Commercial Service Cabinets

Review of available information on energy consumption

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By

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Market

Refrigerated Commercial Service Cabinets (CSCs) are used to store food and/or drink in commercial catering facilities. There are approximately 500,000 units in use in the UK. The vast majority of the cabinets sold are integral cabinets (with refrigeration system within the case) but remote units (where the refrigeration system is separate from the cabinet) are also available. Remote cabinets make up less than 5% of the current market and there is no indications that this is likely to increase in the near future.

Refrigerated CSCs are in use in virtually all-commercial catering facilities. The majority of the market is for chilled or frozen upright cabinets with one or two doors (between 400 and 600 litres for single door cabinets and 1,300 litres for double door cabinets) or under counter units with up to four doors (150 to 800 litres). There is however a sector of the market (approximately 25% of the total number of units) that is bespoke units for particular applications and this can account for between zero and 70% of the market for individual cabinet manufacturers

CSCs use 12% of commercial refrigeration energy (Figure 1) (1). The average energy consumption for chilled cabinets is 2,920 kWh per year and for frozen is 5,475 kWh per year. This equates to 7 PJ (2.2 TWh) per year [**Error! Bookmark not defined.**]. MTP reference and policy scenario figures indicate that the energy used by CSCs will increase to 2020 but if EBP (Energy best Practice) is used the energy consumption will decrease by approximately 30% by 2020 (Figure 2).

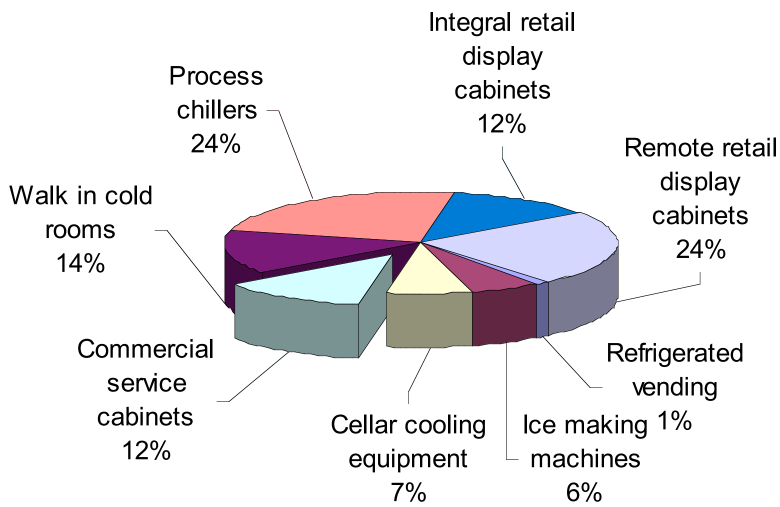

Figure 1. Energy used in commercial refrigeration in the UK.

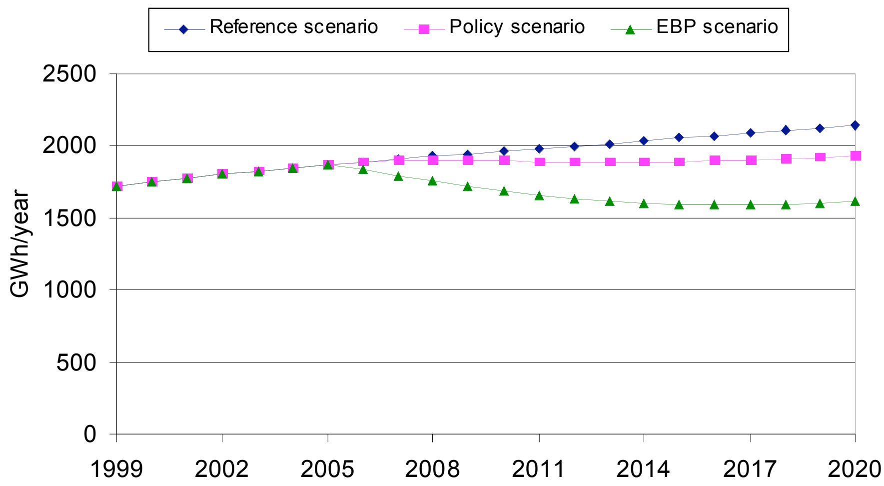

Figure 2. MTP predictions of energy consumed by CSCs to 2020.

