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Energy savings in cold storage

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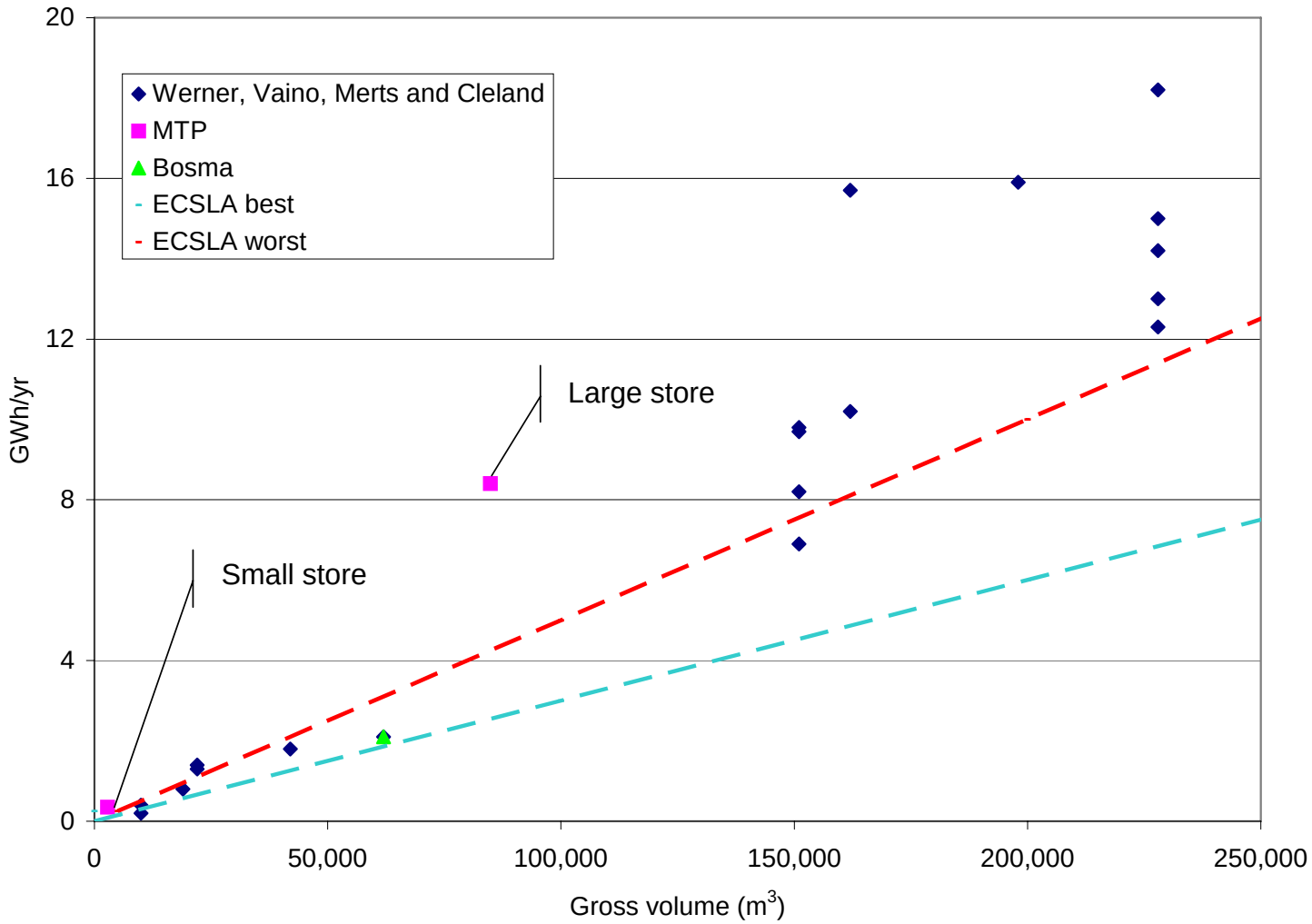
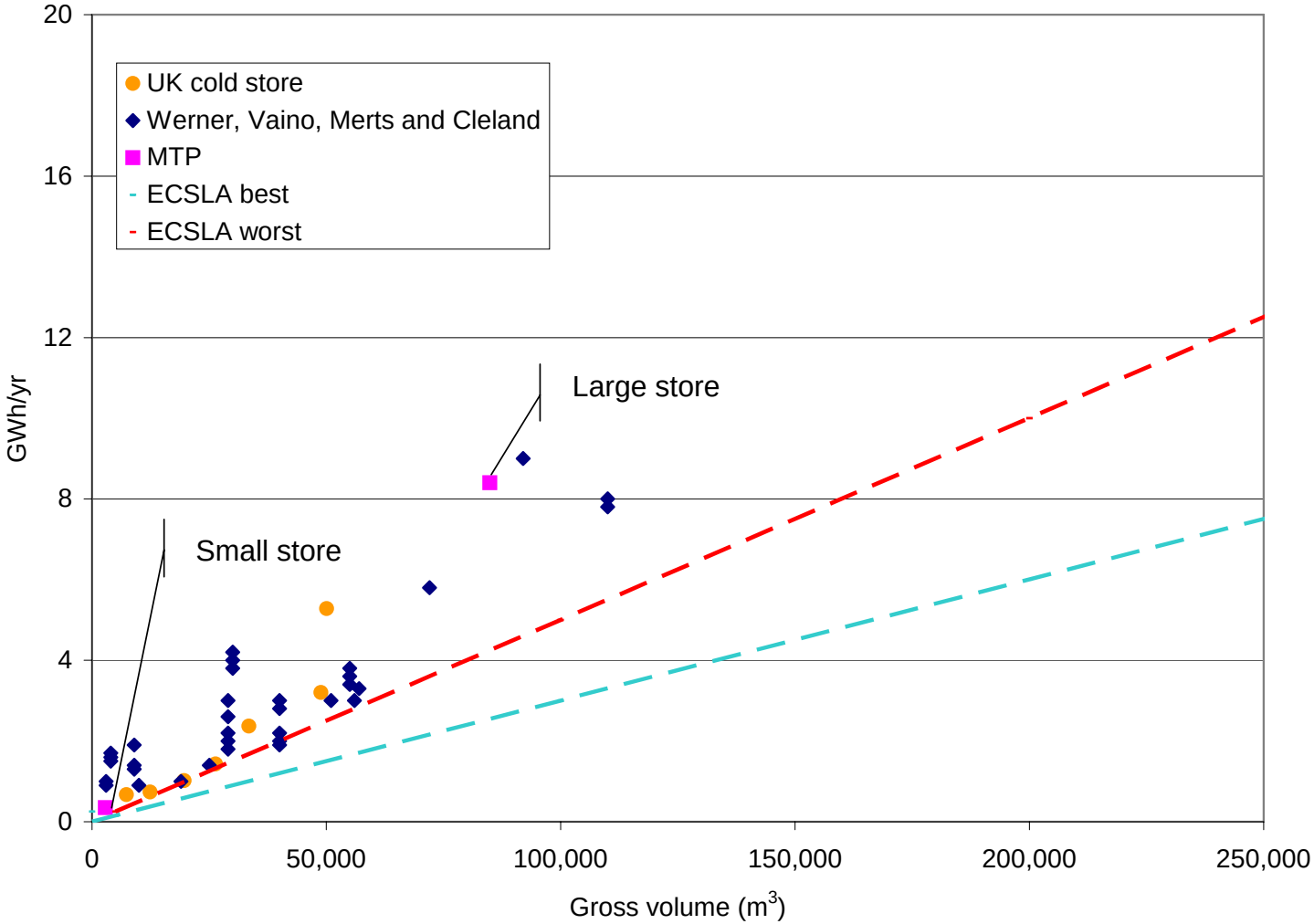
Cold stores – main issues

