Identification of changes needed in supermarket design for energy demand reduction

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Identification of changes needed in supermarket design for energy demand reduction

- Supermarket energy usage/loads
- Difference between design and predicted load
- Modelling route
- Sensitivity differences
- Implications

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UK supermarkets

- Over 91,500 supermarkets in UK
- ~ 300 new stores each year
  - Many others refitted
- Use 3% of UK electricity – on site
- Account for 1% UK CO_2 emissions

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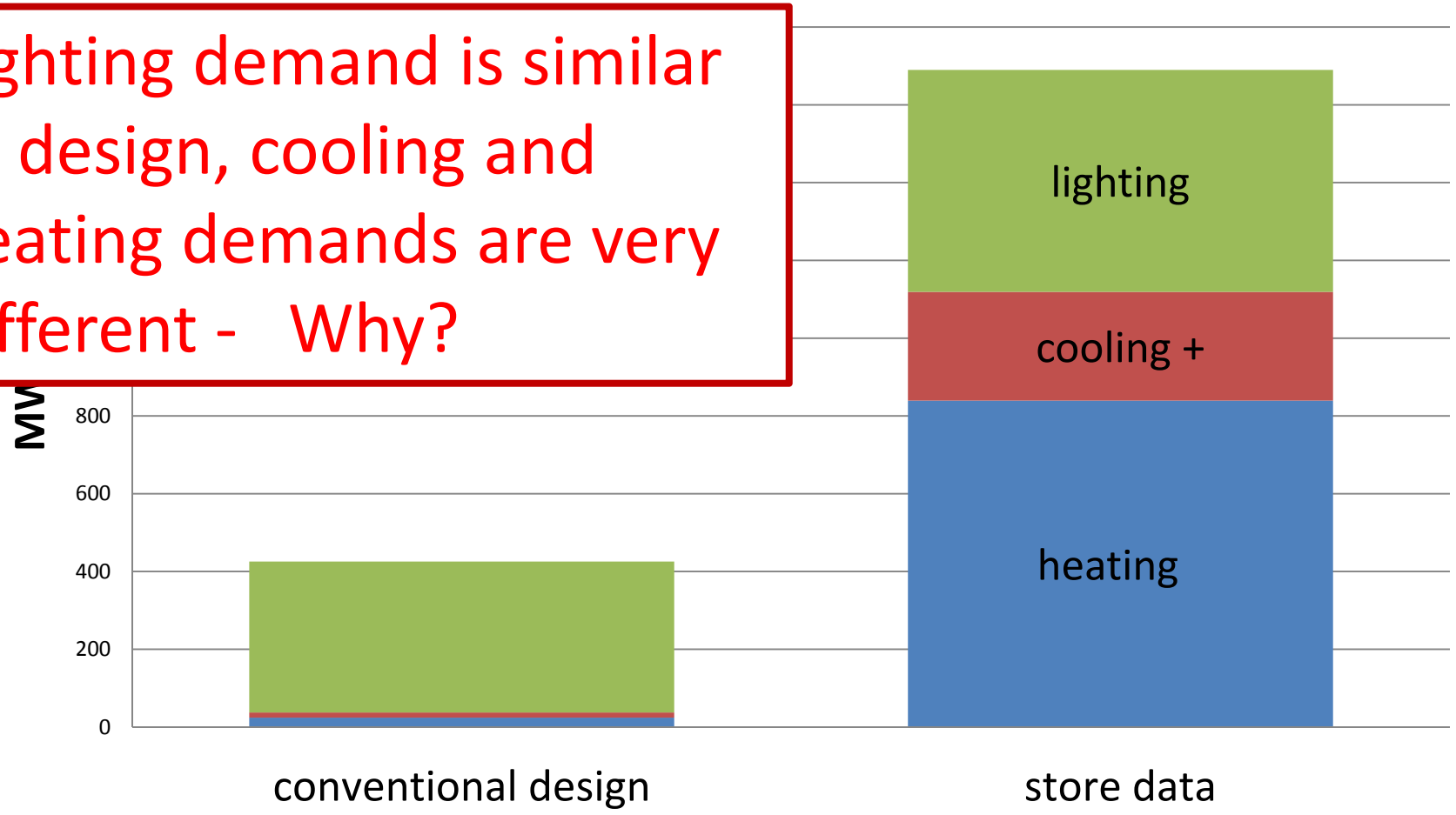
Supermarkets: Reality is very different from design

Lighting demand is similar to design, cooling and heating demands are very different - Why?



