Heat Pump Tumble Driers: Market Development in Europe and MEPS in Switzerland

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Abstract

Electric laundry driers are becoming increasingly popular in European households. This trend may lead to a significant increase in laundry energy consumption. Heat pump (HP) driers use only 50% of the energy a conventional condensing drier uses. Promoting efficient driers is necessary to limit the expected increase in energy consumption due to electric laundry drying in EU households.

This paper contains an overview of the market in the European Union (EU) for high efficiency driers, as defined by the EU energy label. With over 40% sales share, heat pump tumble driers are clearly succeeding in the European market. Differences between countries are, however, considerable.

Obviously, policies in the EU to promote efficient driers have been effective: the old EU Energy Label created an incentive for new, better technologies and allowed innovative manufacturers to market heat pump driers. The new Energy Label now allows consumers to see the superiority of heat pump over conventional driers with the 'Plus-'classes. Switzerland is even a step ahead: since January 2012, only heat pump driers are allowed on the Swiss market. Also in the USA market, the first heat pump driers have been introduced and policies have begun to adapt to the new drier technologies.

Heat pump tumble driers hold a large energy saving potential in Europe. If all driers sold in Europe were of the A+ class efficiency, it would result in 25% lower energy consumption over the lifetime of the driers sold in a given year. That means some 5.6 TWh of energy or €1.1 billion electricity costs per year could be saved.

Background

About heat pump tumble driers

Tumble driers evaporate the moisture by blowing hot dry air through wet laundry. The air is typically heated by an electric resistance heating element. European driers use one of two different technologies to remove the evaporated water [1]:

1. Vented driers (open systems) blow the moist exhaust air (drawn from the building interior) outdoors, which can cause unwanted smells, steam and noise at the external vent.

2. Condensing driers (closed systems) use a heat exchanger cooled by interior air to condense water from the warm moist air in the drier.

Heat pump driers are usually condensing driers which also integrate a heat pump. Warm, damp air flows out of the laundry drum into the evaporator, where the air is dehumidified and the warm air returned to the drum [2].

Heat pump driers consume only about half of the electricity of conventional condensing driers. This makes them a highly efficient alternative to conventional systems. However, within the group of heat pump driers the energy efficiency varies quite considerably[1]. Due to lower operating temperatures heat pump driers also cause less damage to clothing that other types of driers but increase drying times.

[1] See www.topten.eu

Regulatory context: EU Energy Label and Ecodesign requirements

The original Energy Label for tumble driers was adopted in 1995, and became compulsory in April 1996 [3]. This Label's classification system was based on a simple kWh/kg (consumption per cycle divided by the capacity) efficiency, tested at full load and with 60% initial moisture content (before 2005 the test was performed with 70% initial moisture content). Vented and condensing driers are covered by separate classification schemes. The threshold for condenser drier energy efficiency class A, at 0.48 kWh/kg (with 60% initial moisture content, see [4]), could not be met before the first heat pump tumble driers entered the market in the year 2000 [4]. The new technology with an integrated heat pump however clearly exceeded the A class 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.

The aspirational class A of the original Energy Label did a good job of supporting the introduction of this new technology, but once heat pump driers were on the market, class A did not accurately represent the very large efficiency advantage over conventional driers. Conventional driers began to achieve class B only after heat pump driers had entered the market. Also the original Energy Label could not show consumers the significant efficiency differences among heat pump driers, which started to emerge as the technology matured.

The Energy Label was revised in 2012 [5], and addressed these deficiencies by introducing three additional classes, A+ to A+++. This revised Energy Label became compulsory in June 2013 [6], after a transition period. Like under the original Energy Label, classes A and better could only be achieved by heat pump driers (still today, no other technology meets the A class requirements), but since most heat pump driers now achieve A+ class or better performance, the efficiency gap with conventional driers is made visible. Also the 'A Plus'-classes allow consumers to differentiate between more and less efficient heat pump driers. The drawback of the revised Energy Label's classification system is that class A – the class with the most powerful consumer message – is nearly empty, because it defines an efficiency level that heat pump clothes driers have already exceeded.

In addition to different efficiency levels, the revised Energy Label is no longer based on kWh/kg efficiency, but on a more complex Energy Efficiency Index (EEI). The EEI is the relationship of a model's annual energy consumption to the consumption of a reference model of the same capacity (in %). The EEI calculation formula assumes 160 drying cycles per year (around three per week), of which 4 out of seven are assumed to be operated with the drier filled to only half of a full capacity load. The EEI calculation also includes consumption from low power modes (Off and Standby mode). While on the original Energy Label the energy consumption was declared on a per cycle basis, on the revised Label it is declared as annual energy consumption value. Therefore, average energy consumption values according to the original (2004 – 2012) and revised (since 2013) Energy Labels cannot be directly compared.

Table 1: classification of the old and current tumble drier Energy Labels

	Old Label efficiency for condenser 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. In the revised Energy Label fiche, manufacturers additionally declare the standard programme's energy consumption at full and half load, the power consumption of low power modes.

For condenser driers, also the condensation efficiency and the condensation efficiency class are indicated.

In the same year as the revised Energy Label, an Ecodesign regulation for tumble driers was adopted and put into force [7]. Tier 1, starting the 1st of November 2013, requires that tumble driers achieve at least energy efficiency class C and condensation efficiency class D, and bans less efficient driers from the market. In November 2015 the requirements will be tightened, and drier models will be required to reach energy efficiency class B and condensation efficiency class C (see table 3).

Tab. 4: Ecodesign requirements for driers

	Min. energy efficiency	Min. condensation efficiency
Tier 1, since Nov. 2013	Class C, EEI < 85	Class D, 60%
Tier 2, from Nov. 2015	Class B, EEI < 76	Class C, 70%

Switzerland: A+ as Minimum Energy Performance Standard

These requirements apply in the entire European Union. Switzerland has been implementing more ambitious Minimum Energy Performance Standards (MEPS). Since January 2012, only class A (according to the original Energy Label) driers may be sold. This regulation effectively banned all non-heat pump tumble driers from the Swiss market. Since January 2015 this requirement has been further tightened to allow only A+ or better, as indicated by the revised Energy Label which Switzerland has also adopted.