The UK market for CSCs is worth £90-95 m per year and is dominated by 3 companies (Fosters, Williams and Gram). These 3 companies have approximately 75% of the UK market. Other companies such as Electrolux, Metos spa, Porkka, Caravell and imports from China and the Far East constitute the remainder of the UK market. Approximately 58,000 units are sold per year, of which 9,000 are under counter units. Prices per unit range from £900 to £1,800 (depending on size of cabinet) with a typical price of £1,000. The overall market is increasing slowly by a few percent per year.

Performance in test rooms

CSCs are generally tested in test rooms to assess performance in terms of energy and temperature control. No directly applicable test standards exist for testing CSCs and therefore a retail display test standard, EN441, is commonly used. EN441 is now superseded by EN23953 but for assessment for schemes such as the ECA (Enhanced Capital Allowance) EN441 remains the test standard. Generally for such tests the energy consumption is related to the net storage volume of food as an Energy Efficiency Index (EEI). Tests include door openings to replicate usage.

The performance reported in test room conditions (30°C and 55% RH) varies considerably. Data from FRPERC tests, the ECA scheme and the Danish Positive List is presented in Figure 3 (all from tests using EN441). It can be seen that the performance of the cabinets varies considerably in terms of functionality (amount of energy consumed to store a volume of food).

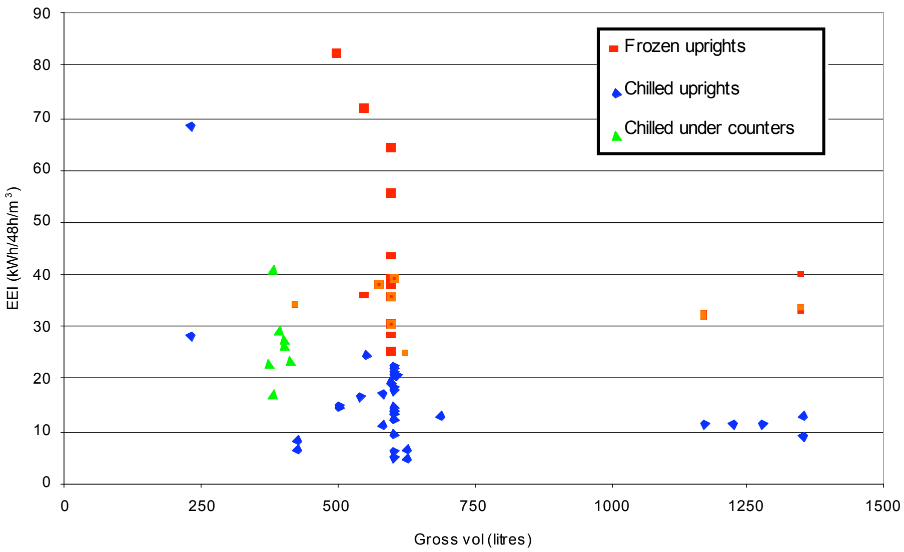

Figure 3. Energy consumed by cabinets in test conditions.

If the functionality of CSCs is compared with retail cabinets using data from the ECA scheme and from data presented in Evans, Scarcelli and Swain, 2007 (2) the functionality of chilled CSCs (solid door chilled cabinets) compares favourably with those with glass doors (Table 1). However, the performance of frozen CSCs (solid door frozen cabinets) compared quite poorly with glass door cabinets. This indicates that there is potential to improve these cabinets.

