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Energy savings in retail and commercial refrigeration

The problem

Reality:

2D view of food

Food increasingly packaged

Product visibility often low

Large variations in temperature

Little flexibility

Ideally:

360° access

Customer able to interact with product, no barriers (i.e. doors)

All product on view

All at same temperature

Flexibility

Weakest link in cold chain

High energy consumption

Range in temperature

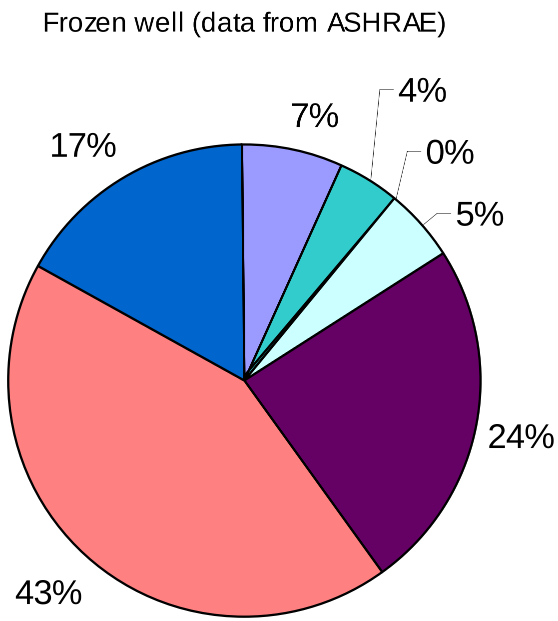
- Rear-front
- Side-side

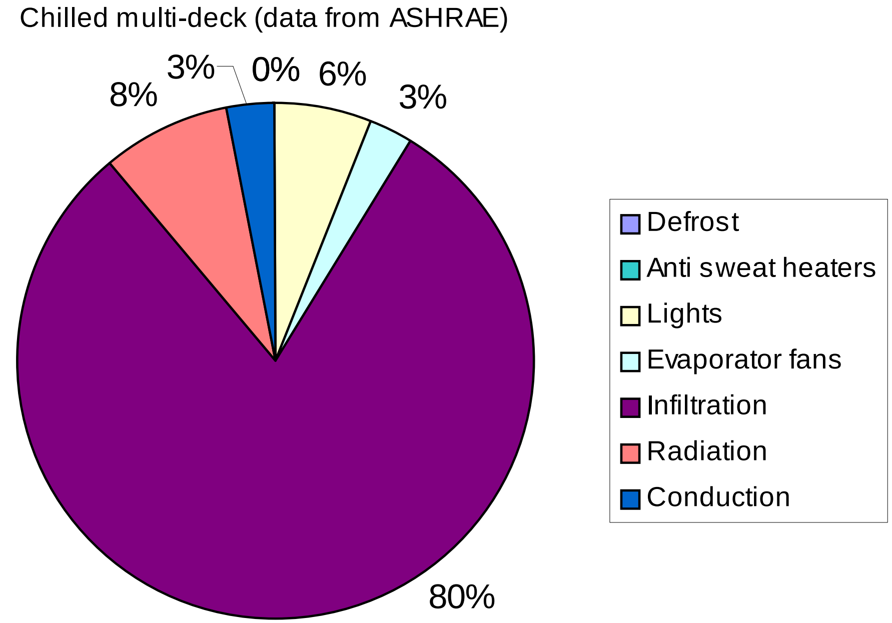
Standards encourage temperature range

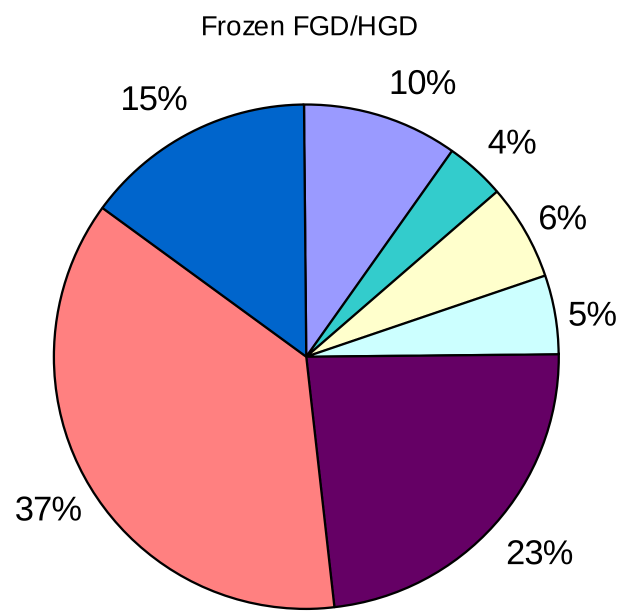
- -1 to 5°C (M1)
- -1 to 7°C (M2)
- -1/1 to 10°C (H)
- <-15, < -18°C (L1)

Are these temperature standards ideal for food quality and low energy consumption?

