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OVERVIEW OF DEFRA ENERGY SAVING PROJECT

Stephen J James
Tuesday 8th June 2010

defra Department for Environment Food and Rural Affairs

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FRPERC Food Refrigeration and Process Engineering Research Centre

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Defra project

3 year Defra funded project to:

“identify, develop and stimulate the development and application of more energy efficient refrigeration technologies and business practices for use throughout the food chain whilst not compromising food safety and quality”

The Partnership

- **Academic - FRPERC, London South Bank, Brunel & Sunderland**
- **Project officer - Christina Goodacre**
- **Steering Group - Stephen Reeson (FDF) Gary Shields (Dairy UK), Mike Lawrence (FETA), John Hutchings (FSDF), Brian Whittaker (CESA) and David Blackhurst (IoR)**

Main topics in work programme

1. Mapping of energy use.
2. Identifying new technologies and business practices.
3. Feasibility studies on promising technologies and business practices.
4. Continuous interaction with food and refrigeration industries.

Mapping of energy use

Objective

Identify and rank 10 'operations' (process/food combinations) in order of the potential by the use of improved technology and enhanced business practice to reduce energy usage in food refrigeration.

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Top 10 in saving potential (GWh/y)

	Sector	Energy	Savings
1	Retail	12,700	6,300
2	Catering - kitchen refrigeration	4,000	2,000
3	Transport	4,800	1,200
4	Cold storage	900	360
5	Blast chilling-ready meals, etc	610	180
6	Blast freezing - potato products	420	130
7	Milk cooling - raw milk on farm	320	100
8	Dairy processing - milk/cheese	250	80
9	Potato cooling/storage	190	60
10	Chilling - meat carcasses	140	40

1- Retail display

- **Improvements insulation, fans and lighting but only 10 to 30% of heat load.**
- **Concentrating on:**
  - **Infiltration in multi-decks (80% of load).**
  - **Radiation in frozen wells (40% of load).**

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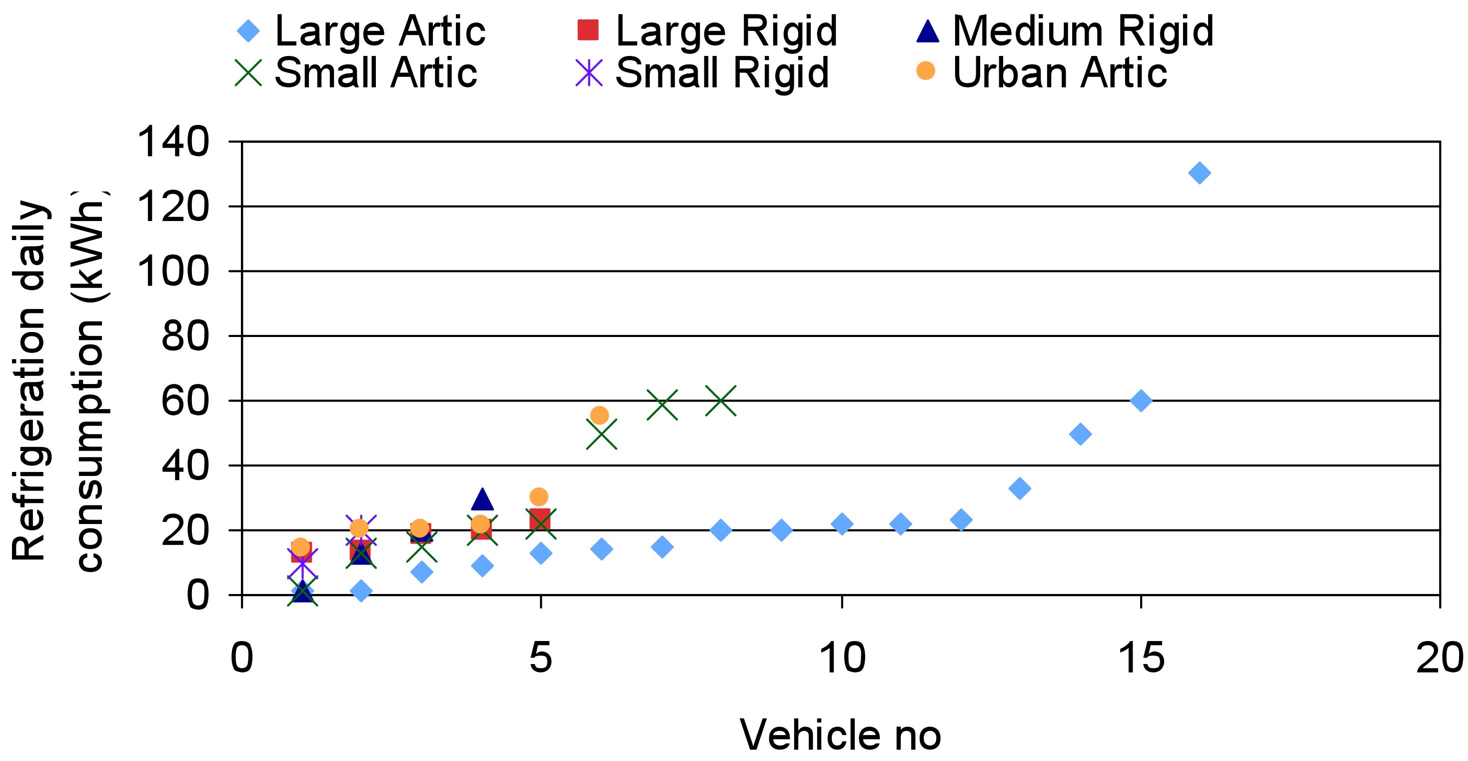
2 - Catering

