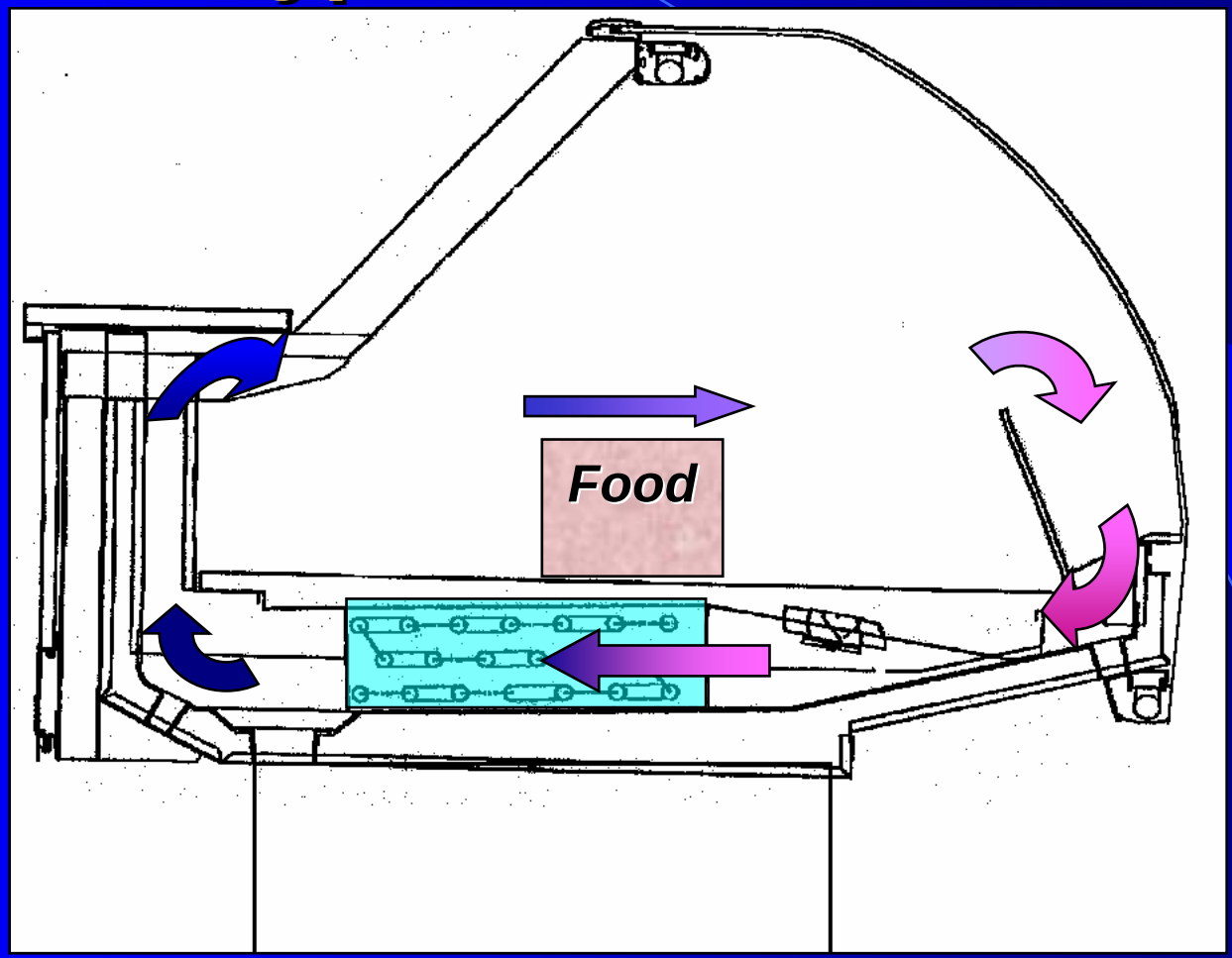
Case Study:
The Serve-over Chilled Cabinet

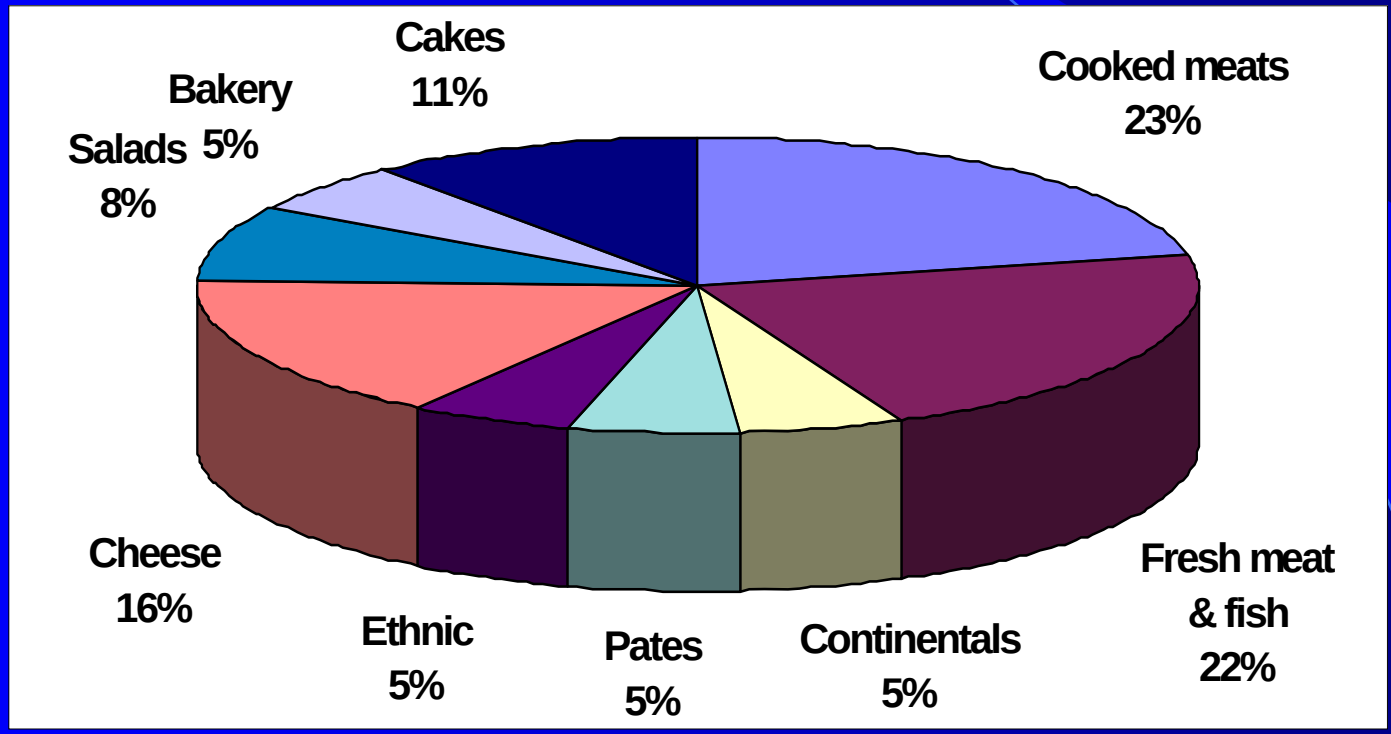
What Happens
Investigation
Potential Improvements

