Grimsby Institute

Improving Energy Efficiency within the food cold-chain

Stephen J James & Christian James

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Food Refrigeration and Process Engineering Research Centre

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”

defra
Department for Environment Food and Rural Affairs

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Main topics in work programme

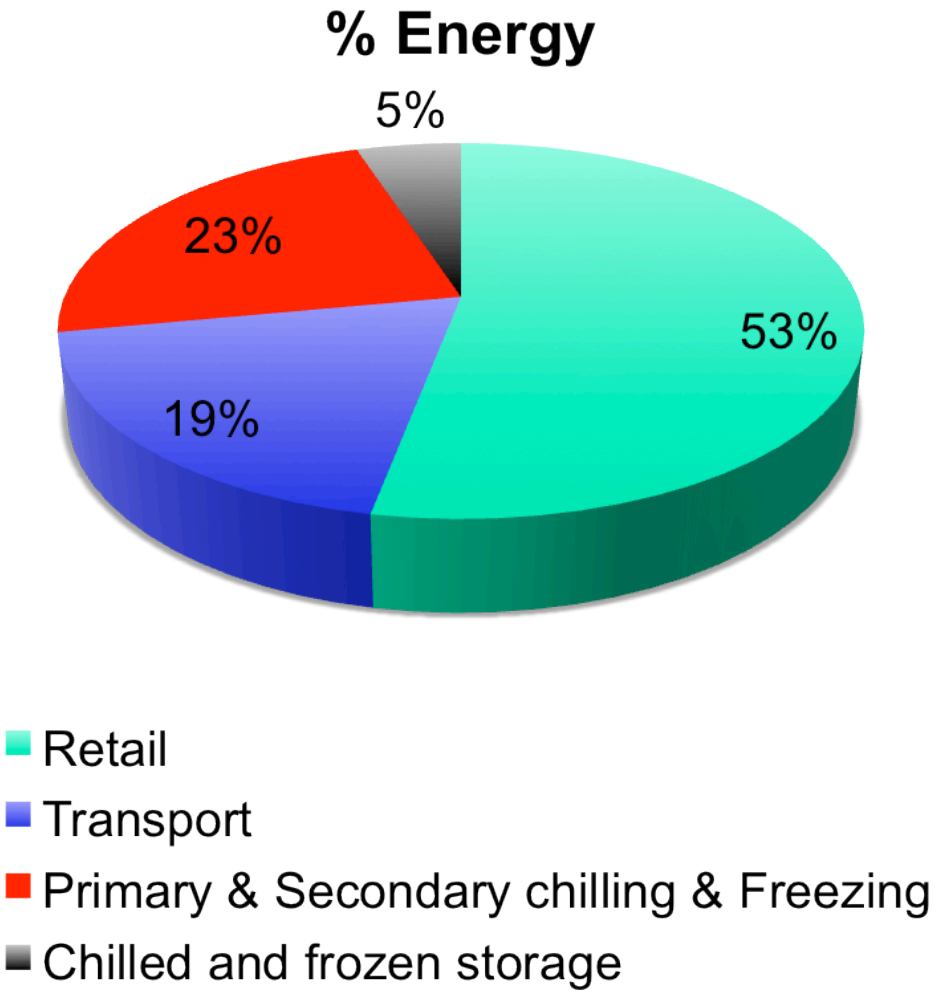
1. **Mapping of energy use**
2. **Identifying new technologies and business practices**
3. **Feasibility studies on promising technologies and business practices**
4. **Continuous interaction with food and refrigeration industries**

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

Mapping – Initial estimate



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Energy mapping – top ten ranking

			Saving	
		GWh/y	%	GWh/y
1	Retail display	5800 - 12700	30-50	6300
2	Catering – kitchen refrigeration	4000	30-50	2000
3	Transport	4820	20-25	1200
4	Cold storage - generic	900	20-40	360
5	Blast chilling – (hot) ready meals, pies	310 - 610	20-30	180
6	Blast freezing – (hot) ready meals, potato products	220 - 420	20-30	130
7	Milk cooling – raw milk on farm	100 - 320	20-30	100
8	Dairy processing – milk/cheese	250	20-30	80
9	Potato storage – bulk raw potatoes	140 - 190	~30	60
10	Primary chilling – meat carcasses	110 - 140	20-30	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)