Best available technology driers

Brand	V-ZUG	Miele	V-ZUG	Gorenje	V-ZUG	Haier	Samsung
Model	Adora TSL WP	T8877 WP EcoComfort / T 88-79 WP	Adora TS WP	D 7565 NA/NB D 7665N	Adora TL WP	HD70-A82	DV70F5E0HGW/WS
Electricity costs (€ 15 years)	342	356	414	448	450	470	475
Capacity (kg)	7	7	7	7	7	7	7
Drying time (min) full load	130	189	124	155	136	140	150
Energy class	A+++	A+++	A++	A++	A++	A++	A++
Energy (kWh/year)	152	158	184	199	200	209	211
Condensation class	A	A	A	A	A	B	B
Efficency Index	22.9	23.9	27.6	29.6	30	31.7	31
Countries available	CH / on demand	CH / DE / on demand	CH / on demand	on demand	CH / on demand	CH / on demand	CH / on demand

Figure 1: Screenshot from Topten.eu: Most efficient 7-kg-driers

The market information shown in Figure 1 comes from the European Topten website (www.topten.eu) on 15 March, 2015. The best performing driers available have already reached highest available Energy Label classes of A+++ for energy efficiency and A for condensation efficiency. Class A for condensation efficiency means that a maximum 10% of the moisture in the laundry may escape into the room.

5 brands already offer A+++/A models: AEG, Beko, Electrolux, Miele and V-Zug (by 15. March 2015).

Very relevant for consumers is also the duration of the drying cycle. These most efficient models show considerable differences. The V-Zug Adora TS requires only 130 minutes, whereas the Miele T8877 model requires 189 min., nearly one more hour for drying the laundry (source: www.topten.eu).

There are 5 brands of tumble driers for semi-professional use that perform at the A++/A level: Bauknecht, Electrolux, Fors, Schulthess and V-Zug. Semi-professional driers are usually used in multi-family houses (ca. 1 drier for shared use by 5 apartments). The program duration of the quickest machine is just 85 minutes.

Electrolux and Miele also offer professional use heat pump driers with capacities up to 13 kg, corresponding to a 325 liter drum volume. The duration of the drying cycle is only about ¾ hours.

USA: first heat pump driers introduced in 2014

The North American market for clothes dryers is undergoing a transformation towards higher efficiency driven by a combination of improved technology, financial incentives, and product labeling [8]. In 2014, two major appliance manufacturers introduced the first hybrid heat pump electric dryers into the North American market; these new dryers offer a 35% improvement in energy efficiency over the standard electric dryer, with one being vented and the other being unvented. Blomberg has subsequently introduced an condensing heat pump-only model with significantly higher efficiency. In addition, the U.S. federal government's ENERGY STAR program has introduced energy efficiency labeling for dryers in the U.S. for the first time. These developments are due in part to the efforts of utility energy efficiency program providers in the US working together through the Super-Efficient Dryer Initiative (SEDI). SEDI was created in 2008 to accelerate the market introduction of highly efficient dryers into the U.S. and Canada, building off of the successful market introduction of heat pump dryers in Europe [8].

Why is market monitoring important

Energy Labels and MEPS for energy using 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 on the market are already in the best Energy 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 [9]. 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 continuously improves (e.g. example refrigerators and freezers in [9]).

When defining effective policy measures, it is critical to understand the market in terms of the products being sold and 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 the timing of their implementation to achieve maximum effectiveness. If sales data are publicly available over a longer period, it is possible to develop stock models to estimate trends in energy consumption and other attributes [10] – 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 [11]).

Most economies have a system to monitor the markets for products that are covered by an Energy Label or MEPS, either based on sales data purchased from a professional market research company, or on information on the models that are on the market from mandatory product registration systems [12]. Australia even combines detailed product specifications from the registration database with sales data [13]. Up to today, Europe has neither mandatory product registration nor does it monitor the markets with sales data [9]. Since little is known about actual market trends, it is difficult for policy makers to launch revisions on time and to define Label classes and MEPS at optimal levels.

Data and Methodology

ADEME[2] (Agence de l'Environnement et de la Maîtrise de l'Energie) set up a project together with the Topten team to purchase and analyse sales data on tumble driers for France and Portugal, plus some similar information at the EU level. Data was purchased from GfK, a professional market analysis company active around the world[3]. In Europe, GfK covers around 90% of the tumble driers market, and is present in 24 Member States. Sales data plus many product characteristics are obtained from retailers.

For France and Portugal, GfK provided tumble driers sales data including information regarding energy efficiency classes, average energy consumption and price, and information about capacities, covering the years 2004 to 2014. For an aggregation of 21 EU Member States[4], 2014 data was provided regarding total sales, sales shares of energy classes, and capacities. Sales data of Switzeland was obtained from [9].

All product performance information about specifications was provided according to the declaration on the Energy Label. There was one exception: the declared energy consumption per drying cycle provided under the original Energy Label (until 2012) was multiplied by 160 cycles to obtain an annual energy consumption estimate comparable with the annual energy consumption value that appeared on the revised Energy Label starting in 2012. However, these annual consumption values are not 100% comparable, because the revised Energy Label's value includes part-load drying and consumption from low power modes as described above.

Similar data, including complete information on EU level, was obtained for refrigerators and washing machines, as presented in the EEDAL conference 2015 (papers No. 50 [13] and 147 [14]). A complete report containing the results of sales data analysis for refrigerators, washing machines and tumble driers will be published on www.topten.eu in May 2015 [15].

Results

In France, sales of tumble driers increased by 23% from 2004 to 2014. The climbing sales graph in [15] 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. After having reached a peak of 63'000 units in 2010, there was a big drop to only 26'000 units in 2012. In 2014, 44'000 tumble driers were sold in Portugal, 26% less than ten years before (2004: 59'000; see [15]). 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 to dry 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.