Heat loads


Frozen well (data from ASHRAE)
7%
4%
0%
5%
24%
43%
17%

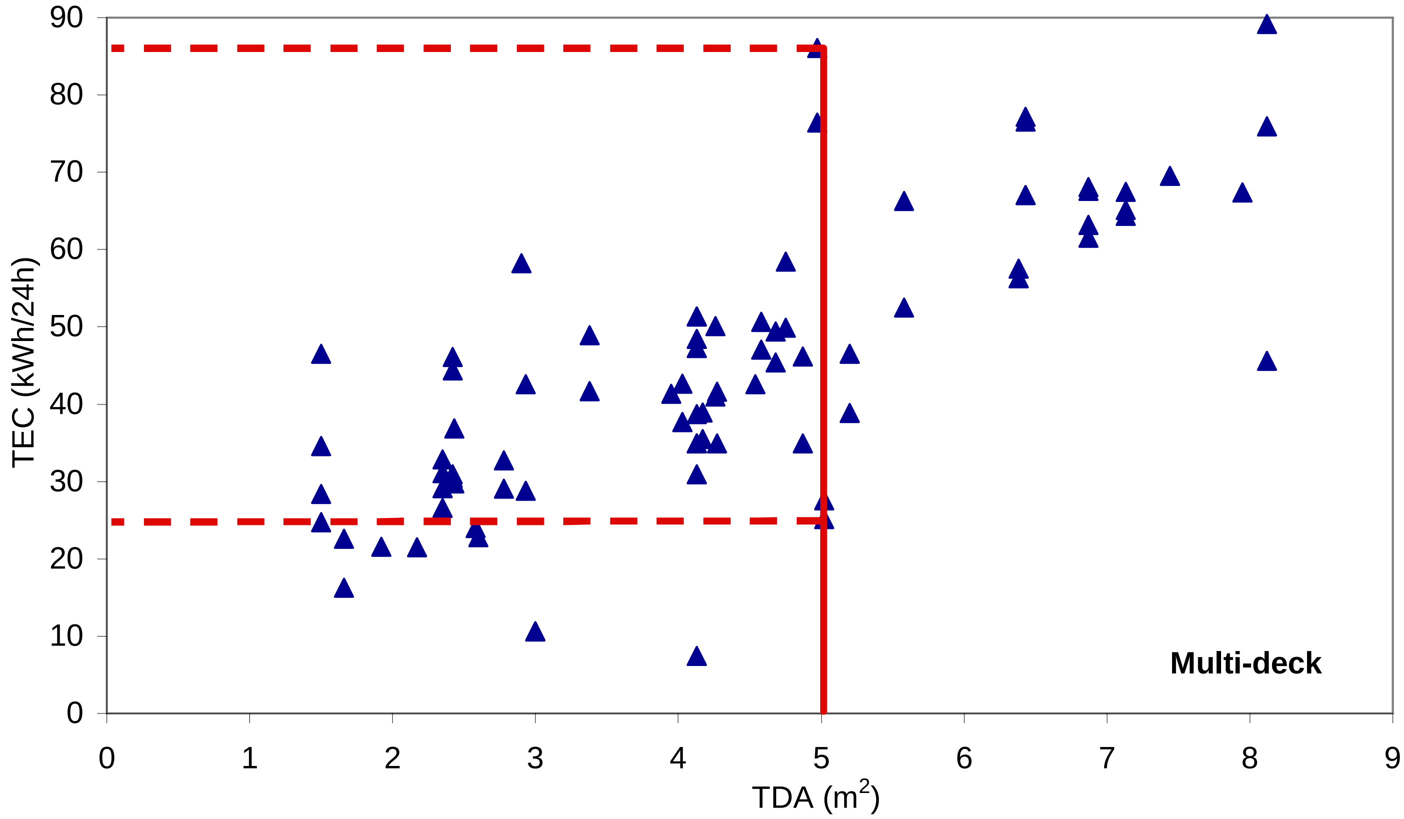

Chilled multi-deck (data from ASHRAE)
0%
6%
3%
80%
8%
3%
Defrost
Anti sweat heaters
Lights
Evaporator fans
Infiltration
Radiation
Conduction


Frozen FGD/HGD
10%
4%
6%
5%
23%
37%
15%

The best technology

- How energy efficient could a cabinet be -
  - Today
    - In the future…..

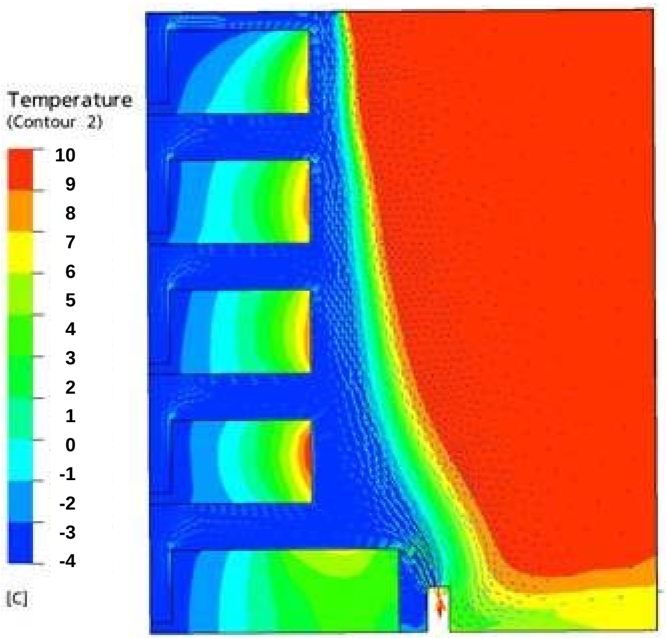
Best on market

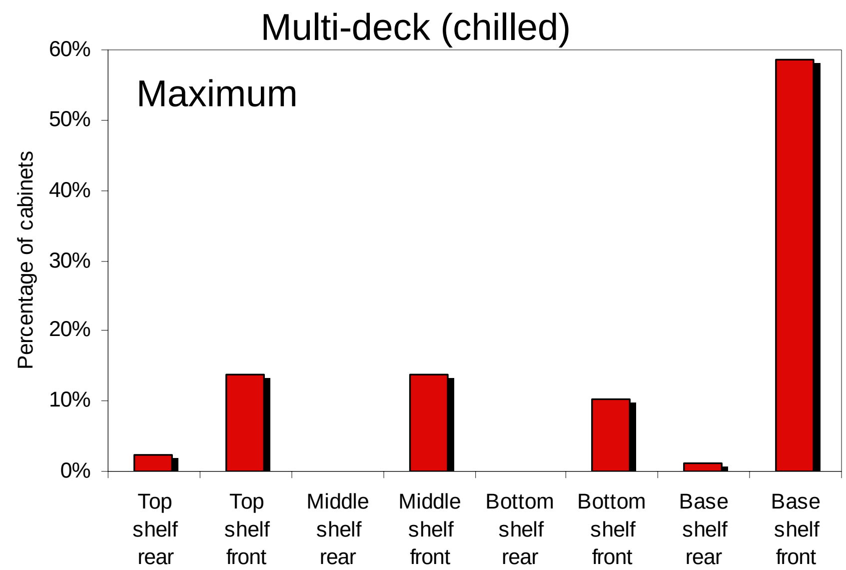


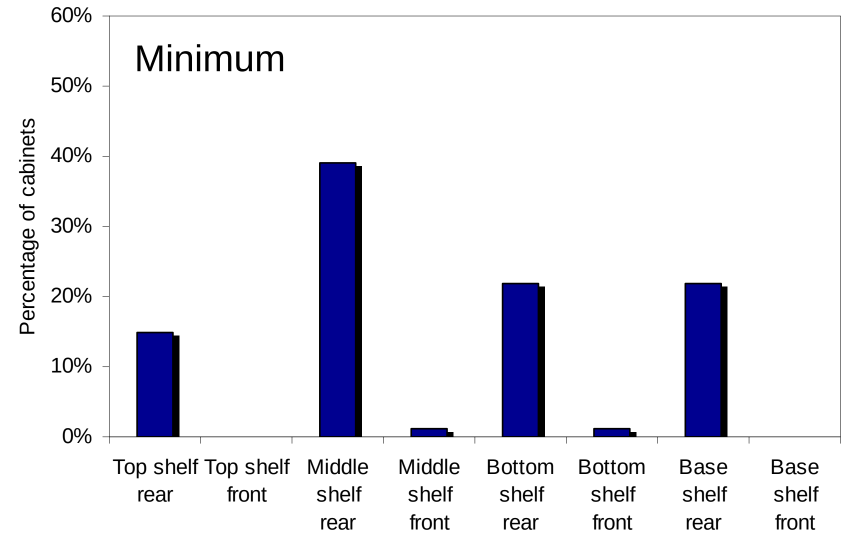
Large range in performance for cabinets that have the similar functionality

