bio Intelligence Service

European Commission DG ENTR

Preparatory Study for

Eco-design Requirements of EuPs

[Contract N° S12.515749]

Lot 1

Refrigerating and Freezing Equipment:

service cabinets, walk-in cold rooms, chillers, ice-makers, ice-cream and milkshake machines, and minibars

Task 3 Working Document

June, 2009

Bio Intelligence Service - Scaling sustainable development
Industrial Ecology - Nutritional Health

Bio Intelligence Service S.A.S - bio@biois.com
1 rue Berthelot - 94200 Ivry-sur-Seine - France
Tél. +33 (0)1 56 20 23 98 - Fax. +33 (0)1 58 46 09 95

Contact Bio Intelligence Service S.A.S.
Shailendra Mudgal – Sanaée Iyama
☏ + 33 (0) 1 56 20 28 98
shailendra.mudgal@biois.com
sanaee.iyama@biois.com

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Project Team

Bio Intelligence Service

Mr. Shailendra Mudgal

Ms. Sanaée Iyama

Mr. Felipe Tibocha

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Content

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3. Task 3 – User Behaviour

The commercial refrigeration equipments identified in task 1 are used by a wide range of users. Service cabinets, blast refrigerators and/or freezers, and walk-in cold rooms are primarily used in restaurants, catering facilities, hotels, and supermarkets[1]. Ice-makers are widely used in hotels, restaurants, and bars. Dessert and beverage machines are most often used in restaurants, catering facilities, bars, and small shops. Water dispensers[2] are more common in offices, hospitals, schools and institutional buildings. Chillers are more often used in the industry[3].

Product-design and product information may influence the user behaviour to some extent which consequently will influence the environmental impacts and the energy efficiency associated with the product during its use phase.

The aim of this section is to explore the user behaviour aspects for the ENTR Lot 1 products and their influence on the energy and environmental performance of these appliances.

First, the analysis focuses on the influence of providing user information on real life efficiency of commercial refrigeration equipment. Further, user behaviour during the use phase and related to end-of-life aspects is discussed.

Preliminary results of task 3 show that user behaviour could have a significant impact on the electricity consumption of commercial refrigeration equipment through operational and maintenance practices.

Preliminary results of task 3 show that user behaviour has a significant impact on the electricity consumption of commercial refrigeration equipment and improving simple operational and maintenance practices could already provide significant energy savings (within a 15% range).

Barriers to ecodesign related to the end-user have been identified such as e.g. lack of user information, focus on first cost, and lack of financial incentives, and will need to be taken into account when focusing on improvement potential (task 6).

Further data collection is still in progress through stakeholder consultation and an online questionnaire[4] has been sent in order to complement the results presented in this document.

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[1] Deneen, Michael A.,Gross, Andrew C. *The global commercial refrigeration equipment market. (Focus on Industries and Markets).* 2002

[2] Mark Ellis and associates. *Boiling and Chilled Water Dispensers. Draft final report prepared for The Australian Greenhouse Office and NAEEEC under the National Appliance & Equipment Energy Efficiency Program*. 2004

[3] E.g. Plastics & Rubber; Lasers; Food & Beverage; Chemical & Pharmaceutical; Metal Working; Mechanical & Engineering; and Paper & Related Applications.

[4] BIO Intelligence Service. *First ENTR Lot 1 online questionnaire to stakeholders*. Different versions of the questionnaire are available depending on the product category and can be downloaded from http://www.ecofreezercom.org/documents_1.php

3.1. INFORMATION AVAILABLE FOR USERS

The objective of this subtask is to analyse whether it would have a significant positive environmental impact to provide users with information regarding the product's sustainable use and ecological profile.

3.1.1. ROLE OF INFORMATION IN SUSTAINABLE PRODUCT USE

Information related to commercial refrigeration appliances can have a significant impact on the equipment's energy efficiency as improving **simple operational and maintenance practices can reduce energy consumption of 15 % or more**[5].

Strategies to reduce energy use and also refrigerant leakages are described in the following sections.

3.1.1.1 Loading instructions

- **Overloading and internal layout**

In the case of service cabinets, blast refrigerators and/or freezers, and walk-in cold rooms, overloaded refrigerated spaces decrease product quality and increase energy use by as much as 10 to 20 % per unit[6] by disturbing the air flow. Load limits indications on the cabinet/storage rooms (load limit shows the maximum filling of the cabinet/ storage rooms) need to be clearly visible and understandable by the end-user. Also users should be aware of the manufacturer's recommendations for shelf positions and sizes to prevent increased refrigeration loads.

