Dr. Steinmaßl
MANAGEMENTBERATUNG

PRELIMINARY STUDY

PLUG-IN REFRIGERATED CABINETS IN FOOD RETAIL

STOCK – POWER CONSUMPTION – POTENTIAL SAVINGS

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ABOUT US

The consultancy portfolio of Dr. Steinmaßl MANAGEMENTBERATUNG covers five fields of business:

- **Business consultancy (strategy development & cost reduction)**
- **Coaching (if you would like to develop your personal profile)**
- **Business mediation (as a cost-effective form of conflict resolution)**
- **Occupational health and safety consultancy (to achieve greater legal certainty)**
- **Energy efficiency consulting (your insurance against rising energy costs)**

Our company provides energy consultancy services several hundred times every year and has the highest number of positive references in the KfW consultant database (beraterboerse.kfw.de) for the whole of Germany.

Dr. Steinmaßl MANAGEMENTBERATUNG takes a comprehensive 360 degree approach to energy consultancy. We look at five areas:

- **BUILDING ENVELOPE**
- **USE OF RENEWABLE ENERGY**
- **UTILITY ENGINEERING**
- **PROCESS TECHNOLOGY AND**
- **BEHAVIOUR-RELATED MEASURES**

from an energy perspective. We then develop practical energy-saving measures and concepts – and implement them with you as well if you wish.

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In recent years, Dr. Steinmaßl MANAGEMENTBERATUNG has recorded and evaluated the load profiles and power consumption of plug-in refrigerated cabinets from a large number of individual measurements. Reactions to the presentation of results have frequently ranged from incredulous disbelief to consternation and indignation. This study has been written for food retailers:

- **so that they are better placed to estimate the power consumption of their refrigerated cabinets;**
- **to give an indication of how great the range of the power consumption of plug-in refrigerated cabinets may be;**
- **to reduce the power consumption of plug-in refrigerated cabinets in stores;**
- **and to be able to estimate and take into account power consumption values in a more meaningful way when purchasing new plug-in refrigerated cabinets in the future.**

It is also a further contribution by Dr. Steinmaßl MANAGEMENTBERATUNG to the sustainable protection of our climate and environment.

Plug-in refrigerated cabinets are a fixed feature of food retail, as they bring numerous advantages[1]. In small stores and supermarkets, there are on average seven such units in use. In hypermarkets, the number of plug-in refrigerated cabinets goes up to from eight to eighteen units, depending on size. Discount stores on average have twenty-two units, primarily low temperature (LT) chest-type cabinets.

The high degree of variation in power consumption within individual groups of refrigerated cabinets was one surprising finding from our measurements. The costs per cubic metre of refrigerated volume and year can vary as follows:

Positive refrigeration (= medium temperature (MT) refrigeration)

- **Shelves, open:[2]** **€785/m³ to €3,567/m³**
- **Shelves, closed:** **€613/m³ to €1,385/m³**
- **Chests, open:** **€1,284/m³ to €6,303/m³**
- **Chests, closed:** **€212/m³ to €357/m³**

Negative refrigeration (low temperature (LT) refrigeration or negative refrigeration)

- **Chests, open with electric defrosting:** **Example measurement: €2,690/m³**
- **Shelves, closed without electric defrosting:** **€292/m³ to €2,178/m³**
- **Chests, closed with electric defrosting:** **€336/m³ to €3,554/m³**

If the costs of plug-in refrigerated cabinets are viewed over their entire life on the shop floor, it is clear that comparatively small amounts can add up to very considerable sums. One beverage refrigerator with just under 900 litre nominal volume over 10 years can cost around €3,100; a different refrigerator that is 360 litres smaller can cost €11,500. The decision to install an additional beverage refrigerator is often made in seconds, but can cost the store owner a total of €8,400 more than necessary. The additional cost represents a loss in available capital that is cumulative – and ultimately decides or at least partially determines a retailer's ability to compete. The situation for LT refrigerated chest freezers is similar. One chest with an approximate nominal volume of 645 litres over ten years can cost €5,700; a different chest with just 395 litres (almost 40% lower nominal volume) can cost €21,000 over ten years. That is an additional cost of around €15,000 – and surely an important reason to weigh up the pros and cons of different refrigerated cabinets.

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[2] A standard energy price of €0.18/kWh has been used throughout this study.

There are a number of ways to save energy with plug-in refrigerated cabinets:

- **Unplug unused chests immediately. Where applicable, gather products into one chest and shut down the chests that are emptied.**
- **Only refrigerate products where there are reasons for doing so.**
- **If the cost of work will pay off, clear out and disconnect chests at weekends.**
- **Set temperatures correctly and check them regularly; correct lower deviations of temperature in good time.**
- **Cover up open chests after closing time.**
- **Maintain the maximum fill levels.**
- **If possible, use weekly timers for MT refrigeration.**
- **Clean condenser fins regularly.**
- **Chests with large display surfaces can consume large amounts of power. If the cost/benefit ratio found to be unfavourable, these chests should be replaced with energy-efficient units.**
- **Select the location of refrigerated cabinets in your store carefully.**
- **Avoid units icing up.**
- **Pass on the costs of the power for promotion cabinets to food producers where applicable.**
- **Wherever possible and economically justifiable, immediately replace inefficient refrigerated cabinets with energy-efficient units.**
- **Energy efficiency tends to increase with the size of the refrigerated cabinet (more advantageous surface/volume ratio). This means that a smaller number of large refrigerated cabinets are preferable to a large number of small units for the same refrigerated volume.**
- **Switch off the lighting on or in refrigerated cabinets wherever possible after closing time.**

SUMMARY

Sweeping statements to the effect that plug-in refrigerated cabinets require more power than multicompressor solutions or that plug-in refrigerated cabinets heat the store because of the additional heat or that automatic defrosting is not available for plug-in LT chests are simply wrong – although they are frequently repeated in some of the specialist literature.

It is very probable that statements which were once completely valid in specific cases are now sweepingly applied without verification.

In fact, it is now the case that:

- **Energy-optimised high-efficiency plug-in refrigerated cabinets have lower or at least comparable power consumption when compared to the latest generation of multicompressor units.**
- **Energy-efficient LT chests only contribute to no more than 12% of the heat in a store at the maximum density of cabinets. Using energy-optimised, plug-in refrigerated cabinets does not mean that an air-conditioning system is needed in the store.**
- **Plug-in refrigerated cabinets with automatic defrosting are now standard technology and not an exception.**

The power consumption of plug-in refrigerated cabinets depends on a number of factors, some of which the manufacturers of refrigerated cabinets cannot control. Environmental conditions on site, maintenance, degree of use, the age of the refrigerated cabinets and the temperature settings are a few examples. Power consumption can rapidly double when such factors are combined. It is also always problematic to measure the power consumption of a refrigerated cabinet without taking into account the general conditions. We make the following recommendations:

- **Measure the power consumption of your plug-in refrigerated cabinets over three to four weeks. Use a meter (consider the accuracy of the meter and consult test reviews). Alternatively, you can employ someone else to measure and evaluate the power consumption.**
- **Calculate the power consumption over 12 months to get an overall indication (if you do not have an air conditioning, the energy consumption will be higher in summer than in winter).**
- **Calculate the refrigerated volume.**
- **Use our traffic light scale to rate the power consumption.**
- **Act immediately if the power consumption seems too high to you.**
- **We would be happy to answer your questions. Do not hesitate to call us.**

Please note:

Measuring a few refrigerated cabinets from a production series of several hundred or even thousands over a few weeks does not tell you about the entire series of units or the model family.

For example, refrigerated units were measured in food retail stores using exactly the same method. The measurements apply to the refrigerated cabinets measured and to the store, but cannot be applied to other stores or refrigerated cabinets.

Industry expertise

Dr. Steinmaßl MANAGEMENTBERATUNG brought together all its energy consultancy activities into a single dedicated business unit in 2008 because of the increasing volume of work. The company now provides energy consultancy services many hundreds of times per year and is therefore one of the largest energy consultants in Germany.

Aims & objectives

A remarkably large number of companies have no clear picture of the energy flows in their business. Estimates of the power consumption for individual refrigerated cabinets are sometimes out by a factor of 25. Incorrect estimates make it difficult or impossible to operate efficiently.

There is urgent need to change the perspective in food retail when it comes to energy management. Erich Kästner once said: “You can stand on a point, but you should not sit on it”.

In recent years, Dr. Steinmaßl MANAGEMENTBERATUNG has performed a large number of measurements on both the AC network (cooling compressors, ventilators etc.) and plug-in refrigerated cabinets. Almost all food retailers we have surveyed were unable to estimate the energy costs of their plug-in refrigerated cabinets and were surprised by the at times extremely high power consumption. The impact was so great that discussions with our clients would be interrupted briefly to unplug one or more particularly power-hungry refrigerated cabinets immediately.

This study has been prepared to remedy the apparent lack of information in food retail. The study should allow readers:

- **To estimate the power consumption of individual refrigerated cabinets more accurately in future.**
- **To get an idea of how great the range of the power consumption of plug-in refrigerated cabinets may be.**
- **To reduce the power consumption of refrigerated cabinets in a targeted manner.**
- **To apply realistic costs to their calculations.**
- **To place greater emphasis of power consumption ratings as a criterion when purchasing new refrigerated cabinets.**

Dr. Steinmaßl MANAGEMENTBERATUNG hopes that the study will bring the power consumption of plug-in refrigerated cabinets to the attention of retailers and thereby reduce power consumption significantly overall.

We consider the free distribution of this study in PDF and print as an additional contribution to active protection of the climate and environment.

[1] The term “plug-in refrigerated cabinets” includes medium temperature (MT) and/or low temperature (LT) refrigerated cabinets that contain all the equipment necessary to generate a (low/medium) refrigeration temperature within the cabinet.

Limits

Measuring plug-in refrigerated cabinets in stores and publishing the power consumption – will anything change?

Yes and no!

No, as measuring one refrigerated cabinet or a few refrigerated cabinets from a series of several hundred or thousands will not tell you about the entire series. One or more of the measured refrigerated cabinets may also be defective as measured. The power consumption of refrigerated cabinets is also not measured over an entire year, but only a few days or weeks and the power consumption measured over the period is then applied to calculate a figure for the year. There is therefore room for error, particularly in stores without air conditioning.

No, as numerous factors that refrigerated cabinet manufacturers cannot control can have a significant impact on power consumption. Air conditioning, drafts, store temperature, location, as well as temperature settings, servicing, maintenance and the age of the refrigerated cabinet all play an important role.

This study should not give the impression that there are good and bad refrigerated cabinets – or refrigerated cabinet manufacturers. Refrigeration units were measured over a short period using one and the same method in food retail as an example. The measurements therefore are valid for the refrigerated cabinets, the store and the period of measurement, but cannot – as already mentioned – be applied to other stores. We in no way are claiming that the measurements represent the typical levels of power consumption for the entire series of units or the group of models.

Yes, because it increases readers' awareness of the issue and the study shows in a striking fashion that there may be units in food retail that are simply burning money.

Yes, because inefficient refrigerated cabinets – if they are installed in large numbers and are used for significant periods – reduce competitiveness in the long term.

Yes, because measurements – even if they only apply to a specific store under the specific local conditions – show that the situation as identified could theoretically also be true of your store.

Some images of refrigerated cabinets lack the clarity of professional images and a number of rating plates have not been taken at the best angle. We should note that none of the images was planned for publication. They were taken solely for internal purposes. We therefore apologies in advance to the refrigerated cabinet manufacturers if a refrigerated cabinet is a few centimetres longer than measured by us. Minor deviations are possible, but do not have a significant impact on the performance figures.

METHOD OF INVESTIGATION

1

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1.1 Issues when determining power consumption

Determining the maximum power consumption of plug-in refrigerated cabinets that indicate the power consumption on a rating plate, e.g. 7.5 kWh/24 h, is straightforward. In this case (see figures below), the calculation is: 7.5 kWh/24 h · 365 d/year = 2,737 kWh/year. If the power consumption is only specified in Watts or Kilowatts, estimating the actual power consumption is significantly more difficult. In the refrigerated cabinet in our example, the rating was 400 Watt. The calculation is then as follows: 0.4 kW · 24 h/d · 365 d/year, so that the power consumption is then 3,504 kWh per year. Which value – 2,737 kWh/year or 3,504 kWh/year – is the actual consumption?

Figure 1: AHT LT refrigerated cabinet

Figure 2: AHT rating plate

Measurement showed that neither of the calculated values was equal to the actual power consumption. If the power consumption is monitored during the day, it can be seen that the refrigerated cabinet frequently cycles on and off. Cycling depends on various factors and is difficult to calculate.

A meter is the most meaningful way of determining the actual power consumption of plug-in refrigerated cabinets.

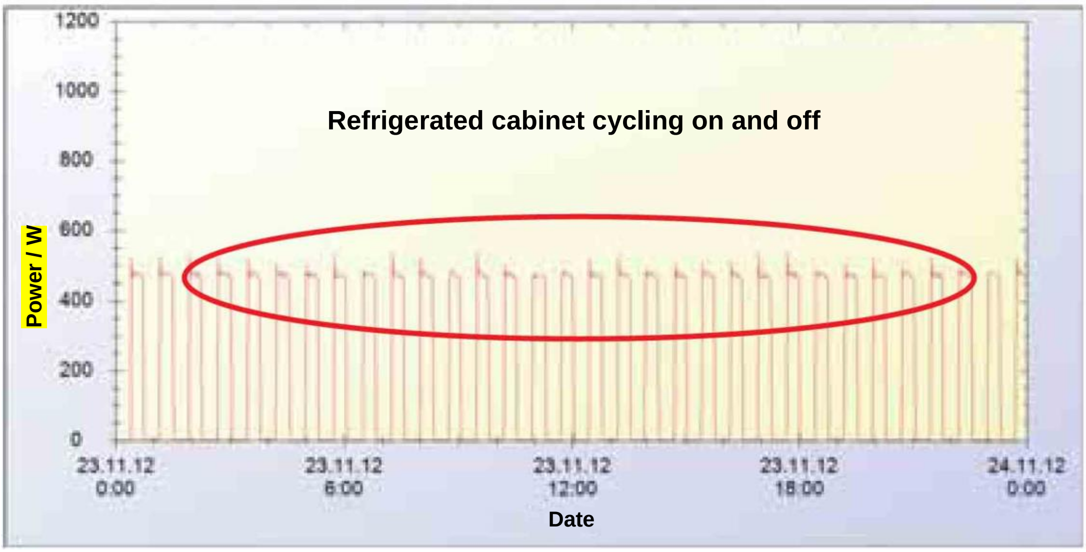

Figure 3: A refrigerated cabinet cycling on and off

1.2 Measurement classification scheme & method

The VOLTCRAFT ENERGY LOGGER 4000 was used to measure the load profile and the power consumption of the plug-in refrigerated cabinets.

Figure 4: Energy Logger [1]

Feature	For socket
Display	LCD
Display range	0,001 – 9,999 kWh
Operating voltage	230 V/AC
Active power range	1.5 – 3,500 W
Frequency	50 Hz
Active current range	0.01 – 15 A
Accuracy class	± (1% + 1 count)
Auxiliary consumption	1.8 W
Max. recording time	4,320 h
MID approved	No
Dimensions	(W x H x D) 164 x 82 x 83 mm
Weight	240 g
Model	ENERGY LOGGER 4000

Table 1: Energy Logger 4000 – Technical Data

Before commissioning, a battery was installed in the units and the basic parameters (unit ID, date and time) were set. The meter was then located between the plug and the electric unit, as per the instructions. It was operated via standard household earthed wall sockets.

The measurement data was evaluated using the EnergyLoggerViewer software provided. The same method of investigation was used for all units.

[1] Image source: Conrad Electronic, www.conrad.biz

1.3 Performance figures

Performance figures are required to be able to compare the power consumption of different plug-in refrigerated cabinets. The following figures are already known:

Specific power consumption of the store

$$\text{Specific power consumption per year [kWh/m}^2\text{]} = \frac{\text{Power consumption per year [kWh]}}{\text{Sales area [m}^2\text{]}}$$

This is generally applicable and widely used in food retail, depending on the density of refrigerated cabinets in the store, but does not provide a specific statement about the refrigerated cabinet.

Power consumption per expansion valve

As the performance per valve can vary by a factor of four, this measure of performance is in practice not particularly meaningful.

Specific power consumption per running metre of refrigerated cabinet (KM)

$$\text{Specific power consumption of RC per year } \left[\frac{\text{kWh}}{\text{run.m}}\right] = \frac{\text{Power consumption of the RC per year [kWh]}}{\text{Running metre of refrigerated cabinet [m]}}$$

The specific power consumption of the refrigerated cabinets per running metre is frequently used in practice provides usable guideline values. Compared to the performance measure “power consumption per refrigerated volume”, there are no disadvantages according to experts. Every operator of refrigerated cabinets can determine the efficiency of her refrigeration equipment using just a few details (running metre per refrigerated cabinet type/family and annual energy consumption of the refrigerated equipment/refrigerated cabinets). The following applies:

- **> 3,000 kWh per running metre per year: Excessive power consumption**
- **2,200 to 3,000 kWh per running metre per year: Average value**
- **< 2,200 kWh per running metre per year: Power consumption within the green range**

Power consumption per display surface (DS)

A further measure of performance for refrigerated cabinets is based on the display surface.

$$\text{Specific power consumption of display surface per year } \left[\frac{\text{kWh}\cdot\text{year}}{\text{m}^2}\right] = \frac{\text{Power consumption per year [kWh]}}{\text{Display surface [m}^2\text{]}}$$

The power consumption per display surface can be used to determine the power consumption of refrigeration equipment. This measure of performance and energy monitoring can be used to evaluate the power consumption values of a refrigeration system in food retail over its entire life cycle. The specific power consumption per display surface can be supplemented by various correction factors and then provide an even more accurate statement. The following are potential correction factors:

- **Climatic region**
- **Store opening times**
- **Refrigerated cabinet types/family**
- **Temperature classes of the refrigerated cabinets**
- **Air conditioning in the store**

A practical definition of the display surface should be consistent for open and closed cabinets:

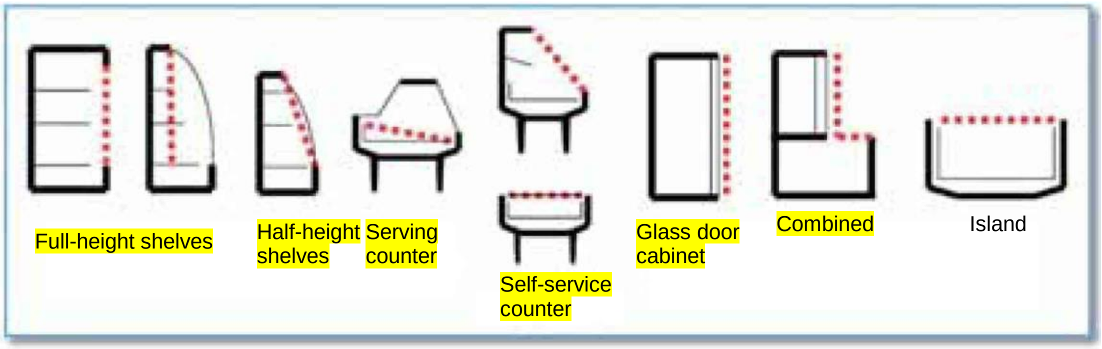

Figure 5: Determining display surfaces [2]

Specific power consumption per refrigerated volume

$$\text{Specific power consumption of the RC per year } \left[\frac{kWh}{m^3}\right] = \frac{\text{Power consumption of the RC per year [kWh]}}{\text{Refrigerated volume [m}^3\text{]}}$$

For this study, the specific power consumption per refrigerated volume was used as a reliable measure of performance.

1.4 Presentation of results

The measurement results were presented to our clients in three parts. The first part included the contact data of the store and described the refrigerated cabinets found in the store.

Unit name	
Store **Address** **Sales area**	
Refrigerated cabinet manufacturer	**Year of manufacture**
Design	**Model**
Power rating	**Refrigerant**
Power consumption	**Volume**
Interior dimensions (W/H/D)	**Temperature**

Figure 6: Part I: location of measurement (store) and description of the refrigerated cabinet

[2] See VDMA Energy Efficiency Working Group U-AK2 Supermarket/commercial refrigeration, refrigerated cabinets. Achieve transparency for energy-efficient supermarket refrigerated systems. “Round table” (VDMA Arbeitskreis Energieeffizienz U-AK2 Supermarkt-/Gewerbekälte, Kühlmöbel. Transparenz schaffen für energieeffiziente Supermarkt-Kälteanlagen. “Runder Tisch”), BMU Berlin, 8/10/09, Bernd Heinbokel

In the second block, the refrigerated cabinet is shown in images so that it could be identified again easily. The load profile in the short and long term was also recorded as a further important criterion of the refrigerated cabinet.