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[2] www.ademe.fr/

[3] www.gfk.com

[4] EU-28 without Bulgaria, Luxembourg, Estonia, Latvia, Lithuania, Malta and Cyprus.

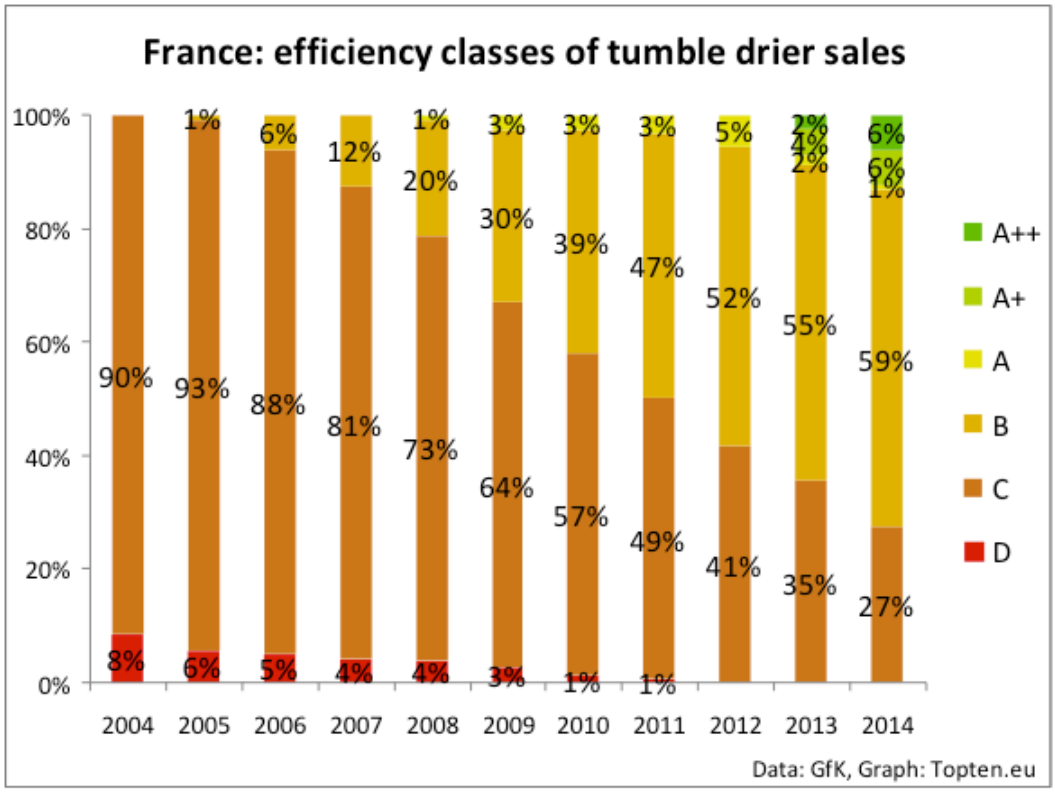

Figure 2: Conventional driers (classes B and C) have been dominating the French drier market

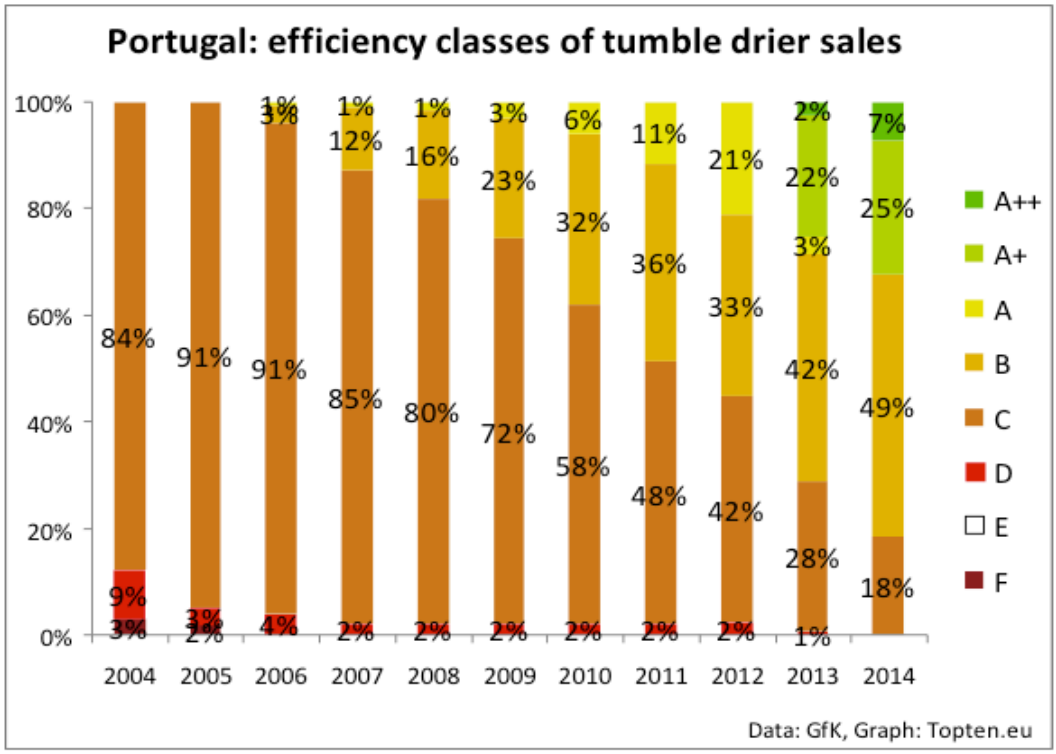

Figure 3: Heat pump driers (classes A/A+ and better) are gaining market share in Portugal

Under the original (pre 2012) Energy Label Class C absolutely dominated the drier markets at the beginning of the ten year period shown in Figure 3. 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.

