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# The first energy labels for professional cooling appliances – lessons learnt and comparison with energy regulation for household appliances

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## Abstract

The European energy labelling and ecodesign regulations for household appliances are one of Europe's greatest success stories with regards to energy efficiency. Almost two decades after the coming into effect of the first regulation for household appliances, similar regulations for equivalent appliances in the business-to-business market segment were considered to not be feasible. Arguments from opponents ranged from concerns about content safety and product functionality to claims of customized production that would make labelling impossible.

After conducting comprehensive preparatory studies, the European Commission adopted the first energy label and ecodesign regulations for professional refrigerated storage cabinets that came into effect in 2016, followed by equivalent regulations for commercial refrigerating appliances with a direct sales function that entered into force on 1 March 2021. Combined, they are expected to save an estimated 52 TWh of annual final energy savings in 2030. For professional refrigerated storage cabinets, the energy efficiency regulations have proven to be significantly more effective than any other previous type of intervention. Functionality and food safety have been maintained while technical innovations have boomed, bringing to the market in the last five years products that reach energy classes A or even A+ and giving European manufacturers an edge on the global market. Professional buyers have increased their awareness and are now able to make informed decisions and a long-term impact on pricing could not be observed. Overall, a significant market transformation has been triggered and is still taking place.

Supporting the market transformation are initiatives like Topten; over the last 20 years, Topten has collected experiences with the implementation of diverse rebate schemes, technical innovation and gained a unique insight into the long-term development of best available technologies (BAT) on the entire market.

This article will discuss the current and future efficiency potentials as well as the contributing effects of rebate programmes, focusing on four main aspects: (a) overview of BAT product development with comparison of development between household and professional appliances and current saving potentials for professional and commercial refrigeration appliances (b) effectiveness of rebate programmes, esp. with regards to multiplier effects (c) analysis of especially efficient technologies for commercial and professional refrigerators (d) potential of further energy efficiency regulations for product categories in the B2B market such as medicine cabinets.

**Keywords**: strategies for increasing efficiency, market transformation, standards and labels, best available technology (BAT), energy saving potential, financial incentives, ecodesign, energy labelling, commercial and professional refrigerators and freezers, natural refrigerants, green procurement.

## Introduction

The European energy labelling and ecodesign regulations for household appliances have been in place for various categories since 1992, reducing the energy consumption for models of the same size by more than 70% (e.g. for refrigerators) [8]. In 2016, more than 20 years after the first EU energy label for house-hold refrigeration appliances was introduced, the first label for professional refrigerated storage appliances came into effect. The label contained a scale from A to G which was extended to A+++ to G

in July 2019 and minimum energy performance standards (MEPS) that banned class G products from the market, followed by class F products in 2019 (with the exemption of heavy-duty cabinets). While some categories like static or horizontal cabinets are not within the scope, the combined savings from the most common, in-scope categories were expected to result in estimated annual energy savings of about 1.8 TWh in 2020 and 4.1 TWh in 2030 [4]. The regulation is currently in the first review process.

Regulations for refrigerating appliances with a direct sales function (commercial display refrigerating cabinets) took significantly longer in part due to necessary adjustments to B2B markets and labelling regulations for various configurations. Nonetheless, the respective energy labelling and ecodesign regulations came into effect earlier this year on March 1st 2021, covering beverage coolers, ice-cream freezers, supermarket cabinets (remote and integrated) and refrigerated vending machines. According to the preparatory study update from 2014, almost 16 million units within that scope were in stock in the EU28 market with an increase to 18 million units expected by 2030 [9]. The combined regulations for refrigerating appliances with a direct sales function are estimated to reach 48 TWh of annual final energy savings by 2030 [5].

Of special interest in both cases is the innovative approach of applying the regulation to strictly B2B (business-to-business) categories as well as the included declaration requirements, for the first time enabling buyers to realistically compare life-cycle-costs of the appliances in order to make informed investment decisions. Both regulations triggered significant market transformations, especially as efficient technologies from household refrigerators could be adopted. While no good overview of yearly sales numbers in connection to the energy label per product exists, the market development can be tracked well through observing the development of best available technologies (BAT) on the market. Topten.eu has monitored the BAT market segment for both categories since 2015 as accurately as possible given the data availability (for commercial appliances the integrated models, i.e. models with integrated system for producing cooling). The resulting data gives insights into the market development as well as further saving potentials.

Topten, the author of this paper, is an independent platform that presents the most energy efficient products on the market for household and commercial use. To be listed, products need to fulfill the selection criteria defined by Topten. They are based on existing standards and regulations and consider the product's energy efficiency and environmental impact, resource efficiency and health impacts. The platform is used by policymakers as a source of data and science-based recommendations to develop new regulation.

## Market Development BAT

### Professional refrigerated storage appliances

Professional refrigerated storage appliances are rather similar to household appliances in terms of cooling technology and basic form, though often larger, stainless steel, using forced-air cooling and occasionally containing extras like locks and more or less sophisticated monitoring and warning systems. The inside temperature ranges are similar to household appliances as well, although a large share of the professional refrigerator models on the market are also equipped to operate in especially hot environments, such as professional kitchens (so called "heavy-duty" appliances, operational at climate class 5 with 40°C and 40% relative humidity).

While in 2017, a Topten.eu market survey showed that more than 50% of the storage appliances were not yet labelled online nor contained regulation product fiches, the data availability has greatly improved by 2020 according to Topten.eu. Efficient, high quality models are more consistently labelled than low efficiency products, most likely because high efficiency can be used as marketing and sales advantage while low efficiency labels have a deterrent effect on buyers.