CARR LSBU 2007

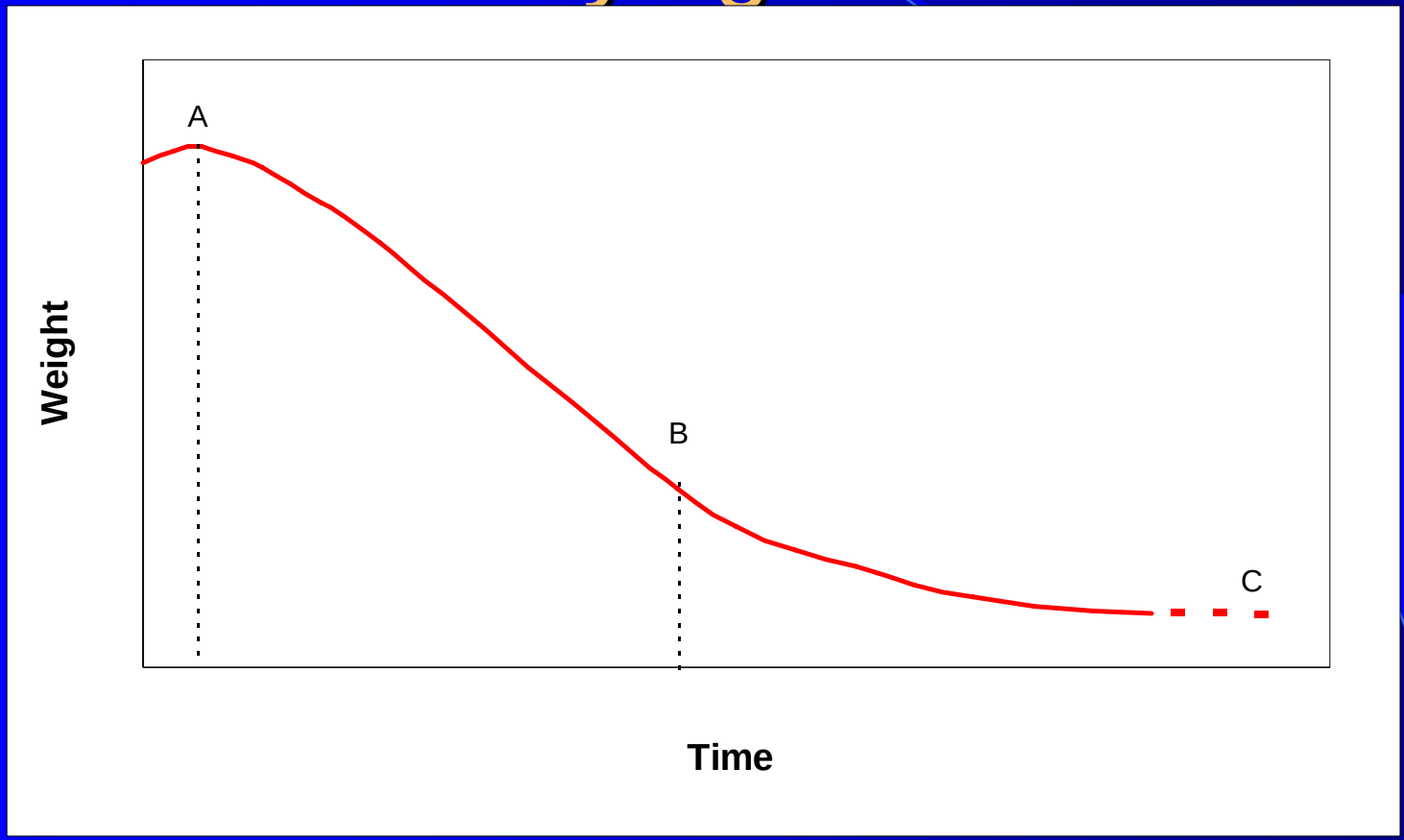
What Happens:1
The Typical Delicatessen



What Happens:2
Food Retailed from the Delicatessen



What Happens:3
The Drying of Food



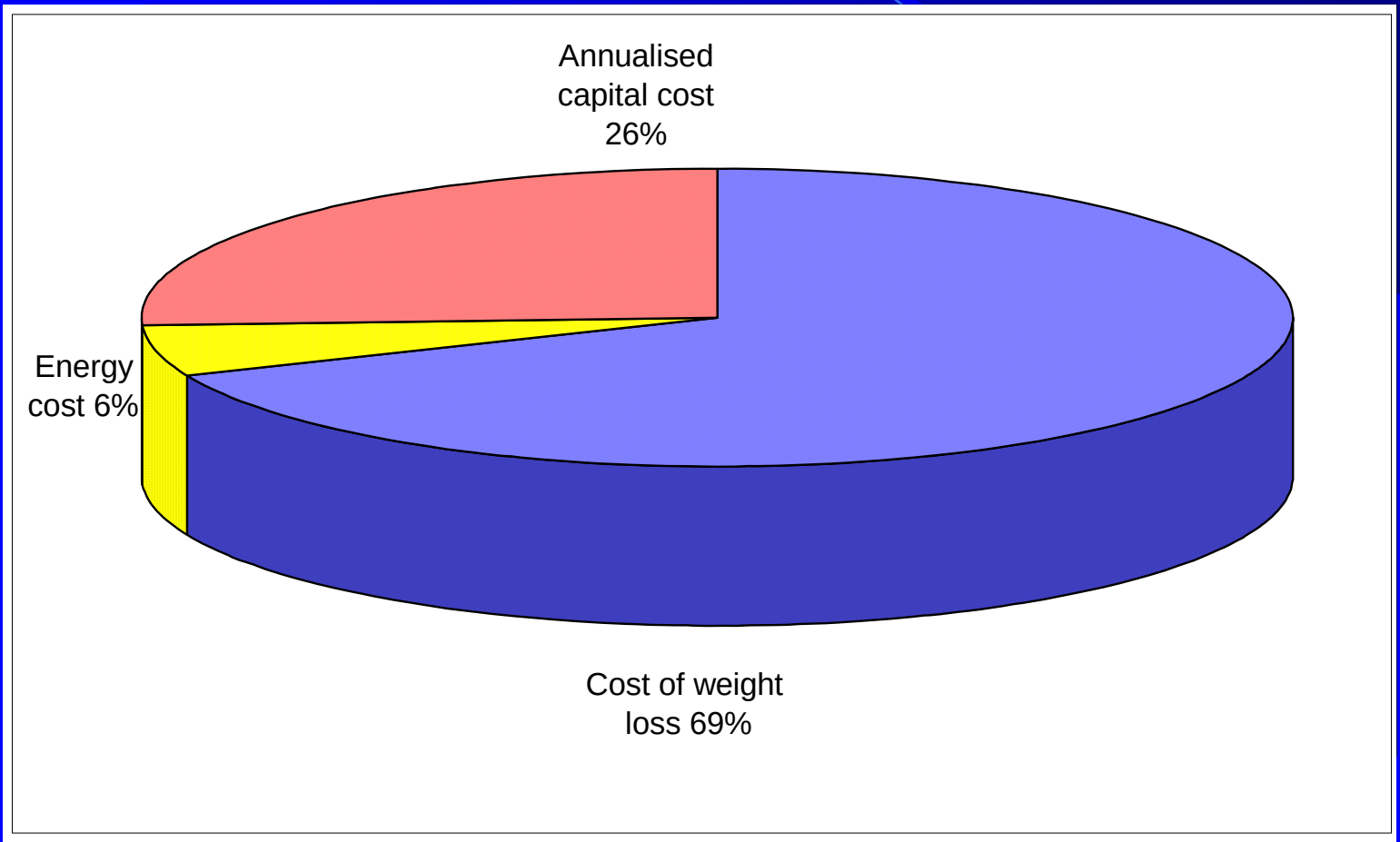
What Happens:4
Why Drying - Dalton's Law