Temperature control - current

Increase set point temperature by 1ºC = energy saving of 2-5%

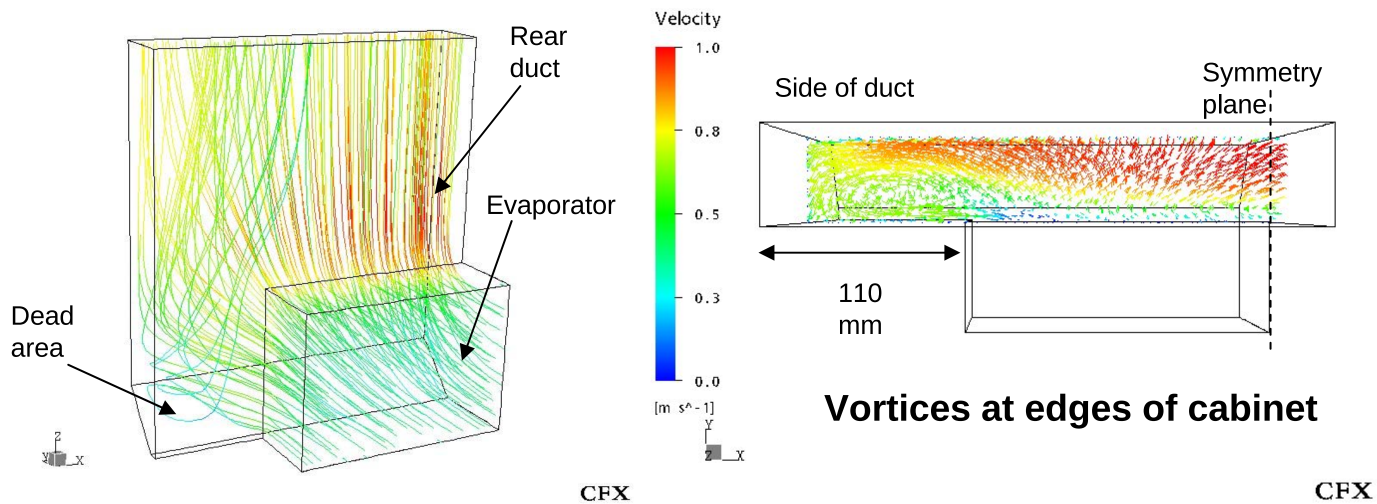






Temperature control - current

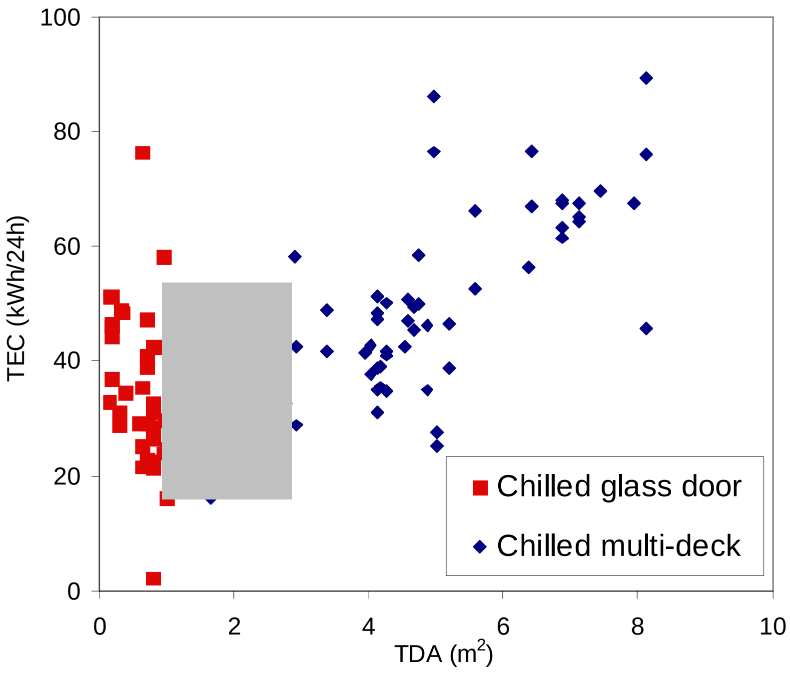
- **More even temperature control = less energy**
  - **Prevent air by-passing evaporator**
  - **Prevent vortices in rear duct**

