

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

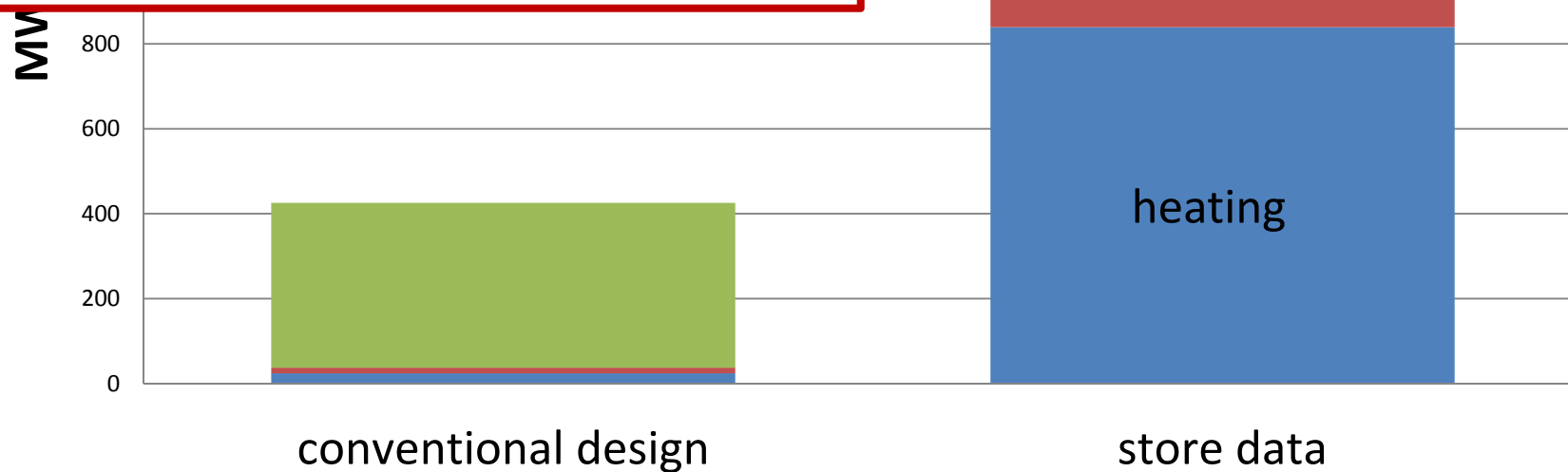
- Supermarket energy usage/loads
- Difference between design and predicted load
- Modelling route
- Sensitivity differences
- Implications