$$Weight\ loss = Area \,.\, K \,.\, (P_{sfood} - P_{air})$$

$$K \sim Velocity$$

$$(P_{sfood} - P_{air}) = Vapour\ pressure\ difference$$

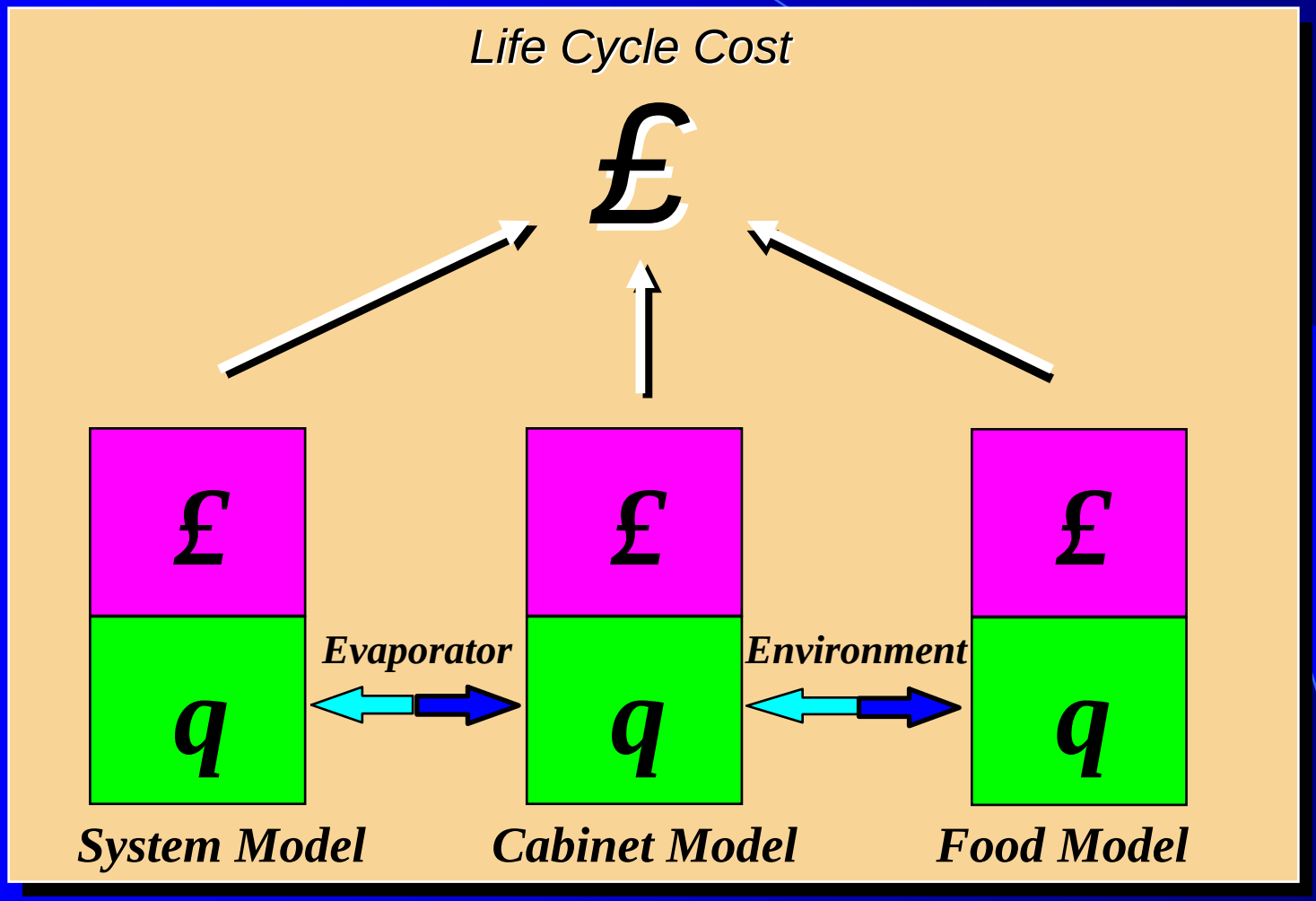
What Happens:5
Economic Consequences



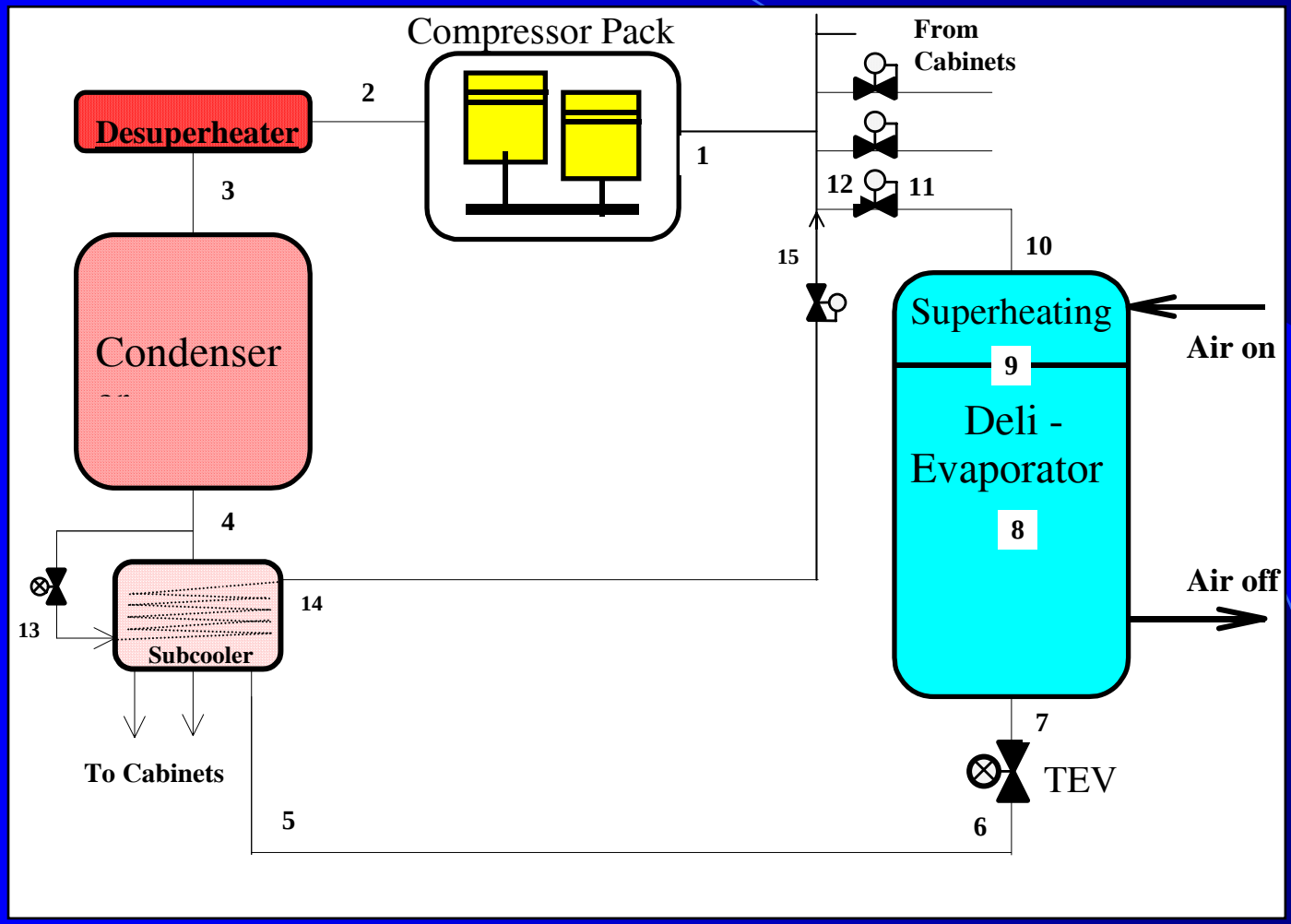
Investigation

using
1. A computer Model
2. Test Validation

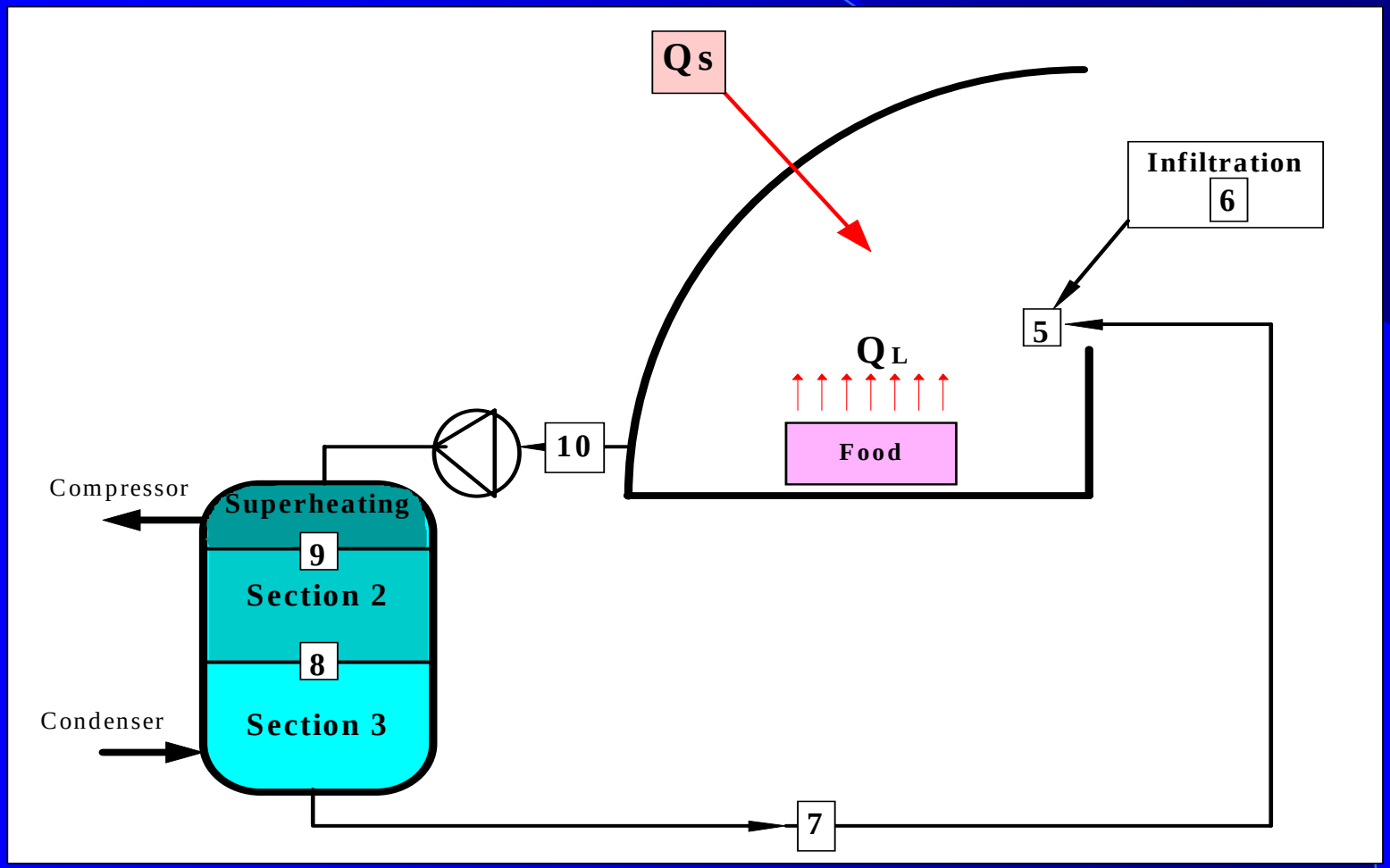
The Thermo - Economic Model



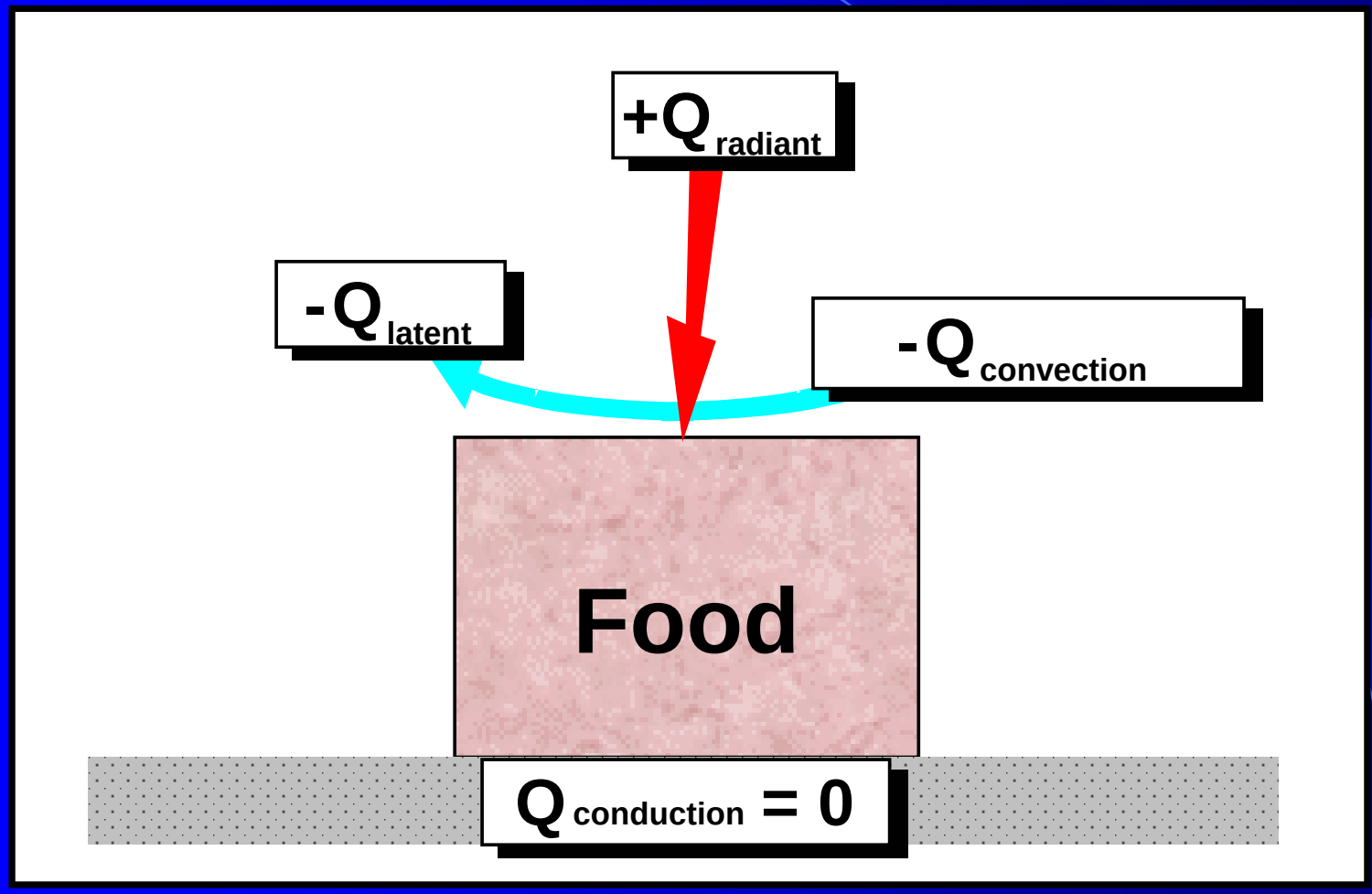
The Refrigeration System Model



The Cabinet Model



The Food Model



Design Variables Examined

- Over 50 variables analysed, from
  - Cabinet envelope
  - Fan and distribution system
  - Evaporator design and application
  - Controls and defrost
  - Conceptual changes
- Over 25 variables gave at least 1% saving
- Most require minimal capital cost

