Supermarket POE modelling including refrigeration heat transfers

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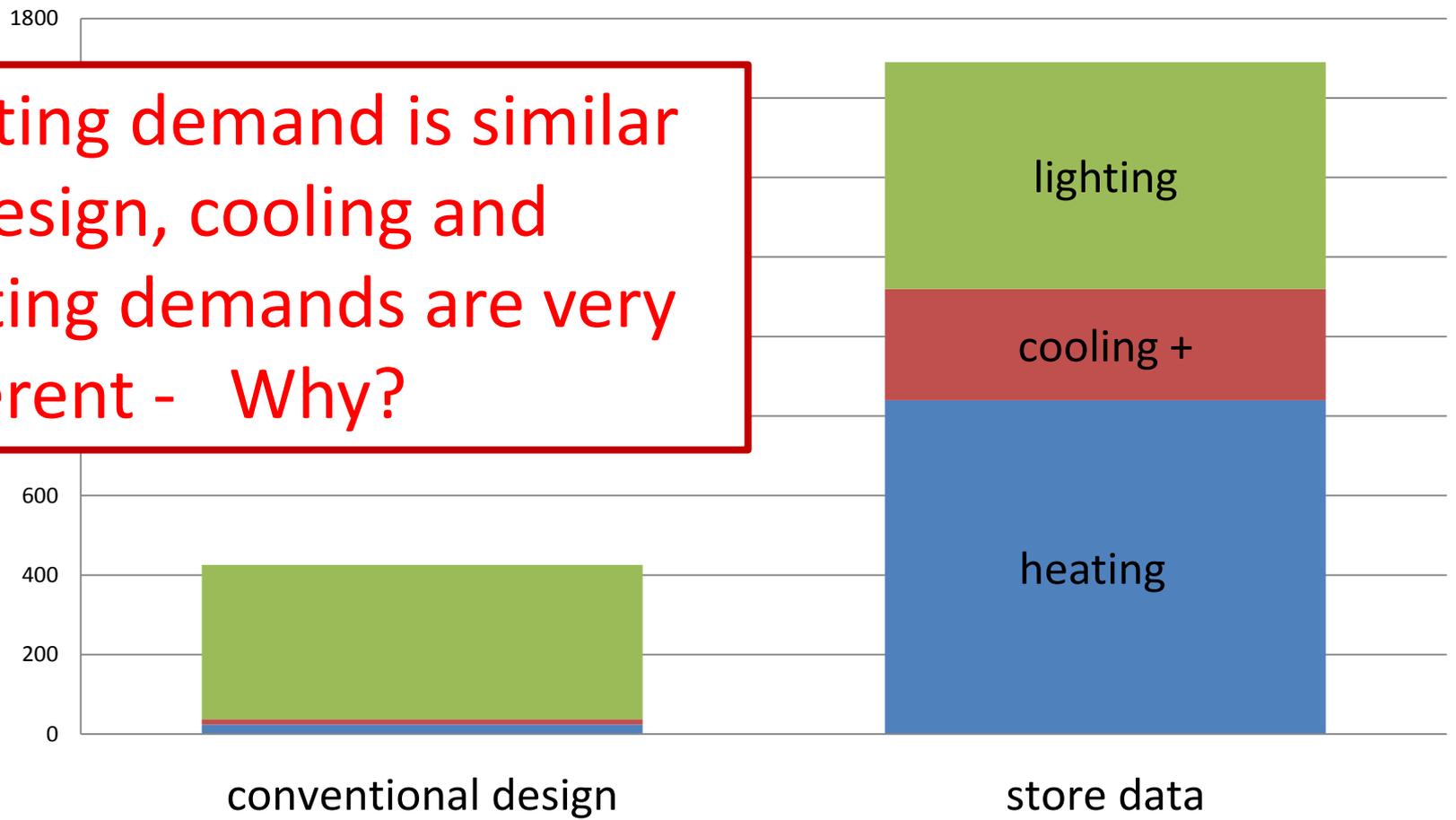# Understanding the gaps between operational energy use and modelling, for supermarkets

- Supermarkets, energy, and CO_2
- Operational energy use vs Design, SBEM/NCM
- Modelling
- Improving design cf NCM
- Conclusions