Rating plate	
Image 1 of the refrigerated cabinet	Image 2 of the refrigerated cabinet
Load profile of the refrigerated cabinet, overview	Load profile of the refrigerated cabinet, short-term observation

Figure 7: Part II, images

The third and last information block included the measurement period, the energy price, the annual projection and an assessment of the refrigerated cabinet. The duration of measurement and the annual projection are significant here. The duration of measurement indicates the number of days that the meter was measuring the power consumption of the refrigerated cabinet. The annual projection is the value measured during the measurement period extrapolated to one year. Increased power consumption values in the summer or reduced power consumption in the winter were not taken into account. To give the reader a better overview of the measurement conditions, the time of year has been noted for each measurement. A correction factor was deliberately not integrated, as seasonal influence can affect each model differently and significant variation is possible even within one model series. The intention is not to give an impression of accuracy that in fact does not exist.

The traffic light rating schema reflects performance measurement system typical in retail.

Calculation:			
From:		**Electricity price, net [€ / kWh]**	
To:		**Period of measurement [days]**	
Annual projection:			
Consumption		**Cost [€]**	
Specific consumption of the refrigerated cabinet			
Rating			

Figure 8: Part III, power consumption of the refrigerated cabinet

The above information is provided in the appendix to this study for refrigerated cabinets that were rated as energy efficient. Refrigerated cabinets rated as yellow and red have been anonymised.

PLUG-IN REFRIGERATED CABINETS IN FOOD RETAIL

2

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2 PLUG-IN REFRIGERATED CABINETS IN FOOD RETAIL

2.1 Retail categories

Stores in food retail are classified by size in various different ways. Following the system used by the EHI Retail Institute, Cologne, and the shop floor areas we encountered in practice, the following classification was used:

Classification of food retail stores by size	Sales area [m²]
Small stores (e.g. nah und gut (“close and good”))	< 400
Supermarket (e.g. aktiv markt (“active store”))	400 to 1,499
Small stores (e.g. neukauf (privately or centrally managed stores))	1,500 to 2,400
SB Centre (self-service stores)	> 2,500
Discount stores	210 to 1,200

Table 2: Classification of food retail stores by size

2.2 Plug-in refrigerated cabinets

2.2.1 Manufacturers/brands

Of the roughly 41,000 German food retails, Dr. Steinmaßl MANAGEMENTBERATUNG has only collected energy data for around 3%. The following breakdown is therefore not a representative cross-section of plug-in refrigerated cabinets in food retail, in particular as not all the business we visited could be included in this study. The ratings, however, are extensive enough to give an initial indication of the breakdown of plug-in refrigerated cabinets in German food retail.

In the case of plug-in low temperature refrigerated cabinets, our visits identified six different manufacturers in particular. The clear market leaders in this segment are AHT And Carrier/Linde [3]/Criosbanc.

There is significant more variety in the stores we visited when it came to positive refrigeration units. AHT and Carrier/Linde/Criosbanc have a particularly strong presence, followed in roughly comparable market shares by De Rigo, Costan, Frigorex, KUB Kunststoff- und Blechverarbeitung Burkhardt GmbH and KMW Kühlmöbelwerk Limburg GmbH.

[3] Linde: We are referring here to Linde Kältetechnik GmbH & Co. KG. In 1998, the remaining 20 percent of Linde AG was taken over by the Italian company, Criosbanc S. p. A. The refrigeration technology business unit was spun off from Linde AG in 2004 and transferred to “Linde Kältetechnik GmbH & Co. KG” and sold to the Carrier Corporation, an affiliate of United Technologies Corporation.

No.	Positive refrigeration units
01	AHT Cooling Systems GmbH
02	Bartscher GmbH
03	C.Bomann GmbH (Kühlschränke)
04	Caravell
05	UTC (Carrier / Linde / Criosbanc)
06	Cibin S.r.l.
07	Costan S.p.A. (Epta)
08	De Rigo Refrigeration srl
09	Dru International nv
10	Electrolux (Kühlschränke)
11	Framec S.p.a. (Eureka)
12	Frigorex S.R.L.
13	Heatcraft Kysor/Warren
14	Intercold
15	Isa S.p.a. und Tasselli
16	Iarp S.r.l. (Eureka)
17	KMW Kühlmöbelwerk Limburg GmbH
18	Kunststoff- und Blechverarbeitung Burkhardt GmbH
19	Liebherr
20	LTH Skofja Loka, D.O.O.
21	Oscartielle S.p.a.
22	Rivacold
23	Tecfrigo S.p.a.
24	True Manufacturing Co.
25	Vestfrost (Kühlschrank)
26	26 Viessmann (MT cells)
27	Zoin Refrigerazione S.r.l.

Table 3a: Refrigerated cabinet brands in food retail in alphabetical order (positive refrigeration units)

No.	Low temperature refrigeration units
01	AHT Cooling Systems GmbH
02	Caravell
03	Carrier / Linde
04	04 Esta (Eureka GmbH & Co. KG)
05	Isa S.p.a.
06	Liebherr

Table 3b: Refrigerated cabinet brands in food retail in alphabetical order (low temperature refrigeration units)

2.2.2 Plug-in refrigerated cabinets by size of store

	Small stores < 400 m² sales area	Supermarket 400 m² to 1.500 m² sales area	Small hypermarket 1,500 m² to 2,500 m² sales area	Large hypermarket > 2,500 m² sales area	Discount stores 200 m² to 1.200 m² surface area
Number of refrigerated cabinets	7.5	7.2	8.1	18.0	22.3
Percentage of LT units [%]	68.3	40.9	37.0	23.3	87.3
Percentage of MT units [%]	31.7	59.1	63.0	76.7	12.7

Table 4: Plug-in refrigerated cabinets by size of store in food retail

On average, 7.5 plug-in refrigerated cabinets per store are used in small stores with up to 400 m² sales area. Around two thirds are LT chests. That is not surprising, as at this size of store traditional refrigeration units (single systems or multicompressors) are frequently not used. The significantly larger supermarkets have the lowest density of plug-in refrigerated cabinets, as at this size of store LT and MT multicompressor units are the norm. The ratio of LT: MT is approximately 40: 60. Small consumer stores are hardly different from supermarkets in terms of the number of plug-in refrigerated cabinets. The comparatively large number of plug-in refrigerated cabinets in larger consumer stores is a consequence of the larger shop floor area. At this size of store, the focus is clearly on mobile cabinets with promotional chests in the MT range.

The discount stores visited by Dr. Steinmaßl MANAGEMENTBERATUNG are the leaders with 22.3 plug-in refrigerated cabinets per location. Almost 90% are LT units at this size of store.

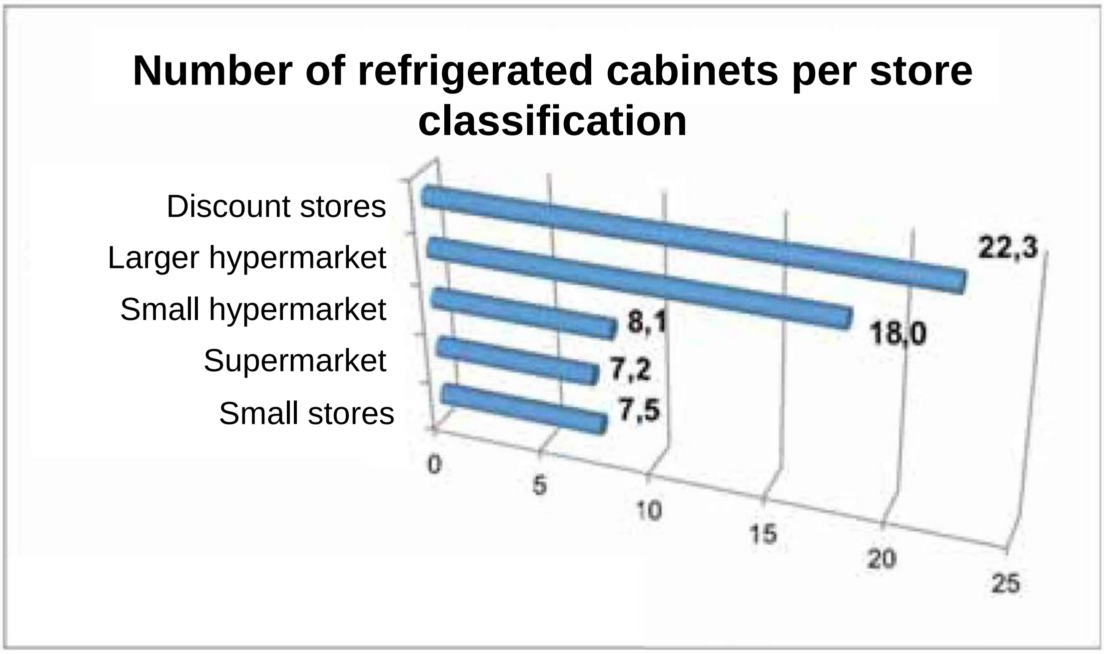

Figure 9: Number of refrigerated cabinets by size of store in food retail

The following charts show the percentages of plug-in refrigerated cabinets by size of store.

Small stores

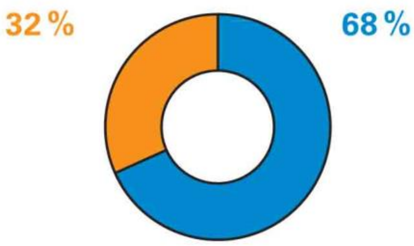

Figure 10: Percentages of LT/MT units in small stores

Supermarket

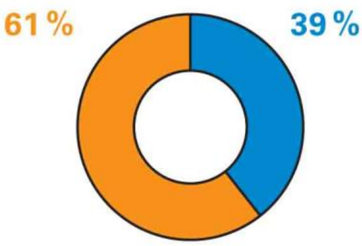

Figure 11: LT/MT distribution in supermarkets

Small hypermarket

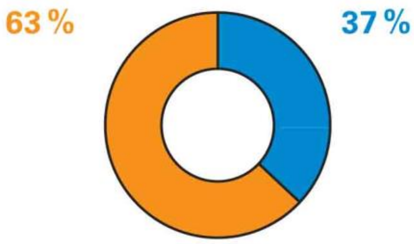

Figure 12: Percentages of LT/MT units in small hypermarkets

Large hypermarket

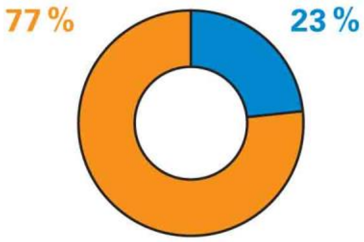

Figure 13: Percentages of LT/MT units in large hypermarkets

Discount stores

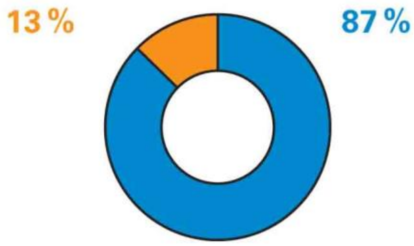

Figure 14: Percentages of LT/MT units in discount stores

Key:

MT (positive temperature refrigerated cabinets)
LT (negative temperature refrigerated cabinets)

EVALUATION OF RESULTS

3

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The measurement classification scheme and the power consumption values for all refrigerated cabinets are listed in the appendix in catalogue format. The results are presented in summary only on the following pages.

The following classification scheme was used to classify the plug-in refrigerated cabinets for power consumption purposes:

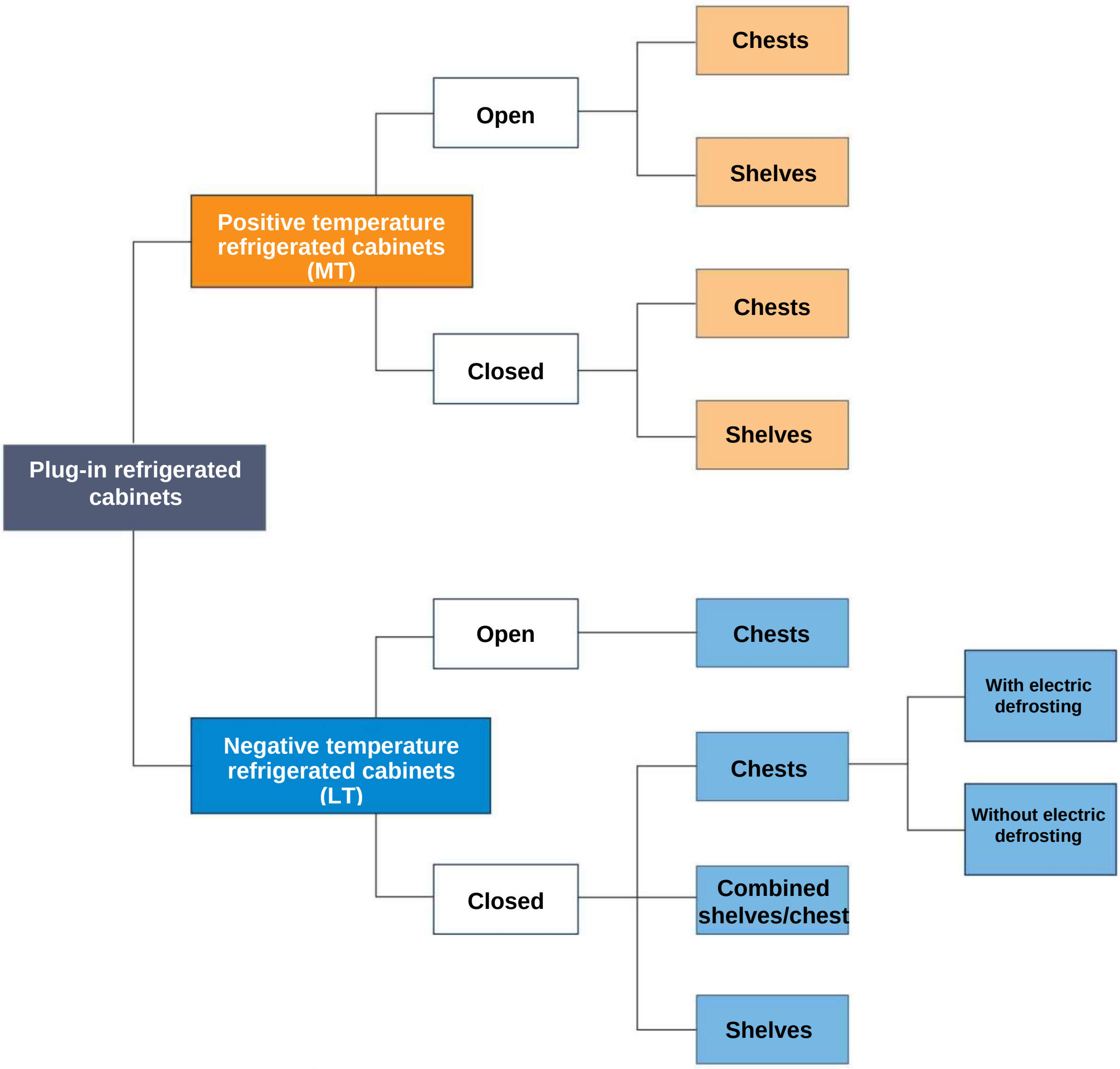

Figure 15: Plug-in refrigerated cabinet classification scheme

As the number of samples was limited, some categories in the main body of the study are not broken down explicitly. Please refer to the appendix in these cases. For example, only one open LT chest was measured to get a rough indication of the power consumption of this category of chests. As such chests are in our experience steadily being taken out of service in food retail, further measurements were not performed.

A traffic light system has proved successful for rating refrigerated cabinets.
Green: Power consumption less than 4,000 kWh/m³ per year, good/very good
Yellow: Power consumption between 4,000 kWh/m³ per year and 8,000 kWh/m³ per year, average
Red: Power consumption more than 8,000 kWh/m³ per year, excessive

3.1 Overview of positive temperature refrigerated cabinets, closed

Rating[4]	No.	MT refrigerated shelves, closed	Number of measurements	Consumption kWh/m³ per year	Cost[5] €/year
Good	1	True GDM-37	2	$\bar{x}$ = 3,404	613.00
	2	Frigorex-FVS1200	2	$\bar{x}$ = 3,625	653.00
	3	Liebherr Megacooler	2	$\bar{x}$ = 3,689	664.00
Average	4	H01M01	2	$\bar{x}$ = 4,274	769.00
	5	H02M01	1	4,540	817.00
	6	H03M01	1	4,792	863.00
	7	H01M02	1	6,041	1,087.00
	8	H04M01	1	6,727	1,211.00
	9	H05M01	3	$\bar{x}$ = 7,693	1,495.00

Table 5: Overview of the power consumption of MT refrigerated shelves, closed

The power consumption values for the True GDM-37, the Frigorex-FVS 1200 and the Liebherr Megacooler refrigerated shelves were very good. The highest consumers in the closed shelf segment are the H05M01 and H04M01.

There is a tendency for refrigerated cabinets with a lower refrigerated volume to have higher specific power consumption.

No.	MT refrigerated shelves, closed	Number of measurements	Refrigerated volume [l]	Consumption kWh/m³ per year
1	True GDM-37	2	892	$\bar{x}$ = 3,404
2	Frigorex-FVS1200	2	903	$\bar{x}$ = 3,625
3	Liebherr Megacooler	2	326	$\bar{x}$ = 3,689
4	H01M01	2	335	$\bar{x}$ = 4,274
5	H02M01	1	482	4,540
6	H03M01	1	500	4,792
7	H01M02	1	292	6,041
8	H04M01	1	374	6,727
9	H05M01	3	530	$\bar{x}$ = 7,693

Table 6: MT refrigerated shelves, closed, volume and power consumption

4 These and the following ratings from good to poor apply only to the refrigerated cabinets measured in the applicable stores and do not reflect the power consumption of the series.

5 A standard energy price of €0.18/kWh has been used throughout this study.

Figure 16: True GDM-37

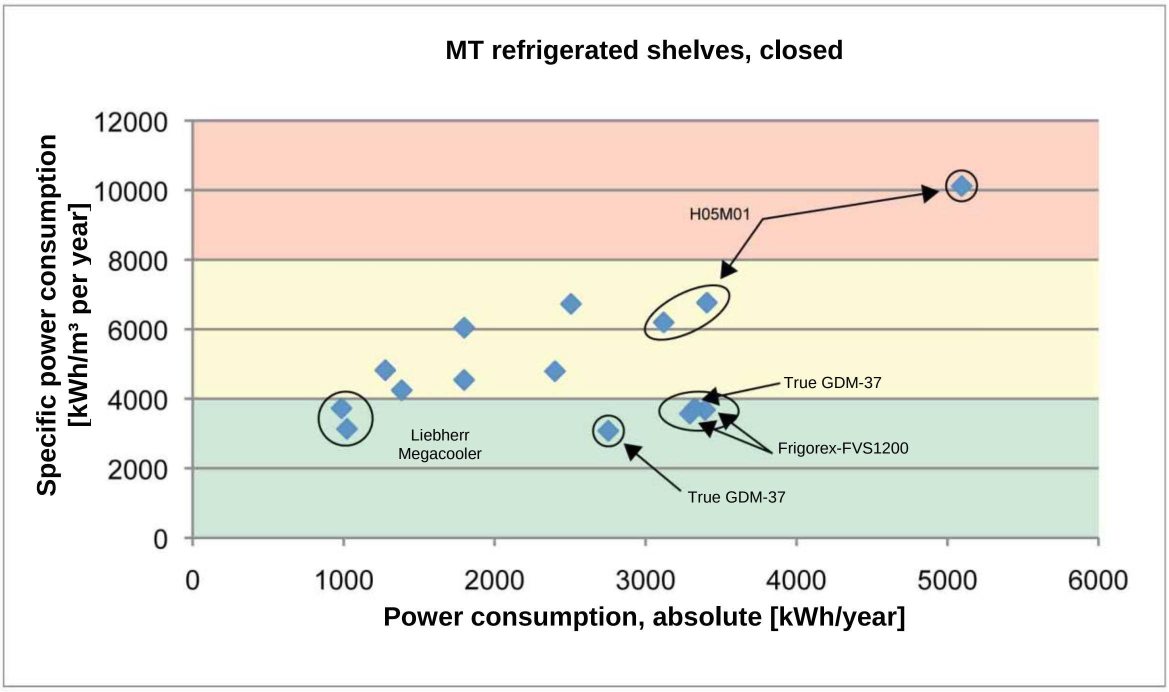

Figure 17: Overview of the power consumption of MT refrigerated shelves, closed

3.2 Overview of positive temperature refrigerated cabinets, open

3.2.1 MT refrigerated shelves, open

Rating	No.	MT refrigerated shelves, open	Number of measurements	Consumption kWh/m³ per year	Cost €/year
Average	1	H06M01	1	4,360	785.00
	2	H07M01	2	$\bar{x}$ = 5,024	904.00
	3	H08M01	1	5,062	911.00
	4	H07M02	1	6,484	1,167.00
	5	H05M02	3	$\bar{x}$ = 8,051	1,449.00
	6	H07M03	2	$\bar{x}$ = 9,397	1,691.00
	7	H05M03	1	16,860	3,035.00
Poor	8	H09M01	3	$\bar{x}$ = 19,815	3,567.00

Table 7: Overview of power consumption for MT refrigerated shelves, open

In the open refrigerated shelving segment, none of the measured units had good or very good power consumption values. The H09M01 and the H07M03 both have exceptionally high values. The H05M02 and H05M03, however, are also the red.