UK supermarkets

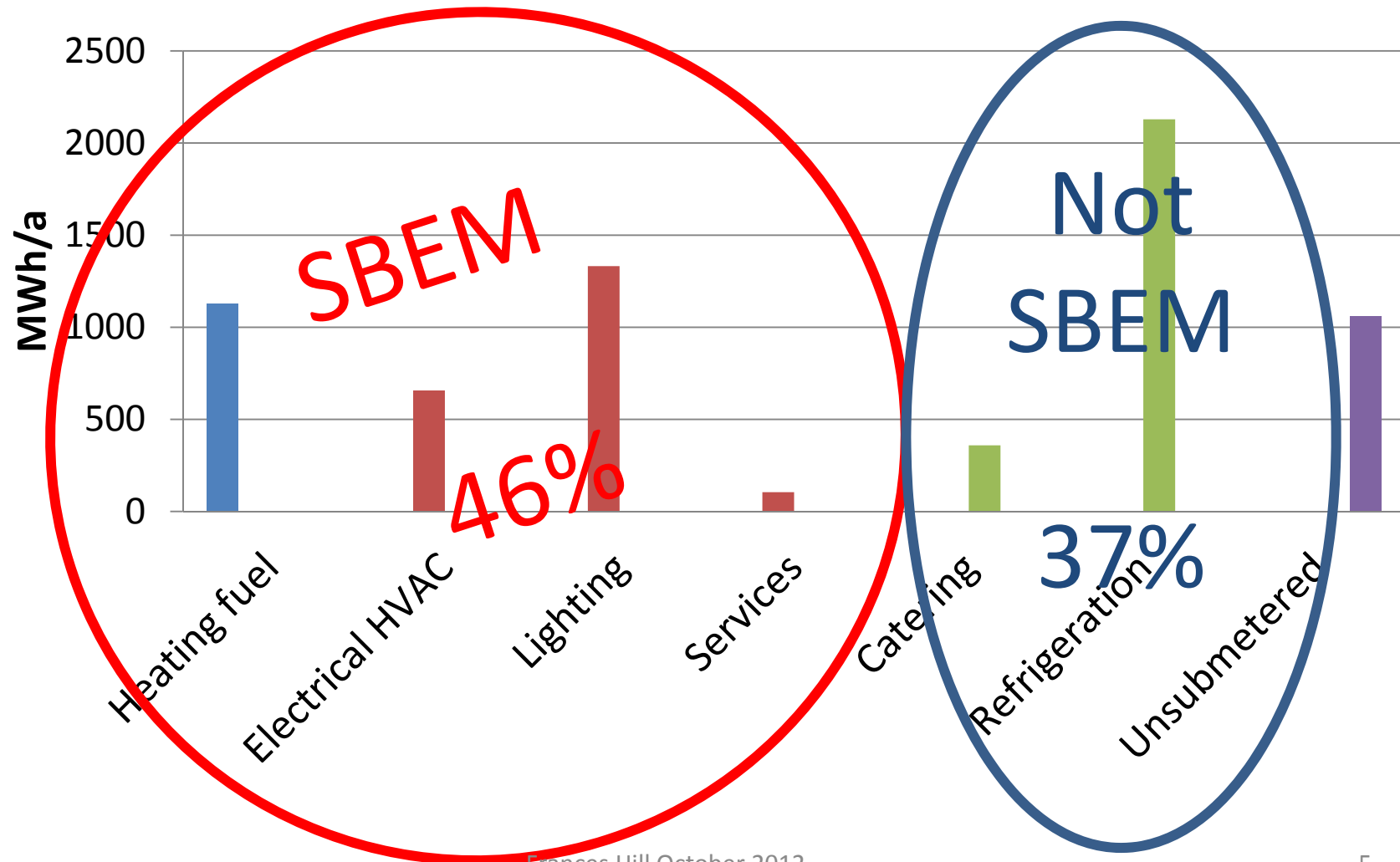
- Over 91,500 supermarkets in UK
- ~ 300 new stores each year
 - Many others refitted
- Use 3% of UK electricity – on site
- Account for 1% UK CO₂ emissions