In the case of chillers, the user should be fully aware of the cooling capacity of the appliance, so as to choose the appropriate size to fit his cooling needs.

- **Foodstuff temperature**

This paragraph is only relevant for service cabinets, walk-in cold rooms, water dispensers, ice makers and dessert and beverage machines.

Foodstuff temperature or water inlet temperature (e.g. in the case of ice-makers) should be kept low when introduced in the refrigeration equipment as these products are not design to pull down warm temperatures but to store at a low temperature (not the case for blast refrigerators and/or freezers which are specifically designed to cool down products).

User should be informed that it should be avoided storing goods in hot areas (e.g. in direct sunlight) before they are loaded in refrigeration equipment, and that pre-cooled products should be transferred as quickly as possible from one refrigerated area to another to avoid their temperature from rising.

- **Loading duration / frequency**

For closed equipment the time taken to load the foodstuff during which the doors are open, allowing bigger heat infiltration from the ambient warm air also influences the

[5] Australia Energy Smart Initiative - http://www.sedo.energy.wa.gov.au/uploads/comm_refrig_28.pdf
[6] Sacramento Utility District - http://www.smud.org/en/business/saving-energy/Pages/conservation-tips.aspx

energy consumption. Information to raise awareness on the energy losses due to excessive door openings could be provided.

3.1.1.2 Other use characteristics

Other use characteristics can influence the energy consumption of commercial refrigeration equipment.

- **Appliance location**

Users should be aware that locating the refrigeration equipment in a cool non-dusty area and not in direct sunlight will help keeping its energy consumption low. Locations such as near cooking equipment should be avoided as well.

Some manufacturers recommend that plug-in equipment should be located in well ventilated areas (with air conditioning) to provide good ventilation of the condenser coils and fans.

- **Information related to maintenance practices**

User's manual should include information on best maintenance practices. These are described in details in § 3.2.3.2.

3.1.2. PRODUCT ECOLOGICAL PROFILE AND BENEFITS OF ECODESIGN

As seen in Task 1, in Europe there are very few energy efficiency programs to promote efficient commercial refrigeration appliances (UK ECA scheme, Eurovent program) and there are no incentives at EU level to communicate on the ecological profiles of commercial refrigeration products and on the benefits of ecodesign. However, preliminary data on the improvement potential[7] through better design of the commercial refrigeration equipment included in ENTR Lot 1 show that there could be room for product differentiation based on product performance (in terms of electricity consumption).

In the US, the experience from the Energy Star label shows that labelled products are significantly more efficient than the average appliance. For example, the program claims that[8]:

- Energy Star labelled commercial refrigerators and freezers (i.e. service cabinets) are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors, which will significantly reduce energy consumption and utility bills. Compared to standard models, ENERGY STAR labelled commercial refrigerators and freezers can lead to energy savings of as much as 35% with a 1.3 year payback.
- Commercial ice machines that have earned the Energy Star are on average 15% more energy-efficient and 10% more water-efficient than standard models.

Such examples illustrate the potential for improvement through ecodesign. However, in Europe, in the absence of certification programs (either voluntary or mandatory) to

[7] See BIO Intelligence Service. *ENTR Lot 1 - Working Document on Task 1, published on 04/05/2009*. 2009. http://www.ecofreezercom.org

[8] US Energy Star http://www.energystar.gov

communicate on the performance of products, there is little incentive for manufacturers to improve their products. Section 3.1.3. further elaborates on the possible barriers for ecodesign and take-up of more efficient products regarding environmental impacts.

3.1.3. POSSIBLE BARRIERS FOR ECODESIGN

- **Focus on first cost**

Purchase decisions for commercial refrigeration equipment are generally not made on life cycle cost or payback considerations. Equipment buyers, whether they are small end-users, medium end-users or large supermarket normally select the equipment that meets specifications at the lowest cost. For medium-sized end-users and large supermarkets, the people in charge of selecting the equipment are generally not the ones in charge of operating it, or the ones paying the final electricity bill, and therefore they do not always focus on energy efficiency as choice criteria. Additionally, instead of energy performance, end users tend to focus on design, size, and additional functions at the time of purchase. The main reason for this is that end users are often unaware of how significant the difference in life-cycle cost can be.[9]

- **Limited information**

End-users are often not aware of the difference of energy efficiency among competing products (i.e. no use of energy efficiency labels). Some end-users also lack information on the cost to power their equipment.