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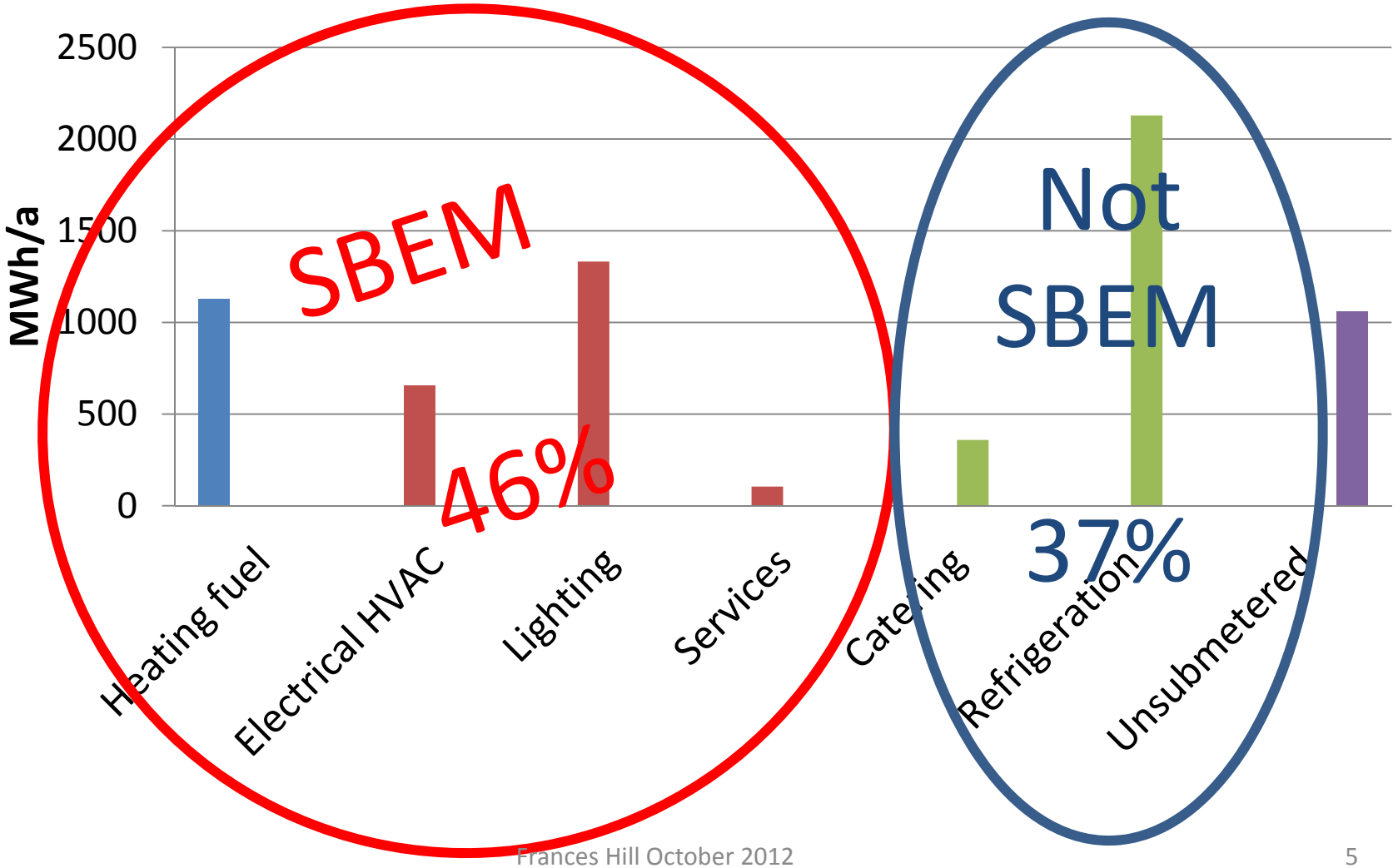
Components of energy use



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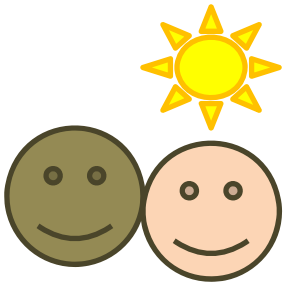
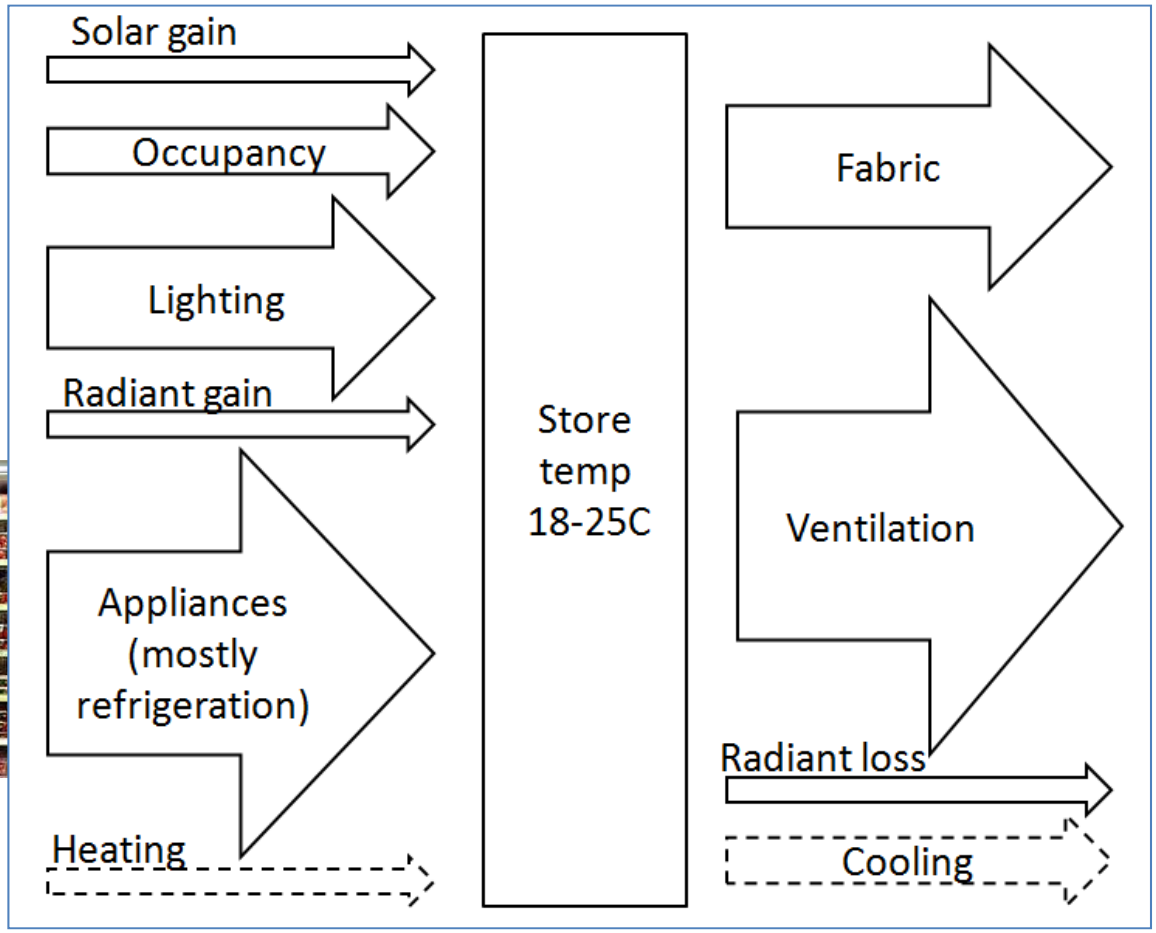
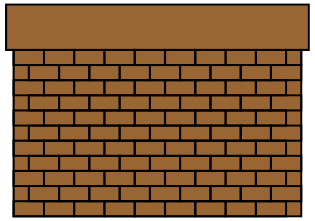
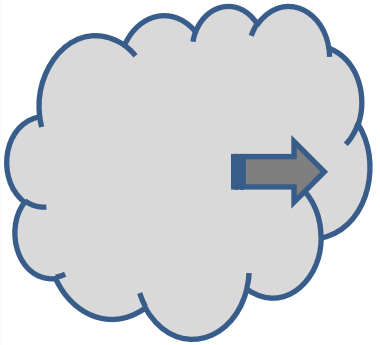
Design of supermarkets – heat gains and losses