In the H05M02 model range, some units were identified with a power consumption of more than 6,000 kWh/m³ per year refrigerated volume; in contrast, the power consumption scale for closed beverage refrigerators begins at around 900 kWh/m³ per year refrigerated net volume. On the basis of conservative calculations, the closed beverage refrigerators have power consumption that is two to three times lower.

In particular, comparatively small beverage refrigerators (H05M03, H09M01, H07M03) have excessively high power consumption values when calculated per cubic metre of refrigerated volume, because of their poor volume/surface area ratio. This class of units appears to be particularly inefficient in terms of energy consumption.

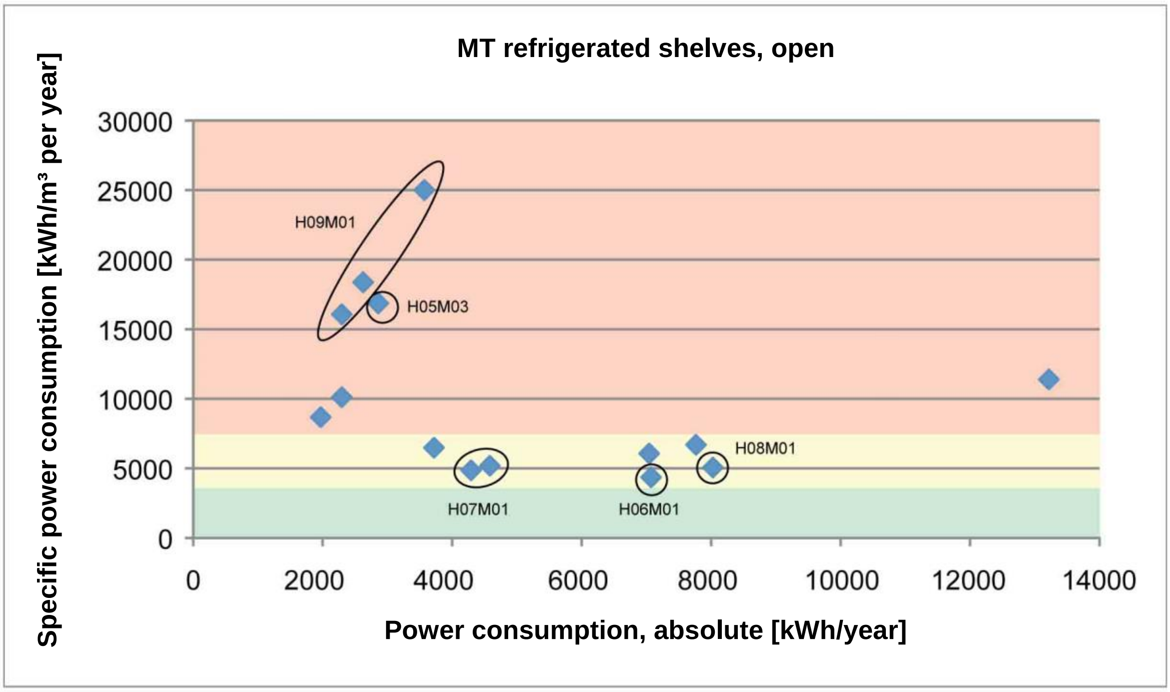

Figure 18: Power consumption of MT refrigerated shelves, open

3.2.2 MT refrigerated chests, open

Rating	No.	MT refrigerated chests, open	Number of measurements	Consumption kWh/m³ per year	Cost €/year
Average	1	H07M04	3	$\bar{x}$ = 7,133	1,284.00
	2	H09M02	2	$\bar{x}$ = 7,138	1,285.00
	3	H10M01	1	7,794	1,403.00
	4	H11M01	5	$\bar{x}$ = 11,677	2,102.00
	5	H12M01	6	$\bar{x}$ = 13,392	2,411.00
	6	H09M03	2	$\bar{x}$ = 16,170	2,911.00
	7	H12M02	5	$\bar{x}$ = 16,178	2,912.00
	8	H08M02	1	17,466	3,144.00
	9	H06M02	1	18,591	3,346.00
	10	H08M03	1	19,266	3,468.00
	11	H13M01	4	$\bar{x}$ = 21,384	3,849.00
	12	H07M05	1	22,194	3,995.00
	13	H08M04	7	$\bar{x}$ = 23,433	4,218.00
Poor	14	H14M01	2	$\bar{x}$ = 35,018	6,303.00

Table 8: Overview of the power consumption of MT refrigerated chests, open

As was the case for open refrigerated shelves, no energy-efficient unit was identified in the group of open refrigerated chests. It would be useful at a later date to supplement the study with refrigerated chests of the latest range from 2012/2013.

Figure 19: Example of an MT chest, open

Figure 20: Example of an MT promotion chest

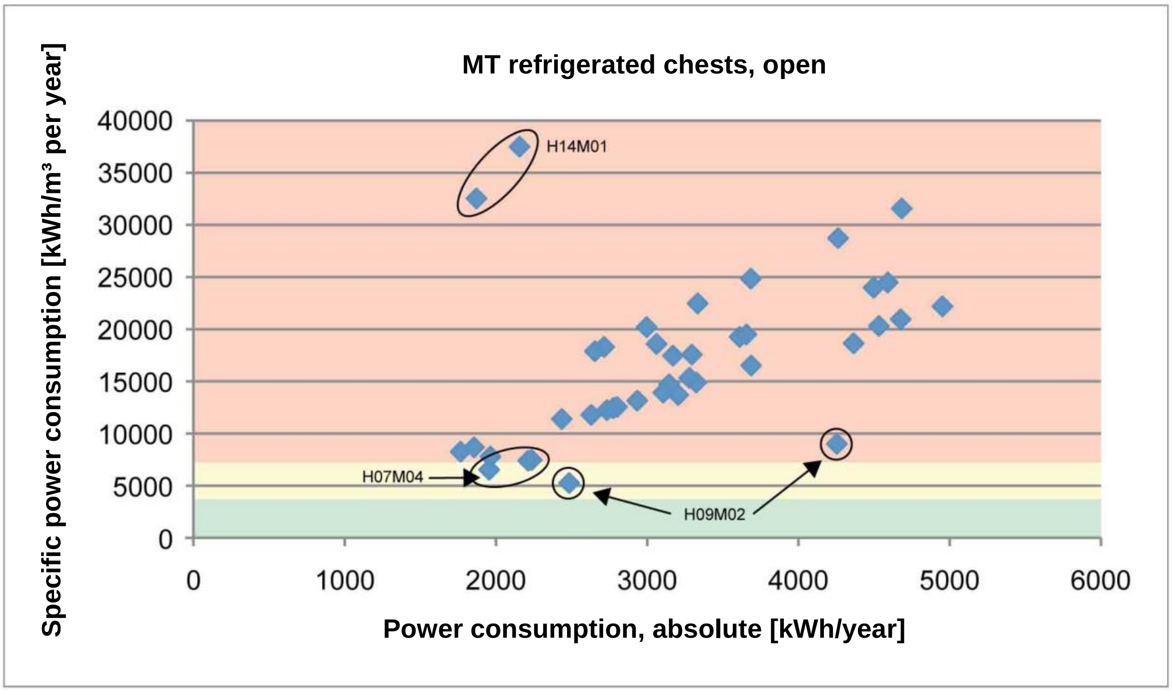

Figure 21: Power consumption of refrigerated chests, open

3.3 Overview of minus temperature refrigerated cabinets, closed

3.3.1 LT chests without electric defrosting

Rating	No.	LT chests without electric defrosting	Number of measurements	Consumption kWh/m³ per year	Cost €/year
Good	1	Liebherr GTE 3702	1	1,620	292.00
	2	AHT GTX 87 SGHL	6	$\bar{x}$ = 1,826	329.00
	3	AHT Salzburg 83/175 (–)	2	$\bar{x}$ = 2,506	451.00
	4	AHT Rio S 150	4	$\bar{x}$ = 2,642	476.00
	5	AHT GTX 89 SGHL	8	$\bar{x}$ = 2,649	477.00
	6	AHT Salzburg 83/210 (–)	7	$\bar{x}$ = 2,700	486.00
	7	AHT Rio H 125	2	$\bar{x}$ = 3,374	607.00
	8	AHT GTX 47 SG	1	3,672	661.00
	9	Nordcap CX 45	2	$\bar{x}$ = 3,754	676.00
	10	AHT Malta 145 (–)	2	$\bar{x}$ = 3,765	678.00
	11	AHT Wien 200 (–) [L]	1	3,780	680.00
	12	H15M01 [L]	1	4,183	753.00
	13	H01M03	1	4,230	761.00
	14	H15M02 [L]	2	$\bar{x}$ = 4,448	801.00
	15	H15M03	1	5,069	912.00
	16	H15M04	1	5,083	915.00
	17	H16M01	1	5,648	1,017.00
	18	H01M04	1	9,776	1,760.00
	19	H17M01	1	12,057	2,170.00
Poor	20	H17M02	1	12,102	2,178.00

Table 9: Overview of the power consumption of LT chests without electric defrosting

Key:

[L] = Interior lighting installed.

To be able to compare the chests approximately, the power consumption of the lighting – where applicable – was deducted from the total power consumption of the chests. However, that does not alter the fact that the contribution of heat to chests with internal lighting is permanent and high, whether or not the contribution slightly more (T8 KVG)[6]or less (LED)[7]. The contribution of heat has to be compensated by additional refrigeration. The power consumption is therefore higher as a consequence. The affected chests are marked with [L] to indicate this factor.

[6] T8 KVG = fluorescent lamp, type T8 (26mm diameter) with conventional ballast

[7] LED = light emitting diode

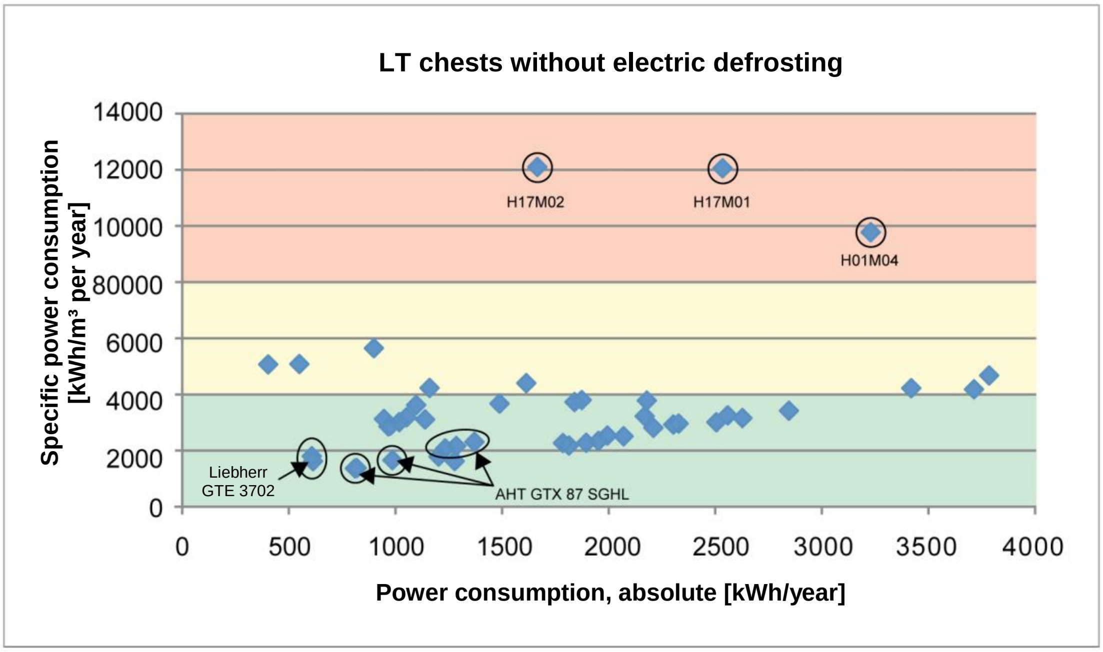

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Figure 22: Power consumption of LT chests without electric defrosting

The LT chests without electric defrosting are mostly very energy-efficient. The overview shows clearly that many chests require between 1,600 kWh/m³ per year and 4,000 kWh/m³ per year. From rank 18, there is a significant fall in energy efficiency. The H01M04 and the two H17M01/H17M02 chests have power consumption of from 9,700 kWh/m³ per year to 12,100 kWh/m³ per year and are therefore the only chests in the red.

Figure 23: AHT GTX 87 SGHL

Figure 24: AHT Rio S 150

3.3.2 LT chests with electric defrosting

Rating	No.	LT chests with electric defrosting	Number of measurements	Consumption kWh/m³ per year	Cost €/year
Good	1	AHT Athen 210 XL	2	$\bar{x}$ = 1,869	336.00
	2	AHT Miami 185 (–)L VSAD	3	$\bar{x}$ = 2,489	448.00
	3	AHT Miami 210 (–)L VSAD	6	$\bar{x}$ = 2,835	510.00
	4	H09M04	2	$\bar{x}$ = 9,696	1,745.00
	5	H09M05	1	12,144	2,186.00
	6	H09M06	1	12,502	2,250.00
	7	H09M07	3	$\bar{x}$ = 13,572	2,443.00
	8	H09M08	3	$\bar{x}$ = 17,572	3,163.00
Poor	9	H07M06	4	$\bar{x}$ = 19,745	3,554.00

Table 10: Overview of the power consumption of LT chests with electric defrosting

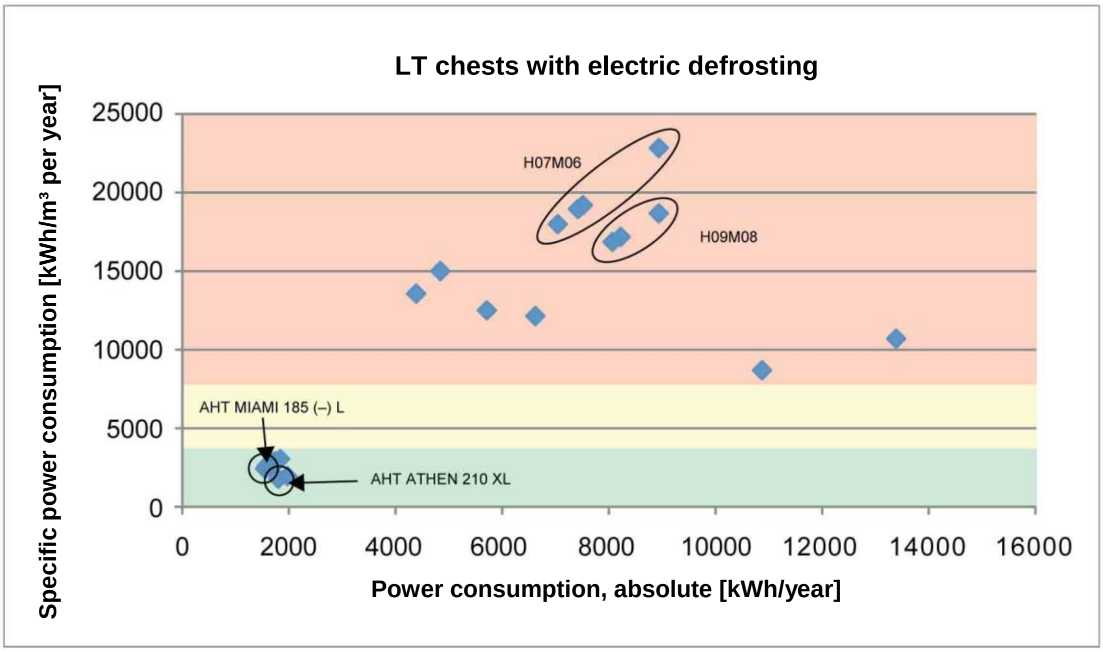

Figure 25: Power consumption of LT chests with electric defrosting

Many readers will find the measurement results difficult to believe or suspect they are incorrect. It is nonetheless a fact that the range of power consumption for plug-in refrigerated cabinets with electric defrosting is from 1,800 kWh/m³ per year refrigerated volume to 19,700 kWh/m³ per year. The higher figure is almost eleven times greater! At first glance, the AHT units appear to be the dream units and the H09/H07 units would seem to be the worst possible. However, the following should be taken into account:

- **With the exception of the H09M05 and the H09M06, all H09/H07 units have a significantly larger display surface (glazed surface).**
- **The AHT units are the latest generation of chests, i.e. from 2012 and since, whereas the H09/H07 chests date from 2008 or before according to the rating plates.**
- **The interior lighting is around 55 Watts for the AHT chest and 144 Watts for the H07M06 according to the rating plates (see appendix).**
- **The measurements only give an unrepresentative cross-section of the chests available in the stores. It was not possible to compare product families or old and new generations of units.**
- **The installed technologies are not comparable. For example, there is a major difference in terms of energy if a chest is defrosted several times a day or just twice a week.**
- **There are single, illustrative measurements (as for all the other refrigerated cabinets).**

In the current instance, the larger display surface areas seem to cause a increase in power consumption of around 7,000 kWh – equivalent to around €1,260 per year and chest. The power consumption is only justifiable in economic terms if the larger display surface areas lead to sufficient increase in turnover. Of course, that is without considering the environmental issues. Where stores have limited space (no advantage to having more glass area), energy-efficient chests are also more beneficial from an economic perspective.

Figure 26: AHT Athen

Figure 27: AHT Miami

3.4 Overview of power consumption and costs

Range of power consumption in closed LT chests with electric defrosting

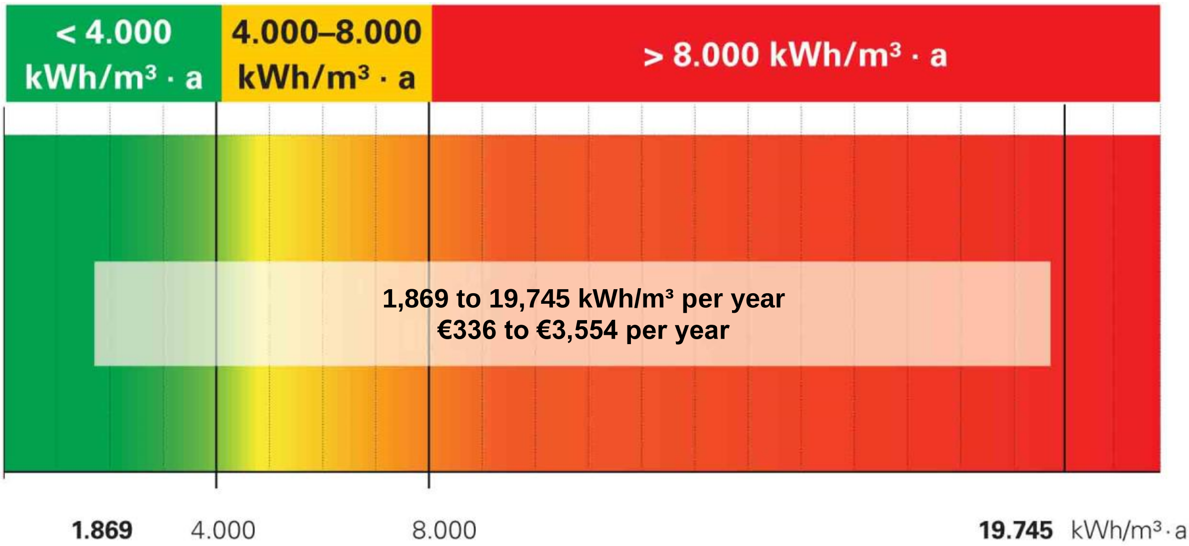

Figure 28: Power consumption of LT chests with electric defrosting

As in all refrigerated cabinets, a certain range of power consumption is to be expected within one types of refrigerated cabinet, as well as among structurally identical units. However, the fact that one cubic metre refrigerated volume in LT chests with electric defrosting can cost from €336 to €3,554 is surprising.

Type of refrigerated cabinet	Consumption [kWh/m³ per year]		Consumption [€/m³ per year]		Range
	from	to	from	to	Factor
MT shelves, open	4,360	19,815	785	3,567	4.5
MT shelves, closed	3,404	7,693	613	1,385	2.3
MT chests, open	7,133	35,018	1,284	6,303	4.9
MT chests, closed	1,179	1,983	212	357	1.7
LT shelves, closed	- – -	9,123	- – -	1,642	- – -
LT combination shelf/chests	- – -	14,268	- – -	2,568	- – -
LT chests, open with electric defrosting	- – -	14,947	- – -	2,690	- – -
LT chests, closed without electric defrosting	1,620	12,102	292	2,178	7.5
LT chests, closed with electric defrosting	1,869	19,745	336	3,554	10.6

Table 11: Power consumption and costs of plug-in refrigerated cabinets

LIFE CYCLE COSTS

4

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4 LIFE CYCLE COSTS

The following calculations are intended to give a rough overview of the life-cycle costs of different plug-in refrigerated cabinets.