The graphs in Figure 1 show a significant increase in most efficient technologies (BAT models) in all six categories covered by the energy labelling for professional storage cabinets. Classes that are not listed or end in dots are not BAT technologies respectively stopped being part of the most efficient market segment due to general market improvements. Topten selection criteria are tightened every time the market allows for it. Most such changes occurred in the years 2015-2017 when data became more widely available and technologies improved due to the introduction of the new label in 2016. The graphs are based on the models listed on Topten.eu in the years 2015-2021.


**Figure 1: Market development of BAT models for professional refrigerated storage appliances from 2015-2021 by category. Data & Graph: Topten.eu**

For counter appliances, both graphs for cabinets in the refrigeration and freezing segment show steady market improvements, with the freezing segment showing a soft decline for 2021. However, for counter freezers this development takes place in the class B efficiency range while for counter refrigerators significant numbers of class A and even A+ models penetrate the market. A similar observation can be made for 1-door appliances: for refrigerators classes A-D were part of the high efficiency market segment in 2015 (low efficiency and data availability) while only two years later in a staggering technical development enough models had been developed and declared class A, that all lower class products could no longer be considered “most efficient”; by now, at least 36 class A models by 19 manufacturers are available on the European market. For 1-door freezers, however, the number of class B models on the market has stagnated or even decreased while the increase in efficient models is happening in the class C range. Manufacturers so far seem unable to develop further models efficient enough for classes B and A; the only class A model on the market was discovered to be falsely labelled and was re-labelled to a lower efficiency class. There are two possible explanations for these differences in efficiency classes between the professional refrigerator types:

1. Differences in EEI calculation. As the efficiency classes are dependent on the calculation factors determined in the preparatory studies and each category of professional refrigerator has its own calculation factors, it is a possibility that some of those differences are caused by the different factors for the EEI calculation of each of those categories.

2. R&D focus on popular categories. According to European manufacturers, counter and 1-door refrigerators are the most commonly sold appliances on the market for professional refrigerated storage cabinets. As such, it stands to reason that manufacturers would focus their R&D resources on those categories first, reaching classes A or even A+ as marketing advantage.

Of course, a combination of those factors is more than likely. An exact weighting of those factors is not feasible at this point.

For 2-door cabinets, the reverse development can be observed. 2-door refrigerators of classes A and B are slowly increasing on the market. While the number of class C freezers on the market increases, no model with an efficiency class A or B has been found on the market. It would be of interest if the ongoing EU review study [2] could investigate this development to determine whether this can be attributed to the EEI calculation factors or a lack of R&D by the manufacturers.

Considering that the "standard model" on the market was defined to have an energy efficiency index of 100 (100%) in 2014 corresponding to the worst class G, the development of the BAT market segment for professional refrigerated storage cabinets has been accelerated significantly through the energy labelling and ecodesign regulation for this B2B category.

**Commercial display refrigerators with a direct sales function**

Commercial display refrigerators with a direct sales function differ more widely from household appliances and between each other. While beverage coolers are designed for non-perishable drinks, having to be able to cool down their content within a certain time due to restocking and being equipped with a night-time energy saving shut-off function, ice-cream freezers have to maintain a certain freezing temperature for their products even when placed in a sunny outside environment during summer heat waves; due to the needed local flexibility, both categories are integral (plug-in) technologies only. Supermarket appliances cover a wide range of horizontal, vertical and combined models in varying chilled and frozen temperature ranges and can be either integral or attached to a remote system with central cooling. Ambient temperatures don't pose a challenge for supermarket cabinets because supermarkets in different climate zones and seasons are widely air-conditioned and stable.

As the energy labelling regulation for refrigerating appliances with a direct sales function has only come into effect on March 1st 2021, the data sets of best available technologies on the market over the last 5 years as shown in Figure 2 are not linearly consistent. Between 2015 and 2019, the energy efficiency index (EEI) values of the BAT models were calculated using the 2014 draft calculation method. However, the draft method differs significantly from the final 2019 calculation method which includes additional factors such as factors for different temperature classes and plug-in vs. remote cabinets. As such, each graph contains two sets of data for 2020, one according to the old 2014 draft calculation, showing the EEIs of the models and one according to the final 2019 calculation method, already translated into the respective energy class. At this point, the total number of available data sets may also vary because for some products manufacturers did not make available the necessary data for the additional factors in the new EEI calculation method while other manufacturers used this opportunity to submit new products developed specifically in preparation for the impending regulation. Though EU energy labelling regulations are intentionally designed to leave class A (and if possible also class B) unpopulated at the time of entry into force in order to promote further innovation, several categories of commercial refrigerators already contained class A products in March 2021 (entry into force of the new regulation), as could be observed on Topten.eu at that time.

For beverage coolers, the number of more efficient products available on the European market started increasing in 2018, a trend that is still ongoing (Figure 2). The number of class A, B and C models on the market was already so high at the time the regulation came into effect that the Swiss government set stricter MEPS for the Swiss market at a maximum EEI of 80 instead of 100 (Switzerland normally adopts the EU energy regulation, although at times with stricter MEPS in order to further promote efficiency on the Swiss market) [12].

For ice-cream freezers, a rapid development can de observed as well. While until 2016, models with an efficiency index (EEI) of up to 75 were considered part of the high efficiency segment, with the entry into force of the new EU regulation in 2021 only the classes B and C qualify as best available technologies – with class B ranging from EEI 20 to 35, this is an increase of efficiency of over 50% compared to 2016. The high number of class C and D models available on the market from a wide

range of manufacturers has also prompted the EU Commission to set stricter MEPS for this category than for the other categories in the scope of the same regulation.

