

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 and Portugal, 2004 to 2014

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Content

LIST OF FIGURES	3
1. SUMMARY	5
2. INTRODUCTION	6
Monitoring the products market could bring a lot to Europe	6
Project objectives	6
Economic situation reflected	7
3. DATA AND METHODOLOGY	7
4. RESULTS AND DISCUSSION	8
4.1 Household refrigerators	8
Regulatory context	8
Results	9
Conclusions	18
Recommendations	19
4.2 Household washing machines	21
Regulatory context	21
Results	22
Conclusions	35
Recommendations	36
4.3 Tumble driers	37
Drier technologies	37
Regulatory context	37
Switzerland: A+ as MEPS	38
Results	39
Conclusions	47
5. SYNTHESIS	48
5.1 European market	48
Refrigerators	48
Washing machines	48
Tumble driers	49
5.2 National markets	49
France	49
Portugal	50
5.3 Market monitoring	50
6. REFERENCES	51

List of figures

Refrigerators

Figure 1: EU: efficiency classes of refrigerator sales	9
Figure 2: France: efficiency classes of refrigerator sales	10
Figure 3: Portugal: efficiency classes of refrigerator sales	10
Figure 4: Switzerland: efficiency classes of refrigerator sales 2004 - 2013	11
Figure 5: Average energy consumption of refrigerator sales in EU, France and Portugal	11
Figure 6: EU: average volume of refrigerator sales	12
Figure 7: France and Portugal: average volume of refrigerator sales	13
Figure 8: Average nominal price of refrigerator sales in EU, France and Portugal	13
Figure 9: EU: total refrigerator sales	14
Figure 10: France: total refrigerator sales	14
Figure 11: Portugal: total refrigerator sales	15
Figure 12: EU: average energy consumption of refrigerator sales / classes, 2014	15
Figure 13: EU: average volume of refrigerator sales according to classes in 2014	16
Figure 14: Average prices of refrigerator sales / classes in EU, France and Portugal	16
Figure 15: Total costs (purchase price + electricity costs) of refrigerator classes	17
Figure 16: Average energy consumption of A+ refrigerator sales, 2004 - 2014	17
Figure 17: Average volume of A+ refrigerator sales, 2004 - 2014	18
Figure 18: EU: average prices of refrigerator sales, best classes 2004 - 2014	18

Washing machines

Figure 19: EU: efficiency classes of washing machine sales	22
Figure 20: France: efficiency classes of washing machine sales	23
Figure 21: Portugal: efficiency classes of washing machine sales	24
Figure 22: Switzerland: sales of washing machines, 2004 - 2013	24
Figure 23: Average energy consumption of washing machine sales	25
Figure 24: Average water consumption of washing machine sales	27
Figure 25: EU: capacities of washing machine sales	28
Figure 26: France: capacities of washing machine sales	28
Figure 27: Portugal: capacities of washing machine sales	29
Figure 28: EU, France and Portugal: Average nominal price of washing machine sales	29
Figure 29: EU: total washing machine sales	30
Figure 30: France: total washing machine sales	30
Figure 31: Portugal: total washing machine sales	31
Figure 32: EU: average energy consumption of washing machine sales / classes, 2014	31
Figure 33: EU: average water consumption of washing machine sales / classes, 2014	32
Figure 34: EU: capacities of washing machine sales according to classes, 2014	32
Figure 35: EU, F and PT: Average price of washing machine sales / classes, 2014	33
Figure 36: EU: average prices of washing machine sales according to capacities, 2014	34
Figure 37: EU: Total costs of washing machine sales in 2014	34

Tumble driers

Figure 38: EU, France and Portugal: Efficiency classes of tumble drier sales, 2014	39
Figure 39: France: efficiency classes of tumble drier sales	40
Figure 40: Portugal: efficiency classes of tumble drier sales	40
Figure 41: Switzerland: sales share of tumble driers	41
Figure 42: France and Portugal: Average declared energy consumption of tumble driers	41
Figure 43: France: capacities of tumble drier sales	42
Figure 44: Portugal: capacities of tumble drier sales	43

Figure 45: France and Portugal: Average nominal price of tumble drier sales	43
Figure 46: France: total tumble drier sales	44
Figure 47: Portugal: total tumble drier sales	44
Figure 48: France and Portugal: average energy consumption of tumble drier sales, 2014	45
Figure 49: EU: capacities of tumble drier sale, 2014	46
Figure 50: France and Portugal: Average nominal price of tumble drier sales in 2014.	46
Figure 51: France and Portugal: average total costs of 2014 tumble drier sales	47

1. Summary

This report presents sales data from 2004 to 2014 for refrigerators, washing machines and tumble driers. The data has been purchased from GfK, thanks to funding from ADEME (Agence française de l'Environnement et de la Maîtrise de l'Energie) and WWF Switzerland. It includes absolute sales and, for each energy efficiency class, sales-weighted average information on absolute energy consumption (and water consumption for washing machines), size and price. Data is available for the EU-21¹, France and Portugal. 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 could be reduced by 25%. Both France and Portugal have lower sales shares of energy efficient refrigerators than the EU average. The average declared energy consumption is highest in Portugal, because larger freezer compartments are chosen. Because data for separate freezers is not available, this result however gives no evidence on the total cooling consumption.

Despite the continuous improvement, higher energy efficiency standards still have an enormous saving potential in the EU: including freezers, close to 10 TWh could be saved, had the 2014 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 declared energy and water consumption between the classes are minimal, and Portugal, with the highest share of energy efficient washing machines, has the highest average declared energy consumption at the same time. The reason is the large size of the washing machines sold in Portugal. Washing machines in better efficiency classes are larger, and the 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 40% of the EU sales in 2014. Differences between countries are large: heat pump driers held one third of the sales in Portugal, and only 12% in France.

The energy saving effect of Ecodesign tier 2, banning class C from November 2015, is not so clear: The average declared energy consumption of class C and B is almost identical. Reasons are an only small efficiency improvement of 11% and increase in size. The efficiency step from class B to A+ (most 'basic' heat pump driers) on the other hand is 45%, and the saving potential is huge. Had all driers sold in the EU in 2014 been in class A+, the savings over their lifetime would amount to 5.6 TWh.

Data like that presented here provides a sound basis for decisions on new Label classes and MEPS, and, if published on a regular basis, on the timing of revisions of these policy measures. The EU should no longer renounce on a systematic market monitoring based on sound market data.

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

2. Introduction

Monitoring the products market could bring a lot to Europe

Energy Labels and minimum energy performance standards (MEPS) for energy related products are crucial policy instruments that support on-going 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, 2014). 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 refrigerators and freezers in (S.A.F.E. and FEA, 2014)).

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 orderly and 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 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 Joint Research Centre JRC publishes an Energy Efficiency Status report every second year or so (e.g. Bertoldi et al., 2012), which is based on the same type of data. 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.

Project objectives

ADEME² (Agence française de l'Environnement et de la Maîtrise de l'Energie) and WWF Switzerland³ launched this White Goods market monitoring project together with Topten. 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 and Portugal. It complements other market monitoring reports such as the ones on TVs [5] and those on household appliances from Switzerland (S.A.F.E. and FEA, 2014). At the same time the data presented here supports the on-going revisions of the Ecodesign and Energy Labelling regulations for refrigerators and washing machines. With national sales data from

² www.ademe.fr/

³ www.wwf.ch

France and Portugal for the 2004-2014 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 – 2014, was a period of financial and economic turmoil in Europe. After 4 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.

3. Data and Methodology

ADEME and WWF Switzerland supported the Topten team in the purchasing of sales data on household refrigerators, washing machines and tumble driers from GfK⁴. 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, are obtained by GfK from retailers.

Table 1: Data obtained from GfK.

'Complete' includes sales (units), average sales-weighted energy consumption, size and price for each energy class.

	Refrigerators*	Washing machines	Tumble driers
EU-21	complete, 2004 - 2014	complete, 2004 - 2014	Label class %, 2014
F, PT	complete, 2004 - 2014	complete, 2004 - 2014	complete, 2004 - 2014

* Refrigerator data covers refrigerators with and without freezer compartment, but no separate freezers

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. Information about these parameters can also be combined, and the years 2004 to 2014 are covered. The data is aggregated and no information on brands or models was included. Refrigerator and washing machine data was purchased aggregated for the EU-21⁵, as well as on country level for France and Portugal. For tumble driers, complete data was obtained for France and Portugal, while for Europe only very basic information was purchased (sales share of efficiency classes in 2014, see Table 1). For comparison reasons, also sales data from Switzerland is used. In Switzerland, sales and sales shares of efficiency classes of household appliances is published annually by S.A.F.E.⁶ (Schweizerische Agentur für Energieeffizienz) and FEA⁷, the Swiss association of the domestic electrical appliances industry (see S.A.F.E. and FEA, 2014).

⁴ www.gfk.com

⁵ AT, BE, CZ, DE, DK, ES, FI, FR, GB, GR, HR, HU, IE, IT, NL, PL, PT, RO, SE, SI, SK.

⁶ www.energieeffizienz.ch

⁷ www.fea.ch

The results are presented in the following order:

1. Total average figures (efficiency, energy (water), size, price) and total sales, as far as available for EU, France and Portugal.
2. Analysis of differences between energy classes: energy (water), size, price. Where available, this analysis is limited to EU data, apart from price. Since for driers EU data is not available, French and Portuguese data is used for this.
3. Additional analysis: total costs and different relevant aspects depending on product category:
 - a. Refrigerators: class A+ energy and size development over time, price development of efficient classes
 - b. Washing machines: analysis of size and efficiency impact on price

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 EEL of 100% and was at the presumed average efficiency level. In 1996 first 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 2012 / 2014, class A is banned from the market in two steps (Energy Efficiency Index < 44 since July 2012, EEL < 42 since July 2014), considering the measurement tolerances that have been tightened.

In 2011, the new Energy Label including class A+++ has been introduced (EC, 2010). 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 launched and will be finalised by December 2015⁸.

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 related to 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

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

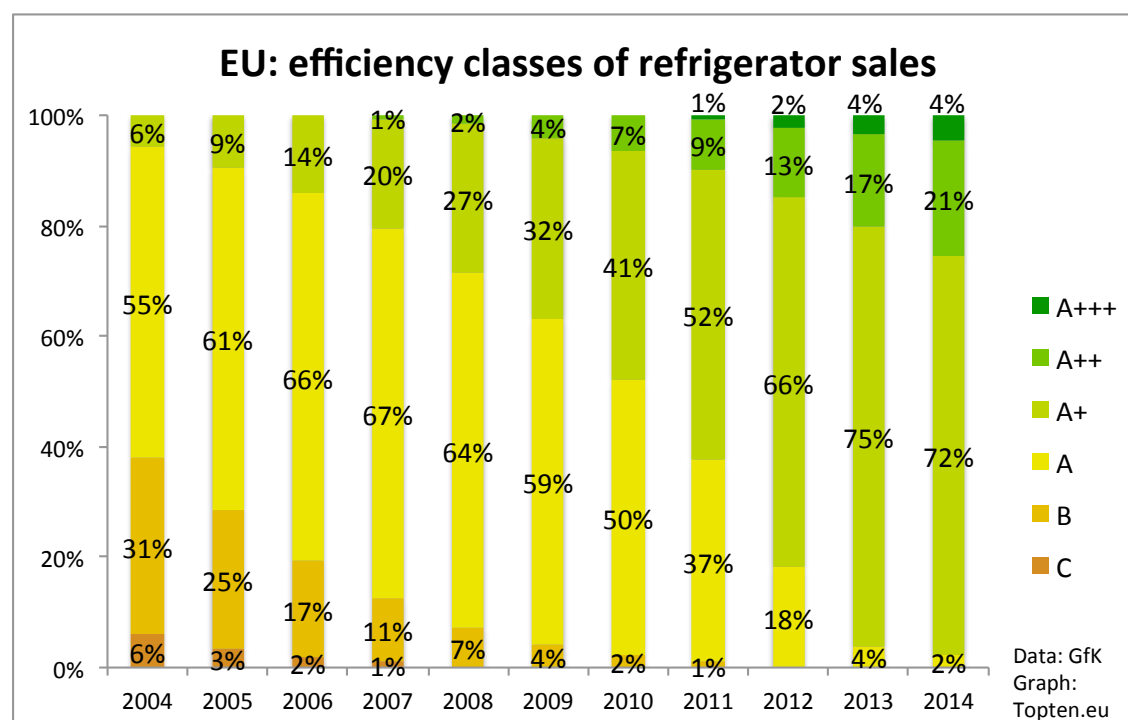


Figure 1: EU: efficiency classes of refrigerator sales

Figure 1 shows continuous improvements in refrigerator efficiency from 2004 to 2014. The average efficiency index has improved by 34% in this period (Average EEI 2014: 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 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+++ appears to be following.

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

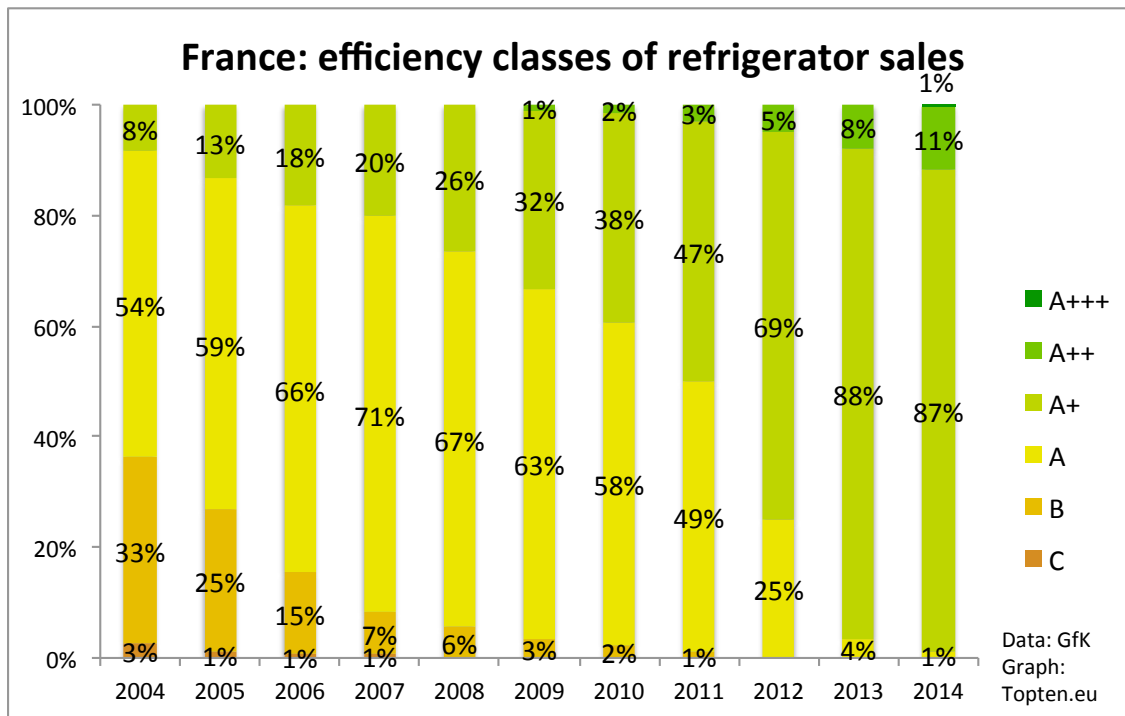


Figure 2: France: efficiency classes of refrigerator sales

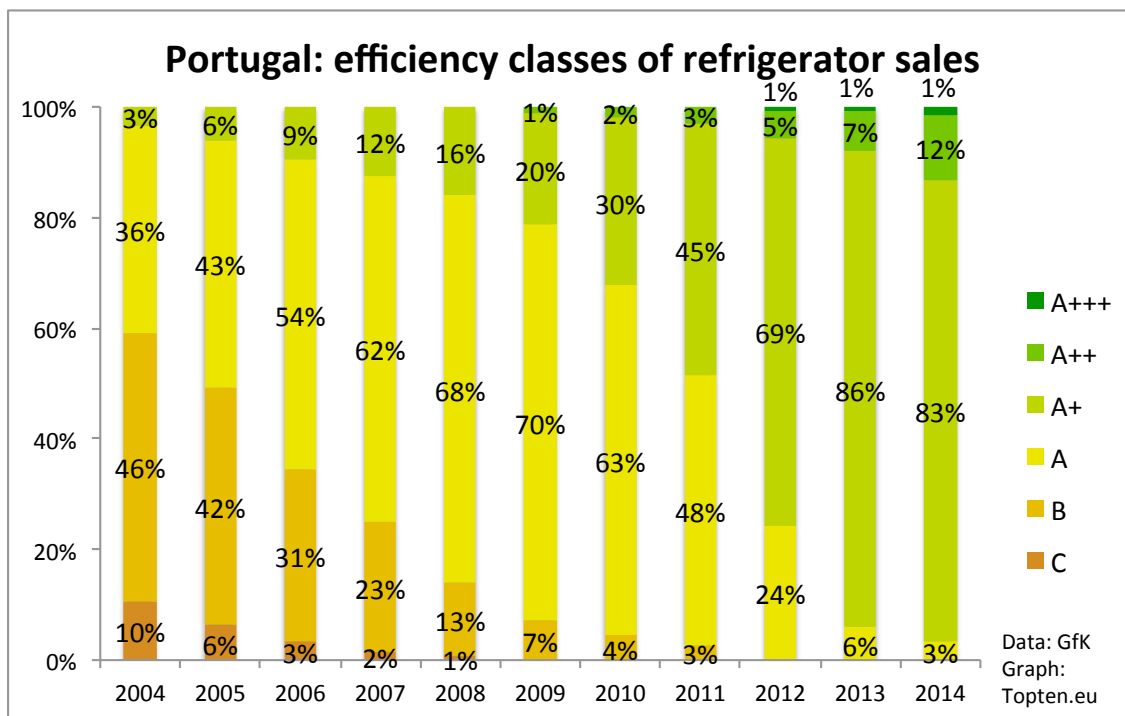


Figure 3: Portugal: efficiency classes of refrigerator sales

Data from France (Figure 2) and Portugal (Figure 3) shows that these trends can vary between EU countries – despite identical legislation and the same manufacturers being present on national markets: in both countries A+ also dominated the 2014 sales, but A++ sales only accounted for 11% (France) and 12% (Portugal), which is clearly below the EU average of 21%. The average EEI in both countries was 41% in 2014.

Data from Switzerland (S.A.F.E. and FEA, 2014, see Figure 4) 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.