	EEI (kWh/48h/m^3)		
	Mean	Max	Min
Solid door (chilled)	**15.24**	**68.74**	**4.85**
Chest freezer	16.26	36.53	4.47
Glass door (chilled)	22.40	41.65	10.07
Multi-deck (chilled)	24.31	68.92	7.85
Glass door (frozen)	38.34	54.58	11.88
Solid door (frozen)	**39.28**	**82.04**	**24.75**
Well (frozen)	43.15	89.19	16.72

Table 1. EEI of chilled and frozen CSCs and various retail display cabinets.

Performance in use

There is little published data on energy consumption of CSCs in use. Available data is shown in Figure 4. Although each cabinet type is of similar size and therefore can be directly compared in terms of functionality there is a large difference in energy consumed by each

CSC type. This is likely to be due to different inherent efficiencies and also to usage and location of the cabinet.

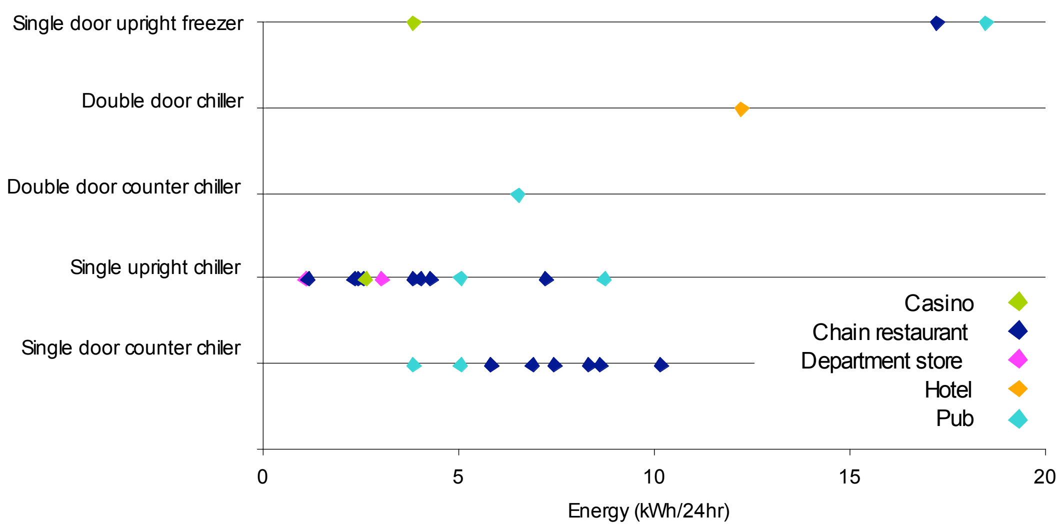

Figure 4. Energy consumed by different types of CSCs in varied locations.

Figure 4 demonstrates that considerable savings in energy are achievable using current technology. If the best and worst cabinets are superimposed on the MTP data from Figure 2 the potential annual savings are approximately 1,000 GWh per year (Figure 5). This equates to an average saving on current EBP of 63%. This demonstrates that considerable savings are achievable using current technology and although improvements in current technology are possible, that one of the major issues is persuading end users to purchase the most efficient cabinets.

Pedersen (3), published a study in 2004 showing improvements to Gram cabinets of 47% (freezers) and 74% (chillers) in usage (from 6.26 kWh/day to 1.62 kWh/day for the chillers and from 8.53 kWh/day to 4.54 kWh/day for the freezers). The original cabinets' energy was divided as shown in Figure 6. By changing the refrigerant, using energy efficient components and optimising heaters, door seals and the control system energy savings were achieved. The greatest savings were achieved by optimising the door seals, using DC fans and by using compressor discharge gas for evaporator water evaporation.