UK supermarkets

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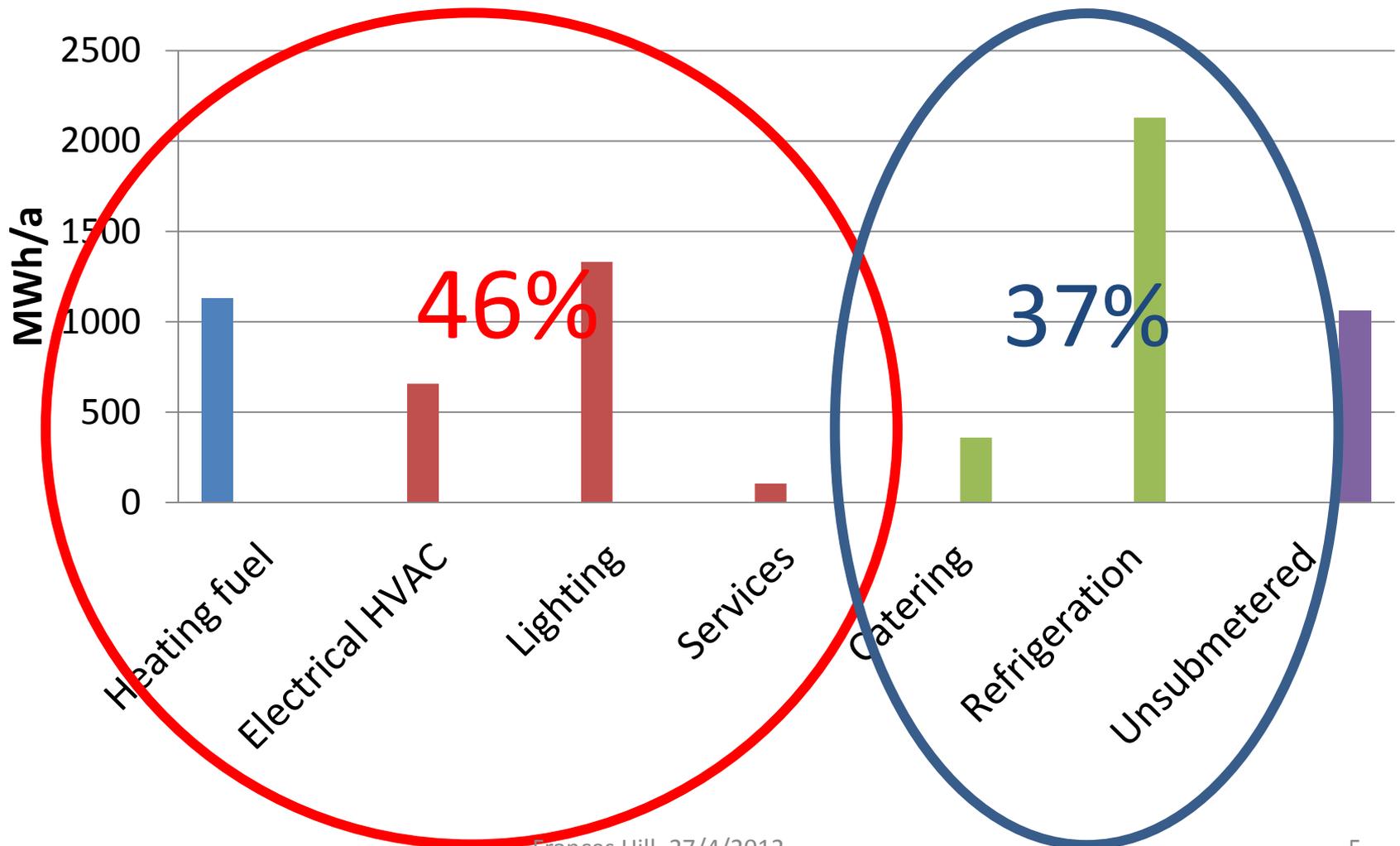- Account for 1% UK CO_2 emissions