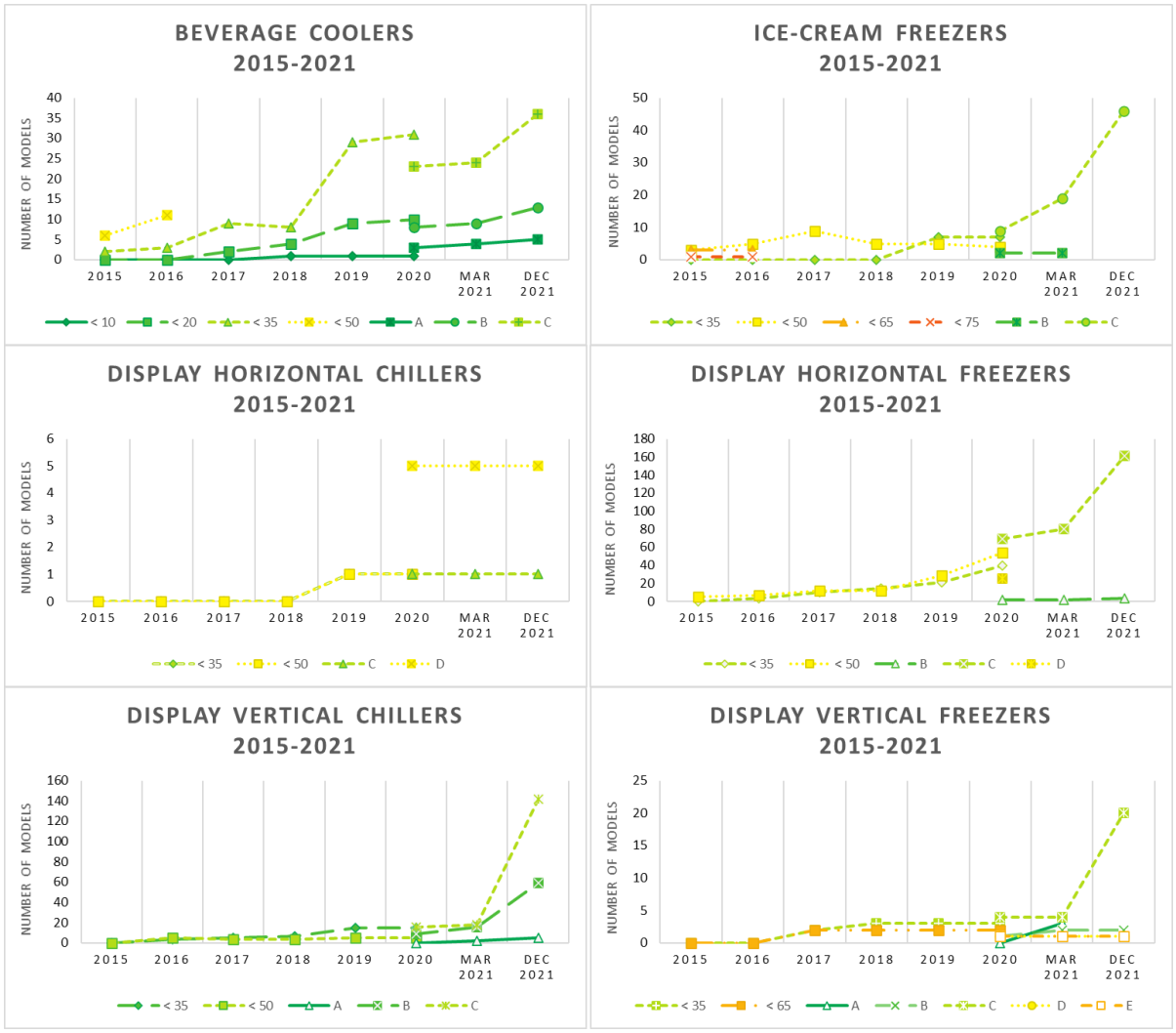



**Figure 2: Market development of BAT models for commercial display refrigerators with a direct sales function from 2015-2021 by category. Data & Graph: Topten.eu**

The category horizontal display refrigerators shows an increase in class D models. Currently, there is no model better than class C on the market. This is a good starting position for the new label, as it allows enough potential for the manufacturers to develop more efficient technologies. It should be noted that the size indicator for supermarket appliances is the total display area ($m^2$) of each appliance; The total display area is part of the formula to calculate the EEI. The larger the size of an appliance ($m^2$) at a given energy consumption, the lower the EEI. Therefore, the market development should be observed closely over the next years to ascertain if manufacturers improve the product technology to raise the energy efficiency of their models or if this specific size indicator serves as incentive (or loophole) to simply increase the display area (glass sides) to reach higher efficiency classes through exploiting the calculation method for reaching more beneficial results.

The display horizontal freezers (including universal chests that can be set to either frozen or chilled temperatures) contain among the highest number of available models in the BAT segment of the B2B market. Notable for this data is that the numbers given in Figure 2 include series products with different sizes of a certain model type (i.e. different lengths of same technical model). In 2020, more than 100 class C and D models were provided by seven manufacturers, while in 2021 164 class B and C models were produced by five manufacturers who cover a large part of the market for this category. Most models are available in 2-10 sizes.

For display vertical refrigerators the variety of class B and C products on the market has been increasing significantly, with the first class A models entering the market. It is to be expected that the BAT segment will soon be limited to class A and B only in the Topten.eu selection criteria of most efficient products on the market for this category.

The first three class A chilled vertical products entered the market in 2020, and these products are small counter top display refrigerators. Within commercial display refrigeration, display vertical freezers are the outliers in the market development of the BAT segment. With regards to large vertical freezers, the BAT segment has remained virtually unchanged since 2017, even including class E products into the BAT segment. During our research a variety of class F models (EEI between 65 and 80) could be found; however, even intensive contact with manufacturers did not result in new data for the BAT segment to date. Whether this is due to the EEI calculation factors or manufacturers focusing their R&D resources on other categories could not be determined.