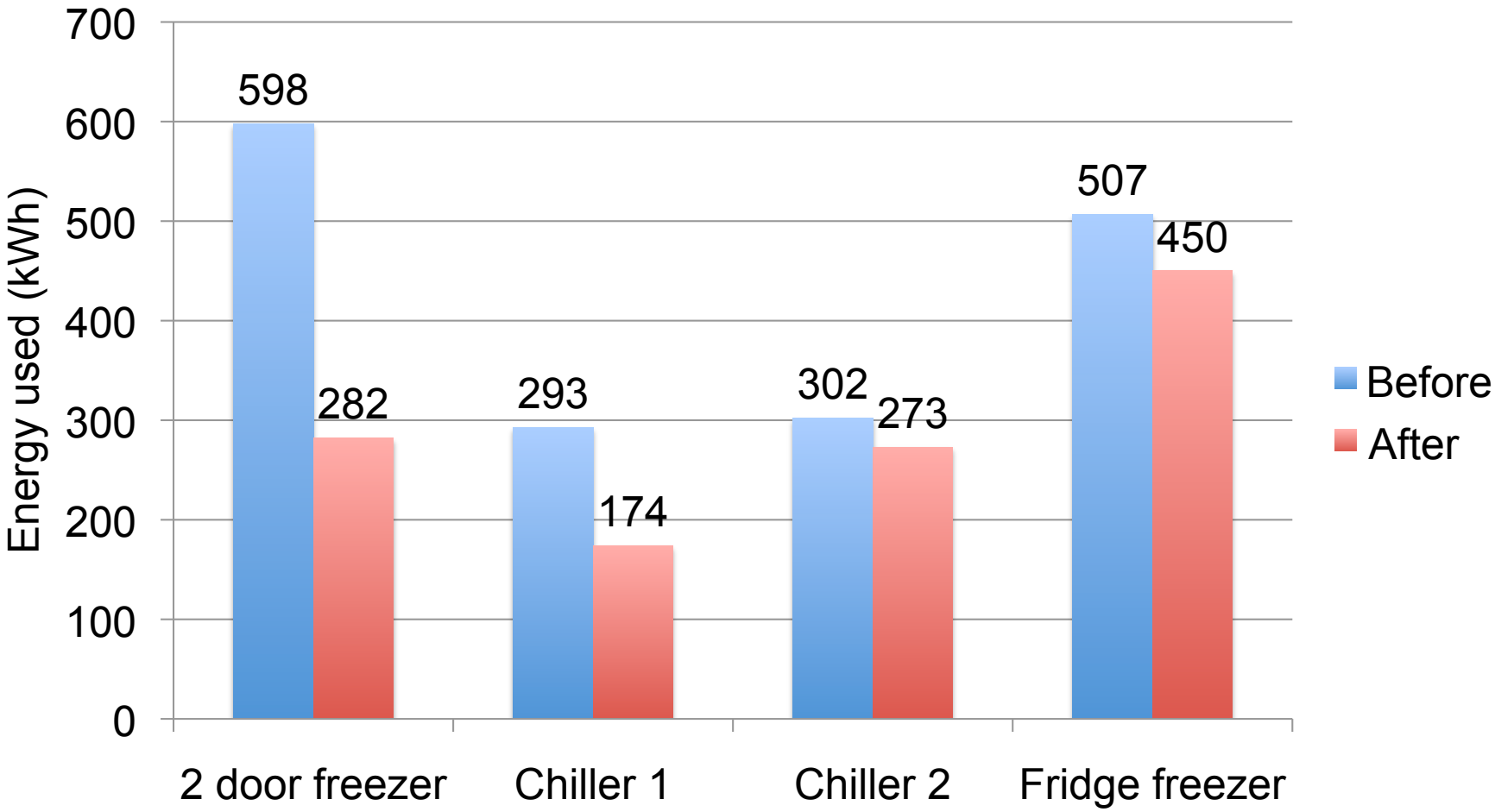
2 - Catering

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

2 - Catering options to improve

- Cleaning the condenser coil reduced consumption by 8%
- Resetting the thermostat to a sensible value saved another 11%