ASSUMPTIONS:

Purchase price:

Average purchase costs have been used for this calculation.

- **Beverage refrigerators: €1,000 (strongly dependent on size)**
- **Ice-cream chest, small: approx. €500 to €800**
- **LT chest: €2,000 to €3,000**

Life cycle:

The life cycle depends on a number of factors. For example, major buyers replace plug-in refrigerated cabinets at the end of warranty after 4 to 6 years as part of fleet maintenance. These refrigerated cabinets are then generally brought back into food retail as used units, so that the actual life cycle is significantly longer. We have regularly seen refrigerated cabinets that have been in stores for upwards of 15 years. To stay on the conservative side and to give an idea of the cost that is as realistic as possible, but that should not simulate higher costs, we have assumed a **life cycle of 10 years**.

4.1 MT refrigerated shelves, closed

A total of 17 measurements were performed on closed MT refrigerated shelves. The life-cycle costs of the refrigerated shelf unit with lowest consumption, the shelf unit with highest consumption and two refrigerated shelves from the upper and mid ranges were compared as an example. This approach was taken to present clearly the worst case scenario in the actual store. The calculations were not adjusted to take into account the difference in storage volume, as the aim was to identify the costs actually incurred by the store.

Key:

Wherever possible, the net volume has been stated. Where that has not been possible, the gross volume has been given instead.

G = gross volume/gross capacity

N = net volume/useful volume/storage volume

The following figure shows the acquisition costs and the energy costs (based on 0.18 €/kWh) at a 3% annual rate of increase in energy prices.

Energy discounts have not been taken into account, as in each case there is one beverage refrigerator in the store and there comparison is only between more and less economical units.

Costs of beverage refrigeration shelves, cumulative in €				
Volume	892 l	500 l	903 l	530 l
Energy	773 kWh/year	2,400 kWh/year	3,293 kWh/year	5,094 kWh/year
Year	RC A	RC B	RC C	RC D
0	1,500.00	1,000.00	1,500.00	1,000.00
1	1,639.14	1,432.00	2,092.74	1,916.92
2	1,782.45	1,876.96	2,703.26	2,861.35
3	1,930.07	2,335.27	3,332.10	3,834.11
4	2,082.11	2,807.33	3,979.80	4,836.05
5	2,238.71	3,293.55	4,646.94	5,868.05
6	2,400.01	3,794.35	5,334.09	6,931.01
7	2,566.15	4,310.18	6,041.85	8,025.86
8	2,737.28	4,841.49	6,770.84	9,153.56
9	2,913.54	5,388.73	7,521.71	10,315.09
10	**3,095.08**	**5,952.40**	**8,295.10**	**11,511.46**

Table 12: Life cycle costs of MT refrigerated shelves, absolute values

Key:

Year 0 = investment costs

RC = refrigerated cabinet

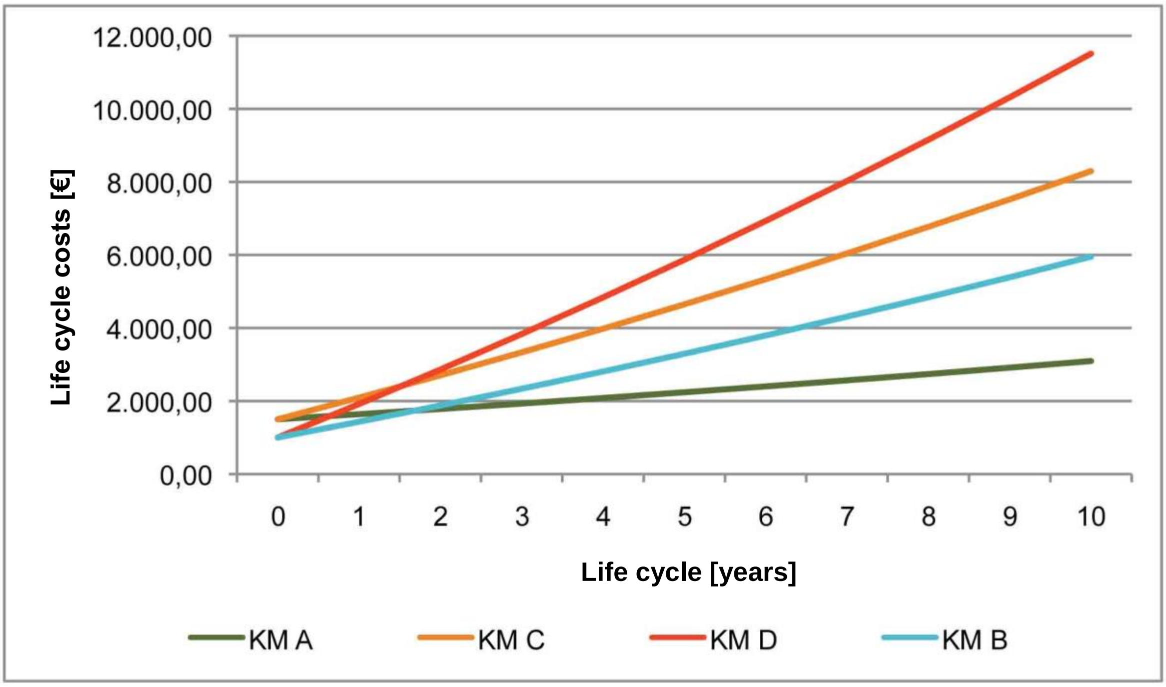

Figure 29: Life cycle costs of beverage refrigeration shelves, closed

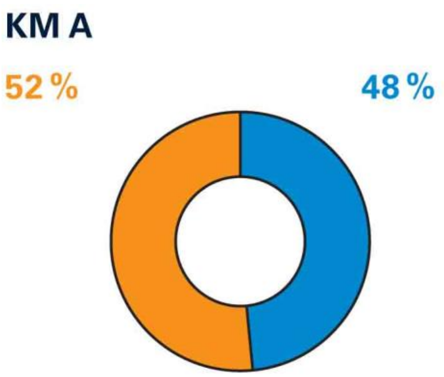

Figure 30: Percentage distribution of costs RC A

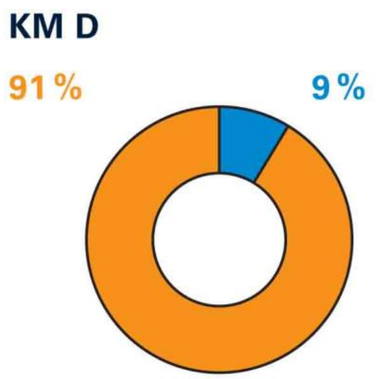

Figure 31: Percentage distribution of costs RC D

Key: Energy Investment

As the above figures and the table show, the energy costs – depending on the power consumption of the refrigerated cabinet – can range from 52% (RC A: €1,595) to 91% (RC D: €10,511) of the total costs. The additional energy costs of the RC D over the ten-year life of the refrigerated cabinet are around €8,900 higher than those of the RC A beverage refrigerator (which also has a significantly larger storage volume). Assuming there are two beverage refrigerators in the store, the loss of liquidity may add up to almost €18,000, even if they are closed.

4.2 LT refrigerated chests, closed, without electric defrosting

In this example, the life-cycle costs of a very energy-efficient refrigerated cabinet RC E from our series of measurements are compared with the RC F that has less favourable consumption. It is worth noting that the energy-efficient RC E has roughly 30% more storage volume than the RC F refrigerated cabinet.

	RC E		RC F	
	Costs [€]	Proportion of the cost [%]	Costs [€]	Proportion of the cost [%]
Investment	800.00	46	800.00	13
Energy	951.27	54	5,224.78	87
Total	1,751.27	100	6,024.78	100

Table 13: Cost structure of the RC E and RC F over a 10-year period

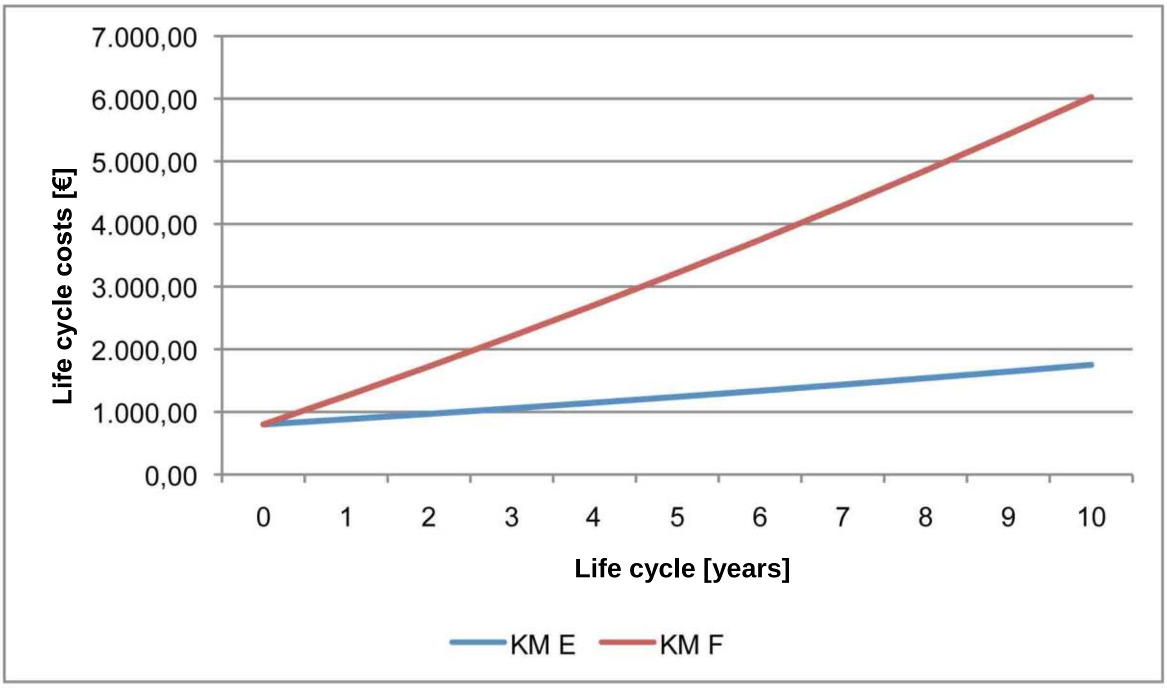

Figure 32: Life cycle costs of LT chests, closed

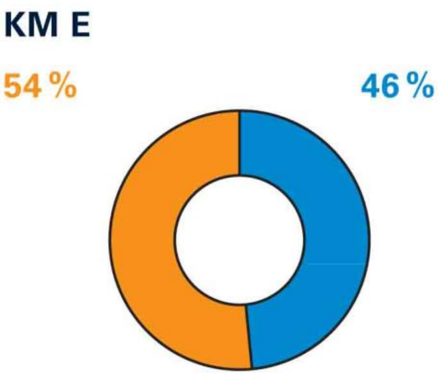

Figure 33: Percentage distribution of costs RC E

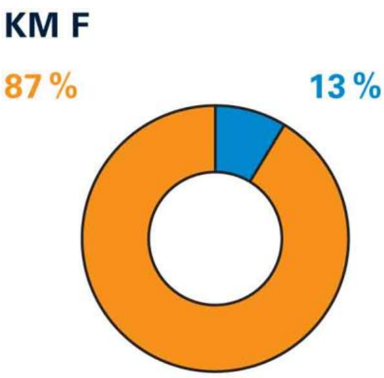

Figure 34: Percentage distribution of costs RC F

Key: Energy Investment

The above example shows that several thousand Euros can be saved over the life of a unit even for comparatively small chests.

4.3 LT chests, closed, with electric defrosting

This example similarly compares an energy-efficient refrigerated cabinet with refrigerated cabinet with less favourable power consumption (the RC G compared with the RC H).

The energy-efficient refrigerated cabinet G has almost 40% more storage volume than that RC H.

	RC G		RC H	
	Costs [€]	Proportion of the cost [%]	Costs [€]	Proportion of the cost [%]
Investment	2,500	44	2,500	12
Energy	3,223	56	18,576	88
Total	5,723	100	21,076	100

Table 14: Cost structure of the RC G and the RC H over 10 years

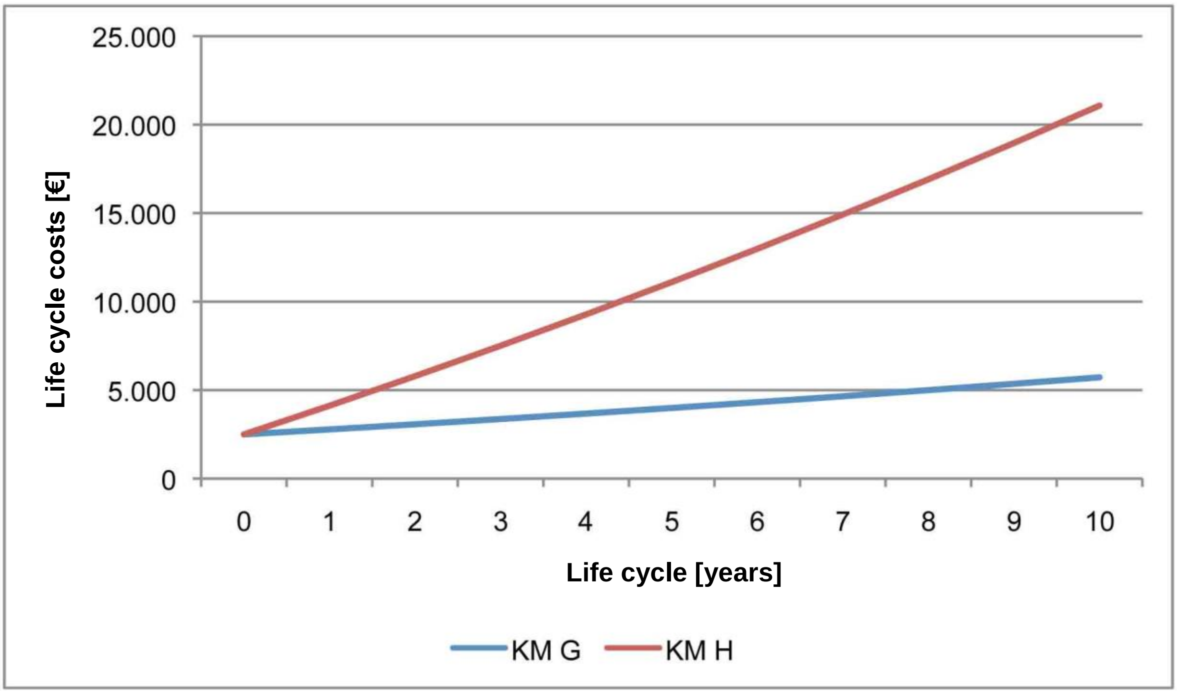

Figure 35: Life cycle costs of LT chests, closed, with electric defrosting

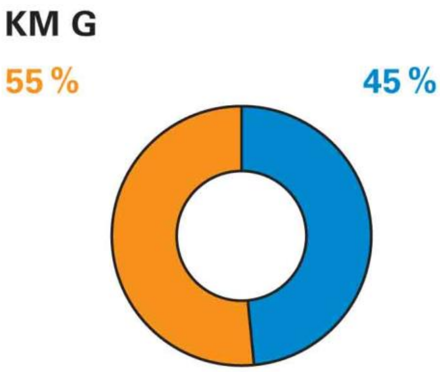

Figure 36: Percentage distribution of costs RC G

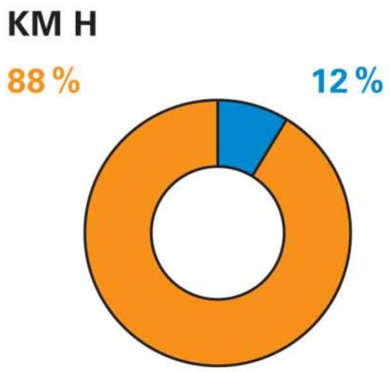

Figure 37: Percentage distribution of costs RC H

Key: Energy Investment

The cost difference between the RC G and the RC H over the life cycle is around €15,000 per chest. Stores should stop and think before using the RC H.

POTENTIAL SAVINGS

5

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5.1 Unplugging chests

While working, we found repeatedly that several small ice-cream chests and beverage refrigerators were still plugged in during the winter months. Stores should check in cold months whether a least some small ice-cream chests and the beverage refrigerators can be switched off, using the available sales figures or restocking rates (tops/flops list). The units could be temporarily put into storage.

5.2 Do not refrigerate products that can be left unrefrigerated

Impulse items can regularly be found in mobile chests that do not have to be refrigerated. Herbs and mushrooms remain fresh for longer when refrigerated, so there is nothing against doing so, and eggs and semi-perishable goods such as cooked salami are not harmed by refrigeration. Refrigeration does damage tomatoes, for example, as refrigeration takes away the flavour.

5.3 Do not apply temperatures that are unnecessarily low

For frozen products, –19 °C should be sufficient; the recommended temperature for ice-cream is –21 °C. In roughly one in four stores we visited, the temperatures were at least 5 °C to 8 °C too low. In some cases, the LT chests are set to the lowest temperature as a precaution. The actual temperatures in the chest then reach values down to –40 °C. The power consumption increases – and so do the costs – when goods are refrigerated to a lower temperature than necessary. In general, keep temperatures as low as necessary and as high as possible.

As a rule of thumb, the power consumption increases by 4 % for every degree centigrade. We were not able to confirm this value from out measurement, but we did identity an increase in consumption of around 10% where the temperature was 5 °C too high.

Figure 38: LT chest set to –34 °C – a common occurrence

5.4 Cover open refrigerated chests after closing time

Figure 39: Chest covered overnight

As the above figures show, covering a refrigerated cabinet overnight can reduce the power consumption.

Covering traps in cold air and reduces the number of switch-on cycles of the refrigerated cabinet. An important side-effect in summer is that the shop floor is not warmed as much.

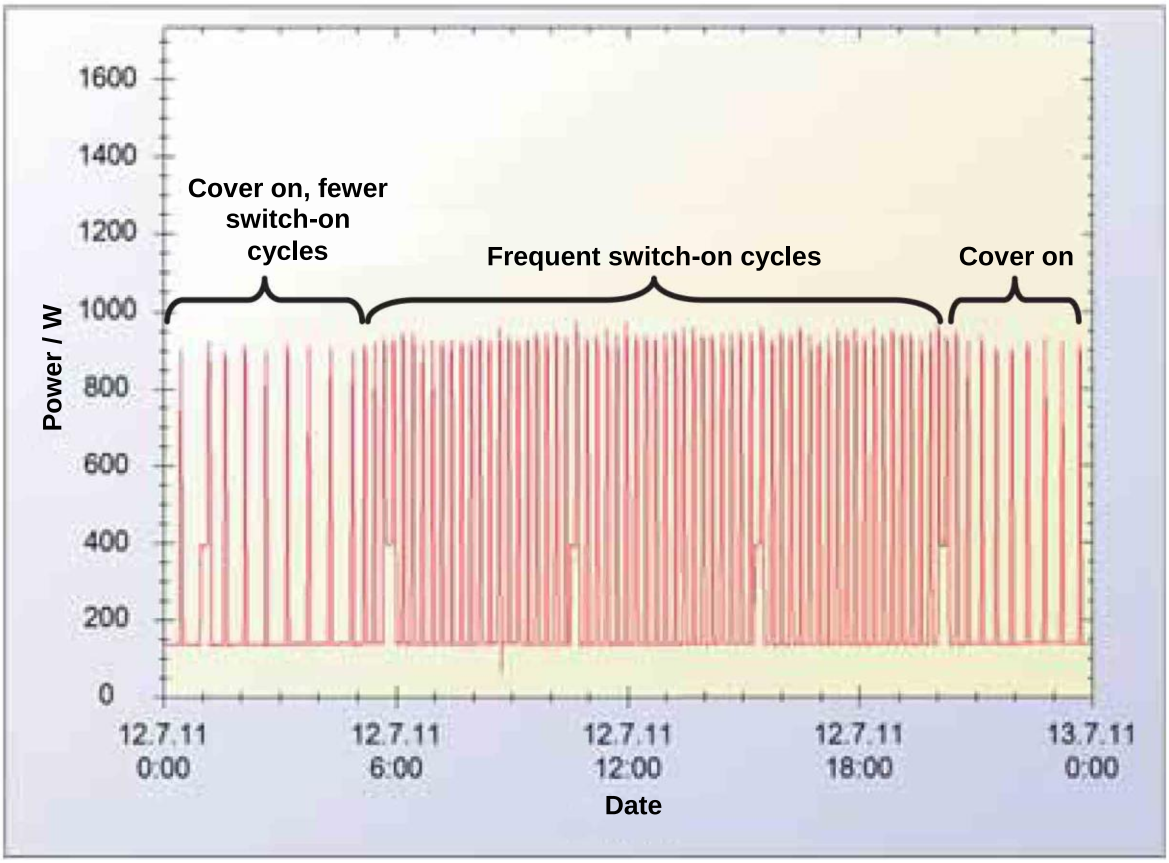
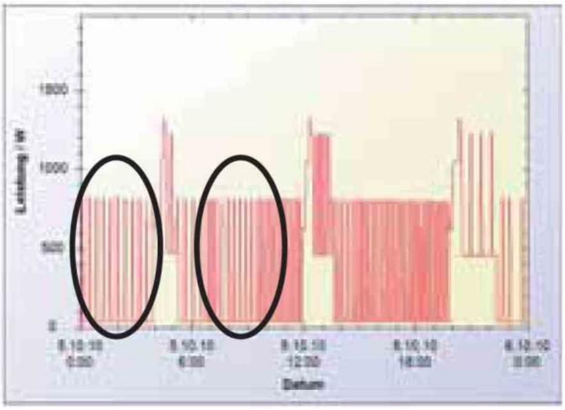


Figure 40: Effect of covering a chest overnight

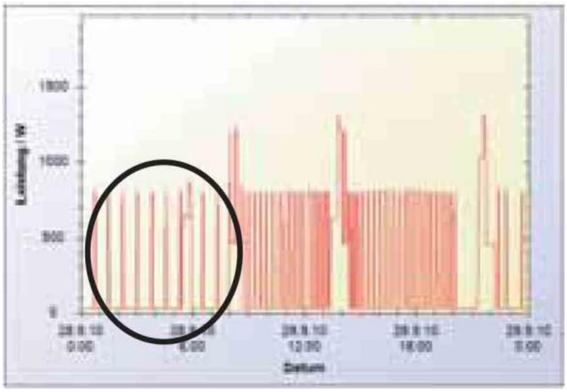
Plastic covers for plug-in refrigerated cabinets

A Styropor panel can be used with packaged foods to check the effectiveness of a cover (the entire refrigerated cabinet top must be covered).