In 2014, heat pump driers (classes A and better) accounted for only 13% of all drier sales in France, but for 32% in Portugal. Both the French and Portuguese drier markets lag behind the EU average. The differences are large among countries, as is underlined by Fig. 4: across the EU, in 2014 heat pump driers accounted for a staggering 43% of total drier sales! 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 Southeastern Europe. In these markets, electric driers are not very common; but if people do buy one, it is usually an energy efficient model.

The tier 1 MEPS, banning class D starting November 2013, seems to have had very little impact – at least in the two countries considered in this paper. The tier 2 MEPS will certainly have some effect, leaving only conventional class B driers on the market. 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!

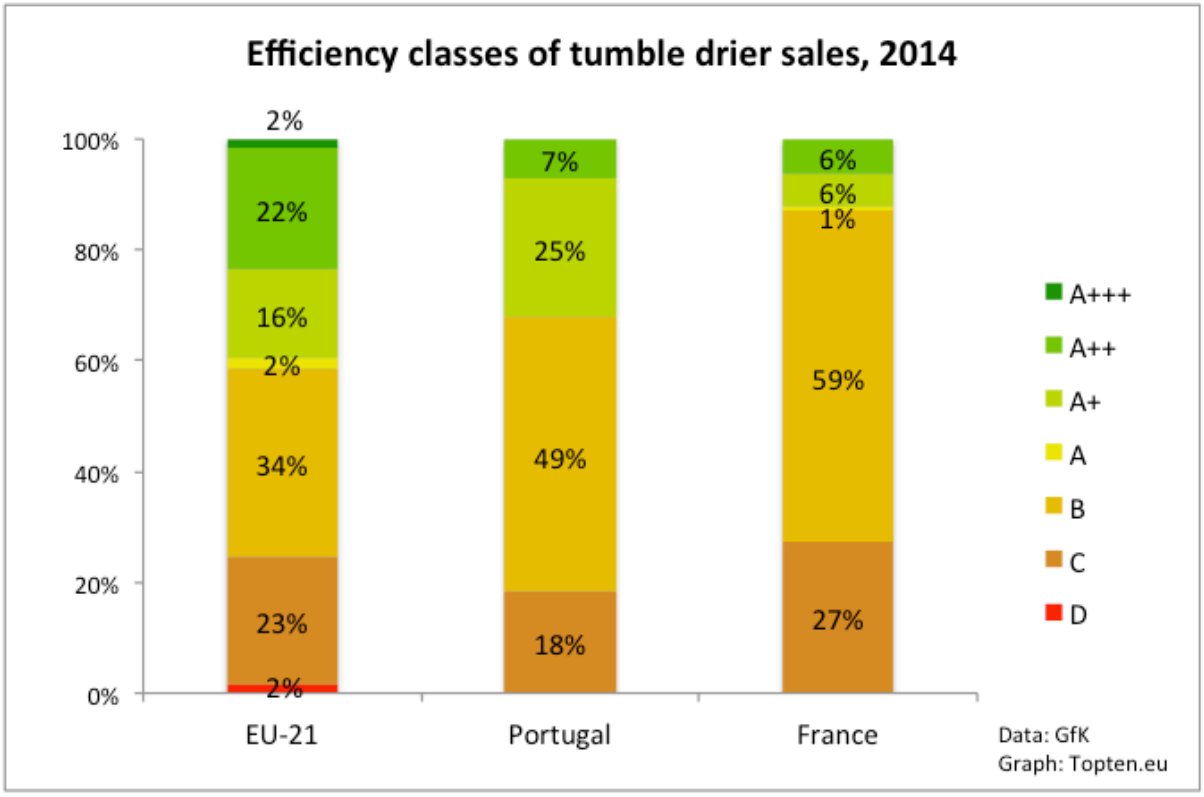

Figure 4: In 2014, heat pump driers accounted for 42% of the total sales across the EU

Sales data from Switzerland, published annually [9], shows a very different picture: by 2011 class A driers already accounted for close to a 50% market share, then the stringent MEPS drove it to 100% in 2012. 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.

Note to the reviewers: for the presentation in August 2015, 2014 sales data from Switzerland will be available, also showing A+, A++ and A+++ sales according to the revised Energy Label.

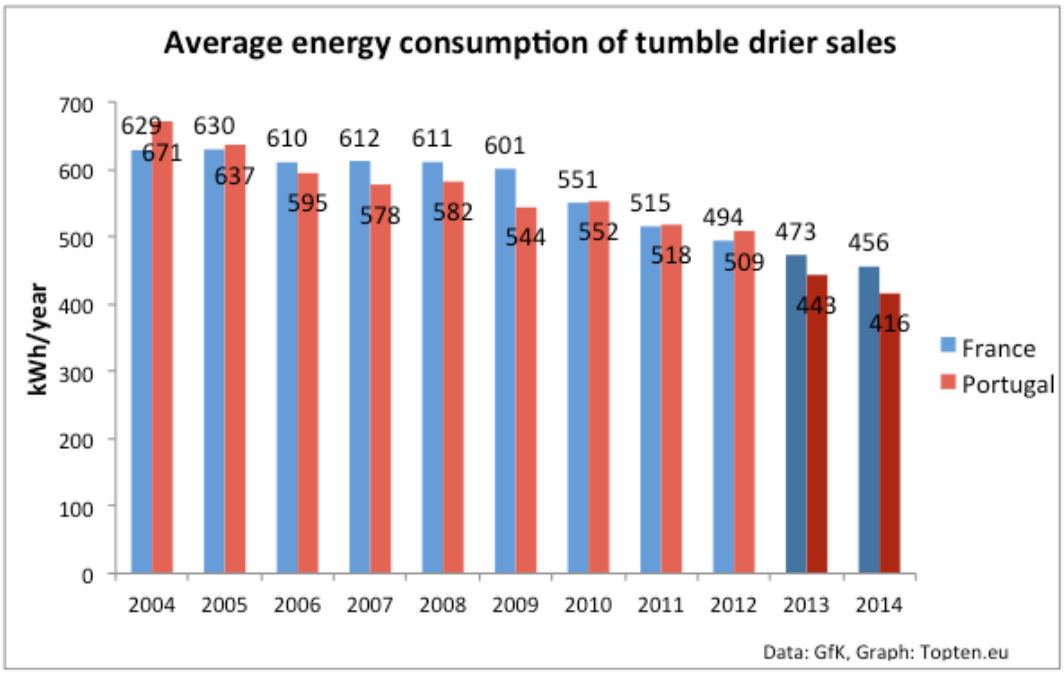

Figure 5: Average declared energy consumption clearly went down in both countries

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 in Europe decreased both in France (by 28%) and Portugal (38%) between 2004 and 2014. 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 in visible in Fig. 5, 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 Fig. 3), in 2014 the average consumption of Portuguese driers was 9% lower than that driers being sold in France.