This lack of resources among end-users for confident and accurate assessment of either the available technology options and related energy saving potentials adds up to the fact that in many cases the new equipment is purchased when the old equipment fails and there is no time to analyse in details the purchase decision (more specifically for small end-users).

- **Preference for stabilised technologies**[10]

Technologies diverging from current practice take time to be introduced into a significant portion of the market. Indeed, the switch for natural refrigerants on remote equipments requires technicians knowing how to install and operate refrigeration systems with such "new" refrigerants.

- **Low significance of energy in operating costs**

Energy costs are often small compared to other operating costs. Although they are not completely insignificant, the energy costs do not represent a large part of the business' revenue and this increases the tendency to disregard energy issues in evaluating sales-boosting design changes such as decrease of initial cost of the equipment. For example, for service cabinets, blast refrigerators and/or freezers, and walk-in cold rooms, an increase of the insulation thickness would reduce their electricity consumption but might not be regarded as a desirable option as it also results in a decrease in storage volume which would reduce sales capacity of a given unit.

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[9] T. Kubo and S.Nadel. *Commercial Packaged Refrigeration: An Untapped Lode for Energy Efficiency. Report for the American Council for an Energy Efficient Economy*. 2002

[10] BIO Intelligence Service. *Ecodesign Preparatory Study Lot 12. Final Report prepared for DG TREN*. 2007 – http://www.ecofreezercom.org

- **Lack of financial initiatives**

The UK Enhanced Capital Allowance[11] is the only programs identified which provide financial incentives for investment in energy efficient commercial refrigeration equipment in EU.

In the UK, end-users can benefit from tax concessions when they choose to buy energy-efficient products. The full list of complying products is available on their website. Among products included in the ENTR Lot 1, the ECA covers packaged chillers and commercial service cabinets.

- **Lack of standards test procedures**

One barrier to address eco-design measures is the lack of standard procedures to measure their energy use for certain product categories (see Task 1, Table 1-22). Without the standards, it is difficult to control accurately the energy performance of different refrigerating and freezing equipment produced by different manufacturers and to make energy efficiency a reality. The European Commission is preparing a single mandate in the field of Ecodesign to European Standardisation Organisations, in order to fill the gaps.

3.2. USER BEHAVIOUR IN THE USE PHASE

The objective of this section is to describe user behaviour in relation to use phase regarding the real-life conditions of use, and real-life maintenance and repair practices. Best practices in sustainable product use will also be discussed.

3.2.1. REAL LIFE EFFICIENCY

Real life efficiency of ENTR Lot 1 products can be impaired by user behaviour aspects. Assessing the way products are being used enables to have a more accurate picture of the performance of these products.

3.2.1.1 Usage pattern

So far very few data from the literature has been found to estimate the typical usage patterns of the products covered by ENTR Lot 1 (Table 3-1).

Commercial refrigeration appliances such as service cabinets are typically used 24 hours a day, without interruption even during the weekends. However, more specific products have more complex usage patterns which will need to be further investigated.

[11] http://www.eca.gov.uk/

Table 3-1: Usage pattern for ENTR Lot 1 equipment

Source	UK Defra MTP[12]	ADL 1996[13]
	Hours/year	Hours/year
Service cabinets	8760	*N.A.*
Blast refrigerators and freezers	*N.A.*	*N.A.*
Walk-in cold rooms	4927.5	*N.A.*
Chillers	4380	*N.A.*
Dessert and beverage machines	*N.A.*	*N.A.*
Water dispensers	*N.A.*	*N.A.*
Ice makers	5840	*N.A.*
Packaged condensing units	*N.A.*	*N.A.*
Refrigeration compressors (not included in plug-in refrigeration equipment)	*N.A.*	Similar to Baseline supermarket refrigeration systems which are estimated to operate 24h/day, i.e. 8760 h/yr

N.A. : Not Available at this stage

3.2.1.2 Load efficiency

This section is relevant for commercial refrigeration appliances designed to store and cool foodstuff items, i.e. service cabinets, walk-in cold rooms, and blast refrigerators and/or freezers.