In general, two overall developments are noteworthy. First, the announcement of the new energy labelling and ecodesign regulation for these products has triggered a significant - and for this category unprecedented - market development even before the new regulations came to effect. Second, there was a sharp uptake in BAT models across all types of products in the months after the regulations entered into force in March 2021. This is due to the continued positive technical development that has started with the announcement of the regulations. Furthermore, all models have to be classified and their efficiency class be made public. This leads to better availability of information, and thus facilitates improved transparency and comparability for buyers.

In the first weeks the new energy label was not very well received. During our online research in March and April 2021, EU energy label arrows were indicated in less than 10% of the products reviewed online on the websites of manufacturers and dealers. In the meanwhile, the picture has become quite clear. There are many manufacturers that display the energy label arrow correctly. There are some manufacturers that do not yet incorporate and display the energy label and therefore do not meet the regulations. And finally, there are a few manufacturers that appear to have modified their online presence (website) to show only as little product information and data, as such that the presentation of the energy class may be deemed not necessary. That could indicate a new and to B2B specific way to circumvent the label and ultimately provide even less information than before. Those manufacturers who already comply with regulations serve as example for the industry and may advance the market towards more energy efficiency and transparency. Another intended database for product data, the European EPREL database, has been delayed [6], currently limiting data research on it.

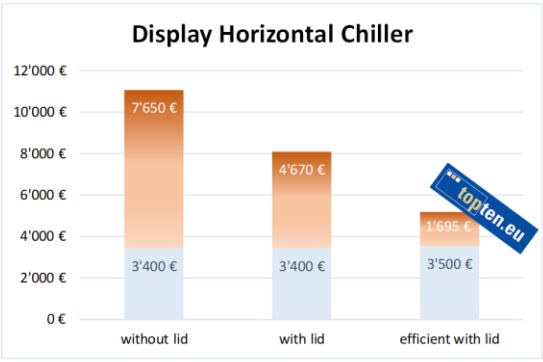
## Saving Potentials of Refrigerators with a Direct Sales Function

The EU energy regulation for both household and professional appliances relies on two main concepts. Concept one is the energy labelling, set to advance the BAT segment by giving manufacturers incentives to develop more efficient products. Concept two is Ecodesign intended to “cut off” the least efficient market segment by setting minimum efficiency requirements, also known as minimum energy performance standards (MEPS). For commercial display refrigerators, it could be argued after viewing the recent development of the BAT segment that concept one has not been stringent enough in its implementation: according to EU directives the energy classes A (and where possible B) should have been set to remain empty, i.e. there are no existing products in the market in these energy classes, at the time of entry into force to provide long-term incentives for manufacturers to develop new and better technologies. However, it should also be noted that due to the lack of data availability and large untapped potentials at the time of the review study, determining appropriate levels would have been very difficult to define. The first review of the regulation after a few years of mandatory data declarations will be able to be more precise.

Regulation two is especially required for supermarket cabinets that are still often open cabinets (no doors or lids), especially in the convenience food sector. The MEPS are not likely to affect many closed glass-door appliances in the first tier but should limit the open cabinets on the market to only the more efficient technologies.

The currently available technical saving potential for appliances can be defined as the difference in consumption between the least and most efficient products on the market. As result of MEPS settings, the least efficient commercial refrigerating appliance allowed to remain on the market need to be below energy efficiency index EEI 100 (except ice-cream freezers at maximum EEI 80), and several product

categories having class A BAT products available with an EEI below 10, the efficiency potential of products already on the market is 90% of the efficiency index EEI. Even presuming the average product on the market might be in the classes E and D for various categories, the current saving potential would still be around 50%. This is not even accounting for saving potential inherent to future, through even more efficient Best Not yet Available Technology (BNAT).




| Net volume | 320 l | 320 l | 451 l |
|---|---|---|---|
| Energy | 4'780 kWh/a | 2'920 kWh/a | 1'060 kWh/a |
| Electricity costs* | 7'650 € | 4'670 € | 1'695 € |
| Purchase price | 3'400 € | 3'400 € | 3'500 € |
| Total costs | 11'050 € | 8'070 € | 5'195 € |

* 8 years, 0.2 € /kWh

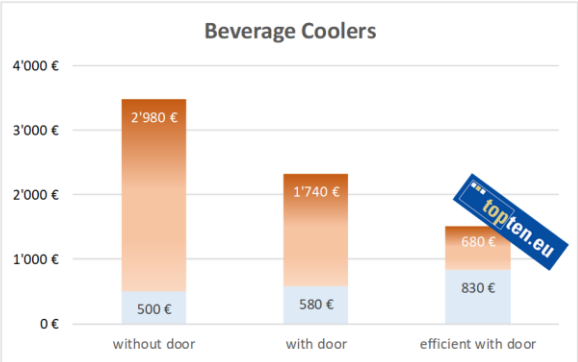
**Figure 3: Saving potential of display horizontal chillers for supermarkets, comparing open, closed and efficient models. Data & Graph: Topten.eu**

Two categories are considered in more detail in the figures below. Display horizontal chillers in supermarkets currently tend to be open, especially in the convenience food segment. Figure 3 shows that such an open appliance that is just compliant with the new MEPS easily causes electricity costs of more than 7'000 € over its assumed 8 year lifetime. An average horizontal chiller with a lid already consumes 40% less energy while a significantly larger, efficient BAT model with lid saves up to 80% energy consumption compared to the inefficient open model. Even an efficient appliance twice as expensive as the inefficient model would have a lower lifetime cost than the inefficient appliance. Many supermarkets still prefer open horizontal and vertical chillers in their stores as they fear that glass lids or doors may be a barrier for impulse buying from consumers, especially as the yearly revenue generated through a refrigerating appliance if often significantly higher than the purchase or yearly energy cost. However, studies have been published in the last years, documenting no long-term overall change in revenue between refrigerating supermarket appliances with and without doors; offsetting the additional barrier is the so called "cold-feet effect" of open appliances that causes consumers to linger less and move on faster to other areas of the supermarket which are not as cold [1].