- Energy large proportion of costs (~60%)
- Recent large increases in energy costs
- Large variations in energy efficiency
- Awareness of global warming, reduction in CO_2 emissions

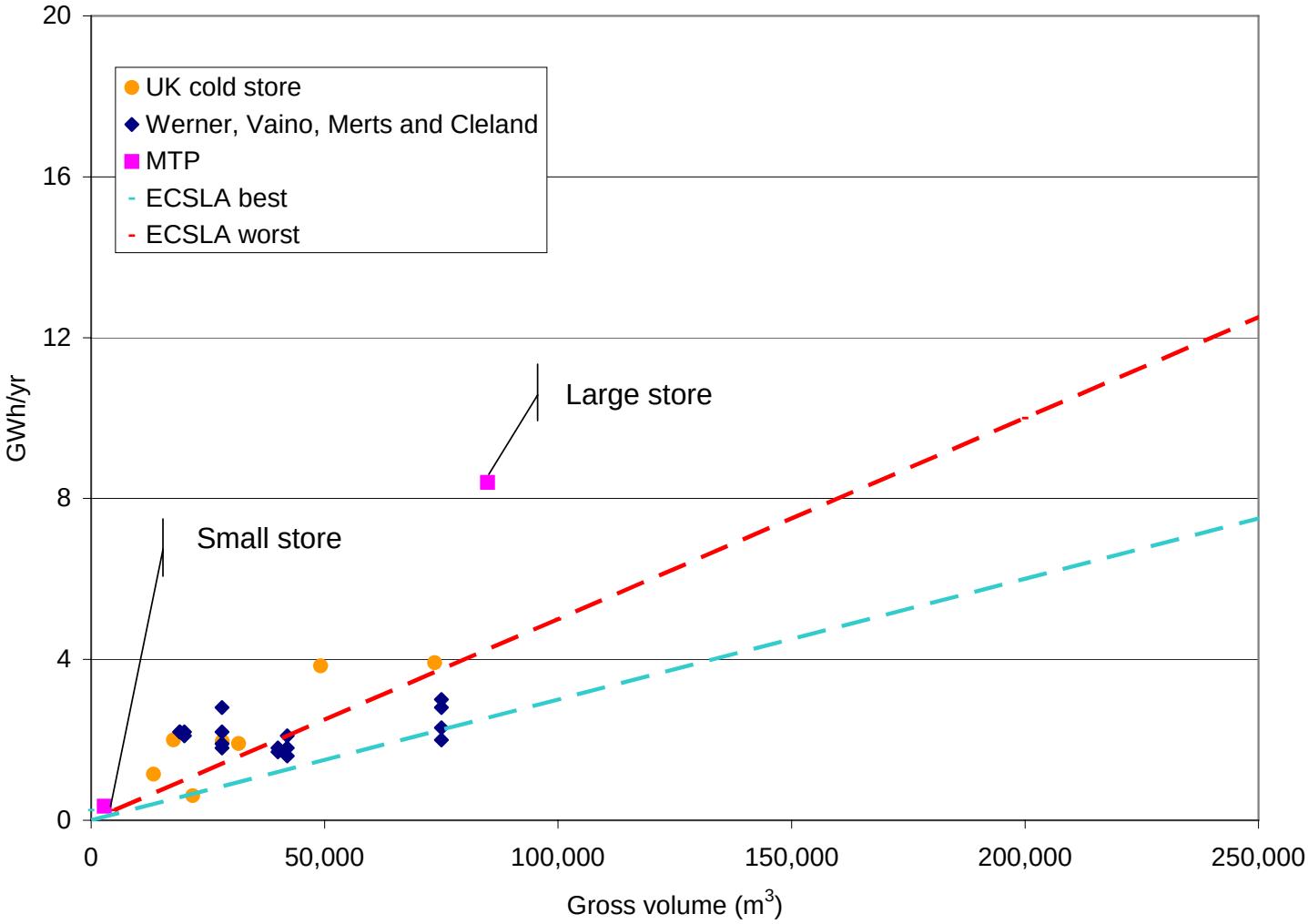
Cold stores - chilled



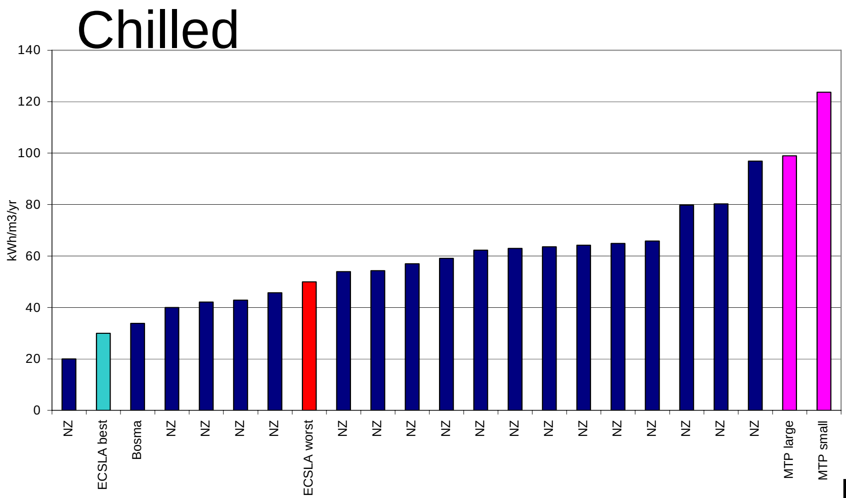
Cold stores - frozen



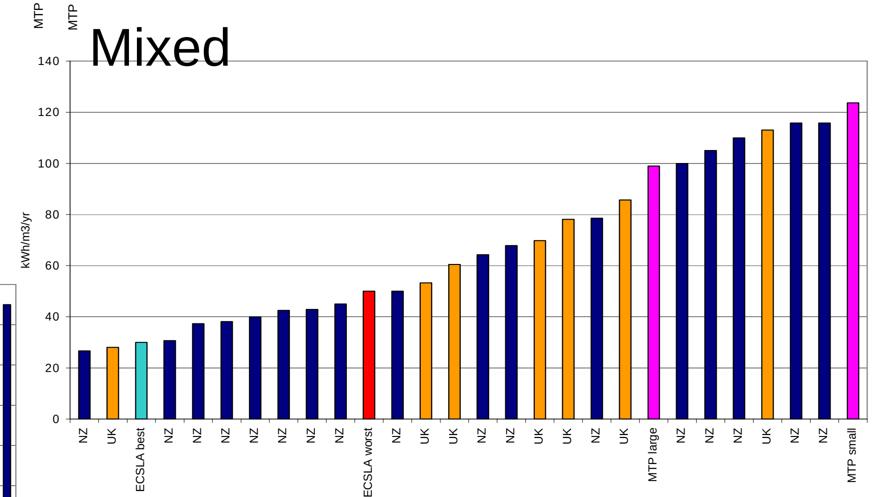
Cold stores - mixed

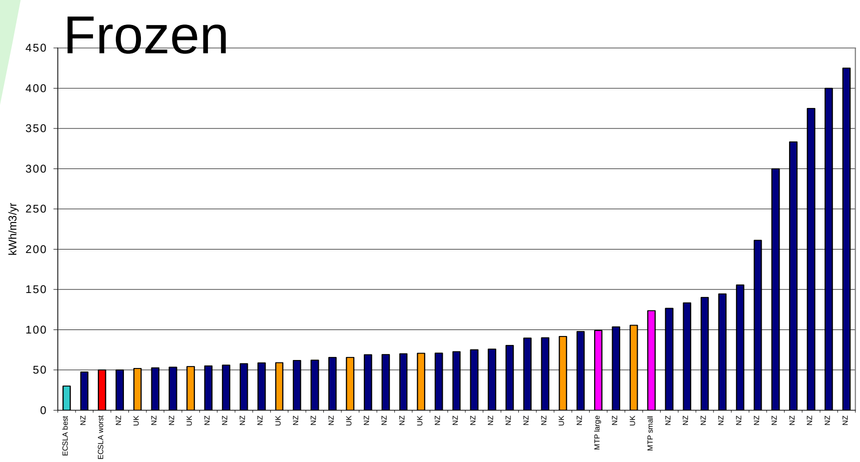


kWh/m³/yr

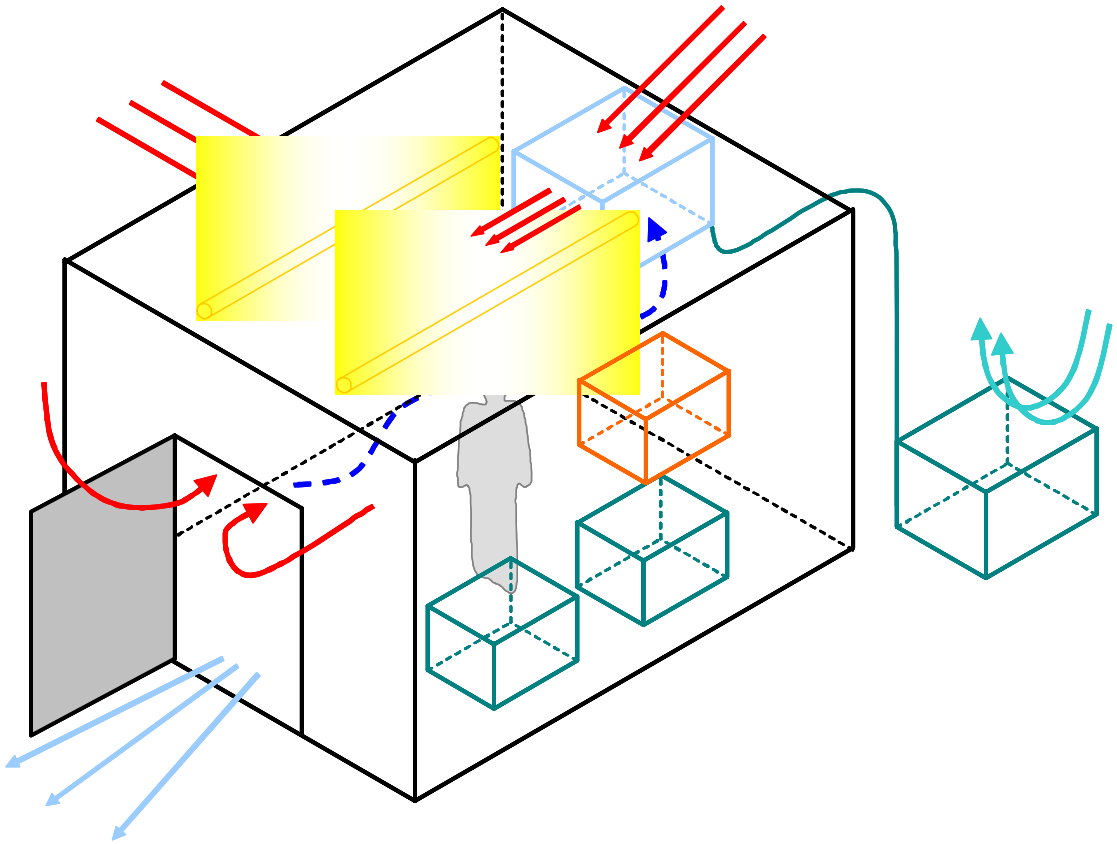


- **NZ (Werner et al)**
- **UK (survey data)**
- **ECSLA best**
- **ECSLA worst**
- **MTP**





Heat loads



1. Conduction
2. Infiltration
3. Fans
4. Food
5. Lighting
6. Machinery
7. People
8. Radiation

Energy saving

- Reduce heat loads from
  - Food
  - Room structure
  - Infiltration
- Optimisation/design of refrigeration system
- Operation of refrigeration system
- Operation of fans
- Choice of equipment
- Maintenance
- Free cooling/heat recovery

Examples of energy reduction in cold stores

1. **R22 DX plants**
   - **All heat loads on store + refrigeration system**
2. **Poorly maintained R717 plant**
   - **Refrigeration system optimisation only**
3. **Well maintained R717 plant**
   - **Refrigeration system optimisation only**