Supermarkets: Reality is very different from design

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



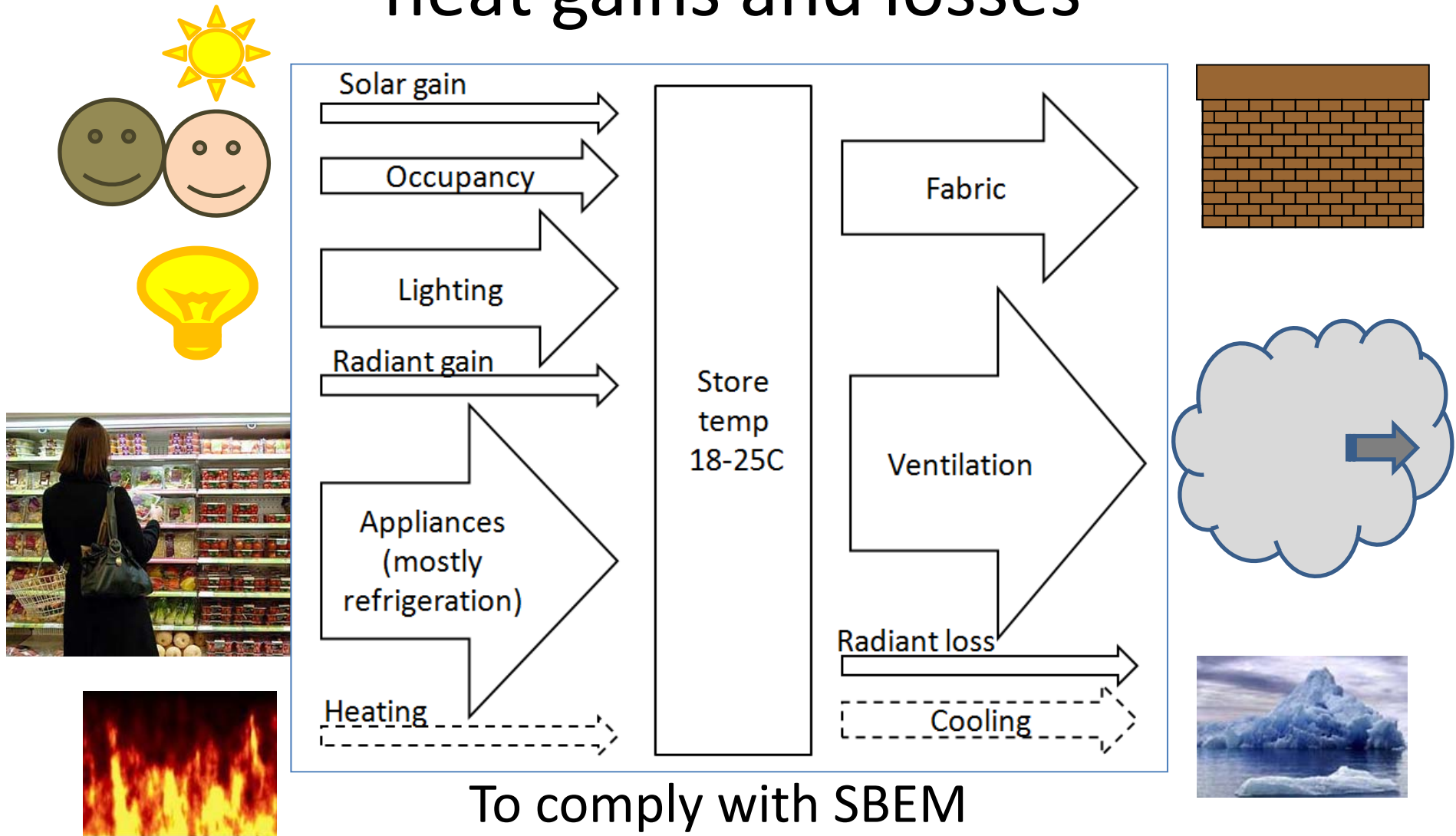
Components of energy use



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Design of supermarkets – heat gains and losses