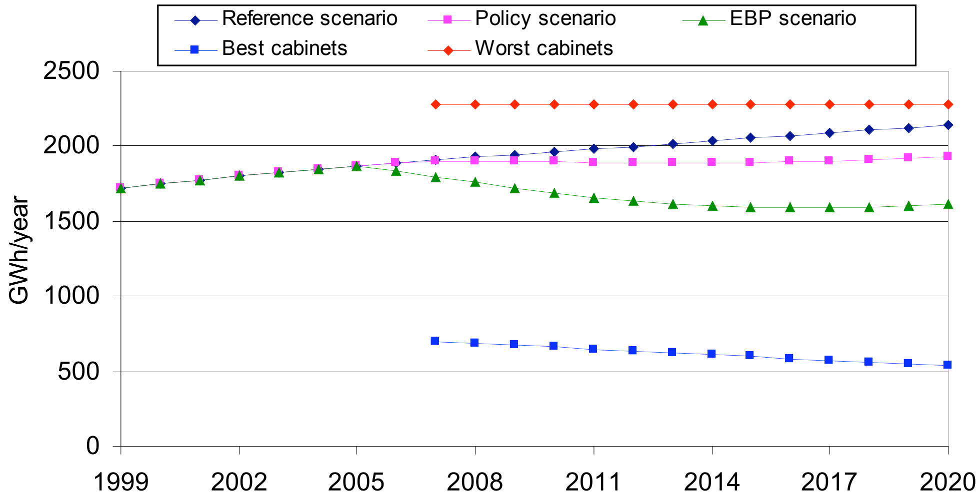

Figure 5. Best and worst cabinets in use superimposed on MTP data (assumes best cabinet improve 2% year on year).

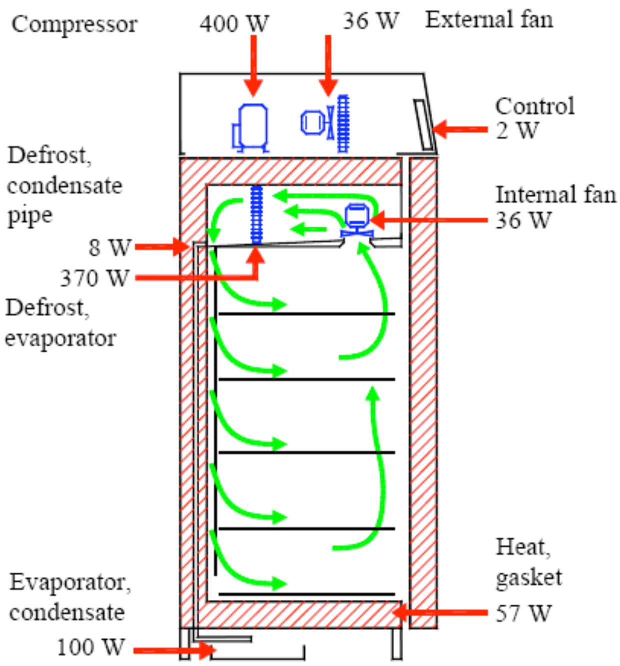

Figure 6. Energy consumption by components in Gram cabinet prior to modifications (from Pedersen, 2004).

Door openings

The cabinets developed by Pedersen were tested in usage and data on real life usage was collected. The number of door openings varied considerably depending on cabinet usage but was up to 24 door openings per day for a freezer and up to 280 door openings per day for a chiller. This compares to test standard (EN441) door openings of 73 door openings per door per 12 hour door opening period[1] (total open time of 0.29 hour per door). This would indicate that the test standard has a tendency to encourage over specification of freezers and under specification of chillers.

The number of door openings should be related to energy consumed and this was shown to be broadly true by Pedersen. The time that the cabinet door is open should also influence energy consumption. If cabinets tested to EN441 (12 second door openings every 10 minutes) and EN23953 (6 second door openings every 10 minutes) are compared the energy consumed by cabinets in the EN23953 tests is approximately 37% lower than that in the EN441 test.