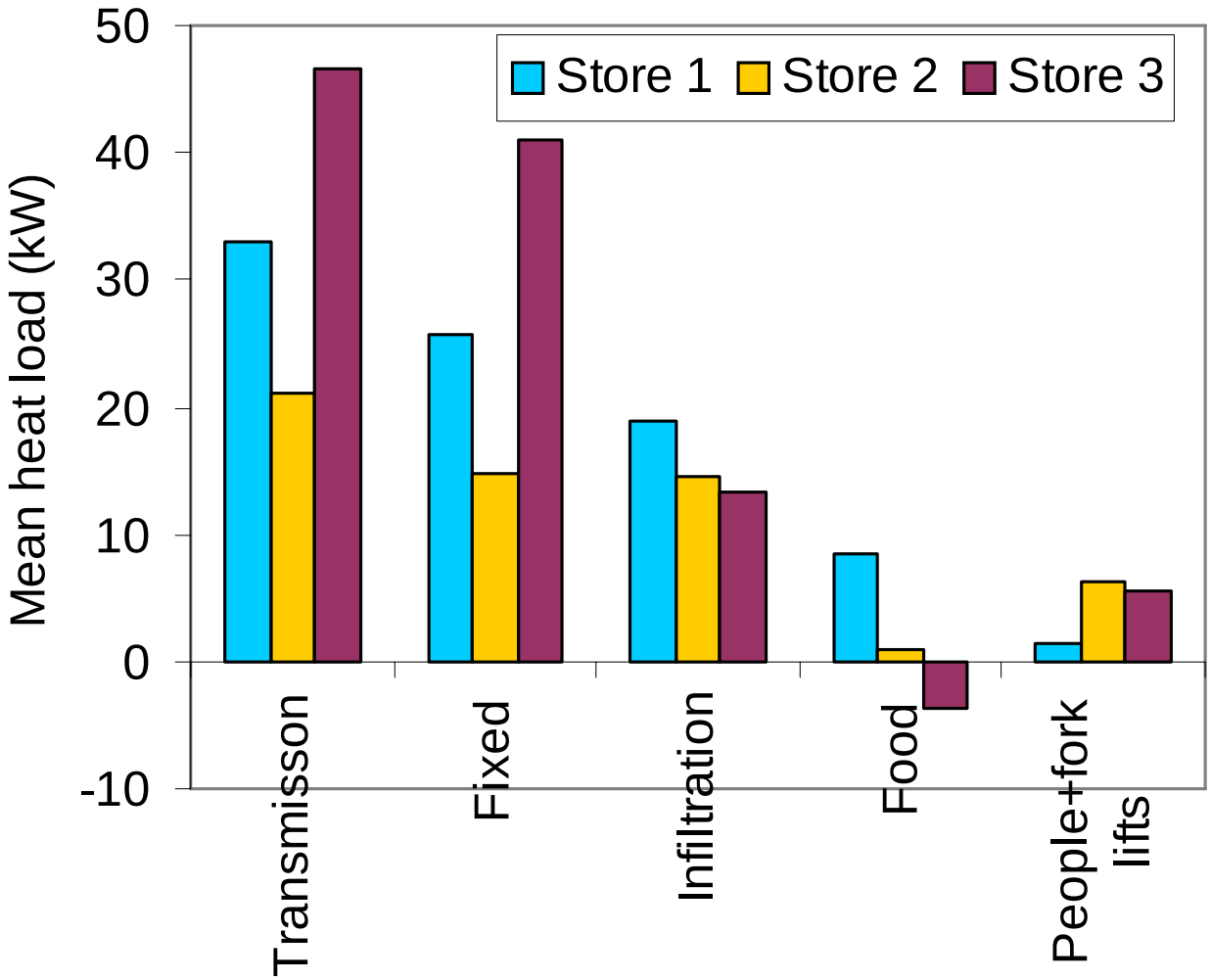
Example 1

Store	Rooms	Size (m^2)	Refrigeration system
1	3 frozen chambers	1550	DX, single stage compression, evaporative condensers, R22
2	1 frozen chamber	910	LP receiver, twin screw economised compressor, R22
3	3 chilled/frozen chambers	2458	DX, single stage compression, evaporative condensers, R22