To comply with SBEM

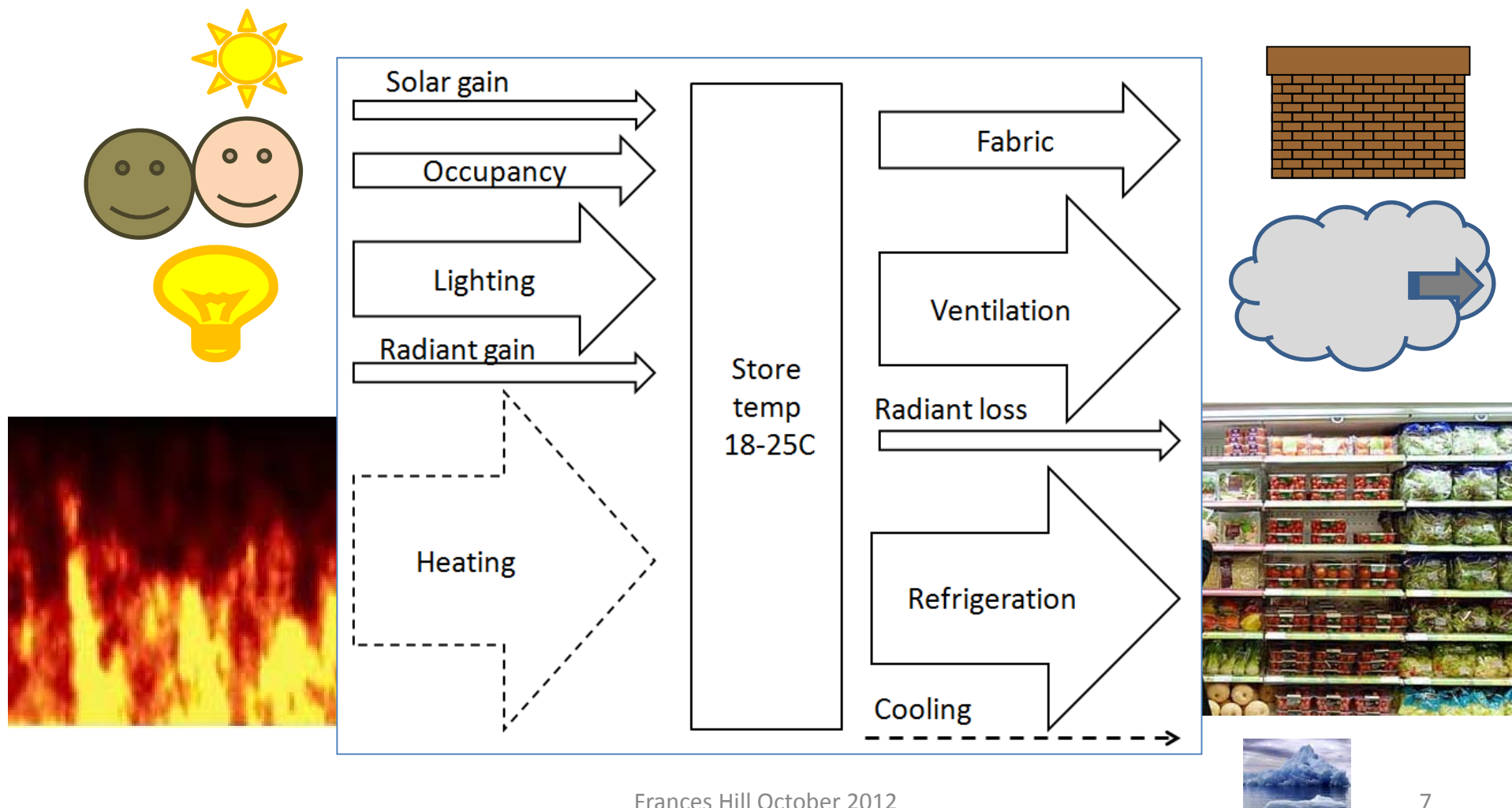
Slide 6

FH1

re size elements to match figs from Excel R@Regs

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



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Slide 7

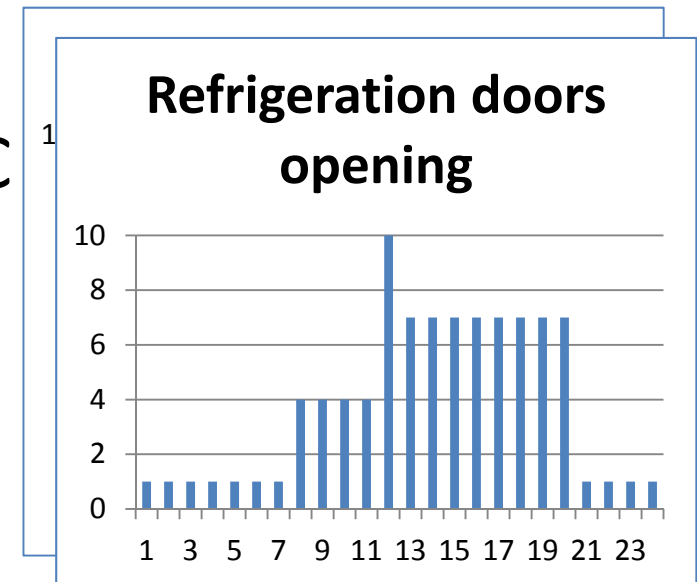
FH2

needs an equipment arrow too, and resizing

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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



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

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

Heating and cooling

- 2 boilers, one cooler
- Modelled as ON / OFF per iteration (15 mins)
- Hysteresis range 2⁰C at each end
 - 18-20C for heating
 - 23-25C for cooling
- Fans and pumps according to demand

Refrigeration

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

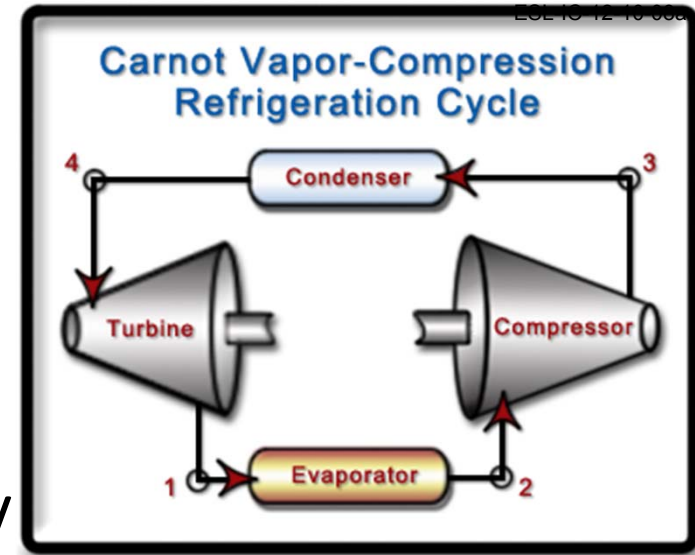
- Fabric
- Ventilation
- Auxiliary power uses