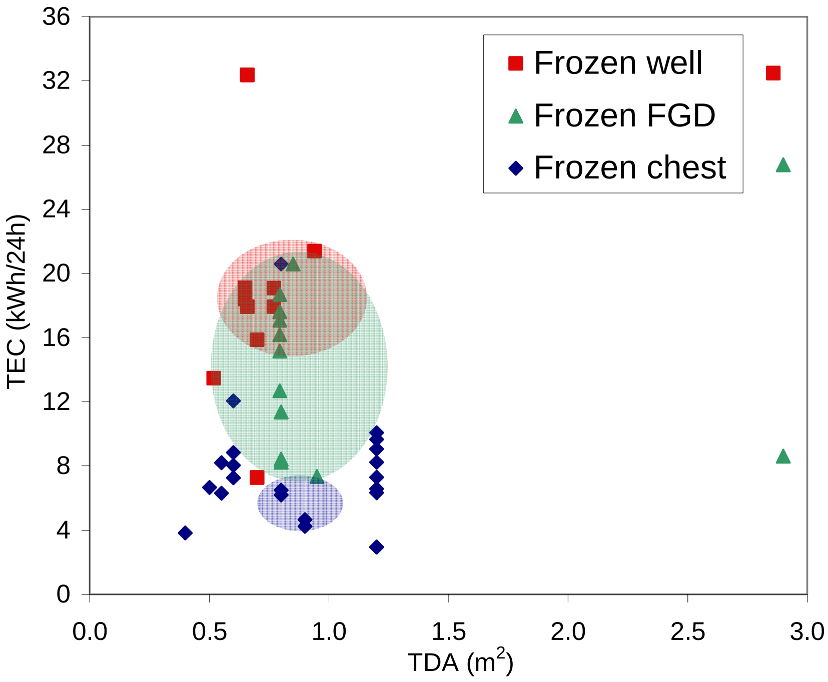


Vortices at edges of cabinet

Infiltration - current

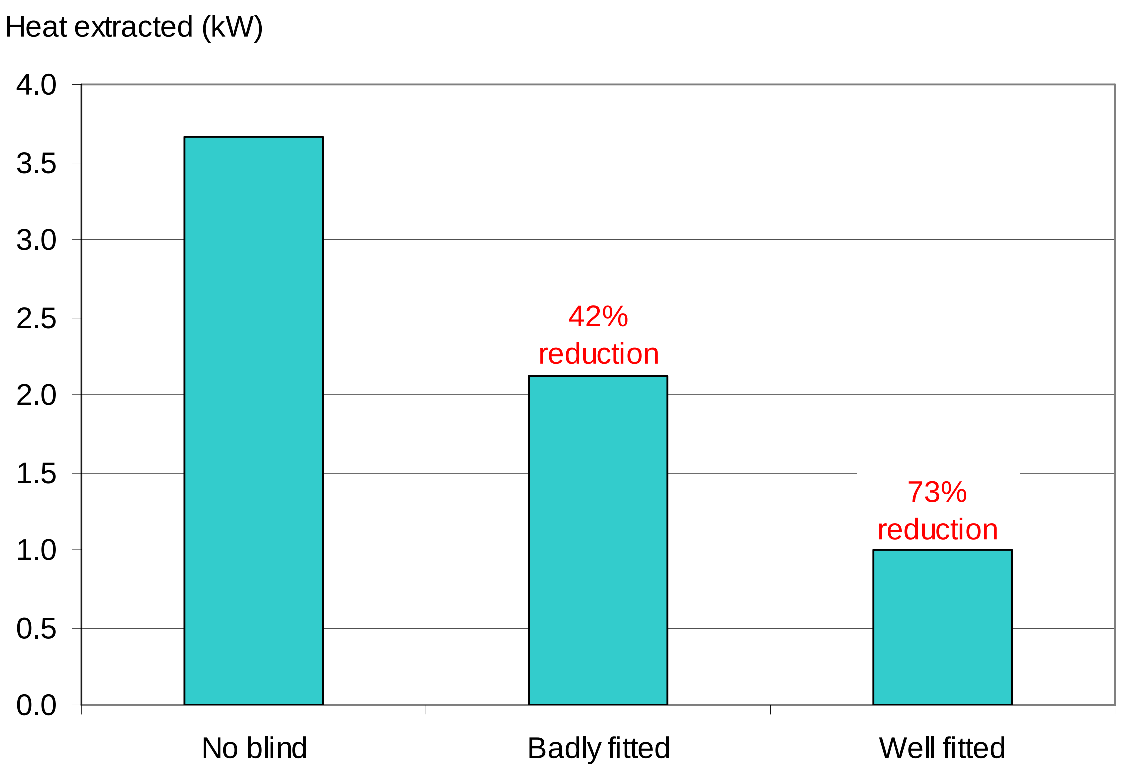
- **Physical barrier**
  - **Doors (up to 50%, depends on usage)**
  - **Up-riser (≈ 8%)**
  - **Shelf front guides (≈ 5%)**





Infiltration - current

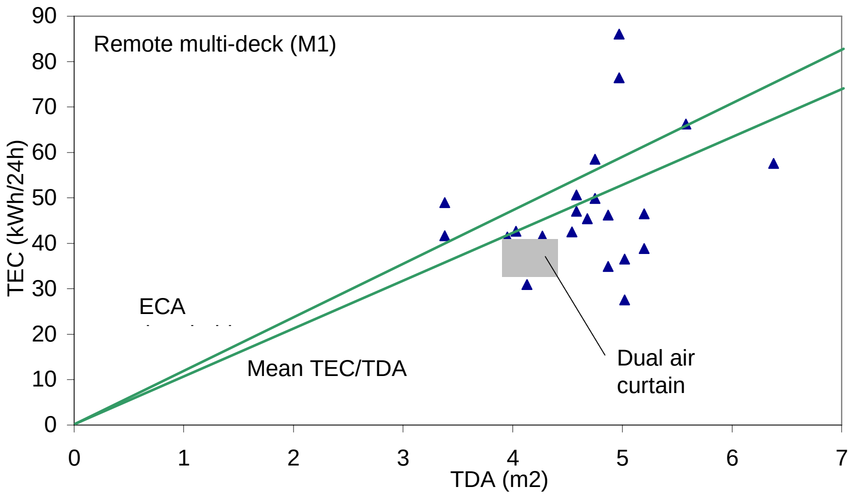
- **Physical barrier**
  - **Strip curtains (30%)**
  - **Night blinds (>75%)**

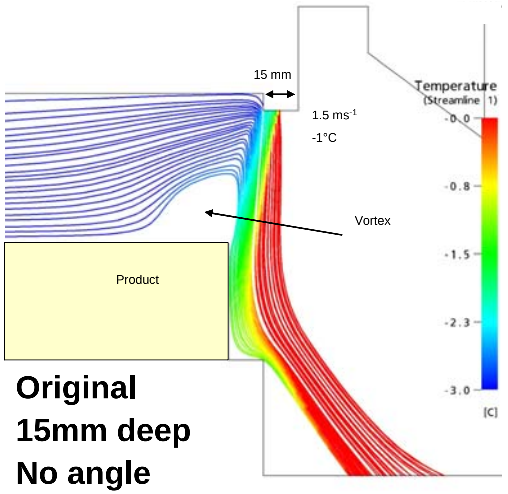


Effect of night blinds

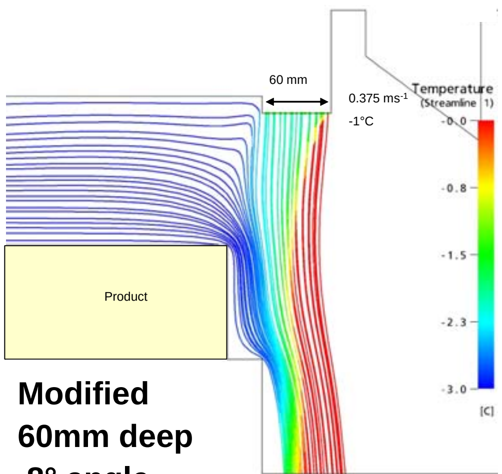
Infiltration - current

- **Air flow optimisation**
  - **Double/triple air curtains**
  - **Curtain turbulence, 10%T to 3%T will reduce infiltration by 8%**
  - **DAG profile optimisation**
  - **DAG-RAG size and spatial relationship**
  - **Air flow through DAG/back panel**
  - **Chute shelves (optimisation?)**