Replacement of devices



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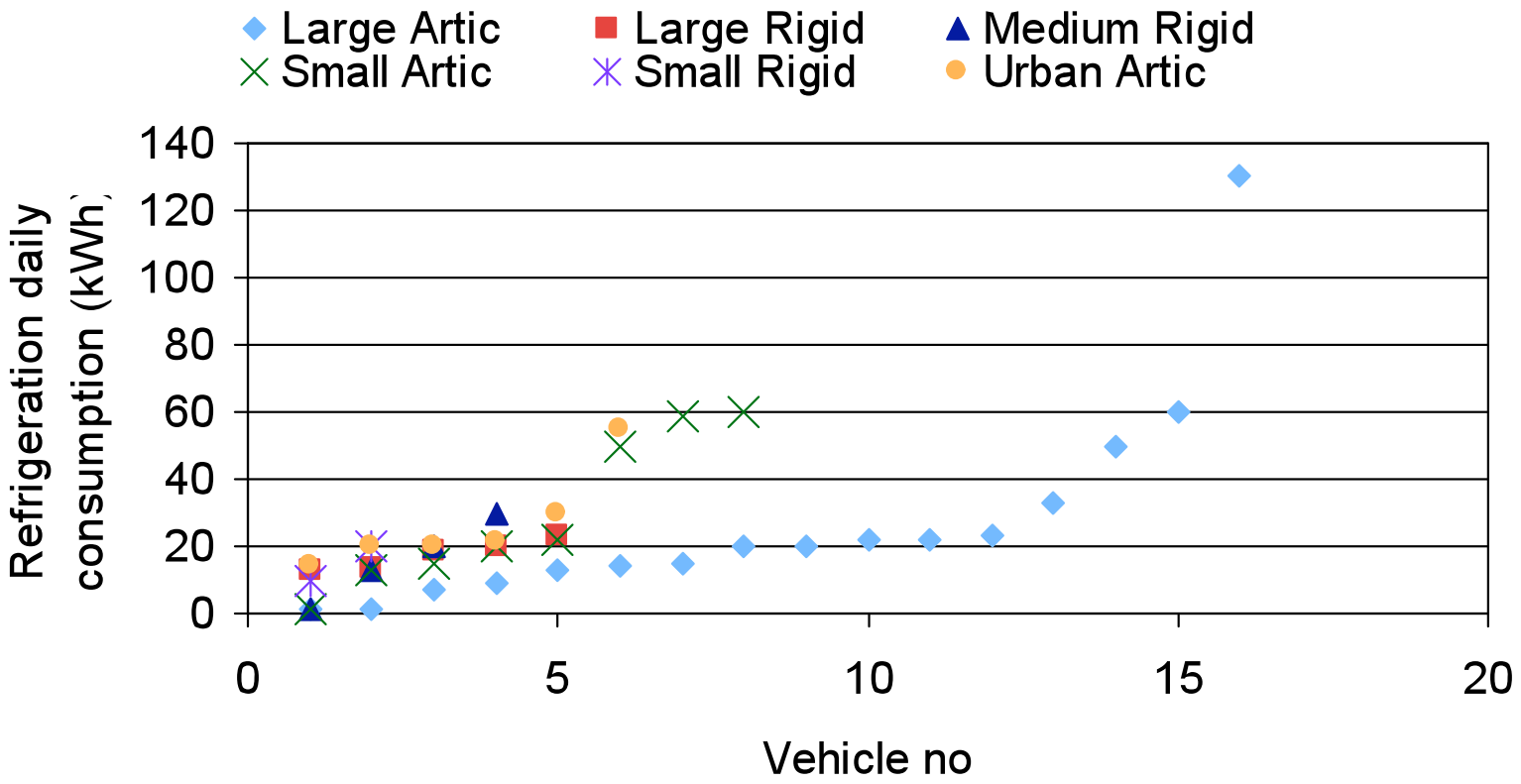
3- Refrigerated transport

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

3 - Transport - Only measured data



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Alternative and Emerging Refrigeration Technologies

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

Alternative technologies

- Currently difficult to see any that will make a step reduction in food refrigeration energy consumption in next decade
- Many will find niche markets