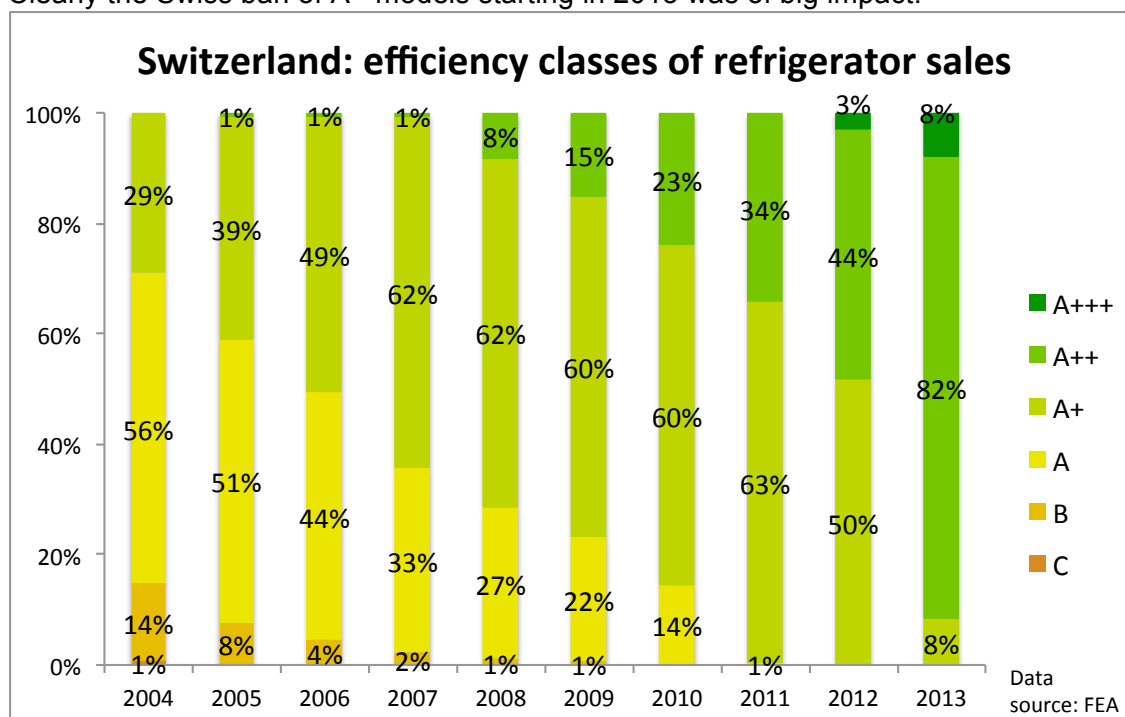


Figure 4: Switzerland: efficiency classes of refrigerator sales 2004 - 2013. Source: S.A.F.E. and FEA, 2014

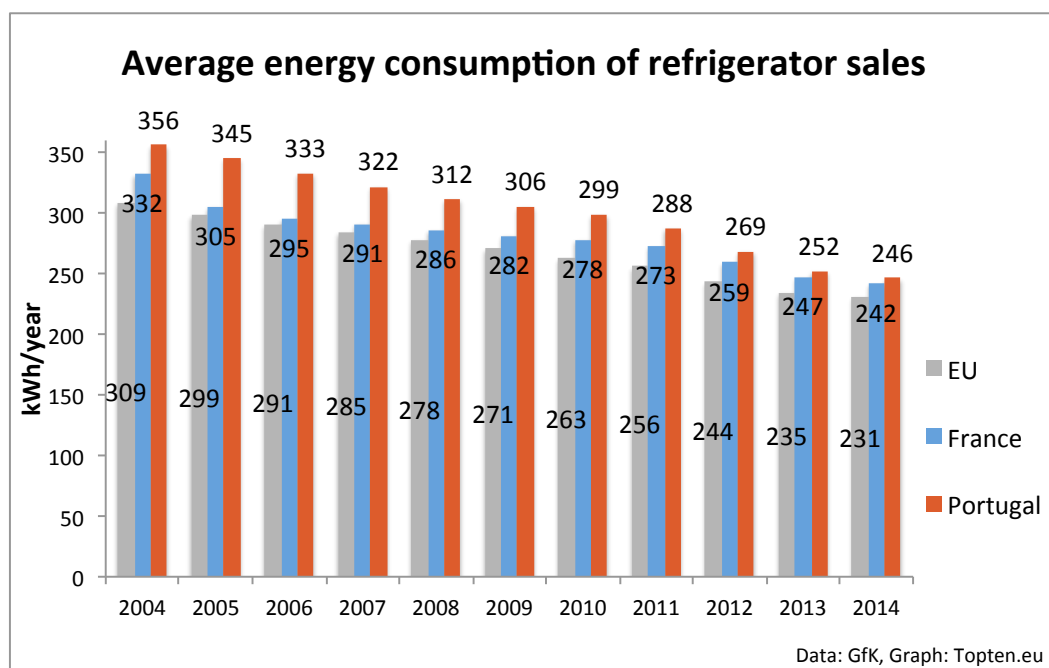


Figure 5: Average energy consumption of refrigerator sales in the EU, France and Portugal

The 25% reduction in average declared refrigerator energy consumption in ten years across the EU is significant. In 2014, the average declared energy consumption of sold refrigerators was 231 kWh/year. In France, 2014 refrigerators consume 11 kWh/year more than the EU average, in Portugal 15 kWh/year more. Also in France the average declared consumption was reduced by 27% over the period, to reach 242 kWh/year in 2014. There was a clear reduction from 2004 to 2005 (-8%) and from 2011 to 2013 (-5% per year), while in the other

years the development was slower. The faster reduction from 2011 – 2013 is probably due to the ban of class A. This effect also shows in the Portuguese consumption data: from 2011 to 2013 it was reduced by 7% and 6% per year, which is more than in other years (2% to 4%). Over the ten years average declared energy consumption of refrigerators sold in Portugal declined by 31%, to 246 kWh/year. The higher declared energy consumption by Portuguese refrigerators compared to the rest of Europe is likely to be due to a preference for larger freezer compartments (see Figure 7).

Comparing the EU energy reduction with what would be expected from the efficiency development in the EU, the savings are smaller than the 34% improvement in efficiency index shown in Figure 1. The difference cannot be fully explained by increased volume (Figure 6). 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 rated for tropical climates, or a chill compartment. Since the European EEL formula rewards these features, it is probable that they have become more common. Another misleading aspect of the EEL 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.

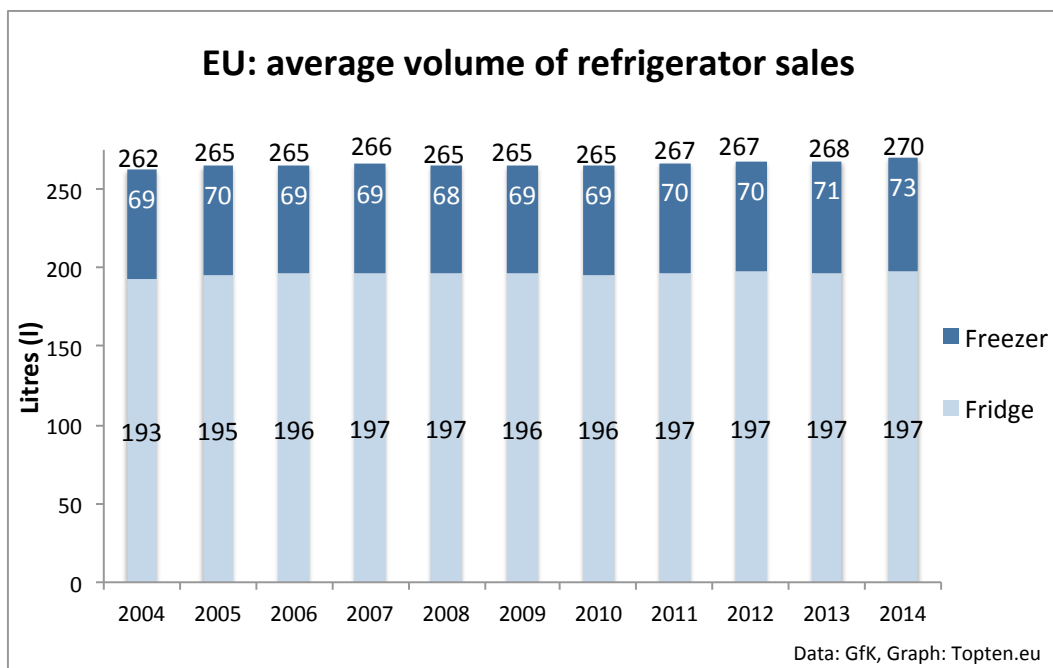


Figure 6: EU: average volume of refrigerator sales

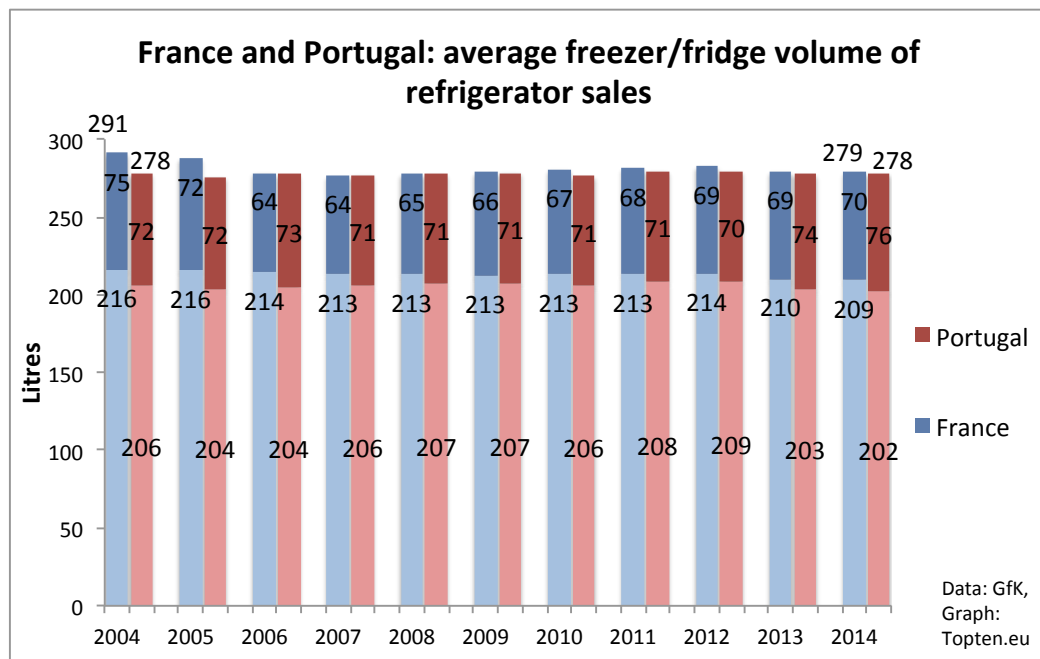


Figure 7: France and Portugal: average volume of refrigerator sales

Average declared volume of refrigerators has not increased a lot in the EU in the past ten years: only by 8 litres (3%) (freezer compartment: +5%, refrigerator compartment: +2%; + 4 litres each). In Portugal, average total volume remained stable (freezer: +6%, refrigerator: -2%), while in France it even decreased by 13 l (total: -4%, freezer: -7%, refrigerator: -3%). There is no reason to fear a trend to oversized refrigerators, and larger size is certainly not a main reason for the gap between energy consumption reduction and efficiency improvement shown above.

In 2014, total average volume of French and Portuguese refrigerators was nearly identical, and 3% larger than the EU average. In France however, average freezer compartments were 3l smaller than the EU average, while in Portugal they were 3l larger. The volume of the freezer compartment has a stronger influence on the energy consumption than that of the refrigerator compartment.

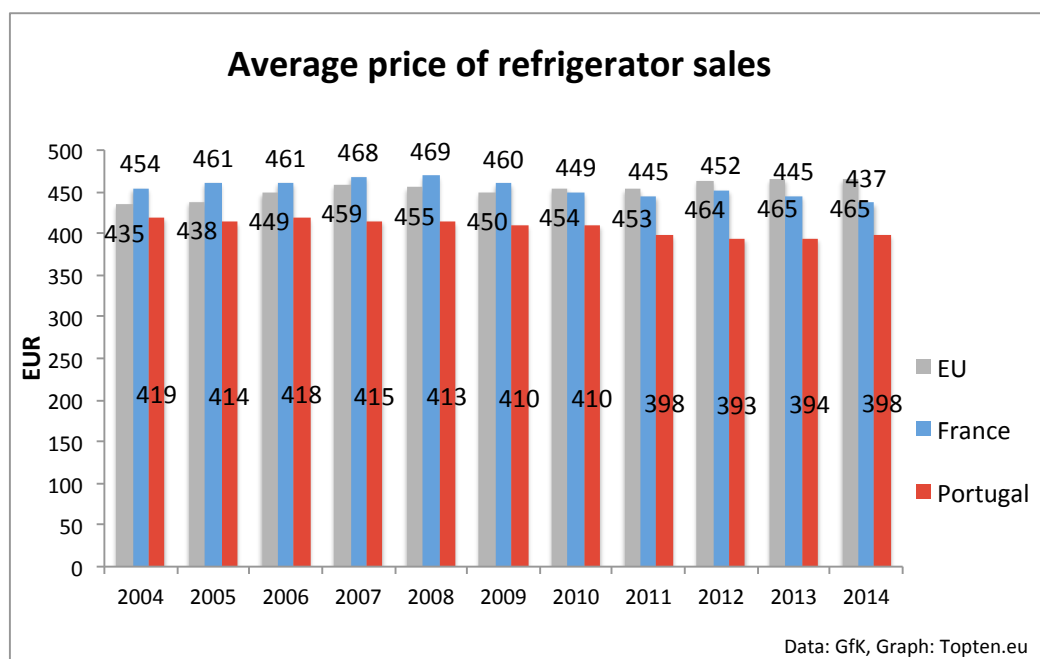


Figure 8: Average nominal price of refrigerator sales in EU, France and Portugal

Since 2004 average EU nominal prices have increased by 7%, while in France and Portugal, prices have decreased by 4% and 5%. In 2014 the average EU refrigerator cost EUR 465. French consumers paid on average EUR 437 and Portuguese EUR 398. While efficiency improved by 34%, the average nominal price paid for refrigerators only increased by 7% over the same period. Total costs for consumers (purchase price plus electricity costs) were reduced from EUR 1130 in 2004 to EUR 985 in 2014¹⁰. In France, they fell from EUR 1201 to EUR 981, and in Portugal from EUR 1220 to EUR 951. Were real prices considered, the cost reduction would be even larger.

Total sales (numbers of units) are shown below in Figure 9 to Figure 11. EU refrigerator sales fluctuate between 14 and 15 Million per year. Sales in France have increased by around 16% over the past ten years. In Portugal there was a drop in sales after 2010. Assumedly the economic crisis is showing here.

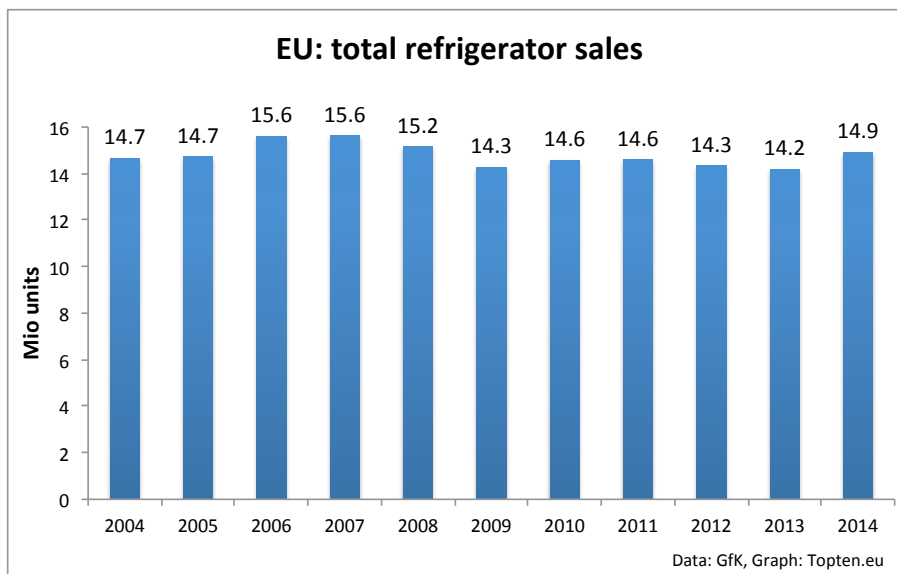


Figure 9: EU: total refrigerator sales

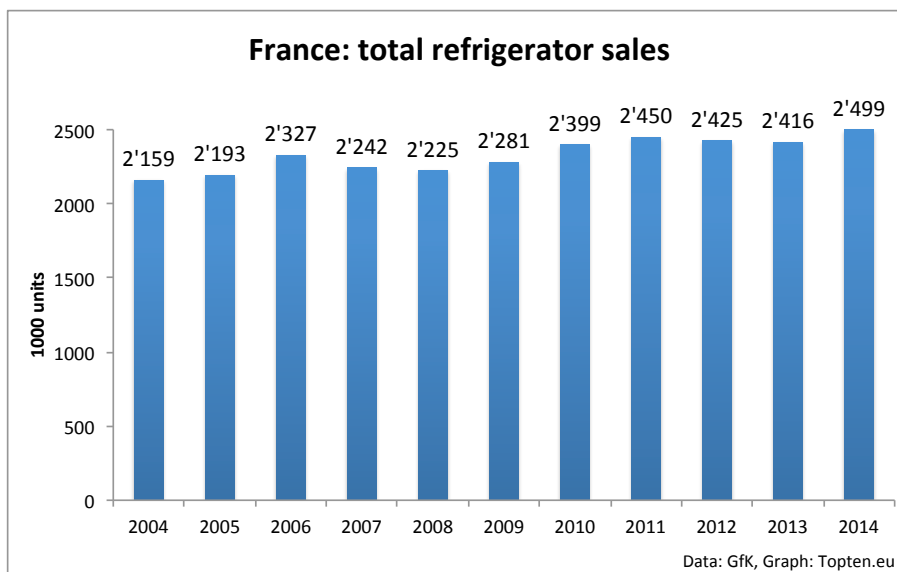


Figure 10: France: total refrigerator sales

¹⁰ Assumptions: 15 years of lifetime, 0.15 Euro/kWh.

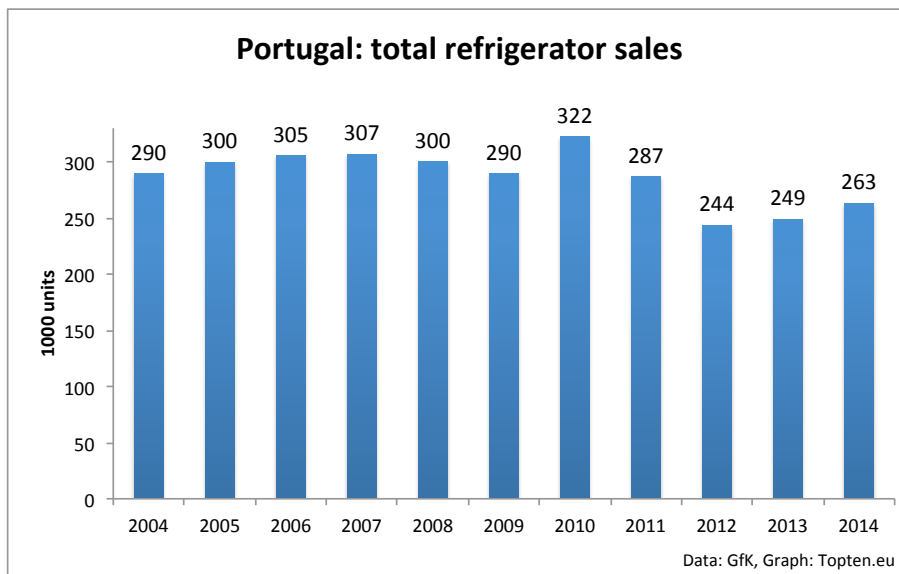


Figure 11: Portugal: total refrigerator sales

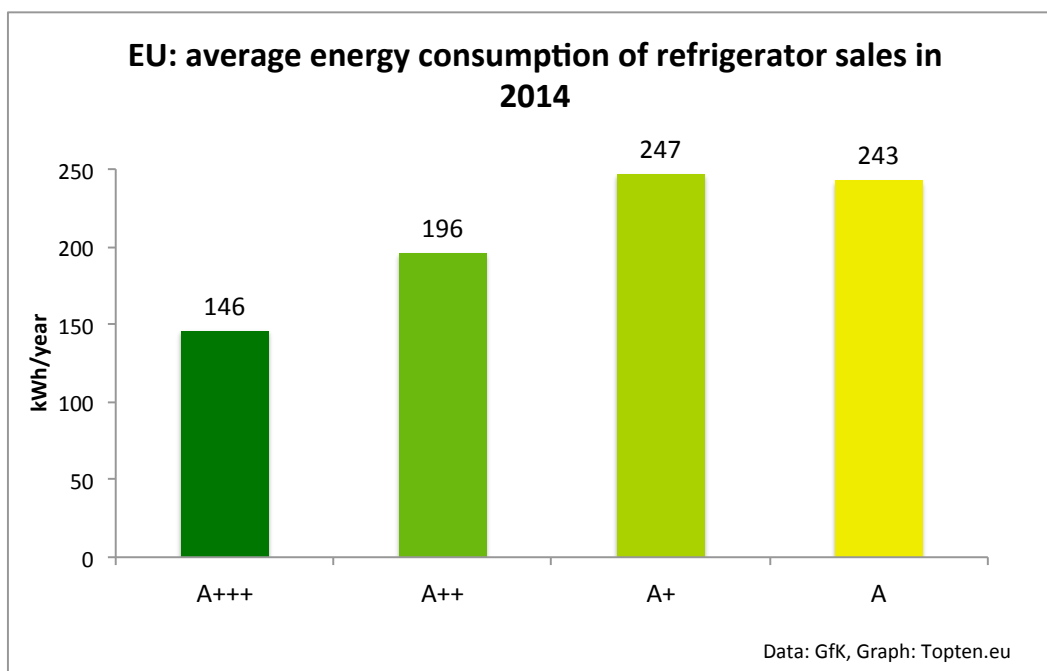


Figure 12: EU: average declared energy consumption of refrigerator sales according to classes in 2014

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 12). 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 energy consumption from the sales weighted analysis. Analysis of the average volume per class shows that the reason for this difference is likely the larger volume of A+++ refrigerators: total volume of A+++ refrigerators was 15% larger than of A+ models (freezer compartment: +17%; Figure 13). Still, the gains in efficiency clearly outweigh the effect of the larger volume on energy consumption.