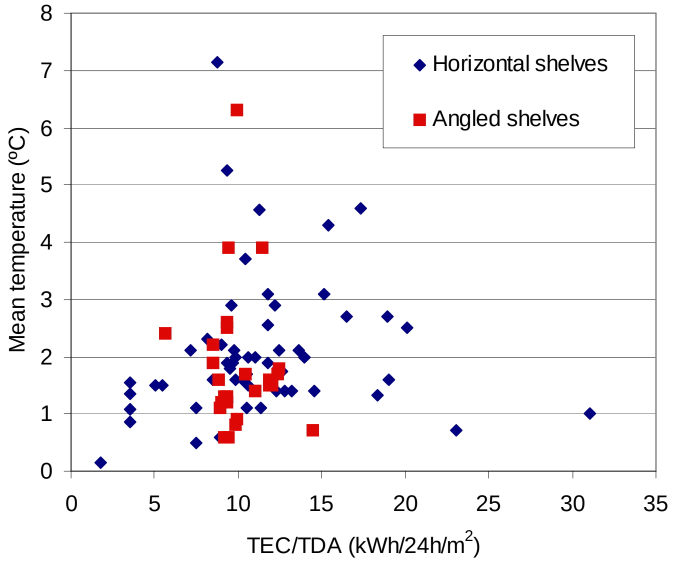
Original
15mm deep
No angle
1.5m/s, -1°C

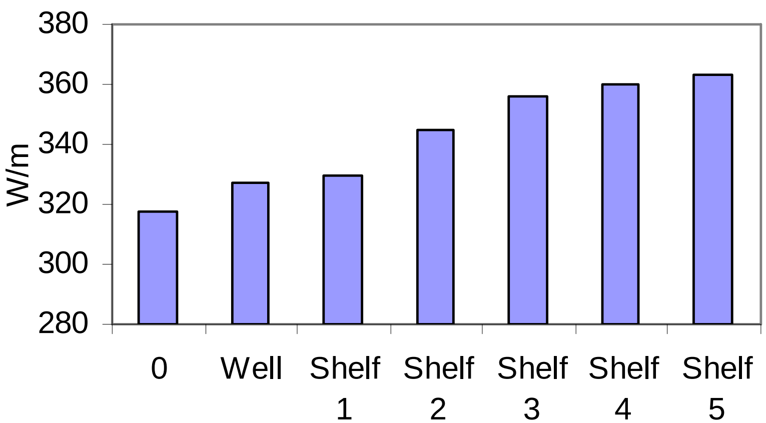


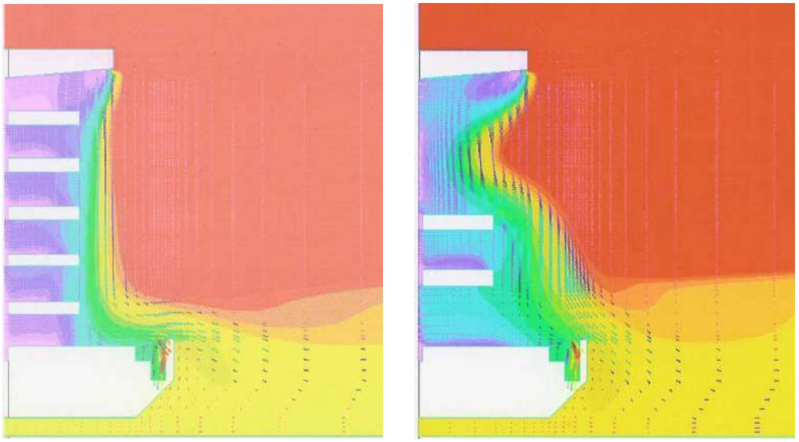
Modified
60mm deep
8° angle
Same volume flow rate and temperature

Infiltration - current

- Gaps between shelves
- Shelf angle
- Labels
- Poor product loading



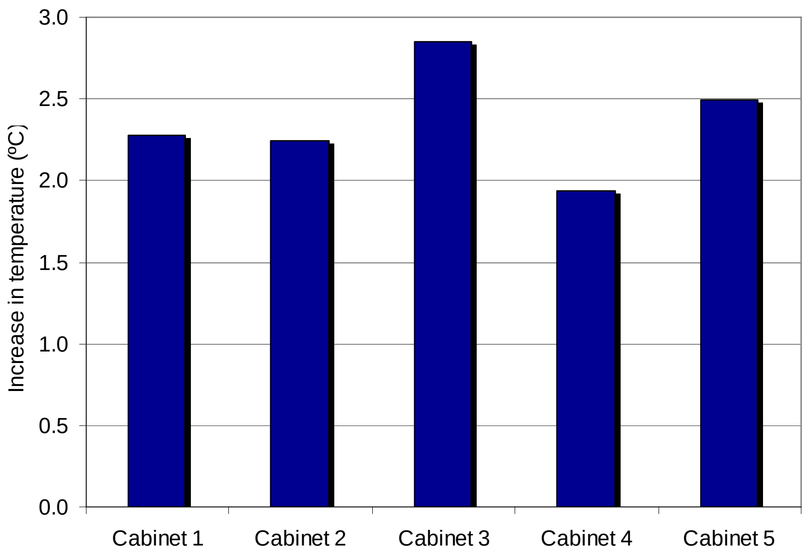


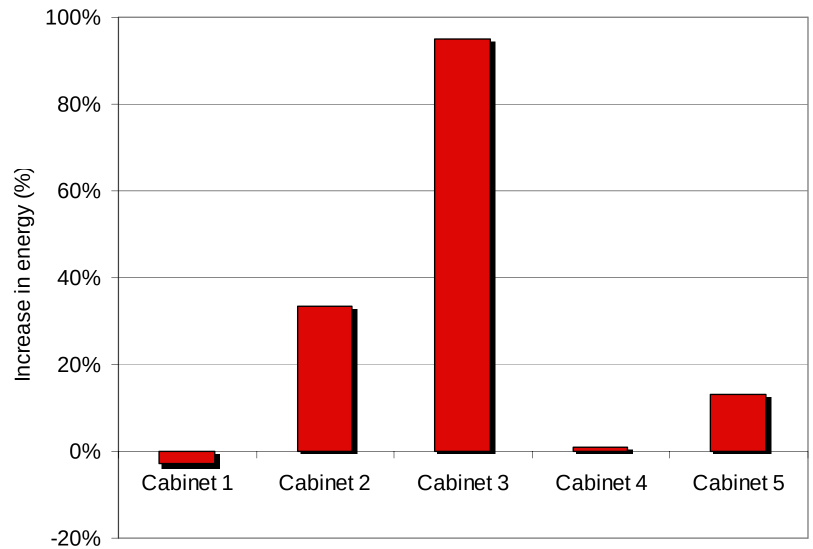


Infiltration - current

- **Store conditions**
  - **Draughts**
  - **Store dehumidification. Reduce RH from 55 to 35% will reduce infiltration by approx. 29% (5% reduction in RH, 5% reduction in total store energy)**