Test performance versus real life performance

There is very little data available to compare energy consumed in tests situations with that in real life usage. The limited data available shows that the most efficient cabinet in a test situation may not necessarily be the most efficient cabinet in use. However, the way the cabinets were used may not be directly comparable and therefore more work is required to quantify differences.

Effect of location

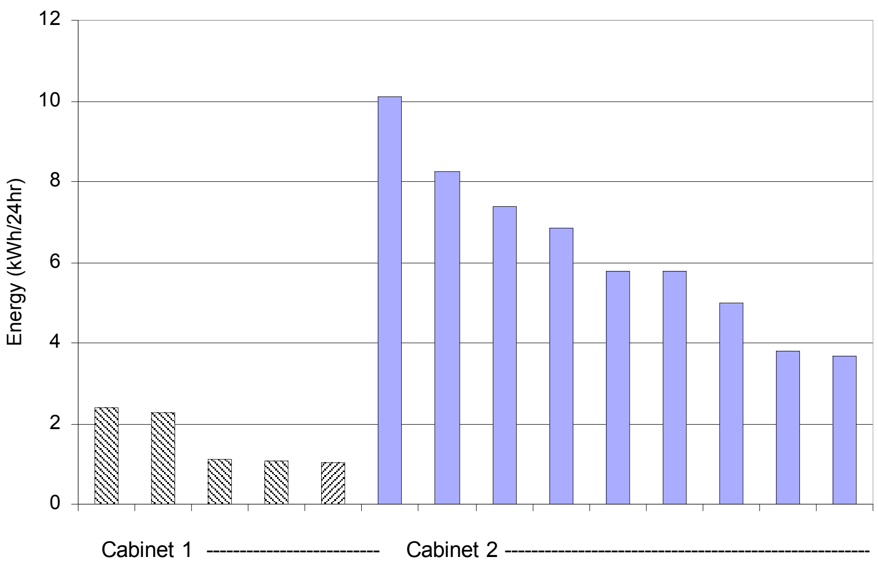

Figure 7. Energy consumed by 2 cabinets in varied locations (cabinet 1 is a single door chiller and cabinet 2 is an under counter chiller/freezer).

[1] N.b. Door openings occur for 12 hours in every 24 hour period of the test.

There is little data on effect of location of cabinet on CSC energy performance. Limited data is shown in Figure 7 that demonstrates that depending on location (and usage) a cabinet can consume vastly varied amounts of energy.

The effect of different locations on energy consumed by a range of cabinets is shown in Figure 8. The data presented is from cabinets of the same size but different model and therefore the inherent efficiency and location of the cabinet will also have an influence on energy consumed. The energy consumed varies considerably demonstrating that location and cabinet model have a large effect on energy consumption. Interestingly the energy consumed by all cabinets is considerably lower than the average in Table 1 indicating that test room conditions provide a harsher environment than in real life usage. This may indicate that chiller cabinets as well as freezers (see comment on freezer specification in 'Door openings' section above) are over specified to pass a test standard and that this may lead to inefficiencies in usage. It should be noted that although energy was recorded in the cabinets while in use the temperature within the cabinet was not monitored and therefore any energy savings achieved may have been at the expense of higher product temperatures.