shelvingdistribution.co.uk

Refrigeration COPs

- COPs on Carnot cycle model
 $-\frac{1}{2} * (\text{evaporation temperature} / \text{evap-condenser temperature differential})$
- Condenser temperature dependent on ambient temperature, therefore
- COPs dependent on ambient temperature



learnthermo.com

Refrigeration on SBEM

The screenshot shows the 'Activity Database' software interface. The 'Object selector' is set to 'A1A2_RetWareSalesChill'. Under the 'Lighting and equipment' section, the 'Equipment W/m2' field is set to 25, which is highlighted with a red box and labeled '25 W/m²'. Other settings include 'Lighting sch.' set to 'RetWarehouse_Sales_Light', 'Number of luxes' at 600, 'Display Lighting' at 10 W/m², and 'Equipment sch.' set to 'RetWarehouse_SalesChill_Equip'. The 'Latent Gain' is set to 0%. To the right of the interface, there are two images: a top-down view of a retail sales chill display (shelvingdistribution.co.uk) and a front view of a domestic refrigerator (mailspeedmarine.com).

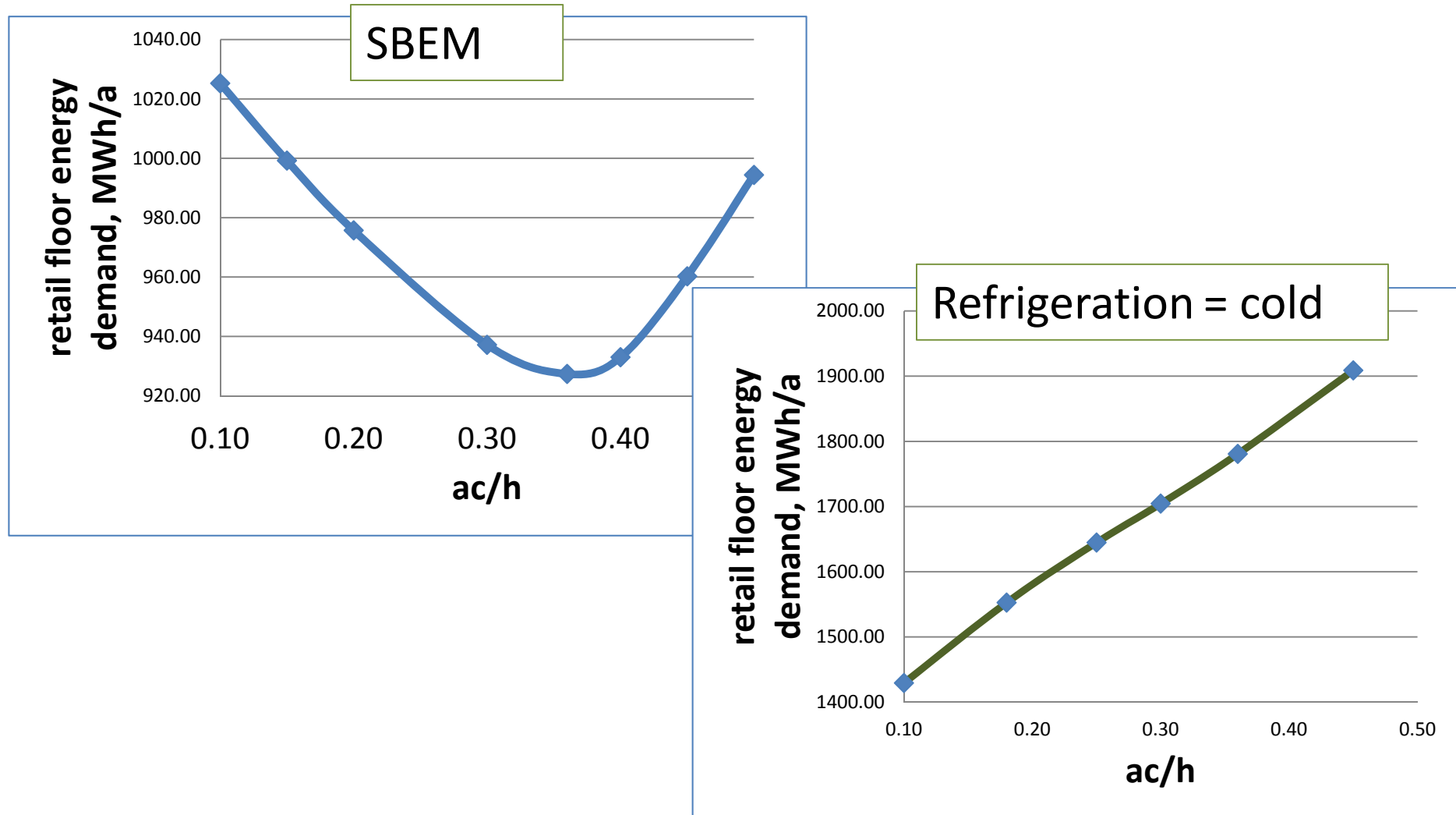
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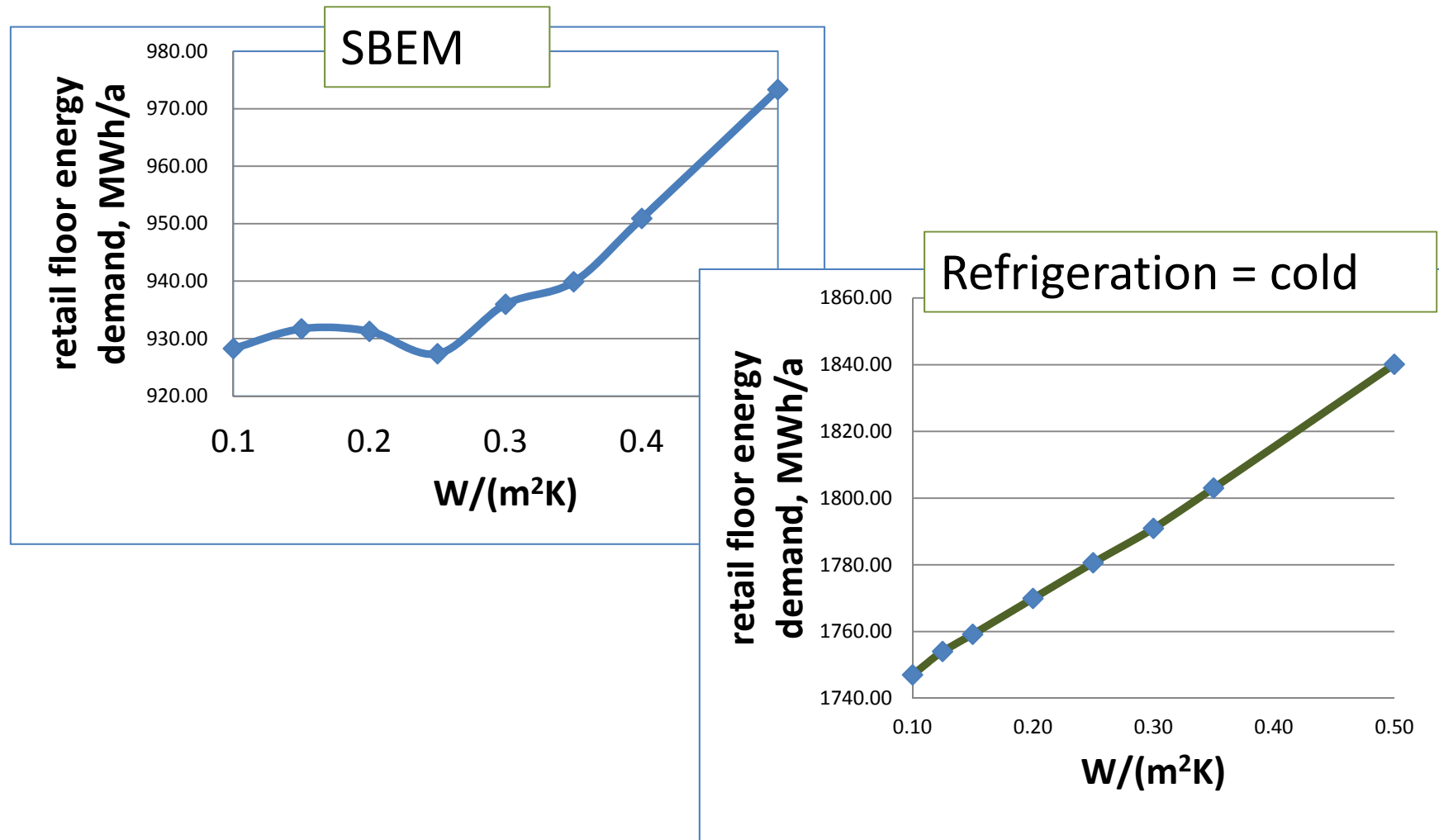
Dehumidification