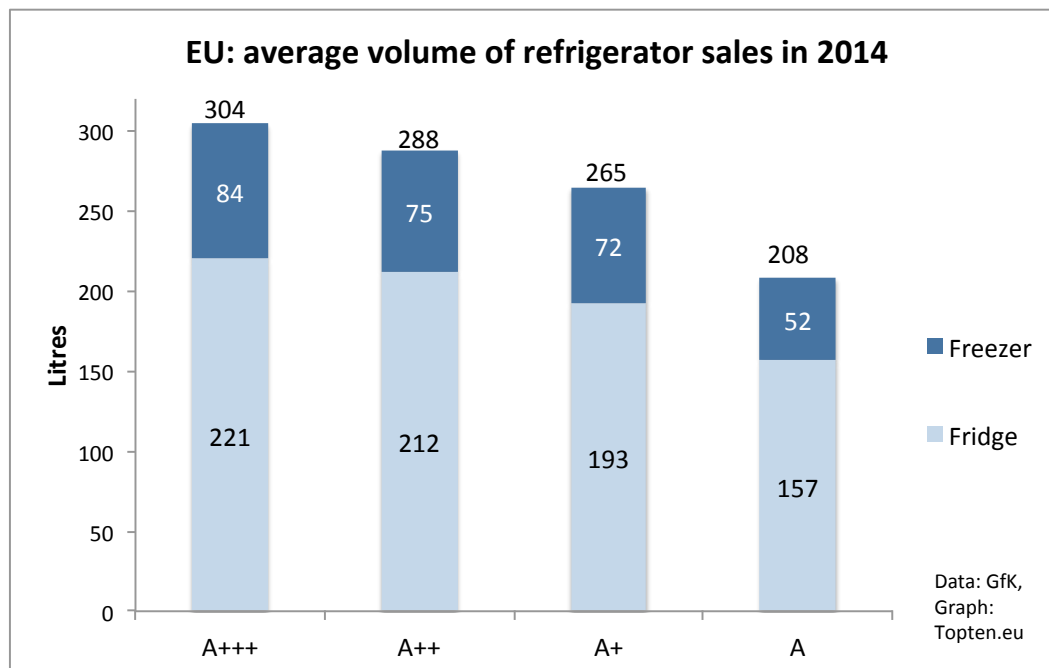


Figure 13: EU: average volume of refrigerator sales according to classes in 2014

Despite their low declared energy consumption, the most energy efficient are the largest refrigerators. The large freezer volume in A+++ refrigerators might be responsible for the below-expectation energy consumption reduction (see above). Freezer volume is 14% larger in A+++ refrigerators than average.

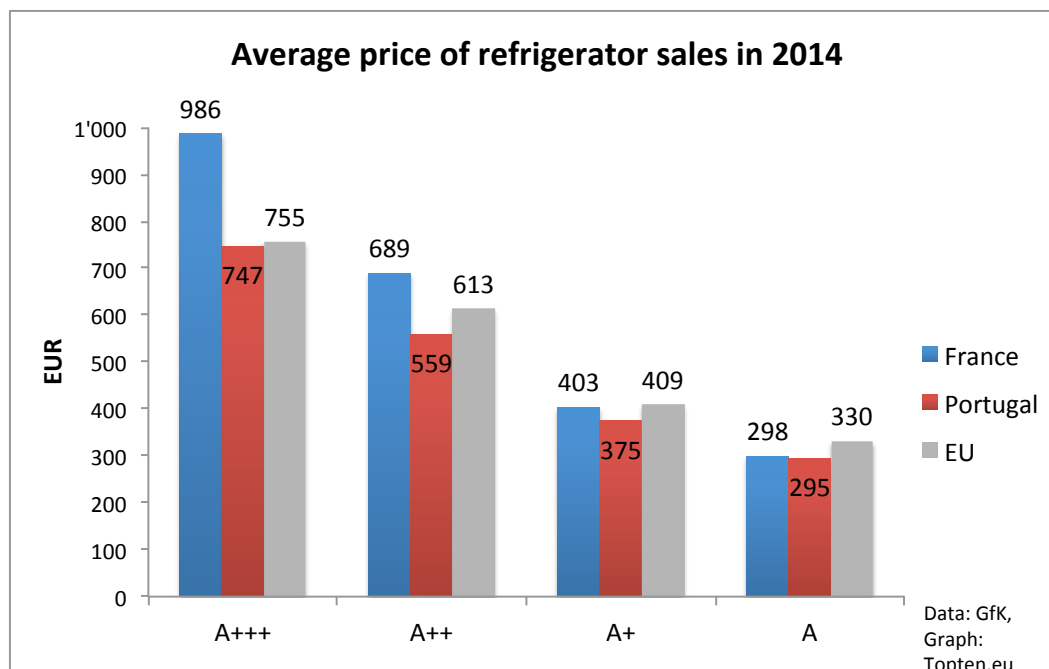


Figure 14: Average prices of refrigerator sales according to classes in EU, France and Portugal

In the EU, average price increase from A+ to A++ is 50%, and 23% from A++ to A+++. A++ and especially A+++ prices are higher in France. There could be an interrelation to the rather low sales shares of these classes (Figure 2). 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 15 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 12), 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 price premium is still higher than electricity cost savings that can be accumulated over the product's lifetime.

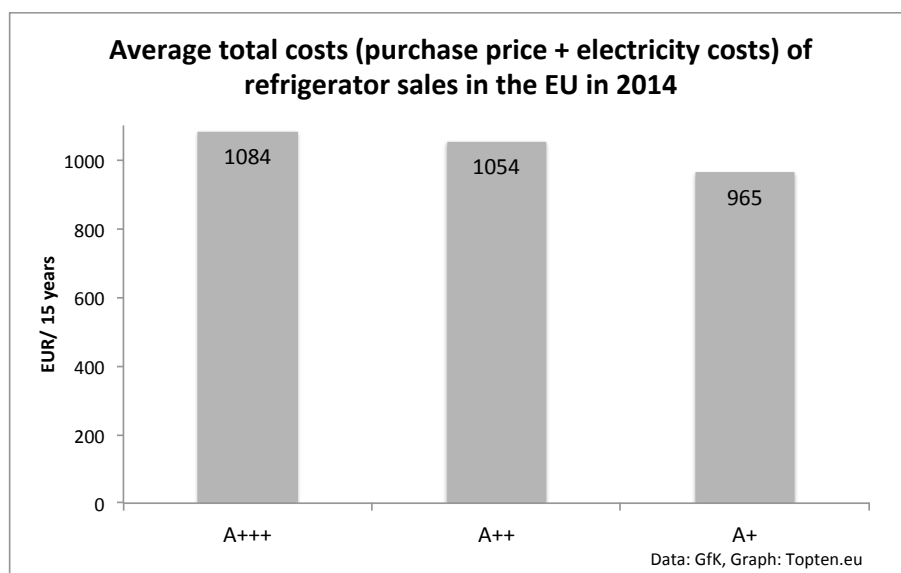


Figure 15: Total costs (purchase price + electricity costs) of refrigerator classes

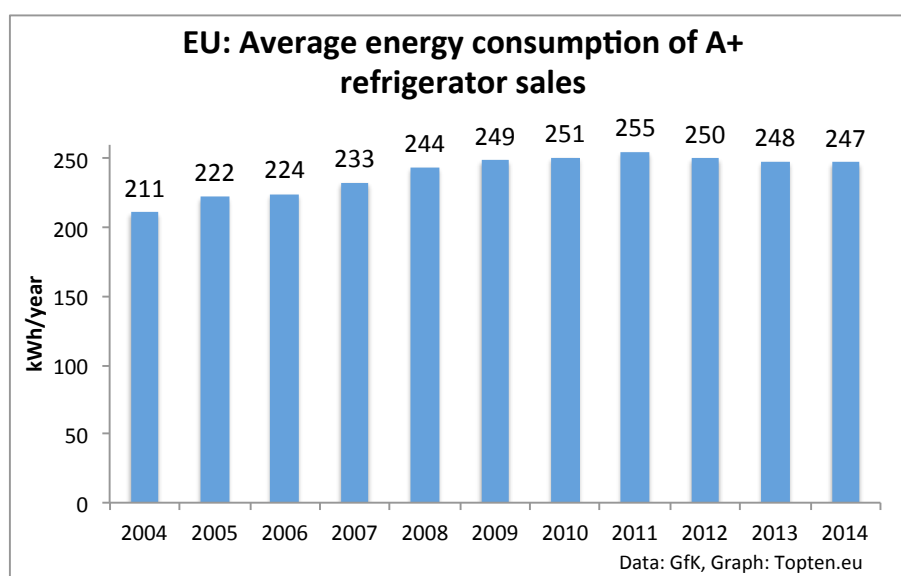


Figure 16: Average energy consumption of A+ refrigerator sales, 2004 - 2014

Within efficiency classes, the average energy consumption can change considerably over time: for A+, the only Label class that has been present over the entire ten-year period, sales-weighted average energy consumption increased by 21% from 2004 to 2011 (introduction of new Label), then decreased again. Analysis of the volume change shows that

¹¹ Total costs include purchase price and electricity costs over the product lifetime. Assumed refrigerator lifetime was 15 years, electricity price 0.15 Euros/kWh.

the energy consumption follows the freezer compartment volume: this increased by 24% on average from 2004 to 2011 (Figure 17).

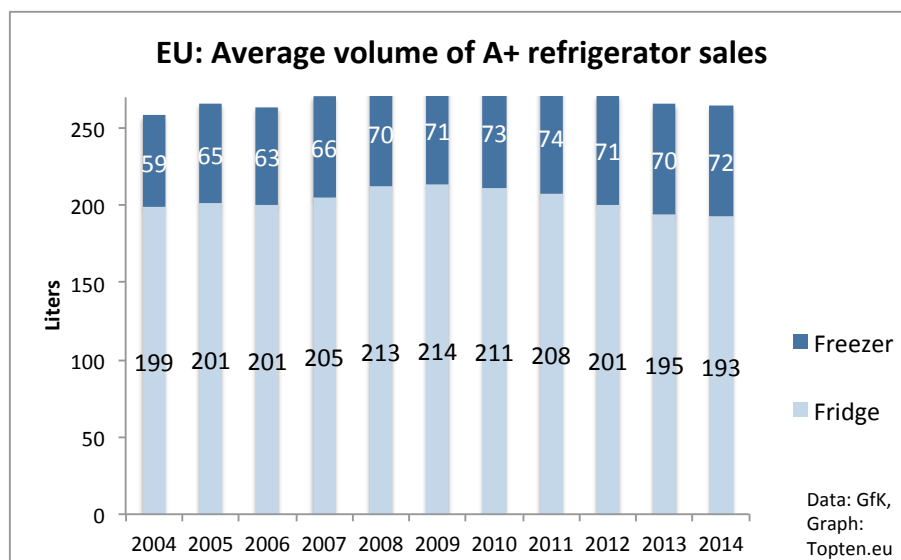


Figure 17: Average volume of A+ refrigerator sales, 2004 - 2014

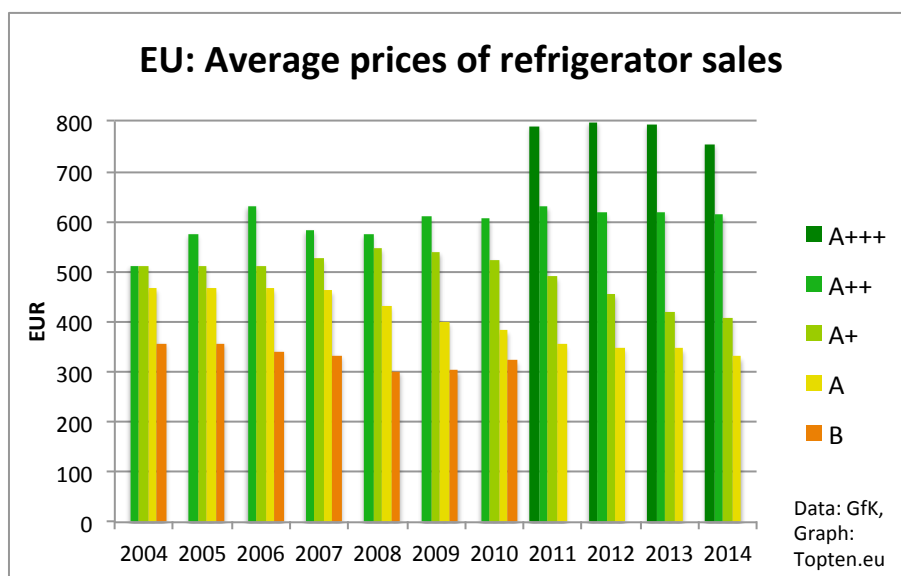


Figure 18: EU: average prices of refrigerator sales, best classes 2004 - 2014

Figure 18 looks at the price evolution of new efficiency classes: Prices of newly introduced classes are high, then slowly go down. Average prices of A++ are quite stable, despite increasing sales share (Figure 1).

Conclusions

A+, the least efficient energy class still allowed on the EU market, has been dominating the 2014 refrigerator sales. The ban of class A in 2012/2014 by the Ecodesign regulation clearly sped up the efficiency development. Differences between national markets are quite large: in both France and Portugal, less energy efficient (A++, A+++) refrigerators were sold in 2014 than across the EU. The Swiss market on the other hand, where A+ cold appliances have been banned since 2013, is more energy efficient. In the EU, average declared energy consumption of refrigerators has been reduced by 25% in the last ten years. Refrigerators sold in France consume 11 kWh/year more than the EU average, those sold in Portugal 15

kWh/year more. The main reason for the difference between the EU average and the two countries is assumedly the lower energy efficiency.

A comparison with German product sales data from 2008 had found that French refrigerators were 30% larger than German ones (SoWatt, Enerdata, 2012). Our data does not show especially large French refrigerators: French refrigerators have a slightly larger cooling compartment than the EU average, while the freezer compartment is slightly smaller. Since the freezer compartment has a much larger influence on the energy consumption than the cooling compartment, the size difference does hardly matter for France. In Portugal however, the larger average freezer compartment could be responsible for the consumption difference to France. French average prices are between those of the EU and Portugal. Average prices of energy efficient refrigerators (A+++ and A++) are however clearly higher in France.

Higher efficiency of refrigerators still holds large electricity saving potentials for Europe. A move from the 2014 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 7.8 TWh for one year of sales (or annual stock savings if the entire stock was replaced)¹². An estimate, which included separate freezers in this calculation, results in nearly 10 TWh of annual savings. These savings could have been hypothetically obtained with the 2014 sales, if the minimum efficiency requirement had been moved to A++ (the Swiss MEPS level). 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 2030.¹³

For France and Portugal, the saving potential of A++ in 2014 was 20% (average EEI: 41%). For France, 1800 GWh could have been saved with the 2014 refrigerator sales over their lifetime according to the data presented here, had only A++ models been sold (without freezers). For Portugal, this saving potential amounts to 194 GWh.

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

¹² 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 approaches the figure of annual stock savings (after full replacement). Assumed lifetime was 15 years. Freezer sales were estimated at 25% of refrigerator sales, based on [1].

¹³ 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. 'Our' A+ scenario corresponds to CLASP scenario 3 tier 1, or close to full scenario 2.

of potential savings per year quantified in this paper: today's class A++ should be announced as the forthcoming MEPS level by 2018.

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 (or even a curve, as in Australia (Michel, Harrington, 2015)) for all categories is sufficient (temperature differences are already considered in the adjusted volume) and 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 has been launched which will make suggestions for new Label and Ecodesign requirements¹⁴. New measures are expected for implementation in 2016.

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: ○ ban of classes B and less efficient ○ max. water consumption depending on capacity ($W \leq 5 \cdot c + 35$) ○ washing efficiency > 1.03 (old washing performance class A)
End of Dec 2013	- Ecodesign tier 2: ○ ban of class A ○ max water consumption tightened ($W \leq 5 \cdot c^{1/2} + 35$)¹⁵ ○ 20°C programme mandatory

¹⁴ http://susproc.jrc.ec.europa.eu/Washing_machines_and_washer_dryers/index.html

¹⁵ 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

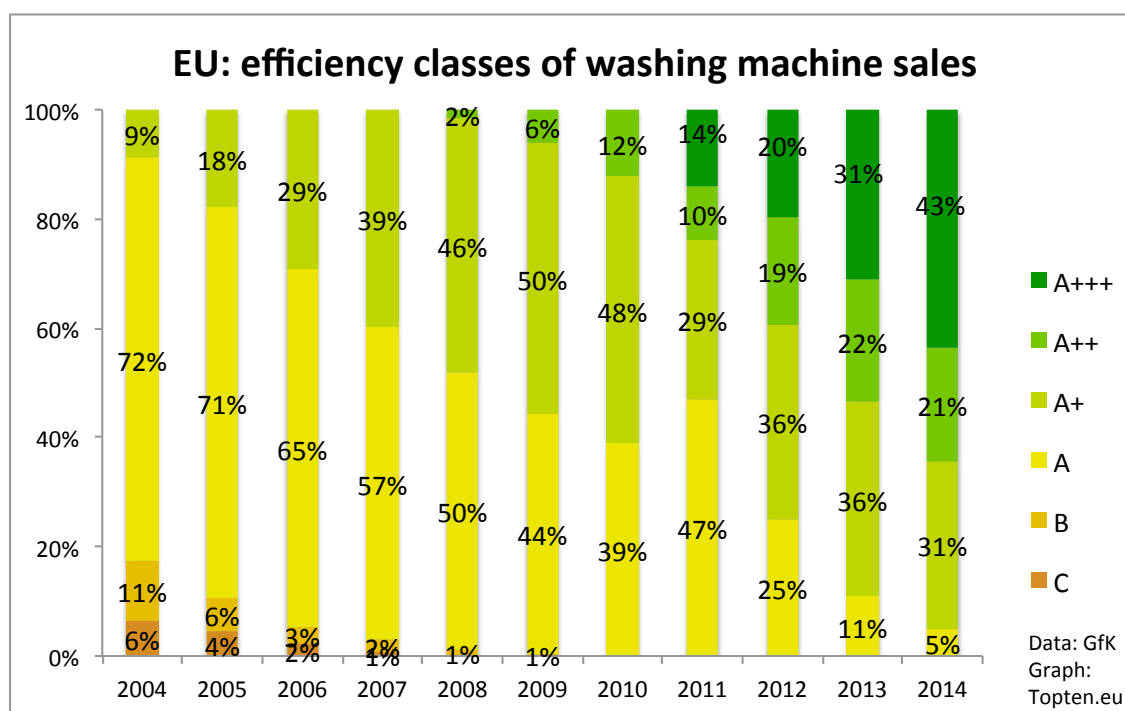


Figure 19: EU: efficiency classes of washing machine sales

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 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. Still, 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 2014, 43% of the sales across the EU were in the top class A+++, meaning that, three years after the current Label became compulsory, close to half of the 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 2017, until then manufacturers have no possibility to market energy efficient innovations. However, these are already on the market: 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 20 to Figure 22 show that popularity of the efficiency classes can vary considerably on national markets. The French market seems to have been less efficient than the EU average since 2005. In 2014, A++ had a higher sales share in France than in Europe (25% compared to 21%), but also A+ (39% vs 31%), and A+++ made up for only 31% of French sales compared to 43% in Europe. In Portugal on the other hand the sales share of A+++ is already close to 50%, while yet in 2004 the sold washing machines were clearly less efficient than in the average of the EU. The high efficiency of the Portuguese washing machines market might be linked to the popularity of large washing machines (large machines tend to reach higher efficiency levels, see Figure 34). Even higher A+++ sales shares can be found on the Swiss graph (Figure 22): 61% in 2013. 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).

