model is exceeding the A+++ threshold by more than 50% (V-Zug Adora SLQ-WP with integrated heat pump; EEI= 22.8, 8kg. Source: www.topten.eu).

Figure 23 to Figure 26 show that the popularity of the top classes can vary considerably on national markets. The French market seems to have been less efficient than the EU average since 2005. In 2015, A+ and A++ had a higher sales share in France than across the EU, while A+++ was less popular (39% vs 55%). With 47% A+++ sales, Italy is between France and the EU average, while Germany, with 81% A+++ sales, seems to be more than two years ahead of the EU average. Nearly as efficient as the German one is the Swiss market (Figure 26). For washing machines, Switzerland implements identical MEPS as the EU, but class A+ was officially added to the Energy Label in 2008 (A+ was defined as ≤ 0.17 kWh/kg, as in the voluntary CECED agreement used by EU manufacturers).

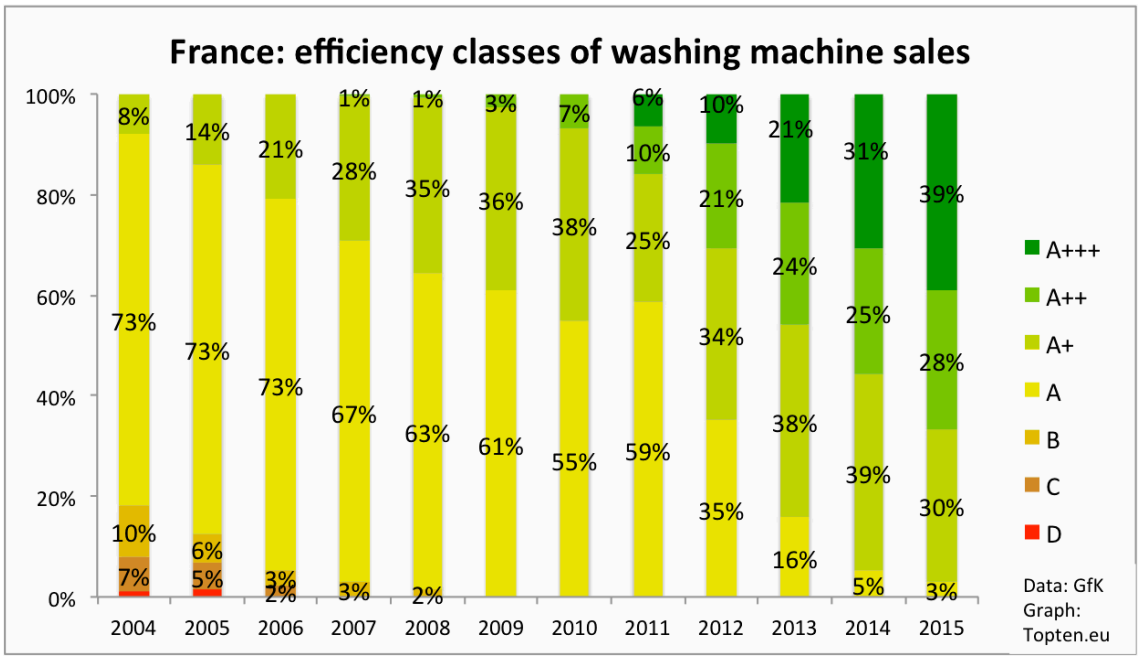

Figure 23: France: efficiency classes of washing machine sales

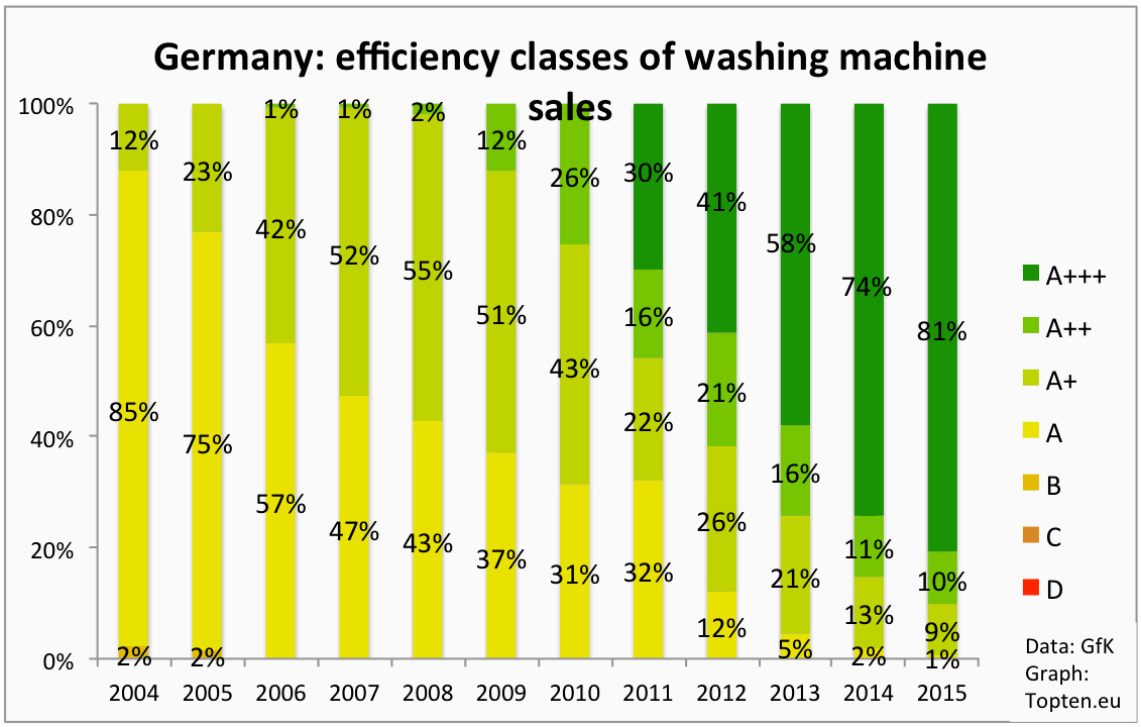

Figure 24: Germany: efficiency classes of washing machine sales

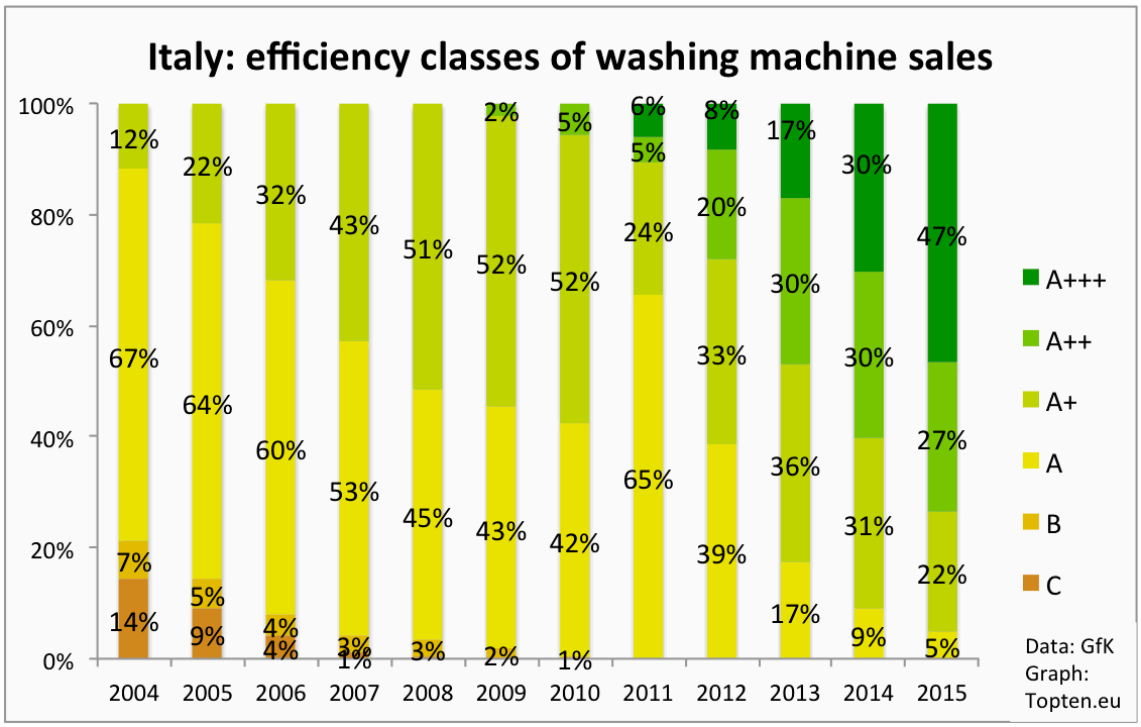

Figure 25: Italy: efficiency classes of washing machine sales

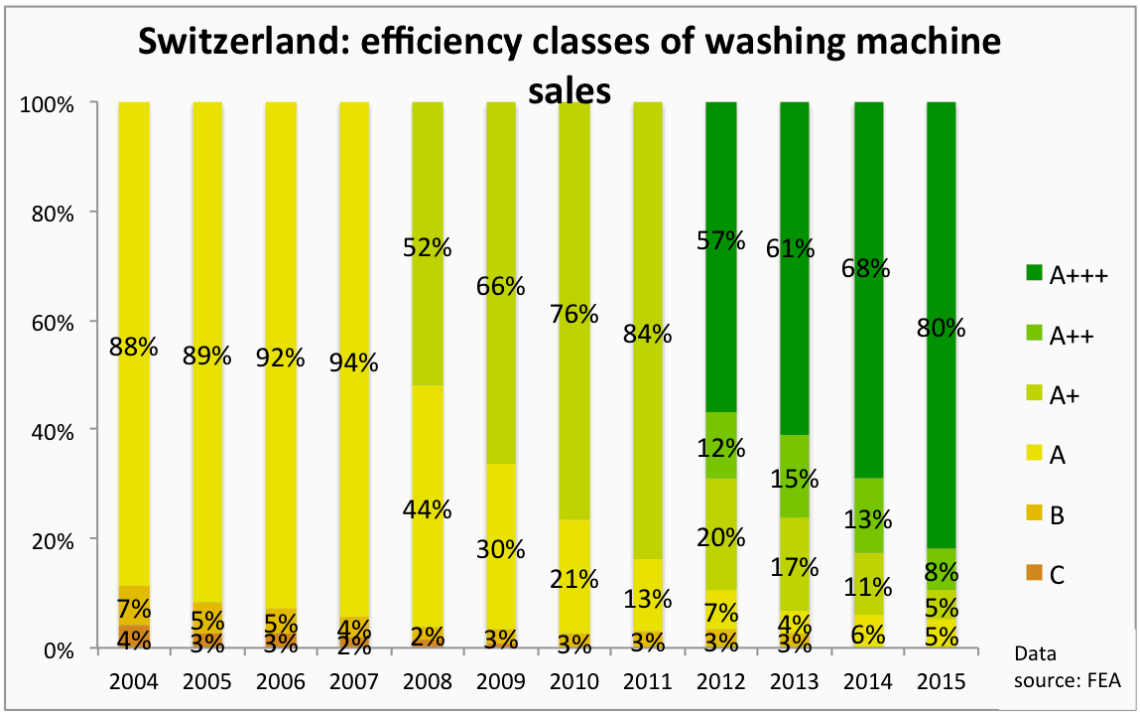

Figure 26: Switzerland: efficiency classes of refrigerator sales. Source: S.A.F.E. and FEA, 2016

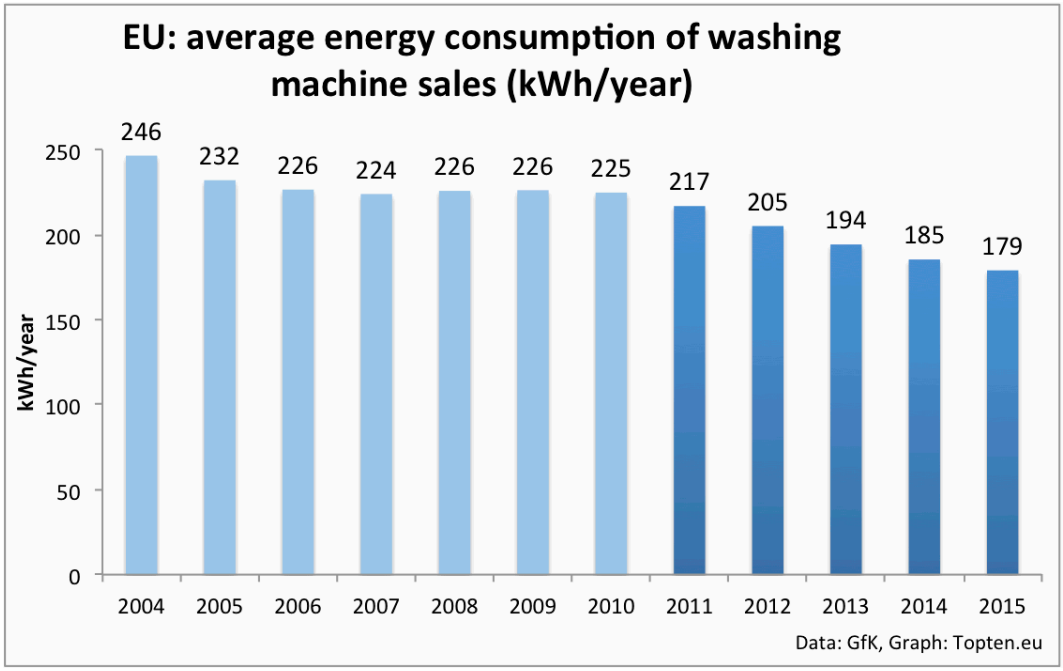

Figure 27: Average energy consumption of EU washing machine sales.

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.

After a reduction from 2004 - 2006, average declared annual energy consumption of the sold washing machines remained stable at around 226 kWh/year in the EU. Only in 2011, with the introduction of the current Label, it started to go down, to reach 179 kWh/year in

2015. The reduction in declared and calculated energy consumption between 2004 and 2015 is 27%. This is comparable with the reduction that happened in refrigerators, as shown above. In the case of refrigerators the energy declaration however remained the same, while for washing machines the real reduction is not so clear because of the changing declarations: the new declaration is no longer based only on full load 60°C washing cycles (three out of seven), but includes also 60°C half load and 40°C half load cycles (each two out of seven), and the measurement standard has changed. These changes mean that there is now an incentive for manufacturers to also optimise the energy consumption of the cotton 40°C and part-load programmes. However part of the lower energy consumption after 2011 might be due to the inclusion of these less energy consuming programmes – while on the other hand newly also low power modes were included (which can represent up to 12 kWh/year (Van Holsteijn en Kemna, 2014)). Own calculations, based on the values recommended by the Commission in 2009 for transitioning between the old and new methods (EC, 2009) and values published on www.topten.eu[17] imply that around 10% of the reduction in declared energy consumption might have occurred due to different methods, leaving a reduction of around 17% that can be credited to technical improvements and programme optimisation. Still, the average declared energy consumption has continuously been reduced since 2011 - despite a strong trend to larger washing machines (Figure 31), showing that the tested programmes have indeed been optimized regarding energy efficiency.

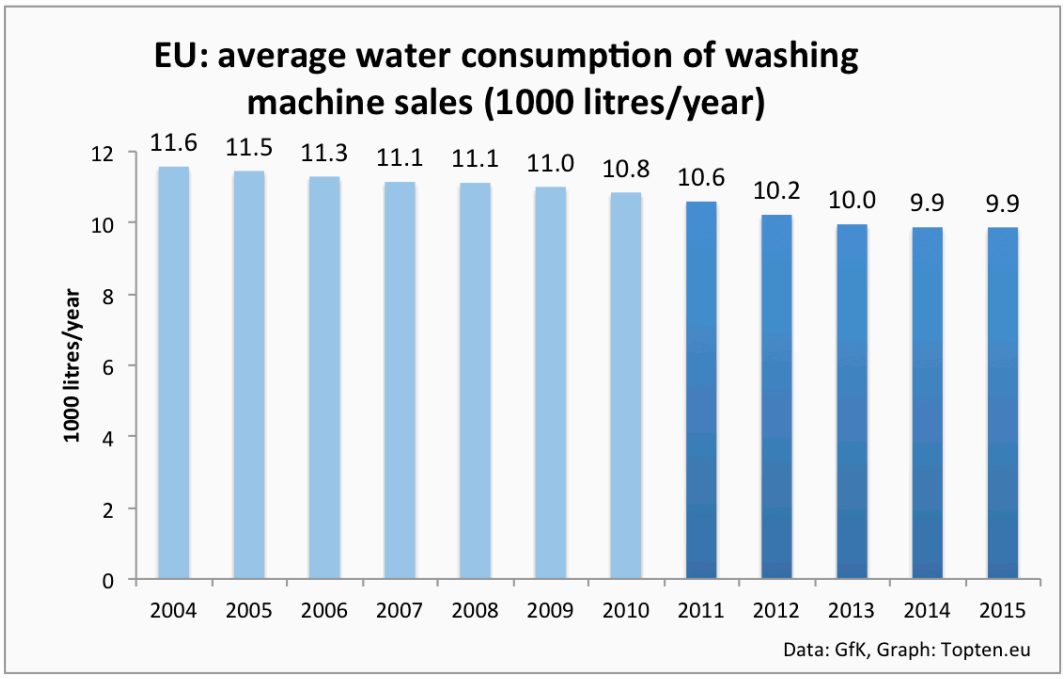

Figure 28: Average water consumption of EU washing machine sales in litres

Note: As for energy consumption, also for water consumption the declaration changed from litres / cycle (multiplied with 220 cycles per year for this figure) to annual consumption with the introduction of the new Energy Label in December 2011. Because also the measurement standard changed, the values are not fully comparable. While the

[17] The Commission recommended to assume that the energy consumption of a 60°C half load programme is 0.8 times that of a 60°C full load, and the consumption of a 40°C half load 0.64 that of a 60°C full load programme. Furthermore, 12.5 kWh per year were added for the Standby and Off modes. Data from Topten.eu shows that these assumptions are still fairly correct (in September 2014), but variations are large. The consumption by low power modes has not been compared.

exact values have to be read with caution, this chart can show trends before and after 2011.

Average yearly water consumption of EU washing machines has been reduced by 1700 litres (15%) since 2004. This is clearly less than the 27% energy reduction. Obviously next to reduced water use, also other efficiency options have been realised.

Differences in average declared annual energy consumption are much smaller than for refrigerators: of the countries considered here, the highest average consumption (France) in 2015 was 22 kWh/year higher than the lowest average consumption (Germany). (For refrigerators this difference was 83 kWh/year).

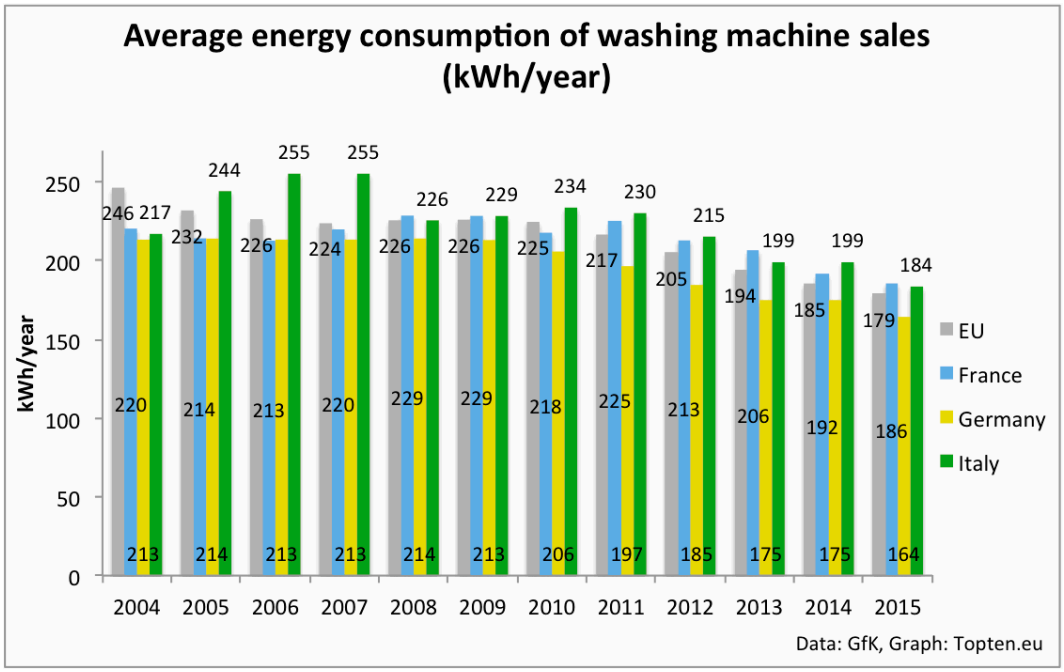

Figure 29: Average energy consumption of washing machine sales in the EU, France, Germany and Italy.