To comply with SBEM

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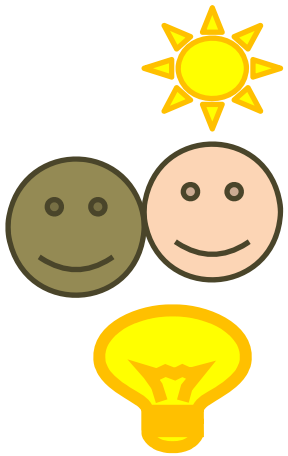
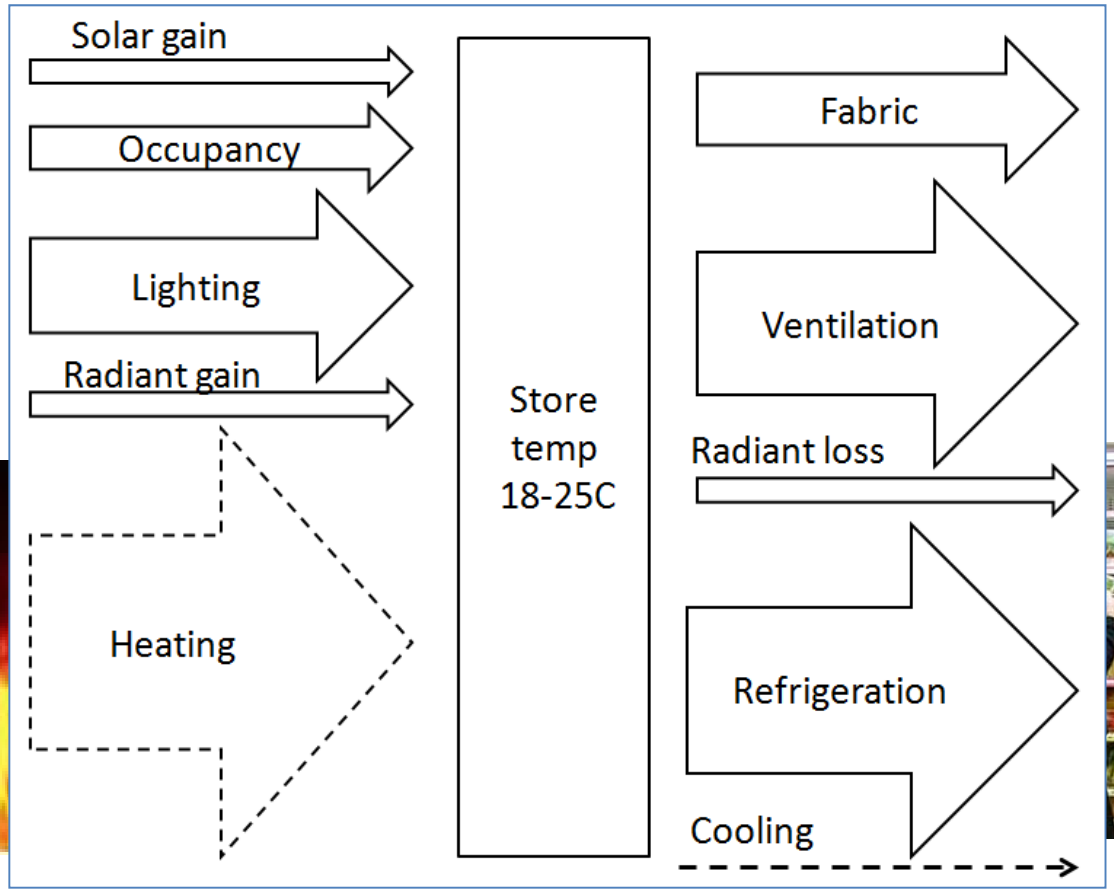
Slide 6