Obviously the declared energy consumption is more strongly influenced by energy efficiency than drier size (capacity; Figs 6 and 7): 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. And Portuguese driers consumed lower 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 – because also here the machines sold in Portugal are of larger size [14].

Ten years ago, both in France and Portugal driers were usually designed for 6kg or less laundry. 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, where a similar development is shown in [total report]. 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 equally-sized housing.

Unlike it is true for washing machines [14], modern more energy efficient tumble driers are not larger than less efficient models, as shown in Fig. 10 below. The new EEI system includes half load drying efficiency, so drier models must also dry efficiently if only loaded partly. And the reference energy consumption (SAEc) does not increase strictly linearly with capacity but includes capacity to the power of 0.8 ($c^{0.8}$). Also there is no obvious link to pricing policies: in Portugal prices are increasing with average capacity (Fig. 8), but in France prices are stable despite more larger driers being sold.

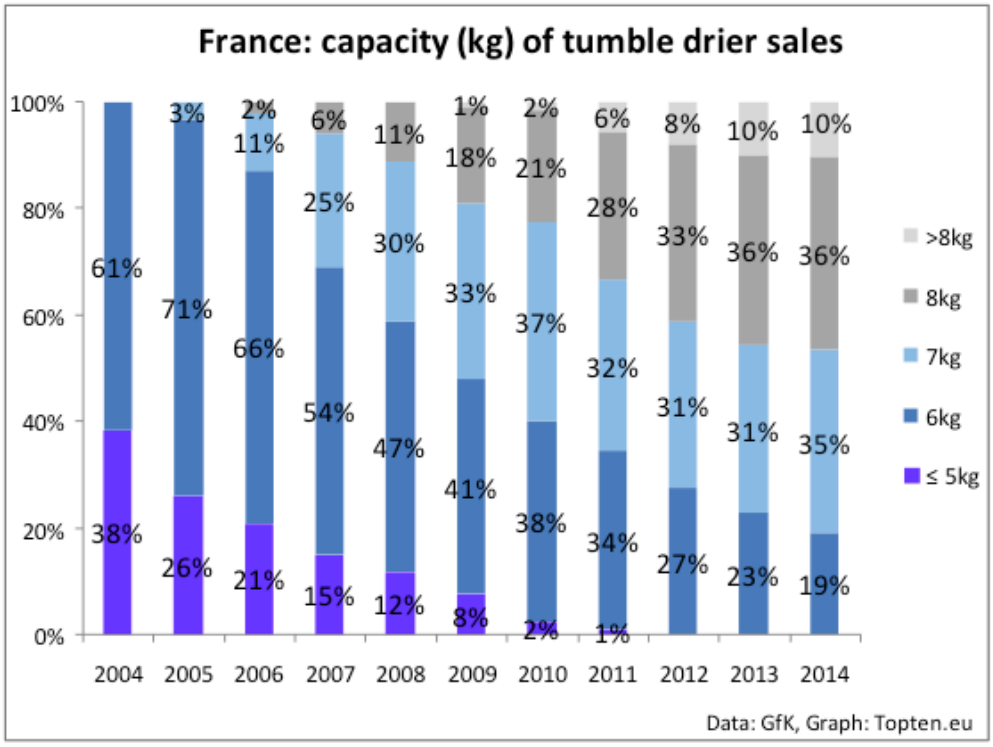

Figure 6: There is a clear trend to larger tumble driers in France

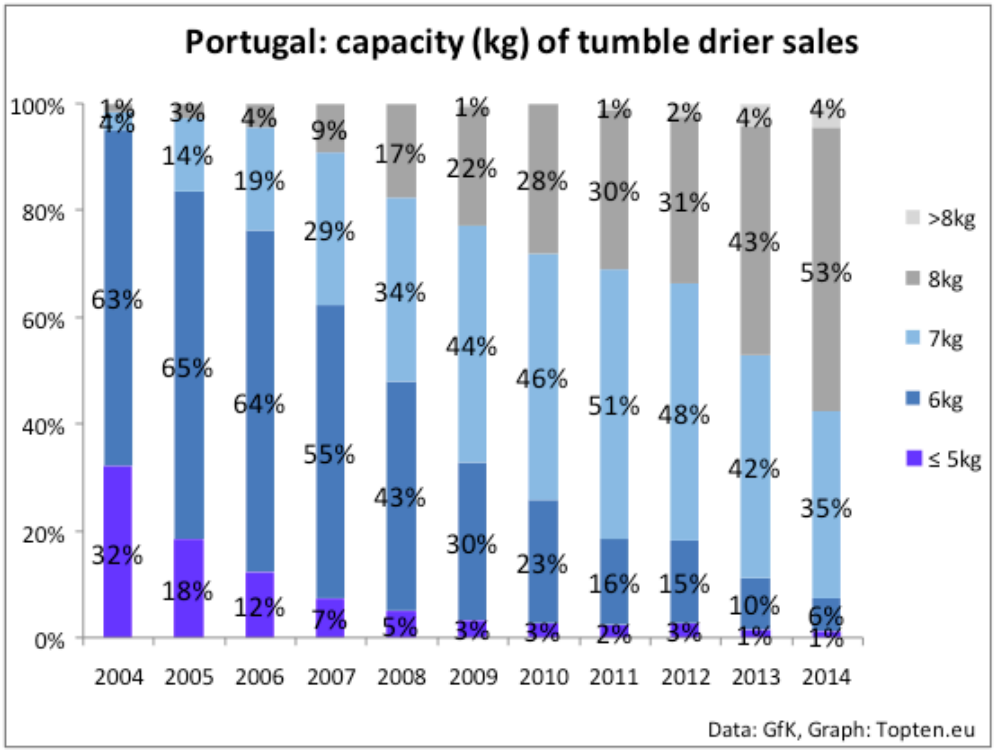

Figure 7: Also in Portugal driers are getting larger

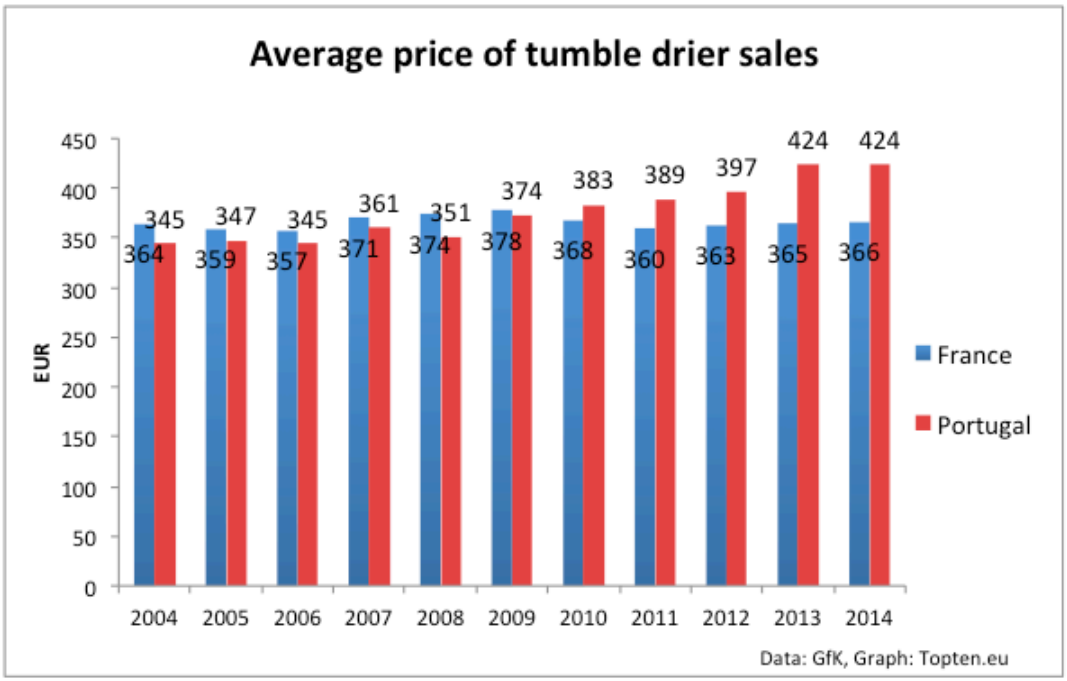

Figure 8: Different price developments in France and Portugal

Tumble driers price in France has been relatively stable over the last decade – despite larger appliances. 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 prices in Portugal.

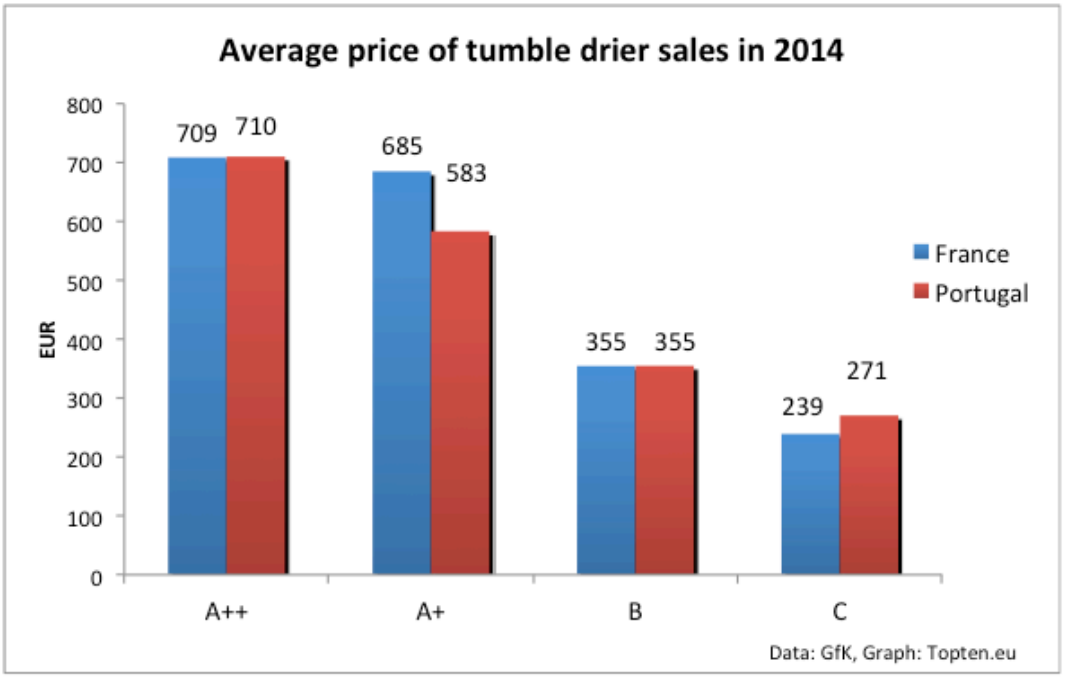

Figure 9: Not surprisingly, more efficient driers have higher average (nominal) prices

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

Both for France and Portugal, we observe higher prices associated to driers with higher energy effciency class. In 2014, average nominal prices for efficiency classes were nearly the same in France and Portugal – except for class A+. For driers of the 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 mad up only 6% (Figs 2 and 3). 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.