Examples of Variable Optimisation

Influence of cabinet insulation

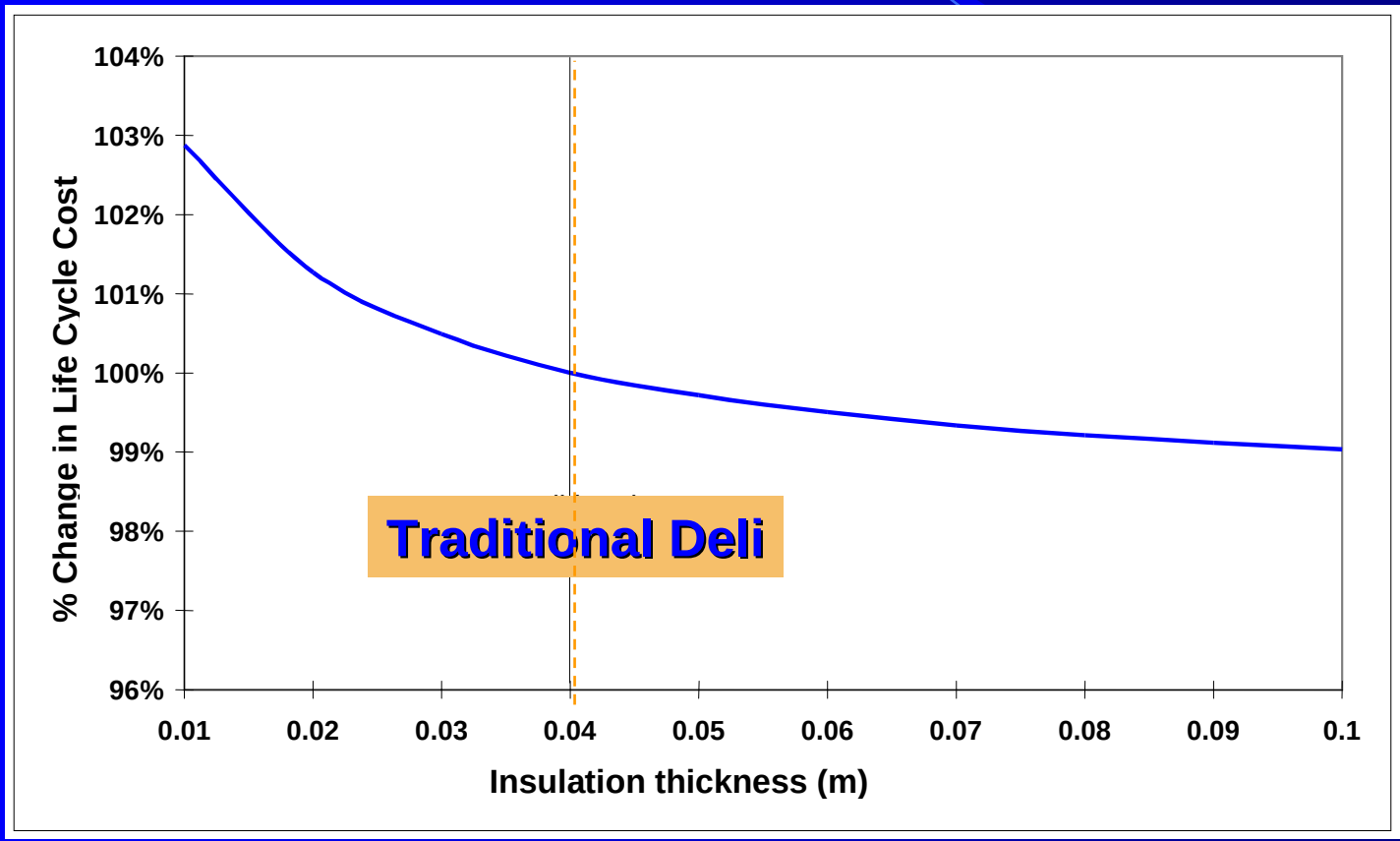
Influence of evaporator height

Influence of thermal radiation

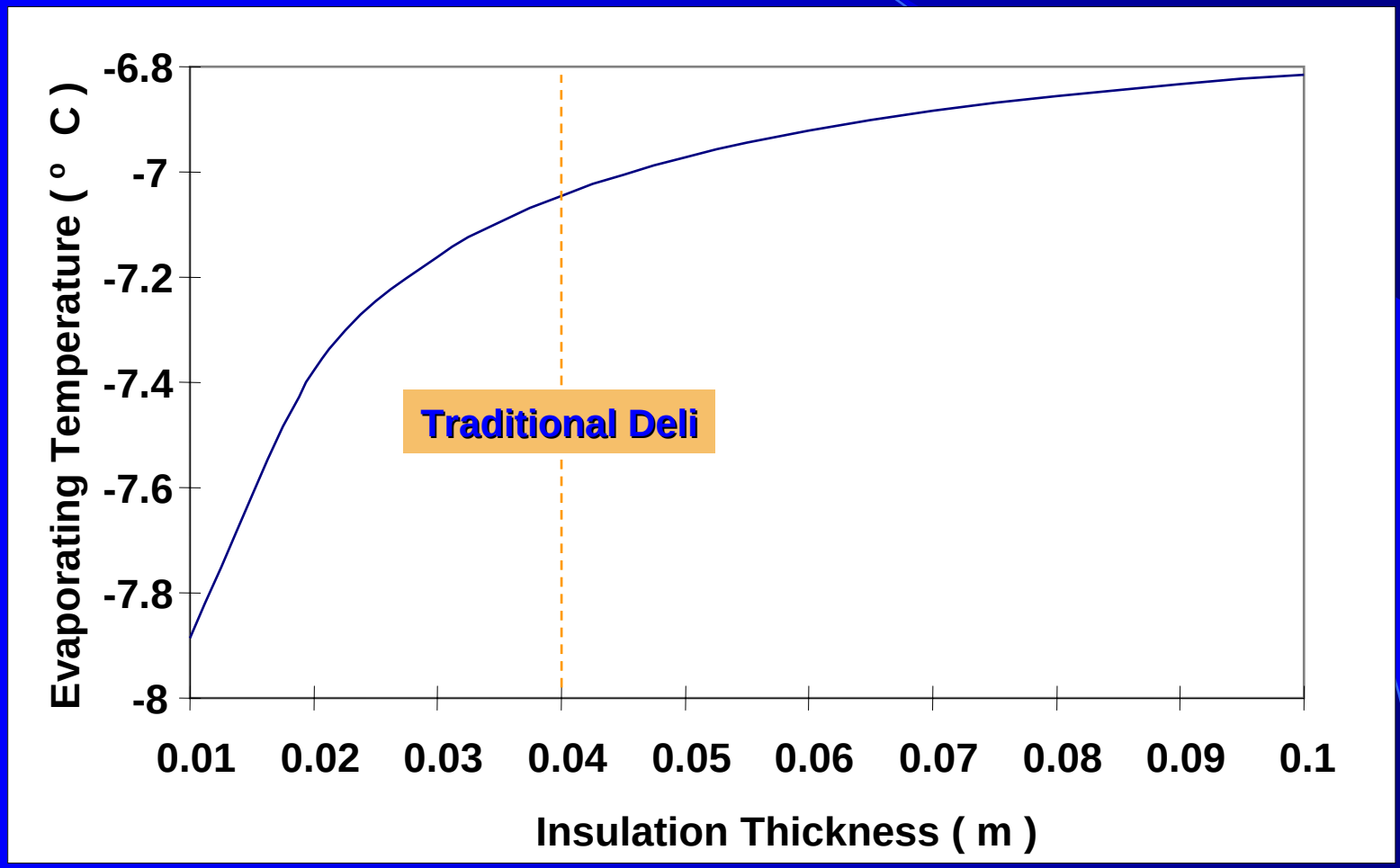
Influence of conduction

Influence of velocity

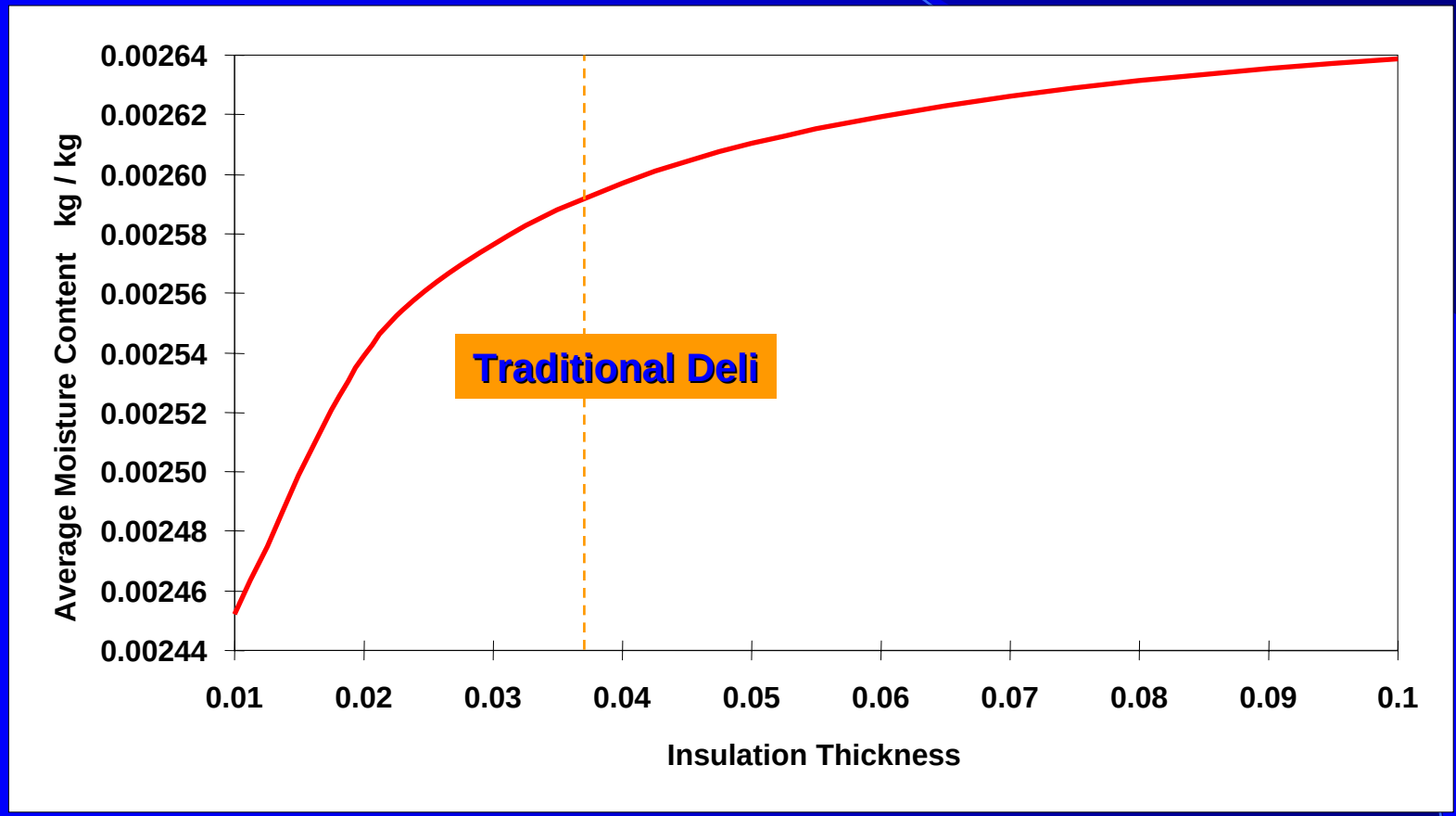
Potential Improvements: Reduced Cabinet Load - Improved Insulation



Potential Improvements
Reduced Cabinet Load - Improved Insulation