French washing machines sales used to have an energy consumption lower than the EU average until 2007 (and in 2010). Between 2006 and 2009 it increased (from 213 to 229 kWh/year). Since no change in declaration occurred, the trend to larger machines (shown in Figure 31 to Figure 34) must have outweighed increasing efficiency in this period.
Since 2011 French washing machines consume more than the EU average (2015: 186 kWh/year vs 179 kWh/year), in 2015 (and 2013) also more than the Italian average. This is clearly due to the comparably low energy efficiency. French consumers buy more small washing machines (6kg and less) than the EU average (Figure 32), therefore the size seems not to be part of the explanation. (It might be linked to top-load washing machines being popular in France, but data on this is not available.)
Washing machines sold in Germany have always had a below-average energy consumption, through 2015 (164 kWh/year vs EU average of 179 kWh/year). Reasons are without doubt the high efficiency sales in combination with a preference for not-so-large washing machines (Figure 33). In last year's market monitoring report (Michel, Attali, Bush, June 2015) we had found a high share of efficient washing machines being sold in Portugal (47% A+++ in 2014), and this was combined with a preference for large models

(80% 7kg and more) – resulting in a high average consumption, despite the high efficiency. For Germany, we can't see this correlation: German do not buy larger washing machines than the EU average (they have a preference for 7kg-machines, see Figure 33). Hence, high-efficiency sales need not go hand in hand with large capacities.

Washing machine sales in Italy showed high average energy consumption 2005 – 2007, which cannot be explained neither by looking at the efficiency classes (Figure 25) nor the capacities (Figure 34). Since then, energy consumption of washing machines sold in Italy has been comparable, but somewhat higher than the EU average. Italians do not buy larger washing machines than the EU average, but less efficient. Comparing Italian sales with France, it is the other way round: Italian washing machines are slightly more efficient, but also a bit larger.

Similar to energy consumption, German washing machines consume least waster, while Italian models consume more than the EU average (**Figure 30**). France is in line with the EU average. The reduction from 2004 to 2015 has been 1600 l/year (-14%) in France, 500 l/year in Germany (-5%) and 2600 l/year (-21%) in Italy.
Since 2004, the differences between countries and the EU in average water consumption have become much smaller.

As for refrigerators, the figures for France can be contrasted with the results from the measurement campaign by Enertech (Enertech 2016). The average energy consumption Enertech measured for 100 washing machines in French homes was lower than in any comparable French study before: 92 kWh/year. This is only 50% of the average declared energy consumption of washing machines sold in France in 2015. This can be surprising, because the washing machines that were measured are quite old (average: > 6 years). Six years ago, in 2009, the average declared energy consumption of washing machines sold in France was even higher that in 2015: 229 kWh/year – nearly 150% more than what has actually been measured.
Aspects that can explain the difference:

- Average use of the washing machines measured by Enertech was 168 cycles per year. This is 20% less than the number of cycles that is assumed for calculating the current Label consumption (220). This cycle number has also been used for calculating the annual energy consumption based on the consumption per cycle that was declared on the old energy label before 2011.
- Washing machines offer a big variety of programmes, some of which use less energy than the standard programmes used for the label declaration. Washing energy consumption is mostly affected by wash temperature: heating up the water is the most energy consuming process in a wash cycle. If users choose cooler programmes than those the Label is based on, the real energy consumption can be much lower than declared. Six years ago, the Energy Label was only based on the 60°C cotton programme; today it is referring to a mix of 60°C and 40°C cotton programmes. As in other consumer studies (e.g. Universität Bonn, 2015), also in Enertech's survey most users preferred the 40°C (48%) and 30°C (31%) programmes over higher temperatures. Less than 20% of all cycles were run at temperatures of 60°C or higher, according to users' indications. Own calculations comparing the average heating needed with the Label and user's programme mix show that the cooler programmes can explain most of the difference in energy consumption.
- Another aspect are programmes for different types of textile. While the Label programmes are tested with cotton, Enertech's user survey shows that users choose

cotton programmes for only 32% of their wash cycles. Often they used programmes for 'Colours / Mixed' (30%) and 'Synthetic' (24%) laundry. Measurements showed at the same time that both of these programmes are on average less energy intense than cotton programmes (Cotton: 748 Wh, Colours / Mixed: 654 Wh, Synthetic: 547 Wh,).

So: study participants wash less often, with cooler and less energy consuming programmes than assumed for the energy label. Therefore, in reality energy consumption can be clearly lower than declared.

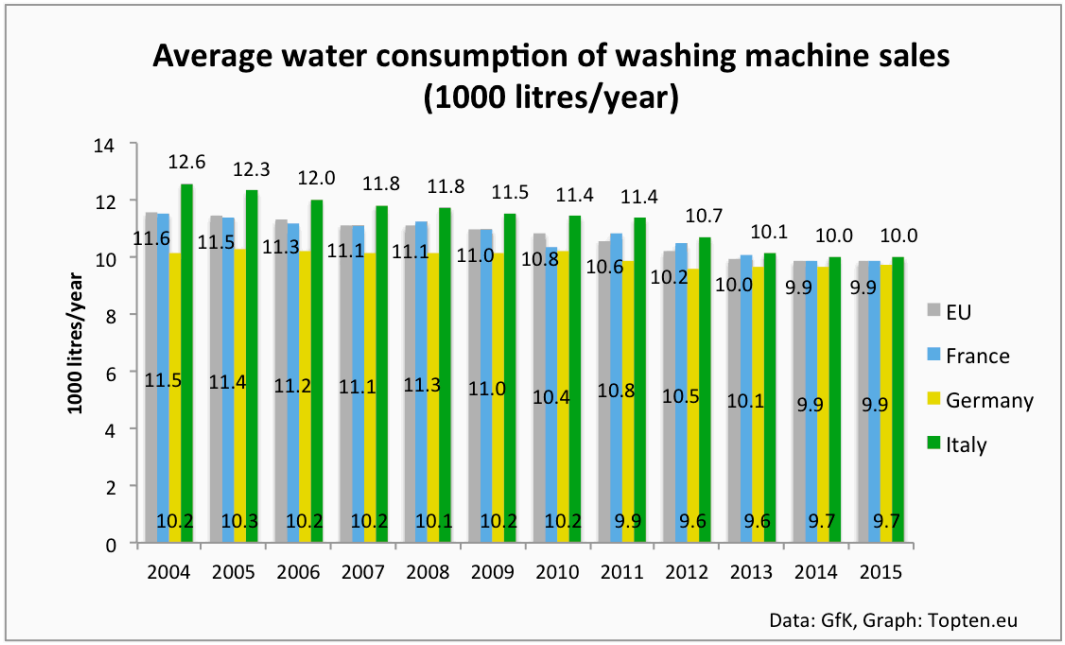

Figure 30: Average water consumption of washing machine sales in the EU, France, Germany and Italy.

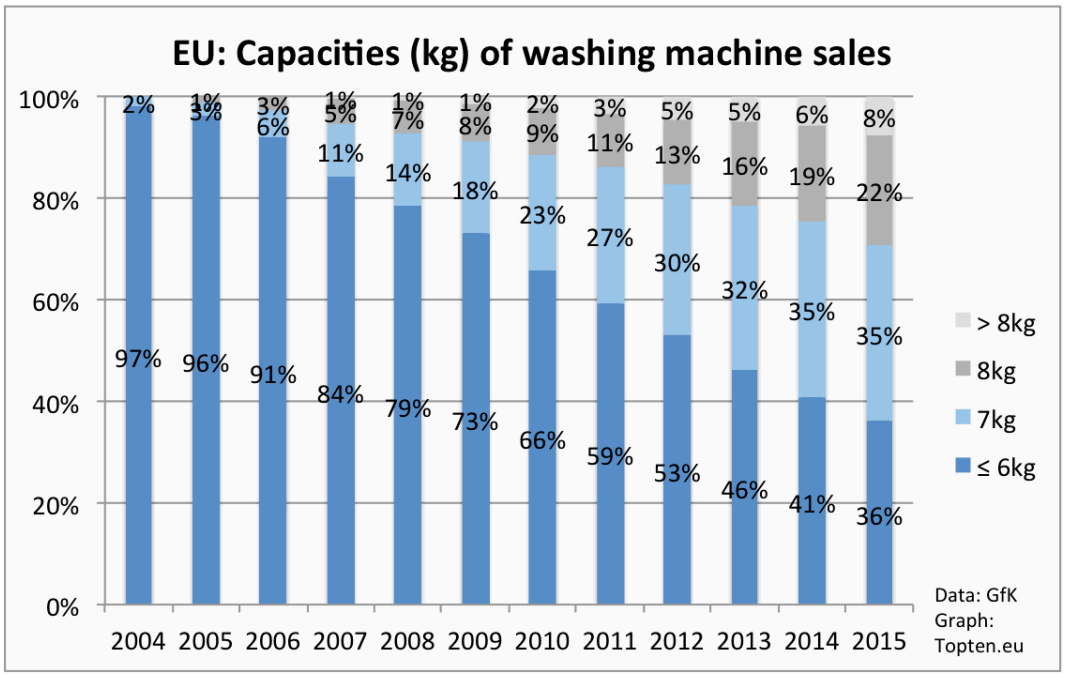

Figure 31: EU: capacities of washing machine sales

Ten years ago nearly all washing machines were for 6 kg of laundry and less, then the strong trend to larger capacities started. In 2015, only 36% of all washing machines sold across the EU were declared to be marketed for washing 6 kg of laundry or less, 35% were designed for 7kg and 30% for 8kg or more.

French consumers choose rather smaller washing machines than the EU average consumer (higher share of 6kg and less, lower share of 7 and 8kg), but very large machines are sold more often in France than across the EU (> 8kg: 11% vs 8%). Germans have a preference for 7kg-machines: with 43% this is the most popular size. Compared to the EU average, Germans buy less washing machines of all other size categories, be it smaller or larger. Italian washing machine capacities are quite in line with the EU average.

It is not clear if the trend to large washing machines is coming from changed consumer demand or rather from the market offer. It is questionable if washing habits are changing so suddenly to washing larger loads, especially since the average household size is declining. Studies show that the average load is still below 4kg (Pochart, Smith, 2016), and that users do not fill large machines with more laundry (Schmitz, Alborzi, Stamminger, 2016). The previous Energy Label might have at least partly supported this trend, since it has been easier for large machines to reach good efficiency levels. With the inclusion of part load washing the effect is less direct than it was in the old Label, but the EEI formula still follows a strictly linear efficiency approach: an A+++ washing machine with 8kg capacity can use nearly 30% more energy than a model with 6kg. Instead of efficiency improvements that lower the machine's energy consumption, good efficiency classes can more easily be reached by increasing the load capacity. Accordingly, the trend to larger washing machines has been continuing. Even if they are in class A+++, oversized washing machines do not contribute to energy saving. Instead, energy and water will be wasted if most wash cycles are run with low part loads (e.g. 2-3kg in 8kg machines).

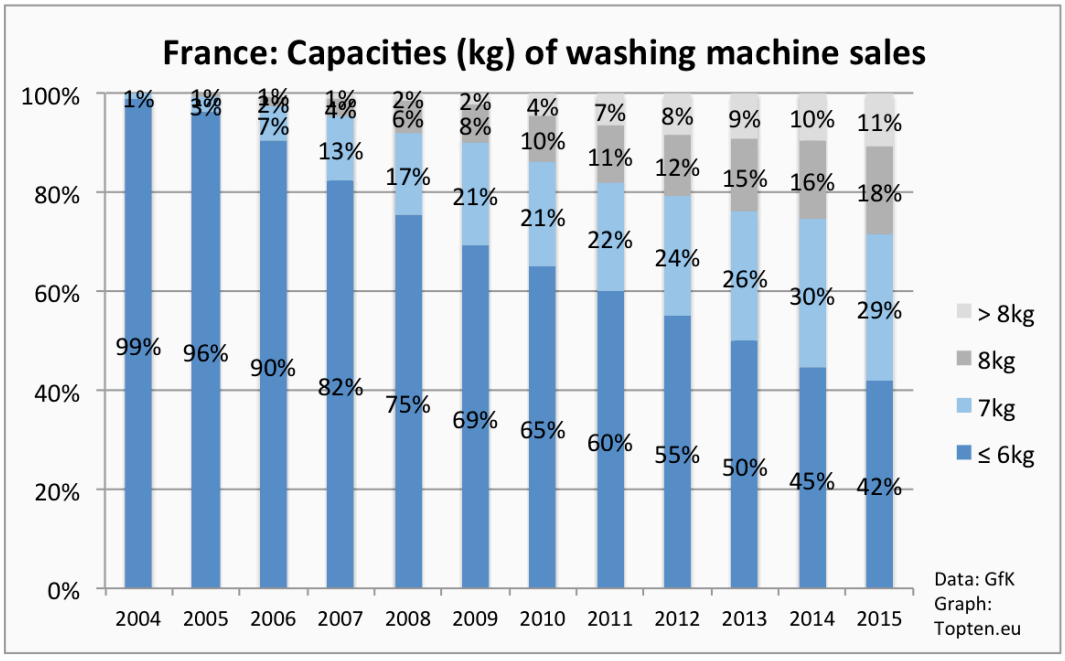

Figure 32: France: capacities of washing machine sales

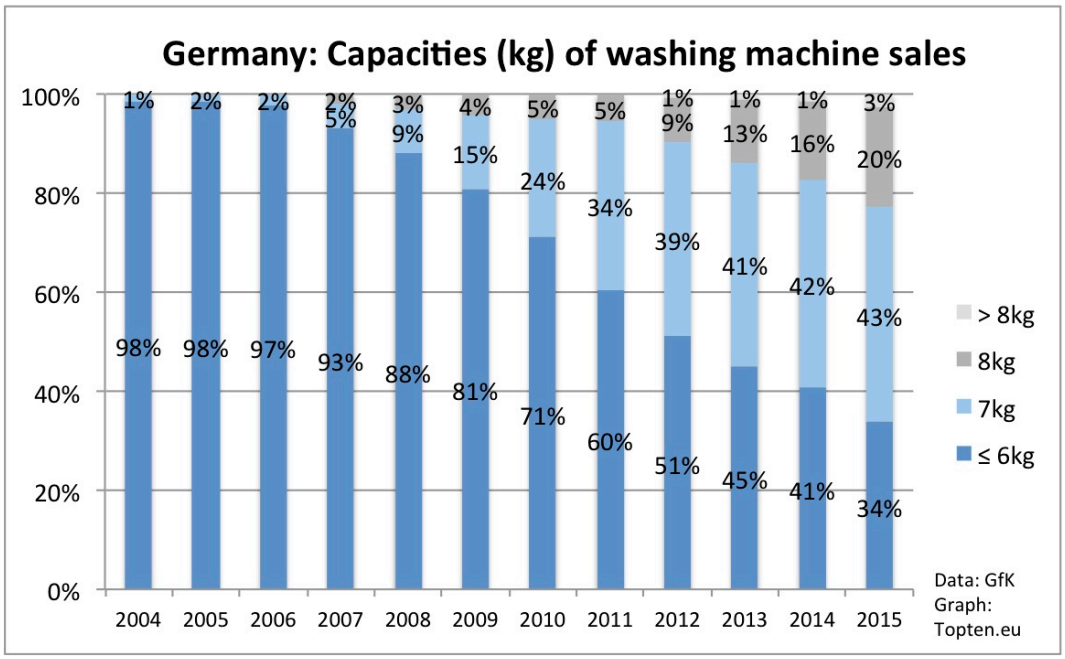

Figure 33: Germany: capacities of washing machine sales

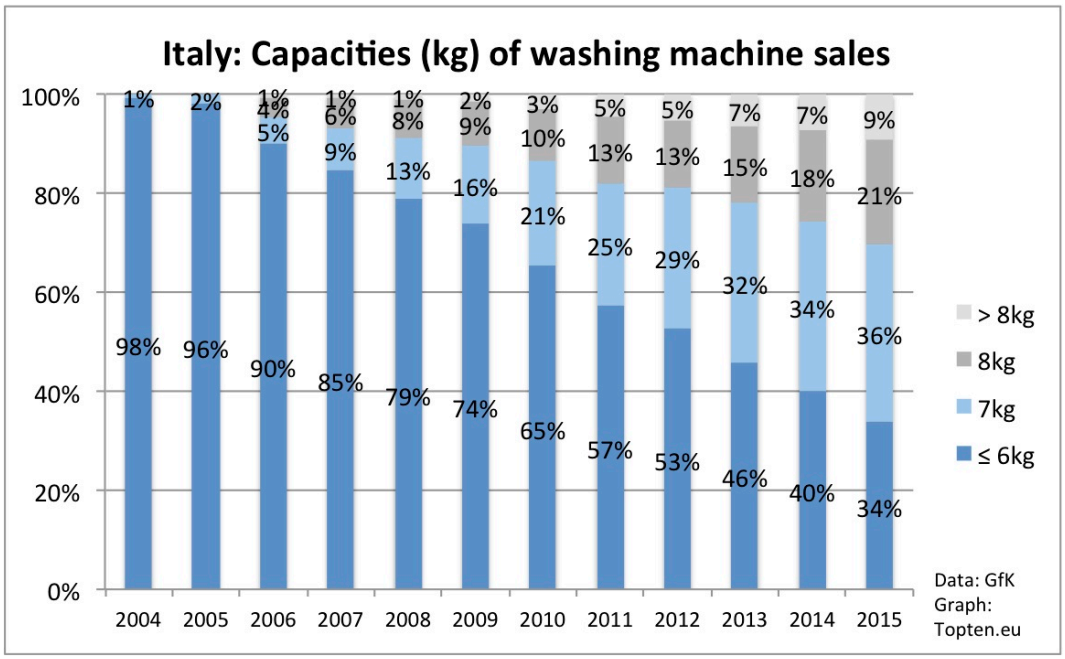

Figure 34: Italy: capacities of washing machine sales

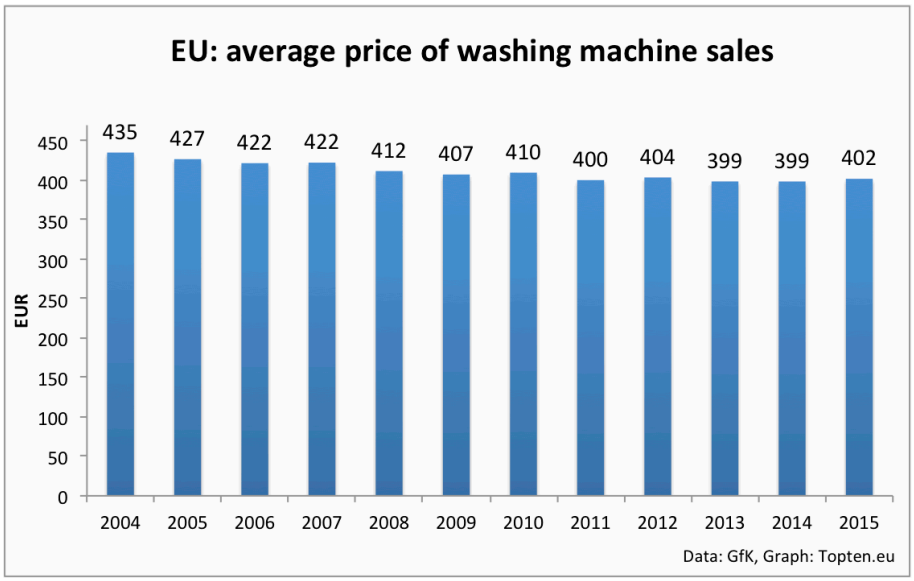

Figure 35: EU: Average nominal price of washing machine sales

From 2011 to 2015 average nominal washing machine prices across the EU-21 have been nearly stable at roughly 400 Euros. But since 2004, they have declined by 8% – despite higher efficiency and larger capacities. Different from refrigerators (and tumble driers), Italian average prices for washing machines have been below the EU average. French prices have been below the EU average since 2009, while German prices are clearly higher. In France, the reduction in price has even been 21%, to reach 363 Euros in 2015. In Germany and Italy, the price reduction has been much lower: 4%. In 2015 average prices were at EUR 480 (Germany) and EUR 368 (Italy), respectively. It is tempting to explain the high Germany price level with the high efficiency of the washing machines. But Figure 44 shows that also the prices for A+++ and A++ washing machines are higher than in the other countries.