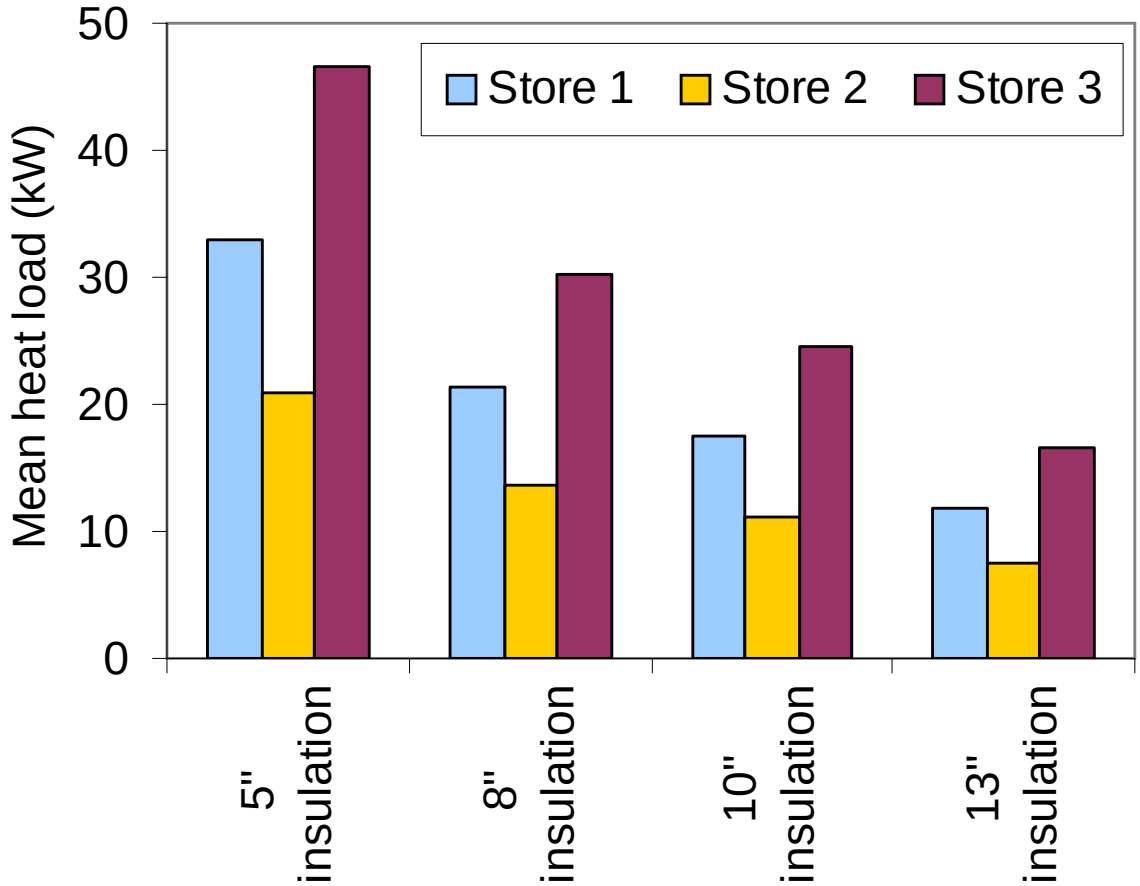
Example 1. Data collected

- Store temperature (air-on, air-off, simulated product)
- Refrigeration system temperatures
- Door openings
- Food entry/exit – quantity and temperature
- People and machinery entry/exit
- Energy consumption (every 30 minutes)
- Meteorological data
- Performance data on refrigeration system components, store construction

Example 1. Results – heat loads



Example 1. Heat load across insulation



8” (203 mm)

reduced by 35%

10” (245 mm)

reduced by 47%

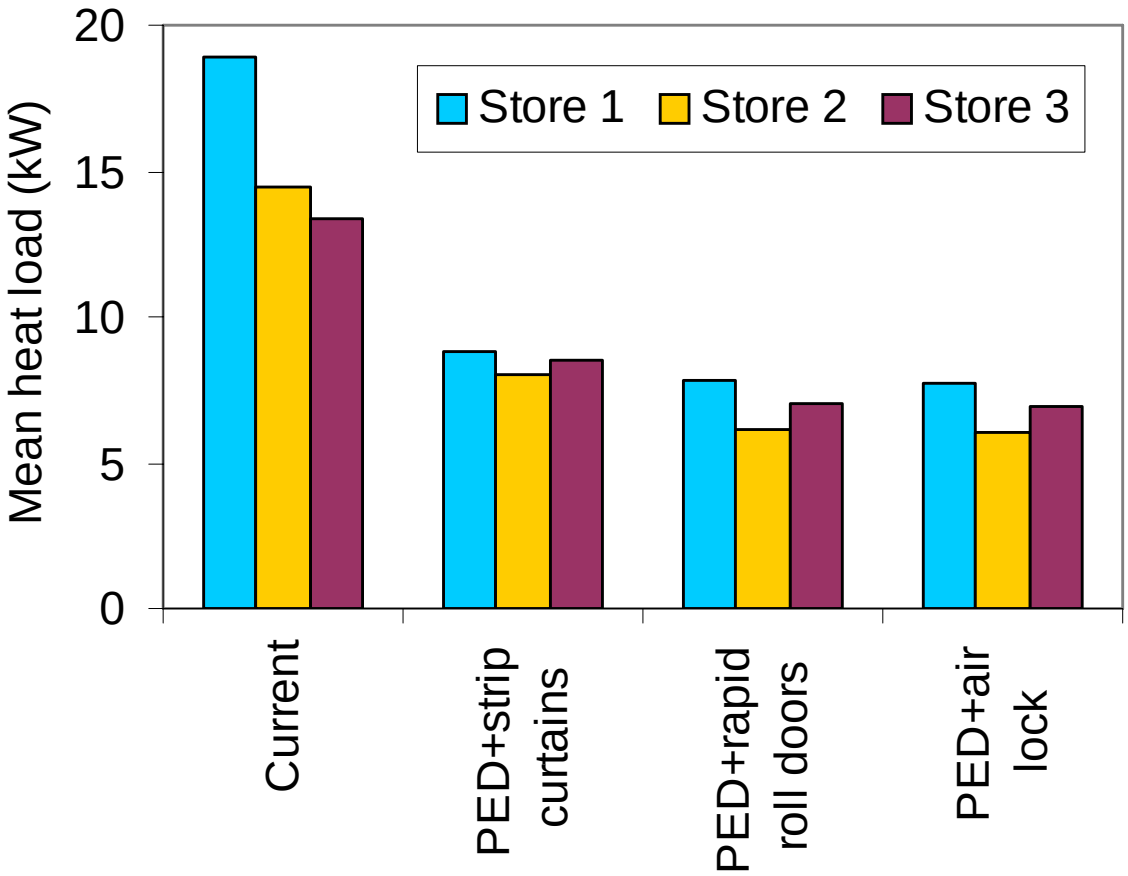
13” (330 mm)