Potential Improvements
Reduced Cabinet Load - Improved Insulation



Effects of Improved Insulation

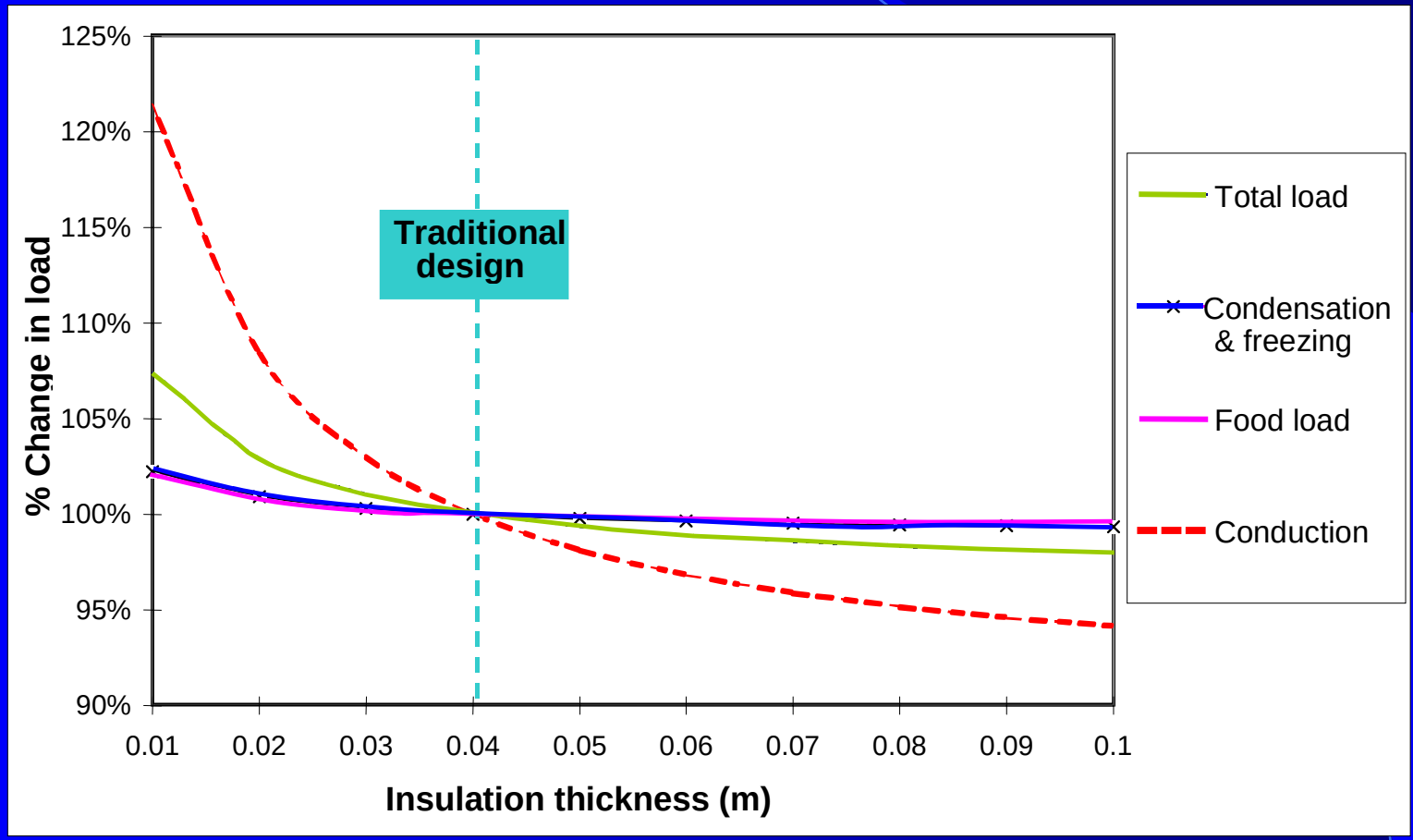
Higher evaporating temperature

Lower cabinet cooling load

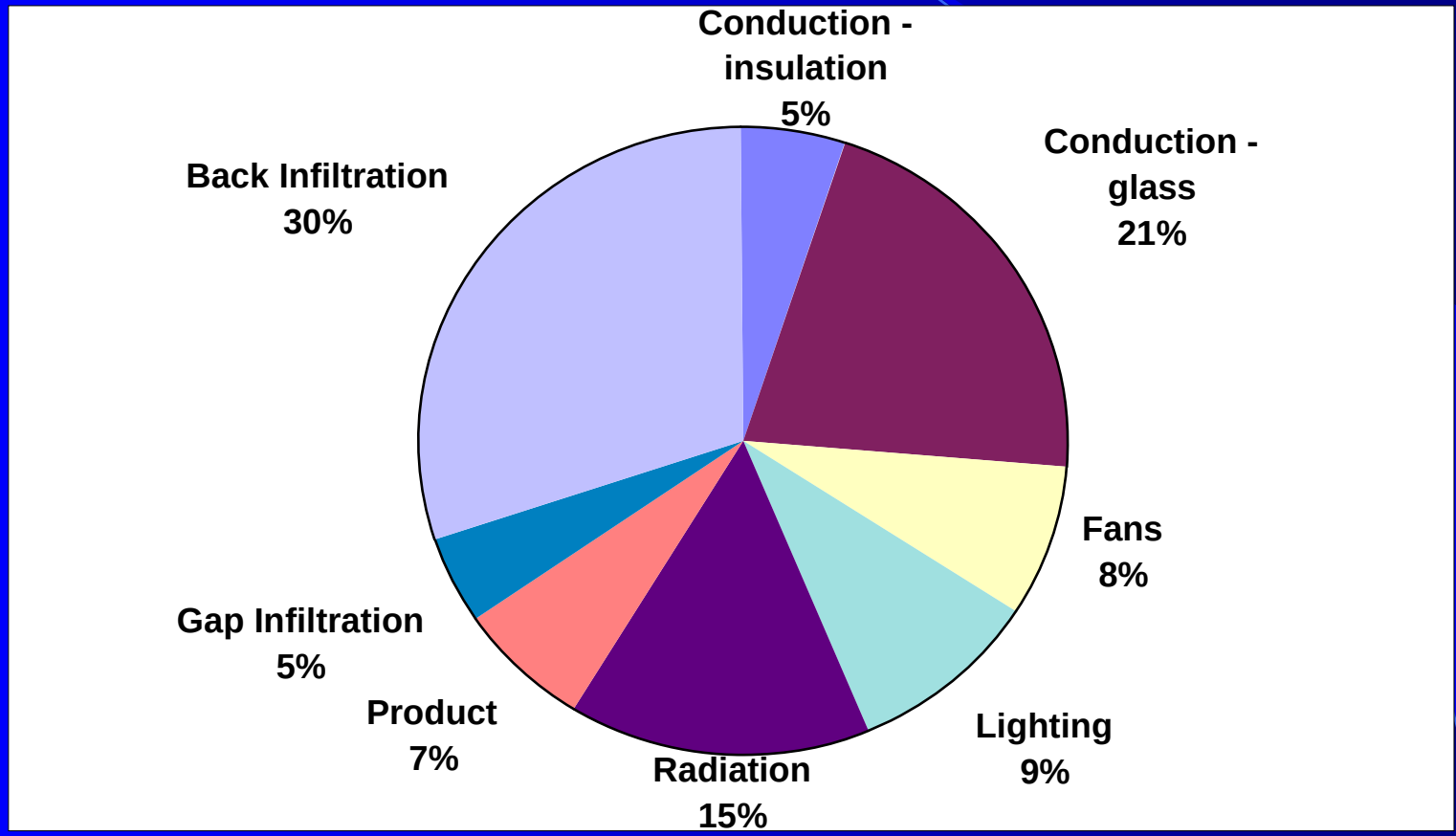
Higher moisture content & vapour pressure air

$$M = A.\ K.\ (P_{sfood} - P_{air})$$

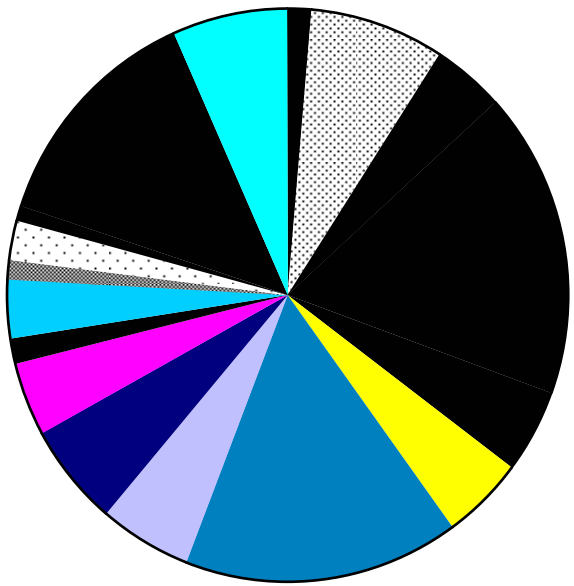
Reduced Cabinet Load - Improved Insulation