- **Overloading**

Most end-users fill their appliances with too much foodstuff despite the "load limits" indications on the cabinets/storage rooms (load limit shows the maximum filling of the cabinet). Bigger supermarket, and restaurants usually respect the loading prescriptions more, due to stricter control from national health departments and overloading is typically more observed in small convenience stores/small users.

- **Foodstuff temperature**

The temperature at which the foodstuff is loaded also influences the performance of the equipment. The cold chain shouldn't be interrupted. However, this is often the case for non-perishable items such as drinks. They are loaded at ambient temperature in the implying an increase in energy consumption to pull down their temperature.

- **Loading duration/frequencies**

Service cabinets and walk-in cold rooms are subject to heavy usage; doors are opened hundreds of times during a day which increases the heat infiltrations.

3.2.1.3 Temperature settings

For commercial refrigeration equipment designed for storage of foodstuff, two levels of temperature exist: medium temperature (1 °C to 4° C) for preservation of fresh food and low temperature (-18 °C to -25 °C) for preservation of frozen food. Differences

[12] UK Defra statistics available at http://whatif.mtprog.com/

[13] Arthur D. Little, Inc. *Energy Savings Potential for Commercial Refrigeration Equipment, Final Report Prepared for US Department of Energy*. 1996

between the recommended temperature (fixed by food and safety regulations) and the real working temperatures can sometimes be observed. For refrigerated cabinets, it is estimated that every degree below the needed temperature increases the appliance's energy consumption of 2% - 3%.[14] These differences can happen when the cabinet thermostat is set on food safety temperatures values and not on manufacturer's recommended values due to the position of the control temperature probes inside the service cabinet: the displayed working temperature of the cabinet (thermometer) could be slightly different from the real temperature inside the refrigerated volume of the cabinet (higher or lower depending from the probe position). In this situation Manufacturer give the right information regarding the correlation between the displayed temperature (set by the thermostat) and the real cabinet working temperature.

3.2.1.4 Other use characteristics

Other use characteristics can influence the energy consumption of commercial refrigeration equipment.

- **Appliance location**

Commercial refrigeration equipment should be located in a cool and well ventilated area to optimise their operation. However, commercial refrigeration appliances are often used in kitchens (near cooking appliances) or outdoors during the summer (e.g. dessert machines) without any air-conditioning systems. In the industry, process chillers can be located near heat sources such as electric motors.

- **Anti-sweat heaters**

Anti-sweat heaters are often used on appliances having doors, such as service cabinets and in walk-in cold rooms, either remote or plug-in to reduce condensation around the door seals. They commonly stay on at full load 24 hours a day.

3.2.2. BEST PRACTICE IN SUSTAINABLE PRODUCT USE

A number of governmental agencies and organisations[15] provide recommendations for smarter use of commercial refrigeration equipment. Such strategies to reduce the energy use aim at reducing the amount of cooling needed which can be achieved through better equipment settings and through the reduction of heat losses and gains.

Refrigerated equipment used to cool down and store foodstuff require constant refrigeration energy intake to offset heat gains and losses mainly due to:

- Heat gains due to openings of the appliance (convection) – this is true for service cabinet, walk-in cold rooms, desserts and beverage machines, and ice-makers.
- Heat gains through isolated surfaces of the equipment (conduction)
- Heat gains through the radiation from surrounding surfaces

[14] Government of South Australia - Energy SA Advisory Service

[15] Such as the Government of South Australia Department of Transport, Energy and Infrastructure, Energy Smart Initiative (Australia), Natural Resources Canada – Office of Energy Efficiency http://oee.rncan.gc.ca/industrial/equipment/commercial-refrigeration/operation.cfm?attr=4

- Heat gains due to the components included inside the furniture (lighting, fans, defrost system, warm foodstuff, …)

Best practices to reduce the amount of refrigeration energy are discussed in following paragraphs.

Efficient product loading

This section is only relevant for service cabinets, blast refrigerators and/or freezers and walk-in cold rooms.

Pulling down the temperature of foodstuff from the ambient temperature to the refrigerated temperature increases the energy demand. Storing goods in a cool area and loading the products when cool saves energy. For equipment with doors, quick loading of items reduces the heat transfer.

Also, the refrigerated space should not be overloaded and used as permanent storage equipment. The stocking should be managed so that the refrigeration equipment is not overloaded.