Energy optimisation of a food refrigeration system

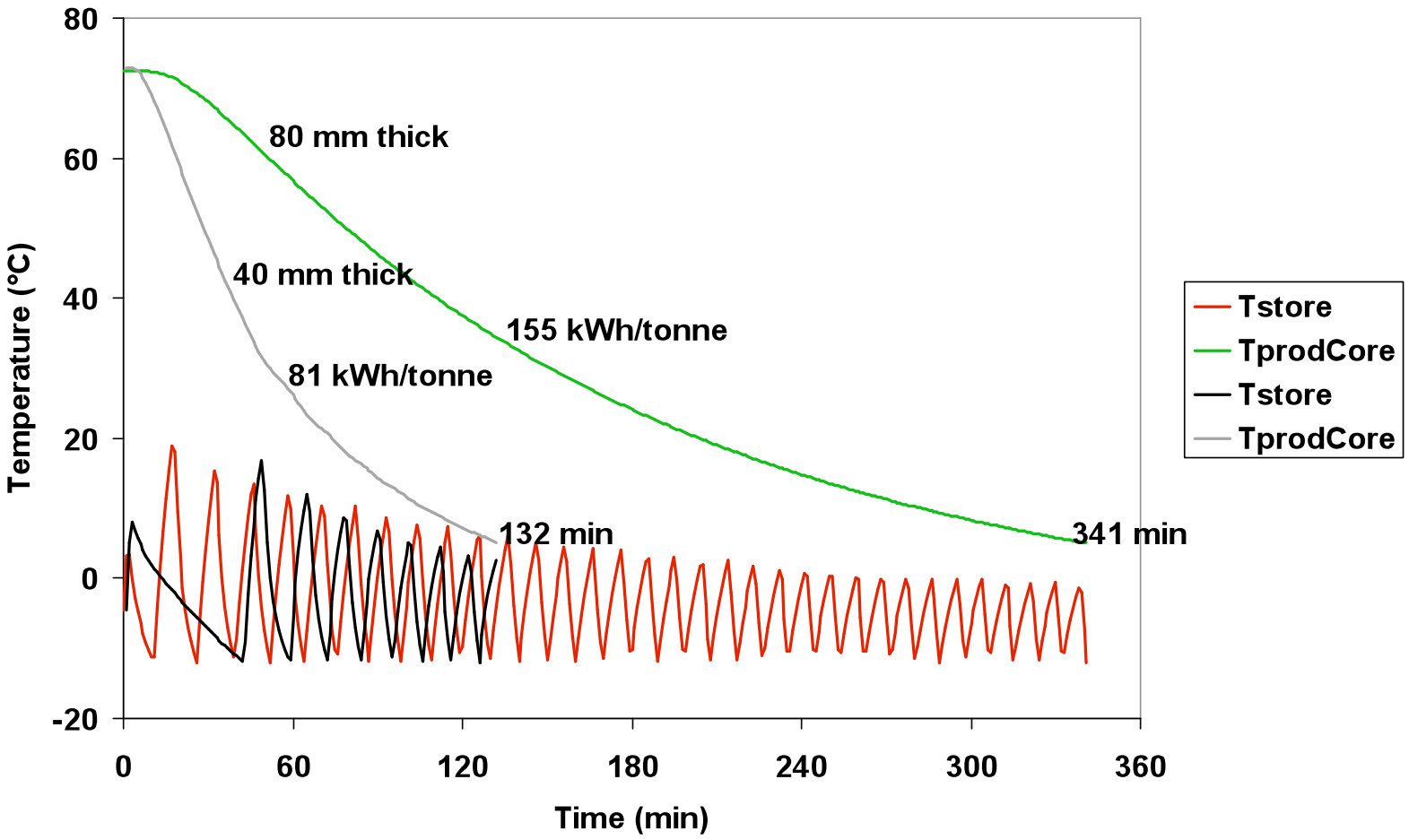
"No accurate model of a complete food refrigeration system is possible unless both the refrigeration users and mechanical plant are considered simultaneously in the model."

(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

Food depth- 80mm or 40mm



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Overall - Potential

- On the best available data the energy saving potential in the top five operations retail, catering, transport, storage and primary chilling lies between 4300 and 8500 GWh/y
- Without real data on energy consumption and heat extracted it is impossible to benchmark existing operations, provide sensible targets or quantify the true effect of energy saving technologies

Overall - Top 10

- Applying current knowledge of most efficient systems would substantially reduce energy consumption in retailing, catering, storage and chilling/freezing processes
- Some generic transfer but real benefits from site to site study
- Much more information on http://www.grimsby.ac.uk/What-We-Offer/DEFRA-Energy/

What is the purpose of the factory/ plant?