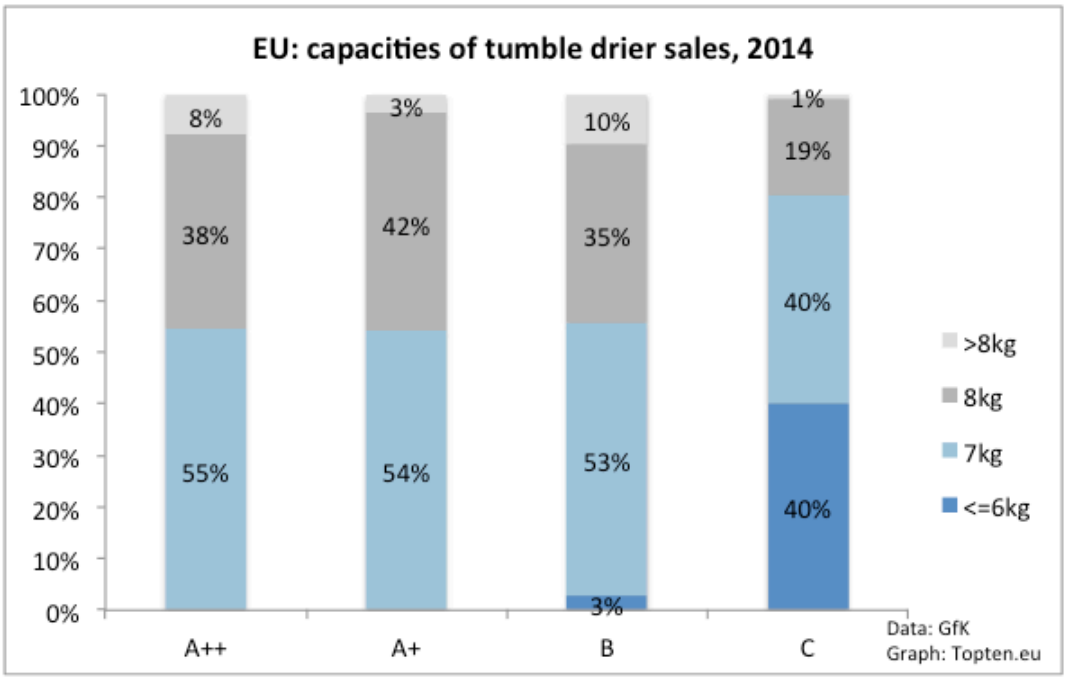

Figure 10:There is no correlation between capacities and energy efficiency class

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

For washing machines, there is a clear correlation between capacity and energy efficiency class [14]: more efficient washing machines are on average larger. This is not true for driers as Fig. 10 shows. Class C driers, to be banned from the EU market from November 2015, are smaller than more efficient driers. Models with 6kg capacity and less are literally non-existent in driers of classes B and better. Instead, 7-kg-models account for the majority of sales in all other classes with considerable market share B, A+ and A++.

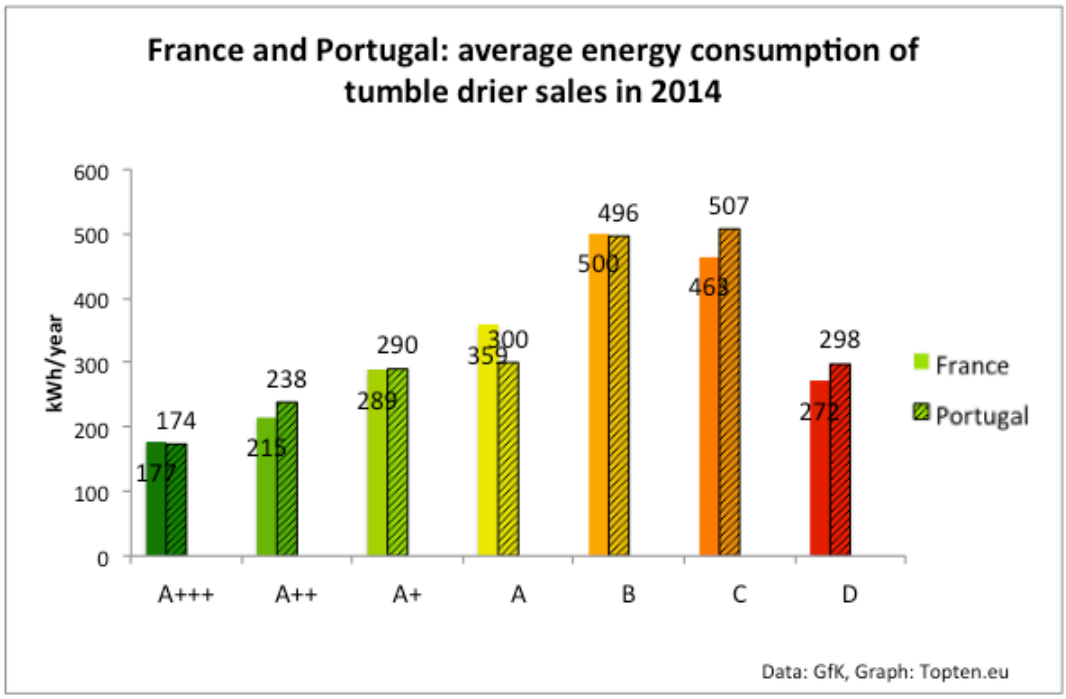

Figure 11: Heat pump driers hold a big saving potential

Figure 11 finally shows that the important energy saving potential lies in the promotion of heat pump tumble driers, without compromises. Fig. 11 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 an increase in size from class C to B (Fig. 10) and 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+++.

Conclusions and energy saving potential

With over 40% sales share, heat pump tumble driers have clearly reached the breakthrough on the European market. 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 created an incentive for new, better technologies and allowed innovative manufacturers to market heat pump driers as high efficiency models. The revised Energy Label now allows consumers to see the superiority of heat pump over conventional driers with the 'Plus-'classes. While tier 1 of the Ecodesign regulation was of little effect, the impact of tier 2, banning class C, is questionable due to small efficiency improvements to class B, which may even be outweighed by larger size.