Beverage coolers with doors have increased over the last years compared to open appliances. Manufacturers seem to have become aware of the significant saving potential available for this category which was even more significant before the coming into effect of the new MEPS on March 1st 2021. Even a larger top efficient appliance with door saves more than 75% energy compared to a smaller, but open beverage cooler just compliant with MEPS and still 60% compared to an average beverage cooler with door.

Beverage coolers are in their technology most similar to household and 1-door storage refrigerators. This makes technology transfer easy and thus results in one of the most efficient categories within the refrigerating appliances with a direct sales function.

Often, beverage coolers are purchased in bulk by large beverage companies or breweries and loaned or rented to vendors in combination with sales of their beverages. Several large beverage companies have informed us that they strive to provide their vendors with high efficiency beverage coolers as part of their company sustainability strategies. Vendors profit from lower electricity bills but often have to be convinced by the beverage companies to use coolers with doors.




| Net volume | 500 l | 500 l | 556 l |
|---|---|---|---|
| Energy | 1'860 kWh/a | 1'085 kWh/a | 425 kWh/a |
| Electricity costs* | 2,980 € | 1,740 € | 680 € |
| Purchase price | 500 € | 580 € | 830 € |
| Total costs | 3'480 € | 2'320 € | 1'510 € |

* 8 years, 0.2 € /kWh

**Figure 4: Saving potential of beverage coolers, comparing open, closed and efficient models. Data & Graph: Topten.eu**

## Comparison to Household Refrigerators

As previously stated, 1-door storage refrigerators are reasonably similar to household refrigerators in their cooling technology. While test standards differ between the two categories, the ambient conditions are similar enough to attempt a reasonable approximation in comparing the available products on the market. Main difference is the door opening sequence in EN 16825:2016 for professional refrigerated storage cabinets that is not present in EN 62552 (2013 or 2020 version) for household refrigerators. Laboratory tests by the ProCold project show a 30-50% higher energy consumption if refrigeration appliances are tested according to EN ISO 23953:2015 (with door opening sequence) as compared to EN 62552:2013 [10]; as the door opening sequence of EN ISO 23952:2015 is longer and more frequent than of EN 16825:2016, the difference in energy consumption accounted for by the different test standards between EN 62552 and EN 16825 is less than 30-50%. **Figure *5*** shows that the difference based on the test standard is even less for the 2020 version of EN 62552 as compared to EN 16825:2016.

Figure 5 shows the energy consumption of a BAT model household refrigerator (one of the top 5 refrigerators without freezer compartment on Topten.eu in May 2021) according to the old and new version of EN 62552 along with their net volume; in comparison, it shows the energy consumption and net volume of a 1-door professional storage refrigerator (one of the top 5 1-door storage refrigerators on Topten.eu in May 2021). The household refrigerator is class C (previously A+++), the professional refrigerator class A.

Even taking into account a very conservative 30-50% additional consumption for the EN 62552 results due to the door-opening sequence, the professional refrigerator consumes about twice as much as a comparable household refrigerator.

This means two things. One, that storage refrigerators – despite their slightly different performance requirement profile – have the potential to be as efficient as household refrigerators: only 6 years after entry into force of the energy labelling for professional storage refrigerators, more than 30 professional models by 17 European manufacturers have almost achieved the same technical efficiency that household refrigerators achieve after more than 25 years (1994 to 2021) of energy labelling, making this highly efficient technology widely available on the B2B market. The new label has obviously pushed the top segment of the market massively, profiting from existing technologies developed for household appliances. It demonstrates the huge untapped saving potential prior to the introduction of the label for professional appliances. Without the energy labelling regulation, this untapped saving potential would have remained unfulfilled. Therefore, the policy proved highly efficient. Two, significant saving potentials can still be unlocked by future phases of the regulation for professional refrigeration appliances.

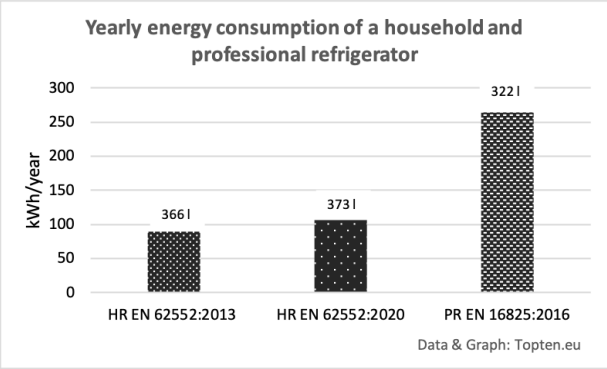



**Figure 5: Yearly energy consumption of a BAT household refrigerator (HR) measured according to EN 62552:2013 and EN 62552:2020 and a BAT professional storage refrigerator (PR) measured according to EN 16825:2016**

It should also be noted that the "standard model" for professional refrigerators – set at EEI 100 in 2014 – had an energy consumption of 1,330 kWh/year at a time where the first class A models already existed (Topten.eu data shows the existence of three class A 1-door storage refrigerators on the market in 2015) – a saving potential of 80% between the average and best models on the market. With class F of professional refrigerated storage cabinets now banned from the market through the second tier of the MEPS, a saving potential of 75% still remains between the worst and best products on the market in 2021; even compared to a class B model, a class A BAT model saves 33% energy consumption. In 2015, the only energy classes for household refrigerators allowed on the market had a saving potential of approximately 40% between class A+ and A+++. This means that the absolute saving potential by setting more stringent MEPS in the currently ongoing review of the regulation for professional refrigerated storage cabinets is huge and should be considered carefully by the review team.