- Input
  - Raw materials (amount/temperature)
  - Packaging
- Output
  - Packaged finished product (amount/ temperature)
- Purpose
  - Transform input into output in most cost effective manner

Input and Output

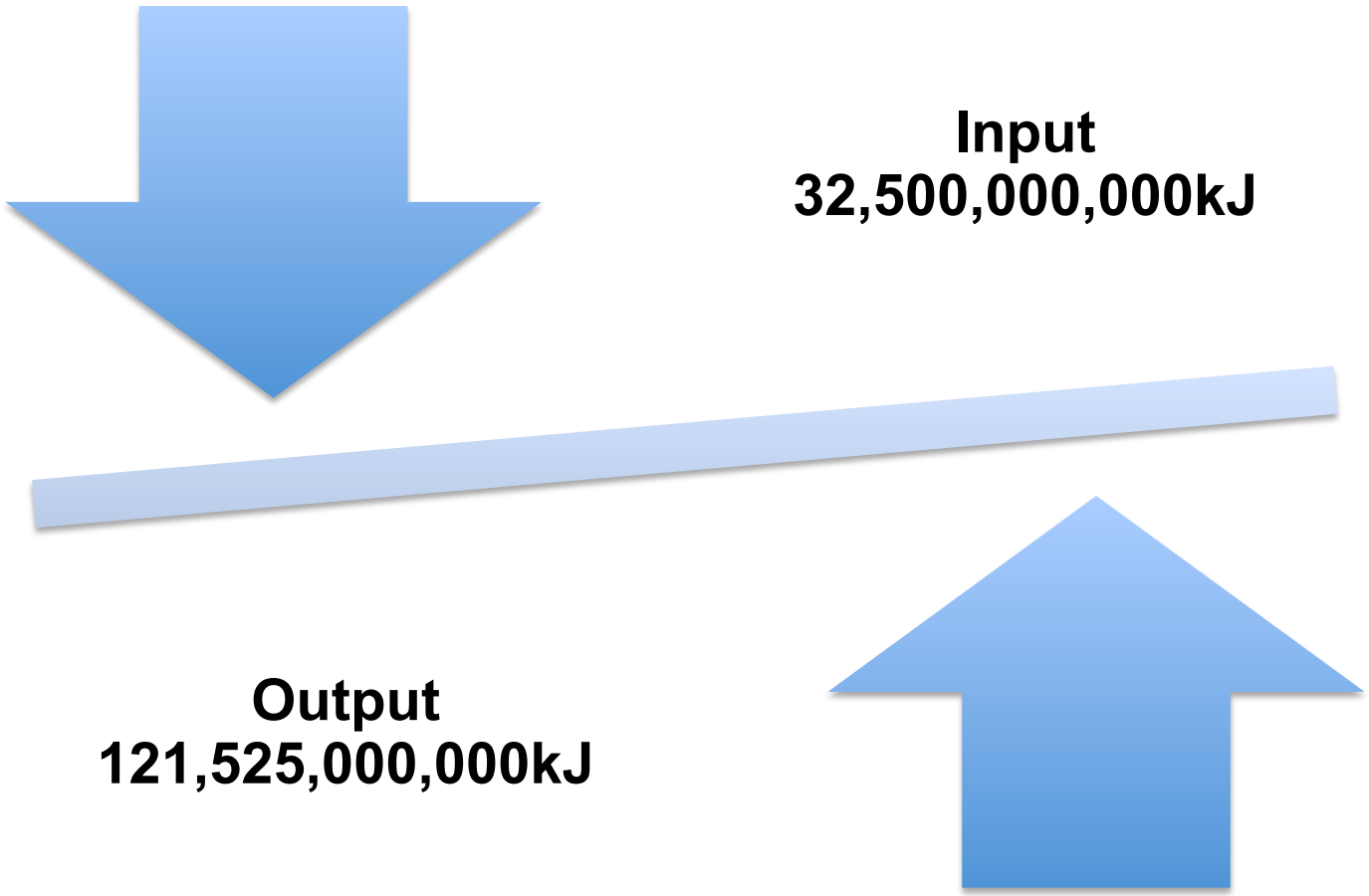
Input

- 350 tonnes at -20°C
- 125 tonnes at 0°C

Output

- 400 tonnes at 3°C
- 75 tonnes at 12°C

Heat energy in product



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Question

Why are refrigeration systems required if the food has to gain heat?

“Cost 600,000 euro per year”