Still these policy measures certainly supported the reduction of the average energy consumption of driers by between around 30% and 40% in the past ten years. The real, big saving potential however lies in heat pump driers, as shown in Fig. 11 and Fig. 12 below.

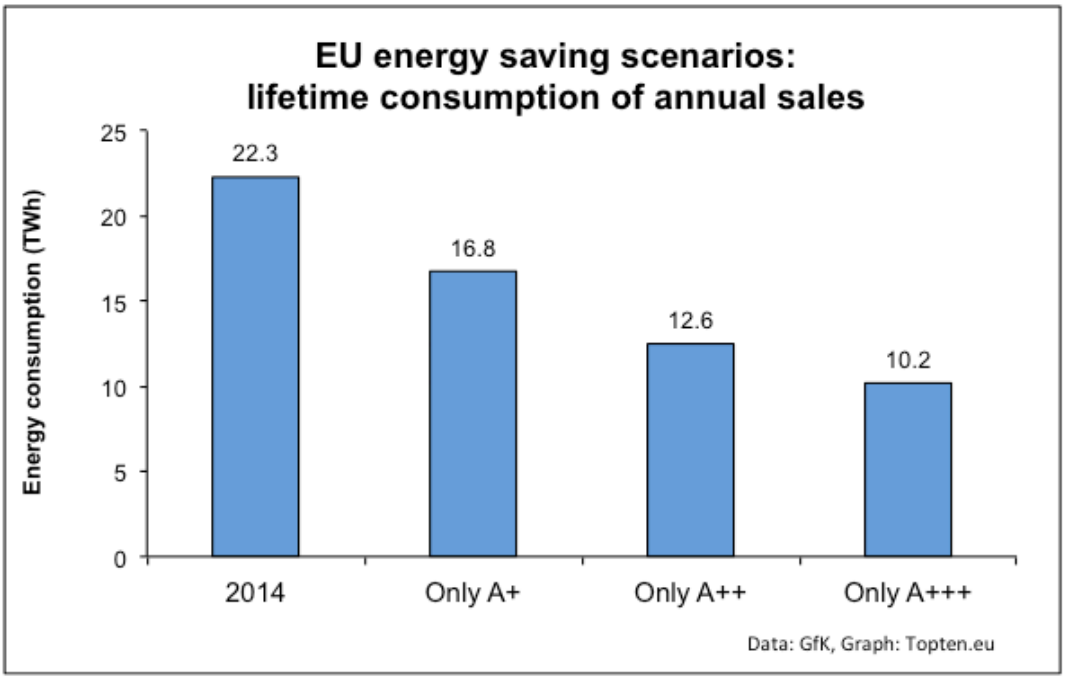

Figure 12: Heat pump tumble driers hold a large energy saving potential in Europe

The total energy consumption of all driers purchased in Europe in 2014 was calculated, assuming a lifetime of 15 years. Several hypothetical scenarios were studied, in order to evaluate the potential energy savings available from sales of more energy-efficient driers.

- Scenario 1: all driers sold in Europe are A+ class. This scenario would result in 25% lower energy consumption over the lifetime of the driers sold in a given year. That means some 5,6 TWh of energy saved, the equivalent annual output of 1.4 medium-sized coal power plants. In economic terms, Europe would save €1.1 billion per year.[5]

- Scenario 2: all driers sold in Europe are A++ class. This scenario would result in 44% lower energy consumption over the lifetime of the driers sold in a given year. That means some 9,8 TWh of energy saved, the equivalent annual output of 2.4 medium-sized coal power plants. In economic terms, Europe would save €2 billion per year.

- Scenario 3: all driers sold in Europe are A+++ class. This scenario would result in 54% lower energy consumption over the lifetime of the driers sold in a given year. That means some 12,1 TWh of energy saved, the equivalent annual output of 3 medium-sized coal power plants. In economic terms, Europe would save €2.4 billion per year.

References

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

[2] Bush, Damino, Josephy, Granda: Heat pump tumble driers: New EU Energy Label and Ecodesign requirements in Europe, MEPS in Switzerland, intiatives in North America. Presented at EEDAL 2013, Coimbra.

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

[5] Assuming an electricity price of €0,20/kWh and coal-fired power plants of 500MW capacity, operating 8'000 hours a year.

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

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

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

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

[8] Christopher Wold, Christopher Granda, Eric Bush, Rebecca Foster, Chris Badger, My Ton: Market Transformation through Emerging Technology: Lessons learned from the introduction of hybrid heat pump clothes dryers into the North America market. Not yet published, will be presented at EEDAL 2015.

[9] S.A.F.E. and FEA: Swiss appliances sales development 2004 – 2013. July 2014. http://www.topten.eu/uploads/File/FEA-Geraetestatistik-2004-2013-EN.pdf

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

[11] Harrington and Lane: Evaluation of Energy Efficiency Policy Measures for Household Refrigeration in Australia: An assessment of energy savings since 1986, prepared by Lloyd Harrington and Dr Kevin Lane, EES for Department of Energy Efficiency and Climate Change, December_2010,_see http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Refrigeration/Domestic_Refrigeration/201010-refrigeration-evaluation.pdf

[12] Michel, Attali, Bush, Jones: Why Europe should introduce mandatory product registration and a public database for energy related products. Discussion paper. November 2014. www.topten.eu/uploads/File/Topten-discussion-paper-product-registration-database_Nov_14.pdf

[13] Michel, Harrington et al.: Household refrigerators: Monitoring efficiency changes in Europe and Australia over the last 10 years. Presented at EEDAL, August 2015.

[14] Michel, Josephy, Bush, Attali, Zuloaga: Monitoring the washing machines market in Europe. Not yet published, will be presented at EEDAL 2015 in Lucerne. July 2015.

[15] Topten.eu: Energy efficiency of White Goods in Europe: monitoring the market with sales data. June 2015. http://www.topten.eu/uploads/File/WhiteGoods_in_Europe_June15.pdf