## Rebates

Rebate programmes are set to increase the market share of most efficient appliances by subsidizing the initial purchase investment because more efficient appliances are often – depending on the category and more importantly the buyer – more expensive than less efficient alternatives. In Switzerland, two rebate programmes for professional storage and commercial display refrigeration appliances have been implemented in the last years with significant positive results. The rebate programmes were **funded by the Swiss Federal Office of Energy** (SFOE) and implemented by Topten Switzerland.

1. **Programme 1 (2014-2017)**: The programme had a volume of 1.3 million CHF (approx. 1.2 million €) and resulted in **total energy savings of 54.6 GWh**. Despite a slow start, 5,955 products were subsidized over the four year programme duration, surpassing the target by 22%. The rebate programme had an effectiveness of 2.4 Rp./kWh, which is **2.2ct/kWh**.

2. **Programme 2 (2018-2020)**: The programme had a volume of 2 million CHF (approx. 1.8 million €) and resulted in **total energy savings of 118.5 GWh**, almost twice the original target. The rebate programme supported the purchase of 10'955 highly efficient appliances over the three years programme duration. The rebate programme had an effectiveness of 1.7 Rp./kWh which is **1.5ct/kWh**.[1]

Both programme concepts were originally calculated with higher cost per kWh; however, large number of submissions for product categories with especially high savings significantly improved the final cost effectiveness of both programmes. The idea behind these programmes by the SFOE is that the saved kWh should be cheaper than the purchase of one.

After a rather slow programme start, the participation of investors has increased steadily over the duration of both programmes. Feedback by buyers indicates that the continuousness of the programmes is of special importance, allowing dealers and buyers to know about the programme and

[1] 1 Rp. = 0.01 Swiss Francs | 1 ct. = 0.01 EUR

allowing for long-term planning which is especially important for large buyers and companies. A third programme was started in 2021 and is scheduled to continue until 2023. Buyers and dealers now actively encourage manufacturers to develop more efficient products to list on Topten so that they may become part of the rebate programme.

One often discussed aspect of rebate programmes is the so called “deadweight effect”, referring to people receiving rebate financing despite the fact that they would have chosen the high efficiency product anyway. However, most large buyers confirm the qualification of certain products for the rebate programme before the purchase, demonstrating that their purchase decision is significantly impacted by the financial subsidy. In addition, the savings of the programme are calculated by comparing an average market model with a high efficiency model. This allows to support the decision of both, potential buyers who would buy low efficiency products as well as those who already buy high efficiency products.

Of greater relevance is the multiplier effect, which is described here based on feedback from participants in the Swiss rebate programmes from 2014-2020. As already mentioned, buyers and dealers actively encourage manufacturers to develop and list high efficiency products that fulfil the strict selection criteria for the rebate programme which is especially effective in the case of larger buyers. Those technological innovations are then often implemented in the wider product range of the manufacturer and sometimes imitated by other manufacturers, leading to a significant multiplier effect. Dealers procure larger numbers of high efficiency products because they anticipate higher sales numbers for those products. They advertise the programme on their websites and advertise it to buyers during sales conversations. Large buyers adjust their procurement accordingly, sometimes at national level. The overview over available BAT products and higher efficiency in the market allows policy makers to make more informed decisions and set tighter MEPS, further increasing the market efficiency. All those effects increase the effectiveness of the rebate programmes by large factors, though they cannot be measured concretely.

## Efficient Technologies

To understand the fast market transformation on the B2B market for professional storage and commercial display refrigerated appliances on the European market in the last few years and further potentials for the future, an examination of the factors that particularly contribute to the energy efficiency of the appliances is useful. There are a few components in the refrigeration cabinets that especially contribute said efficiency of the appliances. The most effective and common technologies will be introduced here, based on discussions of Topten.eu with manufacturers and intensive product research.

1. **VS compressors**. Variable speed compressors are designed to continuously adjust the motor speed to match the output required instead of running continuously at full load like conventional compressors. With less rotations per minute during low demand periods, the energy consumption is correspondingly significantly lower. Example found in the field: the horizontal supermarket freezers (respective universal chests) of a certain product series are available in both configurations either with a regular or variable speed compressor. Of the eight products of each series (different sizes of the same model), seven of the products with VS compressor were one energy class better despite otherwise containing identical technology.

2. **Insulation**: The thickness of the insulation determines how much of the internal temperature the appliance retains without having to compensate it with the cooling apparatus. The better the insulation, the more efficient the product. This is especially relevant for storage refrigerated cabinets where aesthetics is of secondary importance compared to household refrigerators.

3. **Double or triple glazing or air curtains**. As for windows in buildings, double or triple glazing in the door and other glass display areas will retain more of the internal temperature, making this an important aspect of insulation. Similarly, open appliances use air curtains to limit the cold air leaking from the open sides. Some manufacturers have come up with double or triple air curtains to increase its effectiveness and efficiency. Some manufacturers claim being able to reach the efficiency of glass door cabinets through the implementation of advanced air curtain systems; Topten.eu observations at recent trade shows support that the most efficient open cabinets with advanced air curtain systems reach the efficiency of average glass door cabinets, although not yet of BAT model glass door cabinets.