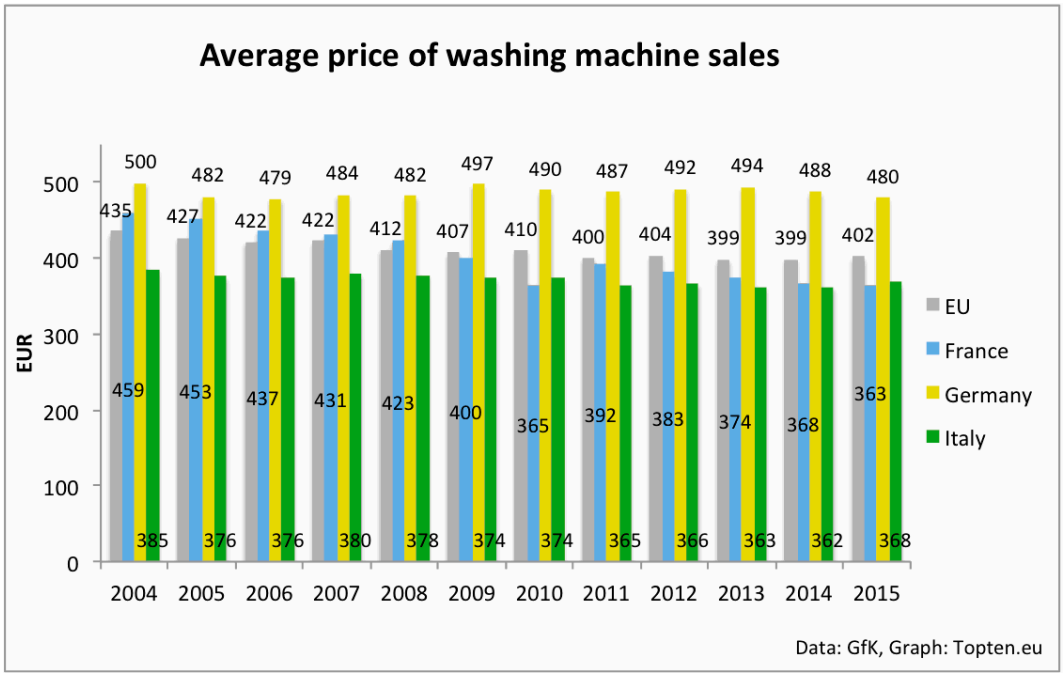

Figure 36: EU, France, Germany and Italy: Average nominal price of washing machine sales

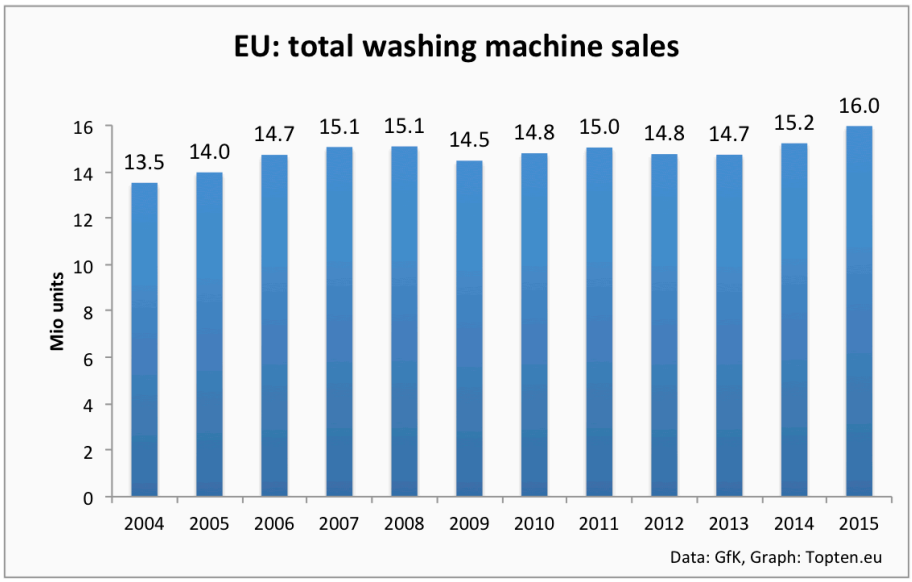

Figure 37: EU: total washing machine sales

Sales numbers increased from 13.5 million to 15.1 million units from 2004 to 2007 in the EU-21, then fluctuated around 15 million units per year before climbing to a maximum of 16 million in 2015 (Figure 37) – i.e. 18% more than 11 years ago. Sales in France show a similar pattern, reaching 2.4 million in 2015 (+19%). In Germany, sales increased by 33% from 2004 to 2015, to reach 2.9 million units in 2015. Italian washing machine sales climbed by 26% in this period: in 2015, 1.8 million models were sold in Italy.
In 2015, sales per 100 inhabitants were 3.2 units across the EU, 3.6 in Germany and France, and 3.0 in Italy.

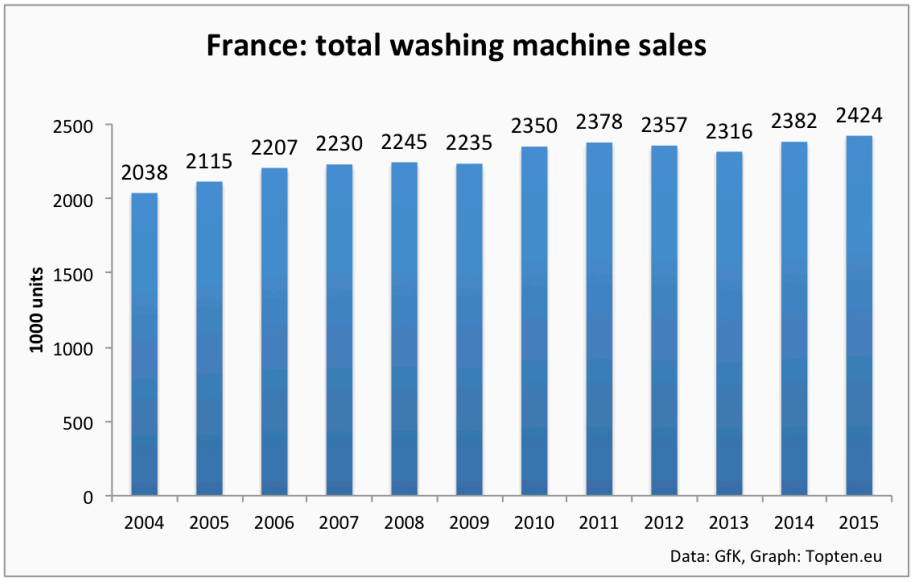

Figure 38: France: total washing machine sales

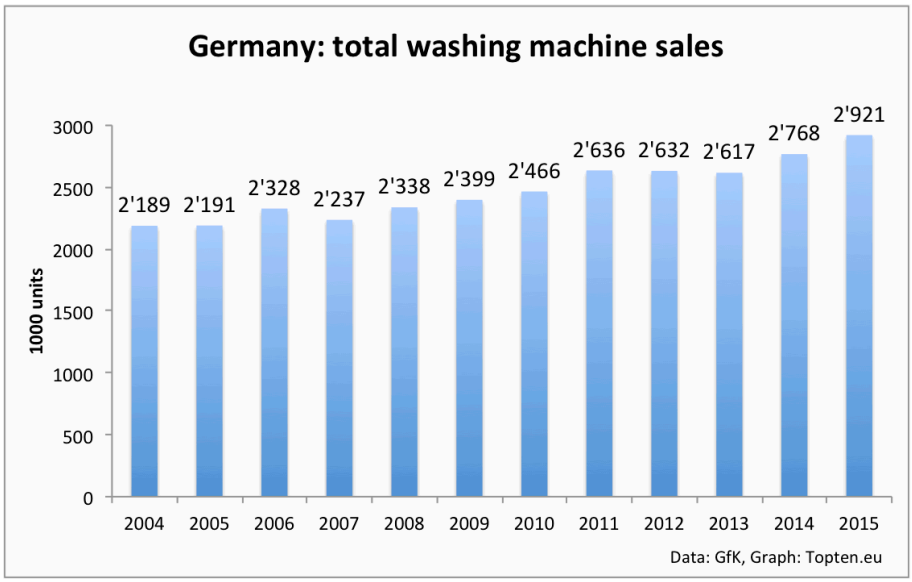

Figure 39: Germany: total washing machine sales

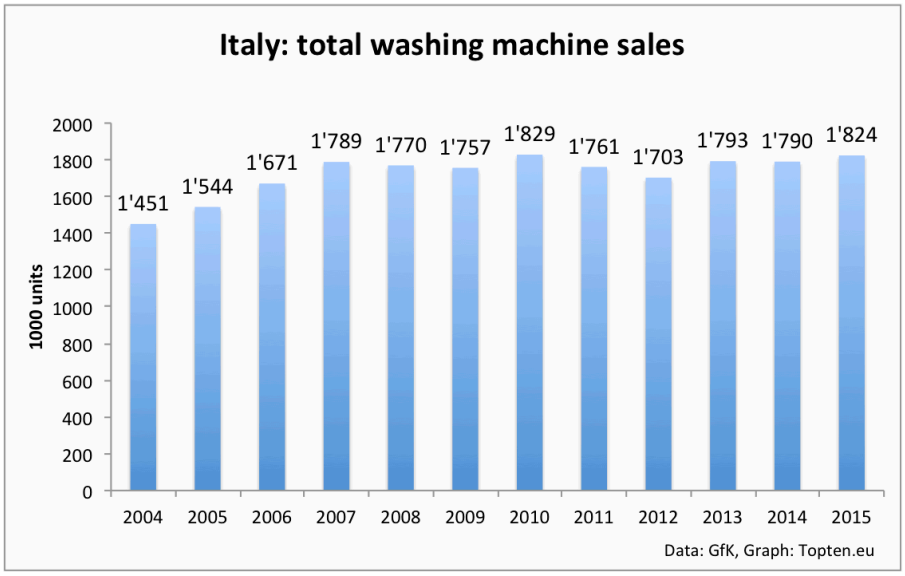

Figure 40: Italy: total washing machine sales

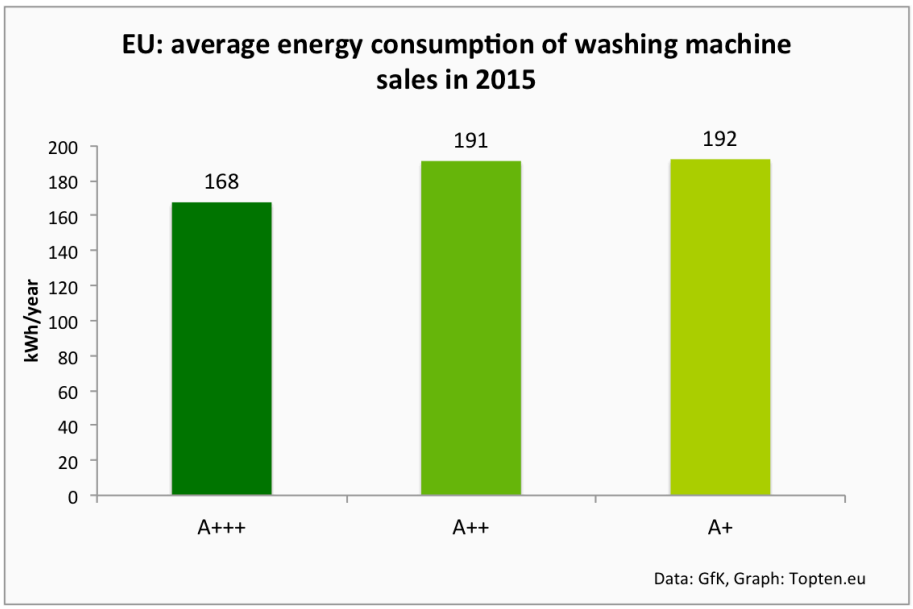

Figure 41: EU: average energy consumption of washing machine sales according to energy classes, 2015

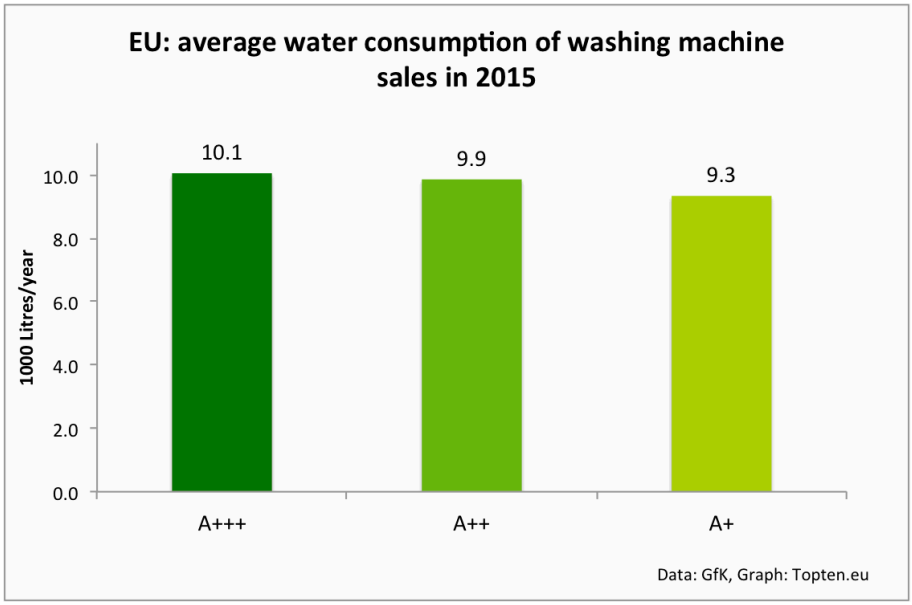

Figure 42: EU: average water consumption of washing machine sales according to energy classes, 2015

Figures 41, 42 and 43 show average declared energy and water consumption and size differences between efficiency classes. The reduction in declared energy and water consumption between the classes is small to nearly non-existent. The average declared energy consumption of all class A+ and A++ washing machines that were sold in 2015 is virtually the same, while A+++ machines on average consume 23 kWh/year less. Average declared water consumption of efficient washing machines is even higher than that of A+ washing machines.

The reason for the negligible reduction in resource consumption by efficient washing machines is probably the size correlation shown in Figure 43: washing machines sold in the two top efficiency classes are sold for clearly larger capacities than A+ models. While A+ washing machines are mainly sold for washing 6kg and less laundry, most A++ and

A+++ sales are for 7kg or more. 43% of the sold A+++ washing machines are sold for washing 8kg or more laundry.
The higher efficiency of A+++ machines compared to A++ outweighs the higher capacities shown in Figure 43. Compared to other domestic appliances, however, the reduction in energy consumption from class A++ to A+++ is modest: for refrigerators (50 kWh/year) average reduction from class A++ to A+++ is double that of washing machines (23 kWh/year).

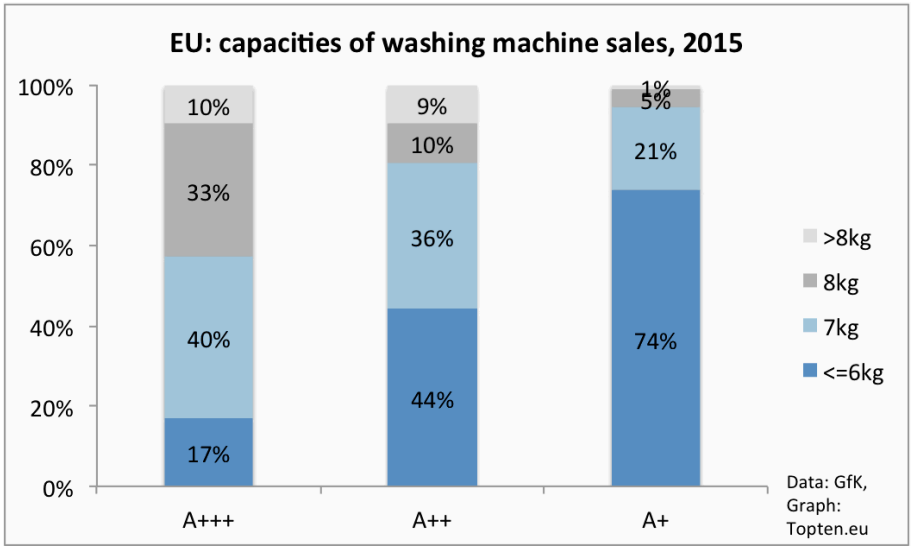

Figure 43: EU: capacities of washing machine sales according to energy classes, 2015

While these declared energy consumption values are valuable for comparing models with each other, they however bear little evidence of how much energy washing machines are consuming in reality, when users choose programmes different from the test programmes or fill their 8-kg-machines with 2kg only. Larger washing machines certainly bear the risk of wasting more energy than smaller ones.

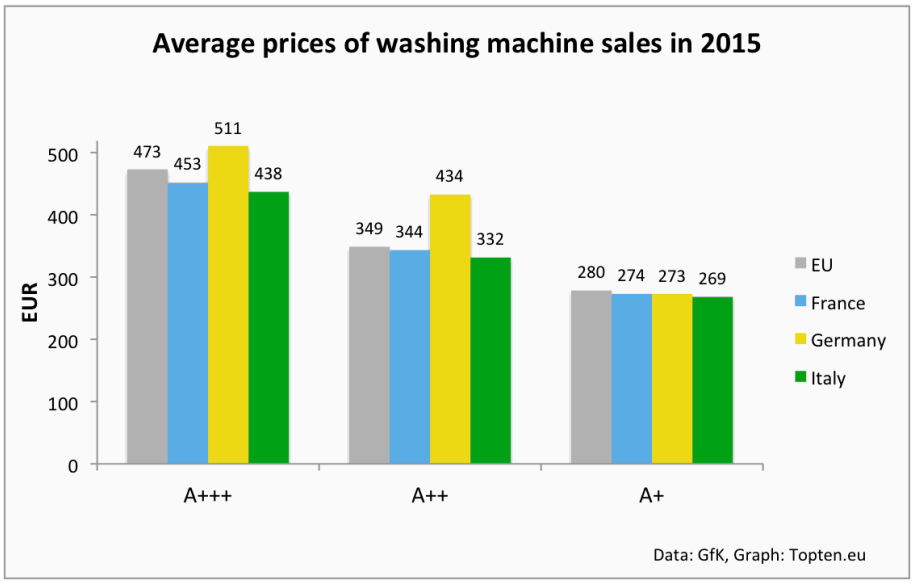

Figure 44: EU, France, Germany and Italy: Average price of washing machine sales according to classes, 2015

Washing machines in the top efficiency classes have clearly higher prices than less efficient ones. Comparing the 2015 EU prices with those from 2014 (in Michel, Attali, Bush, 2015), we can see that prices by energy class have decreased. Due to the shift to higher efficiency shown in Figure 22 and larger average size shown in Figure 31, total average prices (Figure 35) have not decreased.