Load profile of MT chest without overnight cover

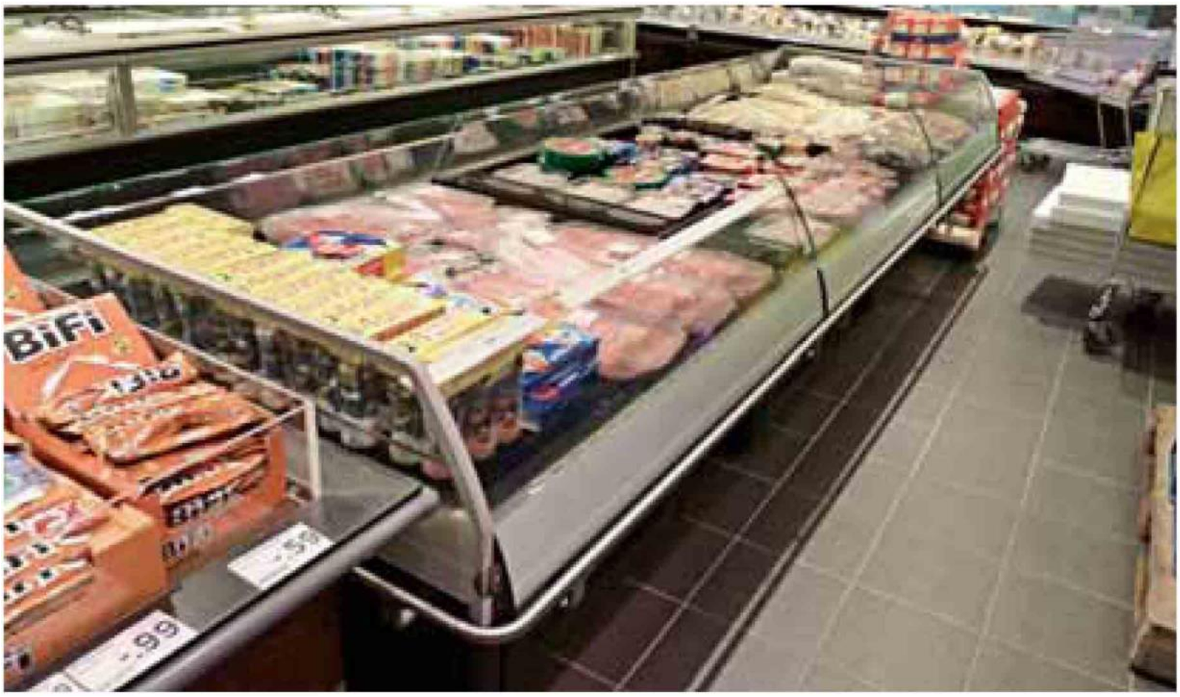
During the early hours of the morning and shortly after the store opens, the cycle frequency only increases slightly.

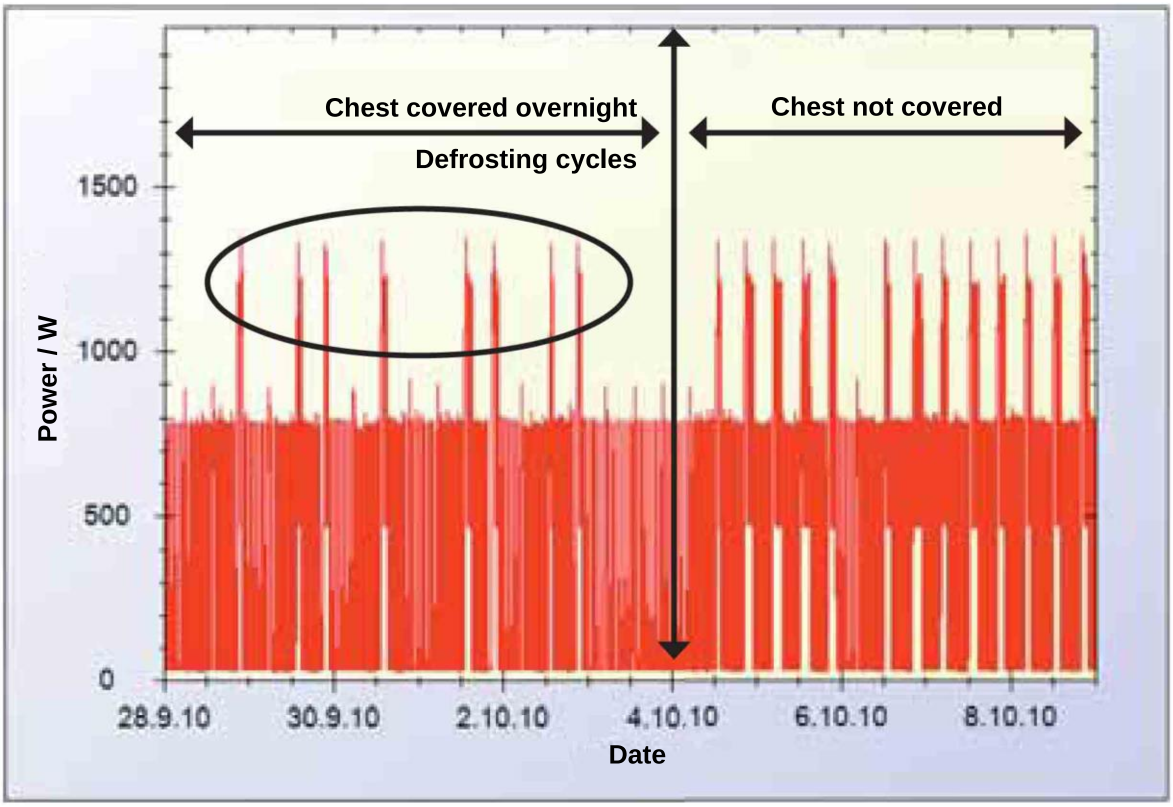


Load profile of the same MT chest with overnight cover (plastic cover).

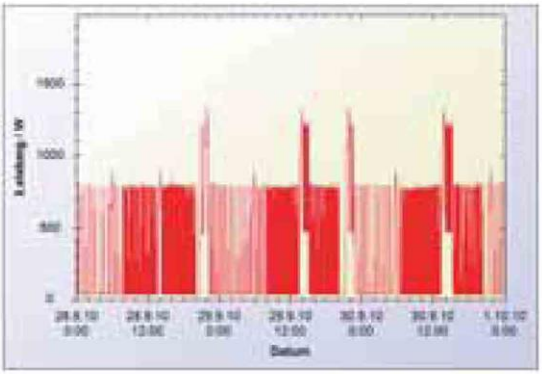
During the early hours, the covered chest cycles significantly less and therefore consumes less energy.

Figure 41: Effectiveness of covers

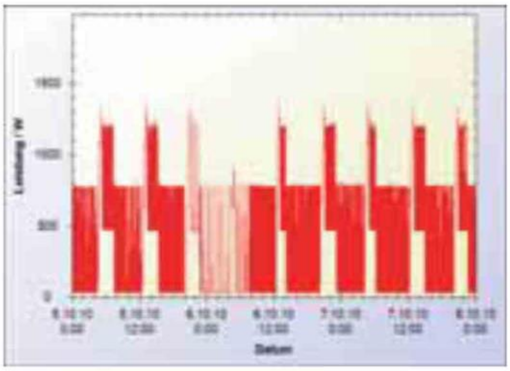




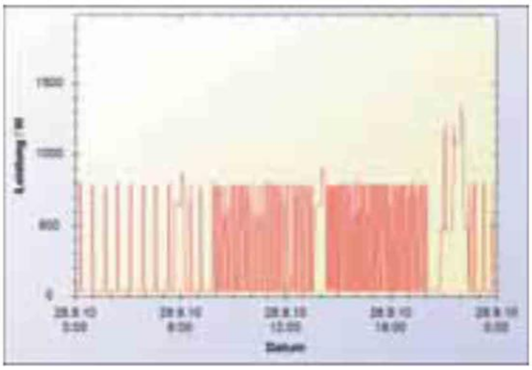
Measurement: from Tuesday 28/09/2010 00:00 to Friday 09/10/2010 00:00. The load profile shows that cover overnight means there are fewer defrosting periods.



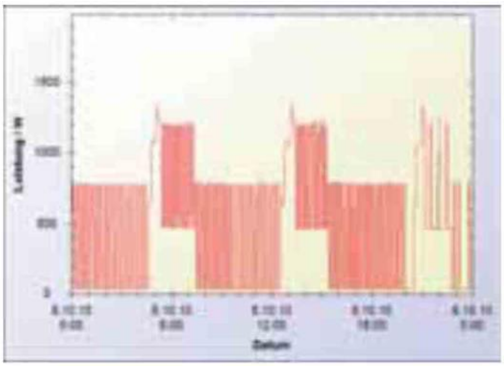
Tuesday 28/09/2010 to Friday 01/10/2010
Chest covered



Tuesday 05/10/2010 to Friday 08/10/2010
Chest not covered



Tuesday 28/09/2010 **chest covered**
Period that chest is covered: 20:05 to 07:55



Tuesday 05/10/2010 **chest not covered**

Calculated monthly consumption

Chest covered	Chest not covered
205 kWh	284 kWh

Calculated annual consumption

Chest covered	Chest not covered
2,499 kWh	3,405 kWh

Potential saving: approx. 26% or €163 per year (€0.18/kWh)

NOTE:

Covering an MT refrigerated cabinet after closing time is one way to reduce power consumption. Savings are only made while the unit is covered. From around 250 measurements, it became clear that the potential savings vary considerably from cabinet to cabinet. The difference in practice range from “not detectable” to “26%”. The benefit of covering should therefore be checked by measurement. On average, there was a approximately 20% reduction in power consumption when chests were covered. If covered for around 50% of the time, the power consumption may be reduced by 10% overall.

Even if the potential savings are comparatively high, it may not be economical to cover chests if the time to put on the covers has to be paid separately.

5.5 Maintain the maximum fill level

External warmth mainly gets into refrigerated cabinets through via the ambient air. If the cabinet is filled beyond its stacking markings, the cold air curtain that separates the warm air of the shop floor and the cold air of the refrigerated cabinet is forced out of the unit, so that more power is consumed. In addition, product quality also suffers.

Figure 42: Not at maximum fill level

Figure 43: At max. fill level

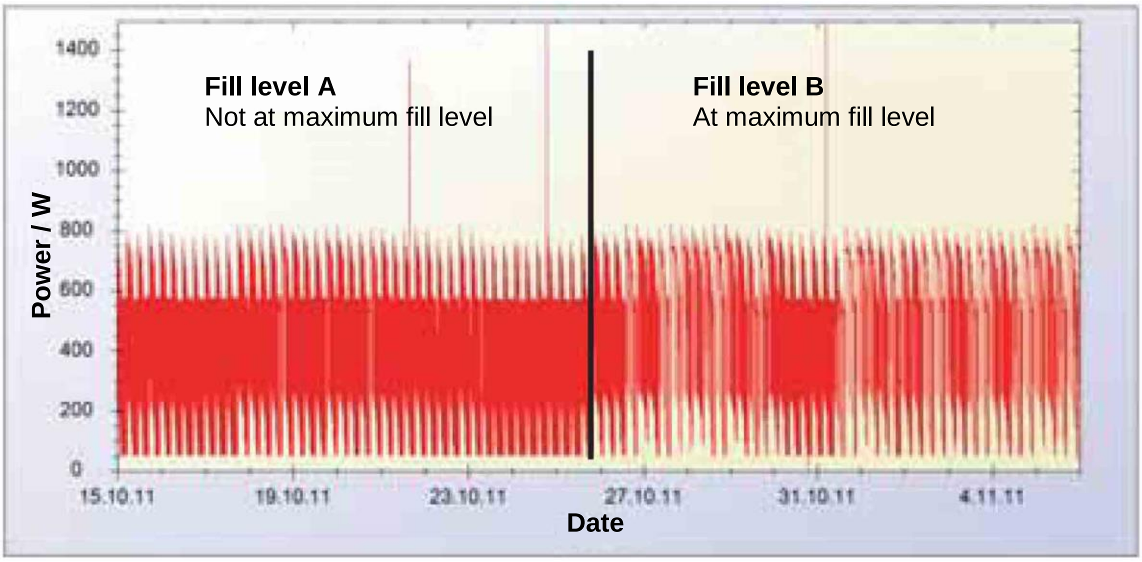


Figure 44: Load profile over a period, change in fill level

NOTE:

The load profile shows the change in fill level clearly – the power consumption fell significantly in the second half of the recorded period.

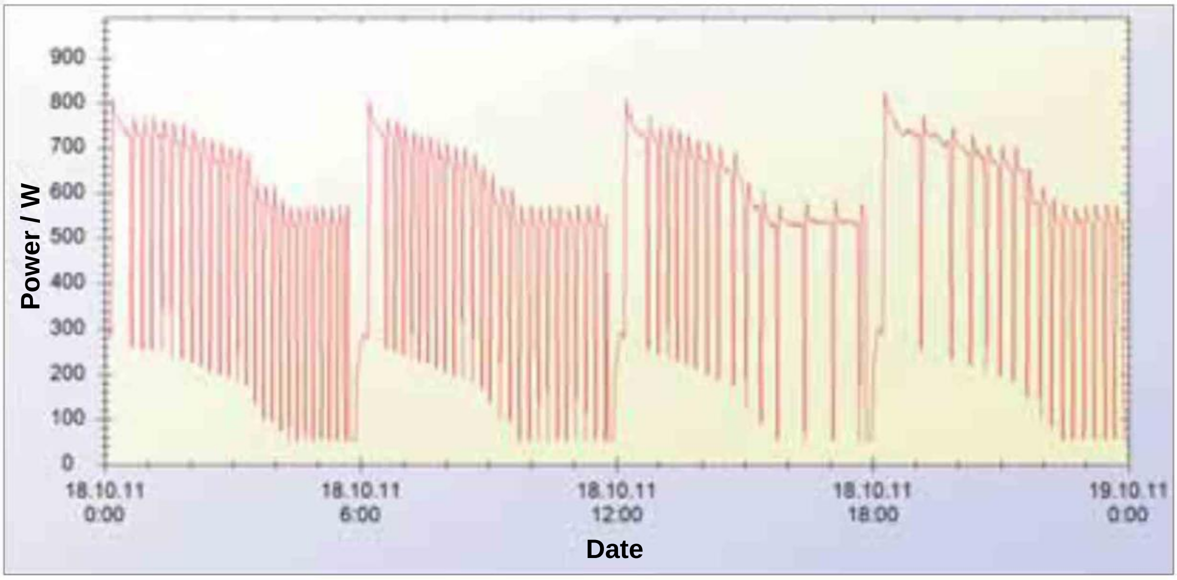


Figure 45: Daytime load profile – maximum fill level exceeded

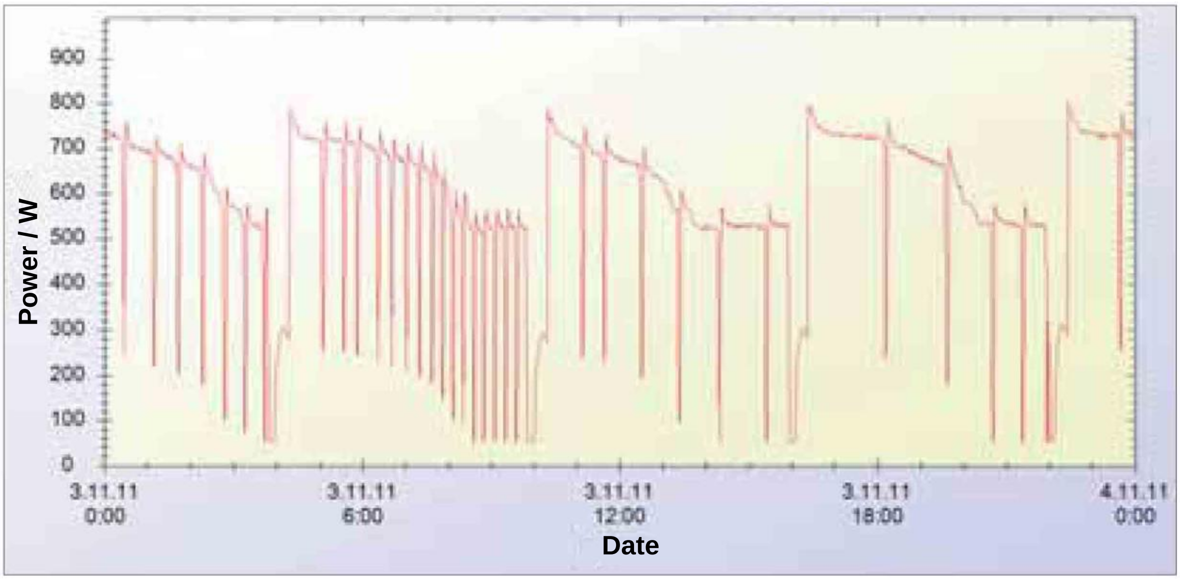
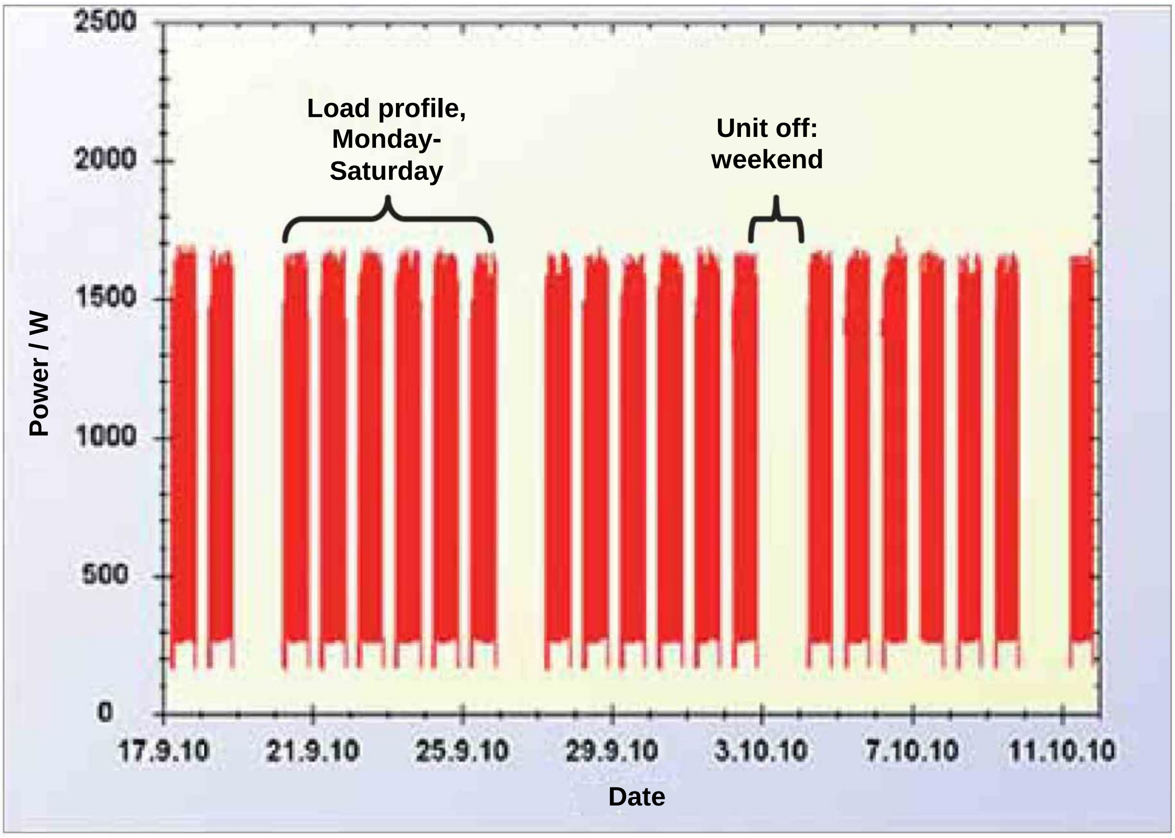