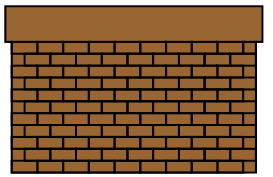
FH1 re size elements to match figs from Excel R@Regs

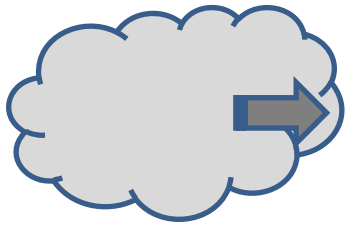
Frances Hill, 23/03/2012

Heat transfers in a supermarket include **cold** refrigeration cabinets









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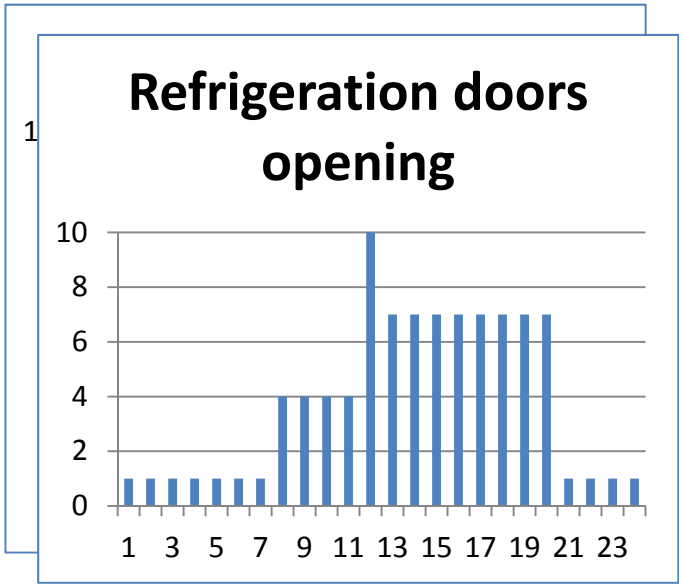
Slide 7

FH2 needs an equipment arrow too, and resizing
Frances Hill, 23/03/2012

Model including non- SBEM (unregulated) energy use

- Spreadsheet in Excel
- Hourly weather data
- Store temperature range 18-25C
- Profiled occupancy, 24hours
- Include refrigeration
  - With doors,
  - opened according to occupancy
- But not catering or in-store bakery
  - Yet



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Building model

- Simple U value box
  - Plus (north) windows and aerogel rooflights
- Rooflight solar gains
- Radiant gains and losses to/from roof and rooflights
- Ventilation rate set values
    - Windcatchers explored
- No stratification

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Lighting

- 900/400lux
- Daylight sensitive
- Light from rooflights evenly spread
- Lighting infinitely dimmable
  - No staging
  - No lower limit
- Heat from lights incorporated into thermal balance

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Heating and cooling

- 2 boilers, one cooler
- Modelled as ON / OFF per iteration (15 mins)
- Hysteresis range 2^0C at each end
  - 18-20C for heating
  - 23-25C for cooling

- Fans and pumps according to demand

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Refrigeration

- Freezer cabinets with doors
- Chiller cabinets with doors
- Open chillers

shelvingdistrbution.co.uk

- Fabric
- Ventilation
- Auxiliary power uses

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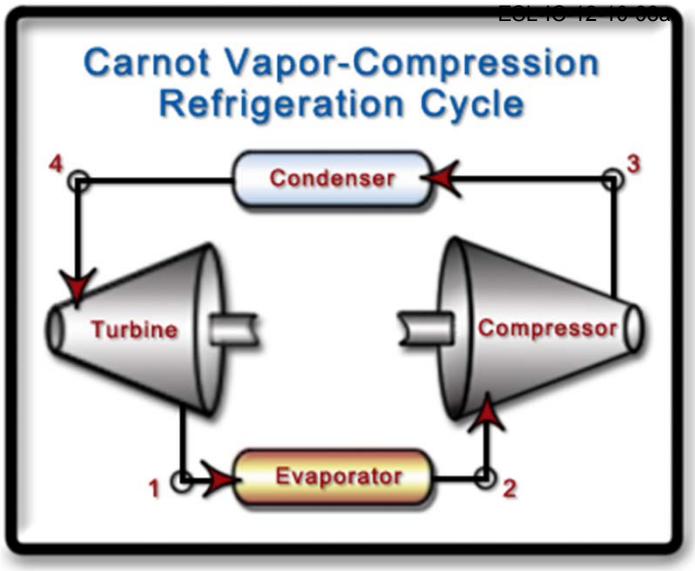
Refrigeration COPs



- COPs on Carnot cycle model
  - ½ * (evaporation temperature/ evap-condenser temperature differential)
- Condenser temperature dependent on ambient temperature, therefore
- COPs dependent on ambient temperature