Supermarket energy demands:
Reality is very different from design

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

Chart axis values: 1800, 600, 400, 200, 0

Bar labels: conventional design, store data

Store data segments: lighting, cooling +, heating

Components of energy use

Reality is very different from design

Model including non- NCM (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
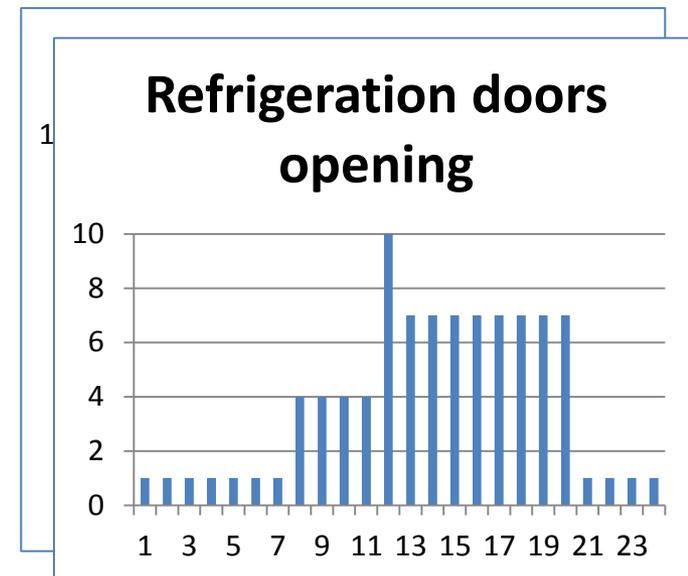
Refrigeration doors opening

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.....For thermal impacts
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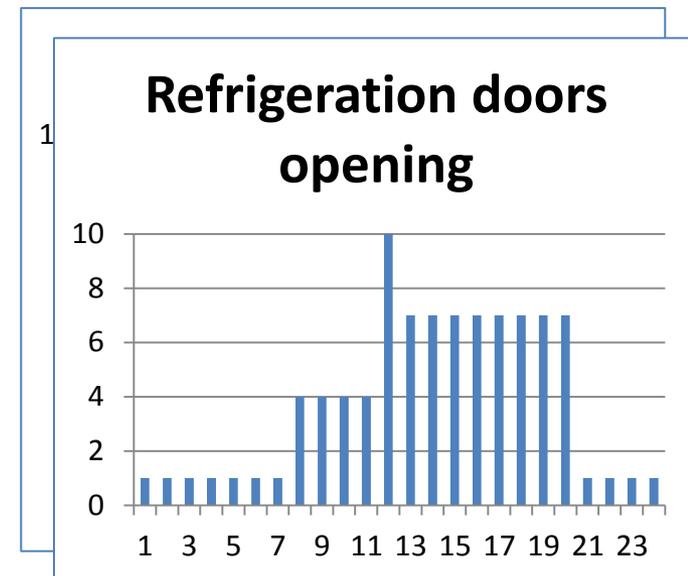
Building model

- Simple U value box
  - Plus windows and aerogel rooflights
  - Thermal bridging not modelled
- 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
  - But not stratified!

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Operational lighting consumption ~ 50% greater than this model predicts

Frances Hill, 27/4/2012

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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