Chilled multi-deck, integral, air blown intermittently into cabinet





University of BRISTOL
Food Refrigeration & Process Engineering Research Centre
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LONDON SOUTH BANK UNIVERSITY
University of Sunderland
defra Department for Environment Food and Rural Affairs

Current technology - radiation

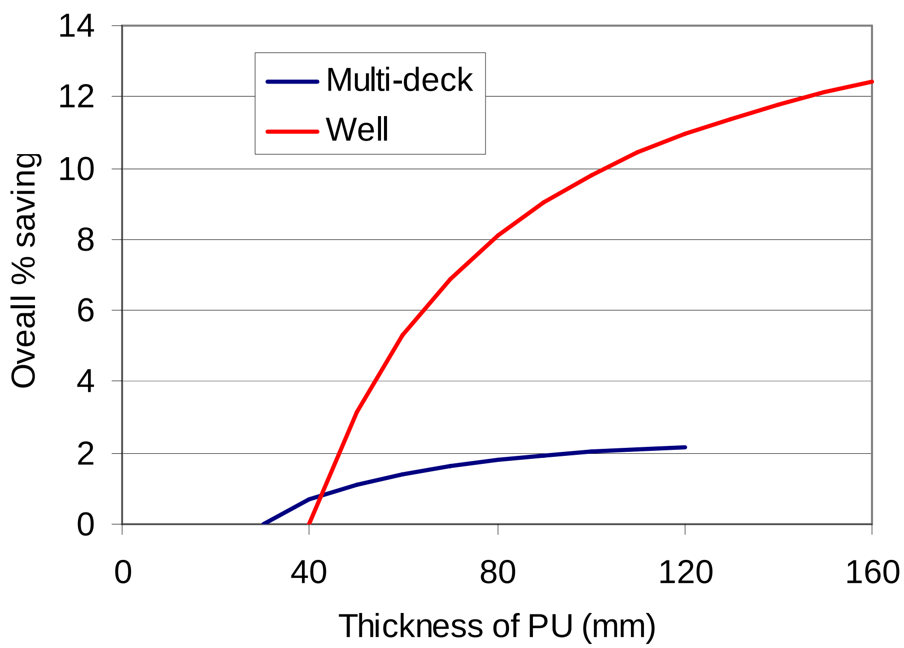
- Reflective packaging
- Mirrored ceilings (above well), 2ºC drop in product temp
- Reflecting night blinds
- Minimise lighting
- Low heat output lighting
- Low emissivity/reflective glazing (‘K’ glass) (1-2K increase in evap temp)

Current technology – lights and fans

- Up to 45% electrical saving (claimed) DC fans
- Pulsed fan control for closed cabinets (up to 30%)
- 63% electrical savings (claimed) by better lighting of store
- LED lights (almost no heat generated), long life (50,000 hours)

Current technology - conduction

- Insulate well base plates (reduce temperatures)
- Prevent thermal bridges in insulation
- Increase insulation



Current technology - controls

- **Chilled – off cycle defrost**
- **Defrost optimisation (frozen well)**
- **Defrost energy = actual energy + overhead (85%)**
- **Supermarket with 40 cabinets, 56 880 kWh/yr (saving of 24.5 tonnes of CO_2)**
- **Demonstration 9% savings**

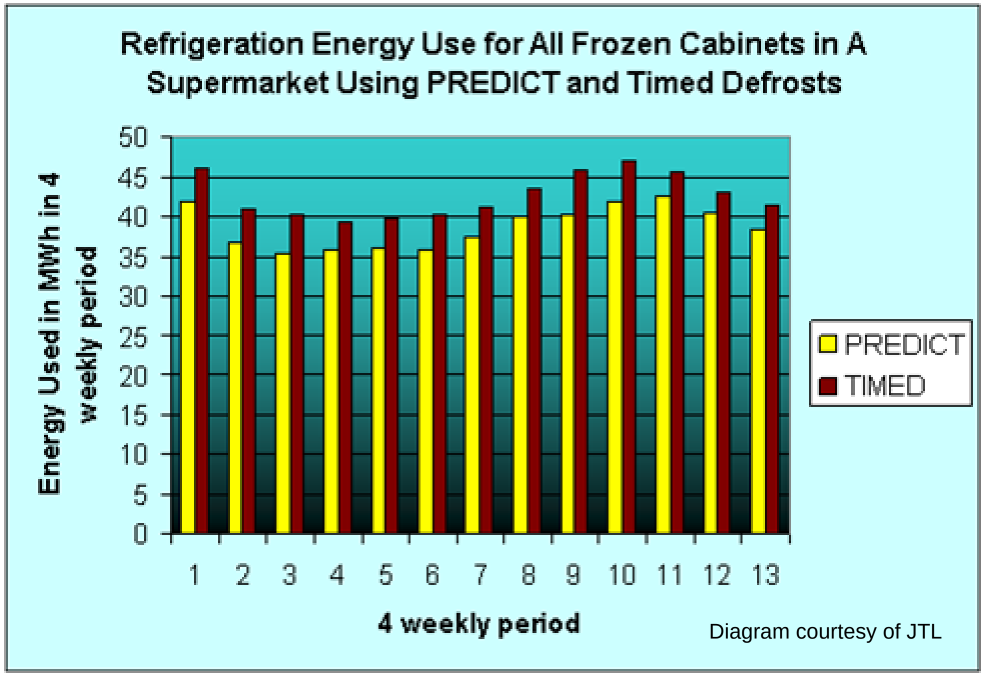
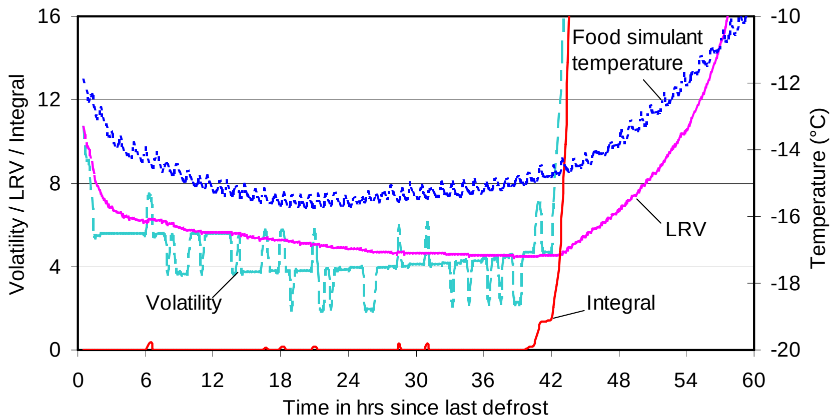
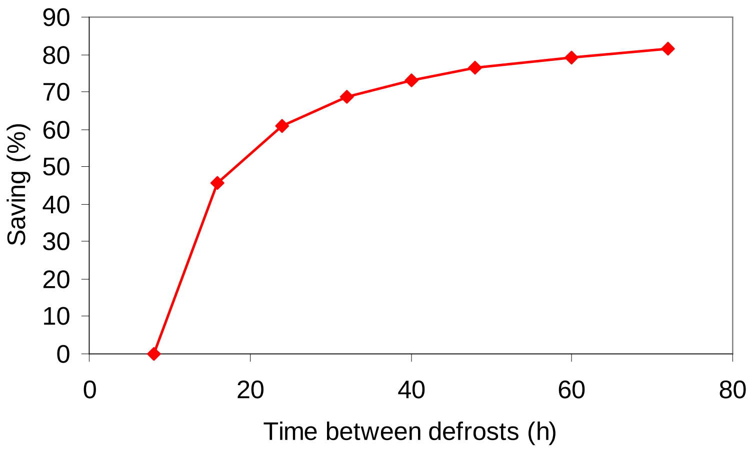