Further a good management of the refrigeration needs can reduce the amount of cooling space needed. In the food distribution business, proper identification of the needs can allow to only store items that meet the demand and use less refrigeration - one fridge with a good turnover making more sense than two which are half full or loaded with slow-moving items.

Review of the thermostat settings

Unnecessarily low temperatures waste energy and do not provide any benefit. For maximum energy savings, the temperatures should be set and kept at the maximum authorised temperature. Often, temperatures are set lower than necessary.

A regular check of the temperatures (which should be set to the maximum suitable temperature for the foodstuff) helps saving energy consumption.

Lighting control

This section is only relevant for service cabinets, blast refrigerators and/or freezers and walk-in cold rooms.

Use of lower wattage light bulbs helps in reducing the amount of heat released and thus saving equivalent refrigeration energy. Switching off lights when unnecessary (e.g. during lunch hours) may result in overall reduction of energy consumption.

Anti-sweat heaters and heating coils control

This section is only relevant for service cabinets, blast refrigerators and/or freezers and walk-in cold rooms.

Anti-sweat heaters and heating coils ensure that no condensation occurs on the parts of the refrigeration furniture which are exposed to the ambient humid air. The power of these devices is normally constant and adds up to the refrigeration load. They are typically used 23 hours per day in low temperature cabinets (frozen) and 12 hours a day in chilled refrigeration equipment[16]. However, energy savings can be achieved by reducing the use of such heaters when the ambient air is colder and has a lower humidity.

The use of anti-sweat heaters can be controlled by switches responding to local dew point or humidity conditions. Appropriately placed sensors can measure dew point and allow the heater to switch off when not required.

Heating coils could also be replaced by a hot gas line running from the compressor to the door frame (for plug-ins only).

- **Locating the refrigeration equipment in a cool environment**

Avoiding direct sunlight, dusty areas, avoiding placing the equipment near a heated unit and providing good ventilation around the condenser and fans (in the case of plug-in equipment) results in higher energy efficiency of commercial refrigeration products.

3.2.3. Repair and maintenance practices

3.2.3.1 Repair practices

At this stage, very few information has been found to describe the typical European practices in terms of product repair. However, data collection is still *in progress*.

3.2.3.2 Maintenance practices

Regular (at least twice a year – or else specified) basic maintenance on commercial refrigeration equipment includes the following practices[17]:

- Evaporator cleaning ,
- Evaporator defrost,
- Condenser cleaning,
- Compressor check,
- Maintaining door/compartments seals,
- Cleaning and sanitizing equipment.

Each of these practices does not apply across all commercial refrigeration equipment and Table 3-2 identifies the correspondence between appliances and their maintenance practices.

[16] Arthur D. Little, Inc., *Energy Savings Potential for Commercial Refrigeration Equipment Final Report*, Building Equipment Division Office of Building Technologies U.S. Department of Energy, June 1996. http://www.eere.energy.gov/buildings/info/documents/pdfs/comm_refridg_equip.pdf

[17] Mitchell, N. Annual Systems Inspections Reduce Electric Energy Consumption. *ASERCOM Symposium*, Nuremburg. 2000

Table 3-2: Different basic maintenance practices across ENTR Lot 1 products

	Maintenance practice	Service cabinets	Blast refrigerators and freezers	Walk-in cold rooms	Chillers	Dessert and beverage machines	Water dispensers	Ice makers
Energy efficiency issues	Evaporator cleaning	x	x	x	x	x	x	X
	Evaporator defrost	x	x	x				
	Condenser cleaning (for appliances incorporating a condenser only)	x	x	x	x	x	x	X
	Maintaining door/compartments seals	x	x	x	x	x	x	X
	Compressor check (for plug-in appliances only)	x	x	x	x	x	x	X
Health issues	Cleaning and sanitising equipment (once a month)	x	x	x		x	x	X

The following paragraphs detail the different maintenance practices and their impact on the product performance.

- **Evaporator cleaning**

Cleaning the evaporator coils monthly and keeping them unobstructed can improve the efficiency. Blocking or partial blocking of the fin coils, and oil logging (oil coming from the compressor) will drop the evaporator temperature which reduces the cooling capacity and the desired cooling temperature might not be reached.

Specially formulated cleaning solutions are available to clean the type of sediment that can collect over time in evaporators. Cleaning the evaporator annually can prevent the sediment collection and increase efficiency. The cleaning requires the power to be shut off and the drain tube to be disconnected. The bottom pan of the evaporator coil can then be unscrewed and removed.