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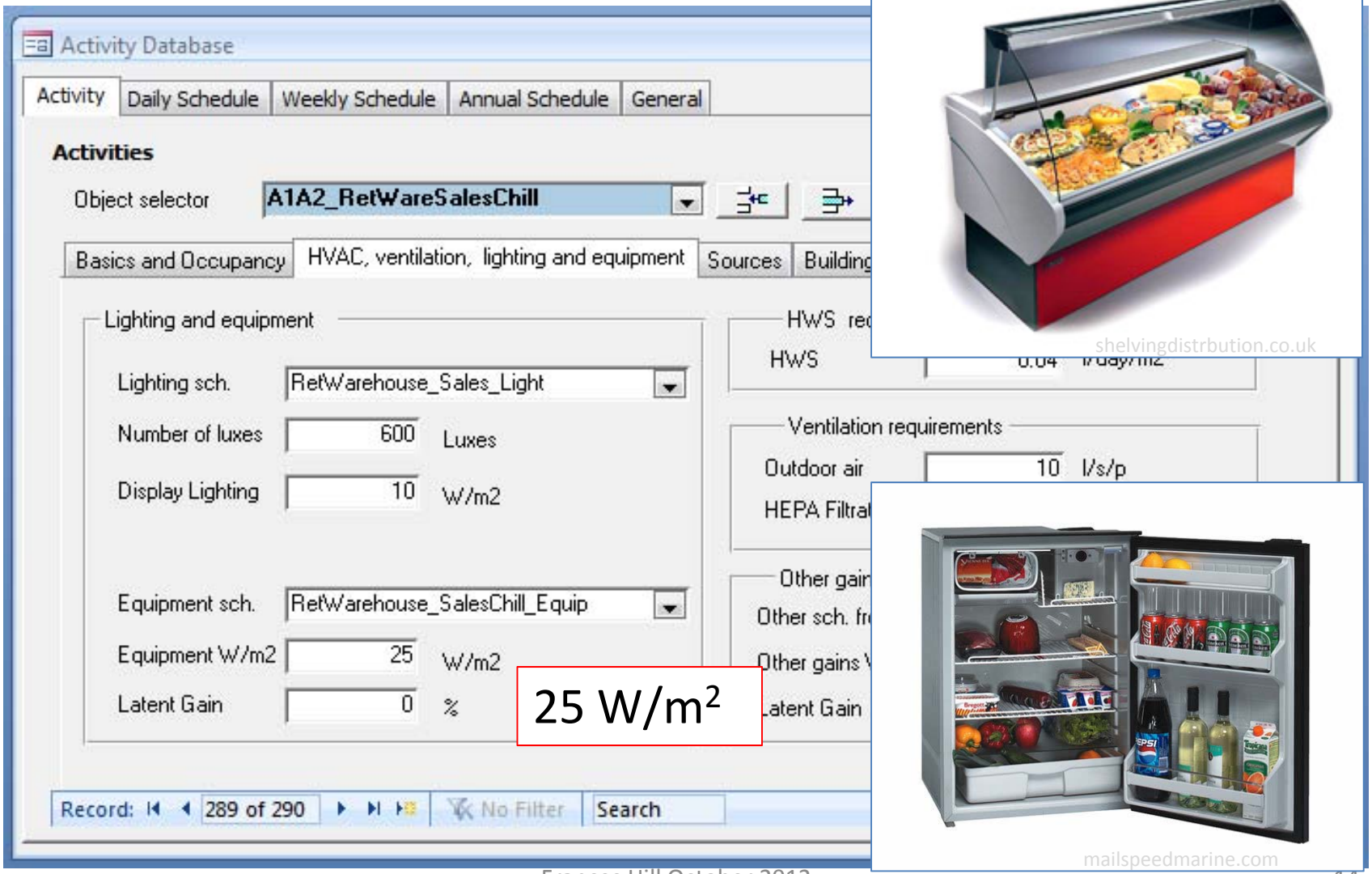
Refrigeration on SBEM



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Dehumidification

- Only if needed
- Humidity ratio maintained at or below 7.5 g/kg
  - Based on ambient humidity and anthropogenic water vapour
  - To maintain efficiency of evaporator coils in refrigeration cabinets
  - (may not be appropriate with mostly closed cabinets)