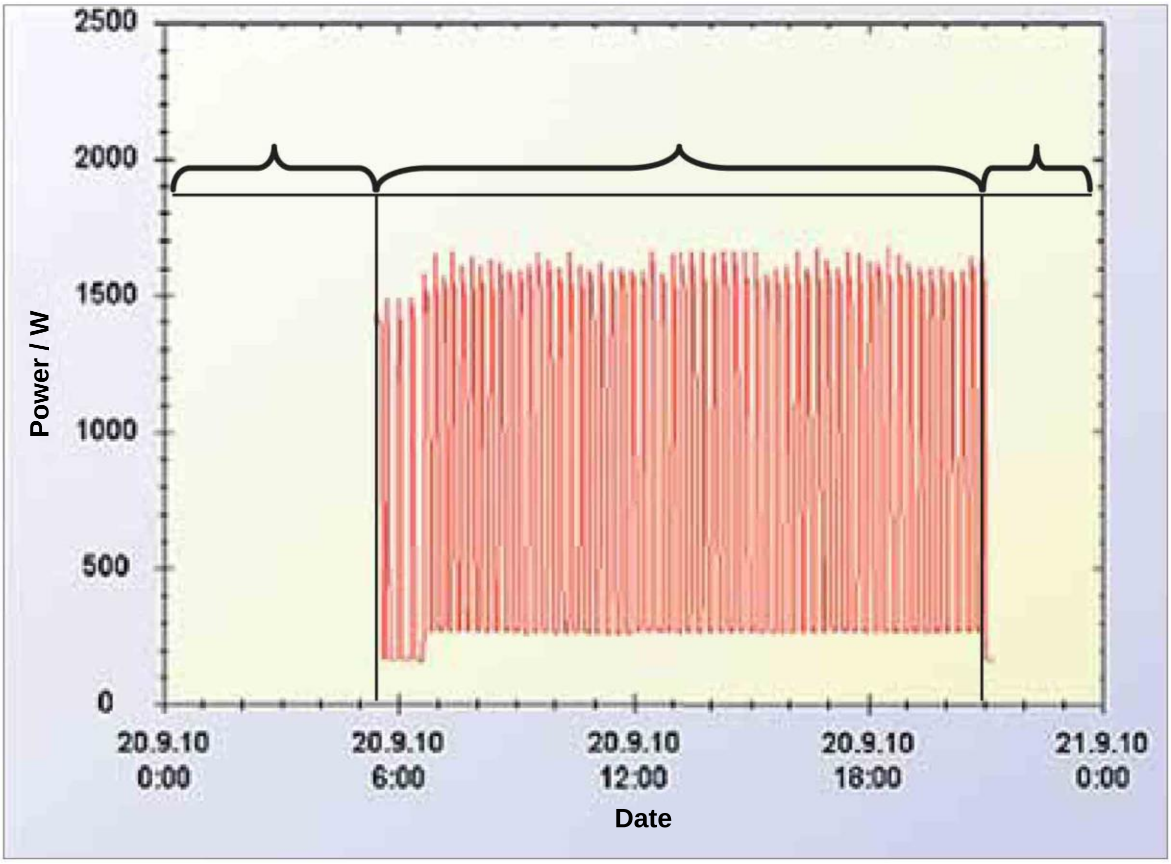
Figure 46: Daytime load profile – at maximum fill level

As only one measurement was undertaken with the change of stock level, we have not quantified how much power can be saved.

5.6 Use a weekly timer

A timer is a device that switches on or off an electrical contact at specified times. The switching times can generally be customised. If, for example, a beverage refrigerator should be ready from 07:00 to 20:00 with cold drinks, but the rest of the time does not need to refrigerate (to save energy), a timer can be set to switch on the refrigerated cabinet at 06:00 and to switch it off again at 19:30. A normal timer repeats the cycle every 24 hours. A weekly timer can be used to set different times for each day of the week. It is therefore possible to take account of the shorter opening times on Saturdays and Sundays. The potential savings from using a weekly time are around 50%.





Figures 47 and 48: Load profile with timer – unit was switched off after closing time

A weekly timer is particularly effective at reducing power consumption in high-consumption plug-in MT refrigerated cabinets.

In the beverage refrigerator measured by way of example, the power consumption was 13,300 kWh/year (€2,394/year).

A weekly time disconnecting the unit after closing time and re-activating it one hour before opening reduced the power consumption by almost 50%. In the example, that equates to around €1,200 per year.

5.7 Clear out and disconnect MT chests at weekends

For refrigerated cabinets that cannot be operated on a weekly timer, e.g. MT convenience chests, consider emptying the chests at weekends as a minimum after closing time and disconnecting them.

Example:
One chest we measured consumed approximately 3,000 kWh per year, connected for 8,760/year (the chest was permanently plugged in). The power consumption was therefore 0.34 kWh/h. The period of time from Saturday 20:00 to Monday 07:00 is 35 hours. Over 52 weekends, the total number of hours in the year is 1,820 or 20.8% of the total time – time during which the chest could be disconnected (without even taking into account holidays). The power consumption can therefore be reduced by 619 kWh per year or €111/year per chest. If the time to clear out the refrigerated cabinets has to be paid for separately, this is not economical.

5.8 Clean condenser regularly

Even if more energy is used, it is obvious that any refrigeration unit cannot refrigerate adequately if the condenser (heat exchanger) is clogged up with dirt. In addition to loss of product quality, the power consumption will also be higher.

Figure 49: Dirt on the condenser 1

Figure 50: Dirt on the condenser 2

Measurements have clearly shown that the power consumption increases as the amount of dirt increases.

Measuring chests with condensers clogged with different levels of dirt.

Condenser clean or with almost not dirt – basis power consumption 100%.

Moderately dirty condenser – power consumption +10%.

Very dirty condenser – power consumption +15%.

Figure 51:
Power consumption against amount of dirt on the condenser

The measurements of power consumption show a 10% to 15% increase in consumption, depending on the amount of dirt.[8]

At power consumption values of around 3,000 kWh/year, an increase of 15% equates to 450 kWh/year or €81/year.

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[8] The measurement results were kindly provided for this study by GLOBUS SB-Warenhaus Holding GmbH & Co. KG, Bauwesen (GM), Mr. Franko Berkenbrink.

5.9 Avoid icing-up

Iced-up LT chests are often found in food retail stores. The cause is damp, warm air that enters the refrigerated zone when the chest is opened, then cools down and condenses. The cooling surfaces iced up by condensate cease to be effective, as the sheet of ice acts as insulation. More energy must be expended to achieve the same performance.

Figure 52: Iced-up chest

The literature shows an increases in power consumption of from 3% to 8% as a result of iced-up chests. From our experience, the actual potential savings are under 3%.

Countermeasures

- **Deice chests, if necessary.**
- **Regularly check that the sliding covers are closed.**
- **If chests ice up unusually quickly, check all seals.**

5.10 Deliberately install LT chests with glass

The main task of food retail is to sell food. Refrigerated cabinets with glass on four sides can make a valuable contribution to that aim. However, it is important that additional power is justified by significantly higher sales figures. Glazed chests work in open spaces. The four sides of glass display the product, e.g. impulse ice-cream, to young and old shoppers from a distance and encourage purchases.

As shown, the H07M06 and H09M08 with glass on four sides require between 7,000 kWh/year and 9,000 kWh/year, equivalent to €1,260/year to €1,620/year at €0.18/kWh.

At an assumed margin of €1.50 per 1 litre of ice-cream, in this example 960 units of 1,000 ml would have to be sold to cover the energy costs alone.

The additional power required as a result of glazing (display surface) compared to a chest of comparable size (H07M06 0.39 m³ / AHT Malta 145 (–) 0.49 m³) is around 6,000 kWh/year to 7,000 kWh/year or around €1,100/year (if energy prices continue to rise, the figures will diverge even further). The extra cost therefore amounts to around 733 “gifted” 1,000 ml units of ice-cream per chest.

The obvious differences between the chests are the result of significantly larger display surface and the design concepts.

The food retailer would be well advised to monitor additional sales from glazed impulse ice-cream chests – if the additional power is not reflected in adequate sales, immediately replace the chest with a more energy-efficient unit.

Figure 53: AHT Malta 145(–)

Figure 54: Chest with large side glass panels, similar to the image shown

	AHT Malta 145 (–)	H07M06
Year of manufacture	2010	2008
Net storage space [litres]	370	approx. 394
Power consumption according to the rating plate [kWh/24h]	8.5	Not stated
Calculated power consumption [kWh/year]	3,103	Not stated
Measured refrigerated cabinets [number]	2	4
Measured average power consumption [kWh/year]	1,855	7,784
Energy costs at €0.18/kWh [€/year]	334.00	1,401.00

Table 15: Rating plate data

The data on rating plates is often not particularly helpful. The power consumption per 24 hours – a important indicator for the buyer at least to get an idea of power consumption under laboratory conditions – is not given, nor is the net storage capacity of the chest. The store owner (buyer) therefore has not means of calculating or assessing the power consumption. This is difficult to understand in an era when, for many years now, every household fridge has had to include an energy label.

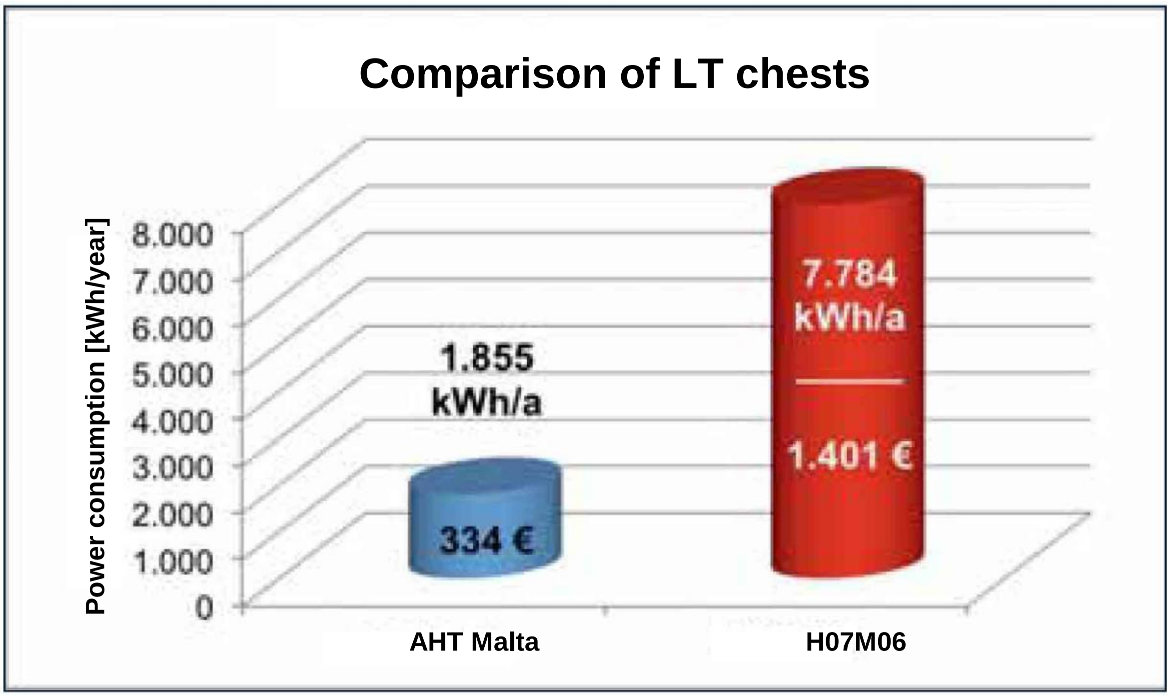

Figure 55: Comparison of the power consumption of LT chests

If the advantages of glass are not used, e.g. because of limited space, glass should be avoided in favour of energy-optimised chests.

Thermal imaging shows that the surface temperature of a glazed chest can be around 14 °C. High transmission heat loss is to be expected in summer in particular.

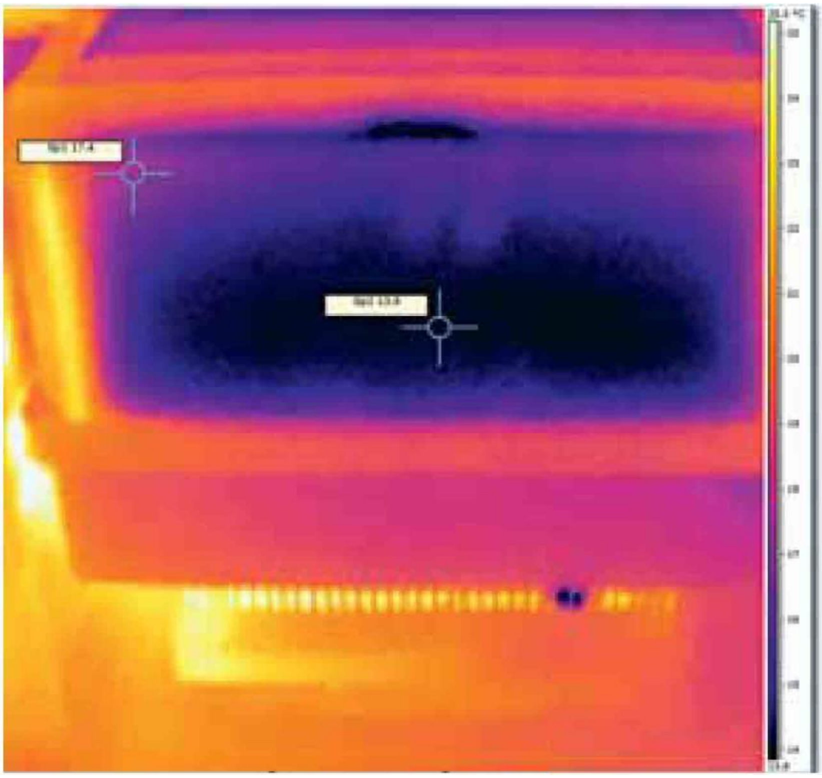

Figure 56: Thermal imaging of a glazed chest

The following figures show glazed LT chests where adverse layouts have completely or partially cancelled out the advantages of the large display area. If comparable chests are standing in your store and consuming too much power compared to the turnover they are generating (requires checking on a case-by-case basis), implement suitable countermeasures.

Negative example	**Description (reduced display surface in conjunction with high or even very high power consumption)**
	Goods not visible from the side, as the transport packing has not been removed. The benefits of the display surface have been almost completely lost. Three sides of glass are also ineffective (directly in contact with the wall and shelf unit).
	Chest difficult to see from the side.
	View of goods blocked by promotional basket.
	The chests are placed right next to each other. Two to three sides of glass cannot be seen.
	The chests are in narrow aisles, the side view is hidden and the benefits paid for in high power consumption are lost.
	Chests with view hidden on two sides. Display surface reduced by 50%.

5.11 Consider carefully the location of the refrigerated cabinet in your store

The location of a plug-in refrigerated cabinet in the store can also have a major influence on the power consumption. In the following example, two islands with three refrigerated cabinets of the same types were measured at different location within a store. The first MT island was located right next to the dairy product shelf and the serving counter, i.e. in the refrigeration zone. The second MT island was placed in the fruit and veg department at the entrance. A glass facade also means that significant heat will enter the store, particularly on sunny days.

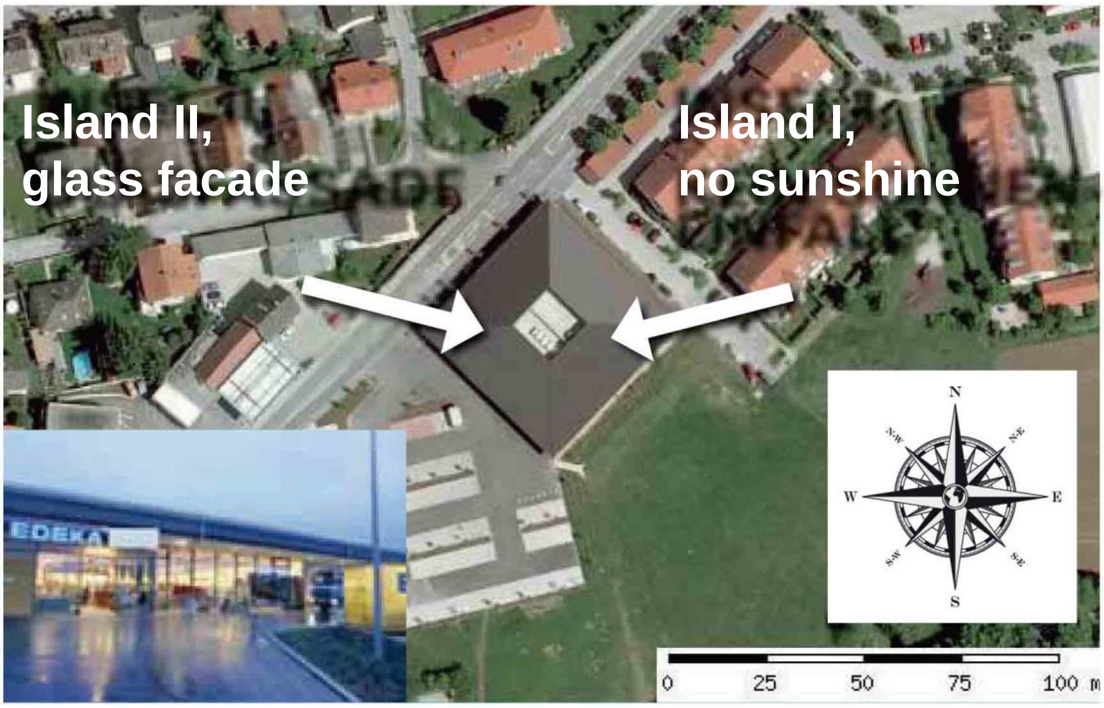

Figure 57: Southwest-facing glass facade

Figure 58: MT island 2, glass facade

Figure 59: MT island 1, refrigeration zone

Refrigerated cabinet and storage capacity	Consumption per year	Costs per year			
MT island 1, refrigeration zone:	**Power consumption, kWh/year**	**Costs [€/year]**[09]	**Location**		
I **S**ausage	2,996 (1.5 °C)	539.00	C	E	**S**
II **E**DEKA selection	2,715 (1.1 °C)	489.00	C	**E**	S
III **C**heese	2,654 (1.5 °C)	478.00	**C**	E	S
Total for MT island 1:	**8,365**	**1,506.00**	**Δ 11 %**		
MT island 2, near the glass facade	**Power consumption, kWh/year**	**Cost [€/year]**			
IV **M**ushrooms	4,683 (1.9 °C)	843.00	**M**	S	B
V **S**alad	3,334 (3.1 °C)	600.00	M	**S**	B
VI **B**erries	3,685 (1.6 °C)	663.00	M	S	**B**
Total for MT island 2:	**11,675**	**2,106.00**	**Δ 29 %**		
Difference between islands 1 and 2	**2,135 kWh**	**369.00**	**Δ 28 %**		

Table 16: Overview of power consumption

Although all six refrigerated cabinets were the same model from the same manufacturer, the differences in power consumption are considerable. The temperature was not set lower for MT island 2, so could not be a cause of the higher power consumption. It seems to be the case that refrigerated cabinets in warmer areas to need around 25% to 30% more power than in the cooler zones of the store.

5.12 Cost sharing with food producer

In many cases, food producers provide plug-in refrigerated cabinets to retailers under advertising subsidy agreements[10]. It can be the case that the energy costs for the refrigerated cabinet far exceed the advertising subsidy.