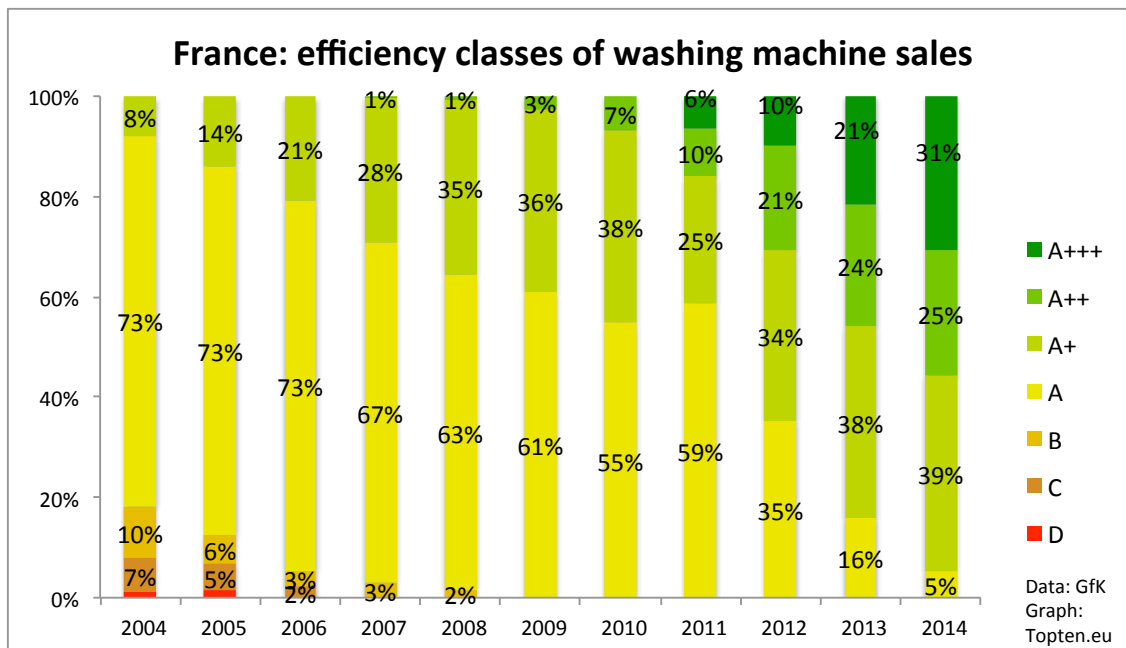


Figure 20: France: efficiency classes of washing machine sales

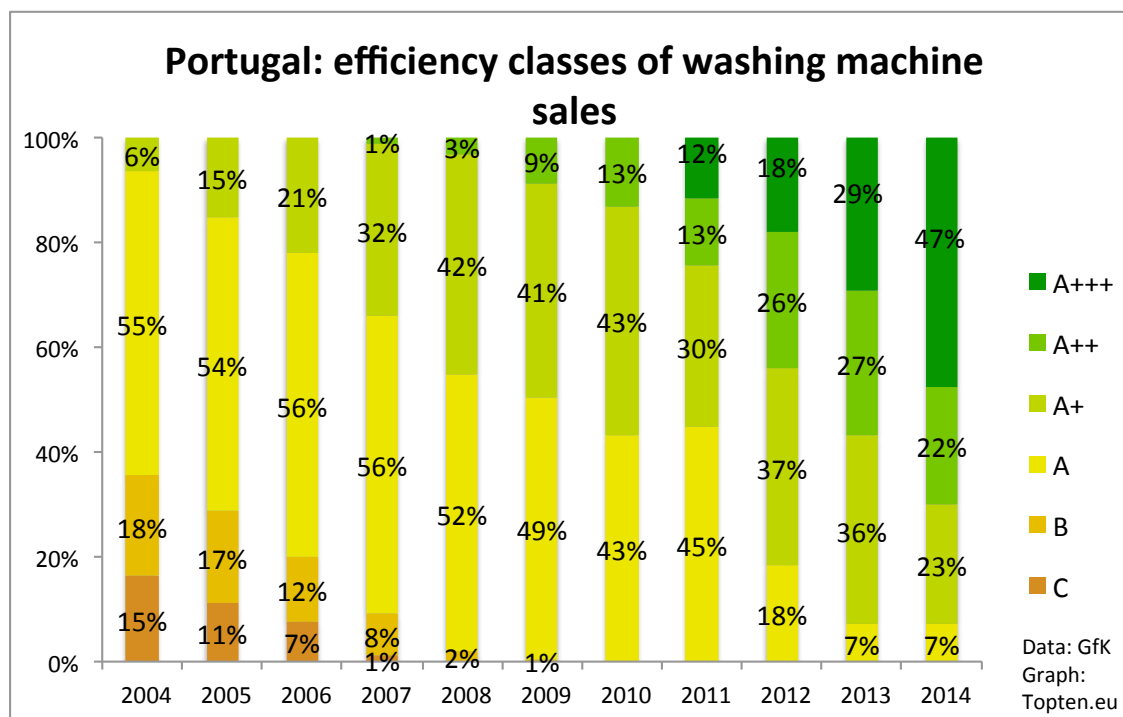


Figure 21: Portugal: efficiency classes of washing machine sales

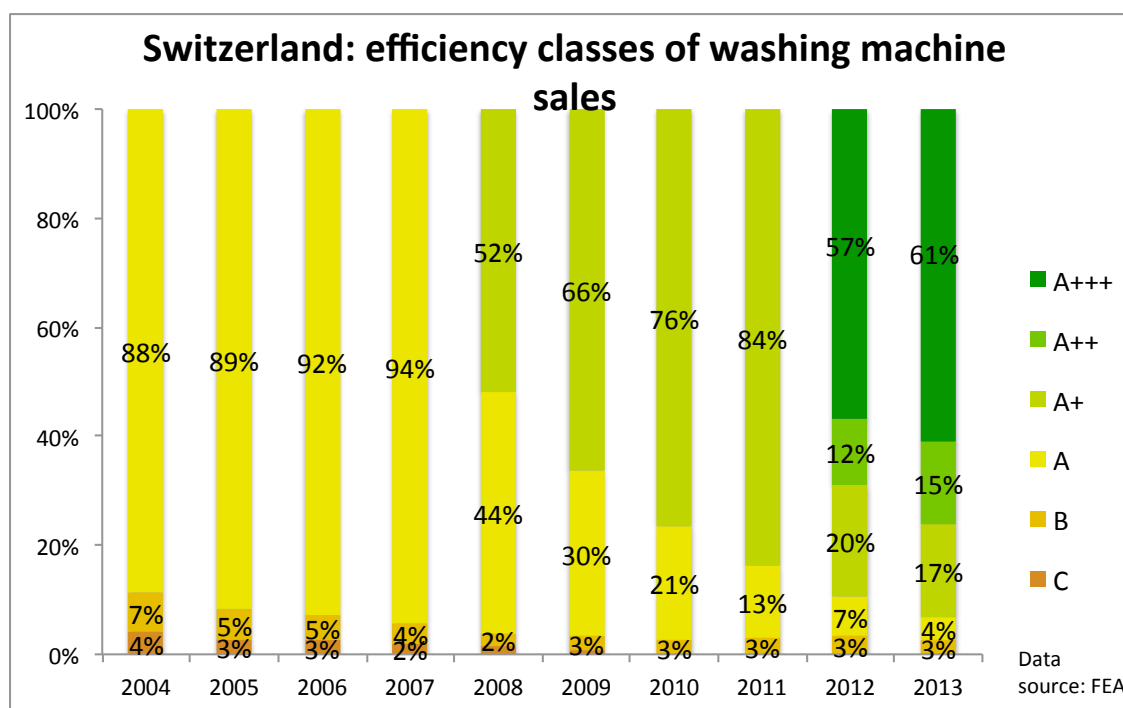


Figure 22: Switzerland: sales of washing machines, 2004 - 2013 (Source: S.A.F.E. and FEA, 2014).

Note: unlike GfK, FEA reports only official efficiency class declarations. Therefore, A++ and A+++ appear from 2012 only. A+ was official in Switzerland starting in 2008.

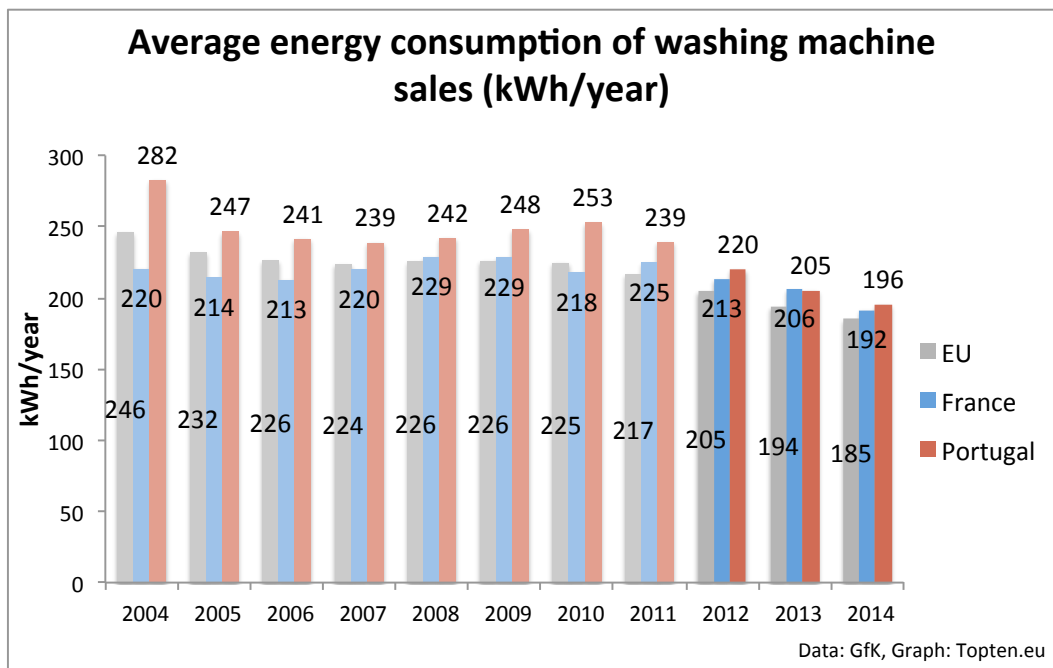


Figure 23: Average energy consumption of washing machine sales.

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 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. In France and Portugal, average energy consumption even increased between 2006 and 2009 / 2007 and 2010, respectively, before also decreasing. Since no change in declaration occurred, the trend to larger machines (shown in Figure 25 to Figure 28) must have outweighed increasing efficiency in this period. In 2014, average declared annual energy consumption of the sold washing machines was 185 kWh per year in the EU-21, 192 kWh/year in France and 196 kWh/year in Portugal.

The reduction in declared and calculated energy consumption between 2004 and 2014 is 25% at EU level, 30% in Portugal and 13% in France. 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 only based 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.eu¹⁶, imply that around 10% of the reduction in declared energy consumption might have occurred due to different methods. Still, the average declared energy consumption has continuously been reduced since 2011 - despite a strong trend to larger washing machines (Figure 25), showing that the tested programmes have indeed been optimized regarding energy efficiency.

It is surprising that in Portugal, where most energy efficient washing machines were sold, the average energy consumption is the highest. An explanation can be found in the comparable large capacities that Portuguese buy: while across the EU in 2014 still 41% were 6kg and smaller machines (Figure 25), in Portugal only 20% were small (we use the term 'small' here for convenience reasons, even though 6 or even 5kg machines were the standard ten years ago), 44% were declared as 7kg machines and 28% as 8kg (Figure 27).

This situation shows that larger capacity can cancel or even outweigh the savings of better-rated machines – at least for a usage according to the Energy Label.

This does not necessarily mean that Portugal has a higher overall washing machine energy consumption. First, the capacity of washing machines is not measured according to a standard, but simply declared by the manufacturer. It is therefore possible that different 'capacity declaration policies' are used in different countries (for identical models). Since the declared capacity influences the amount of laundry used in the test, also the declared energy consumption depends on the declared capacity. Second, total sales in Figure 31 show that relatively fewer washing machines are sold in Portugal: in 2014, 2.7 washing machines per 100 inhabitants were sold in Portugal; the equivalent figure was 3.1 in the EU-21 and 3.7 in France. The average annual energy consumption of all washing machines sold in 2014 relative to population is lower in Portugal (5.3 kWh/person-year vs. 5.8 kWh/person-year in the EU-21 and 7 kWh/person-year in France). If Portuguese households bought fewer but larger washing machines because they wash fewer but larger loads, this could mean a lower energy consumption. However, according to a product expert¹⁷ from Portugal, Portuguese use their washing machines often (more often than dishwashers) and wash rather small loads. According to the expert, Portuguese consumers do not choose large washing machines because they wash large loads, but because nearly no small machines are offered on the market.

Effective energy consumption of washing machines depends on the actual usage, and can hardly be estimated from the declared values. Figure 23 shows trends in *declared* energy consumption, but it is not known what this means for actual energy consumption.

¹⁶ 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, just after the product lists were updated), but variations are large. The consumption by low power modes has not been compared.

¹⁷ Oral information from Laura Carvalho, Quercus / Topten Portugal (www.topten.pt/) in March 2015

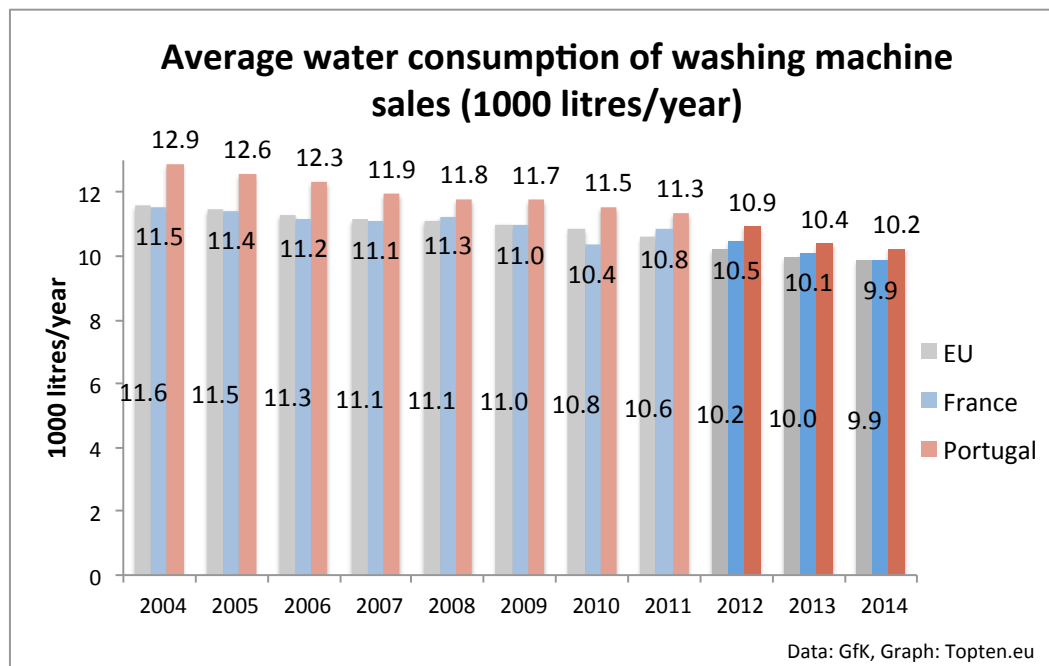


Figure 24: Average water consumption of washing machine sales.

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

It is not surprising that the Portuguese data also shows a higher average declared water consumption than across the EU and in France. This goes hand in hand with rather large (declared) capacities (Figure 27) and relatively high average declared energy consumption shown in Figure 23 above. Average declared water consumption seems to have been steadily reduced across the EU and in Portugal, while French data shows two 'bumps' of higher consumption in 2008 and 2011/2012. The second bump is likely to be linked to the change in declaration. In the ten-year period, average declared water consumption was reduced by 1700 litres/year (15%) across the EU, 1600 litres/year (14%) in France and 2700 litres/year (21%) in Portugal. While for France the reduction level is similar as for the declared energy consumption (13%), relative energy reduction is clearly stronger across the EU and in Portugal. Obviously next to reduced water use, also other efficiency options have been realised.

Ten years ago nearly all washing machines were for 6 kg of laundry and less, then the strong trend to larger capacities started. In 2014, more than half of all washing machines sold across the EU were declared to be designed for washing 7 kg laundry and more. In France, in 2014 a higher share of washing machines for 6kg and less was sold than across the EU (45% vs 41%), also less for 7kg (30% vs 35%) and 8kg (16% vs 19%), but more above 8kg (10% vs 6%). Washing machines sold in Portugal are on the contrary declared for larger capacities than across the EU average: only 20% were declared for 6kg and less in 2014 (EU: 41%), and most were declared for 7kg (44%). More than one third were declared for 8kg and more in Portugal.

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. The 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 does still follow a strictly

linear efficiency approach: an A+++ washing machine with 8kg capacity can use 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 A+++, oversized washing machines do not contribute to energy saving. Instead, energy and water will be wasted if most wash cycles run with low part loads (e.g. 2-3kg in 8kg machines). On the other hand it seems that the outer dimensions of the models remained the same, but in most cases only the drum size has been optimised. Also the declaration of the drum capacity is not standardised, as mentioned above, and it is possible that manufacturers' 'capacity declaration policies' vary between countries or over time. What all this implies regarding real life energy and water consumption is not clear.