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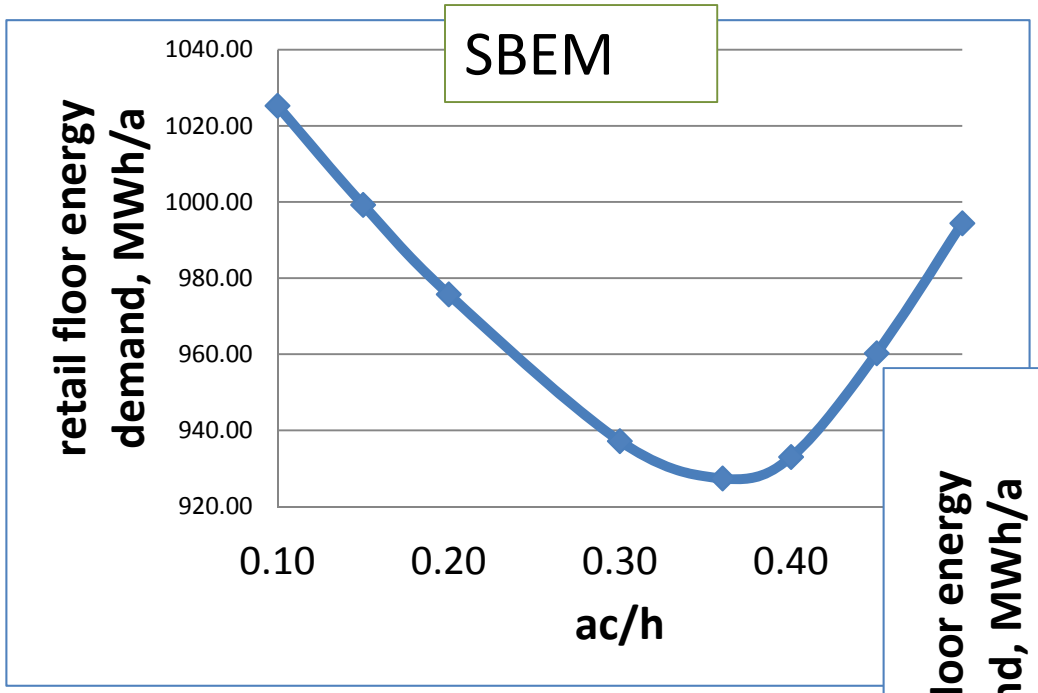
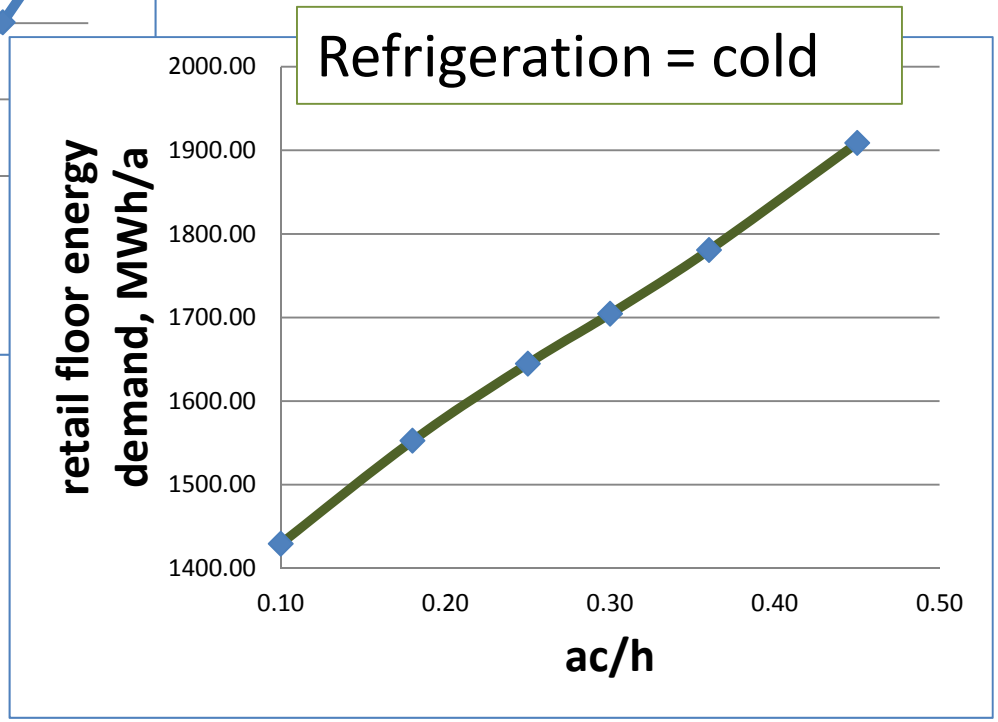
Optimisation - ventilation





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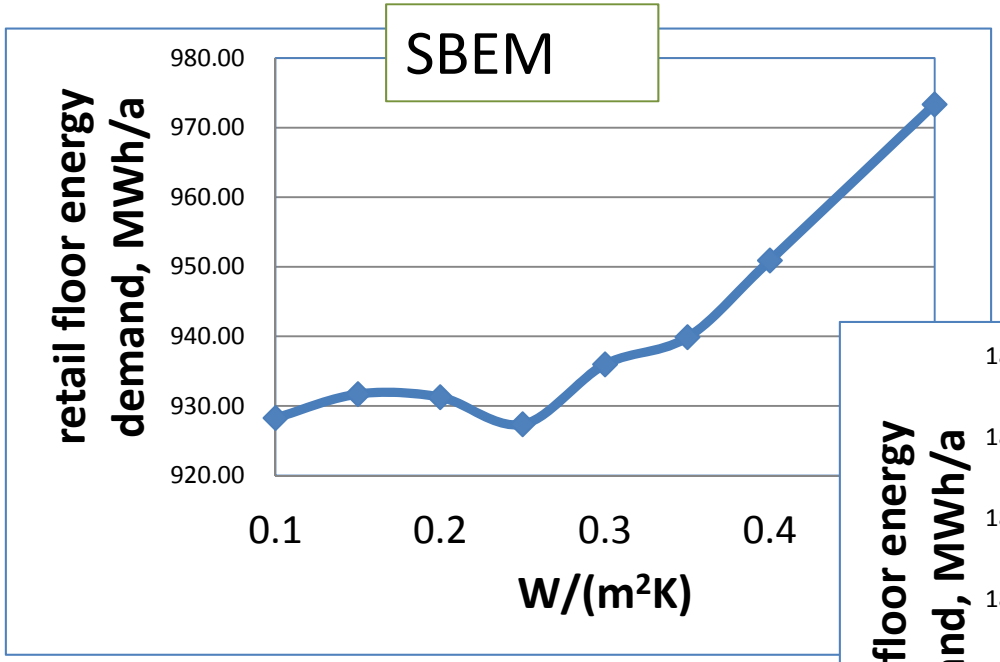
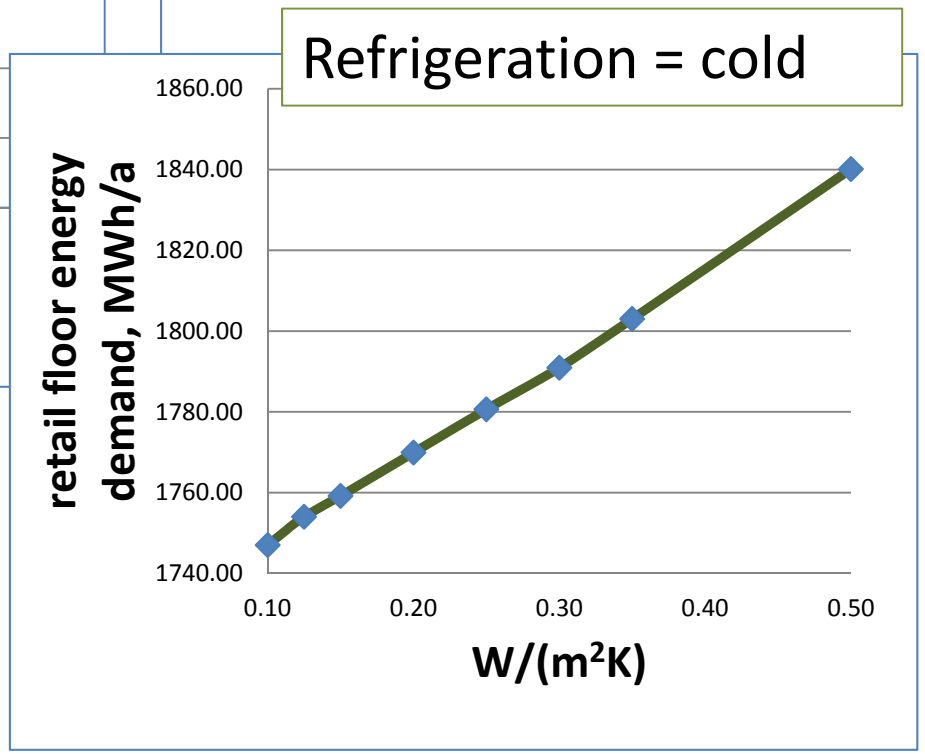
Optimisation - insulation