Refrigeration

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

- Fabric
- Ventilation
- Auxiliary power uses

shelvingdistrbution.co.uk
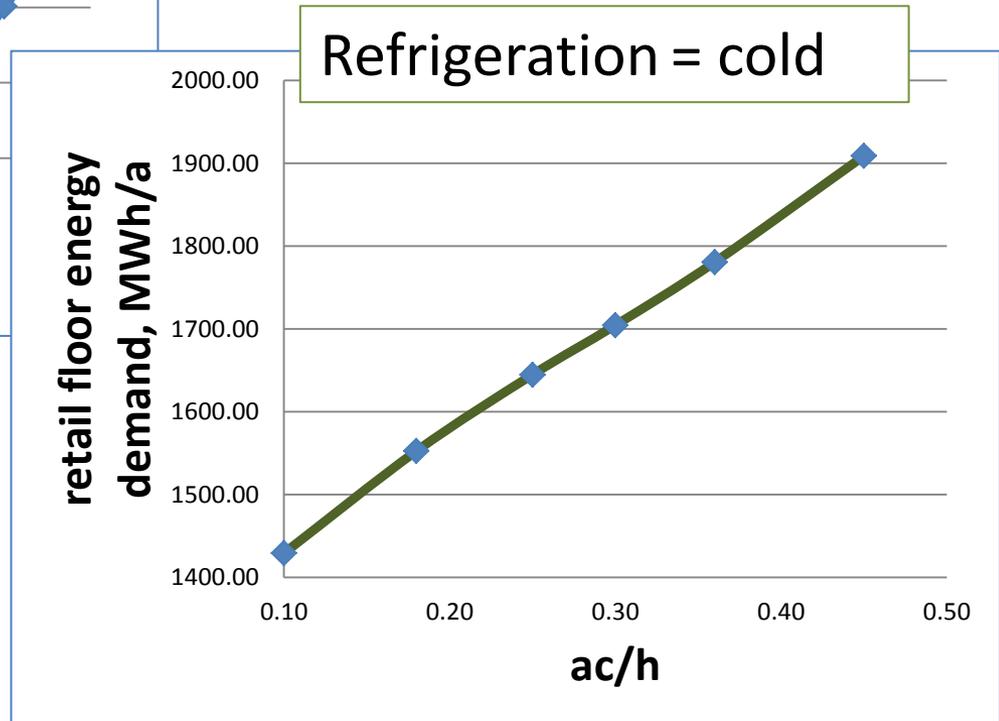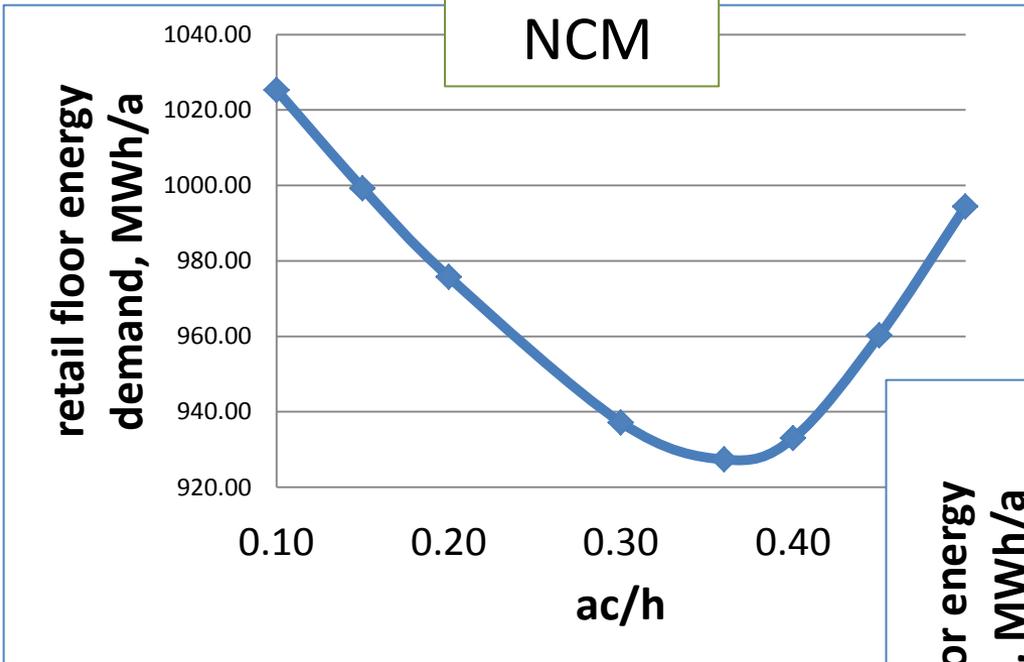
Refrigeration on NCM