This is true in many cases in particular when refrigerated and un-insulated promotional chests made of cardboard or plastic are placed in the store. Trusting store owners often let the producer's sales representatives set up several promotional chests without considering the costs. In practice, these “chests” often stay in the store for significant periods of time and generate costs that are not always covered by sales. Power consumption up to 2,200 kWh (€396) per year was measured in refrigerated cabinets with cardboard or plastic shells, despite very limited refrigerated volume. Control measurements can therefore rapidly pay for themselves.

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[9] A flat rate of €0.18/kWh was applied, as in the other calculations in this study. The price is not exactly the same as the actual costs of energy incurred by the stored.

[10] An advertising subsidy is a money payment or free goods passed from the producer to the retailer for advertising purposes. The advertising subsidy is used by the retailer to finance its own advertising and sales promotion activities, where the products and services of the applicable producer are given special attention.

Figure 60: Example of a cardboard refrigerated cabinet

Figure 61: Example of a plastic refrigerated cabinet

! **Tip:**

Smart store owners get the energy costs refunded, as well as the refrigerated cabinet at POS.

5.13 Check whether to replace chests

The following example provides a calculation of profitability that shows whether it is worth replacing chests immediately. Similar refrigerated cabinets are compared, in particular in terms of display surface and the store conditions, to ensure as extensive comparability as possible. Two LT chests with electric defrosting were selected from the catalogue (power consumption values in the appendix). One of the chests from the mid-range with power consumption of 5,700 kWh/year and 0.46 m³ refrigerated volume is here compared with a highly efficient chest with 1.00 m³ refrigerated volume and power consumption of 1,900 kWh/year. The new, energy-efficient chest therefore has more than twice the volume. That has not been taken into account in the calculations, nor the fact that the maintenance costs of the chest are likely to be higher. This means that all the premises are favourable to the available chests.

ASSUMPTIONS:

Assumptions	Old chest no replaced	Old replaced for new chest
Start year	2014	2014
Life cycle [years]	10	10
Imputed interest rate [%][11]	1.86	1.86
Net investment [€]	0.00	1,900.00
Energy costs [€ per year]	1,026.00	342.00
Maintenance costs [€ per year]	0.00	0.00
Increase in energy costs [%/year][12]	3	3

Table 17: Assumptions underlying the investment calculation – refrigeration

[11] The KfW Energy Efficiency Programme GU 10/02/10 (KfW Energieeffizienzprogramm GU 10/2/10) with rating “B”, i.e. 1.86%, was applied to assess the interest rates.

[12] In this scenario, a 3% annual increase in energy prices is assumed. Over the past 15 years, the price has risen by around 3.7% per year. The EU assumes that energy prices will continue to rise significantly for a further 20 years. The IHK forecasts a price increase of up to 5% per year. The 3% applied here is therefore an optimistic scenario.

Results		
Capital value 1.86% [€]	5,164.00	
Internal rate of return [%]	36.9	
Dynamic amortisation 1.86% [years]	2.8	28% of life cycle
	Old chest	**New chest**
Annual costs including annualised investment [€/year]	1,171.00	600.00
Annual cost saving [€/year]		571.00

Table 18: Results of the investment calculation

In this example, the chest should be replaced immediately. Measures with a 36.9% internal rate of return over 2.8 years of dynamic amortisation are not typical in food retail. The annual saving from new investment is €571.

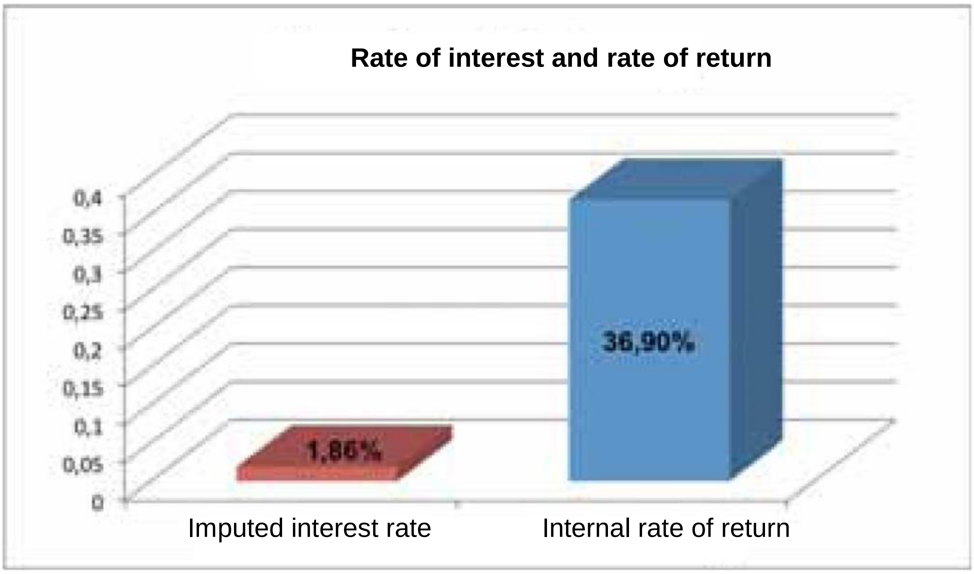


Figure 62: Chest replacement: Imputed interest rate and internal rate of return

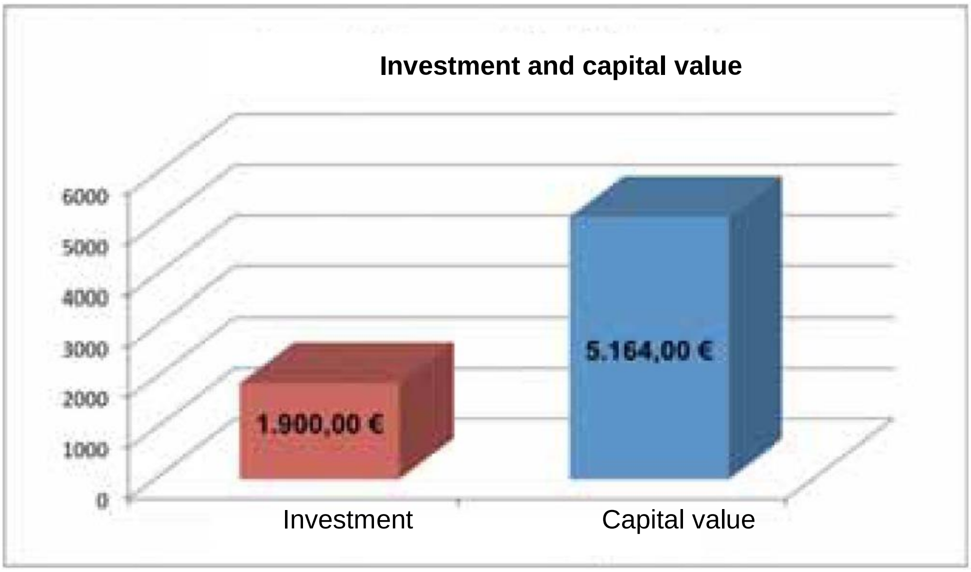


Figure 63: Chest replacement: Comparison of investment and capital value

5.14 Switch off lighting after closing time

Our measurements showed again and again that fluorescent bulbs on or in refrigerated cabinets are used to light products to best advantage. It is also possible to switch off these bulbs separately. The appendix includes several load profiles where the lighting has not been switched off when the store is closed. Lighting costs were identified of up to €130 per year per chest. The potential saving by using simple timers is around €65 (lighting costs) per chest in this example. The cost of cooling the additional heat, if the bulb is inside the chest, must also be included in the potential savings.

5.15 Product safety – a digression

One of our clients wanted to check whether and for how long products would remain safe in its LT chests in the event of a power failure. The case was extreme with store temperature highs of around 30 °C at the peak of summer.

The temperature profile was measured during a simulated power failure in the two different LT chest models in the store, the AHT GTX 89 SGHL and the H09M04. The year of manufacture of the chests was not provided, but was probably around 1998. The H09M04 chest has large display surfaces on the sides.

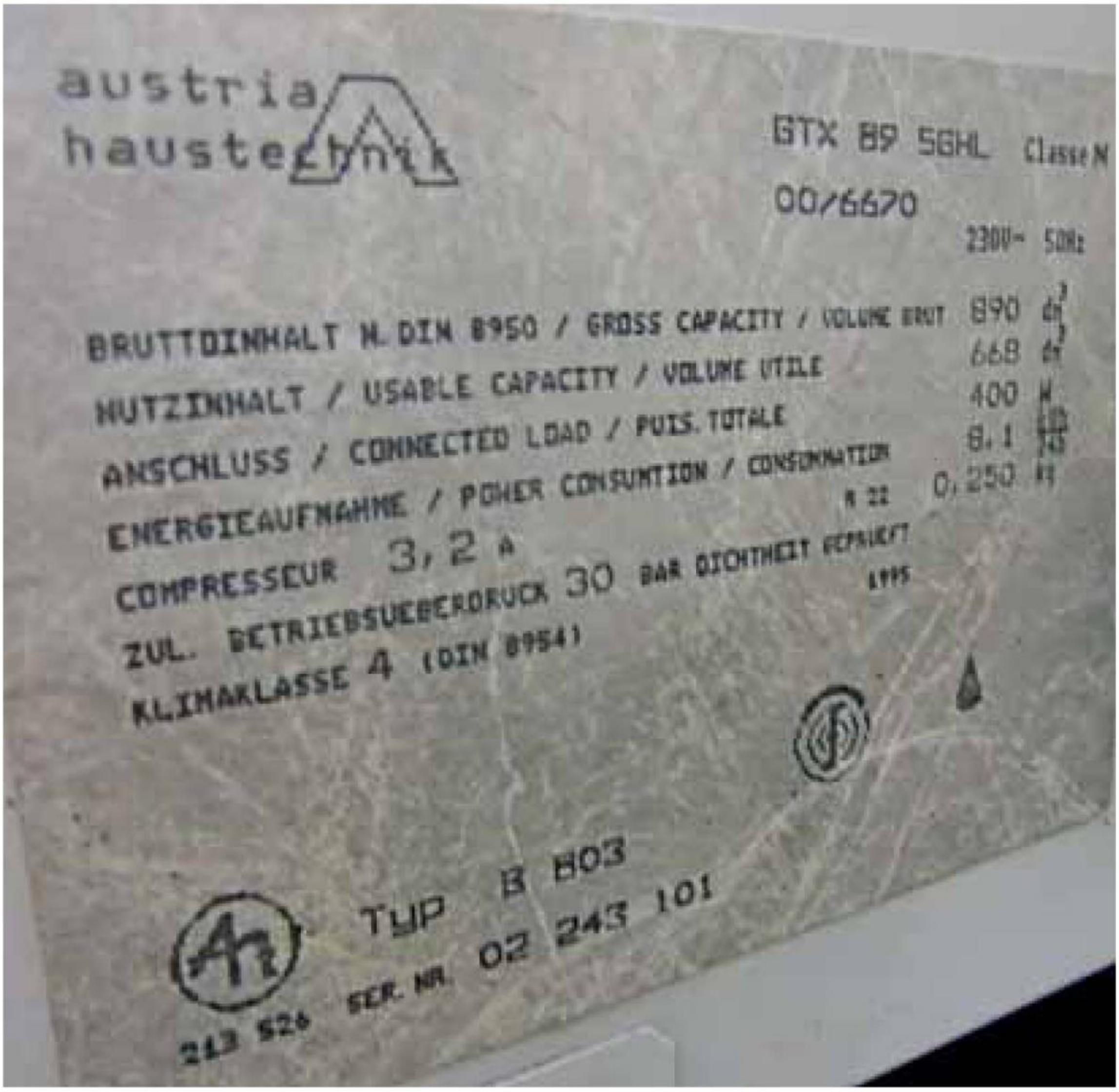
The temperature profile was measured in minute intervals using the LogTag HAXO 8 device.

The HAXO LogTag Humidity and Temperature Data Logger can record up to 8,000 high-resolution measurements within a measurement range from 0 to 100% relative humidity (RH) and –40 °C to +85 °C.

Figure 64: LogTag

The accuracy of the logger is +/– 1.75 °C within the measurement range.

5.15.1 AHT GTX SGHL



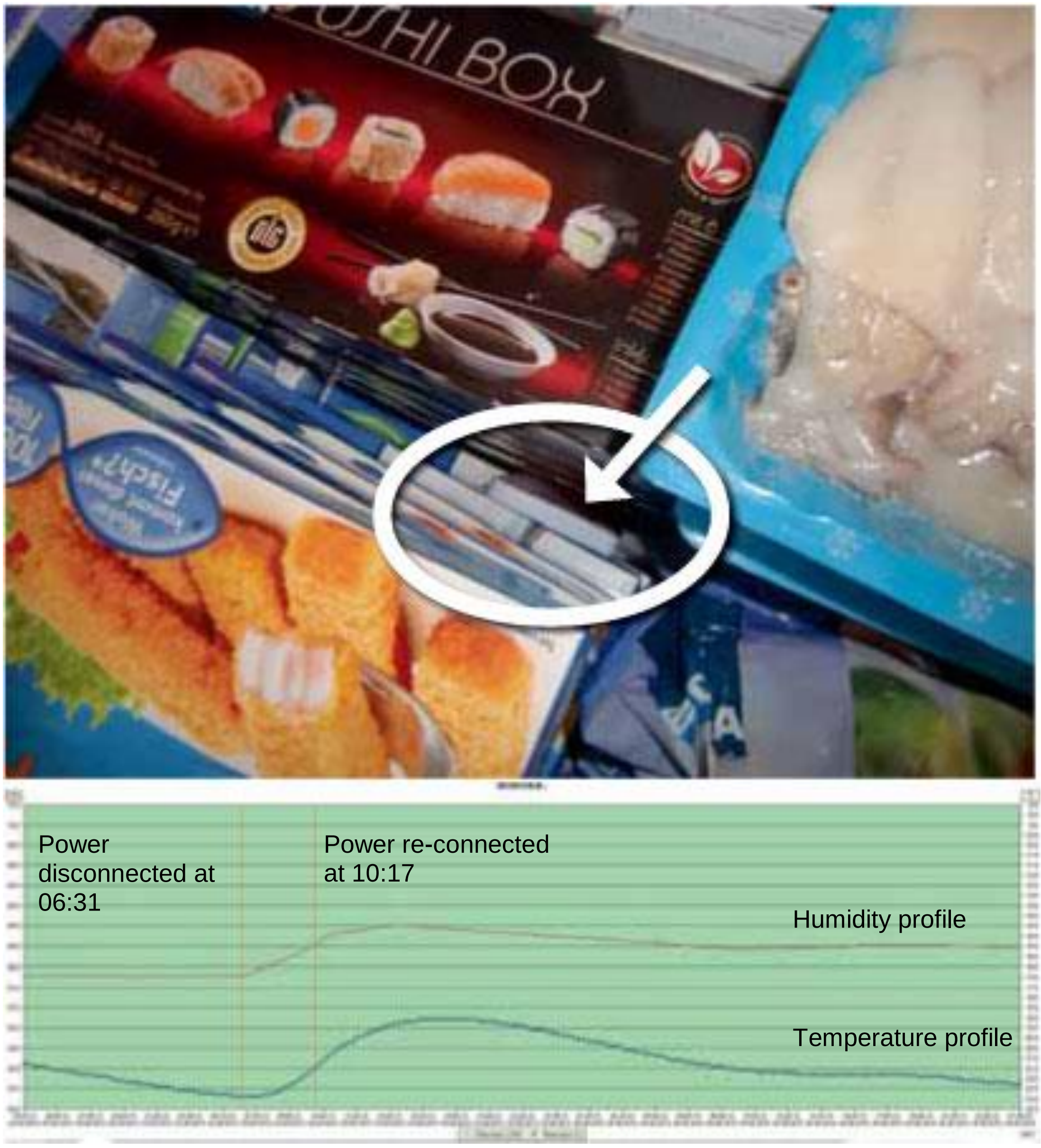


Figure 65: Temperature and relative humidity profiles for the AHT LT chest

The temperature profile clearly shows that the temperatures rose from –23 °C to –21.5 °C over the 3 hours and 46 minutes that the power was disconnected. The total increase in temperature in the chest was therefore only 1.5 °C at store temperatures of around 30 °C.

A power failure during the night should therefore not be a problem for the products in the AHR LT chest, as long as the failure is noticed the next morning.

5.15.2 H09M04


Ristorante
BISTRO
2 59
2 59
2 59
2 59


Ristorante
PROSCIUTTO
Baguette
Baguette

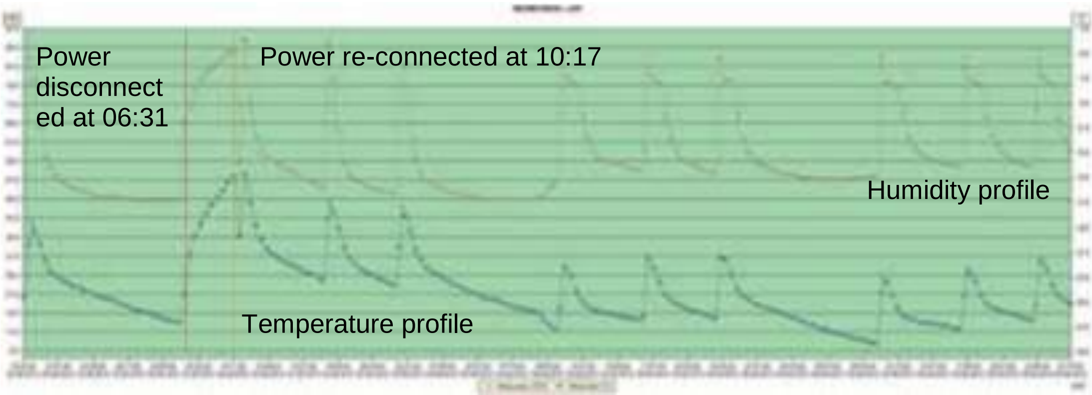


Figure 66: Temperature and relative humidity profiles for the H09M04 LT chest

The temperature profile clearly shows that the temperatures rose from –24 °C to –15 °C over the 3 hours and 46 minutes that the power was disconnected. The total increase in temperature in the chest was therefore 9 °C at store temperatures of around 30 °C.

Any power failure overnight would means that the products in the H09M04 chest would have to be thrown away.

5.15.3 Product safety comparison

AHT GTX 89 SGHL

Store temperature: 30 °C
Power failure: 3 h 46 mins
Temperature increase: –23 °C to –21.5 °C
Change in temperature: Δ 1.5 °C
Summary:
Overnight power failure poses very low risk of product waste.

H09M04

Store temperature: 30 °C
Power failure: 3 h 46 mins
Temperature increase: –24 °C to –15 °C
Change in temperature: Δ 9 °C
Summary:
Overnight power failure poses very high risk of product waste.