Diagram courtesy of JTL





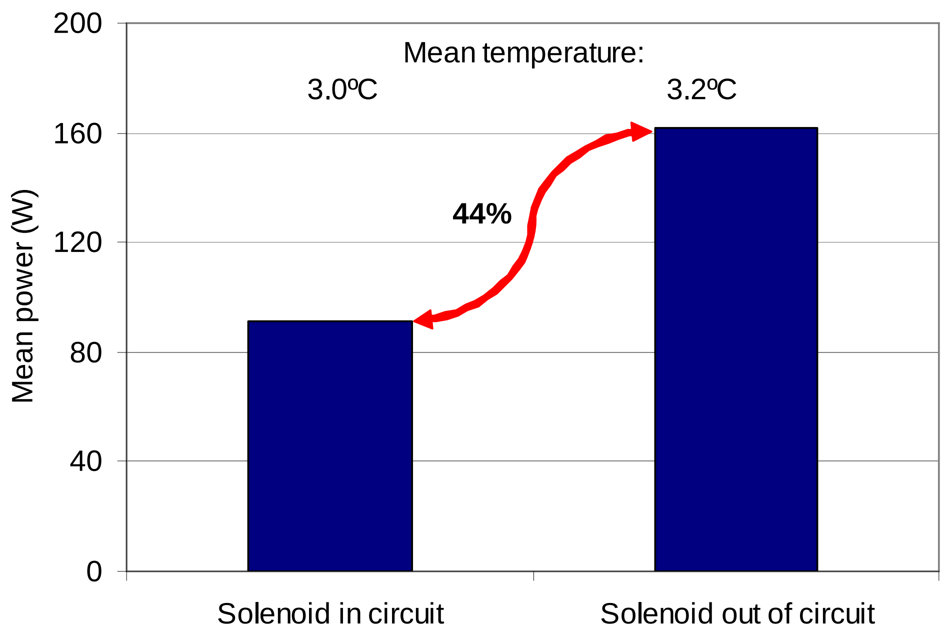
Current technology - controls

- Suction pressure optimisation
- Suction pressure controlled according to cabinet requirements
- 10-30% saving on pack power

Diagram courtesy of JTL

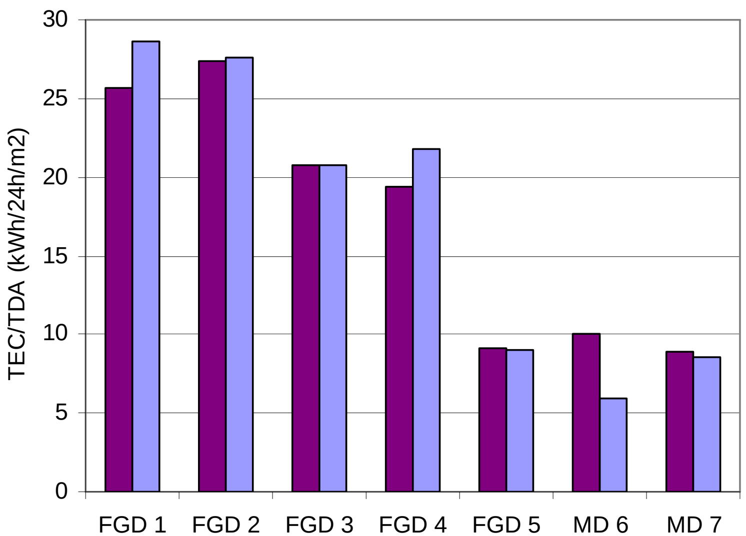
Current technology - controls

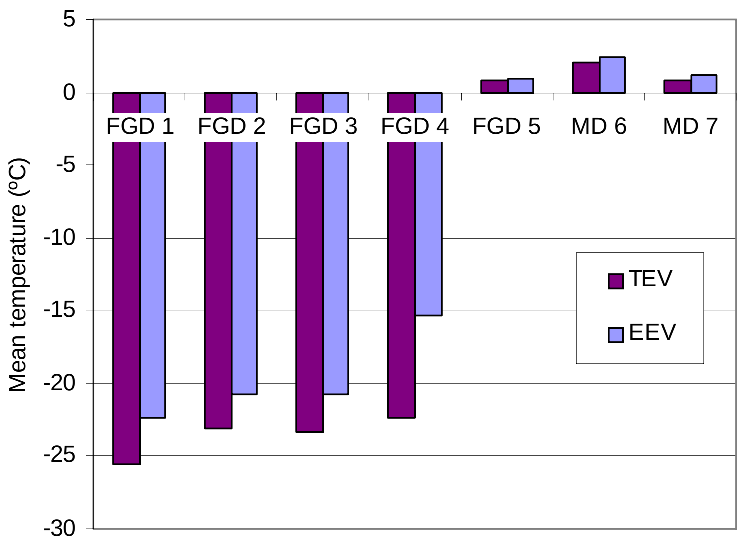
- Capillary based systems
  - Liquid line solenoid to prevent ‘off cycle losses’