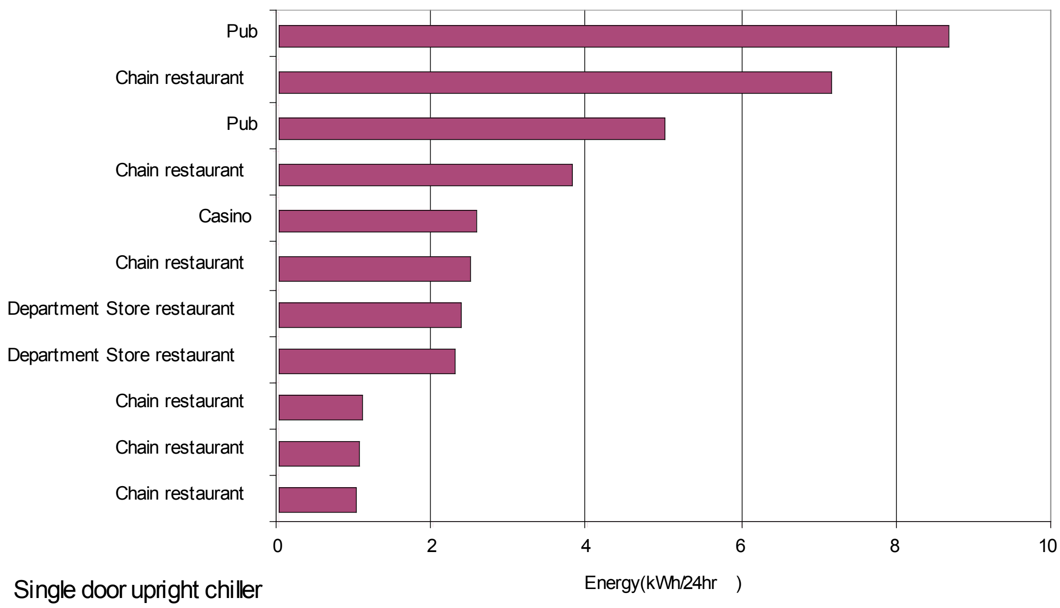

Figure 8. Effect of location on energy consumed by a single cabinet type (single door chiller).

Energy saving features

Table 2 shows energy saving features either commonly incorporated into CSCs or which could be utilised to reduce energy.

Technology	Rationale	Commonly used in CSCs	Estimated energy saving potential
Suction-liquid heat exchange	Sub cool liquid	Yes	10%
Liquid line solenoid	Removed 'off-cycle' losses	Not standard	10% (dependent on off cycle time)
Control systems - fan pulsing, compressor start up control	Reduce unnecessary loads	Not standard	Up to 30%
Inverter driven compressors	Reduction in start up losses, off cycle losses	No	20%
Off-cycle defrost	For chilled cabinets only	Yes	5%
Discharge gas defrost water evaporations	Removed need for electrical heaters	Yes	2%
DC fans	Lower energy usage	Not standard, becoming more widely used	1%
Gasket heaters	Removing/reducing gasket heaters. Lower energy usage	Not standard	1%
Improved insulation	Reduced heat load	No	20%

n.b. savings are not necessarily cumulative.

Table 2. Energy saving features in CSCs.

Future potential

The fundamental design of CSCs has changed little over the past 20 years. Step changes have occurred that have improved efficiency. There is still an emphasis on first cost of units rather than life cycle costing and manufacturers have difficulty justifying the higher costs of energy saving components against imported cabinets that have a low initial cost but higher energy consumption in use.

Potential exists to improve frozen CSCs as these compare unfavourably with other options. In a commercial kitchen frozen cabinets are usually only opened at the beginning and end of a day and therefore chest freezer should be a more efficient option that would not have a great influence on usability of the cabinet.

Schemes such as the ECA have reduced compliance thresholds and are therefore encouraging manufacturers to implement DC fans and other energy saving features. There is still a large variation between the most, and least, efficient cabinets and there is considerable potential to save energy using currently available technologies.

There is considerable lack of data on performance of cabinets in use. Improved understanding of requirements in commercial kitchens would enable cabinets to be designed and optimised for usage.

References

1) Sustainable products 2006: Policy analysis and projections. MTP.

2) Evans, J.A., Scarcelli, S., Swain, M.V.L., 2007. Temperature and energy performance of refrigerated retail display and commercial catering cabinets under test conditions. International Journal of Refrigeration 30, 398-408.

3) Pedersen, P.H., Soe, L. and Jensen, F. New Generation of Professional Kitchen Appliances with Natural Refrigerants and Reduced Energy Consumption. 6th Gustav Lorentzen Natural Working Fluids Conference, Glasgow, UK

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