- 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)

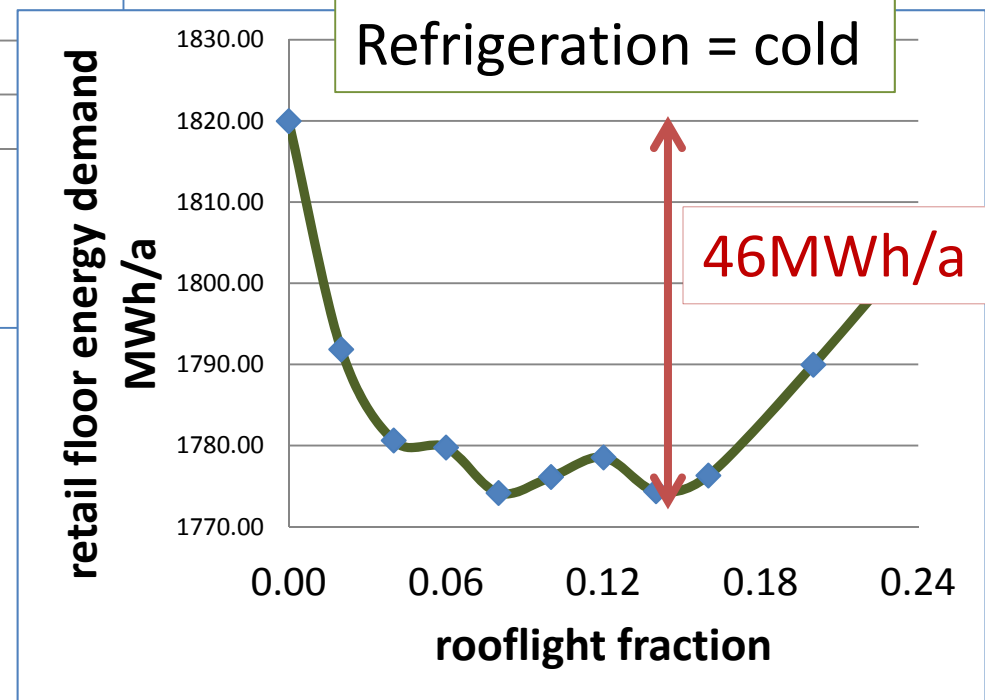
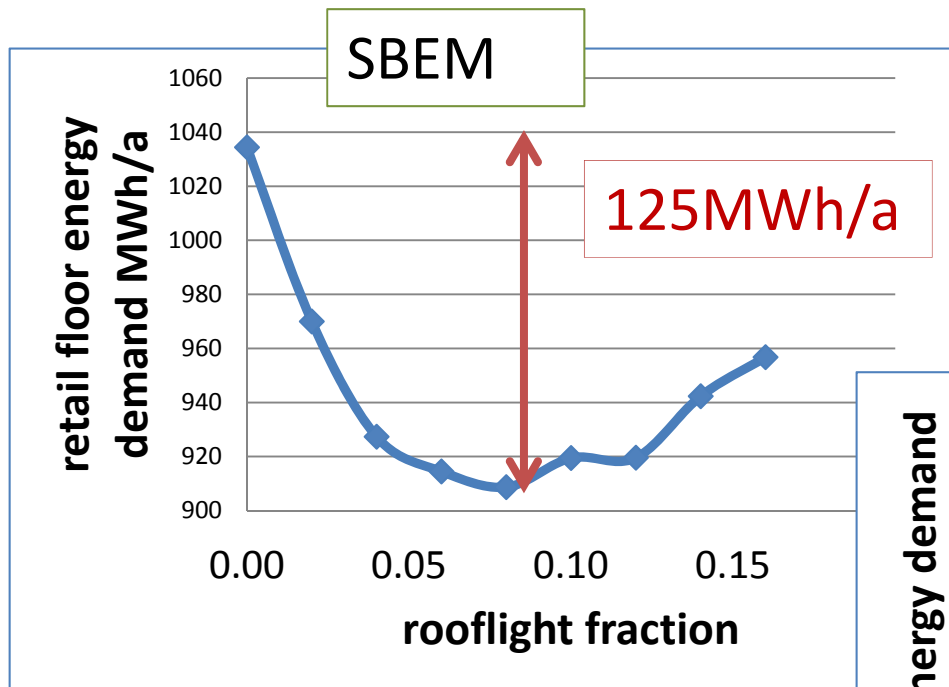
Optimisation - ventilation