French and Italian washing machine prices are below the EU average for all classes, while German consumers pay less for A+, but clearly more for A++ and A+++ machines. (German consumers choose smaller washing machines than the EU average, so large capacity cannot be the reason for the high German prices. It must be other quality aspects.)

The general price premium for A++ and A+++ machines might however also be linked to size. Figure 45 shows the correlation between size and price. A+++ washing machines are more expensive because they are efficient and large.

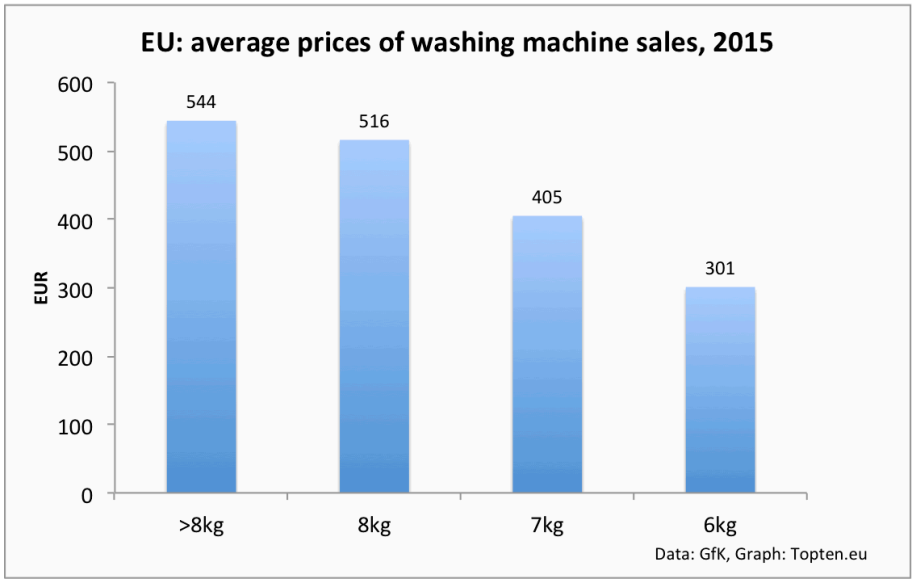

Figure 45: EU: average prices of washing machine sales according to capacities, 2015

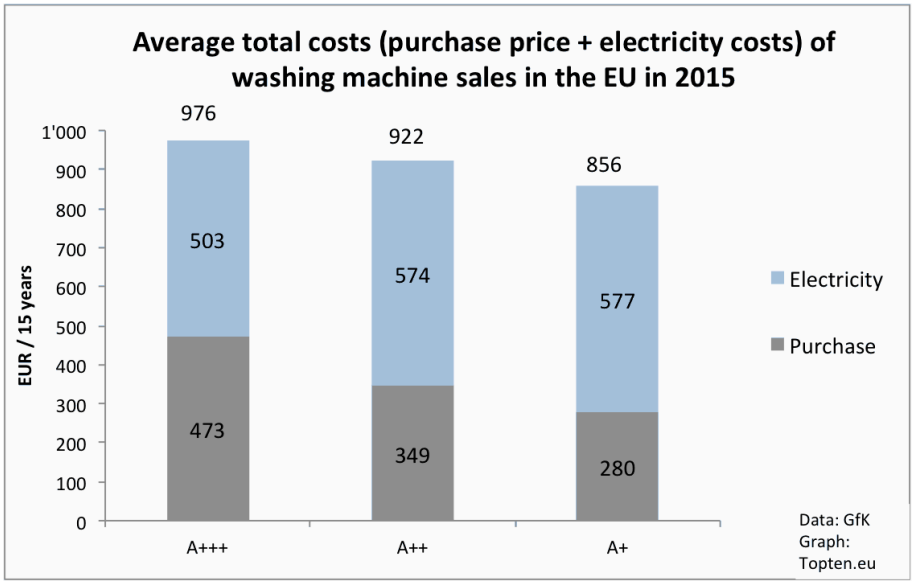

Figure 46: EU: Total costs[18] (purchase price + electricity costs) of washing machine sales in 2015

In the case of washing machines, in terms of total costs, EU consumers were better off with A+ models than more efficient ones in 2015. Large price differences for machines in better efficiency classes combined with little energy efficiency gains lead to total costs[15] being higher for more efficient washing machines. However, of course also this graph includes a size bias: the fact that washing machines in better efficiency classes are larger is reflected in both parts of the lifecycle costs – in purchase price as well as electricity costs (because the declared annual energy consumption is based on tests with a larger load). Effective total costs depend strongly on actual usage.

Conclusions

In 2015, across the EU, 55% of all washing machine sales have been in the A+++ class; in Germany even 81%. The fact that the market has shifted to high energy efficiency so fast is good news. Four years after the introduction of three new classes A+, A++ and A+++ the next label revision, which is actually on-going, is already overdue.
On the other hand it seems that the 2010 classes have not been designed ambitiously enough: as explained above, improvement steps between the classes are much smaller than for other appliances. Additionally, part of the reduction in energy consumption may be due to the inclusion of 40°C-programmes into the test and EEI calculation, as well as other standard changes in 2011.

Since the introduction of the 2010 energy label, the declared energy consumption has decreased.
However it is not clear to what extent this declared energy consumption reflects the actual consumption in households. Washing machines offer a large programme diversity, while only the standard cotton 60°C and 40°C programmes are tested. Also other variables affect the energy consumption, such as type and amount of laundry, number of wash cycles per year or detergent type. Users do not wash their laundry according to the test standard, and the actual energy consumption may be considerably different from that

[18] 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.

declared. Enertech's measurement results imply that real consumption can be much lower than declared, presumably mainly due to lower wash temperatures and less cycles per year.
Still, the strong trend to larger capacities is worrying because a lot of energy may be wasted if the machines are not fully loaded. Because heating up the water uses up most of the washing energy, and more water is used to fill a larger drum, the risk of wasting energy is higher for large drums.
Most large washing machines have only slightly larger outer dimensions than models with lower capacity – it is mainly the drum size that has been optimised. If the water use is very well adapted to the amount of laundry for all amounts (also loads < 50%), a larger drum needs not lead to a higher water and energy consumption. It is unclear how well modern washing machines adapt water and energy use to loads different from standard loads (50% of full load) and for programmes other than standard programmes. The larger the machine, the more wash cycles will be run at low part loads (e.g. 2kg in an 8kg machine). If a machine does not adapt water and energy use optimally to the 'real' load for all programmes, much more energy and water can be wasted if the drum is larger.
It seems that the Energy Label's EEI formula presents only little incentive for reductions in energy consumption: the strictly linear efficiency approach makes it easier for large machines to reach good efficiency classes. High efficiency washing machines may on average have a lower declared energy consumption than lower-efficiency machines. But due to the larger drums they may effectively consume more energy and water in reality, not less. Clearly the misleading incentive by the Energy Label towards larger washing machines must be removed in the frame of the on-going revision.
For the future, one of the largest saving potentials in washing that is independent of declared values lies in the promotion of cold wash. Topten tests showed that washing at 20°C can lead to equal results as at warmer wash temperatures, but saves 60% energy compared to 40°C (Josephy et al., 2015).

Recommendations

1. Energy Label: A to G with empty top classes, stop the trend to larger machines

The current Energy Label has been implemented too late, and the added classes were not ambitious enough, efficiency steps between the classes are too small. The on-going revision should avoid these mistakes and define a Label with classes that can encourage the development of more energy-efficient washing machines for several years into the future. The new Label should be guided by BAT: the best washing machine model is exceeding the A+++ threshold already by more than 50% (www.topten.eu): V-Zug Adora SLQ-WP with integrated heat pump. EEI= 22.8) In addition, the Label should be re-scaled to the original A-G scheme, which has shown to be most effective in many studies (e.g. Molenbroek et al., 2014), with the top classes reserved for future innovations.
Furthermore the new energy label for washing machines must stop encouraging larger machines. This can be achieved with a progressive reference line for the EEI calculation ('Standard annual energy consumption', SAEc): the requirements for reaching a specific efficiency level should be higher for larger machines. At the same time we recommend to include a 'small' load test cycle (2kg, e.g. replacing the half load test) into the EEI and energy consumption calculation (see also Topten policy recommendations[19]).

[19] http://www.topten.eu/?page=washing-machines-3&fromid=

2. Label programmes need to be user-friendly and easy to find, no duplication

A recent consumer survey (Universität Bonn, 2015) shows that the standard programmes are used in less than 17% of all cases. Information on washing habits collected by a detergent manufacturer even indicates a much lower use of long-duration label programmes (only 1 out of 99 wash cycles in French households lasted longer than two hours (Pochart, Smitz, 2016)). This means that for more than 80% of all wash cycles the energy consumption is unknown and can be higher than declared. Many of today's machines have two versions of the standard programmes: a 'standard' version (for test and declaration) and a 'normal' version (for use) – the latter often being much easier to access. It is important to have label programmes that are also relevant for real life use, and easily accessible. This means that not only should the standard programmes be optimised regarding energy efficiency, but also the duplication of the 40°C and 60°C cotton programmes (one for declaration, one for use) should be prevented. Instead, manufacturers should make real trade-offs between energy consumption/efficiency and programme time for the most used programmes. A differentiated time cap for the test cycles should also be considered, in order to avoid excessive programme duration.

3. New MEPS, banning high-consuming washing machines

Based on today's label, no efficiency requirements are possible without banning small, low-consuming models. Based on a new, appropriately progressive efficiency formula, new MEPS should be introduced. Another possibility would be to base MEPS on consumption instead of efficiency and to ban washing machines that are consuming more than 200 kWh/year.

4. Future: promote cold wash

More extensive use of the cold (20°C) wash programme holds by far the biggest saving potential. A Topten study has shown that cold wash can yield good wash results (Josephy et al., 2015). In the future, a minimum washing performance level should be required for the cold wash programme. This would guarantee users can get clean clothes using only little energy. The test standard should be updated to include liquid detergent, so that performance tests of the cold wash programme are possible.

4.3 Tumble driers

Drier technologies

Tumble driers evaporate the moisture by blowing hot dry air through the laundry. The air is heated up by the electric heating element. There are two different basic technologies that exist to remove the evaporated water (Nipkow et al., 2009):

- Vented driers (open systems) blow the exhaust air (initially air from the room) outdoors. This can cause disturbing smells, steam and noise at the external outlet.

- Condensing driers (closed systems) use a heat exchanger cooled by interior air to condense water from the warm moist air in the drier. Condensing driers with an integrated heat pump ('heat pump driers') are the most energy efficient driers, consuming only about half of the electricity of conventional condensing driers.

Regulatory context

The original Energy Label for tumble driers was adopted in 1995, and became compulsory from April 1996 (EC, 1995). This Label's classification was based on a simple kWh/kg efficiency (consumption per cycle divided by the capacity), tested at cotton full load and with 60% initial moisture content (before 2005 the test was performed with 70% initial moisture content). Different classification schemes applied for vented and condensing driers. For a long time, both technologies did not reach efficiency classes beyond class C.

Starting in 2000, heat pump condensing driers were introduced to the market. They did reach class A from the beginning, and even exceeded the threshold: first heat pump driers reached efficiency values of around 0.3 kWh/kg from the start, nearly 40% better than the class A threshold (Werle et al., 2011). Even if only heat pump tumble driers were able to reach class A, the Energy Label did not allow to show the real, huge efficiency advantage of this technology over conventional condensing driers (that started to appear in class B after heat pump driers had entered the market). Also the Label could not show efficiency differences among heat pump driers, which started to emerge with the technology maturing.

The revised Label from 2012 (EC, March 2012) addressed these deficiencies by introducing classes A+ to A+++. This new Energy Label became compulsory from June 2013 (EC, May 2012), the year before being a transition period. Like before, classes A and better were 'reserved' for heat pump driers (until today no other technology meets the A class requirements), but since most heat pump driers reached classes A+ and better, the efficiency gap to conventional driers is made visible. Also the 'Plus'-classes allow consumers to differentiate between more and less efficient heat pump driers. The drawback of the new classification is that class A – the class with the most powerful consumer message – is nearly empty, since it is located at the 'technology gap': heat pump driers are in classes A+ and better (with very few exceptions in class A), while driers without heat pump do not reach classes beyond B.

The new Label is no longer based on kWh/kg efficiency, but on a more complex Energy Efficiency Index (EEI). The EEI is the relation of a model's annual energy consumption to a reference model's (of the same capacity) energy consumption (in %). The EEI calculation formula assumes 160 drying cycles per year (around three per week; tested with cotton), of which 4 out of seven are assumed to be operated with a half load filling, and includes also low power modes (Off and Standby mode). While on the old Label the energy consumption was declared on a per cycle basis, it is declared as annual energy consumption on the new Label. Therefore, average energy consumption values according

to the old (2004 – 2012) and the new Energy Label (since 2013) cannot be directly compared.

Table 6: classification of the old and current tumble drier Energy Labels

	Old Label efficiency for condensing driers (in kWh/kg*, until 2012)	New Label efficiency (EEI, since 2013)
A+++		EEI < 24
A++		EEI < 32
A+		EEI < 42
A	≤ 0.48 kWh/kg	EEI < 65
B	≤ 0.56 kWh/kg	EEI < 76
C	≤ 0.64 kWh/kg	EEI < 85 (banned since Nov 2015)
D	≤ 0.72 kWh/kg	EEI ≥ 85 (banned since Nov 2013)
E	≤ 0.8 kWh/kg	
F	≤ 0.88 kWh/kg	
G	> 0.88 kWh/kg	

* based on 60% initial moisture content

The revised Energy Label also indicates the duration of the standard drying cycle and, like the original Energy Label, the rated capacity of the drier model and the noise level generated by the standard drying cycle. For condensing driers, also the condensation efficiency class is indicated. A higher condensation efficiency means that more of the humidity retrieved from the laundry is condensed instead of expelled to the room air, where it can cause damages. Class A means that at least 90% of the humidity is condensed.
In the same year as the new Energy Label, also the Ecodesign regulation for tumble driers was adopted and put into force (EC, October 2012). Tier 1 banned class D from November 2013, since November 2015 tier 2 applies: new models must at least be in energy efficiency class B (Table 7). This means that driers without heat pump are still allowed on the market, as vented driers which reach class B.
Ecodesign and Energy Labelling regulations are due for a review no later than in 2017.

Table 7: EU energy policies related to household tumble driers

Year of application	Policy measure
1996	A to G Energy Label
June 2013	A+++ to D Energy Label
November 2013	Ecodesign tier 1: - ban of energy classes D and less efficient - ban of condensation efficiency classes E and less efficient
November 2015	Ecodesign tier 2: - ban of energy class C - ban of condensation efficiency class D

Switzerland: A+ as MEPS

Switzerland has been implementing more ambitious Minimum energy performance standards (MEPS) than the EU: since January 2012, only class A (according to the old Label) driers can be sold. This regulation actually banned all non-heat pump tumble driers from the Swiss market. Since January 2015 this requirement has been tightened to A+, to be in line with the new Energy Label which is also being implemented in Switzerland.

Results

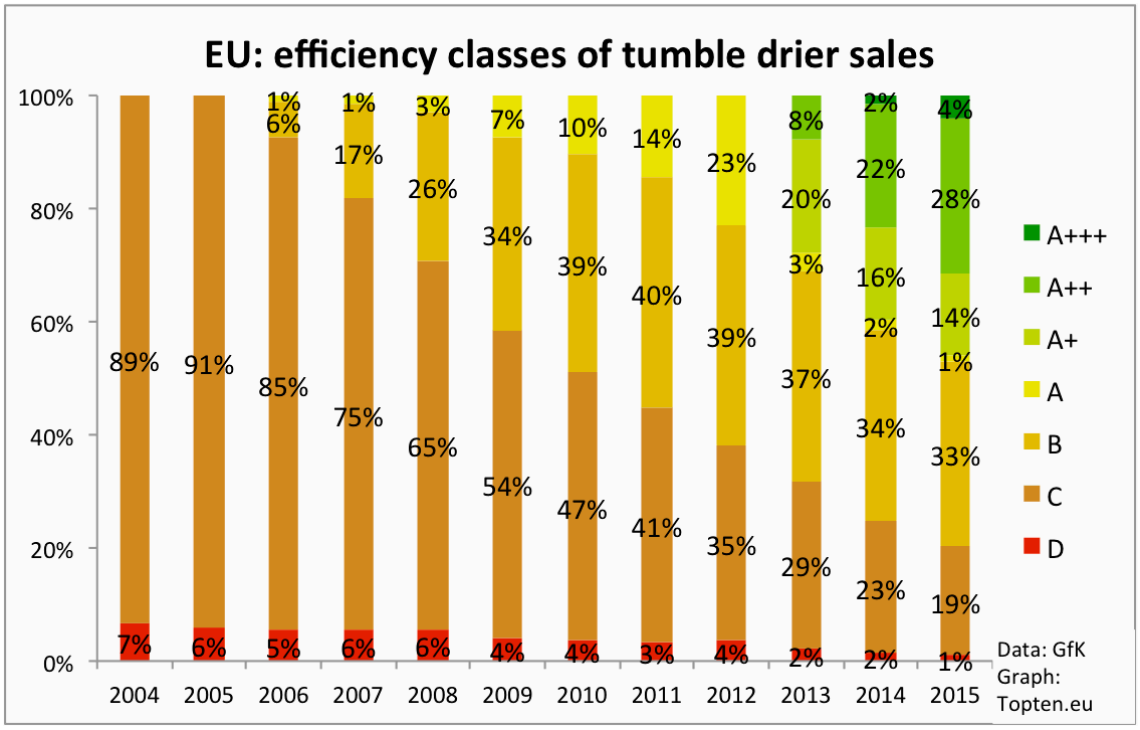

Figure 47: EU: efficiency classes of tumble drier sales

Figure 47 shows that energy-efficient heat pump driers started to emerge on the market in 2006. Before this and until around 2009, the market was dominated by conventional class C driers. Not only heat pump driers (class A) appeared in 2006, but also class B driers. Until 2011 class B increased its market share stronger than class A, then, with the introduction of the new energy label in 2013, heat pump driers (now in classes A – A+++) quickly became more popular. In 2015, heat pump driers already had a market share of 47% across the EU-21. The heat pump technology was becoming more popular before 2013, but the new label visibly helped to increase the sales of these energy-efficient models.

With the introduction of the revised Energy Label in 2013, class A virtually disappeared (since it is located at the 'technology gap', see above). The fear that the strong communicative value of class A might create an incentive for less efficient heat pump driers seems not to be justified. Instead the revised Energy Label offers the possibility to market even more efficient heat pump driers as such, and show to consumers which heat pump driers are more efficient.

The ban of class D in late 2013 (Ecodesign tier 1) has been of little impact: these models of low efficiency had never had a high market share since 2004, and only of 4% in 2012, the year before the ban. Since November 2015 no class C models may be put on the EU market. This tier 2 certainly has a bigger impact than tier 1, since it is banning the least efficient 19% of the market. Results later in the chapter however put a question mark to the energy saving effect of tier 2 (Figure 64).