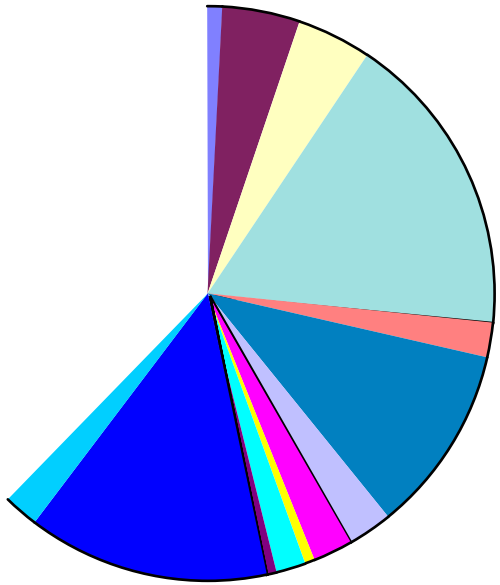
The Cabinet Cooling Loads



Potential Reductions in Cooling Load

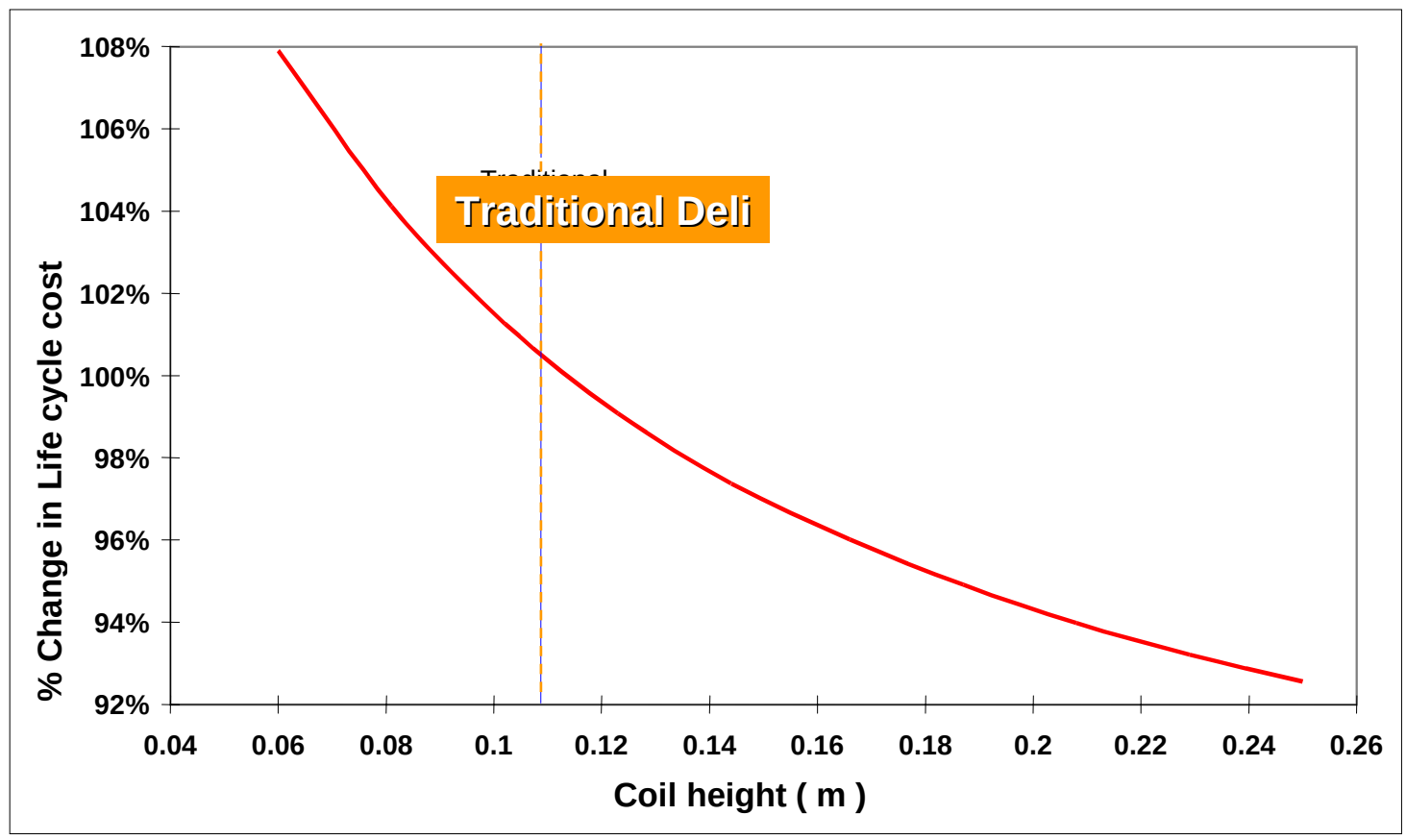


Before

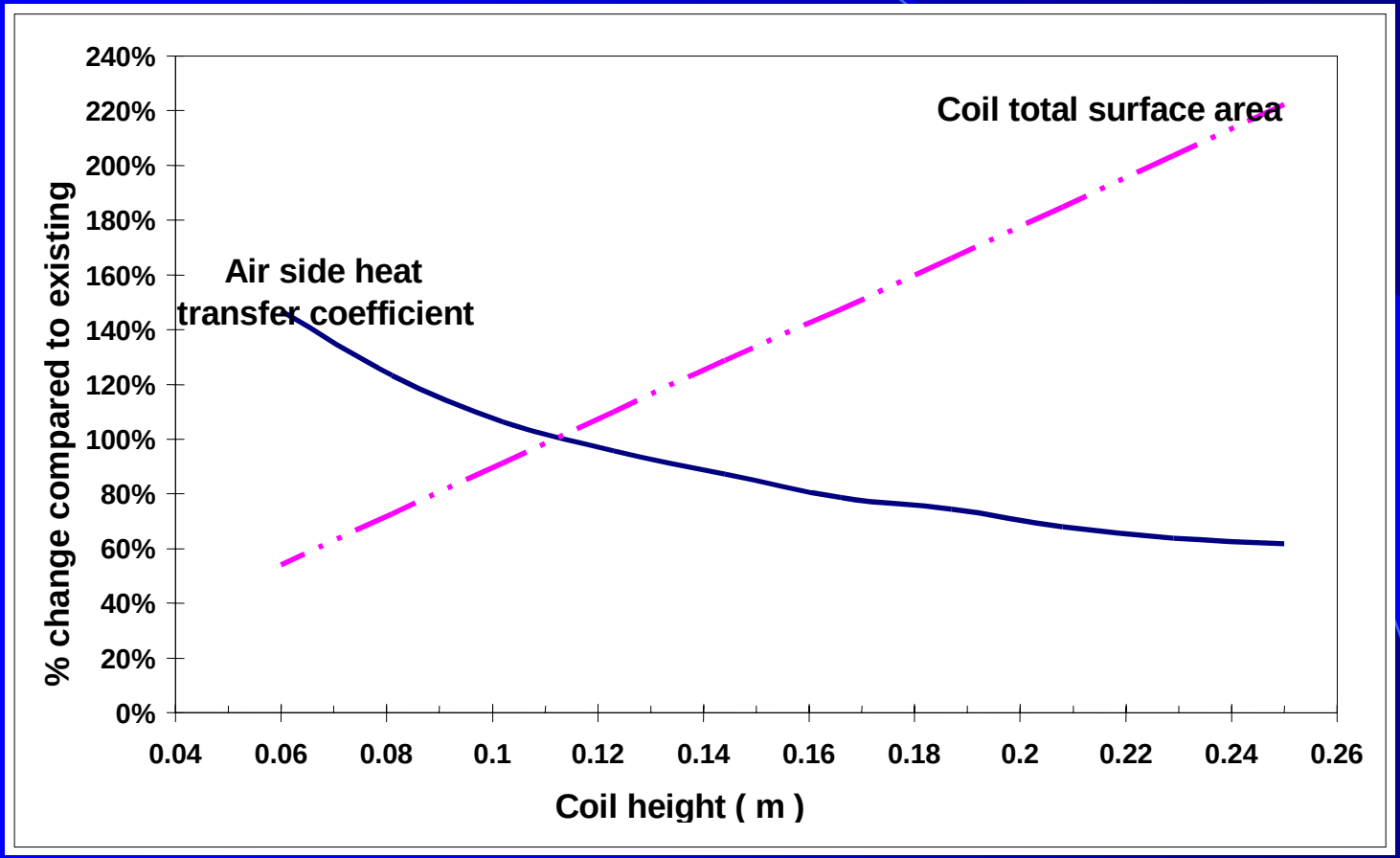


After

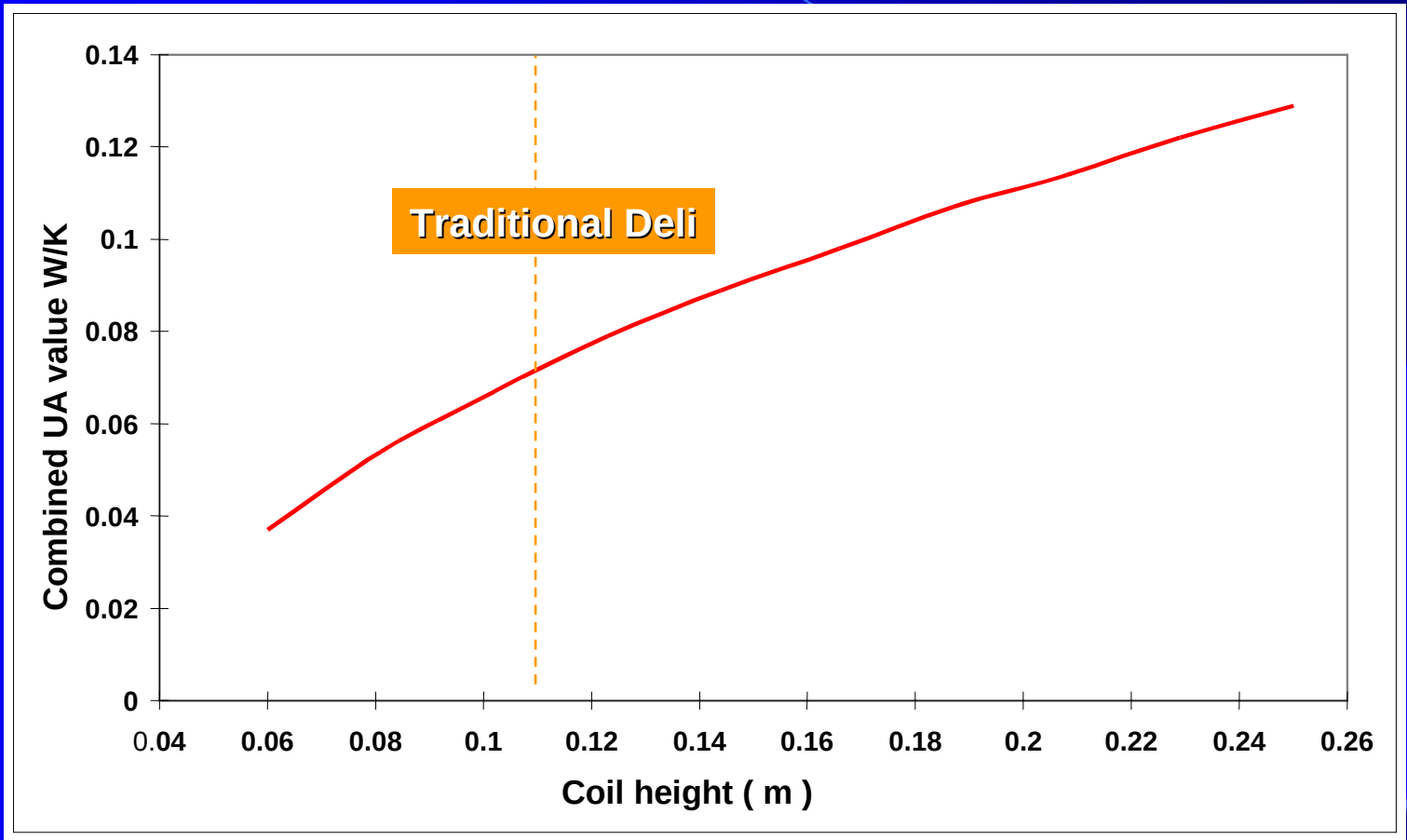
Influence of Coil Height



Influence of Coil Height



Influence of Coil Height



Effects of Coil Height

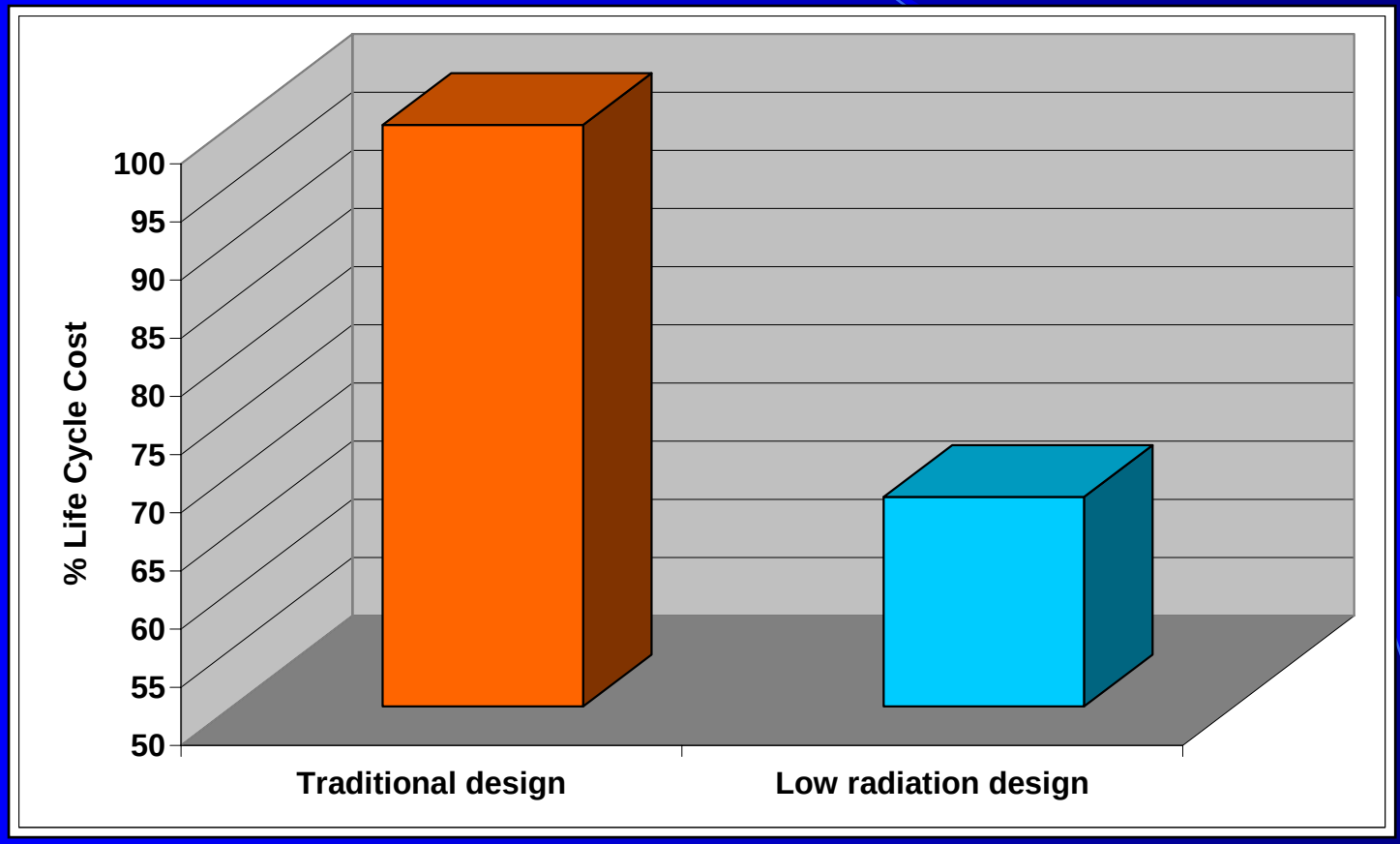
Higher heat transfer

Higher evaporating temperature

Higher moisture content & vapour pressure air

$$M = A.\,K.\,(P_{sfood} - P_{air})$$

Lower Radiation



Effects of Lower Radiation 1.

Lower cabinet cooling load

Higher evaporating temperature

Higher moisture content & vapour pressure air

$$M = A.\,K.\,(P_{sfood} - P_{air})$$

Effects of Lower Radiation 2.