- **Evaporator defrost**

Service cabinets, blast refrigerators and freezers, walk-in cold rooms are mostly used in catering facilities (e.g. kitchens, bakeries) where ambient humidity is high (around 60 %). When in contact with the evaporator, the water condenses and freezes and a layer of frost forms on the outside of the evaporator acting as an insulator and hindering the heat exchange with the air that needs to be cooled. This results in poor energy efficiency.

Regular defrost prevents ice build-up. Different types of defrost methods exist: defrost through compressor shutdown, electric defrost and hot or cool gas defrost.

In the case of defrost through compressor shutdown the flow of refrigerant liquid in circulation inside the evaporator is temporarily stopped but the ventilators are kept in operation. The evaporator heats up melting the ice and the water resulting from defrost is drained and collected in the defrost water tray. The water from defrosting is then either evaporated within the appliance's storage volume (using an evaporator pan) or drained externally (drain line).

During the operation, the temperature rises above the set-point temperature and the food products' temperature rises as well. Therefore the duration of defrost is limited to ensure that the foodstuff is kept under good storage conditions. Defrost cycles are set automatically[18] and stop when the temperature reaches 12 °C , temperature above which no frost could subsist. The evaporator is then fed with refrigerant liquid and the vapour compression cycle can restart.

However, this defrost method is only acceptable for chilled refrigerated equipment and cannot be operated in the case of freezers because it would require the refrigeration cycle to stop for a long time and this would impair the food preservation.

In freezing equipment, one common defrost method used to reduce the duration of the ice melting is the electric defrost through the use of defrost heaters. They consist of high power resistances that are fixed near the evaporator (defrost coil which is integrated to the evaporator coil) and that are switched on to accelerate defrost. During this process the refrigerant supply is switched off and the ventilators are kept in operation to blow the warmed air on to the evaporator. A few minutes is then needed to achieve the complete melting of the ice and electric defrost is also very simple to use. However, higher electricity consumption is needed for the resistances and defrosting brings heat to the refrigerated storage space that needs to be taken out.

In an ADEME study[16], it has been shown that in typical supermarket frozen display cases, less than 20 % of the electricity used by the defrost heaters is actually used to melt the ice build up. The rest heats the air flow blown in the display case, heating up the equipment which will require to be cooled down after defrost. The total duration of the electric defrost per day is estimated to 30 minutes in low temperature (frozen) display cabinets in a typical supermarket.

Hot or cool gas defrost are potentially efficient methods although they require additional piping (implying higher risks of refrigerant leakages) and maintenance. Hot gas defrost uses the hot discharge (high pressure) gas directly from the compressor piped to the evaporator, and the cool gas defrost involves the circulation of gas from the liquid receiver with a control valve to begin and end the defrost cycle. The cool or hot gas condenses in the evaporator, releasing heat which melts the ice from the evaporator coils. The merits claimed for cool gas defrost are that there is less temperature shock to the piping and evaporators compared to hot gas defrost. During this operation, the fans are switched off to prevent water carry-over from the coils. The refrigerant leaving the evaporator is piped back to the liquid manifold of the compressor pack for distribution to other refrigerated equipment circuit (Figure 3-1). In supermarkets, refrigeration systems can supply refrigerant liquid to a number of different appliances (display cases, walk-in cold rooms) which are piped in parallel. For this reason, the number of appliances which can be defrosted at the same time is restricted to avoid starvation of the compressor and system shut-down due to low suction pressure.

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[18] The defrost operation can be automatic (no end-user action is required to initiate and stop the defrost), semi-automatic (automatic defrost with manual removal of the defrost water, or defrost initiated by the end-user which then stops automatically), or manual (the defrost is initiated and stopped by the end-user).