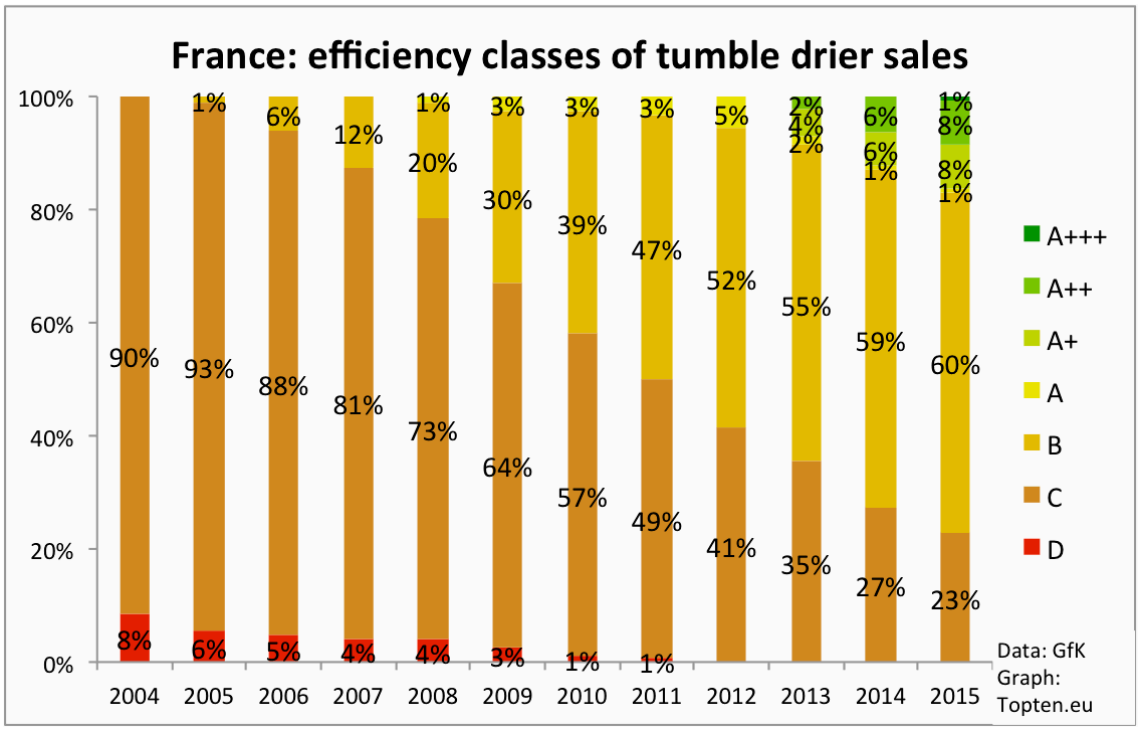

Figure 48: France: efficiency classes of tumble drier sales

Figures 48 to 50 visualise the big national differences in drier efficiency development. In France, heat pump driers are having a hard time. By 2012, before the new label was introduced, this technology had gained a market share of only 5%. The EU average was already at 23% in that year, other countries such as Germany (44%) or Italy (67%) were already far ahead. In 2015, energy-efficient heat pump driers accounted for only 18% of all French drier sales (vs EU: 47%, DE: 75% and IT: 93%). In Italy, newly banned class C has already disappeared from the market. In Germany, this least efficient class accounted for 5% of the sales, in France for 23% - more than classes A to A+++ together. In Switzerland heat pump driers have 100% sales share since 2012: since then, only class A (and better) driers are left on the market. In Switzerland the revised Energy Label was introduced later than in the EU, therefore the new classes appear only since 2014 and also 2013 sales show a 100% market share for A class.

The success of heat pump driers in Germany, Italy and Switzerland is very positive from an energy saving point of view. In Italy this technology seems to have been very popular from the start. Heat pump driers save 50% and more energy compared with inefficient class B or C models.

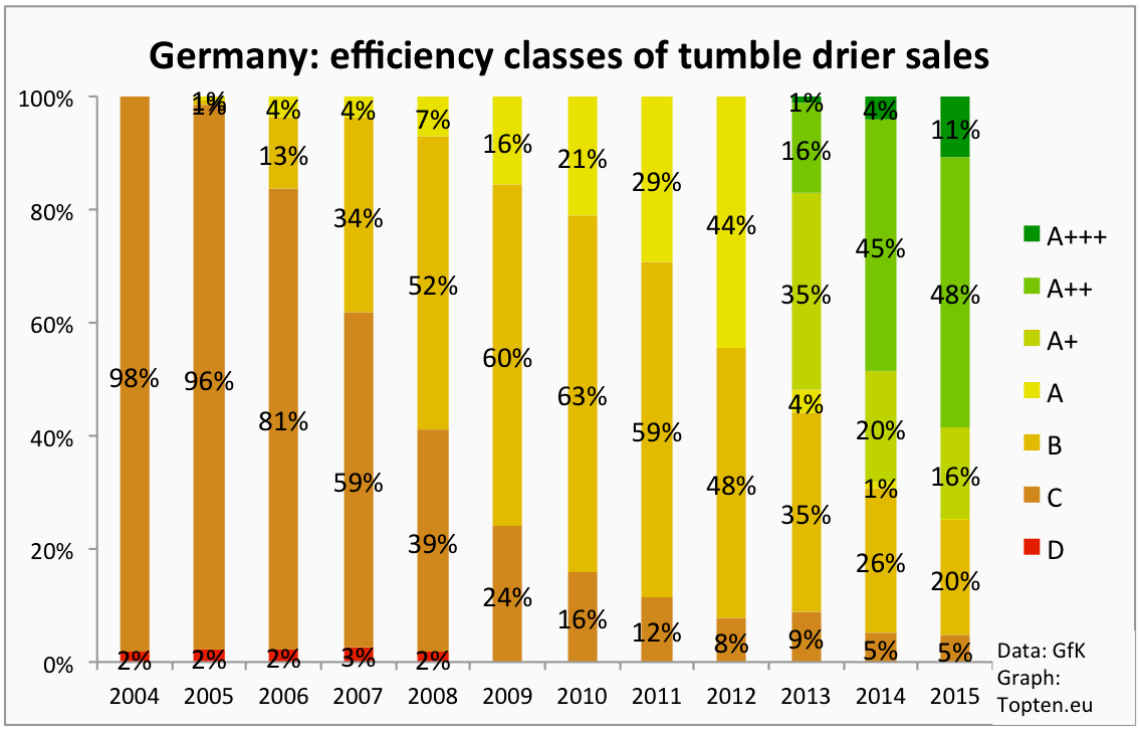

Figure 49: Germany: efficiency classes of tumble drier sales

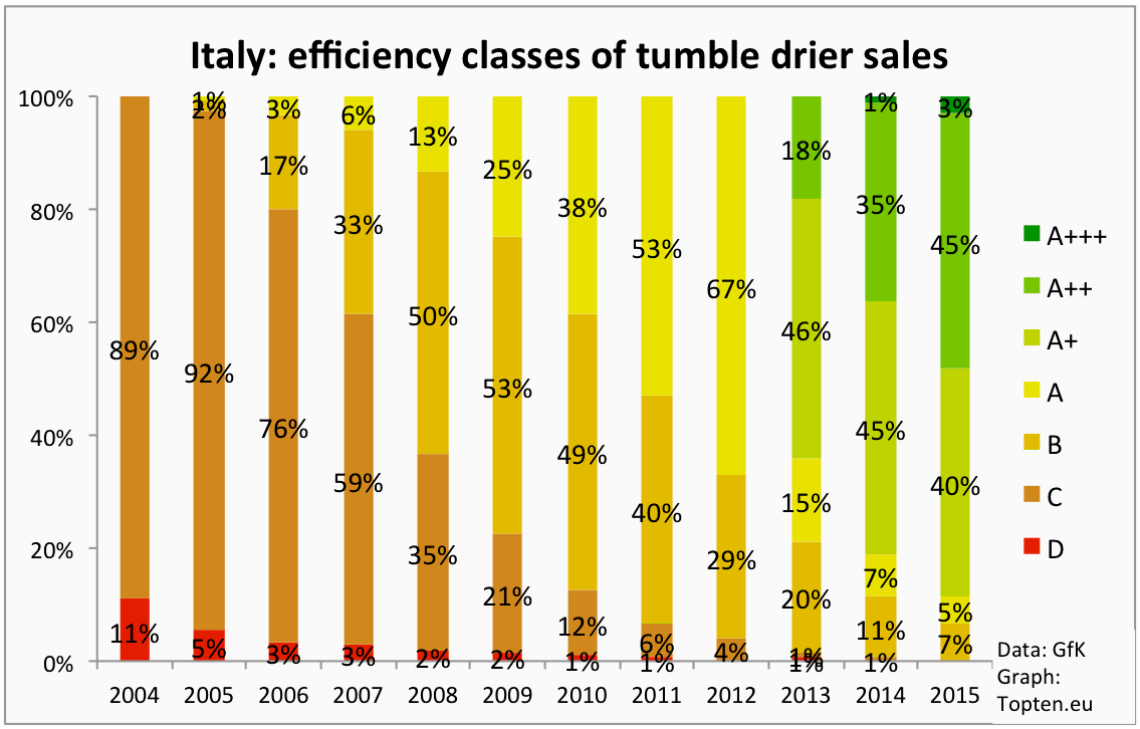

Figure 50: Italy: efficiency classes of tumble drier sales

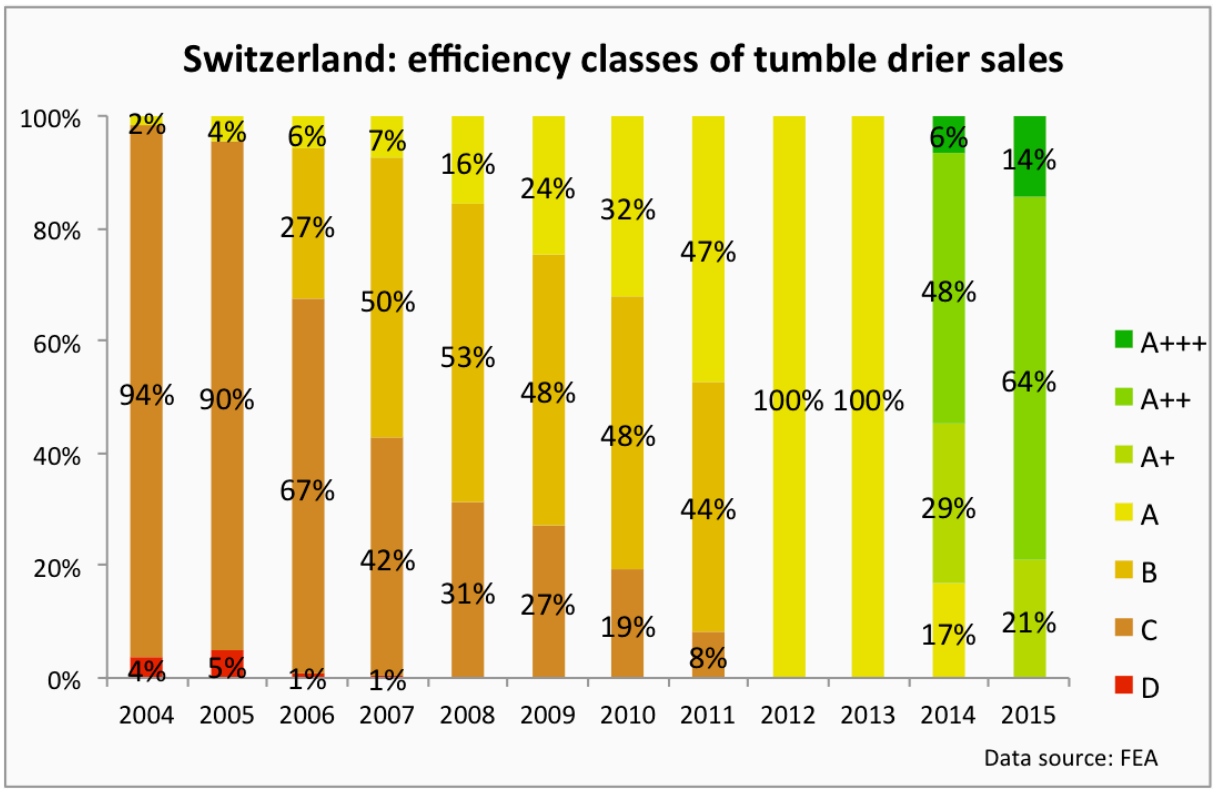

Figure 51: Switzerland: efficiency classes of tumble drier sales. Source: S.A.F.E. and FEA, 2016

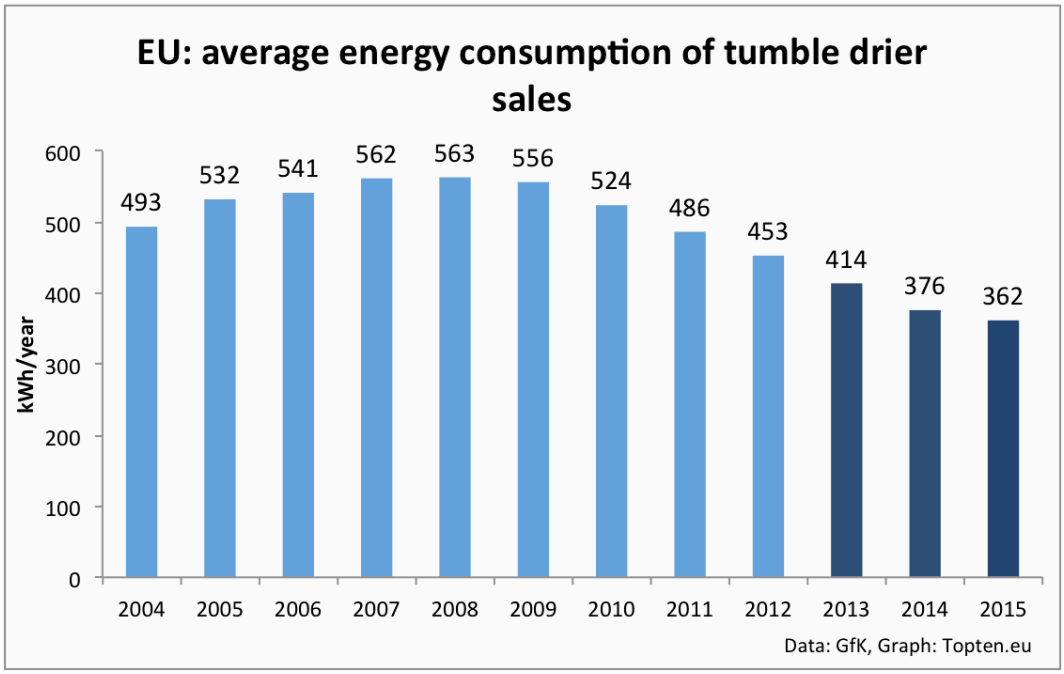

Figure 52: Average energy consumption of EU tumble drier sales.

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.

From 2004 to 2008 the average energy consumption of EU tumble driers increased. In those years, efficiency gains by a (modest) shift to better efficiency classes were presumably outweighed by the trend to larger capacities (Figure 54). Since 2010 the average yearly energy consumption has been decreasing at a fairly constant rate of around 8%, slowing to 4% for 2014-2015. In 2015 average EU tumble drier energy consumption was 362 kWh/year – 27% less than in 2004, and 36% less than the peak average consumption in 2008.

For Germany, the energy consumption pattern since 2004 has been very similar to the EU average, with a peak in 2009 and a strong decrease since then. For Germany, the reduction until 2015 has been 45% since 2004, and 48% since the peak year 2009. For driers sold in Germany, the average energy consumption was 293 kWh/year in 2015. The close-to-50% reduction reflects the strong shift to heat pump driers.

Tumble driers sold in France and Italy were consuming clearly more energy than those sold in the rest of the EU in 2004 – 2008. In Italy this has completely changed since 2010 – of the countries considered here, Italian driers have the lowest average consumption (2015: 272 kWh/year). In 2015, Italian driers consume 57% less energy than those sold in 2004!
Driers sold in France also consume clearly less energy than yet in 2004: since 2004 average energy consumption has been reduced by 29%, and was at 447 kWh/year in 2015. The reduction is however much lower than across the EU, and the average consumption of French driers is 85 kWh/year higher than the EU average.

These energy consumption values are reflecting the efficiency developments shown above.

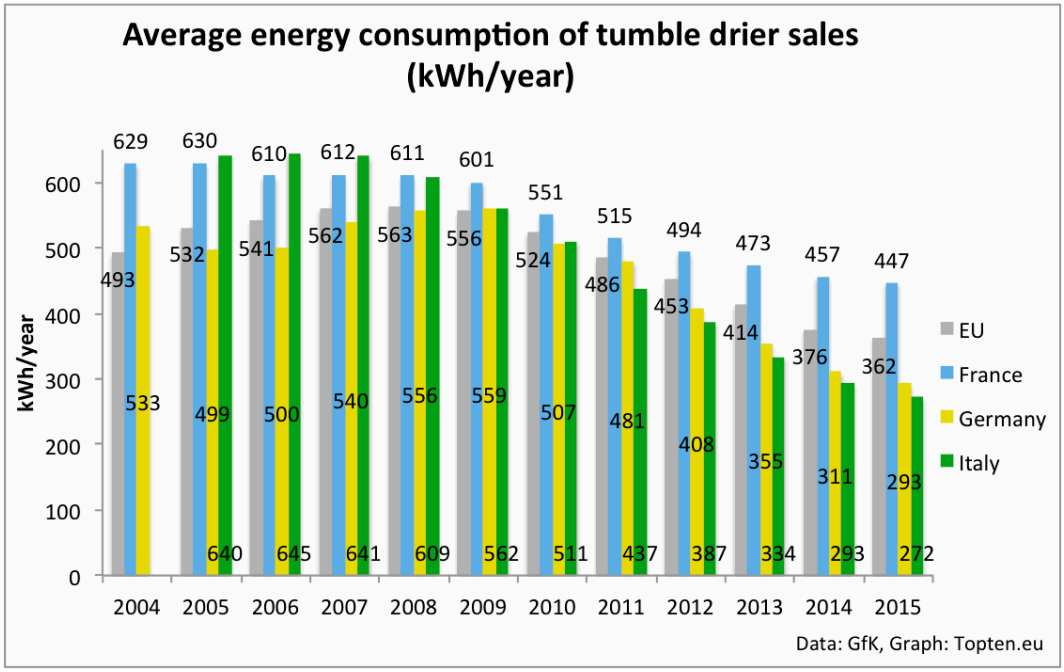

Figure 53: Average energy consumption of tumble drier sales in the EU, France, Germany and Italy.

The ADEME measurement campaign performed by Enertech also measured the consumption of 23 tumble driers in French homes (Enertech 2016). The average annual energy consumption measured was only 199 kWh/year – 55% less than what the

declarations based on sales data are reporting for France in 2015 (447 kWh/year). This is very surprising, since these driers are quite old (nearly 9 years on average), and Fig. 53 shows that 9 years ago, the average declared consumption was even higher (2006: 610 kWh/year). The measured energy consumption was only one third of what would be expected from the declared consumption.

Lower usage can explain some of the big difference: The French users ran their driers on average 140 times per year (but with a huge variation: 3 to 416 cycles per year), which is 12% less than the 160 cycles that are assumed for the Label calculation. The measured driers used on average 1.4 kWh/cycle, and the cotton programme, which is also the Label programme, was used in more than 50% of these cycles. Calculated average consumption from the declared 2006 values is 3.8 kWh/cycle – more than 2.5 times what has been measured.

Lower loading degree and lower initial moisture content (due to better spin-drying by washing machines) could offer some explanation for the big difference. However, old tumble driers have no sensors and simply run for a specified time, without reducing programme duration and energy consumption to lower humidity.

Other programmes do neither seem to be a valid explanation. The cotton programme, which is also the reference for the Label, was the most popular programme (54%). Other programmes on average used more (Synthetic, used for 22% of all cycles), but also less ('Others', 17% of all cycles) energy than the cotton programme.

The huge variance in Enertech's drier results make them difficult to interpret, and the sample was not very large. French driers can be used very differently, depending on the geographic location or season. It seems that many French driers are used seldom, and much less regularly than assumed for the Label.