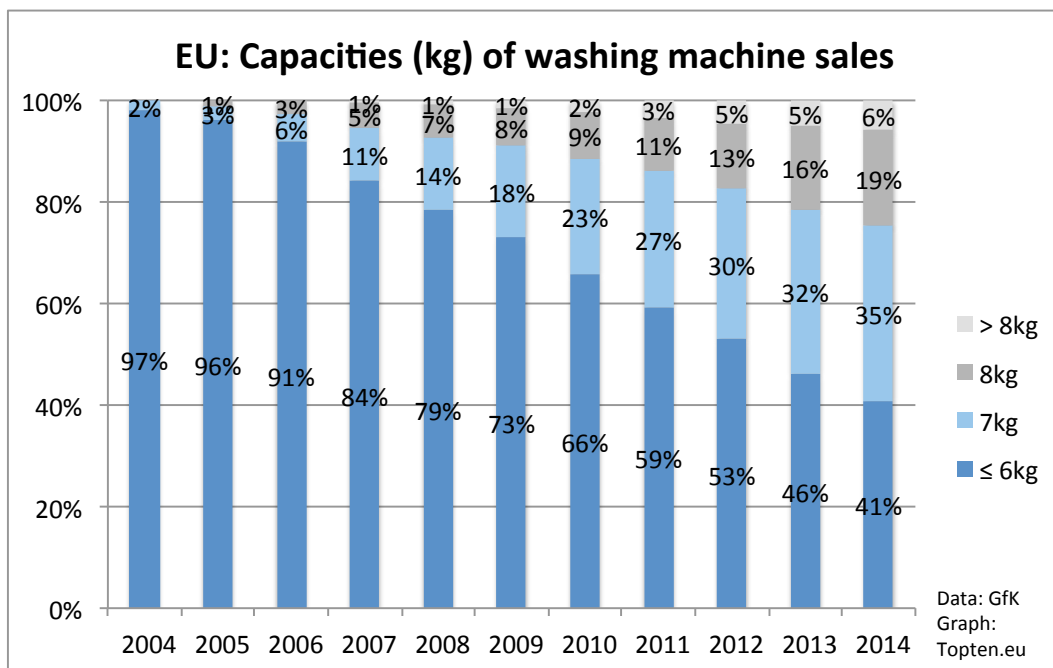


Figure 25: EU: capacities of washing machine sales

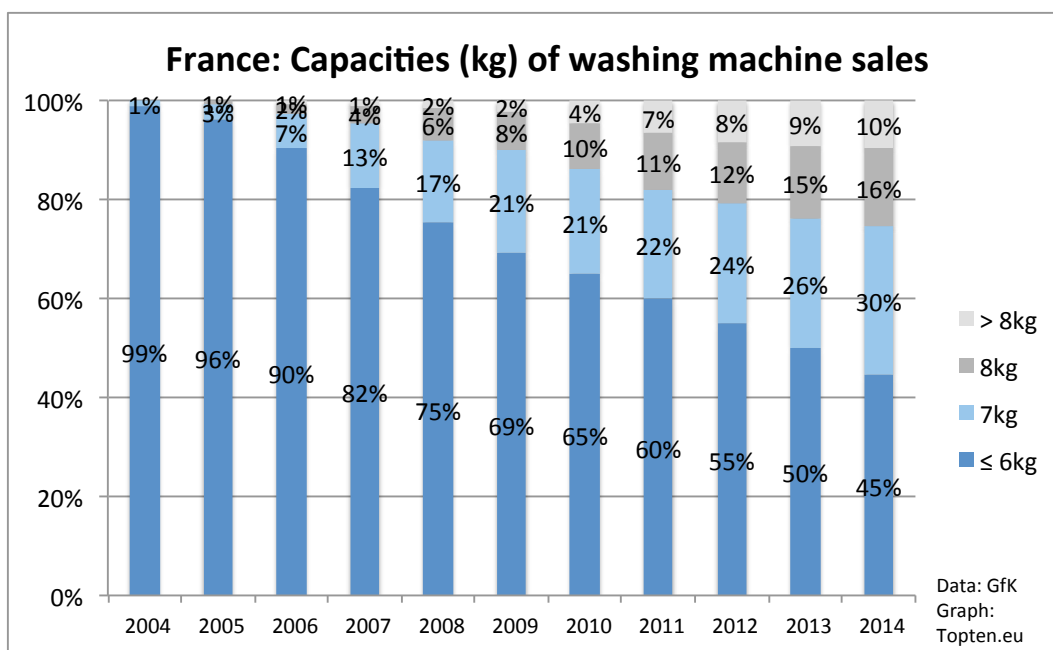


Figure 26: France: capacities of washing machine sales

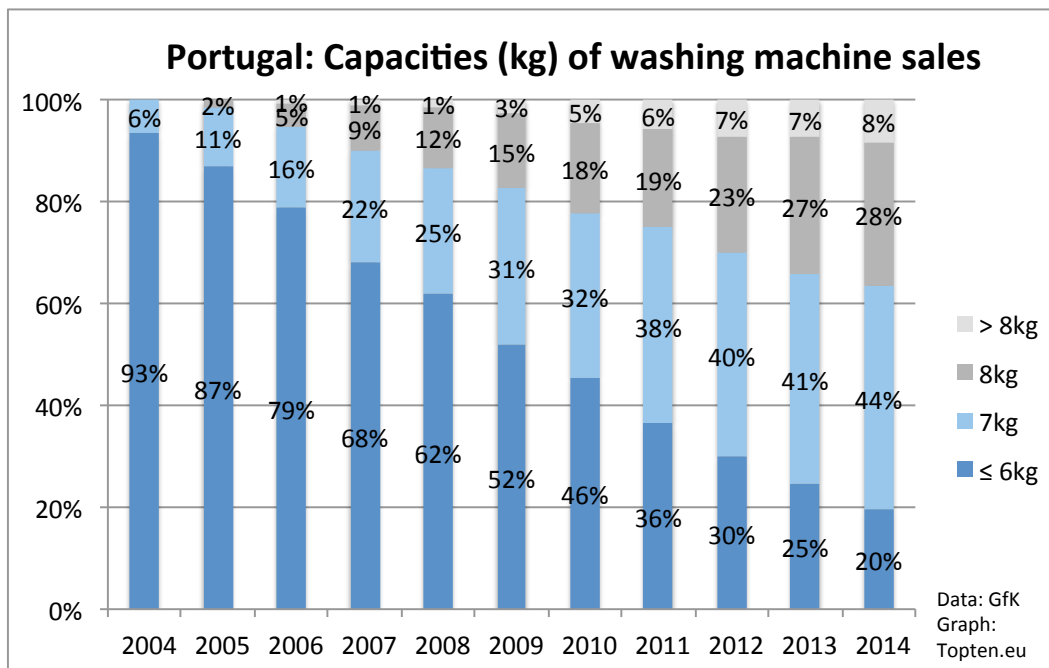


Figure 27: Portugal: capacities of washing machine sales

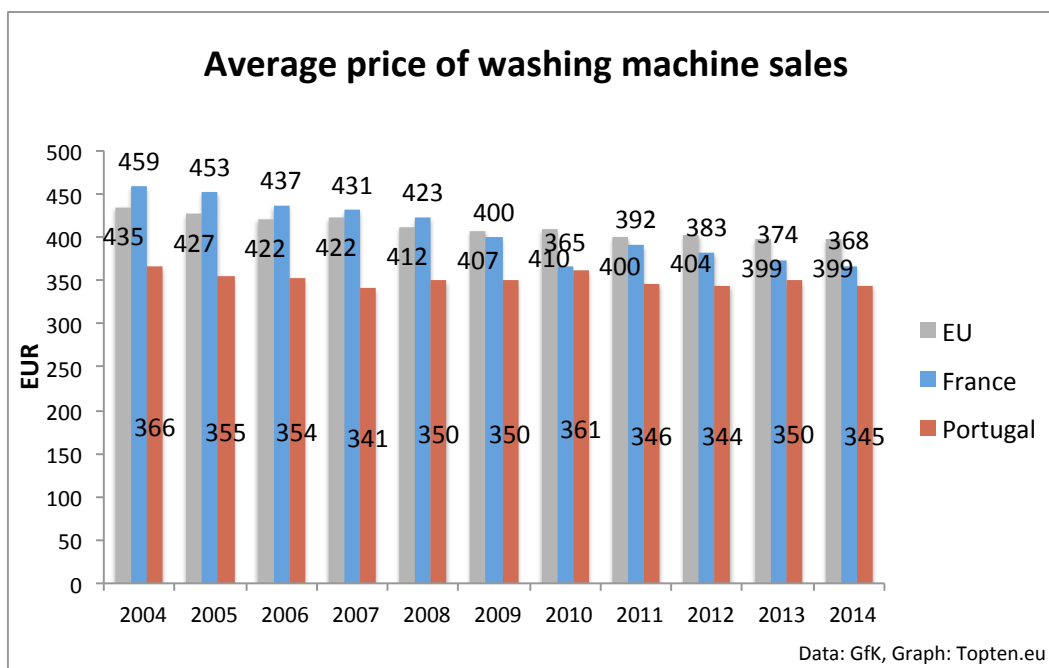


Figure 28: EU, France and Portugal: Average nominal price of washing machine sales

Across the EU-21, average nominal washing machine prices have declined by 8% from 2004 to 2014 – despite higher efficiency and larger capacities. In France, the reduction in price was even 20%. In Portugal, where the sold washing machines are larger and more efficient, average prices are lower. The price reduction in ten years was 6% in Portugal. Since 2009, French and Portuguese average prices have been increasingly below the EU average.

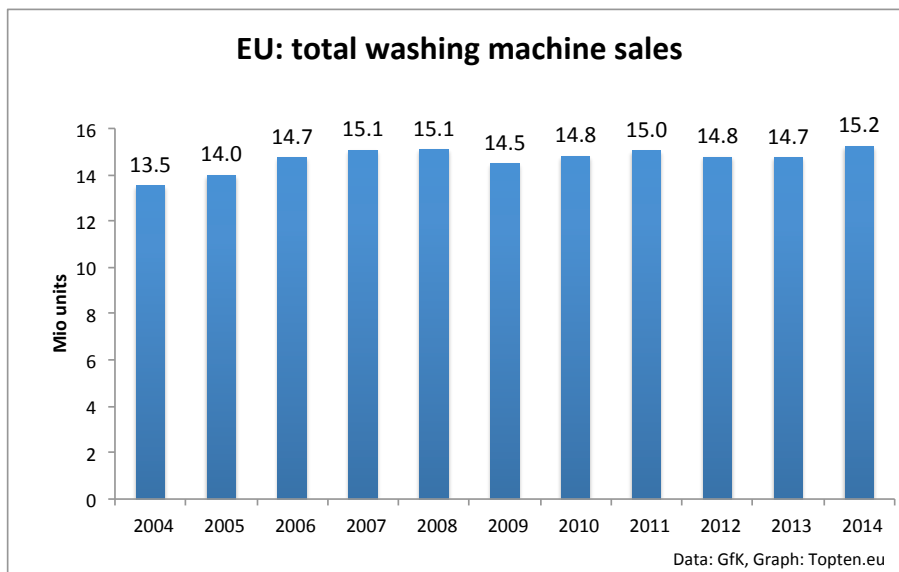


Figure 29: EU: total washing machine sales

Sales numbers increased from 13.5 million to 15.1 million units from 2004 to 2007 in the EU-21 considered here, then fluctuated around 15 million units per year (Figure 29). In 2014, 15.2 million washing machine units were sold. Sales in France show a similar pattern, stabilizing after 2010 (Figure 30). In 2014, 2.38 million units were sold in France. In Portugal sales numbers climbed until 2011, then declined in 2011 and 2012 (Figure 31). In 2014 sales were back at the 2009 level, at 284'000 units.

Per 100 inhabitants, 3.1 washing machines were sold in the EU-21 in 2014, 3.7 in France and 2.7 in Portugal.

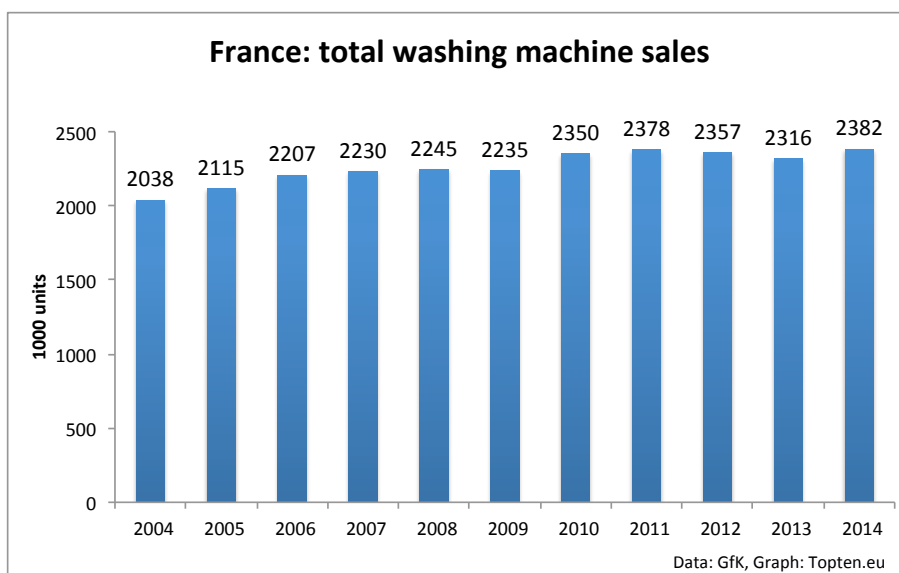


Figure 30: France: total washing machine sales

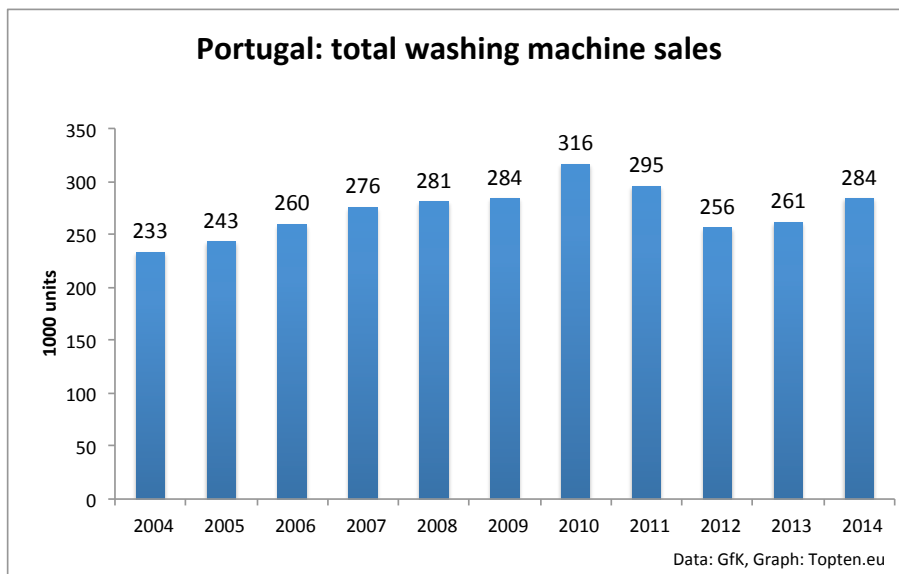


Figure 31: Portugal: total washing machine sales

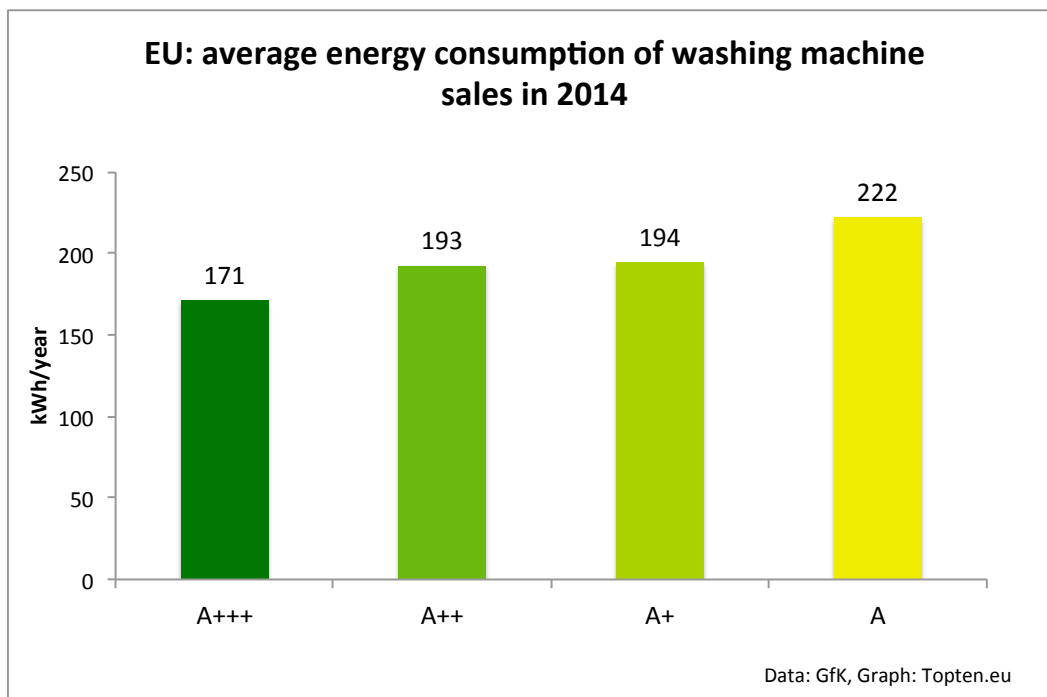


Figure 32: EU: average declared energy consumption of washing machine sales according to classes, 2014

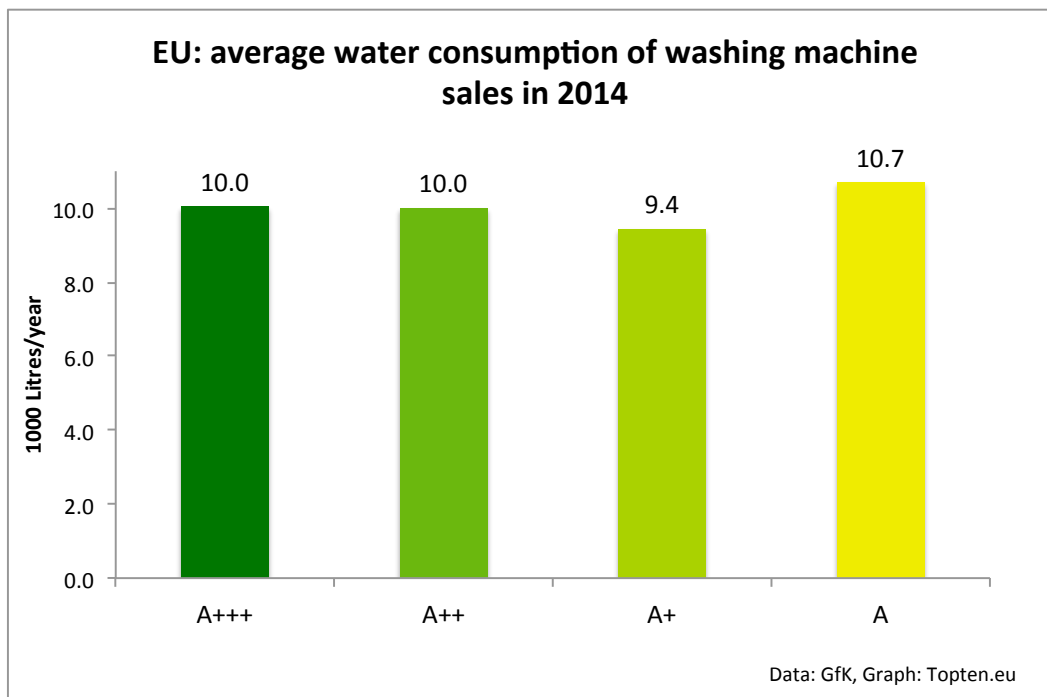


Figure 33: EU: average declared water consumption of washing machine sales according to classes, 2014

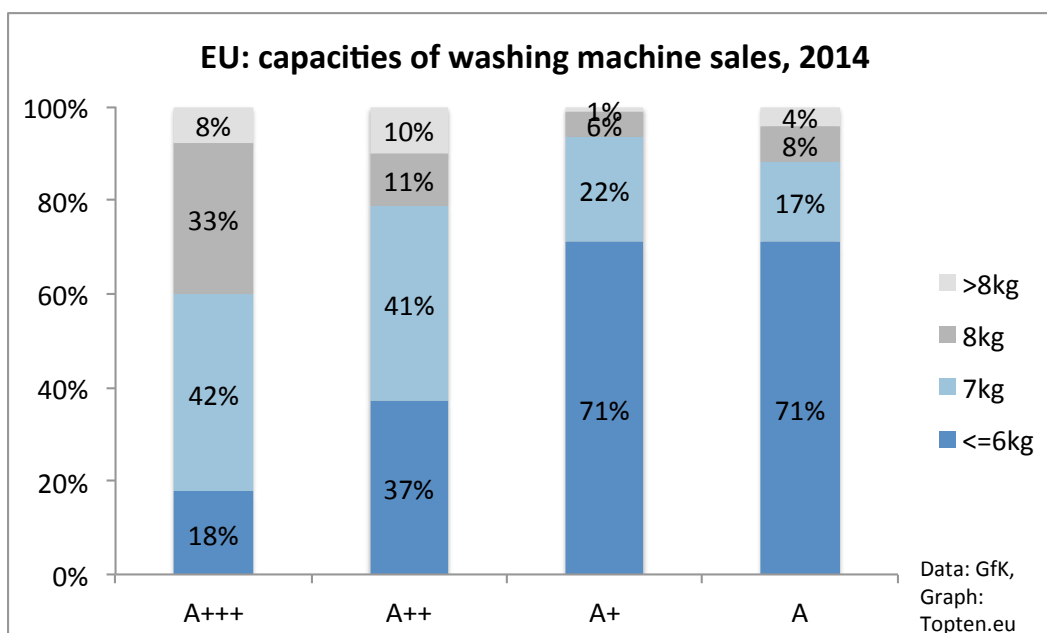


Figure 34: EU: declared capacities of washing machine sales according to classes, 2014

Figure 32, Figure 33 and Figure 34 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 2014 is virtually the same. Average declared water consumption of A++ and A+++ washing machines is identical.