- Approximately 500,000 commercial service cabinets.
- Chilled consume 2,900 kWh per year.
- Frozen consume 5,500 kWh per year.
- Large differences in efficiency.

3- Refrigerated transport

- 52,000 refrigerated vehicles in use.
- Average 26 litres/day for refrigeration.

3 - Transport - Only measured data



Transfer of existing technologies

Ambient cooling as one example

Ambient cooling

- Surface temperature of cooked/baked products very high >80°C on exit from cooking systems.
- Temperature difference between ambient air and surface is typically >60°C.
- Initial ambient cooling stage has potential to reduce energy required without significantly extending cooling time.

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Encouraging ambient cooling

- Common in bakery products
- Problems
  - Belief that encourages microbiological contamination
  - Significant capital and maintenance costs
- Blast cooling is one of the top 10 energy users in the cold chain
- Therefore has a role in energy reduction.

Freezing hash browns

- Spiral failed to freeze 5 tonnes per hour of hash browns
- Two problems:
  - Initial heat load too high
  - Too much moisture deposited and freezing on coil
- Short study to determine amount of heat and moisture that could be removed using ambient cooling stage.

Hash browns in ambient (22°C)

	Core temperature (°C)				
	Time (m)				
	0	2.5	5	10	20
2.0 m/s	87	70	57	40	26

Weight loss during cooling

		Weight loss (g) during ambient cooling					
	During Frying	0 -5	5-10	10-15	15-20	20-25	25-30
Mean	2.25	0.94	0.31	0.22	0.13	0.15	0.12

5 minutes of ambient cooling

- Removes 562,500 kJ of heat energy from 4.5 tonnes of hash browns every hour.
- Stops 60 kg per hour of water freezing on the coils.
- Insignificant increase in total freezing time.

Chilling gourmet pies

Required effective chilling process.