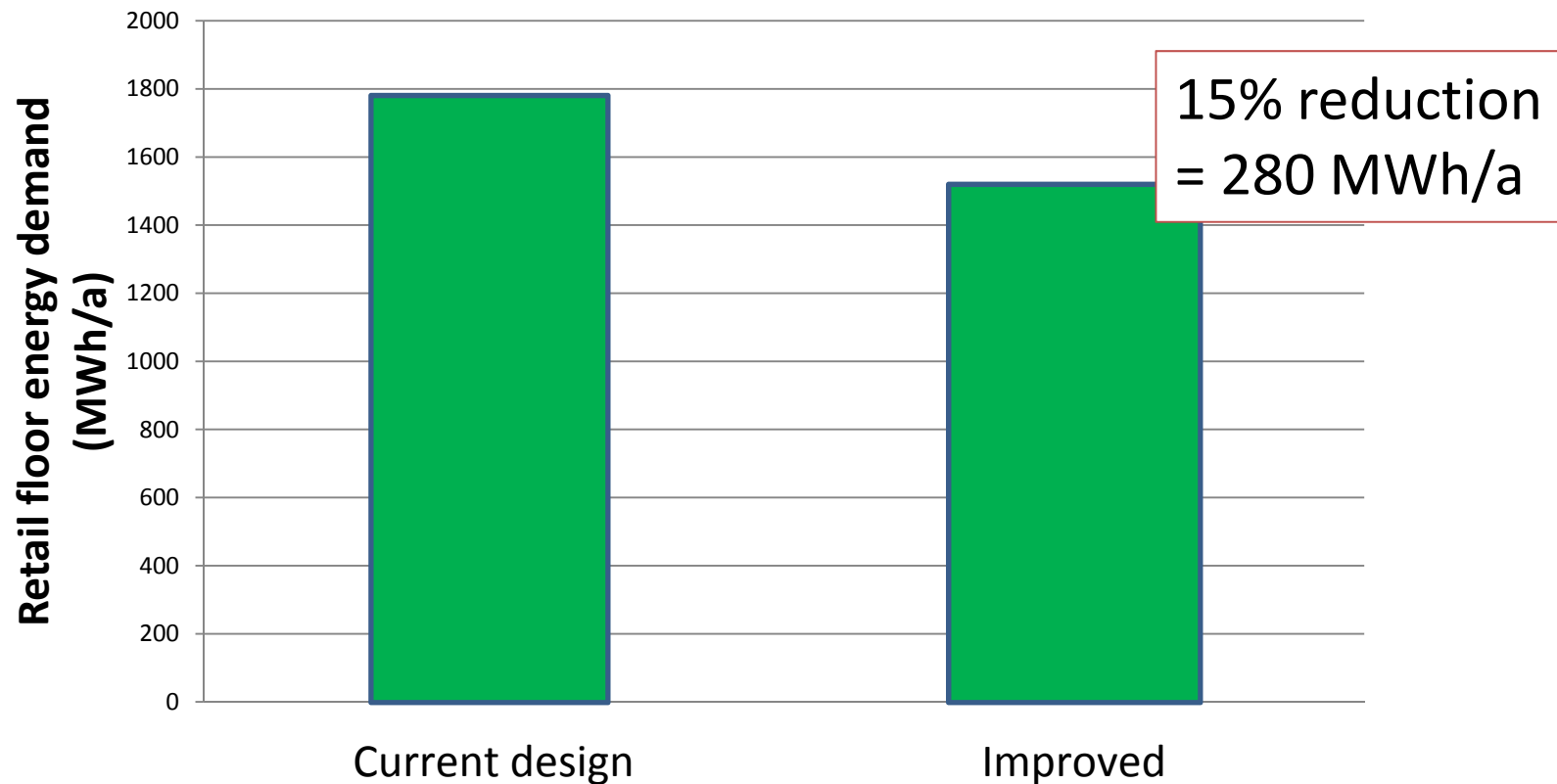
Optimisation - insulation



Optimisation – rooflight fraction



Optimising on insulation and ventilation



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

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