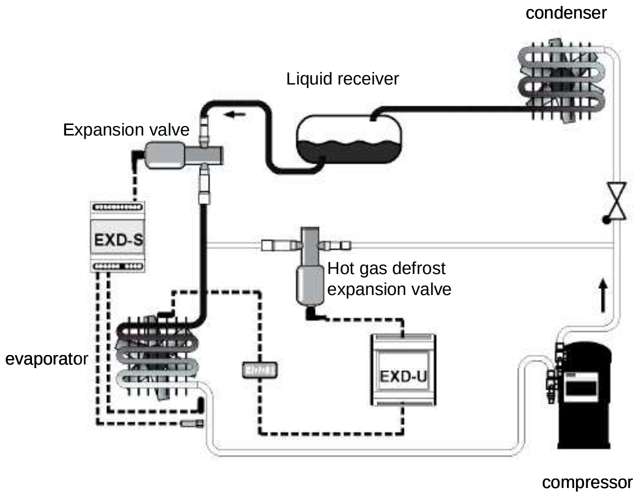

Figure 3-1: Typical configuration of hot gas defrost in a refrigeration system[19]

Energy efficiency and better temperature control can be helped by initiating defrost operations only when it is required (and not through a timer), through control systems detecting lack of performance and by stopping the defrost cycle as soon as the evaporator is clear of ice.

A number of defrost control strategies have been applied over the years which include: measuring the air pressure drop across the evaporator, sensing the temperature difference between the air and the evaporator surface, fan power sensing, variable time defrost based on relative humidity and air differential across the coil. Most recent methods include measuring the ice thickness through monitoring the resonant frequency of an acoustic oscillator installed on the evaporator, measuring the thermal conductivity of the ice, using photo optical systems and fibre optic sensors to measure the presence of frost.

However, cost and the simplicity of use is an important factor for end-users since the number of refrigeration appliances in a modern supermarket or a restaurant may range from 5 to 150 units and electric defrost remains the most typically used method.

- **Condenser cleaning (for appliances incorporating a condenser only)**

The cleanliness of the surface of the air-cooled condenser is very important. If condenser coils get too dirty, the compressor discharge pressures can get high enough to break the compressor in a short period of time. A regular check on this component can prevent reaching high discharge pressures resulting in higher efficiency.

In the case of an air-cooled condenser, even if the condenser is located in a ventilated area, if the air cannot directly contact the heat transfer surface because of dust and dirt (see Figure 3-2) then the condensing temperature will rise. Keeping the condenser coils clean will help reducing the electricity consumption. Manufacturers recommend the condenser to be cleaned at least twice a year in the case of beverage merchandisers.

A case study[20] in UK showed that as much as 8 % electricity savings could be achieved just by cleaning the condenser.

[19] Copeland Alco control catalogue 2006

Figure 3-2: Top mounted condenser on plug-in service cabinet prior/after cleaning

In case of water cooled condensers[21], the condenser should be checked in case of corrosion and formation of scale. Tube scaling and fouling can be monitored by logging pressure drop across the condenser bundles.

Cleaning the condenser fan blades also ensures increased energy efficiency.

- **Maintaining door/compartment seals**

Regular checks to verify that the door seals are providing sufficient insulation can also result in saving energy by preventing heat leakages.

- **Compressor check**

Compressor maintenance includes the following practices:

- Vibration analysis: checking all alignments to specifications,
- Checking all seals,
- Lubrication of moving parts,
- Checking the oil system (oil and filter),
- Check all strainers, valves, etc.

- **Cleaning and sanitising the equipment**

In the case of ice-makers, the ice produced is consumed by customers; therefore the ice-maker is considered a food contact surface area. Following manufacturer's instructions, the appliance should be cleaned and sanitised at least once a month. Cleaning will remove scale/lime build-up and other mineral deposits and sanitising will remove harmful bacteria, algae and slime growth. Same applies for other appliances which have a direct food contact area (dessert and beverage machines, and water dispensers).

Service cabinets, walk-in cold rooms and blast refrigerators and freezers do not come directly in contact with the foodstuff but also need to be regularly sanitised and cleaned.

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[20] Mark J. Swain . *Energy use in the catering sector, Case study – Refrigeration at the Langford canteen.* University of Bristol. 2009 http://www.frperc.bris.ac.uk/defraenergy/docs/catr-casestudy.pdf

[21] FEMP 2004. O&M Best Practices Guide 2.0., FEMP 2002. Continuous Commissioning Guidebook for Federal Energy Managers.

In service cabinets and blast refrigerators and freezers, the condensate (resulting from defrost operations) drain lines can be blocked by spillages and debris, causing leaks and generating a possible health risk. Indeed, the drains and condensate trays are a breeding ground for bacteria which can grow at a very fast rate. Correct condensate tray and drain sanitisation and regular cleaning will initially remove the bacterial growth.[22]

Hygiene in walk-in cold rooms is important particularly if dealing with fresh meat and produce as fatty deposits from foodstuff can contaminate the airflow and restrict the airflow. Regular sanitisation with a food safe sanitizer will break down and remove fatty deposits stuck on evaporator fins ensure that hygiene levels are maintained. Walk-in cold room walls, floors and ceilings and internal shelves also require being cleaned and sanitised.