4. **Water loop or remote systems**. In remote systems, the cold is “produced” centrally and transported throughout the cooling system to the connected appliances. In reverse, the waste heat is used in other areas such as room or water heating. A hybrid version for plug-in appliances exists in the form of water loop systems. While the appliances are integral, they are connected to a water system, that transports the waste heat to other parts of the building system where it can be used and loops the cold water back to the appliance. The disadvantage seen in this system by buyers is that the plug-in appliances lose their flexibility through the fixation in such systems, as generally the advantage of plug-in appliances in large stores with existing remote systems is their flexibility that allows them to be re-arranged weekly in accordance with weekly product offers.

5. **Green refrigerants**. The European F-Gas regulation [3] promotes the use of refrigerants with a low global warming potential in integrated and remote systems by phasing out high GWP refrigerants in several steps (e.g. ban on refrigerants with GWP above 150 by 2022 for integrated refrigeration cabinets). As a result, manufacturers of commercial and professional refrigerating appliances have started to switch from using refrigerants such as R404a with a GWP of 3,922 or R134a with a GWP of 1,430 to low GWP refrigerants such as R290 and R600a, both with a GWP of 3. A GWP of 3,922 means that R404a has about 1,300 times as much global warming potential as R290. As leakage is a widely common phenomenon in cooling systems [7], the use of green refrigerants significantly reduces the impact on the environment. Though not strictly related to the energy efficiency of a product, R290 and R600a are highly flammable HCs and as a result have long been restricted to 150g per cooling circuit for product safety. As multiple cooling circuits are expensive, manufacturers have aimed to make the most of the available refrigeration in single circuits, making the models often significantly more energy efficient than equivalent high GWP (non-flammable) refrigerant models with no refrigerant restrictions.

## Further B2B Categories

The current regulations for the B2B categories commercial and professional refrigerators cover the products with the highest market share. However, further categories also present significant saving potentials and could be considered for future energy regulation. E.g. refrigerated medicine cabinets can be found in every pharmacy, hospital and doctor’s office and are used to store medicines and vaccinations that need to be refrigerated. Especially under the current COVID-19 pandemic circumstances the number of refrigerated medicine cabinets on the market has likely increased significantly. Refrigerated medicine cabinets are different from other similar equipment, such as laboratory grade refrigerators and freezers, ultra-low temperature freezers, blood storage refrigerators or refrigerated plasma storage equipment, because they are set for different internal temperatures and are covered by different existing test standards. From professional refrigerated storage cabinets, refrigerated medicine cabinets differ mainly by the accuracy of the inside temperature setting between +2…+8°C and advanced warning systems, though the latter are regularly applied to storage refrigerators as well. Topten has compiled a study on refrigerated medicine cabinets on behalf of the Swiss Federal Office of Energy (SFOE) to identify data reliability and saving potentials [11].

In order to have comparable data, a common test method has to be selected. For refrigerated medicine cabinets, both EN 16825:2016 “Refrigerated storage cabinets and counters for professional use – Classification, requirements, test conditions” or DIN 58345:2007 “Refrigerators for drugs – Definitions, requirements, testing” could be considered. As EN 16825:2016 does not currently test for the accuracy of the pre-set inside temperature, something that is of vital importance for sensitive medicine and vaccinations, DIN 58345:2007 can be considered hitherto the best basis for a European test standard. No official European test standard has to date been defined or commissioned. A request to CEN-CENELEC is currently being prepared.

Comprehensive online research revealed 40 refrigerated medicine cabinets with declared energy consumption. Out of those declarations, 27 energy consumptions were declared according to DIN 58345:2007, while the rest did not specify the test method. In order to determine the efficiency of the products, an EEI value was calculated using the formula for EEI calculation for professional storage refrigerators. Where net volumes were not declared, a factor of 0.77 was applied to determine net volume, the average factor that corresponds to the ratio between gross and net volumes of appliances that declared both values. The available data is plotted in Figure 6. The resulting linear function is nearly horizontal.

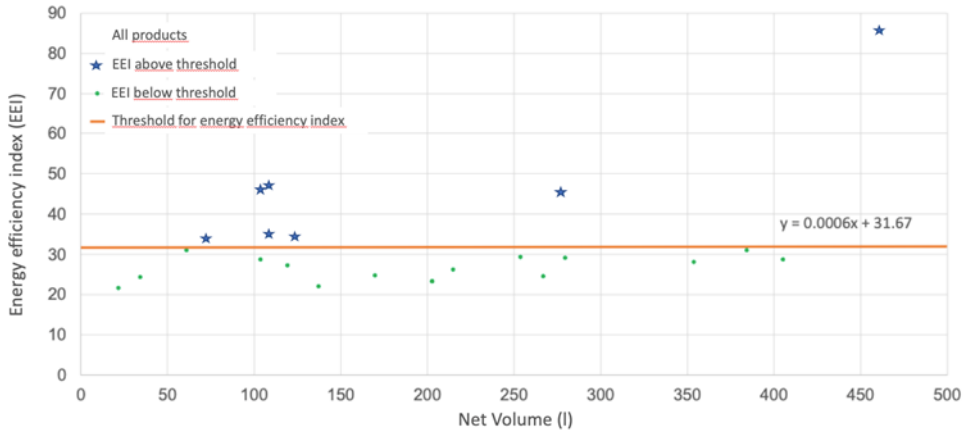



**Figure 6: EEI and net volume of the refrigerated medicine cabinets with declared energy consumption values. Data & Graph: Topten.ch**

In order to determine the saving potential of refrigerated medicine cabinets, a market average appliance has to be identified as reference. Taking into account that with no mandatory declaration, manufacturers of such appliances obviously only declare values for the most efficient products, however, no average market appliance could be derived from the collected data. In the absence of other options, an average model could be considered at the level where the EU preparatory study for professional refrigeration appliances set the standard model for storage refrigerators at EEI 100. As medicine cabinets are not yet part of the scope of current EU regulations, the positive developments shown for the development of the BAT segments for storage refrigerators cannot be assumed for medicine cabinets. Allowing for some transfer of efficient technologies and being extremely conservative, the market average appliance for refrigerated medicine cabinets is set at EEI 75 / class D. The criteria for the BAT market segment is set at EEI 35 in accordance with Figure 6 and the energy class threshold for storage refrigerators.