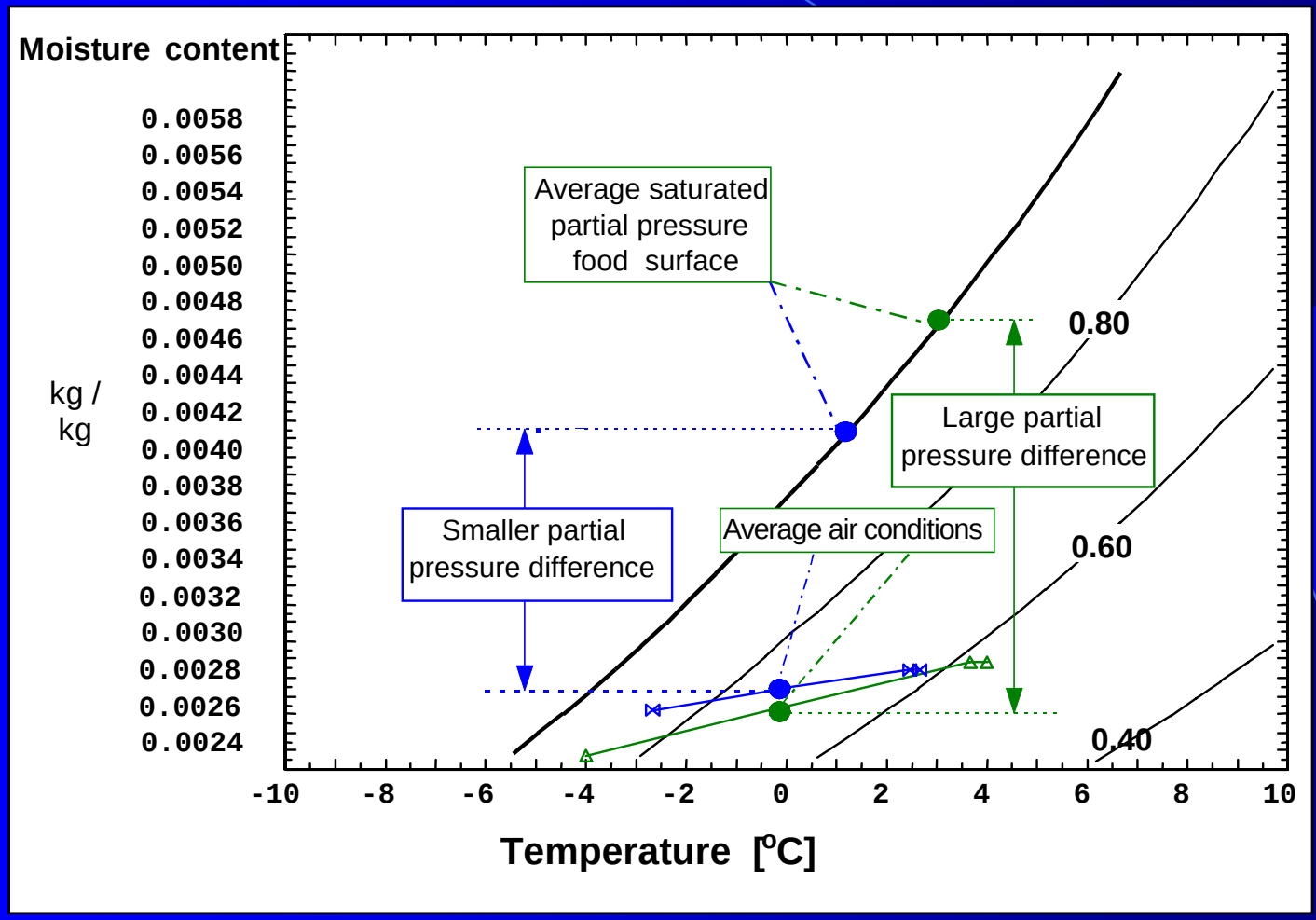
Lower radiation to food

Lower food surface temperature

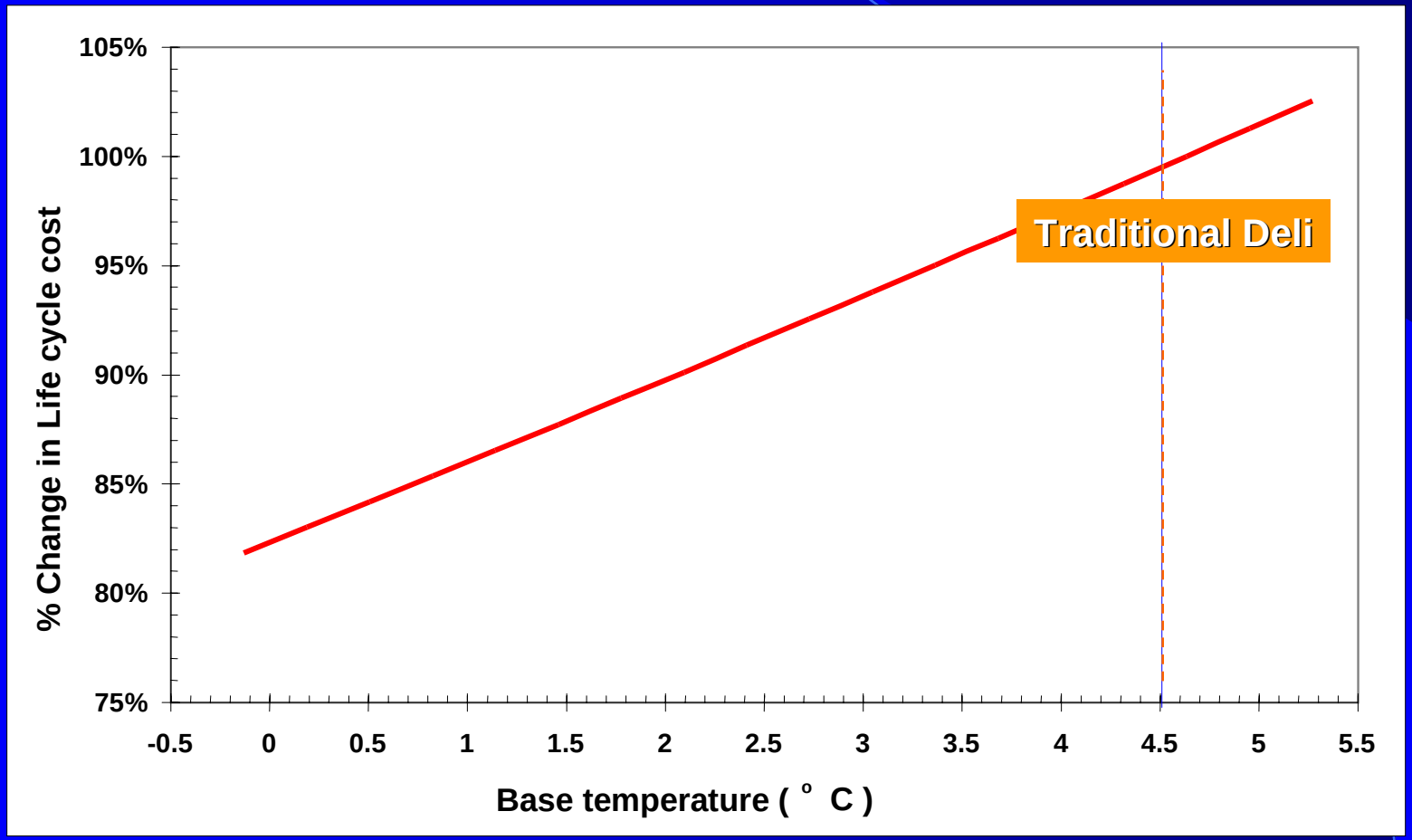
Lower vapour pressure at food surface

$$M = A.\,K.\,(P_{sfood} - P_{air})$$

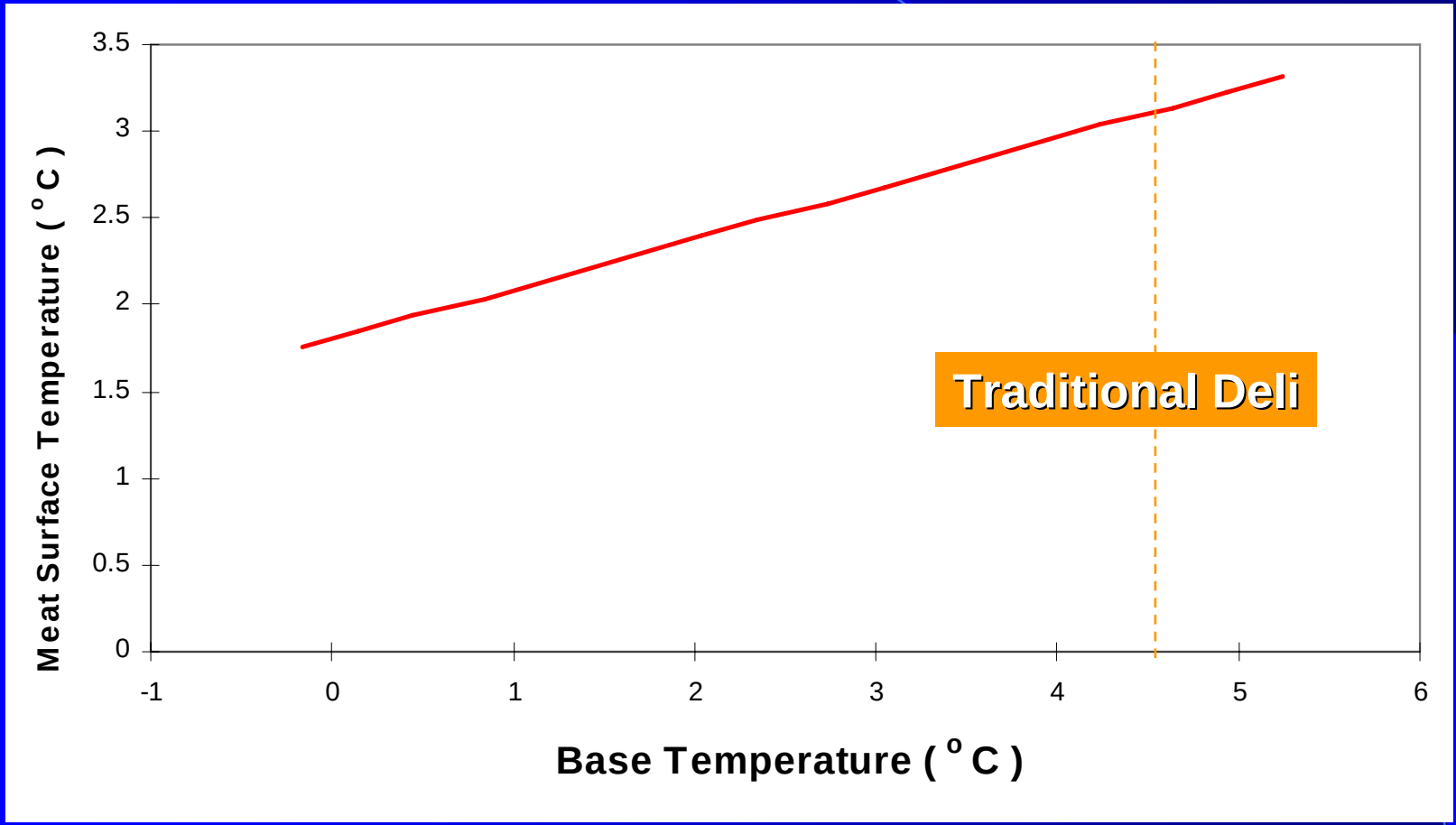
Effect of Lower Radiation



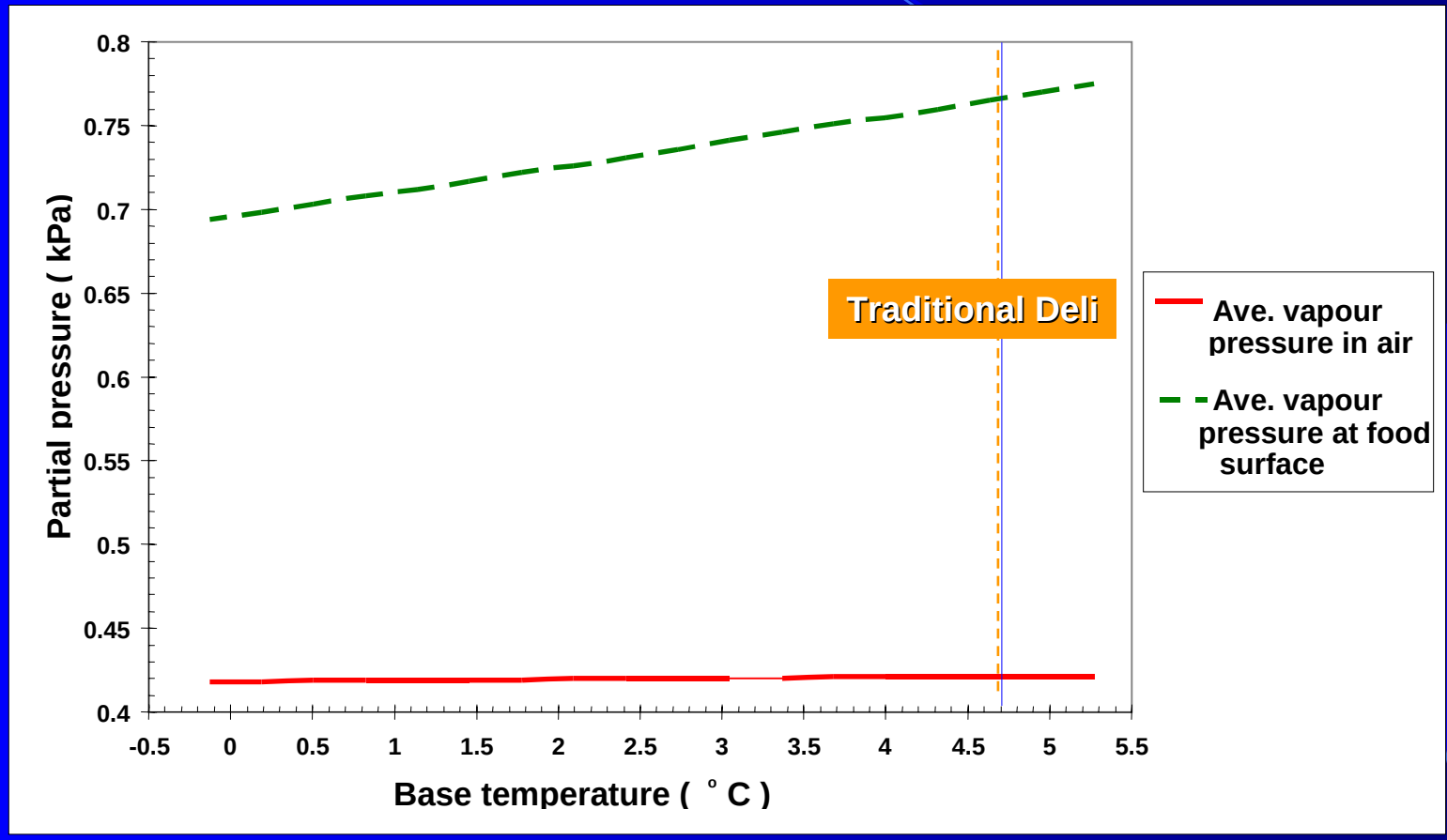
Increased Conduction



Increased Conduction



Increased Conduction



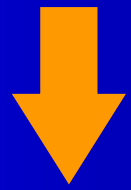
Effects of Increased Conduction

Increased cooling to food

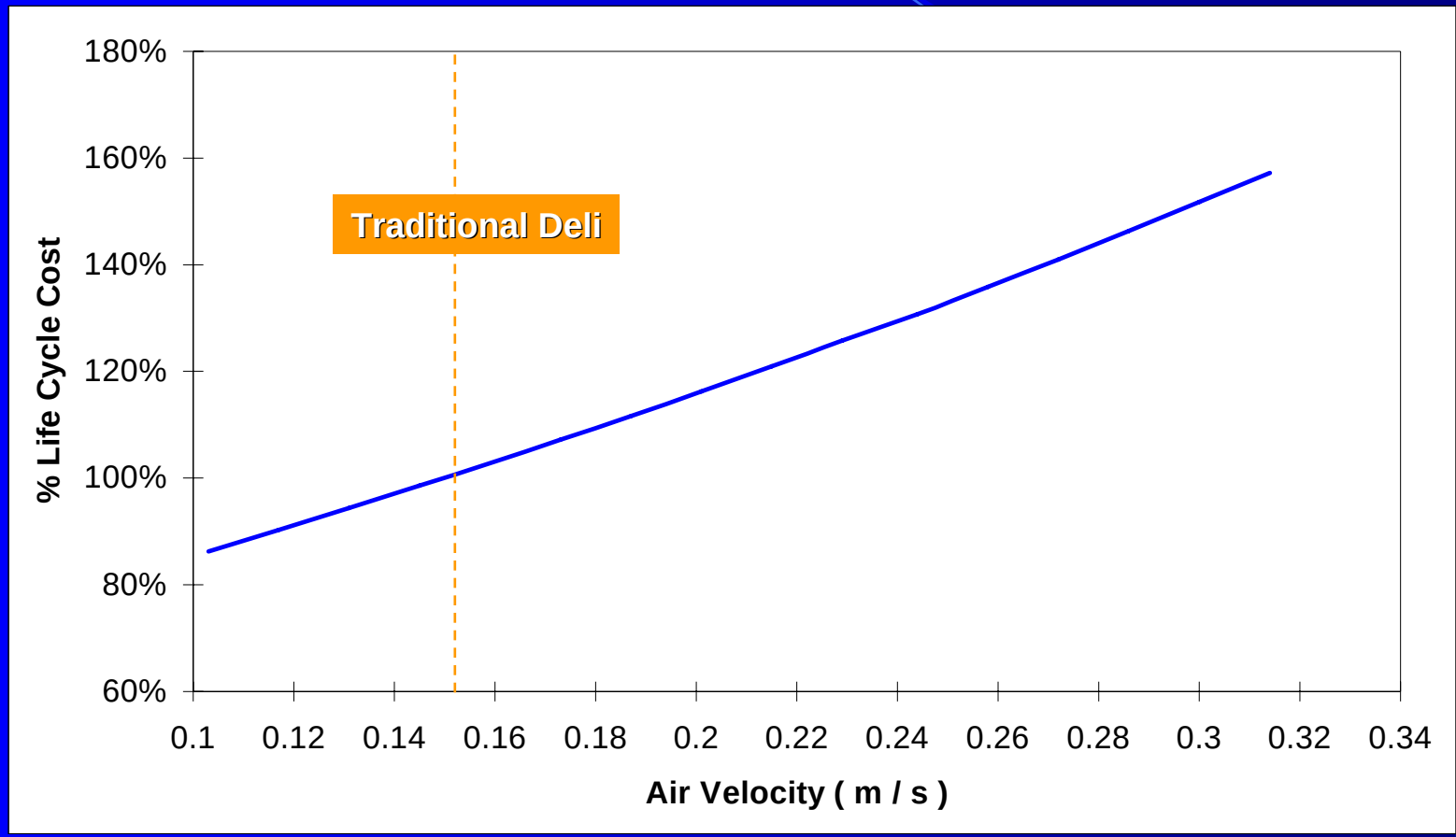
Lower food surface temperature

Lower vapour pressure at food surface

$$M = A.\,K.\,(P_{sfood} - P_{air})$$



The Influence of Air Velocity

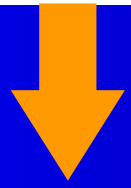


Effects of Lower Velocity 1.

Lower mass transfer coefficient

Lower weight loss

$$M = A.\ K.\ (P_{sfood} - P_{air})$$



Effects of Lower Velocity 2.