The reason for the negligible reduction in resource consumption by efficient washing machines is probably the size correlation shown in Figure 34: washing machines sold in the two top efficiency classes are sold for clearly larger capacities than A+ (and A) models. While A+ washing machines are mainly sold for washing 6kg and less laundry, most A++ and A+++

sales are for 7kg. 41% of the sold A+++ washing machines are sold for washing 8kg or more laundry.

Our calculations show that a difference of four classes (A to A+++) results in a reduction in energy consumption of 23% only. In the case of refrigerators for example, this reduction is achieved with a step of one single class. At least between classes A and A+ as well as A++ and A+++ the difference in average declared energy consumption is similar to the efficiency improvement on the Label (the EEI difference). The higher efficiency of A+++ machines compared to A++ outweighs the higher capacities shown in Figure 34.

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.

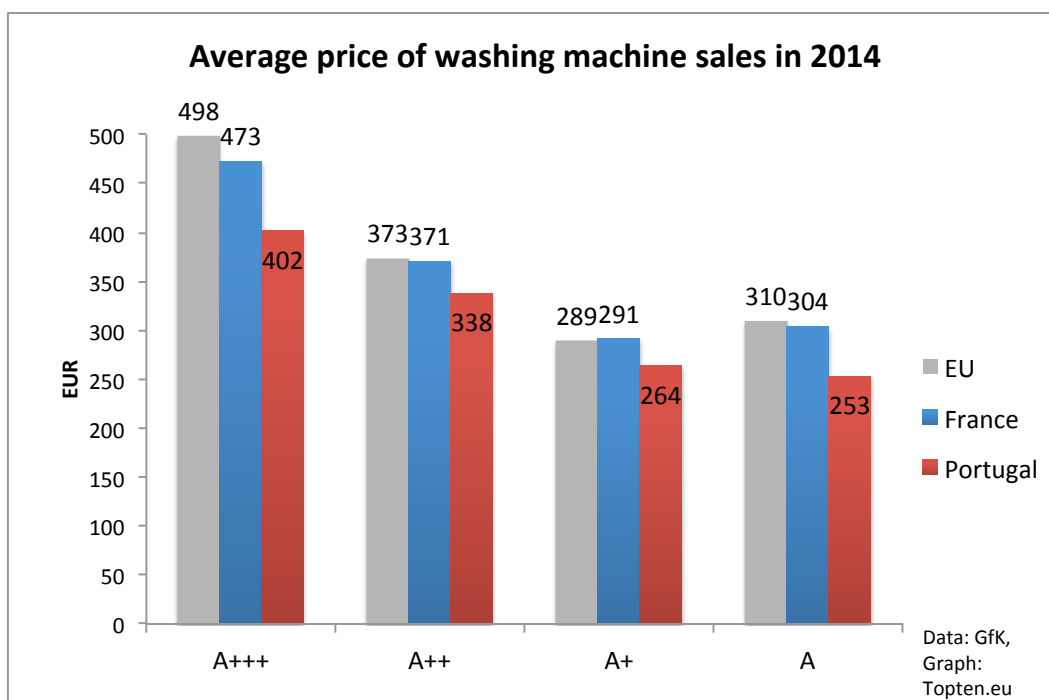


Figure 35: EU, France and Portugal: Average price of washing machine sales according to classes, 2014

Washing machines in the top efficiency classes have clearly higher prices than less efficient ones. This price premium might however also be linked to size. Figure 36 shows the correlation between size and price. A+++ washing machines are more expensive because they are efficient and large.

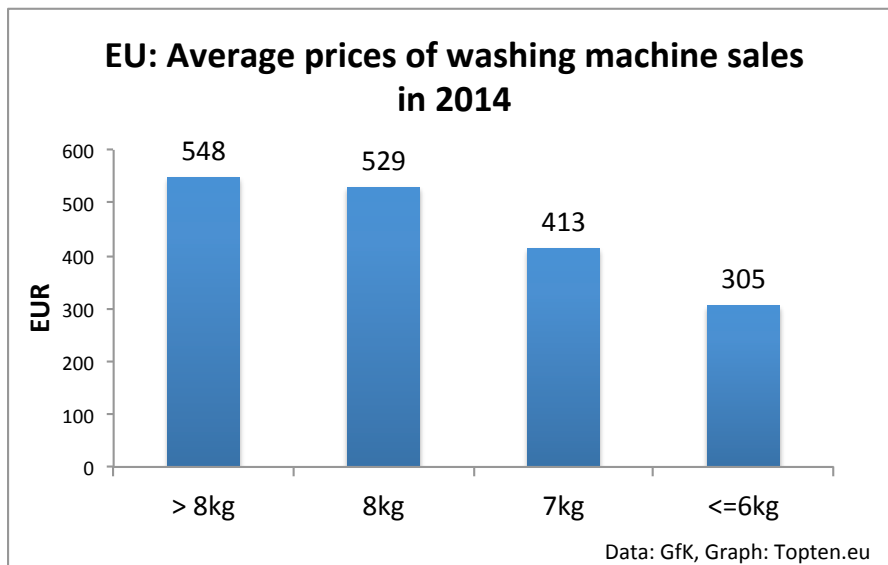


Figure 36: EU: average prices of washing machine sales according to capacities, 2014

Based on average capacity prices and capacity composition of the Label class sales, the expected price for A+ washing machines would be EUR 345 (effective average price shown in Figure 35: EUR 289), for A++ machines EUR 395 (effective: EUR 373) and for A+++ EUR 447 (real: 498). For A+++ sales the high efficiency seems to lead to a price premium, while for the other two classes the average price is below what would be expected from the size-price analysis.

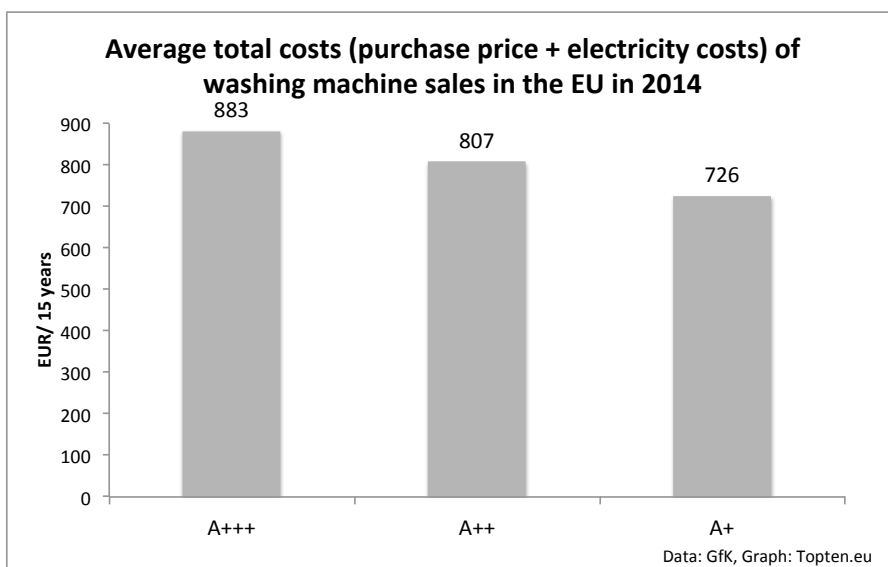


Figure 37: EU: Total costs¹⁸ (purchase price + electricity costs) of washing machine sales in 2014

In the case of washing machines, in terms of total costs, EU consumers were better off with A+ models than more efficient ones in 2014. Large price differences for machines in better efficiency classes combined with little efficiency gains lead to total costs¹⁵ being higher for more efficient washing machines. However, of course also this graph includes a size bias:

¹⁸ Total costs include purchase price and electricity costs over the product lifetime. Assumed washing machine lifetime was 15 years, electricity price 0.15 Euros/kWh.

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). Again, effective total costs depend strongly on actual usage.

Conclusions

For washing machines, even with such extensive sales data analysis, many questions regarding actual impact of market trends remain unanswered. However, sales data clearly show that the last Label revision was too late, with nearly 100% of the sold washing machines in the official top class A for many years. It is also clear that washing machines are reaching better efficiency classes on the Energy Label today than before the introduction of the revised Label – close to half of the sold units is in the top class A+++ -, that increasingly large capacities are sold and prices have been slowly decreasing.

Also in the case of washing machines there are considerable differences between national markets. The French washing machine market is less efficient than the EU average (only 31% A+++ vs 43%), while Portuguese consumers bought more A+++ washing machines (47%). Average declared energy consumption is declining since 2010, when the revised Energy Label was introduced. It is higher in France than across the EU and, interestingly, even higher in Portugal – assumedly because large washing machines are more popular in Portugal. Also across the EU and in France the trend to larger machines is ongoing, even if at a lower level and slower than in Portugal.

It is however not clear what the reduction in average declared energy and water consumption means in terms of actual consumption. Consumption differences between the efficiency classes are small to inexistent, and the impact of the shift to better efficiency classes is not clear.

Trends in the ten-year period are difficult to interpret because of the change in declaration and measurement standard that happened around 2011 and 2012. In addition, consumption values do not necessarily reflect actual consumption because they are valid for the combination of the standardised programmes, but are of little relevance for other wash programmes that consumers can choose and different, possibly much smaller loads.

The strong trend to larger capacities seems to be opposing energy saving measures. A study comparing sales of capacities with the market offer could investigate the question if the trend is coming from consumer demand or market offer rather.

However, it is clear that the Label's EEL 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 in washing machines today means rather large capacity than low energy consumption.

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. The problem is that it is not clear how well modern washing machines adapt water and energy use to loads different from standard loads (50%, only cotton) and for programs other than standard programs. 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 programs, much more energy and water can be wasted if the drum is larger.

It is only clear that larger washing machines bear the risk of wasting more energy, if the machines do not adapt the water and energy consumption well enough to small loads.

Washing machines offer many usage possibilities, which strongly influence water and especially energy consumption. These possibilities cannot be grasped by the Energy Label. A more complicated measurement standard, including more different programmes, would be too expensive and represent an even larger barrier for market surveillance (compliance

tests). The Energy Label must content itself with being a comparison tool according to standard usage.

One of the largest saving potentials in washing that is independent of declared values lies in the promotion of cold wash. Topten tests show 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 the 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 efficiency classes, the most important communicative aspect of the Energy Label, must also be the most important aspect defining the energy consumption – more important than capacity. The new energy label for washing machines should stop encouraging larger machines. Both can be achieved with a progressive reference line (SAEc): the requirements for reaching a specific efficiency level should be higher for larger machines. At the same time it is recommended to include an ‘average’ or even ‘small’ load test cycle (3kg or less) into the EEI and energy consumption calculation (see also Topten policy recommendations¹⁹).

2. Ecodesign requirements: high performance of 20°C programme, declaration for all programmes and standardised capacity declaration

The least questionable and probably largest saving potential lies in the usage of cold wash (20°C). Therefore, washing performance requirements should not only apply to 60°C and 40°C programmes, but also for the 20°C programme.

The discussions in this chapter have shown that actual energy and water consumption of washing machines needs not have a lot to do with what is declared, but is mainly influenced by actual usage. Energy and water consumption, programme duration etc. of all available programmes should therefore be declared in the booklet, to support users in selecting the appropriate programmes.

Capacity declaration influences the declared energy efficiency and consumption. Like all other specifications, also capacity should be declared according to a standardised procedure (it can be simple: e.g. filling with ping pong balls).

3. Promotion of cold wash

By performing and analysing tests, Topten could show that washing at 20°C saves around 60% energy compared to 40°C and gives good results when using good machines and good detergent. ‘Cold wash’ holds a huge saving potential and should be promoted with information campaigns²⁰, but also policies (good cold wash performance of washing machines and detergents).

More detailed policy recommendations can be found on [topten.eu](http://www.topten.eu)¹⁹.

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

²⁰ see Topten leaflet:

http://www.topten.eu/uploads/File/Professional/Other%20Pro%20Guidelines/Flyer_Coldwash_2014.pdf

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 the 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 located at the 'technology gap'.

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 from 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 and the condensation efficiency class are indicated.

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 applies since 1st November 2013: tumble driers must reach at least energy efficiency class C. For condensing driers additionally condensation efficiency class D applies. This means that the worst performing driers are banned from the market. In November 2015 the requirements will be made more ambitious, and drier models will have to reach the energy efficiency class B and condensation efficiency class C (see Table 7).

Today also vented drier model can reach class B, so this technology will not disappear from the market after November 2015.

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

Ecodesign and Energy Labelling regulations are due for a review no later than in 2017.

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

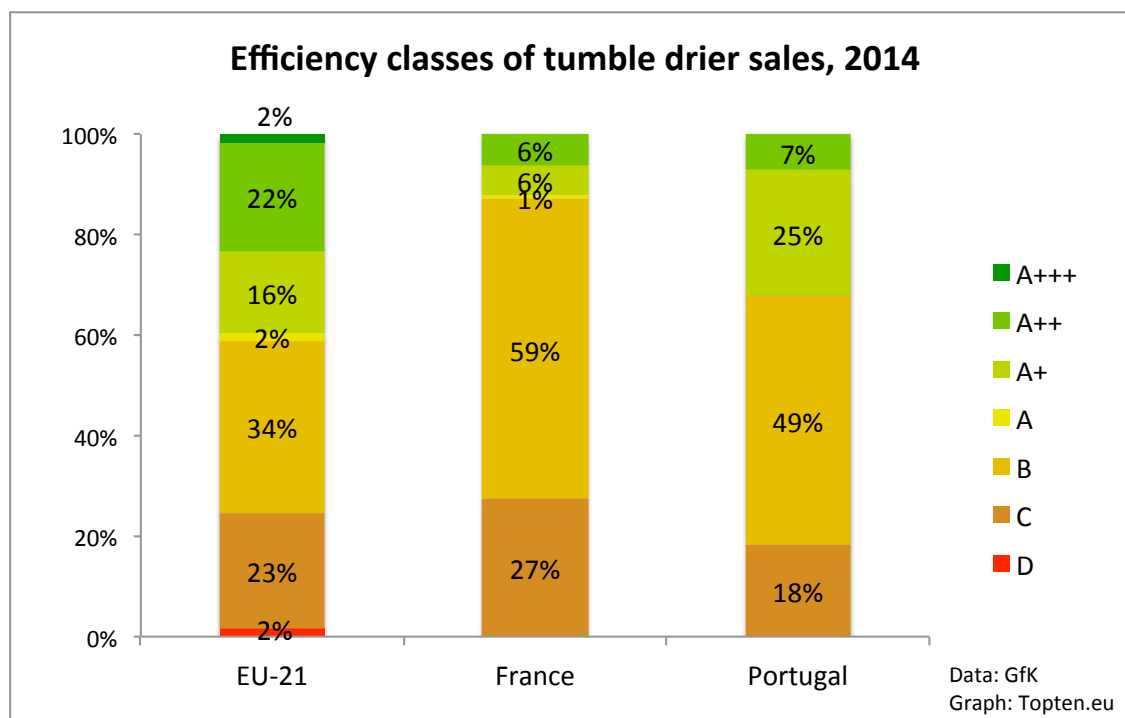


Figure 38: EU, France and Portugal: Efficiency classes of tumble drier sales, 2014

Figure 38 shows surprisingly high sales share of energy efficient driers across the EU in 2014: heat pump driers (classes A and better) accounted for a staggering 42% of total drier sales! The 2014 sales from France and Portugal show that there are large differences between countries: heat pump driers accounted for only 13% of all drier sales in France, and for 32% in Portugal. Both the French and Portuguese drier markets lag behind the EU average. According to information from GfK it is not the big countries that drive the high efficiency of the EU drier market, but rather a high number of not so large markets that show a preference for high efficiency driers – especially in South-eastern Europe. In these markets, electric driers are not very common; but if people do buy one, that it is usually an energy efficient model.

Figure 39 and Figure 40 show that under the original (before 2012) Energy Label, Class C absolutely dominated the drier markets at the beginning of the ten-year period. Class B driers started to appear on the French market in 2005, and in Portugal in 2006. While in Portugal heat pump driers (class A) entered the market at the same time as class B conventional driers, class A driers appeared in France starting only in 2008. While the market share of heat pump driers sold has increased steadily in Portugal since 2009, the development went slower in France. Here, the introduction of the revised Energy Label seems to have accelerated the market uptake.

The tier 1 MEPS, banning class D starting November 2013, seems to have had very little impact – at least in France and Portugal. The tier 2 MEPS, leaving only driers of classes B and better on the market, seems to be promising some effect. Results later in the chapter however put a question mark to an energy saving effect of tier 2 (Figure 48). It is not surprising that 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 allows consumers to tell less and more efficient heat pump driers from each other. The positive effect can clearly be seen on EU level.