**Table 1: Calculating the saving potential of refrigerated medicine cabinets per year**

| | Average EEI | Average Volume | Average annual energy consumption |
|---|---|---|---|
| **Market average model** | 75 | 195 litres | 697 kWh/year |
| **Average BAT model** | 26 | 195 litres | 273 kWh/year |
| **Saving potential** | 49 | | 455 kWh/year |

Table 1 shows that the yearly saving potential of a medicine cabinet is 455 kWh or 6,825 kWh over the assumed product lifetime of 15 years that is communicated by manufacturers. That translates to saved energy costs of 1,365 € over the product lifetime (at an estimated price of 0.2€/kWh – real prices vary on a national level). As all estimates are very rough and extremely conservative, the true saving potential is likely a lot higher.

It has often been argued that energy efficiency cannot be applied to refrigerated medicine cabinets because it risks the safety of the content and consequently human health. However, the same argument was prominently made for refrigerated storage cabinets and food safety. The last five years have shown that even at highest efficiency of existing products (classes A and A+), food safety and performance are not negatively impacted at all. In addition, various methods of monitoring and warning systems are installed in case of a system failure – which is independent of high or low product efficiency. As such, with a test method that tests the performance of the refrigerated medicine cabinets as well as their energy consumption, there is no reason why the saving potentials of this growing category should not be realized.

## Conclusion

The energy regulations for professional storage and commercial display refrigerated appliances proved to be highly effective. Huge saving potentials have been realized on a technical level as demonstrated by the development of BAT models on the market and highly efficient models are moving into broad market spectrums instead of remaining small (and expensive) elite segments. The new energy labelling and ecodesign regulation for commercial display refrigerators with a direct sales function has triggered

a significant market development even before the new regulations coming into effect but especially after the coming into effect.

Further saving potential exists for commercial display refrigerators where the energy regulation is fairly recent and even average models have a saving potential of about 50% compared to best models on the market and for professional storage refrigerators despite the already impressive development of the last 6 years. Main contributing technical aspects towards appliance efficiency are compressors, insulation, quality doors or air curtains, remote systems and green refrigerants. Additional categories such as refrigerated medicine cabinets should be added to the scope of the regulations in order to optimize their impact.

Rebate programmes have proven to be highly effective policy tools to boost market transformation, resulting in less cost per kWh than the purchase price of the kWh would be. Of greater effect is the multiplier effect of rebate programmes, providing incentives to manufacturers to develop better technologies and to dealers to adjust their product range and highlight efficiency as important aspect in sales discussions.

In conclusion, energy labels and minimum requirements have proven to be effective tools on the B2B market, by giving innovative manufacturers an edge, dealers a new sales argument and investors the chance to make truly informed decisions.

## References


[1] Cool Products (2017). Why don't supermarket fridges have doors? Available at: https://www.coolproducts.eu/eu-ambition/why-dont-supermarket-fridges-have-doors/

[2] DG Grow (2021). Review study Ecodesign & EU energy label of Professional Refrigeration Products. Available at: https://ecoprorefrigeration.eu/documents.htm

[3] EC (2014). Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014R0517

[4] EU (2015). Commission delegated regulation (EU) 2015/1094 of 5 May 2015 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of professional refrigerated storage cabinets. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2015.177.01.0002.01.ENG

[5] EC (2019). Commission delegated regulation (EU) 2019/2018 of 11 March 2019 supplementing Regulation 2017/1369 of the European Parliament and of the Council with regard to the energy labelling of refrigerating appliances with a direct sales function. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R2018

[6] EC (2021). EPREL Product database. Available at: https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/product-database_en

[7] EIA (2021). Leaking Havoc – Exposing your Supermarket's Invisible Climate Pollution, "Climate-friendly Supermarkets". Available at: https://www.climatefriendlysupermarkets.org/leaking-havoc

[8] Geilinger, Eva (2015). Commercial and Professional Refrigeration Products: Promoting Energy Efficiency with Legislation, Empowered Stakeholders and Rebates. Available at: https://storage.topten.eu/source/files/EEDAL15_Eva_Geilinger_Commercial_and_Professional_Refrigeration_Products.pdf

[9] JRC (2014). Ecodesign for Commercial Refrigeration, Preparatory study update Final report. Available at: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/ecodesign-commercial-refrigeration-preparatory-study-update

[10] ProCold (2018). Appliance Testing Professional and Commercial Refrigeration Equipment. Available at:https://storage.topten.eu/source/files/Topten_Focus_201901.pdf

[11] Rochat, H., Bush, E. (2021). “5x Basics: efficient commercial equipment. Part: Commercial coffee makers”, Swiss Federal Office of Energy SFOE. Available at: https://pubdb.bfe.admin.ch/de/publication/download/10718

[12] Swiss Federal Office of Energie SFOE (2020), EnergieSchweiz Factsheet regarding the energy label for refrigerating appliances with a direct sales function in Switzerland. Available at: https://www.bfe.admin.ch/bfe/de/home/effizienz/energieetiketten-und-effizienzanforderungen/gewerbliche-geraete/kuehlgeraete-mit-direktverkaufsfunktion.exturl.html/aHR0cHM6Ly9wdWJkYi5iZmUuYWRtaW4uY2gvZGUvcHVibGljYX/Rpb24vZG93bmxvYWQvMTAwOTk=.html