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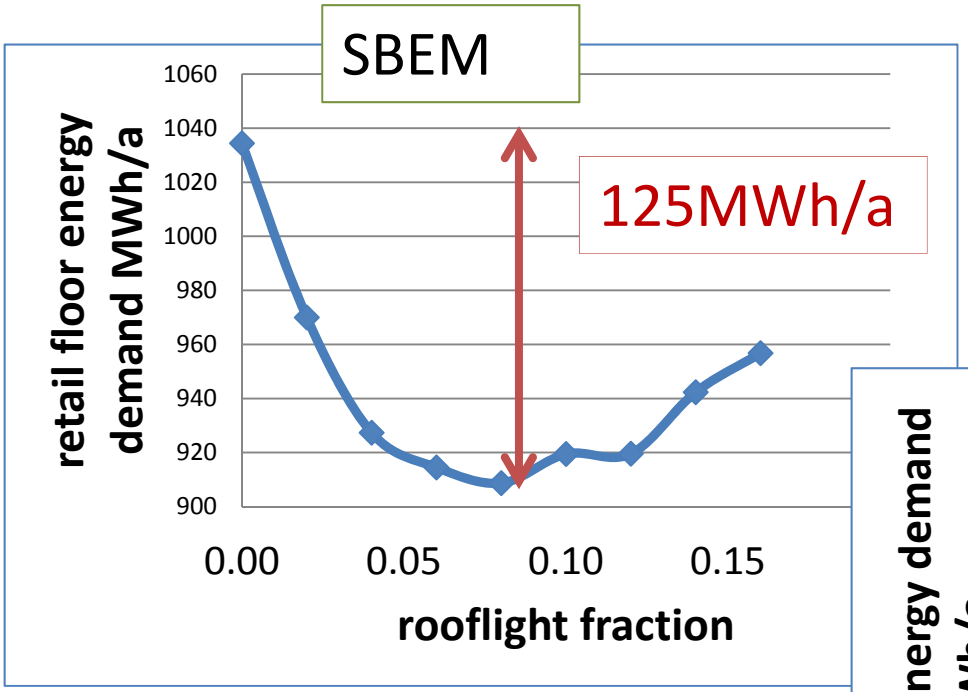
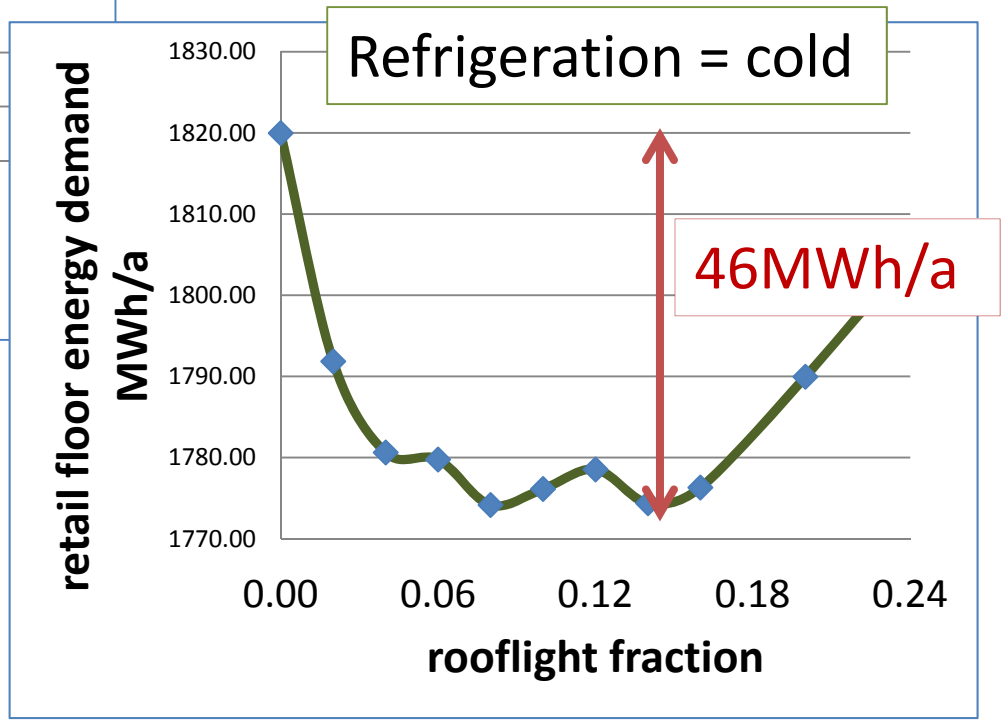
Optimisation – rooflight fraction