Current technology - controls

- **ASH controlled on ambient dew point (7%)**
- **Expansion valves – EEV operate against low pressure drop (inherent energy saving not clear compared to optimised TEV)**





Current technology - refrigeration

- LPA (up to 20% saving)
- Variable speed and high efficiency compressors (up to 20%)
- Evaporative condensers
- Suction-liquid heat exchange (in most cases)
- Trigeneration
- External heat rejection
- Economiser, heat reclaim
- CO_2
  - Evidence to date suggests similar or slightly less efficiency than equivalent HFC system
  - Lower GWP due to no leakage of greenhouse gasses
- HC for small integrals

Future technologies - refrigeration system

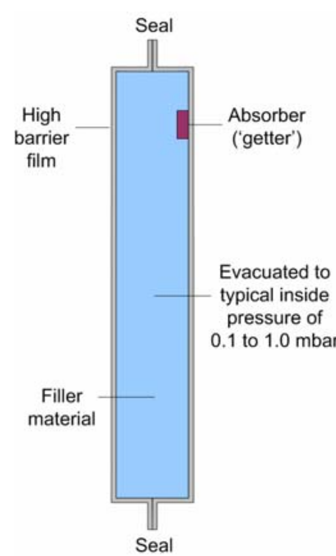
- Evaporate at higher temperatures
  - Multi-evaporator defrost - reduce T by up to 8ºC
  - High efficiency heat exchangers - increase htc by 60 to 93%
- Inverter compressors - especially integrals
- Localised cooling
- PCMs (Phase Change Materials)
- Alternative refrigeration systems (e.g. magnetic)

Future technologies – conduction, radiation, controls

- Pulse electro-thermal de-icing (PETD)
- Heat pipes
- Low emissivity packaging
- ‘Intelligent/smart’ packaging
- VIPs - Conductivities up to 5 times lower than typical current insulation such as polyurethane (PU)

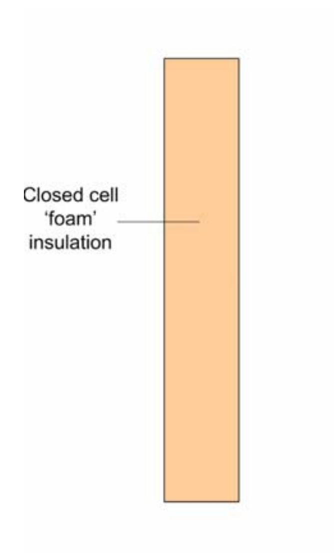
VIP

Conductivity less than $0.005 Wm^{-1}K^{-1}$



PU

Conductivity typically $0.025 Wm^{-1}K^{-1}$



Future technologies – food/supermarkets

- New shopping concepts
- Automation
- New foods (less/more refrigeration?)
- Supercooling/chilling of food

Summary

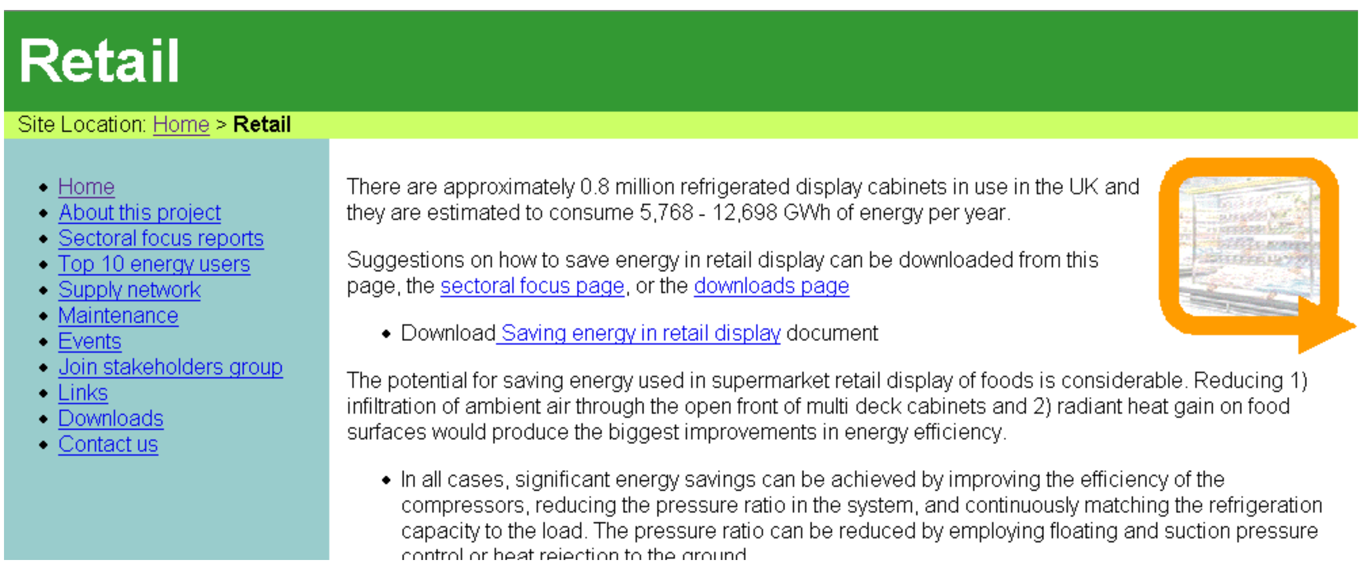
- Large differences between cabinets currently on market
- Considerable savings by selecting best on market
- However, some real challenges to further improve performance
- Novel designs often not developed due to timescales, practicality in fitting into preset supermarket configuration, cost, supermarket/food producer constraints and customer expectations
- Balance between food quality value and energy consumption costs

Further information:

http://www.frperc.bris.ac.uk/defraenergy/index.html

Specifically on retail cabinets:

http://www.frperc.bris.ac.uk/defraenergy/retail.html



Retail

Site Location: Home > **Retail**

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- Sectoral focus reports
- Top 10 energy users
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- Events
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There are approximately 0.8 million refrigerated display cabinets in use in the UK and they are estimated to consume 5,768 - 12,698 GWh of energy per year.

Suggestions on how to save energy in retail display can be downloaded from this page, the sectoral focus page, or the downloads page

- Download Saving energy in retail display document

The potential for saving energy used in supermarket retail display of foods is considerable. Reducing 1) infiltration of ambient air through the open front of multi deck cabinets and 2) radiant heat gain on food surfaces would produce the biggest improvements in energy efficiency.

- In all cases, significant energy savings can be achieved by improving the efficiency of the compressors, reducing the pressure ratio in the system, and continuously matching the refrigeration capacity to the load. The pressure ratio can be reduced by employing floating and suction pressure control or heat rejection to the ground