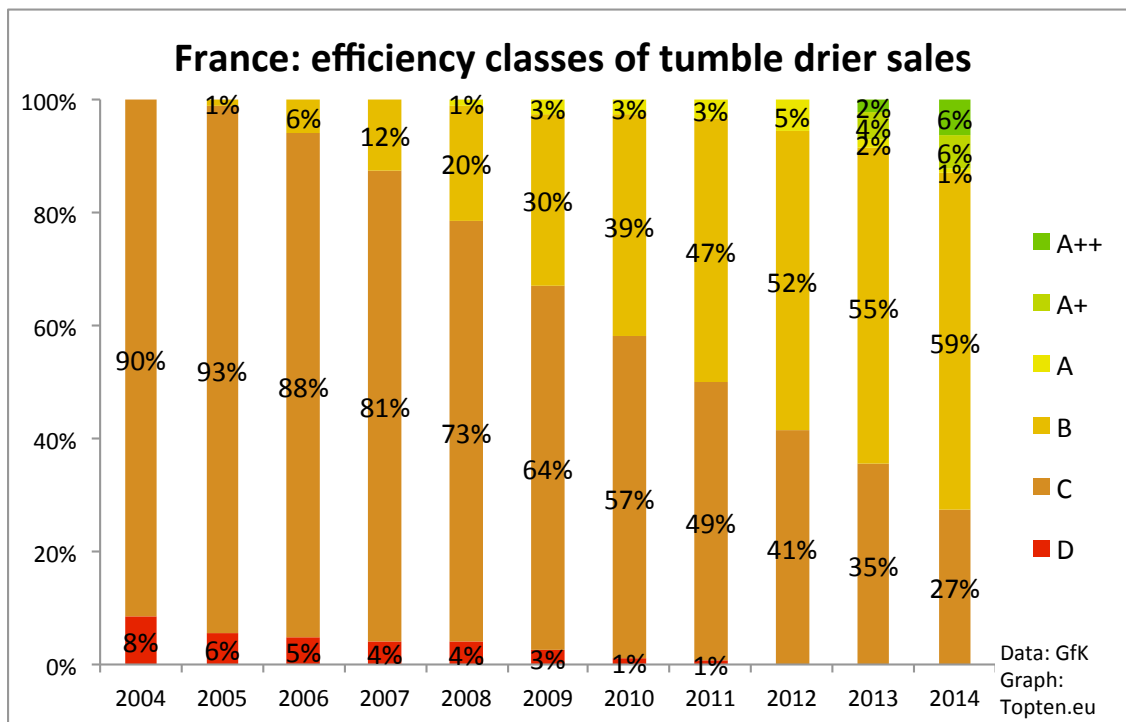


Figure 39: France: efficiency classes of tumble drier sales

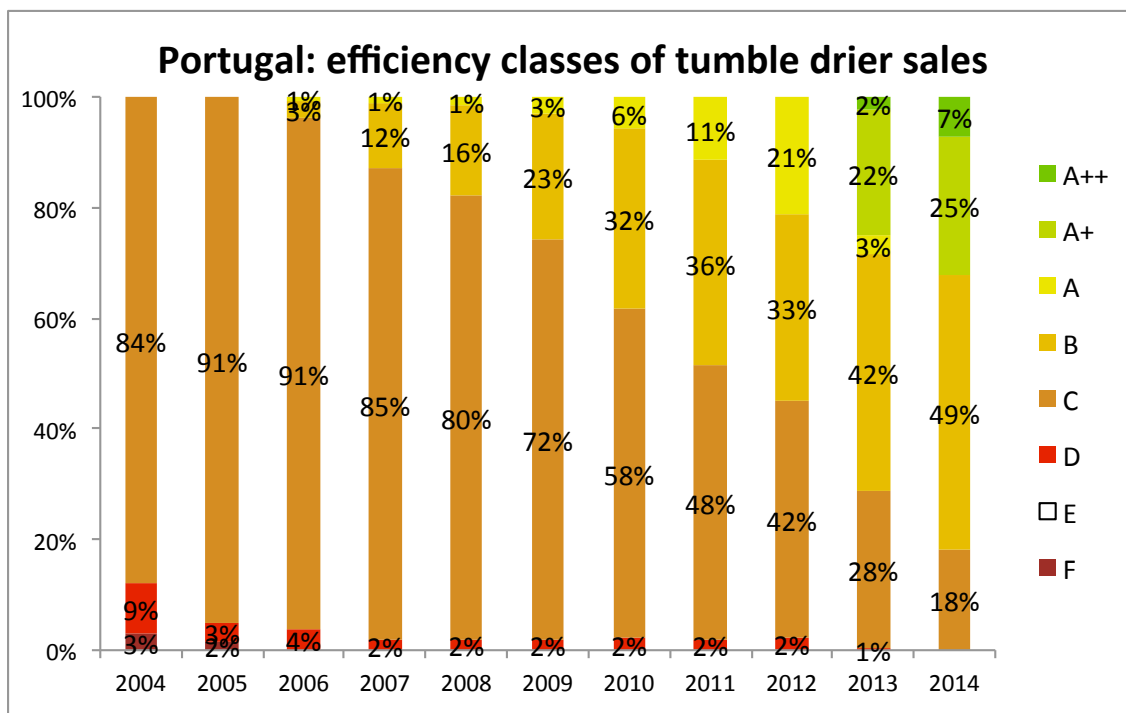


Figure 40: Portugal: efficiency classes of tumble drier sales

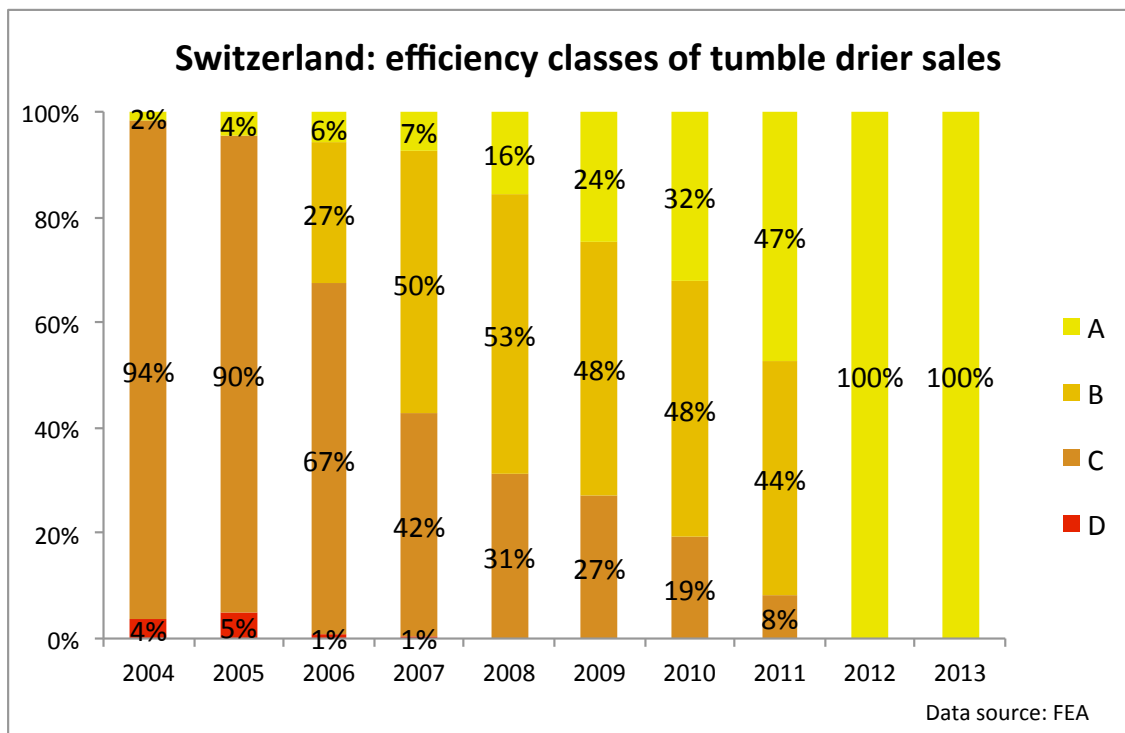


Figure 41: Switzerland: sales share of tumble driers

A clearly different picture can be seen on the Swiss market: due to the stringent MEPS introduced in 2012, only heat pump driers are sold on the Swiss market (Figure 41). In Switzerland the revised Energy Label was introduced later than in the EU, therefore the new classes appear only in 2014 and also 2013 sales show a 100% market share for A class. This graph shows that the average EU market would also be ready for a ban of non-heat pump driers soon: the average sales share of heat pump driers across the EU in 2014 was higher than in 2010 in Switzerland – two years before the Swiss MEPS was successfully implemented.

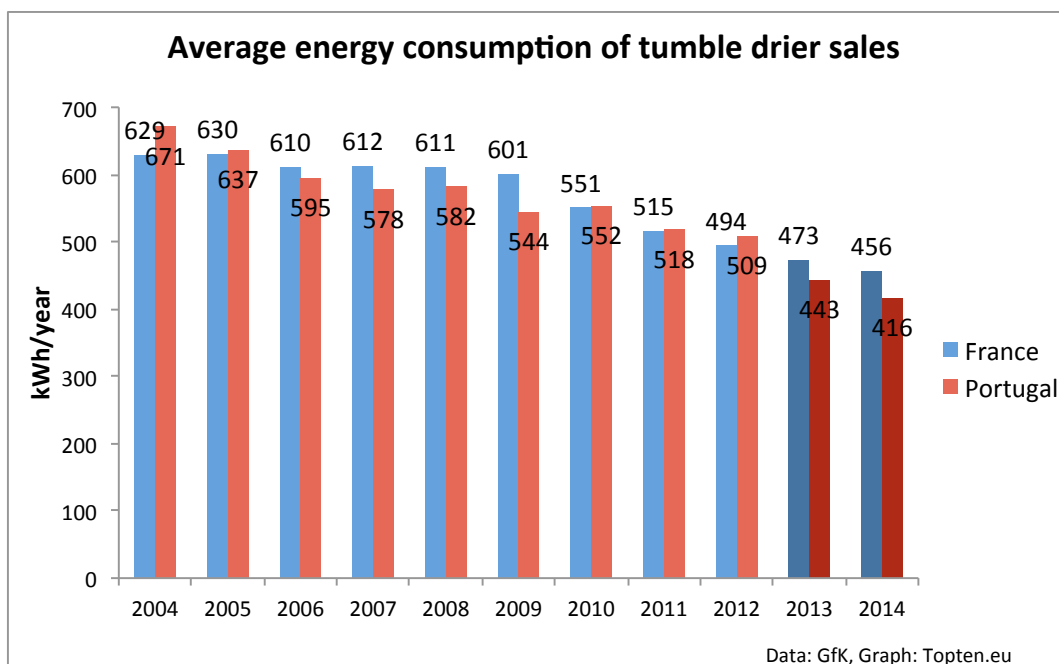


Figure 42: France and Portugal: Average declared energy consumption of tumble driers

Note: Declared energy consumption according to the old Label (2004 – 2012, in kWh/cycle) has been multiplied by 160. It is however not completely comparable with the declaration on the new Label, because this includes part load drying and low power modes consumption.

The average declared energy consumption of tumble driers sold decreased both in France (by 28%) and Portugal (38%) between 2004 and 2014 (Figure 42). It has to be kept in mind that energy consumption values before and since 2013 cannot be directly compared. While for Portugal indeed a 'jump' to lower average energy consumption from 2012 to 2013 is visible in Figure 42, no change can be seen in the French sales data.

While the average energy consumption was yet higher in Portugal than in France in 2004 (probably due to class F driers being on the market, see Figure 40), in 2014 the average declared consumption of Portuguese driers was 9% lower than that driers being sold in France.

The declared energy consumption is more strongly influenced by energy efficiency than by the drier size (capacity; Figure 43 and Figure 45): in France the average declared energy consumption went clearly down in the ten year period, while at the same time there was a strong trend to larger capacities. Portuguese driers consumed less energy than French driers in 2014, even though Portuguese seem to prefer larger driers. This is in contrast to washing machines, where Portuguese sales consume more energy than the EU and French average, despite being of higher efficiency.

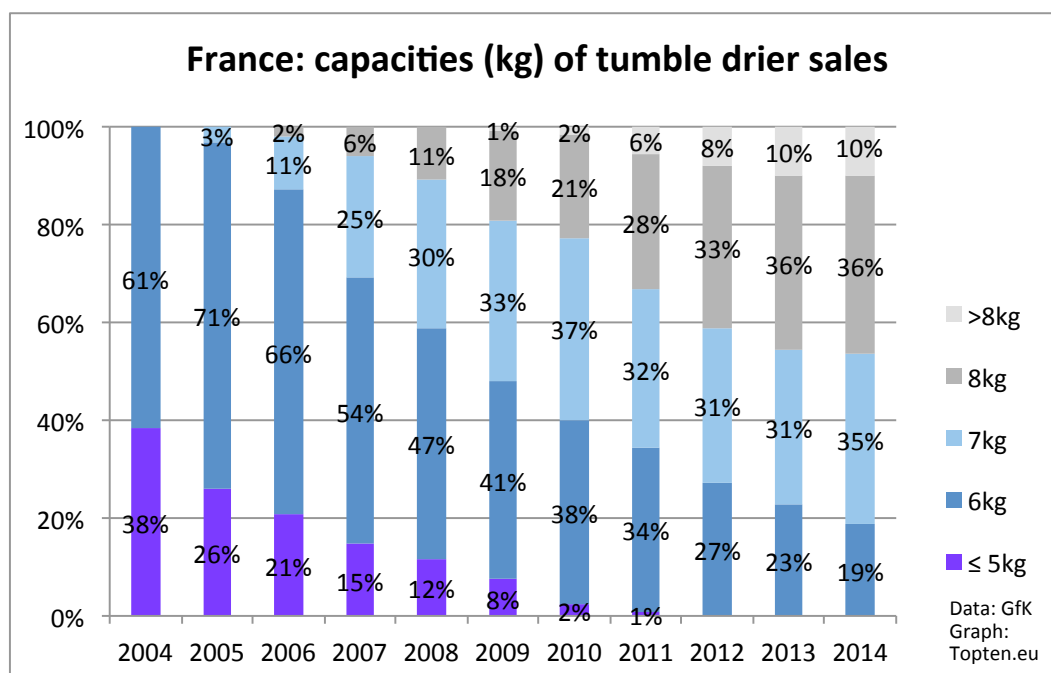


Figure 43: France: capacities of tumble drier sales

Ten years ago, both in France and Portugal driers were usually designed for 6kg or less laundry (Figure 43, Figure 45). In 2014, most driers sold in Portugal can dry 8 kg (+ 30%), and between 7 and 8 kg in France. This trend to larger models seems to be even faster than for washing machines shown in the chapter above. As in the case of washing machines it is questionable if this trend is really originating from changed consumer demand, especially since the average household size is becoming smaller. Instead, the development could mainly be steered by the market offer. It is possible that thanks to the development of smaller components the drum can be larger even within an equal-sized housing.

Unlike the situation for washing machines, modern more energy efficient tumble driers are not larger than less efficient models, as shown in Figure 49 below. The new EEI system includes half load drying efficiency, so drier models must also dry efficiently if only loaded partly. The reference energy consumption (SAEc) does not increase strictly linearly with

capacity but includes capacity to the power of 0.8 ($c^{0.8}$). There also is no obvious link to pricing policies: in Portugal prices are increasing with average capacity, but in France prices are stable despite larger driers being sold (Figure 45).

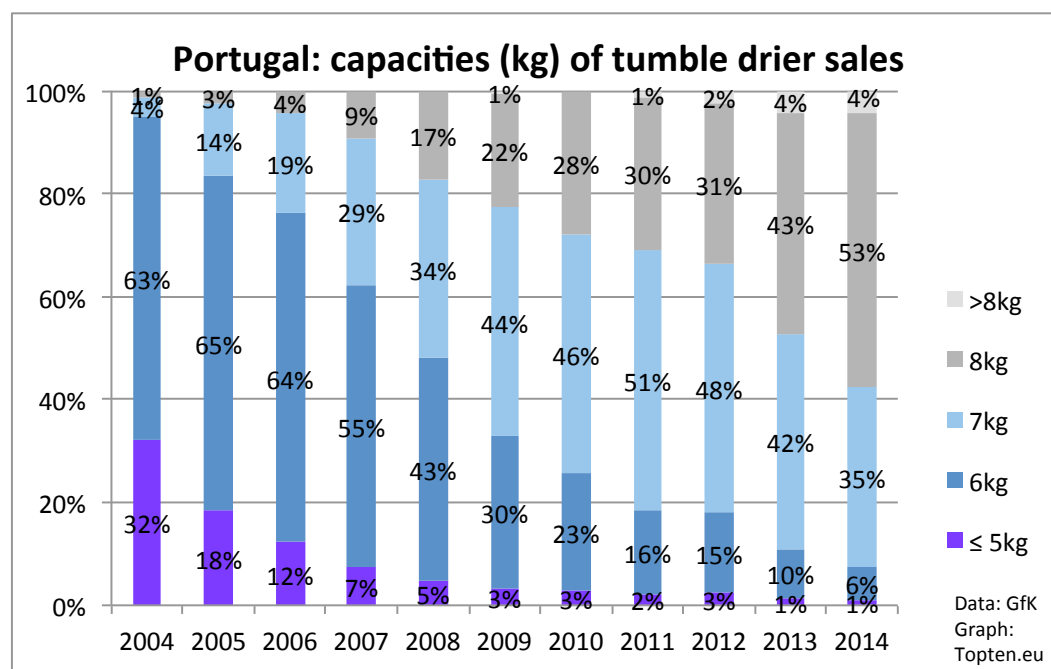


Figure 44: Portugal: capacities of tumble drier sales

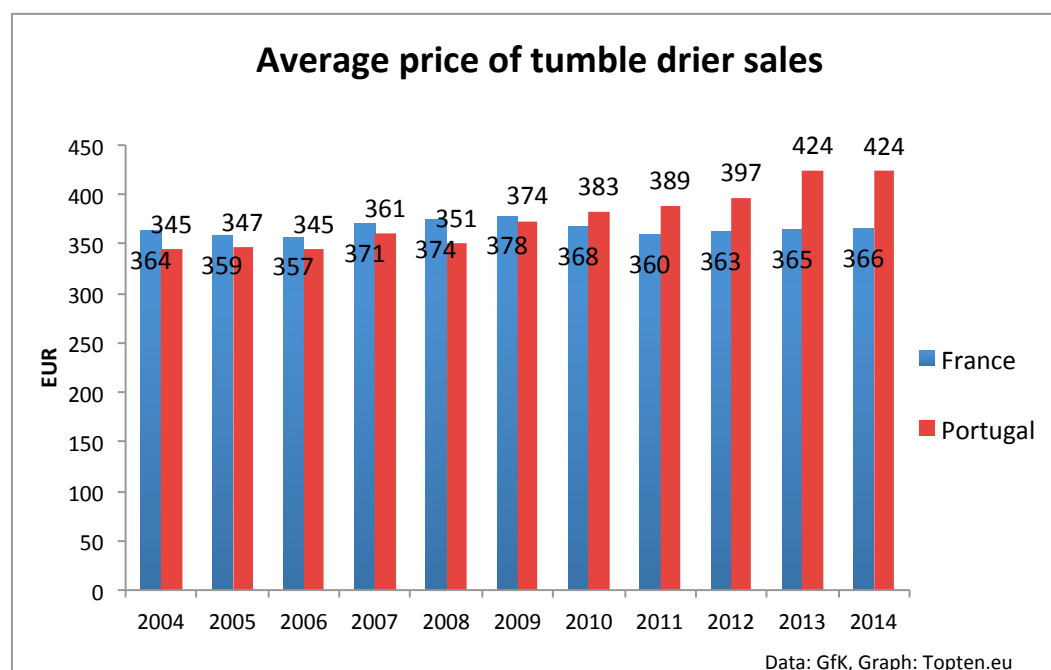


Figure 45: France and Portugal: Average nominal price of tumble drier sales

Tumble driers price in France has been relatively stable over the last decade – despite larger and more efficient appliances being sold. In Portugal we observe a slight but steady price increase of 23% (average of 1.6% per year) over the 10-year period between 2004 and 2014. The price development might partly reflect the size increase of around 30%. And since 2013 the new Label with A+ and A++ driers seems to have brought higher average prices in Portugal.

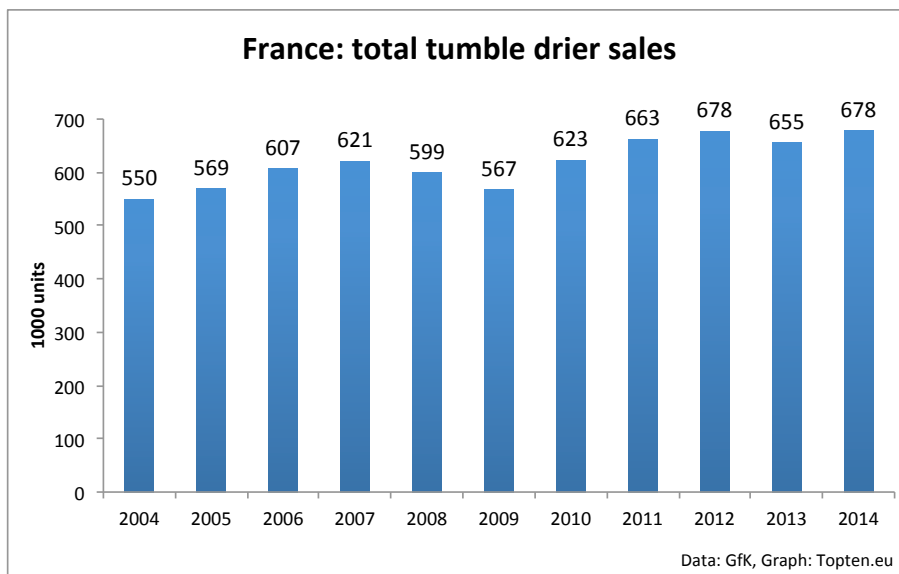


Figure 46: France: total tumble drier sales

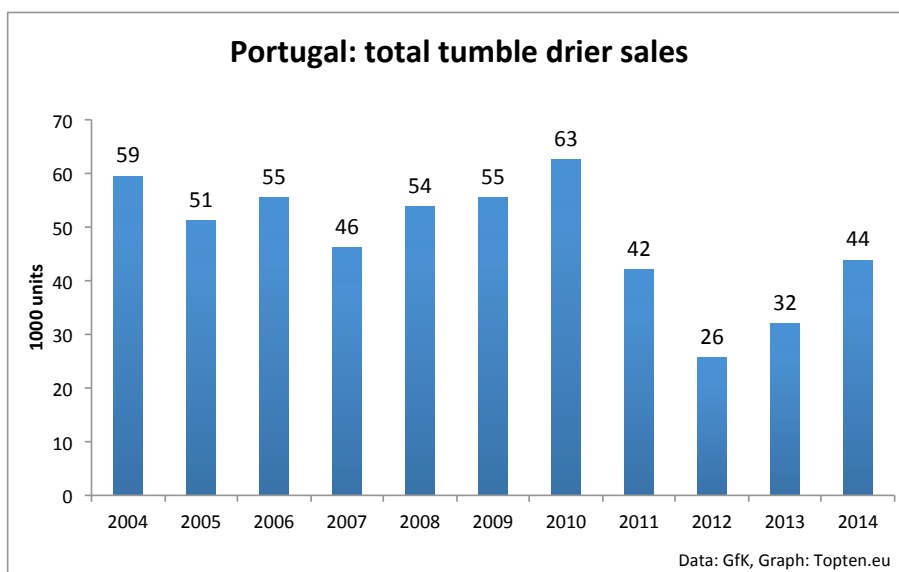


Figure 47: Portugal: total tumble drier sales

In France, sales of tumble driers increased by 23% from 2004 to 2014 (Figure 46). The climbing sales graph shows two 'valleys' of lower sales in 2009 and 2013. In 2014, 678'000 tumble driers were sold in France. In Portugal, tumble drier sales varied strongly over the years (Figure 47). After having reached a peak in 2010, there was a big drop in 2012. In 2014, 26% less tumble driers were sold in Portugal than ten years before.