25 W/m²

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
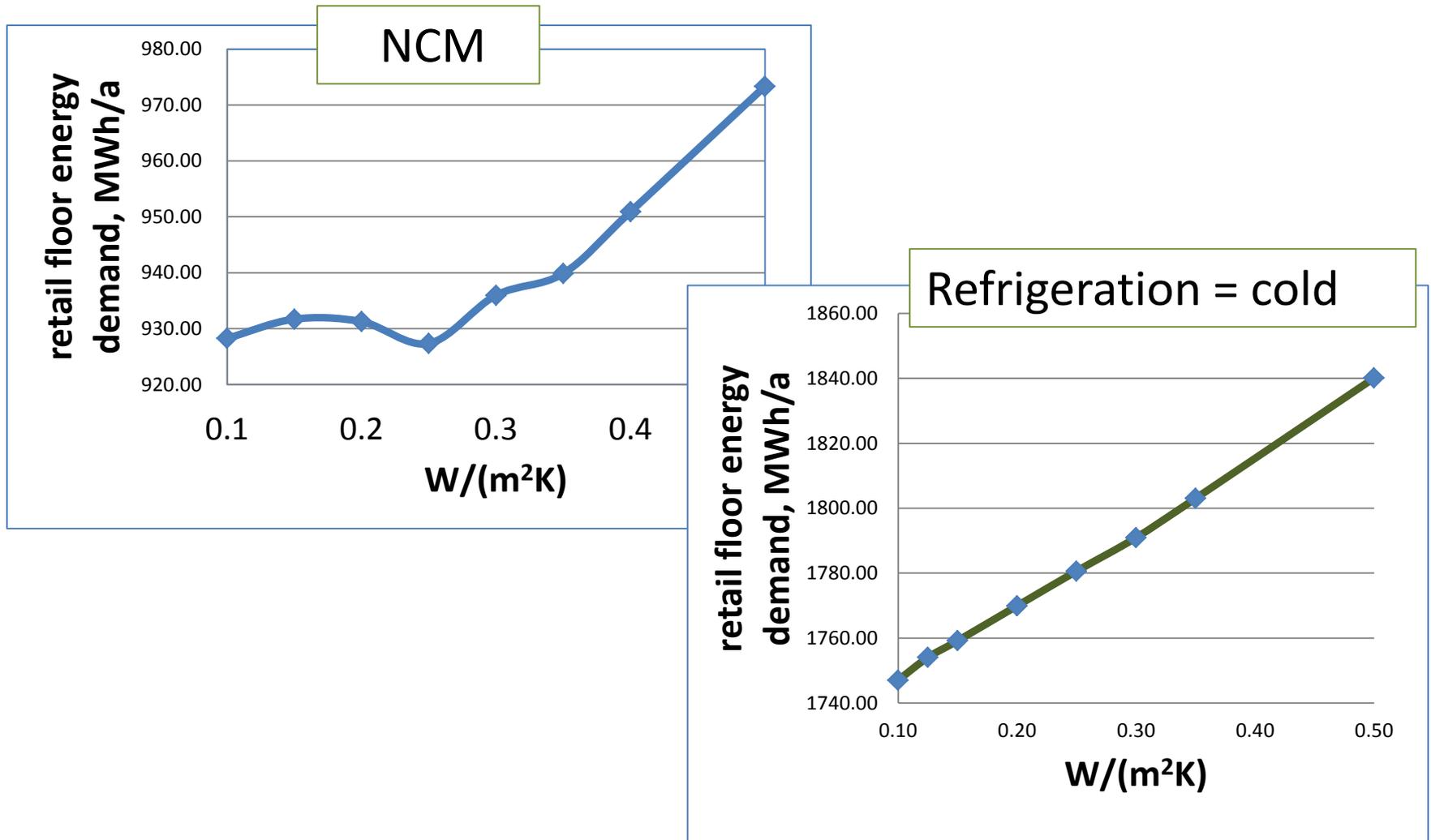 - (may not be appropriate with mostly closed cabinets)