reduced by 64%

Example 1. Fixed loads

- Pulsing fans
- Increased load shedding
- Defrost optimisation
  - Off-cycle in chillers (40,000 kWh per year in store 3)
  - Optimisation of settings

Example 1. Infiltration



47 - 59% reduction in heat load by fitting PED and improving door protection

Example 1. Efficiency of refrigeration plant

Refrigeration plant	Energy used to remove 1kW of heat from the evaporator (kW)
Cold store 1	0.66-1.07
Cold store 2	0.79
Cold store 3	1.09 (frozen), 1.02-1.10 (chilled)

Operated at -14°C (others -22°C)

Operated at -22°C, LP receiver, fully flooded

Not optimised for chillers

Plant set for -22°C ran in summer at -20°C

Stores 1 and 3 head pressure control – LP amplification would allow head pressure to float

All plant except 2 ran with high superheat, SLHE increase useful area of evaporator

Example 1. Options to improve

	Store 1 (F)	Store 2 (F)	Store 3 (F/C)
Size (m^3)	1550	910	2458
	kWh/m^3/yr		
Current	**59**	**91**	**52**
Pedestrian doors	**53**	**85**	**50**
Rapid rolls doors/improved strip curtains	**52**	**82**	**49**
Defrost optimisation	**58**	**91**	**49**
Off-cycle defrost			**51**
Separate entrance to store	**51**		
Automatic closing door	**57**		
Preventing door being jammed open		**88**	
Suction liquid heat exchangers	**56**		**44**
Liquid pressure amplification	**49**		**38**
Evaporative condensers	**58**	**56**	
Low pressure receiver (lpr)	**40**		**32**
Improve insulation on walls to 10"	**51**	**86**	**46**
Reduce the speed and off load compressor			**50**
Potential saving from best technology	**>32%**	**>38%**	**>38%**
Potential achievable by updating current	**>14%**	**>10%**	**>15%**

Best mixed = 27 kWh/m^3/yr (best savings = 32 kWh/m^3/yr)

Best freezer = 48 kWh/m^3/yr (best savings = 40/56 kWh/m^3/yr)

Energy savings achieved

- Not all improvements carried out (long payback periods)
  - PED doors
  - Rapid roll doors
  - LPA
  - SLHE
  - Evaporative condenser
- Should have achieved 17.3% reduction in energy if implemented all above improvements
- Achieved 9.4%

Example 2

- 2 large cold store plants
- Store 1+blast freezer
- Stores 2+3 freezers
- Ammonia, 2 stage compression, pump recirculation system
- 35 years old

Example 2. Cold stores - options to improve

	Store 1+blast freezer (F/C)	Store 2+3 (F)
Size (m^3)	12,399	7,347
	kWh/m^3/yr	
Current	**88**	**79**
Increase load, operate plant for shorter periods	**84**	**78**
Adjust surge drum and intercooler pressures to loads	**85**	**79**
Clear evaporators of ice, repair defrost timers	**86**	**78**
Overhaul compressors	**61**	**76**
Repair hot gas valve	**87**	**n/a**
Repair PRV in ammonia pumps	**86**	**78**
Reinsulate pipes to plant	**76**	**74**
Reinsulate surge drum	**86**	**79**
Potential saving from better maintenance	**10-60%**	**3-16%**

Maintenance

n.b. Only refrigeration, potential additional savings from operation and heat loads

Best mixed = 27 kWh/m^3/yr (best savings = 61 kWh/m^3/yr)

Best freezer = 48 kWh/m^3/yr (best savings = 74 kWh/m^3/yr)

Example 3

- 2 large cold store plants
- Store 1 freezer (2 rooms)
- Store 2 freezer (5 rooms)
- Blast freezer
- Ammonia, 2 stage compression, pump recirculation system, evaporative condensers
- Various ages (20-40 years old)
- Well maintained