Relative to the population, more than twice as many tumble driers were sold in France than in Portugal in 2014: per 100 inhabitants, 1.04 driers were sold in France, versus 0.42 in Portugal. This is not surprising, since the climate in Portugal allows drying the laundry by the sun and wind almost throughout the year.

In the EU-21, nearly 3.9 million tumble drier units were sold in 2014. This equals 0.8 units per 100 inhabitants.

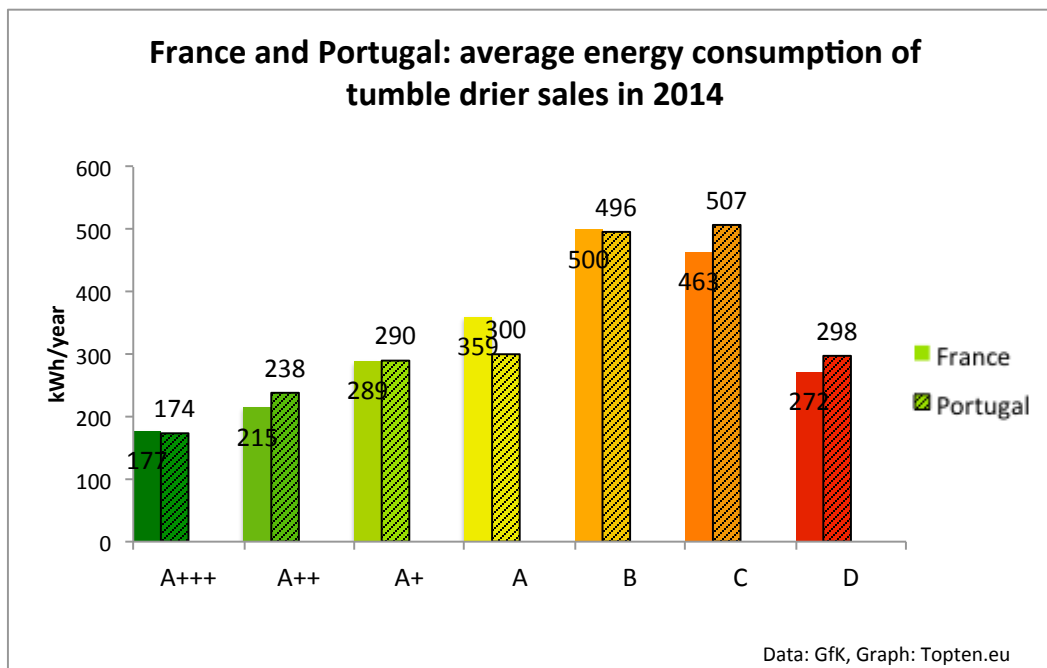


Figure 48: France and Portugal: average energy consumption of tumble drier sales, 2014

Figure 48 shows that the important energy saving potential lies in the promotion of heat pump tumble driers, without compromise. This figure even questions the energy saving impact of tier 2, which will ban class C driers from the market starting from November 2015: surprisingly, average energy consumption of the 2014 sales is not lower for class B driers than class C (in detail: it is 2% lower for Portugal, but 8% higher for France)! This effect is likely a combination of the increase in size from class C to B (shown in Figure 49) and mainly low improvement in energy efficiency: class C is only a 11% 'wide', while other classes require up to 25% (A++, A+++) and even 35% (A+) efficiency improvement.

A jump from class B to A+, from conventional to 'basic' heat pump driers, means an average energy reduction of over 200 kWh/year (-42%) in both countries. More than an average of 300 kWh/year or 65% can be saved per appliance with a jump to A+++.

Differences between the countries in Figure 48 are likely to be caused by the larger capacities that are sold in Portugal (class D, C and A++). A class has a very low sales share and nearly no models exist in this class, therefore this result is not very relevant.

While washing machines in better efficiency classes are on average clearly larger, this is not true for driers as shown in Figure 49. Only class C driers, soon to be banned from the EU market, are smaller than driers in better efficiency classes. Models with 6kg capacity and less are literally non-existent in driers of classes B and better. Instead, 7-kg and 8-kg-models account for the majority of sales in all other classes with considerable market share (B, A+ and A++).

Both for France and Portugal, we observe higher prices associated to driers with higher energy efficiency class (Figure 50). In 2014, average nominal prices for efficiency classes were nearly the same in France and Portugal – except for class A+. For driers of this efficiency class, French consumers paid more than EUR 100 more than Portuguese. The price difference of these heat pump driers is reflected in different sales shares in the two countries: while in Portugal A+ driers accounted for 25% of the total sales in 2014, in France they made up only 6% (Figure 39 and Figure 40). For A++ driers on the other hand, where the prices are nearly identical, also the sales shares are nearly the same: 7% in Portugal and 6% in France. The low sales share of A+ driers in France is certainly linked to high average prices.

Prices of heat pump driers are clearly higher than of conventional driers: in France the average price of A+ driers is nearly twice that of class B driers. In Portugal the price increase is only 64%. The price increase from A+ to A++ driers is much smaller: 22% in Portugal and only 4% in France. For French consumers this small price increase contrasts with a reduction in energy consumption by 26%, if they chose an A++ instead of an A+ drier. This certainly explains why A+ and A++ driers had identical sales shares in France in 2014.

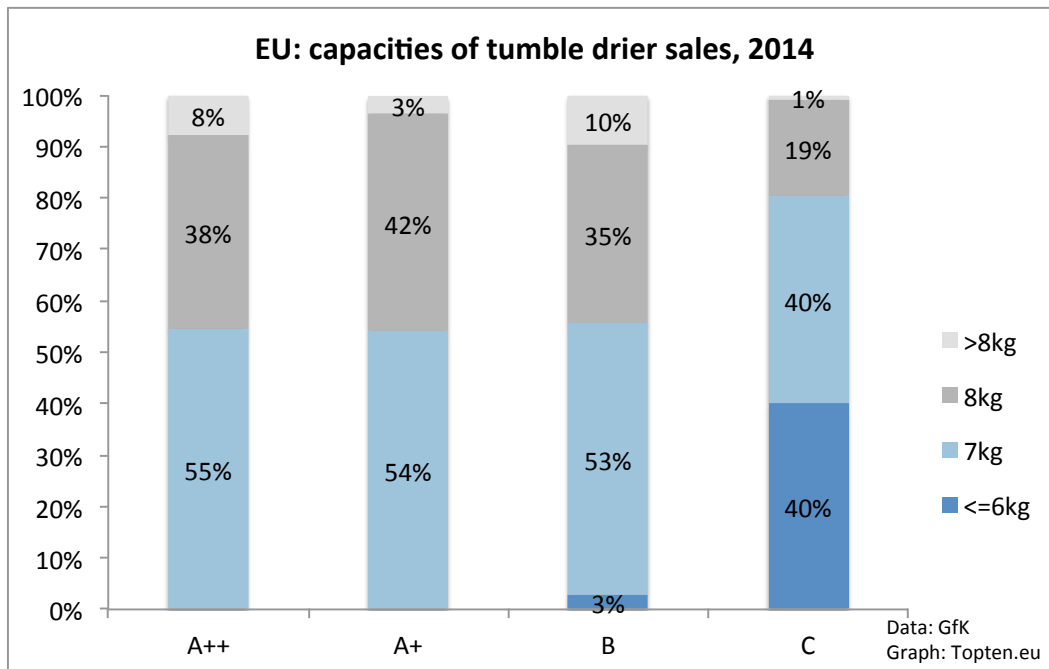


Figure 49: EU: declared capacities of tumble drier sale, 2014

Note: class A is not included in this graph, because A class driers are nearly non-existent

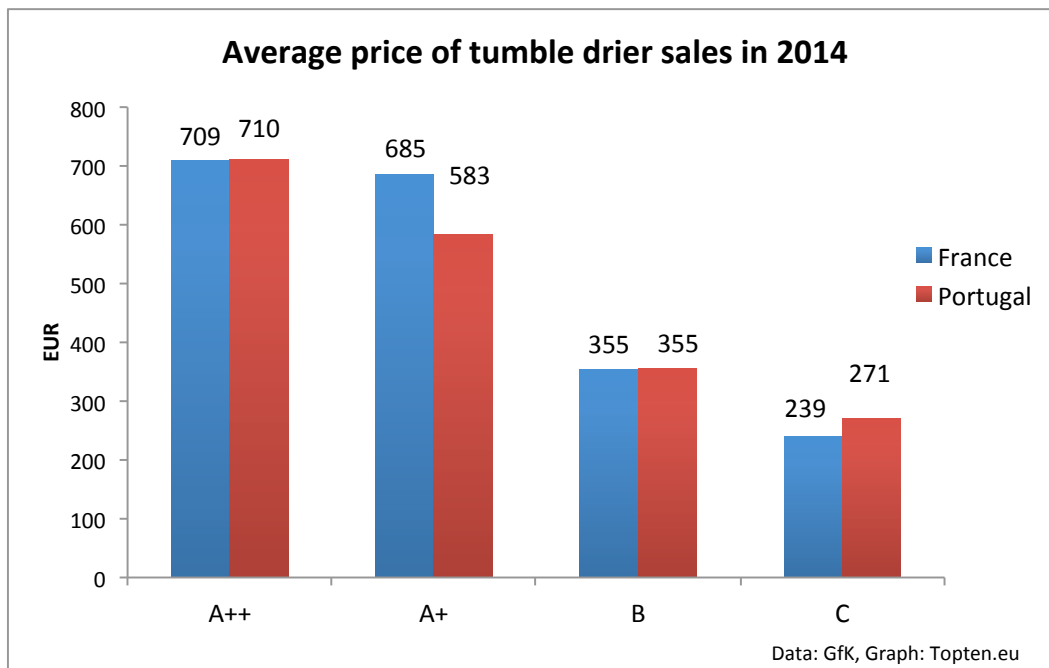


Figure 50: France and Portugal: Average nominal price of tumble drier sales in 2014.

Note: class A is not included in this graph, because A class driers are nearly non-existent.

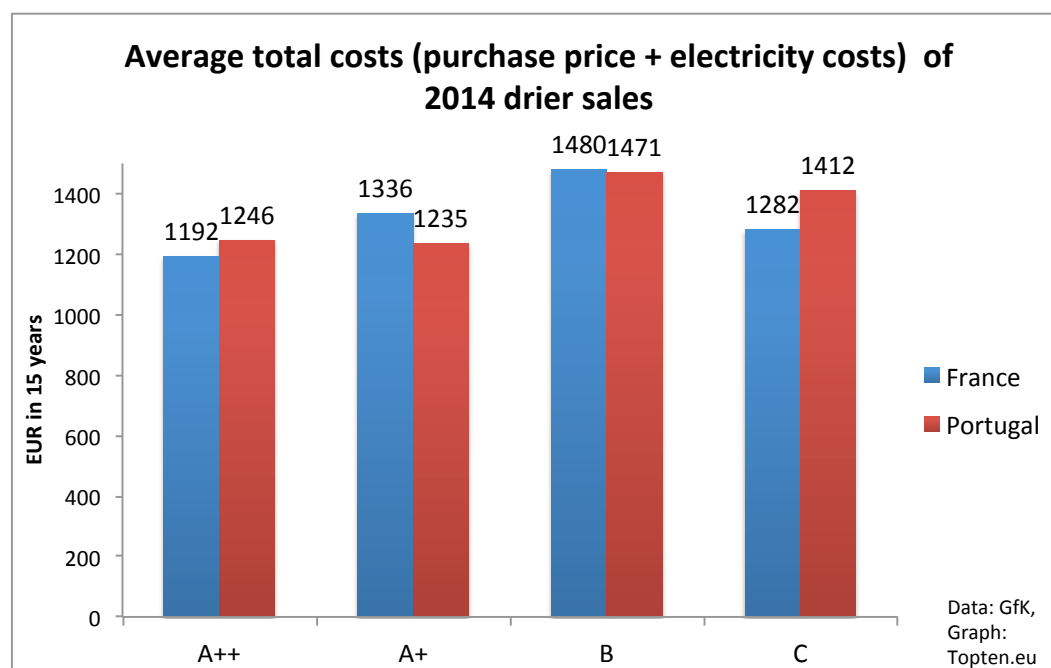


Figure 51: France and Portugal: average total costs²¹ (purchase price and electricity costs) of 2014 tumble drier sales

When looking at the product total costs, A++ was the least costly drier choice for French consumers in 2014. Due to the clearly lower purchase prices, A+ was the cleverest choice in Portugal. In both countries however, high electricity costs might make their class B drier become a suboptimal choice. Total costs shown in Figure 51 have been calculated based on the declared average annual energy consumption – of course effective total costs depend on actual usage.

Conclusions

With over 40% sales share, heat pump tumble driers have reached the breakthrough in Europe. Differences between countries are however considerable, and it seems that they are linked to factors such as price and legislation: the low share of A+ driers in France compared to the EU average and Portugal might be linked to high average prices. And in Switzerland heat pump driers hold 100% market share – clearly supported by the stringent MEPS that have been introduced in 2012.

Policies in the EU also have been effective: the original Energy Label allowed to show that heat pump driers (class A) were more efficient than conventional driers (class C, later also B) – even though the classification could not communicate how much better the new technology really was. The revised Energy Label also 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, is questionable due to the small efficiency improvements needed to reach class B, which can even be outweighed by larger size.

²¹ Total costs include purchase price and electricity costs over the product lifetime. Assumed drier lifetime was 15 years, electricity price 0.15 Euros/kWh.

Heat pump driers of classes A+ and A++ result in lower total costs for consumers than class B conventional driers. For future MEPS there is no other viable option than to leave only heat pump tumble driers on the market in the entire EU, following the Swiss example. The average EU market will soon be mature enough for MEPS at class A+ level – the sales share of heat pump driers was higher in 2014 than 2010 in Switzerland, when the Swiss MEPS, valid from 2012, was announced. If all driers sold in 2014 had been in class A+, these would have saved 5.6 TWh over their lifetime of 15 years compared to what was sold. For France and Portugal, equivalent savings would have amounted to 1700 GWh and 90 GWh, respectively. In individual countries however, (e.g. France), market shares of heat pump driers are not yet high. Promotion programs could support a faster market uptake, since high prices could be a barrier.

Recommendations

The Energy Label and Ecodesign regulation will be reviewed in 2017. The sales share of heat pump driers will most probably be more than 50% by then, and A+ can be announced as new MEPS. The Energy Label will have to be adapted accordingly.

Portugal and especially France could support the shift to heat pump driers on their markets, e.g. with information and awareness campaigns. Consumers could be informed about the lower total costs of these initially more expensive, but much more efficient models.

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 translates into a reduction in energy consumption of 25%, which is considerable. The only drawback is that the reduction in consumption is smaller than what would be expected from the efficiency improvement. 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 the correction factors for compressors that can work in the tropics, frost-free functions, built-in appliances and chill compartments and by reducing the categories (and reference lines) to just one.

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 calculation formula and the measurement standard changed. Portugal has the most energy efficient market, yet Portuguese washing machines have the highest energy consumption – because they are larger. The efficiency steps between classes are very small. As a consequence, capacity can be more important determining the energy consumption than the energy class. 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).

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 and stop the trend to larger machines, which bear the risk of energy waste.

Tumble driers

Starting from November 2015 only class B and better driers will remain on the EU market. All driers in classes A and better are heat pump driers – and this technology already accounts for more than 40% of the EU sales. Even though also driers are becoming larger, the energy savings seem to be less questionable than in the case of washing machines. Apart from class C being smaller, there is no correlation between efficiency class and size like for washing machines, and the (larger) drum needs not be filled with more (heated) water. The saving potential of heat pump driers is huge with 45% 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 and Portuguese 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. An investigation of the reasons of higher domestic electricity consumption in 2012 showed also lower efficiency compared to Germany (SOWATT, Enerdata, 2012). Comparison with Portugal however delivers a more balanced picture: for refrigerators the efficiency of the French and Portuguese markets is nearly the same. In the case of washing machines, the Portuguese market is more energy efficient– but the average energy consumption is lower in France than in Portugal (because washing machines are larger in Portugal). Only for tumble driers French consumers buy more energy hungry appliances than Portuguese.

This 2012 report also found that larger models were preferred in France (SOWATT, Enerdata, 2012) – a finding that is not confirmed with our data: French washing machines are smaller than the EU average and Portugal and tumble driers are smaller than in Portugal. Only refrigerators are slightly larger than those sold in Portugal and across the EU, but the freezer compartment, which is much more relevant for energy consumption, is smaller. For refrigerators and washing machines, the average declared energy consumption in France is between that of the EU average and Portugal. For tumble driers, the average energy consumption is higher than in Portugal – because much less A+ driers were sold in France in 2014. Low sales share of energy efficient appliances in France seems to be linked to high prices for tumble driers and refrigerators: A+ tumble driers have 17% higher prices in France

than in Portugal; while A++ refrigerators are 12% more expensive and A+++ refrigerators even 30% expensive than across the EU. Washing machine prices in France are meanwhile comparable to EU and Portuguese prices. High prices for energy efficient products on the French market have also been found in (Toulouse, 2015), comparing prices of Topten products in France, Germany and Switzerland, and (SOWATT, Enerdata, 2012). SOWATT and Enerdata also suggested explanations for French market characteristics.

Portugal

For both refrigerators and washing machines, 2014 sales in Portugal have a higher declared energy consumption than the EU average and sales in France. The situation is different, while the meaning for the real energy consumption is unclear for both product categories: refrigerators sold in Portugal are less energy efficient than across the EU, and therefore consume more energy. The higher energy consumption compared to France, where the energy efficiency is the same, is probably due to larger freezer compartments chosen in Portugal. In order to judge the total energy consumption of cooling, also freezer data would be needed – which is not included here. It is thus possible that Portuguese have less separate freezers, and the data presented here does not necessarily mean that in Portugal more energy is spent on cooling and freezing than elsewhere. The same is true for washing machines, where little is known on the real energy consumption, which depends on many variables. The declared energy consumption of Portuguese washing machines is high because they are large – larger than across the EU and in France – despite their high energy efficiency (more efficient than EU and France). For tumble driers there are less questions: heat pump tumble driers have constantly increased their market share since 2008. In 2014 one third of all driers sold in Portugal were energy efficient heat pump driers. A+ (heat pump) driers cost on average 64% more than class B (conventional) driers in 2014 – it is not obvious that consumers are ready to pay that much extra for an energy efficient technology! From a long-term financial point of view however, this choice was the right one: the sum of purchase price and electricity costs is the lowest for A+ driers. In the case of refrigerators and washing machines, Portuguese prices are lower than across the EU and in France, and for washing machines in particular, this is true even for the high efficiency and large capacity models.

5.3 Market monitoring

This report demonstrates the huge 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.

Such a monitoring system would be inexpensive to implement when compared to the vast energy and economic savings that it will enable. It is hard to understand that Europe renounces on the huge benefits of market monitoring: professional market research companies have the data and it does not cost a lot. Analysing the market on a systematic basis with sound data would be more cost-effective than today's rather chaotic practice. Even if market monitoring on the longer term was based on a mandatory product registration system and on model data, monitoring based on sales data can start now.

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