Lower heat transfer coefficient to food

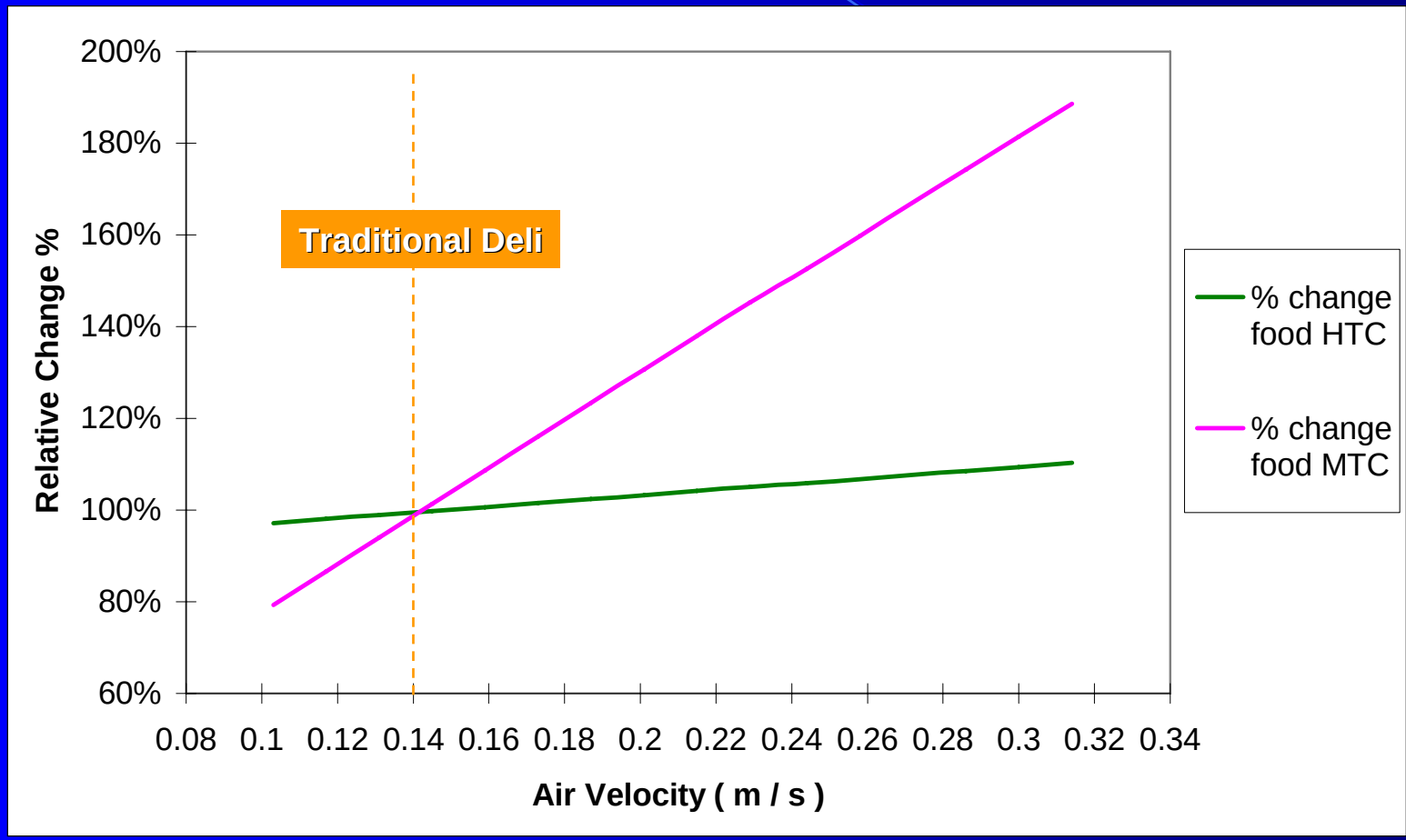
Higher food surface temperature

Higher vapour pressure at food surface

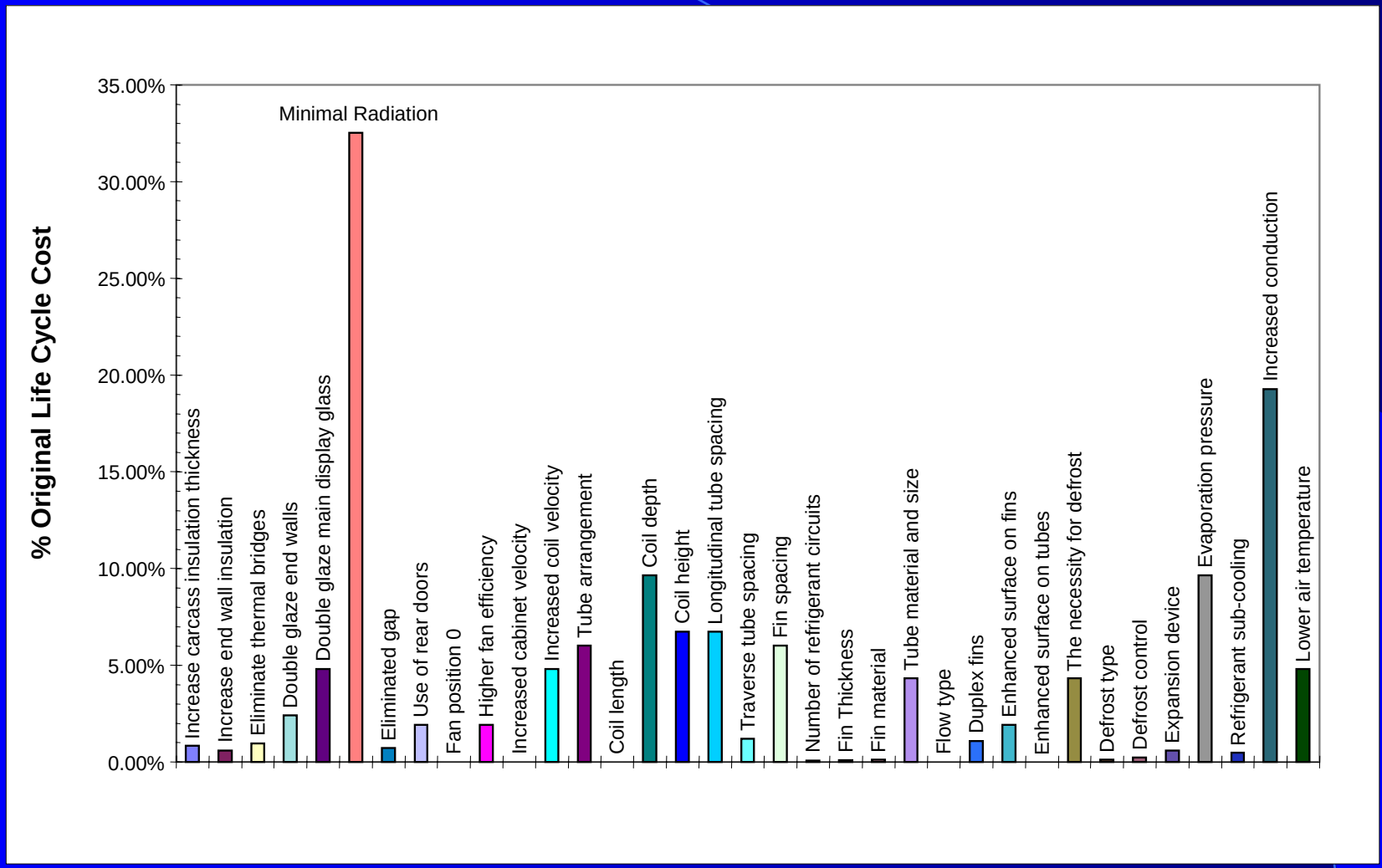
Higher weight loss

$$M = A.\,K.\,(P_{sfood} - P_{air})$$

The Influence of Air Velocity



Influence of Design Variables on Cost



Conclusions from the Investigation

Improved Optimum Environmental Conditions

Minimum air velocity <0.2 m/s

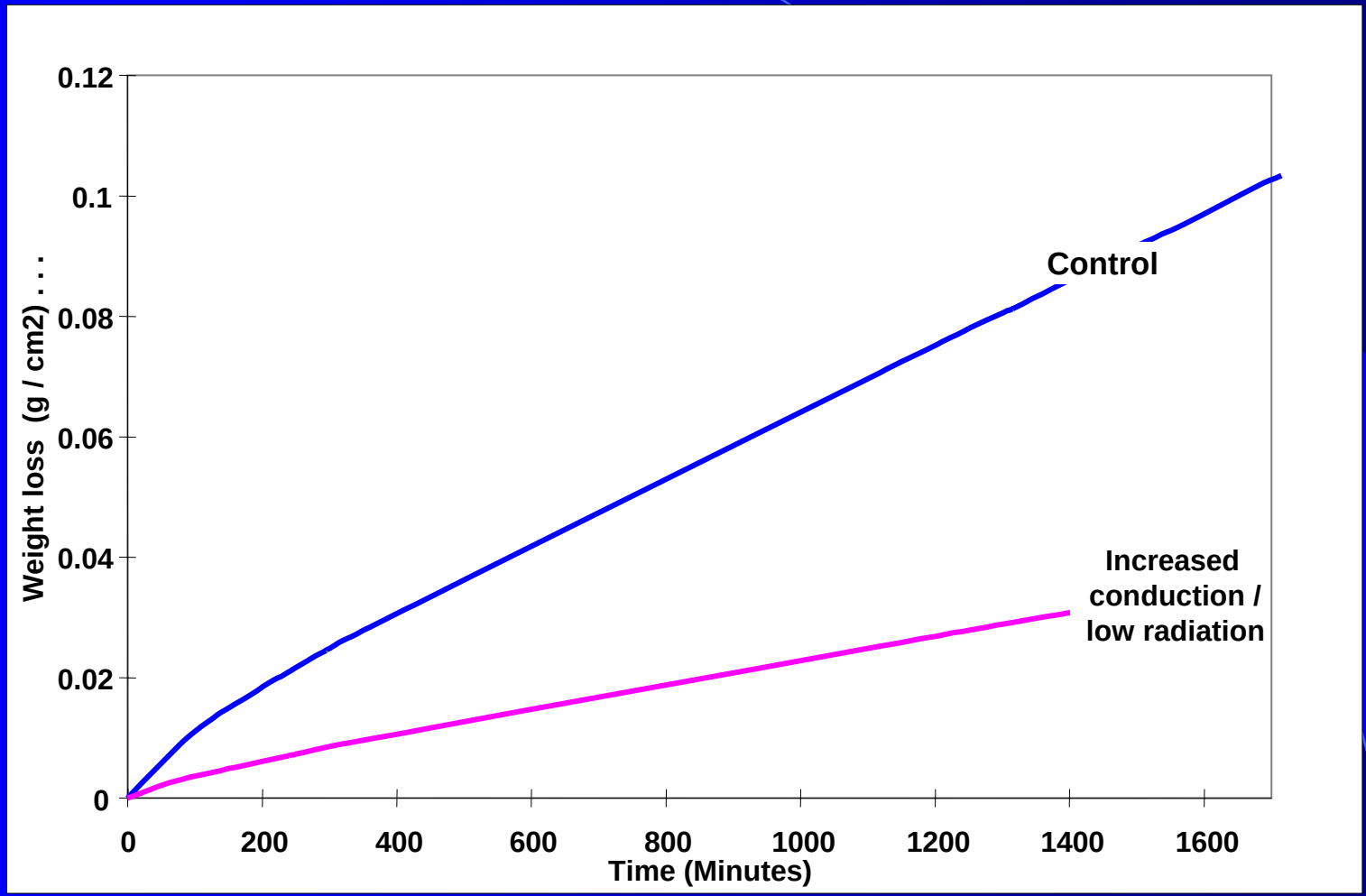
Minimum air temperature 0 to 2 ^{o}C

High Relative humidity 90% - 95%

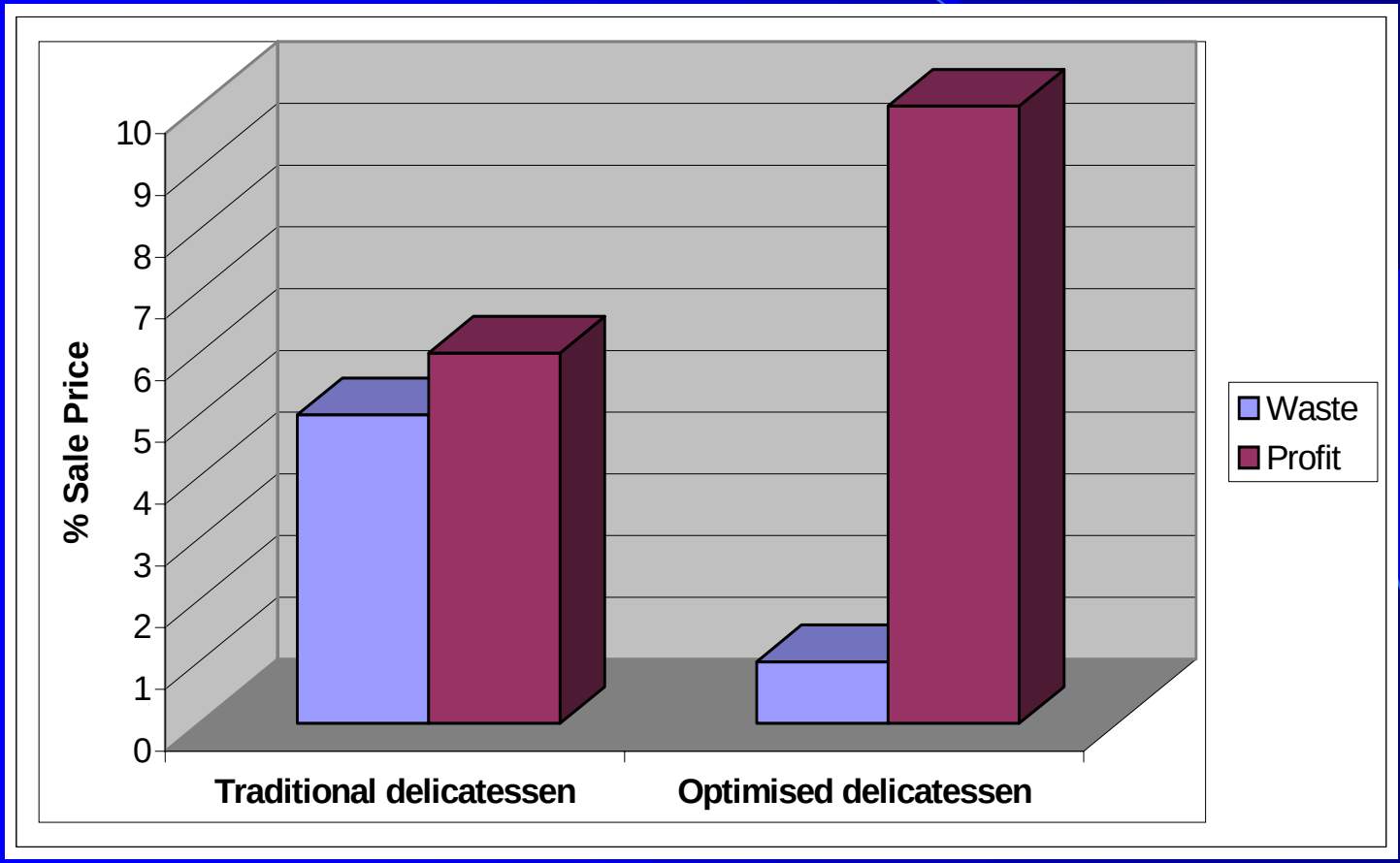
Minimum radiant heat

Low base temperature 0 to -2^{o}C

Prototype results



Increased Profit from Lower Weight Loss



Conclusions

Weight loss is costly in delicatessens

Large cost savings are achievable

Fundamental factors

Thermo-economics has wide application

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