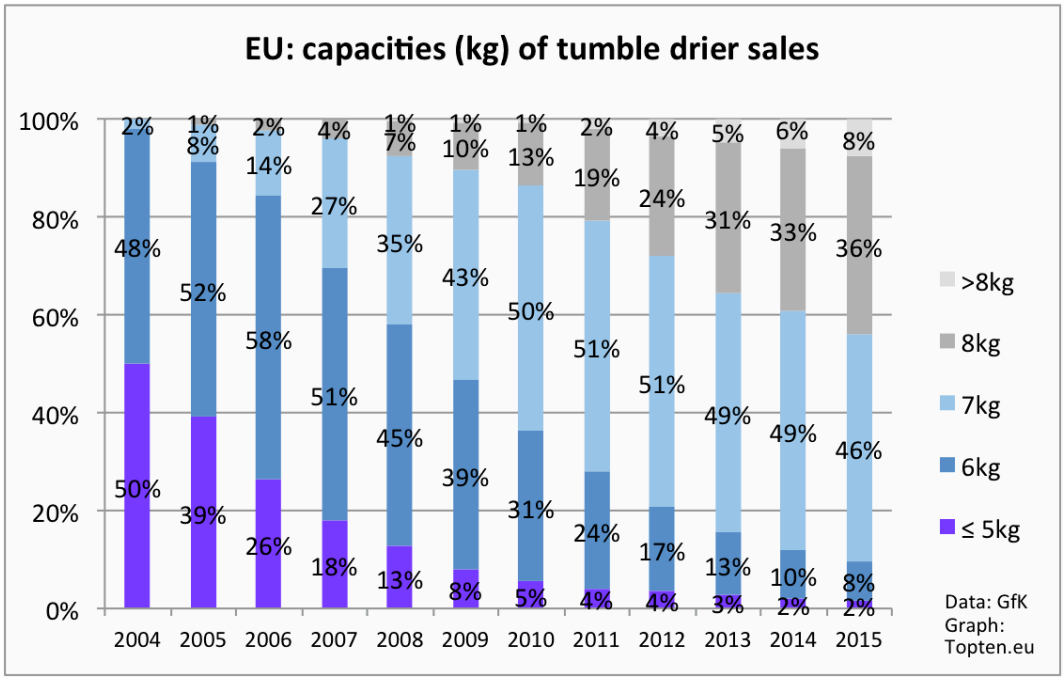

Figure 54: EU: capacities of tumble drier sales

Similar as for washing machines, also sold tumble driers are larger than eleven years ago. In 2004, tumble driers had capacities for 6, 5 and less kilogrammes of laundry. In 2015, these 'small' driers have nearly disappeared, instead most are able to be charged with 7 or 8 kg. It seems natural that driers have to follow the size trend of washing machines – otherwise only a small proportion of the washed laundry would fit into the drier.

The trend to larger capacities seems even stronger than for washing machines (Figure 31), while the reduction in energy consumption has been 27% since 2004 for both product categories.

French consumers choose a little more driers of 6kg than the EU average, apart from that they also have a slight preference for large driers of 8kg and more. The higher sales of 6kg-models is clearly linked to the higher sales of class C driers. Figure 65 reveals that in 2015, 6kg-driers are uniquely sold in class C.
In Germany and Italy nearly no 6kg-driers are sold –because very few or no class C driers are sold. Apart from this, the share of the capacities is similar to the EU average, with Italians having a slight preference for larger driers.

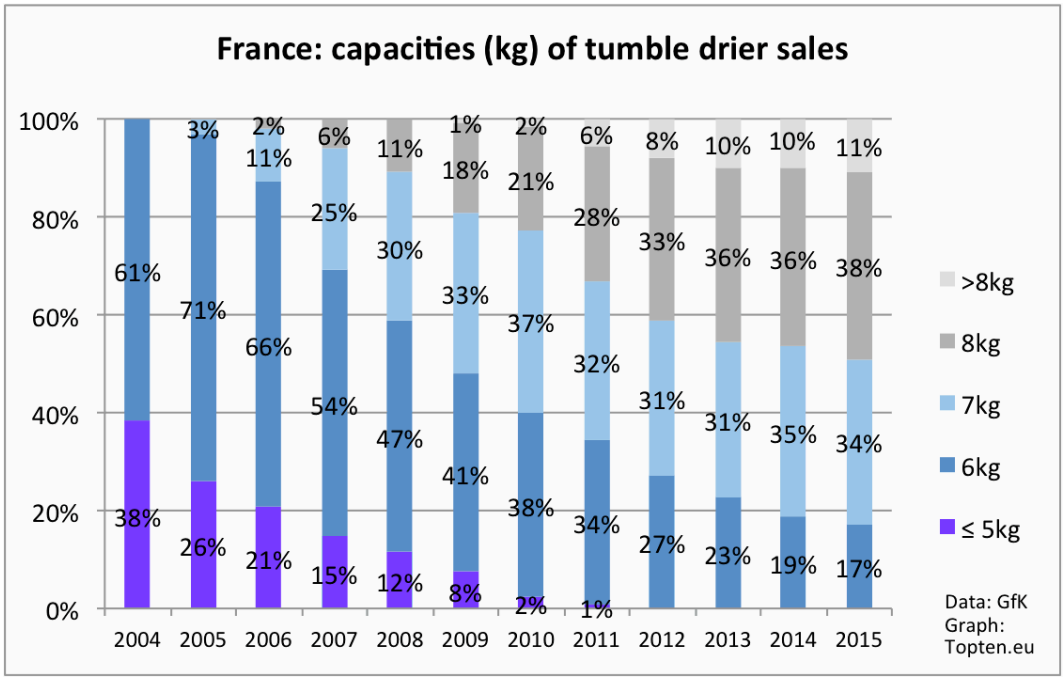

Figure 55: France: capacities of tumble drier sales

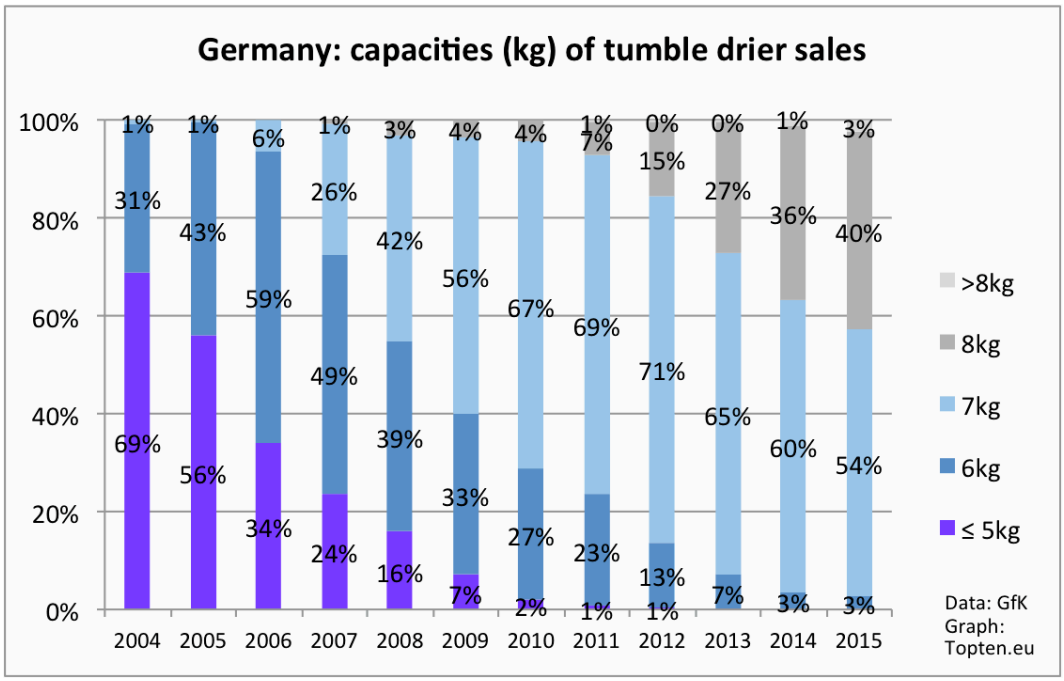

Figure 56: Germany: capacities of tumble drier sales

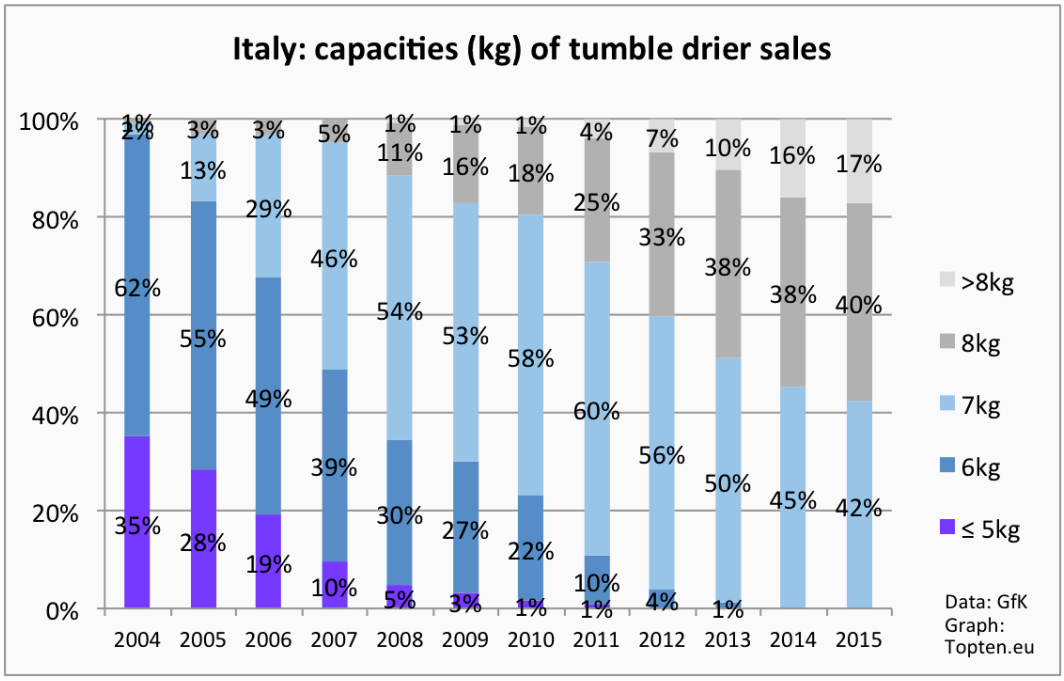

Figure 57: Italy: capacities of tumble drier sales

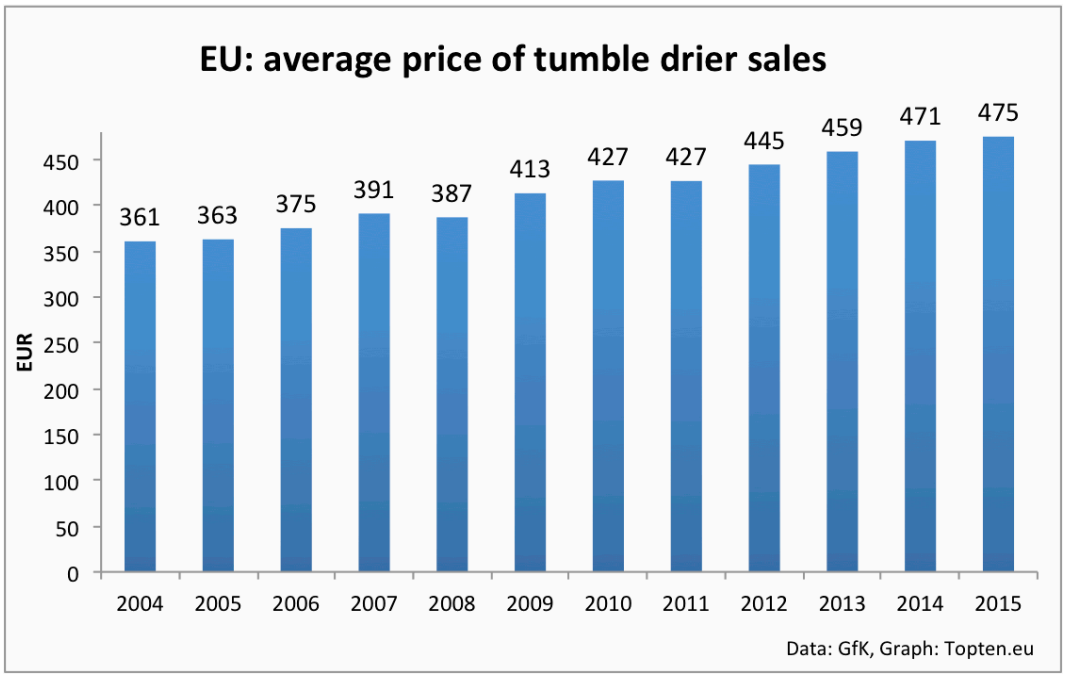

Figure 58: EU: Average nominal price of tumble drier sales

In 2015, the average EU driers cost 475 Euros. Average prices of tumble driers have increased by 32% over the period 2004 – 2015. This is certainly linked to the technology jump to the much more efficient heat pump driers. Over the same period, average energy consumption has decreased by 27%, and average capacity increased by around 35%.
Figure 59 shows that the price developments for the different countries differ a lot: prices in France have increased by only 1% over the eleven-year-period, in Germany by 39% and in Italy 16%. In 2015, consumers paid on average EUR 369 in France, EUR 559 in Germany and EUR 628 in Italy for a tumble drier. For France, the low prices may reflect the low efficiency, while the rather high prices in Germany and Italy may be due to the comparably high energy efficiency and high sales share of the more costly heat pump technology. For Italy, a surprising peak in average price shows around the year 2011, which finds no reflection in the efficiency graph Figure 50. A possible explanation might be provided by the data on the non-official A+ and A++ classes, that were used by manufacturers already before 2013: they indicated if their drier models were 10% ('A+') or > 20% ('A++') better than the official class A threshold. GfK sales data indicates that in Italy in 2011 50% of all sold driers were labelled with the non-official 'A++' class – a peak that correlates with the price peak.

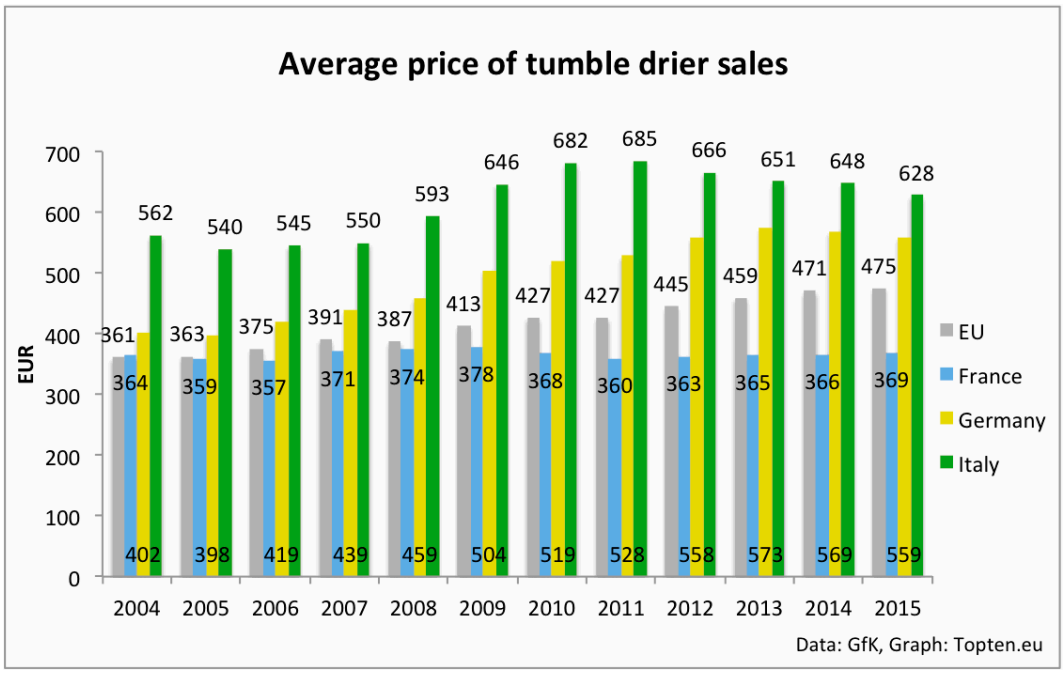

Figure 59: EU, France, Germany and Italy: Average nominal price of tumble drier sales

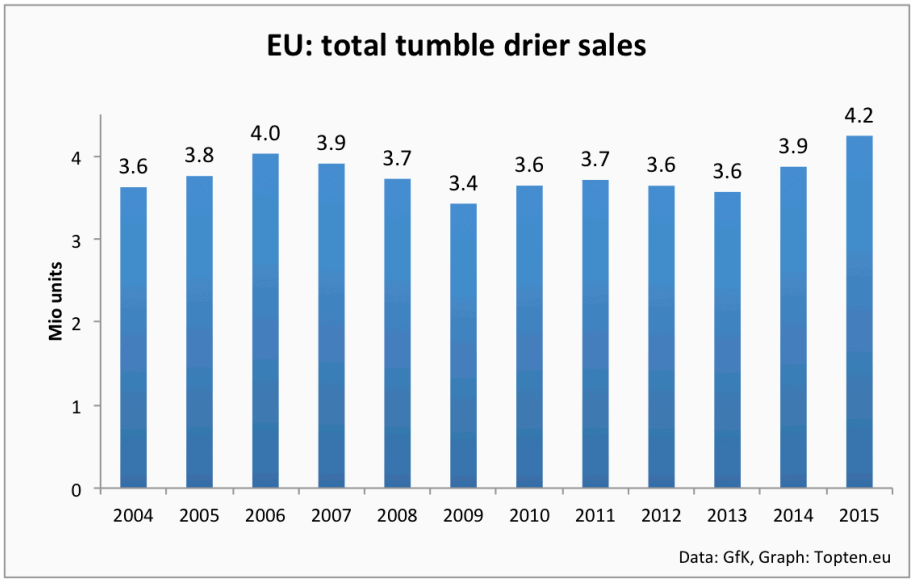

Figure 60: EU: total tumble drier sales

Tumble drier sales reached a first peak of 4 million units in 2006, then dropped to around 3.5 million units until 2013. In 2015 a new maximum of 4.2 million tumble driers were sold across the EU-21 (around 0.8 units per 100 inhabitants and year). Tumble drier sales in France reached their peak in 2012, and in 2015 659'000 units were sold (around 0.99 per 100 inhabitants and year). In Germany, drier sales have been increasing constantly since 2008, reaching 1.1 million units in 2015 (corresponding to around 1.35 driers per 100 inhabitants). In Italy, driers only seem to have recently become popular, and sales are at a lower level than in other countries. Since 2004, Italian drier sales have multiplied by six, to reach 308'000 units in 2015 (corresponding to around 0.5 units per 100 inhabitants).
The sales seem to follow a North – South-logic: In Italy, having the warmest climate of the countries included here, relatively fewer driers are sold than across the EU, while in Germany, more to the North and having a cooler climate, more people want to dry their

laundry electrically. A correlation might be made between the low relative sales in Italy and the high efficiency level of the driers sold there: it seems that if Italians decide to buy a laundry drier, they are set for a high quality product in most cases.