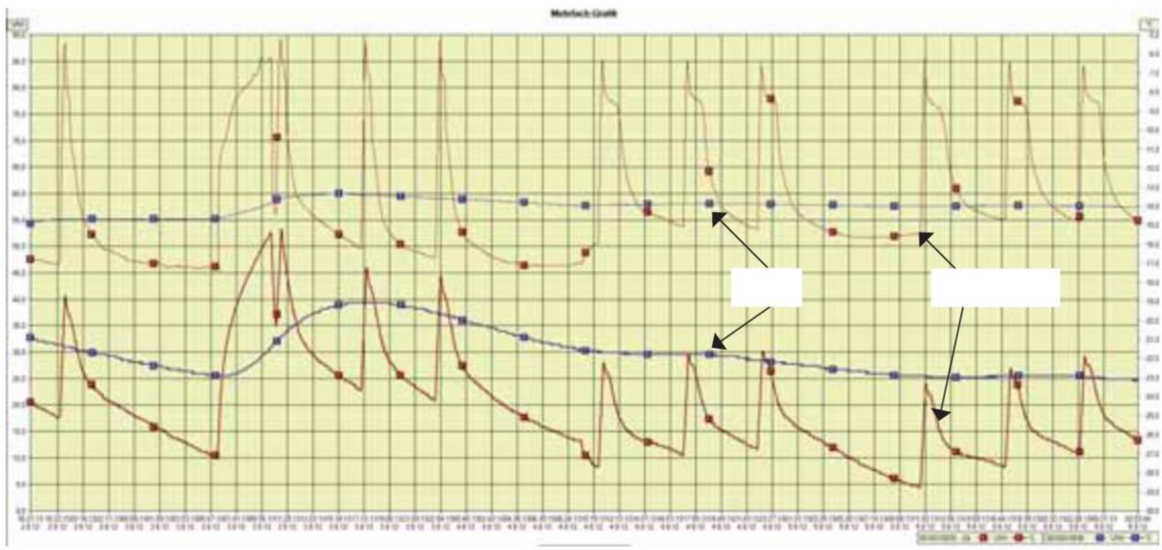


Figure 67: Comparison of temperature and humidity over time

Thermal imaging shows graphically the causes of the rapid loss of temperature in the H09M0 chest:

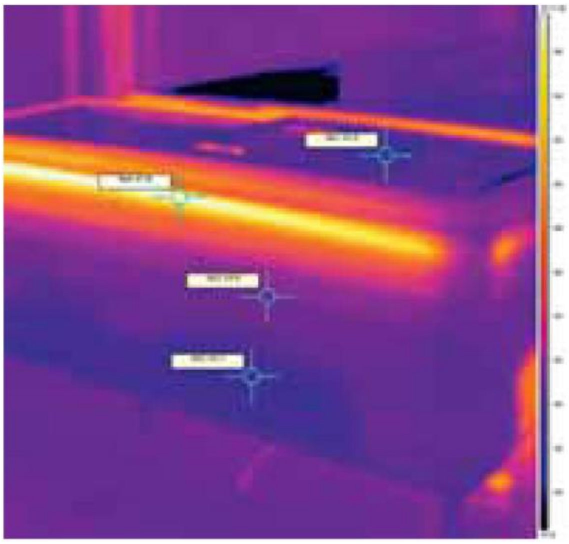


Figure 68: AHT thermal image

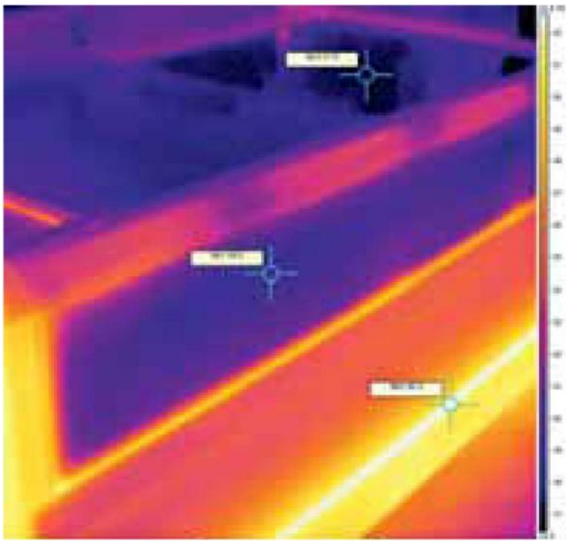


Figure 69: H09M04 thermal image

The surface temperatures of the H09M04 chest on the glazed surface were 17 °C to 18 °C at a store temperature of 30 °C. In the AHT chest, the temperature on the glazed surface was also 17 °C, but was 20 °C in insulated areas. The temperatures in the H09M04 chest increased significantly after a short time because of the higher rate of flow of cold to the outside.

ADVANTAGES & DISADVANTAGES OF PLUG-IN REFRIGERATED CABINETS

6

Dr. Steinmaßl

MANAGEMENTBERATUNG

6 ADVANTAGES & DISADVANTAGES OF PLUG-IN REFRIGERATED CABINETS

Often the advice in the literature is not to use plug-in refrigerated cabinets in food retail. The argument is mainly based on the heat generated by refrigerated cabinets. plug-in refrigerated cabinets emit heat extracted from the cooling area directly onto the shop floor, whereas multicompressor solutions extract the heat into the air via condensers or (in very rare cases) the heat is used for other purposes. That means, so the argument runs, that using plug-in refrigerated cabinets in your store requires good cross ventilation or an air-conditioning unit. Other arguments made against plug-in refrigerated cabinets include the fact that multicompressor solutions have de-icing heating and in some cases lower power consumption.

Advantages and possible disadvantages of plug-in refrigerated cabinets

ADVANTAGES

Low investment costs

- **Refrigerated cabinets can be installed and removed progressively in contrast to comparatively inflexible multicompressor solutions.**

Faster and simpler to commission

- **No expensive installation with any necessary refurbishment**

Manageable consequences of failures

- **If a chest fails because of a technical defect, the damage is comparatively low. If the entire multicompressor rack fails, the damage can be huge.**

Greater flexibility

- **Over time (promotions, ice-cream)**
- **In space (any location in the stores and across stores)**
- **No inflexible fixed cost pool, in contrast to compressor. Individual chests can be disconnected with ease.**

Less noise

- **In city centres, compressors and condensers can be a significant source of noise.**

DISADVANTAGES

Higher power consumption, exhaust heat is wasted

- **Shop floor is heated**
- **If using a large number, air conditioning is needed in the store**

Often does not have automatic defrosting unit

- **More rapidly ices up**
- **Manual defrosting**
- **Products have to be cleared out and stored in the interim.**

The following sections will discuss these broad statement against plug-in refrigerated cabinets in more detail.

6.1 Energy costs

6.1.1 Factors influencing power consumption

The total range of plug-in refrigerated cabinets is broken down into a number of segments, such as:

- **LT and MT refrigeration**
- **Open and closed refrigerated cabinets**
- **Morphology: Refrigerated shelves, refrigerated chests, combi units and islands**
- **LT cabinets with and without electric defrosting etc.**

As already shown, there is an exceptionally large range of power consumption within each segment. For example, closed beverage refrigerators had power consumptions of between 870 kWh/m³ per year and 10,118 kWh/m³ per year. The difference is a factor of 11!

Against this background alone, it is obvious that a broad statement such as "plug-in refrigerated cabinets consume more power than multicompressor units" is problematic and cannot stand up to serious investigation. The following LT comparison should clarify the issues.

6.1.2 Comparison of LT multicompressor unit and LT plug-in refrigerated cabinet

Twelve stores with sales areas of between 2,000 m² and 8,500 m² were randomly selected from the Dr. Steinmaßl MANAGEMENTBERATUNG data pool. The focus was on large stores because the refrigeration units in larger stores are generally optimally dimensioned and regularly maintained. However, the intention was not to build in advantages for plug-in refrigerated cabinets artificially.

Consecutive No.	LT chests [m³ or thousand l]	Power consumption LT chests [kWh/year][13]	Specific Power consumption LT chests [kWh/m³ per year]
01	38.88	105,144	2,704
02	27.72	124,644	4,496
03	46.56	329,739	7,082
04	42.08	344,885	8,196
05	23.83	107,228	4,500
06	21.61	127,756	5,912
07	45.25	272,728	6,027
08	34.75	172,042	4,951
09	21.56	277,424	12,868
10	31.56	409,279	12,968
11	53.37	286,847	5,375
12	23.70	48,074	2,028
$\bar{x}$	**34.24**	**217,149**	**6,426**

Table 19: Specific power consumption of LT multicompressor chests

[13] Three criteria were taken into account when determining the power consumption of the negative temperature refrigeration: 1) load analysis, 2) LT central refrigeration system, 3) refrigerated volume of the LT chests.

The specific power consumption of the LT multicompressor chests varied under normal operating conditions in the 12 investigated stores between 2,028 and 12,968 kWh/m³ per year refrigerated volume. The average was 6,426 kWh/m³ per year. It should be noted that an R134A/R744 (CO_2) unit manufactured in 2011 came first in terms of energy efficiency. The units at the bottom of the pile included closed LT chests at number 9 (unit from 1997, refrigerant: R404A) and open LT chests with overnight cover at number 10 (manufactured: 2005, R404A).

By contrast, the plug-in LT chests with electric defrosting had power consumption of between 1,785 kWh/m³ per year and 22,834 kWh/m³ per year. The range is therefore greater than for multicompressor units.

The measurements show that highly efficient, new plug-in refrigerated cabinets operating under normal day-to-day conditions can require less power than highly efficient new multicompressor units (CO_2 cascade systems, MT = R134a/LT = R744). The measurements also show that the energy efficiency of some units in use on a day-to-day basis is open to criticism, among both multicompressor units and plug-in refrigerated cabinets.

Range of power consumption

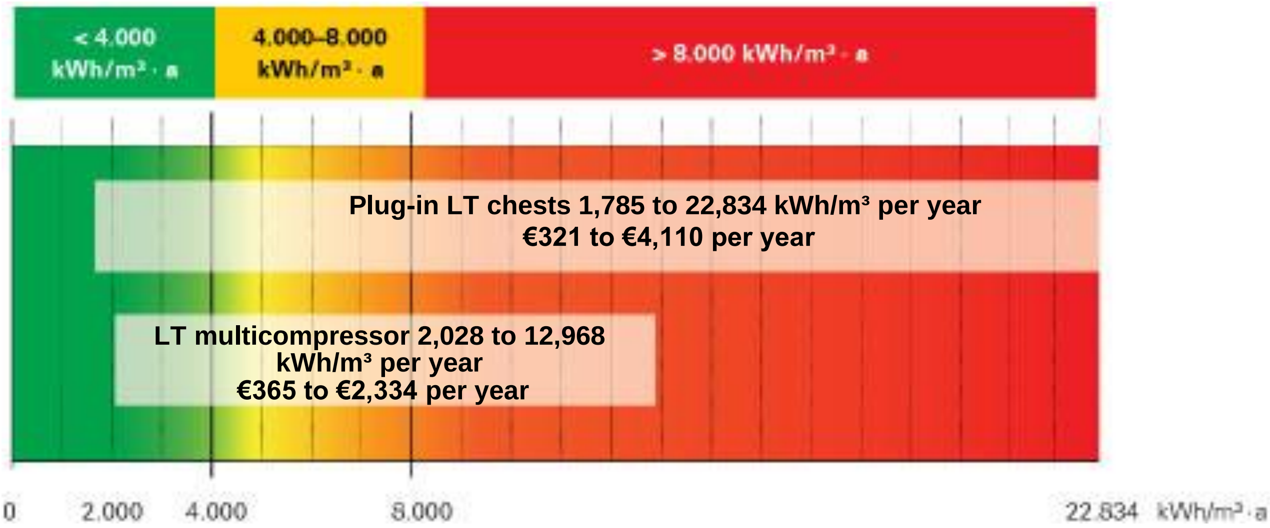


Figure 70: Power consumption of LT chests

6.1.3 Economic comparison

ASSUMPTIONS:

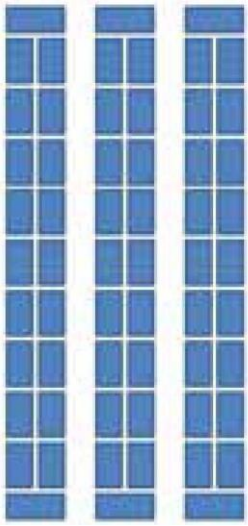


Figure 71: Plug-in layout

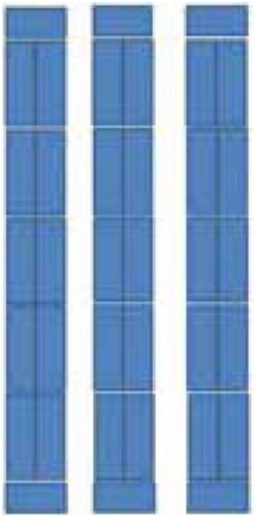


Figure 72: Multicompressor layout[14]

Comparison of chests:

Plug-in refrigerated chests
54 x highly efficient plug-in chests
6 x high-efficiency gondola end chests

Figures for plug-in chests
Total block length: 62.66 m
Total net volume: 52,728 l

Investment costs of plug-in chests

54 x 2,100	€113,400
6 x 2,200	€13,200
Total:	**€126,600**

Investment costs for equipment
None, all equipment in the chest

Total investment costs of plug-in chests
€126,600

Specific investment costs
€126,600 / 52.7 m³ = EUR/m³ 2,402

Investment costs for 45 m³ of chests **€108,102**

CO_2 multicompressor (only LT section)
15 x recognised manufacturers 3.75
6 x gondola end chests, recognised manufacturer

Figures for multicompressor chests:
Total block length: 63.03
Total net volume: 40,758 l

Investment costs of multicompressor chests

15 x 6,500	€97,500
6 x 6,800	€40,800
Total:	**€138,300**

Investment costs for equipment
Approx. total:[15] €95,000

Total investment costs of multicompressor chests
€233,300

Specific investment costs
€233,300 / 40.8 m³ = EUR/m³ 5,718

Investment costs for 45 m³ of multicompressor chests **€257,316**

[14] Some assumptions have been made to undertake an economic comparison between the plug-in chests and modern R134A/R744 systems with frequency-controlled compressors. For example, prices from well-known manufacturers have been used and an LT landscape typical of large stores has been reproduced. Recognised manufacturers were chosen for both plug-in chests and LT multicompressor systems. The prices are approximate.

[15] This cost item includes: LT multicompressor unit, condenser, evaporator, LT unit assembly, control cabinet, refrigerant connection lines, gas detector, temperature indicators and transport costs.

OTHER ASSUMPTIONS:

Assumptions	Plug-in	Multicompressor
Start year	2014	2014
Life cycle [years][16]	10	15
Imputed interest rate [%]	1.86	1.86
Net investment [€]	108,102	257,316
Energy costs [€ per year]	15,236	16,427
Maintenance costs [€ per year]	200	1,500
Increase in energy costs [%/year]	3	3

Table 20: Assumptions underlying the investment calculation – refrigeration

NOTE ON ENERGY COSTS:

In the worst case scenario where minimum power consumption of the LT multicompressor unit (2,028 kWh/m³ per year, R134A/R744 unit with frequency-controlled compressors) is compared to average power consumption of high-efficiency plug-in LT chests (1,881 kWh/m³ per year), the energy costs are:

LT multicompressor unit

- **2,028 kWh/m³ per year · 45 m³ = 91,260 kWh/m³ per year**
- **91,260 kWh/m³ per year · €0.18/kWh**[17] **= €16,427**

Plug-in LT chests

- **1,881 kWh/m³ per year · 45 m³ = 84,645 kWh/m³ per year**
- **84,645 kWh/m³ per year · €0.18/kWh = €15,236**

6.1.4 Results of calculation

Results		
Capital value 1.86% [€]	138,053	
	Plug-in	**Multicompressor**
Annual costs including annualised investment [€]	29,535	41,479
Annual cost saving [€/year]	11,944	

Table 21: Results of the investment calculation

As the investment for the plug-in option is lower than for the standard version, even taking into account the shorter life cycle of 10 instead of 15 years (and the lower operating costs), the payoff period if “0”. That means that the plug-in option should be implemented immediately.

[16] To stay on the conservative side and to give an idea of the cost that is as realistic as possible, but that should not simulate higher costs, we have assumed a life cycle of 10 years. A life cycle of 15 years has been used for the multicompressor refrigeration systems.

[17] In the experience of Dr. Steinmaßl MANAGEMENTBERATUNG, €0.18/kWh reflects the average net energy price in food retail in 2013 for special contract customers.

Even if the imputed interest rate is increased from 15% to 20% (standard practice for investment calculations), the cost effectiveness of the plug-in LT chests does not change. In this scenario, capital value and annual costs savings would continue to rise.

SUMMARY:

High-efficiency, plug-in LT chests can deliver positive capital value (€138,000) and annual costs savings of around €12,000 compared to multicompressor solutions, even on conservative assumptions.

Note:

The findings have been made on the basis of a relatively small population. The statistical degree of confidence is not 95%. This practical example is therefore only indicative.

6.2 Waste heat

One argument that is regularly put forward against plug-in refrigerated cabinets is that waste heat is emitted into the store and unused which – as often stated in the literature – can mean that a partial air-conditioning system has to be installed.

Dr. Steinmaßl MANAGEMENTBERATUNG is fundamentally in favour of heat recovery from refrigeration units, but has found that in practice no heat recovery systems are installed in around 95% of food retail. The waste heat generated by refrigeration units is therefore almost exclusively emitted into the environment.

The question remains whether plug-in refrigerated cabinets contribute to the need to install a partial air-conditioning system in a store.

In practice, we regularly found up to 25 plug-in refrigerated cabinets in small stores (energy- hand, we also visited stores that had only installed plug-in promotional chests and still needed a partial air-conditioning system.

For this reason, heat sources and heat sinks in different types of food retail store should be more closely considered and evaluated approximately.[18]

[18] The following assumptions are values that we have obtained from market leaders under normal operating conditions or are estimates. The calculations are rough calculations only. The aim is to obtain approximate values so that heat inputs can be assessed more accurately. A more exact, dynamic simulation is outside the scope of this study.

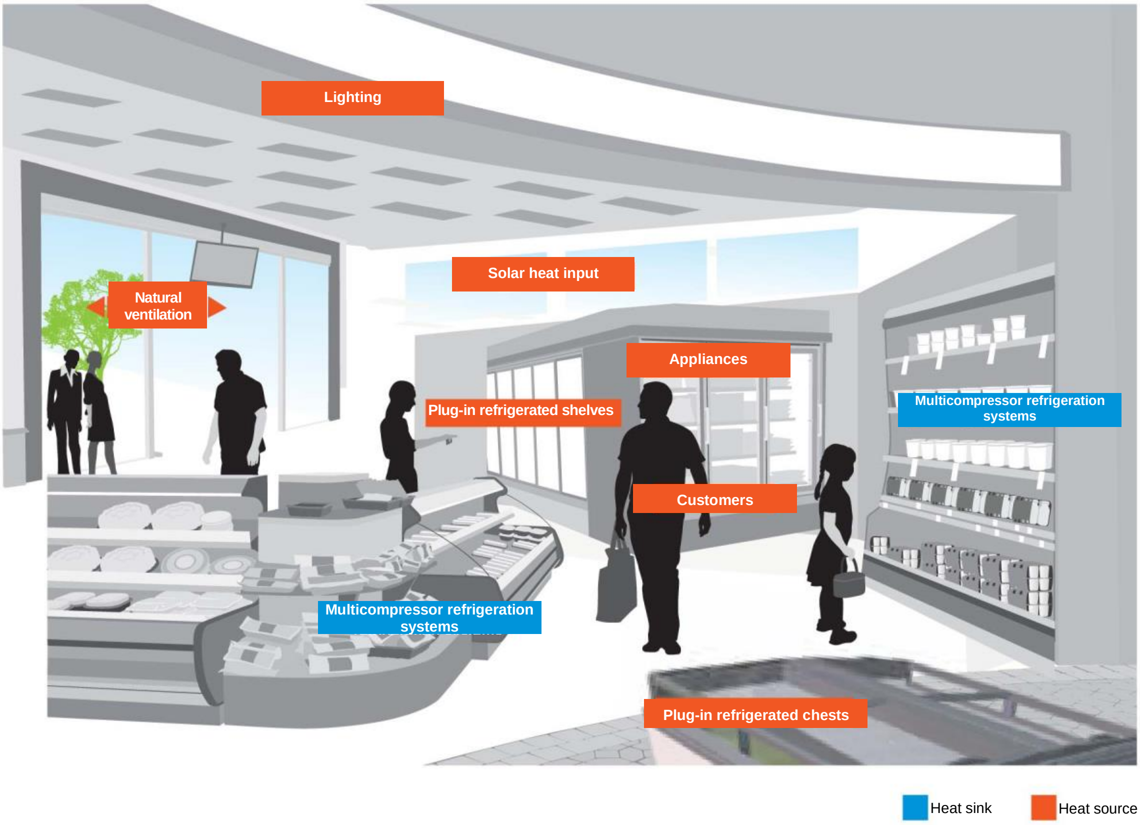


Figure 73: Heat sources and heat sinks in a food retail store

Three categories of food retail store were identified in terms of energy characteristics:

- **Energy-optimised supermarkets with energy-optimised equipment in well-insulated buildings (around 10% to 15% of the total population).**
- **Standard stores (65% to 70%).**
- **Stores with excessive power consumption and poorly insulated buildings and equipment with high energy consumption (approx. 20%).**

The figures behind these calculations are set out clearly in the appendix. The following table shows the results.

Assumptions	Energy-optimised		Standard store		Energy-intensive	
	[W/m²]	%	[W/m²]	%	[W/m²]	%
Customers	7	21	7	15	7	8
Natural ventilation	8	24	8	17	8	9
Lighting	7	22	17	35	30	33
Appliances	3	9	3	6	3	3
Multicompressor refrigeration (LT/MT)	-23		-28		-32	
Plug-in refrigerated cabinets	4	12	9	19	23	25
Solar window	2	6	2	4	3	3
Solar roof	2	6	2	4	17	19
Heat input, max.	33	100	48	100	91	100
Energy balance	10		20		59	

Table 22: Heat input in a food retail store extreme case

The contribution of plug-in refrigerated cabinets to the total heat input is between 12% and 25% in these scenarios.

The actual temperature increase using energy-efficient plug-in refrigerated cabinets compared to the units in the standard store may in practice be around 1 °C to 2 °C in the worst case. An air-conditioning system is not necessary. The situation is different in an energy-intensive store. Here, the plug-in refrigerated cabinets contribute around 25% of the total heat input into the store and may also be responsible for chocolate melting on hot days and the need for air conditioning in the store.

6.3 Automatic defrosting

As shown in this study, plug-in LT refrigerated cabinets are available both with automatic defrosting and without electric defrosting. It is interesting in this regard that – as shown in the comparison of multicompressor units with refrigerated cabinets – highly efficient refrigerated cabinets with automatic defrosting may be the most energy-efficient units.

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Jürgen Steinmaßl

Dr. Steinmaßl

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