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Experimental trials

- Looked at effect of:
  - Air temperature
  - Air velocity
  - Pie support
- Ambient cooling first stage

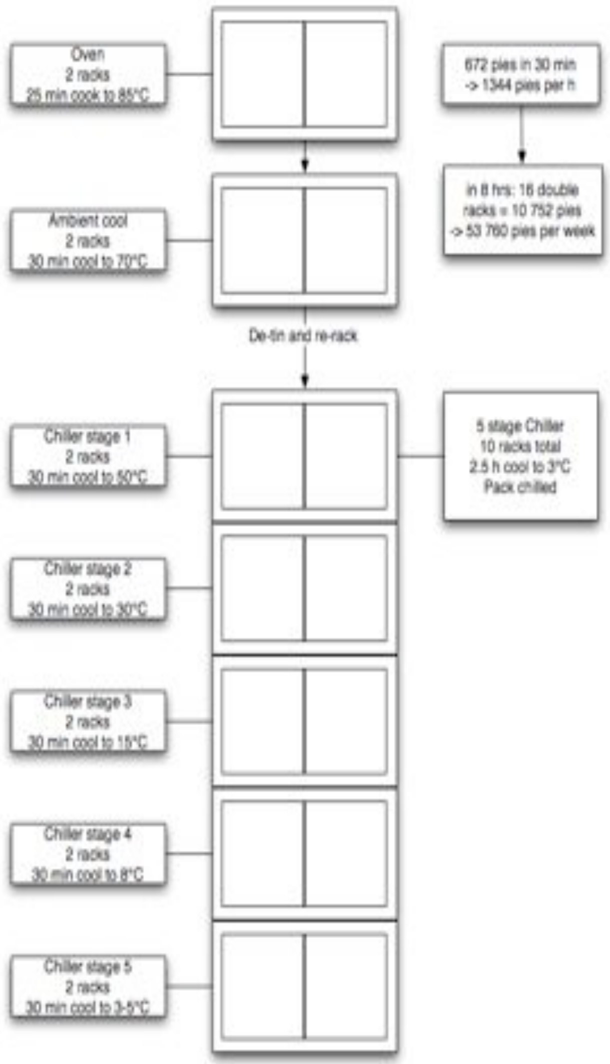
Pie temperatures

Conditions	Pie temperature after 30 min (°C)	Time to 3°C (m)		
		Total	In chiller	Control
30 m at 10°C 1.3m/s then 0°C 3.3 m/s on tray	**45**	**136**	**106**	**120**
30 m at 10°C 3.3m/s then 0°C 3.3 m/s on tray	**47**	**136**	**106**	**120**

Final system

- Effectively continuous processing:
  - Two racks cooked for 30 min.
  - Hot pies would be pre-cooled in ‘ambient’ air for 30 min before they are de-tinned.
  - Pies then transferred into aluminium baking trays, racked on steel trolleys and placed in the blast chiller.
  - Pies chilled to 3-5°C in 2.5 h in air at 0°C and air velocities between 1 to 3 ms^{-1}.

Final system



Conclusions

- An ambient cooling operation can significantly reduce energy consumption of chilling and freezing systems.
- Two cases studies clearly demonstrate this

Alternative and Emerging Refrigeration Technologies

- Magnetic
- Thermoacoustic
- Thermoelectric
- Stirling cycle
- Air cycle
- Tri-generation
- Sorption technologies (absorption and adsorption)
- CO_2 refrigeration systems

Solar, hydrogen & geothermal

- -23°C solar power refrigeration demonstrated
- Hydrogen system claimed be 15 to 50% more efficient than conventional systems and total cost of a hydride heat pump less than £500 per ton of cooling
- Geothermal jam cooling system in Japan with 260 kW of refrigeration and claimed energy use of 25% of conventional.

Energy consequences of maintenance

- Badly fitting doors, poor door seals, wet insulation, etc increase heat loads.
- Dirty/choked condenser coils increase energy consumption.
- However, does a well maintained food refrigeration plant itself consume less energy than a poorly maintained one?

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Energy optimisation of a food refrigeration system

"No accurate model of a complete food refrigeration system is possible unless both the refrigeration users and mechanical plant are considered simultaneously in the model."

(Cleland 1990)

This project's model

- Integrates
  - A dynamic model of a refrigeration system (evaporator, compressor, condenser, etc.).
- With
  - A dynamic model of the food space and the temperature response of the food.

Full deliverables of the project

http://www.grimsby.ac.uk/What-We-Offer/DEFRA-Energy/

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