◆ **Additional maintenance practices**[23]

Additional maintenance practices to be performed at least twice a year include the following:

- Oiling accessible moving parts and bearings,
- Examining and checking for refrigerant leaks and refrigerant level,
- Verifying the electrical connections (insulation, tightness of electrical connections, fuse check, electrical contacts, etc.),
- Checking the defrost/anti sweat system (control and heaters) where relevant,
- Checking water pipes and waste water pipes for leaks where fitted,

3.2.4. Economic product life (=actual time to disposal)

The economical products life in the case of commercial refrigeration products is assumed to be less than their technical life. As sometimes, they are replaced because of hygiene reasons even if the technical components are functioning properly.

Table 3-3 provides preliminary average economical product life estimates which will be used in LCC calculation during tasks 4 and 6.

No data was available to estimate the lifetime of blast refrigerators and/or freezers and of dessert and beverage machines. As a preliminary estimate, the product lifetime for blast refrigerators and/or freezers was estimated to be the same as for service cabinets (i.e. 8.5 years); and the product lifetime of dessert and beverage machines the same as water dispensers (i.e. 9 years).

[22] Myddleton Maintenance Services Ltd
[23] APEX Commercial Refrigeration & Air Conditionning Ltd.

Table 3-3: Average economical product life of commercial refrigeration equipment

Product category/Source	UK Defra MTP[24]	ADL 1996[25]	ME 2000[26]	Study estimates
Service cabinets	8	8 to 10	9	8.5
Blast refrigerators and freezers	*N.A.*	*N.A.*	N.A.	8.5 (assumed similar to service cabinets)
Walk-in cold rooms	18	insulated box: 12 to 25 years semi-hermetic compressor servicing refrigeration equipment: 8 to 12 years	*N.A.*	insulated box: 18.5 years semi-hermetic compressor servicing refrigeration equipment: 10 years
Chillers*	15	*N.A.*	*N.A.*	15
Dessert and beverage machines	*N.A.*	*N.A.*	*N.A.*	9 (assumed similar to water dispensers)
Water dispensers**	*N.A.*	*N.A.*	9	9
Ice makers	8	7 to 10	10	9
Packaged condensing units (air cooled only)	*N.A.*	8 to 12	*N.A.*	10
Refrigeration compressors (not included in plug-in refrigeration equipment)	*N.A.*	8 to 12	*N.A.*	10

**Liquid chilling packages only (i.e. packaged chillers)*
*** Bottled water dispenser based on 2009-2010 data only*
N.A. not available

3.3. END-OF-LIFE BEHAVIOUR

In European fridge recycling facilities, less than 1 % of the appliances are commercial equipments. Commercial refrigeration equipment can be frequently renewed for either aesthetic/hygiene reasons although it is still operational. Most of the commercial refrigeration equipment is then refurbished and introduced in the second-hand market. The used equipment is generally sold in East and Central Europe or in African/Asian countries.

Other practices also exist: when the equipment is not suitable for second hand use, some retailers sell the old equipment to scrap metal dealers. Valuable materials such as copper, aluminium and steel are also recovered.

3.4. CONCLUSIONS ON TASK 3

Preliminary results of task 3 show that user behaviour could have a significant impact on the electricity consumption of commercial refrigeration equipment through

[24] UK Defra statistics available at http://whatif.mtprog.com/
[25] Arthur D. Little, Inc. *Energy Savings Potential for Commercial Refrigeration Equipment, Final Report Prepared for US Department of Energy*. 1996
[26] Mark Ellis and Associates. *Self-contained Commercial Refrigeration.* March 2000

operational and maintenance practices. Barriers to ecodesign related to the end-user have been identified and will need to be taken into account when focusing on improvement potential (task 6).

Stakeholder consultation is still in progress and an online questionnaire[27] has been sent in order to complement the current understanding of user behaviour aspects.

[27] BIO Intelligence Service. *First ENTR Lot 1 online questionnaire to stakeholders*. Different versions of the questionnaire are available depending on the product category and can be downloaded from http://www.ecofreezercom.org/documents_1.php