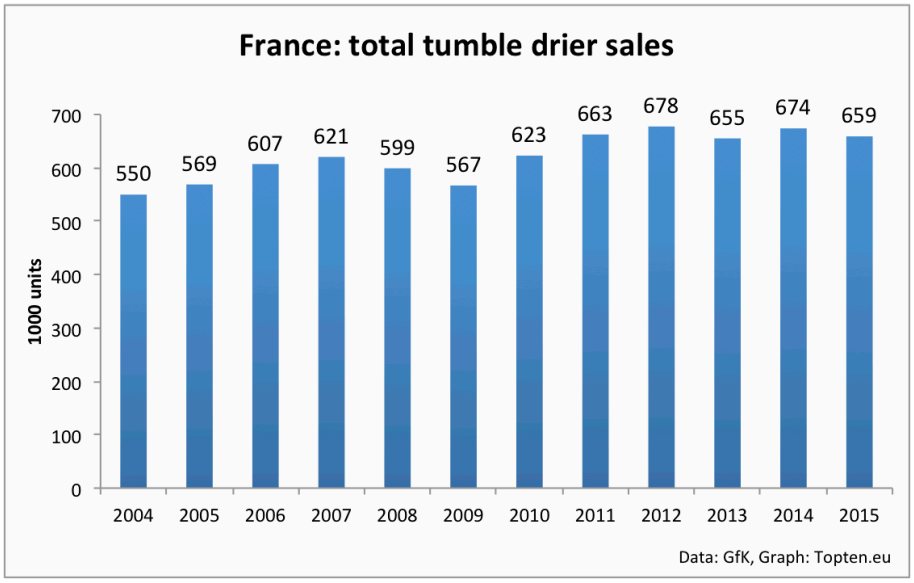

Figure 61: France: total tumble drier sales

Figure 62: Germany: total tumble drier sales

Figure 63: Italy: total tumble drier sales

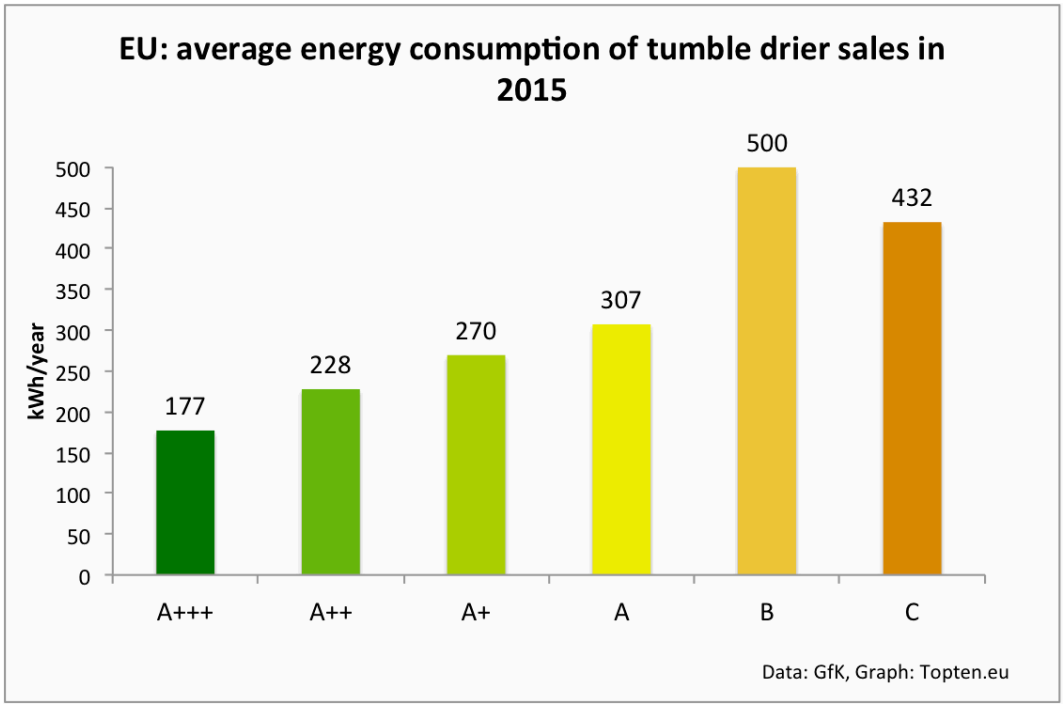

Figure 64: EU: average energy consumption of tumble drier sales, 2015. A class has a very low sales share and nearly no models exist in this class, therefore this result is not statistically significant.

Figure 64 shows that the important energy saving potential lies in the promotion of efficient heat pump tumble driers, without compromise. The difference between driers without (class B, 500 kWh/year) and with heat pump (A+, 270 kWh/year) is nearly 50%. Even the differences between classes A+, A++ and A+++, all heat pump driers but of different efficiency levels, are considerable: a jump from A+ to A++ saves on average 42 kWh/year, to A+++ even 93 kWh/year.

The bad news is that this figure strongly questions the energy saving impact of tier 2, which bans class C driers from the market since November 2015: average energy consumption of the 2015 sales is higher for class B driers than class C! This effect is likely a combination of the increase in size from class C to B (shown in Figure 65) and low

improvement in energy efficiency: the step from class C to B is only 11%, while other classes require up to 25% (A++, A+++) and even 35% (A+) efficiency improvement.
A shift of class C sales to class B can thus result in higher energy consumption instead of lower – if we assume that potential class C buyers stick to the lowest price available and choose class B instead.

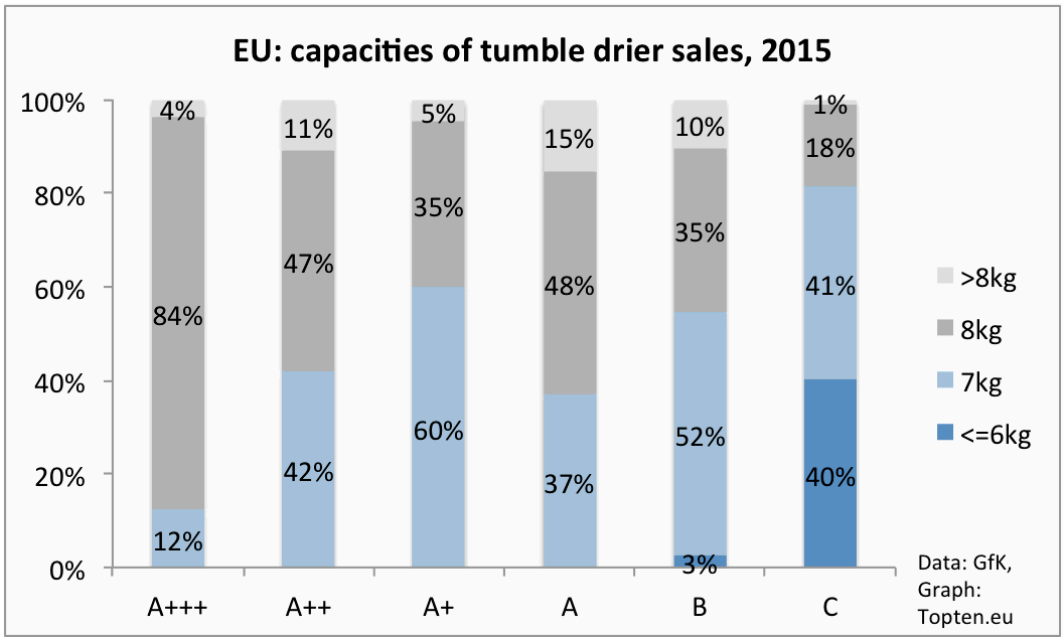

Figure 65: EU: capacities of tumble drier sales according to classes, 2015. A class has a very low sales share and nearly no models exist in this class, therefore this result is not statistically significant.

Figure 65 shows that also for tumble driers, there is a tendency to larger capacities for higher efficiency models. This tendency cannot be spotted in 2014 data published last year: then, capacities were nearly the same for classes A++, A+ and B. Hence, conclusions should be drawn with caution. Also in the 2015 data, classes B and A+ both have very similar capacities. 6kg-driers can nearly exclusively be found in class C, while driers in A+++ are mostly 8kg-machines. We are less concerned about the size trend for driers than for washing machines because driers are not filled with water that needs to be heated up.

Equivalent data to Figure 65 for France shows that of class C sales, even 70% are 6kg-models. Possibly French consumers choose inefficient driers because they prefer small driers, which are only available in low efficiency classes? It is more probable that French consumers choose small and inefficient driers, because those are the least costly ones.

Figure 66 shows a very clear correlation of average product prices with energy efficiency in the EU. The price difference between class B and A+, thus the jump to a heat pump drier, was EUR 218 (+60%) in 2015. 'Only' 97 Euros (17%) was the price difference between A+ and A++, and even less the step to the best class: EU consumers paid 73 Euros (11%) more for an A+++ versus an A++ drier.

Figure 67 includes the price differences between classes for France, Germany and Italy. French prices are above the EU average for those classes with low French sales share (A+, A++), and below for high-sales classes B and C. German prices are surprisingly low,

lower than the EU average except for classes B and C. German drier prices might be rather low because of the relatively high general sales volume. The contrary is true for Italy: driers do not have a high sales volume in Italy, and prices are comparatively high. Despite the high price premium of A++ driers over A+ driers in Italy (EUR 169, + 30%), this class is relatively popular in Italy (45% of all sales).

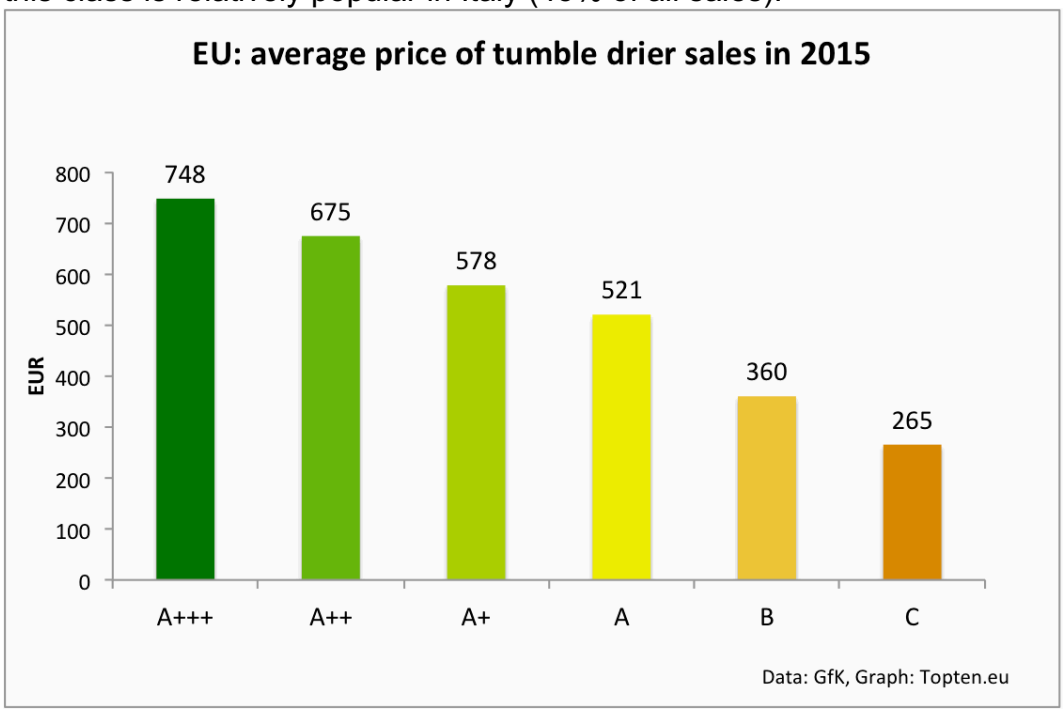

Figure 66: EU: Average nominal price of tumble drier sales in 2015. A class has a very low sales share and nearly no models exist in this class, therefore this result is not statistically significant.

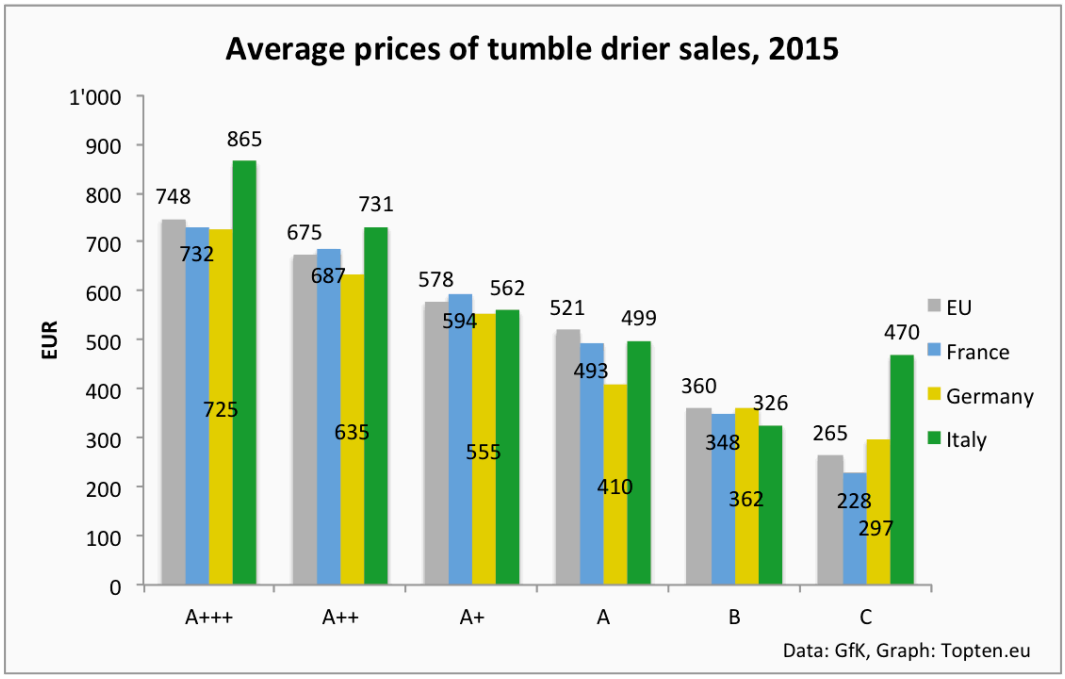

Figure 67: EU, France, Germany and Italy: Average nominal price of tumble drier sales in 2015. A class has a very low sales share and nearly no models exist in this class, therefore this result is not statistically significant.

The good news for all consumers who were ready to pay more to get an energy-efficient tumble drier is that they will save money on the long term. Considering the total costs (Figure 68), it is clearly beneficial for consumers to buy energy-efficient driers. Despite their high purchase price, A+++ drier models save most. Cheap driers without heat pump (classes B and C) generate high electricity costs during their lifetime, and end up being more costly for users. The ban of class C (Ecodesign tier 2, since November 2015) is worrying not only regarding energy consumption (Figure 64), but also total costs to consumers: consumers who are not able to pay the price premium of heat pump driers will end up with higher total costs. This conflicts with the requirement that Ecodesign MEPS should be defined at the least lifecycle cost (LLCC) level. For driers it seems that tier 2 is located at the highest lifecycle cost level instead.

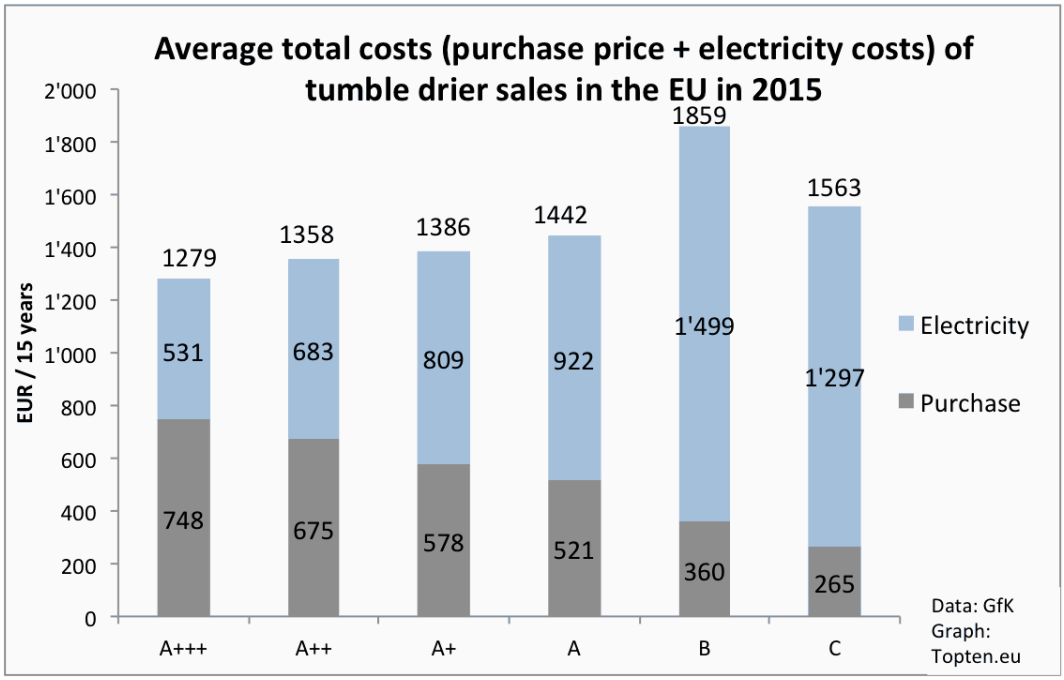

Figure 68: EU: average total costs[20] (purchase price and electricity costs) of 2015 tumble drier sales. A class has a very low sales share and nearly no models exist in this class, therefore this result is not statistically significant.

Conclusions

Almost every second drier sold in the EU-21 in 2015 was a heat pump drier, in some countries like Italy and Switzerland they even account for more than 90% of the sales. Switzerland has banned non-heat pump driers since 2012, a measure which allows achieving large savings. Energy-efficient driers are popular and pay off: consumers choosing efficient driers in total pay less, because heat pump driers save a lot on electricity costs compared to driers in classes B or C.
Some countries like France need to catch up: only 18% of the driers sold in France have a heat pump, consumers there are left with unnecessarily high electricity costs.

Policies in the EU have been effective: the original Energy Label allowed to show that heat pump driers (class A) were more efficient than conventional driers (class B and C) – even though the classification could not communicate how much better the new

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

technology really was. The revised Energy Label allows consumers to see the superiority of heat pump over conventional driers, and it can also show differences between heat pump driers. While tier 1 of the Ecodesign regulation was of little effect, the impact of tier 2, banning class C since November 2015, is highly questionable: class B driers on average consume even more energy than class C driers, and total costs to consumers are clearly highest. Reasons are small efficiency differences from class C to B, and larger size of B driers. While the Ecodesign MEPS level should actually be defined at the least lifecycle cost (LLCC) level, for driers it seems to be at the maximum cost level! The data presented here clearly calls for an updated MEPS level in the 2017 revision – one that bans all non-heat pump driers.

If all driers sold in 2015 had been in class A+, these would have saved 5.8 TWh over their lifetime of 15 years compared to what was sold. (The calculated potential savings are higher than in last year's report, because total sales were higher in 2015.) France could have saved 1600 GWh over 15 years, had only A+ driers been sold in 2015. Even Germany could have saved 550 GWh, despite its efficient driers' sales: the high-consuming driers of classes B and C make up 42% of the whole sales' consumption, even though they only account for 25% of the sales. Italy, with its small but efficient drier market, could have saved 16 GWh with this measure.

Results from Enertech's measurement campaign in France (Enertech 2016) indicate that driers can be used irregularly and real drier consumption can be lower than declared. Therefore, also real saving potentials can be smaller than calculated above. More information about consumer drying behaviour would be valuable.

Recommendations

The Energy Label and Ecodesign regulation will be reviewed in 2017. The EU sales share of heat pump driers will most probably be more than 50% by then, in some countries it will be close to 100%. New MEPS must be announced to save energy and prevent consumers from being burdened with unnecessarily high electricity costs: at the (real) LLCC level, and certainly banning all non-heat pump driers. The energy label will have to be adapted accordingly, to bear no empty classes at the bottom, but have empty top classes that incentivise further innovation and follow an A-G scheme.

5. Synthesis

5.1 European market

The markets of refrigerators, washing machines and tumble driers have become more energy efficient – in terms of sales of energy label classes – in Europe over the last ten years. These changes can be judged differently for the three product categories.