Thermal mass

- Floor

- Goods

- Air

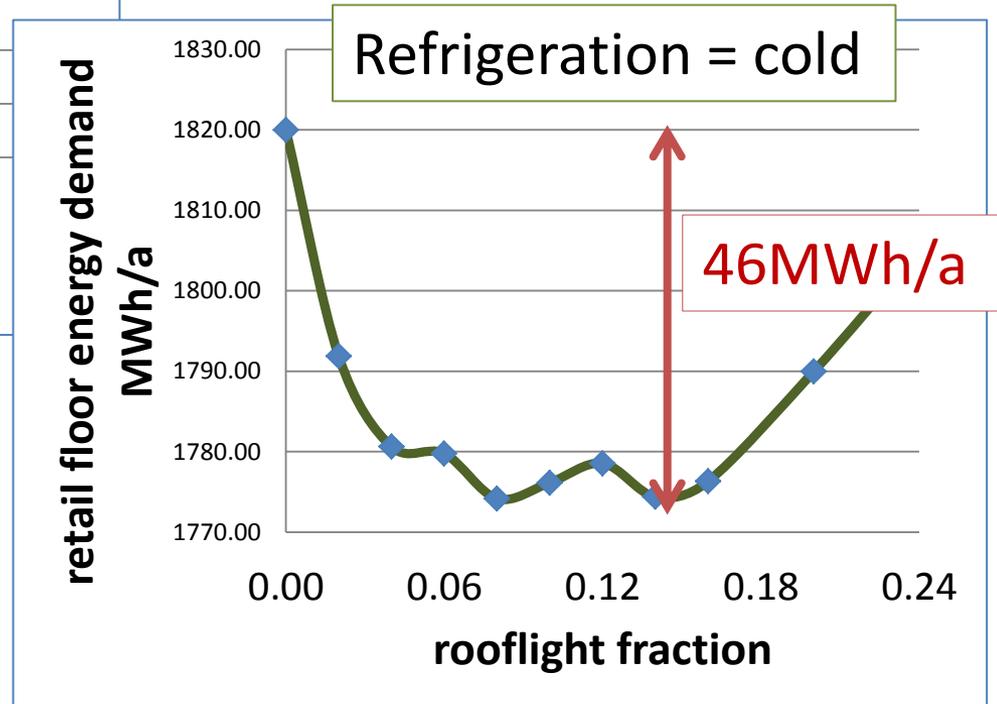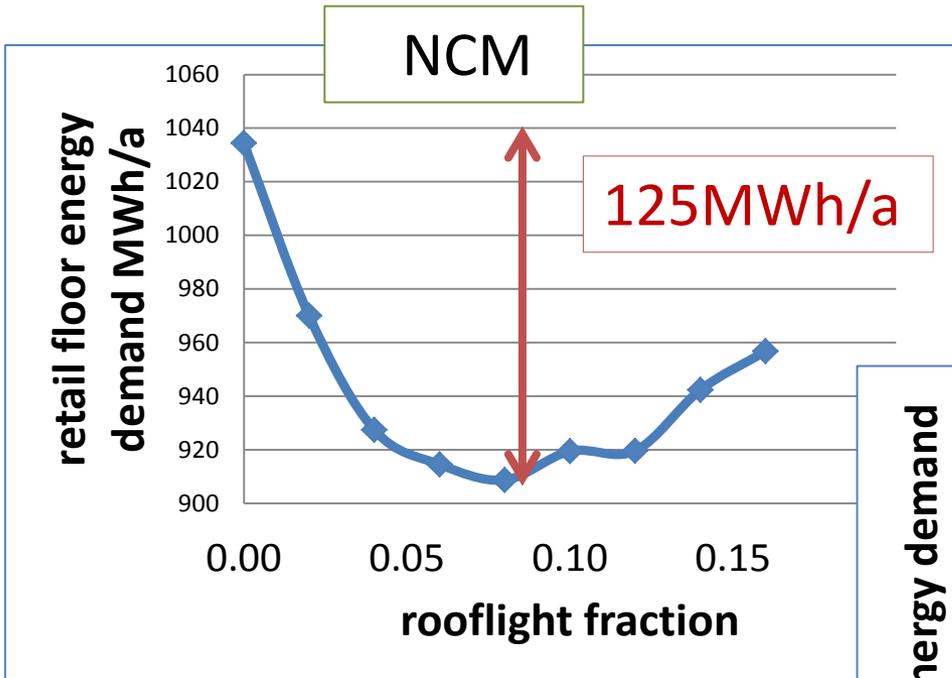- Used with first order equation on 4x hourly iteration