Example 3. Cold stores - options to improve

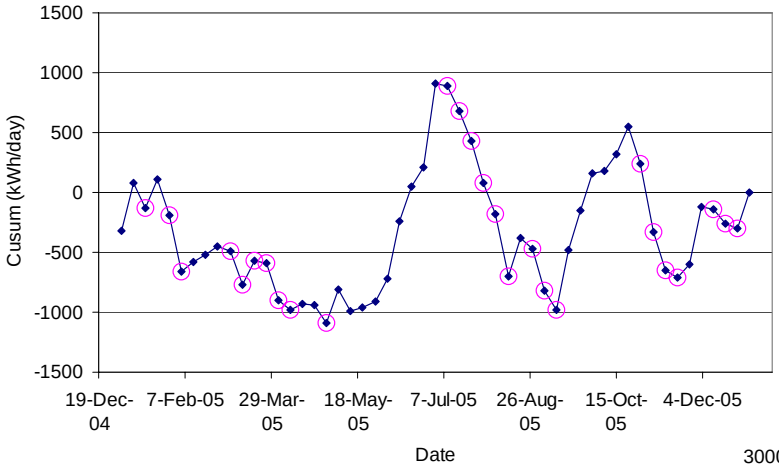
	Store 1 (F)	Store 2 (F/C)	Blast freezer
Size (m^3)	13,925	21,783	4,981
	kWh/m^3/yr		
Current	**30**	**28**	**415**
1 Reduce condenser pressure	**26**		
2 Reduce surge drum temperature	**36**		
1+2	**30**		
1 Float condenser pressure		**25**	
2 Increase evaporator temperature		**25**	
1+2		**21**	
Fully flooded evaporator, compressor offloading			**415 (faster freezing)**
Potential saving from better operation	**0 (13%)**	**26%**	**Better operation**

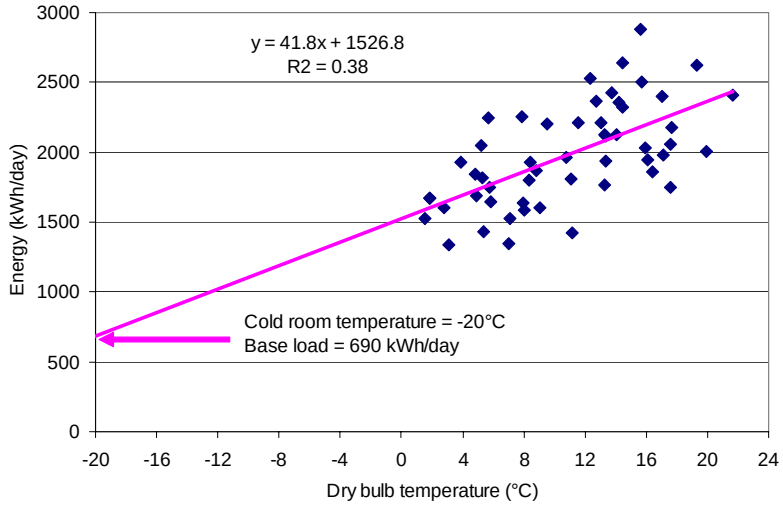
n.b. Only refrigeration, potential additional savings from operation and heat loads

Best mixed = 27 kWh/m^3/yr (best savings = 21 kWh/m^3/yr)

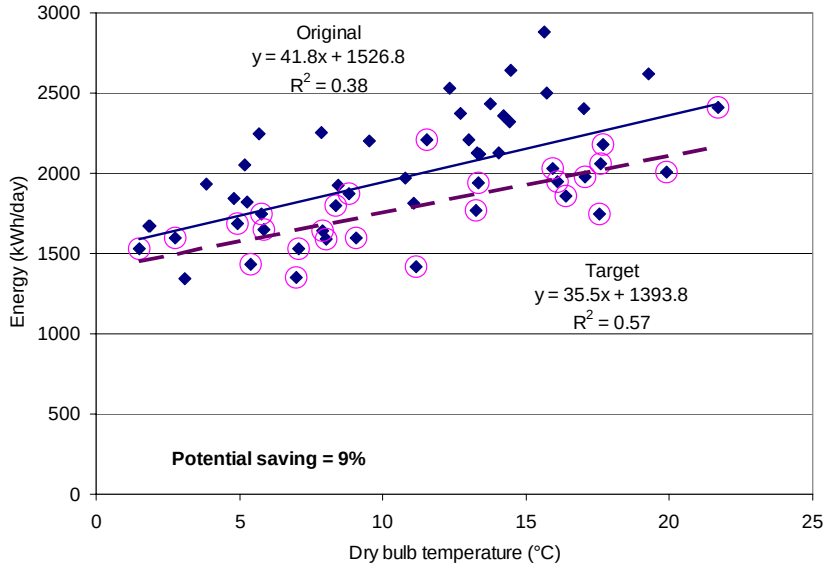
Best freezer = 48 kWh/m^3/yr (best savings = 30 kWh/m^3/yr)

Target and monitoring





Useful method to take charge of energy usage



Leakage

- Contribution to global warming
- Leakage
  - Lack of detailed information 7-10% (UNEP, 2003)
  - May be higher 17% (Clodic and Palandre, 2004)
- Cold stores – R22 (15-20%), R717 (60-70% of industrial refrigeration)
- Lower leakage of R717 due to pungent smell
- R22 is an HCFC – being phased out from 2010
- 15% loss of refrigerant can double energy for a given amount of cooling

GWP	R717	R22	R404A	R134a	R407C	R507	HC	CO_2
	0	1,700	3,750	1,300	1,980	3,300	0	1

Options to improve

- Large range in efficiency of current stores
- Often varied issues to reduce energy
- Potential improvements available, some simple and inexpensive
- Identifying improvements not always simple or easy for end users
- Data to justify investment in savings not always available

Further information:

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

Specifically on cold storage:

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