Refrigerators

For refrigerators, the efficiency gains happened constantly, continuously supported by the Energy Label and the Ecodesign regulation from 2009. The efficiency improvement results in a reduction of the energy consumption of 26%, which is considerable. The only drawback is that the reduction in consumption is smaller than what would be expected from the efficiency improvement (37%). The reason for this deviation is not an increase in size, but factors contributing to higher energy consumption that are rewarded and thus supported by the Energy Label. These wrong incentives can be corrected in the current revision of the regulations by removing from the definition of the EEI the correction factors for compressors than can work in the tropics, frost-free functions, built-in appliances and chill compartments and by reducing the product categories (and reference lines) to just one or two.

Washing machines

In the case of washing machines, the introduction of the Energy Label with classes A+ to A+++ sped up the uptake of 'higher efficiency' washing machines. Despite the on-going, strong trend to larger machines, the declared energy consumption is going down since the introduction of the current Label. Clearly the standard programmes have been optimised regarding energy efficiency. What this really means for the energy consumption is however unclear. The comparison with older data (before 2012) is difficult, because the EEI calculation formula and the measurement standard have changed. The efficiency steps between classes are very small. As a consequence, with more 'efficient' washing machines being larger, the differences in energy consumption between different classes are minimal to inexistent. Furthermore the declared energy consumption relates only to the standard programmes, and the real energy consumption can vary strongly depending on the actual programme choice, wash temperature, number of cycles and amount and type of laundry. There are concerns that the standard programmes are not often used, because they last too long (often 3-4 hours; Topten.eu, 2015) or can be relatively hidden on the programme selection panel.
Because the top efficiency classes are hardly linked to energy savings, the current Energy Label provides no basis for future meaningful MEPS. The Energy Label needs to be revised fundamentally to bring real energy savings: the trend to larger machines, which bear the risk of energy waste, must be stopped, and standard programmes must be user-friendly and easily accessible.

Tumble driers

Since November 2015, new tumble drier models must be in class B or better. All driers in classes A and better are heat pump driers – and this technology already accounts for close to 50% of the EU sales. Ecodesign Tier 2, banning class C driers, does not bring any energy savings. The real saving potential clearly lies in the promotion of heat pump driers. The saving potential of heat pump driers is huge with 25% and more, and the next

Ecodesign review in 2017 should announce the ban of driers less energy efficient than A+, accompanied by a Label revision.

5.2 National markets

As has been shown before (e.g. SOWATT, Enerdata, 2012; or constantly on the national Topten sites showing the most energy efficient products – www.topten.eu), also our report shows that national markets can differ strongly – even though the same regulatory framework applies in all EU Member States, and the same international manufacturers dominate most markets. In addition, the data used for this report does not allow to assess the impact of the economic crisis that has hit the European countries and their populations in different ways, at different times, affecting standards of living and possible equipment choices.
For the product categories considered here, the French, German and Italian markets can be characterised as follows:

France

On the French market, less energy efficient products are sold than across the EU for all three product categories studied here. Comparison with Germany confirms the findings from an investigation from 2012, which found more efficient products being sold in Germany than in France (SOWATT, Enerdata, 2012). Also in Italy, more energy efficient products are sold than in France. Hence, refrigerators, washing machines and tumble driers sold in France consume on average more energy than in the other two countries and in the EU average (only Italian refrigerators consume more, probably because they're larger). It is striking that average prices that French consumers are paying for their new appliances are clearly lower than in Germany, Italy and the EU average. For refrigerators, energy-efficient models (A++, A+++) have high prices compared to other countries, but they have a very low market share. Refrigerators are slightly larger than the EU average, but the freezer compartment, which is more relevant for energy consumption, is smaller. In the case of washing machines, prices are below the EU average also when looking at the different energy classes – and still efficient washing machines are not popular in France. The French preference for small (6kg) washing machines might be linked to low efficiency (because efficient washing machines tend to be larger). The same pattern can be observed for driers: In 2015, only 18% of the sold tumble driers are heat pump driers, and the average energy consumption is 20% higher than the EU average. Class B was the most popular class in 2015. There is the risk that class B sales will be even higher in 2016, following the ban of class C since November 2015. The problem is that class B driers on average consume even more energy than those of class C. Furthermore, consumers who do not choose an energy-efficient drier are left with high total costs.

High prices for energy efficient products on the French market have been found in (Toulouse, 2015), comparing prices of Topten products in France, Germany and Switzerland, and (SOWATT, Enerdata, 2012). And analysis of the price levels and popularity of energy-efficient classes in Germany and Italy (below) reveals that high average class prices need not prevent consumers from buying such appliances. So, it seems possible that French consumers are just focusing on buying cheap products: low-efficiency, not too large, at low prices. More information about total costs might provide an incentive to choose more energy-efficient products. Driers might be the best product category to test such a campaign: the potential energy and total cost savings for consumers are large. Figure 69 confirms that also French consumers would be clearly better off with heat pump driers.

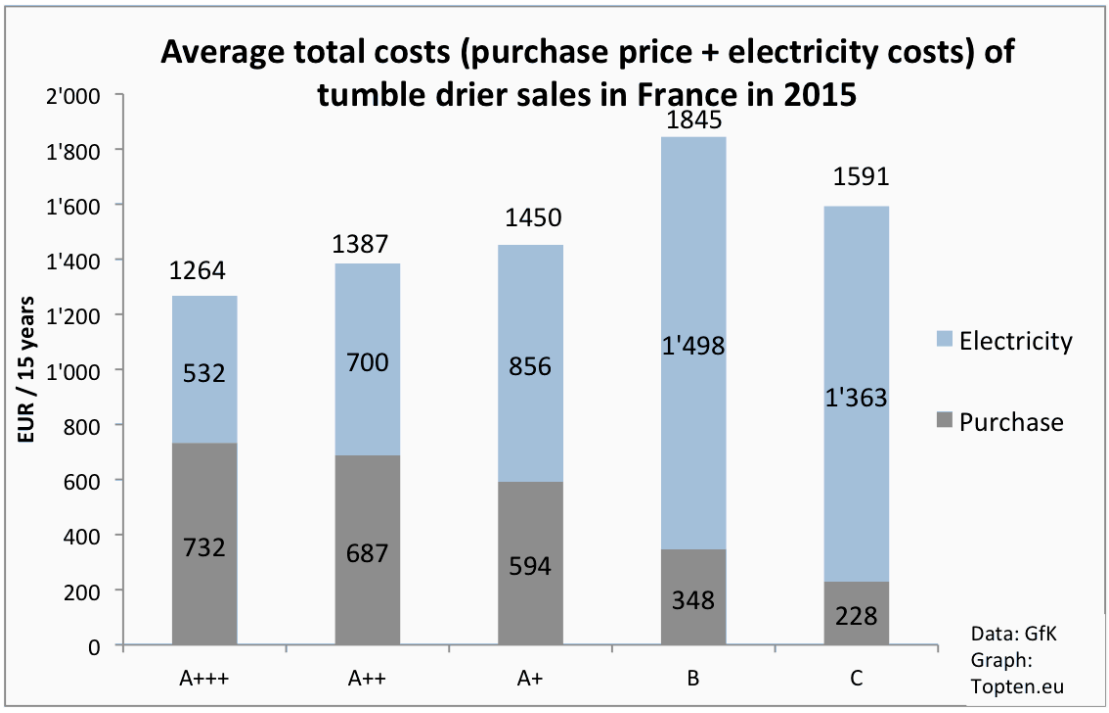

Figure 69 : France: average total costs[21] (purchase price and electricity costs) of 2015 tumble drier sales

Germany

The German market is characterised by high sales shares of energy-efficient products. The data presented here confirms that German consumers buy more energy-efficient and high-quality products, and are ready to pay higher prices for this – more than other nation's consumers (this has previously been shown e.g. in (Attali, Bush, Michel, 2009)). For refrigerators, the average EEI in Germany is clearly better than across the EU (DE: 34, EU: 39), and the average consumption of German refrigerators is 21% below the EU average. This has also to do with the German preference for relatively small refrigerators. Average prices for specific energy classes are lower than the EU average, but the high sales share of good, more expensive energy classes, results in above-average total average prices. Already 81% of the sold washing machines in Germany were in the top class A+++ in 2015, even though the average price for this energy class (as for A++) was clearly higher than the EU average. German consumers have a preference for 7kg-machines. The average declared energy consumption is 8% lower than across the EU. Tumble driers are generally quite popular in Germany – they have higher relative sales than in the other countries and across the EU. This can certainly partly be explained by the cooler German climate, which makes drying the laundry outdoors impossible during a long period. With driers having a higher market penetration than in Germany, Italy and the EU average, it's good that German consumers buy energy-efficient models: heat pump dries account for already 75% of the sales share. However, the 25% class C and B driers contribute 42% of the electricity consumption of the driers sold in 2015. Therefore, a ban of non-heat pump driers would result into energy savings also in Germany. Like for refrigerators, the average prices for popular classes (A++, A+) are below the EU price level, but high sales share of these classes result in higher total average prices for tumble driers than across the EU.

[21] Total costs include purchase price and electricity costs over the product lifetime. Assumed drier lifetime was 15 years, electricity price 0.2 Euros/kWh.

Italy

The Italian white goods market seems to be quite peculiar. Italian consumers buy less energy efficient refrigerators and washing machines than the EU average consumer, while for driers, energy-efficient models with heat pump are extremely popular (93% of all sales!). For refrigerators, Italians also prefer larger models. The combination of rather large refrigerators with below-average efficiency results in an average consumption that is 15% higher than across the EU. The elevated price level of Italian refrigerators, for all classes, is quite surprising. Possible explanations might be the fragmented retail market with few sales in discount or online stores, and the preference for larger models. For washing machines on the opposite Italian prices are lower than the EU average, no matter if considering the total average or the average price per energy class. Due to the lower efficiency levels, Italian washing machines consume a bit more energy than the EU average machine. For driers, as mentioned above, the Italian market is pretty small and of high energy efficiency. Probably for climatic reasons, Italians do not buy many tumble driers. However, driers are becoming increasing popular; sales are rising quite fast. Considering this, it is very positive that energy-efficient driers have a very high sales share in Italy. The most popular efficiency class is A++, making up already 45% of all sales (nearly as high a share as all heat pump driers, classes A to A+++, reach across the EU). Despite this high sales share, the average price of A++ driers is clearly higher than in other countries. Even though prices for A+ driers are below the EU average, this results in total average prices for Italian driers being 32% higher than the EU average.

5.3 Market monitoring

This report demonstrates the big potential of systematic market monitoring for Europe. It reveals market trends, differences between national markets and also problematic aspects. A market monitoring on a regular basis (every year) would allow policy makers to launch improvements and Label updates on time, and to base their decisions on sound data. The risk of too late revisions and Label classes that are not ambitious enough (as in the case of washing machines) could be minimised.

The planned European product database will provide an overview on products that are on the market, allow to track market changes on model level, and it will greatly facilitate the international sharing of verification test results, thus making market surveillance activities more effective and efficient. It will take some time to build up the database, whereas market monitoring based on sales data can start immediately. Also for the future, once the database is operational, it is interesting to complement information from this with sales-based information. Information from the database will not be weighted according to sales: each model has the same weight, no matter if it's selling well or not. Sales-based data on the other hand weights each model according to its market relevance, and aggregated data is already stripped from all irrelevant detail information and requires much less analysis efforts.

Information based on declared energy consumption values should be compared to and contrasted with results from measurement and user behaviour studies. Understanding how users behave and how declared values translate into 'real' consumption is key. Declared values and improved energy-efficiency levels on the energy label need to be consumer-relevant in order to translate into real energy savings.

6. References

General

Anette Michel, Sophie Attali, Eric Bush: Energy efficiency of white goods in Europe: monitoring the market with sales data. June 2015. http://www.topten.eu/uploads/File/WhiteGoods_in_Europe_June15.pdf

Attali, Bush, et al.: Can Europe continue deciding on product policies (MEPS; labels, etc.) without monitoring the market? Presented at the eceee summer studies in France, June 2013.

Bertoldi, Lorente, Labanca: Energy Consumption and Energy Efficiency Trends in the EU-28 2000 - 2014. JRC, 2016.

European Commission: Directive 2010/30/EU of the European Parliament and of the Council on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products.

Enertech : Campagne de mesures des appareils de production de froid, des appareils de lavage et de la climatisation. Rapport final, juin 2016. Funded by ADEME.

Harrington and Lane: Evaluation of Energy Efficiency Policy Measures for Household Refrigeration in Australia: An assessment of energy savings since 1986, prepared by Lloyd Harrington and Dr Kevin Lane, EES for Department of Energy Efficiency and Climate Change, December 2010, see http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Refrigeration/Domestic_Refrigeration/201010-refrigeration-evaluation.pdf

Michel, Attali, Bush: European TV market 2007 – 2013. Second report, complemented with 2012 sales data. July 2014. http://www.topten.eu/uploads/File/European_TV_market_2007%E2%80%932013_July14.pdf

Michel, Jones, Attali, Bush: Why and how Europe should introduce mandatory product registration and a public database for energy related products. A recommendations and discussion paper. November 2015. www.topten.eu/uploads/File/Topten-recommendations-product-registration-database_Nov_15.pdf

S.A.F.E. and FEA: Swiss appliances sales development 2004 – 2015. August 2016. http://www.topten.eu/uploads/File/FEA-Geraetestatistik-2004-2015-EN.pdf

SOWATT and Enerdata: French higher domestic specific electricity consumption compared to Germany: explanatory factors assessment. Study carried out by SoWatt and Enerdata for Ademe. June 2012.

Toulouse et al.: Lessons from a decade of efficient product market analysis. EEDAL conference 2015.

Refrigerators

CLASP: Estimating potential additional energy savings from upcoming revisions to existing regulations under the ecodesign and energy labelling directives. A contribution to the evidence base. February 2013.

European Commission: Commission Directive 94/2/EC of 21 January 1994 implementing Council Directive 92/75/EEC with regard to energy labelling of household electric refrigerators, freezers and their combinations

European Parliament and Council: Directive 96/57/EC of the European Parliament and of the Council 3 September 1996 on energy efficiency requirements for household electric refrigerators, freezers and combinations thereof

European Commission: Commission Directive 2003/66/EC of 3 July 2003 implementing Council Directive 92/75/EEC with regard to energy labelling of household electric refrigerators, freezers and their combinations

European Commission: Commission regulation No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances

European Commission: Commission delegated regulation No 1060/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household refrigerating appliances

London Economics LE: Study on the impact of the energy label – and potential changes to it – on consumer understanding and on purchase decisions. Final report, prepared for DG ENER / European Commission. October 2014.

Michel, Harrington, Bush, Attali: Household refrigerators: Monitoring efficiency changes in Europe and Australia over the last 10 years. EEDAL conference in August 2015 in Lucerne, Switzerland.

Molenbroek, Waide, Attali et al.: Evaluation of the Energy Labelling Directive and specific aspects of the Ecodesign Directive. Final technical Report. Ecofys, June 2014.

S.A.F.E. and FEA: Swiss appliances sales development 2004 – 2015. August 2016. http://www.topten.eu/uploads/File/FEA-Geraetestatistik-2004-2015-EN.pdf

Cabinet Olivier Sidler : Etude expérimentale des appareils électroménagers à haute efficacité énergétique places en situation réelle. Rapport final, Janvier 1998.

SOWATT and Enerdata: French higher domestic specific electricity consumption compared to Germany: explanatory factors assessment. Study carried out by SoWatt and Enerdata for Ademe. June 2012.

VHK and Armines: Preparatory / review study on ecodesign and energy labelling of household refrigeration appliances. Final report, March 2016.

Washing machines

European Commission: Commission Directive 95/12/EC with regard to energy labelling of household washing machines. May 1995.

EuropeanCommission. Draft COMMISSION REGULATION (EC) implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines. Version of 18 March 2009.

European Commission: Commission delegated regulation No 1061/2010 with regard to energy labelling of household washing machines. September 2010.

European Commission: Commission regulation No 1015/2010 with regard to Ecodesign requirements for household washing machines. November 2010.

Joint Research Centre JRC: Ecodesign and Energy Label revision: Household washing machines and washer-dryers. Tasks 1-4 and 5-7. Draft versions, 2015. http://susproc.jrc.ec.europa.eu/Washing_machines_and_washer_dryers/index.html

Barbara Josephy, Eric Bush, Ralf Geisel, Jürgen Ripperger, Jörg Siebolds: Cold wash – tests on washing performance. EEDAL 2015.

Molenbroek, Waide, Attali et al.: Evaluation of the Energy Labelling Directive and specific aspects of the Ecodesign Directive. Final technical Report. Ecofys, June 2014.

Nicolas Pochart, Andrew J. Smith: Energy Labeling for Laundry Washers. A Procter & Gamble Perspective. Presentation at a CECED workshop, November 3rd 2016.

S.A.F.E. and FEA: Swiss appliances sales development 2004 – 2015. August 2016. http://www.topten.eu/uploads/File/FEA-Geraetestatistik-2004-2015-EN.pdf

Topten.eu: Washing machines & combined washer-driers: Policy recommendations. December 2015. http://www.topten.eu/english/recommendations/washing-machines-3.html&fromid=

Universität Bonn: F. Alborzi, A. Schmitz, R. Stamminger: Washing behaviour of European consumers 2015. October 2015.

University of Bonn: Angelika Schmitz, Farnaz Alborzi, Rainer Stamminger: Large washing machines are not used efficiently in Europe. Tenside Surf. Det.

Van Holsteijn en Kemna: 'Omnibus' review study on cold appliances, washing machines, dishwashers, washer-driers, lighting, set-top Boxes and pumps. Final report, March 2014.

Tumble driers

European Commission: Commission Directive 95/13/EC of 23 May 1995 implementing Council Directive 92/75/EEC with regard to energy labeling of household electric tumble driers.

European Commission: Commission delegated regulation (EU) No 392/2012 of 1 March 2012 implementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labeling of household tumble driers.

European Commission, Corrigenda: Corrigendum to Commission delegated regulation (EU) No 392/2012 of 1 March 2012 implementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labeling of household tumble driers. May 2012.

European Commission: Commission regulation (EU) No 932/2012 of 3 October 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household tumble driers.

Nipkow Jürg, Eric Bush: Promotion of energy-efficient heat pump dryers. Swiss Agency for Efficient Energy Use (S.A.F.E.), Topten International Group. Paper for the proceedings of Energy Efficiency in Domestic Appliances and Lighting EEDAL, Berlin. 2009.

Rita Werle, Eric Bush, Barbara Josephy, Jürg Nipkow, Chris Granda: Energy efficient heat pump driers – European experiences and efforts in the USA and Canada. Presented at the EEDAL conference in Copenhagen, 2011.

S.A.F.E. and FEA: Swiss appliances sales development 2004 – 2015. August 2016. http://www.topten.eu/uploads/File/FEA-Geraetestatistik-2004-2015-EN.pdf

ABOUT ADEME

The French Environment and Energy Management Agency (ADEME) is a public agency under the joint authority of the Ministry of Ecology, Sustainable Development and Energy, and the Ministry for Higher Education and Research. The agency is active in the implementation of public policy in the areas of the environment, energy and sustainable development.

ADEME provides expertise and advisory services to businesses, local authorities and communities, government bodies and the public at large, to enable them to establish and consolidate their environmental action. As part of this work the agency helps finance projects, from research to implementation, in the areas of waste management, soil conservation, energy efficiency and renewable energy, air quality and noise abatement.
www.ademe.fr.

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
MINISTÈRE DE L'ÉCOLOGIE, DU DÉVELOPPEMENT DURABLE ET DE L'ÉNERGIE
MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR ET DE LA RECHERCHE

ADEME
20, avenue du Grésillé
BP 90406 | 49004 Angers Cedex 01

www.ademe.fr