Sensitivity to ventilation

Sensitivity to insulation
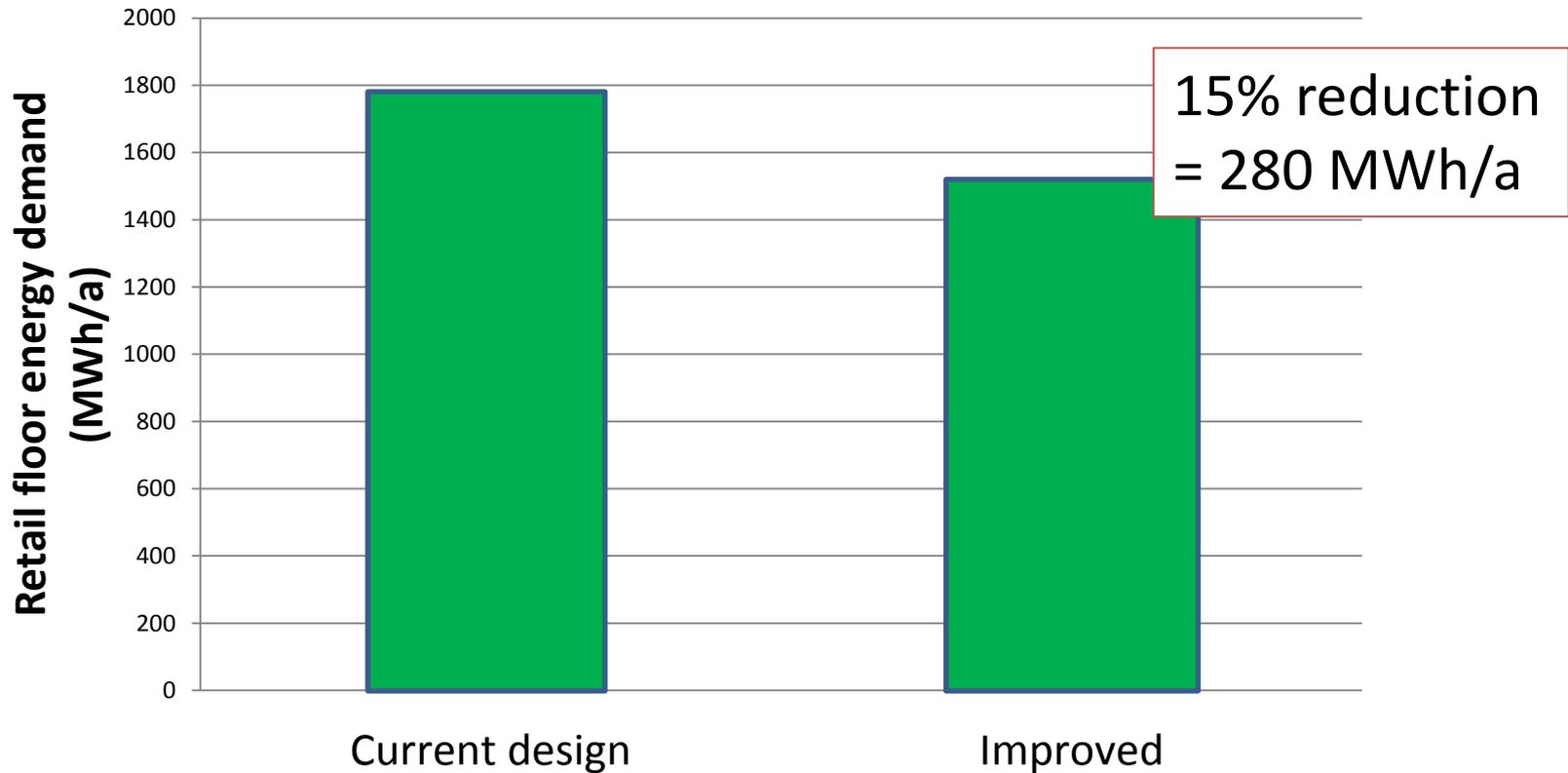
Sensitivity to rooflight fraction

NCM

125MWh/a

Refrigeration = cold

46MWh/a

Halving ventilation, doubling insulation

15% reduction = 280 MWh/a

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 15%

- Inclusion could also incentivise improvement in cabinet design, as improvements have effect on both refrigeration and heating demands

Thank you!