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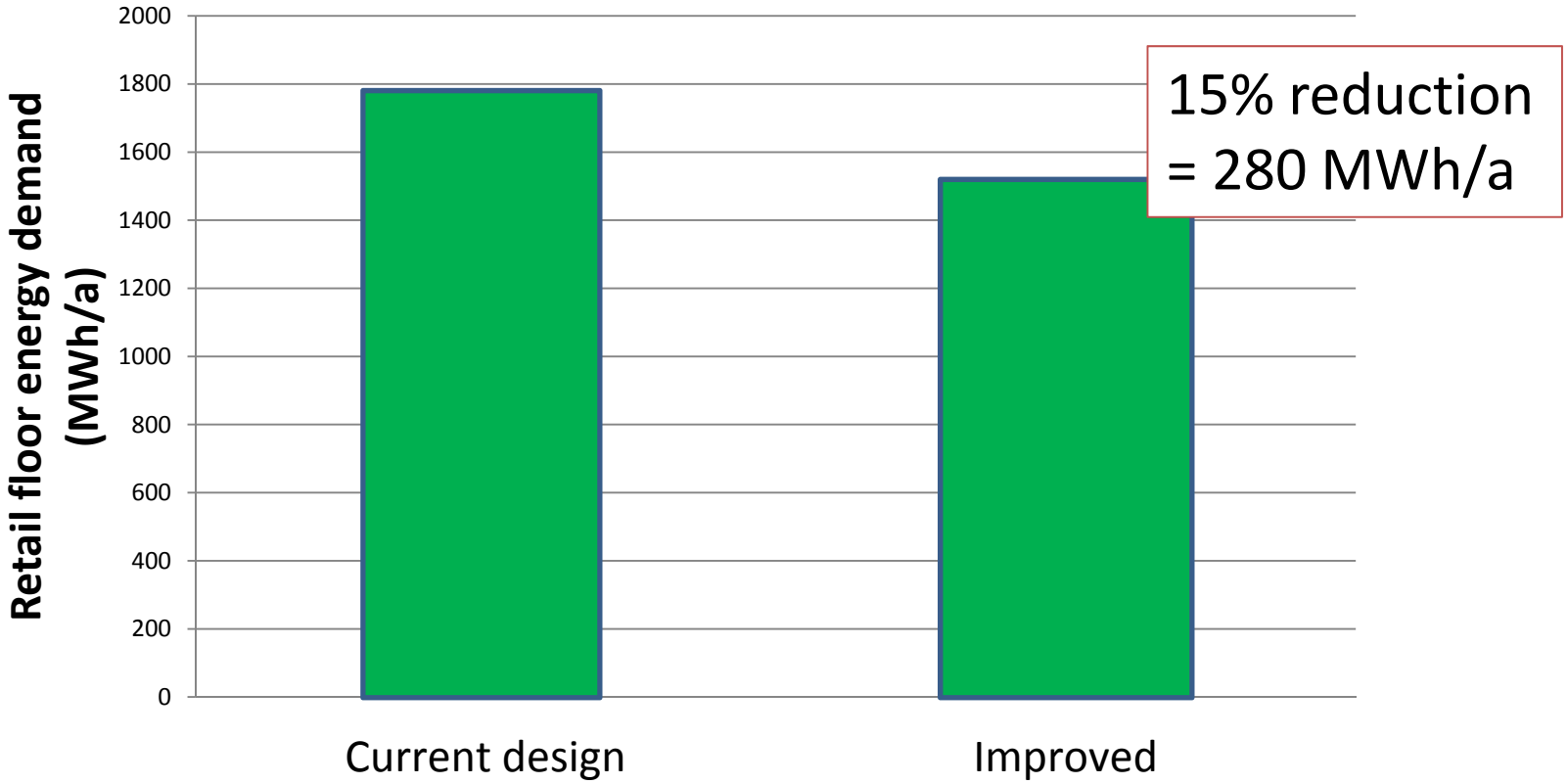
Optimising on insulation and ventilation



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Further research

- Modelling in EnergyPlus finds
  - Very similar comparison SBEM/COLD refrigeration
  - 25% potential savings from insulation, airtightness improvements suggested
- Stratification (present in case study store) may be responsible for further 10-25% heat losses
  - Which would not be an issue if cooling were needed as SBEM suggests

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Conclusion

- In a supermarket, omission of refrigeration heat transfers on the retail floor is causing a major gap between operation energy use and design expectations
- Inclusion of refrigeration cabinet heat transfers at design stage could reduce energy demand by 25-40%
- Inclusion could also incentivise improvement in cabinet design, as improvements have effect on both refrigeration and heating demands

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