

Viking Thermal Energy Storage

Energy Storage Comparison: PCM vs. Frozen Food Product

The following example illustrates the energy benefits of using Phase Change Material (PCM) for thermal storage as compared to using only the mass of frozen product.

- 84% of heat infiltration will be absorbed by the TES modules
- Refrigeration system will remove the heat from the TES modules 5 times faster than frozen product alone

Analysis for a typical 10,000 square foot frozen storage warehouse

	Thermal Energy Storage (TES) Cells	Frozen Product
Thermal Mass	350 Cell Modules	900 Pallet Positions
	18x44x4 in. module size; 1 module per 30sqft	42x48x48 in. pallet size; 90% occupied
	25 lbs PCM per cell module	1500 lbs product per pallet
	8,500 lbs total PCM	1,200,000 lbs total product
PCM is < 1% of the total thermal mass in the room		

Thermal Capacity	129 BTU/lb (Latent heat)	0.4 BTU/lb.°F (Specific heat)
PCM has 325 times the thermal capacity per lb.°F		

Thermal Energy Storage (of 1°F temp delta)	1,100,000 BTU	480,000 BTU
PCM can store 2.3 times more thermal energy		

Thermal Resistance (Surface)	0.58 hr-sqft-°F/BTU (see figure A below)	5.36 hr-sqft-°F/BTU (see figure B below)
Thermal Energy Cells have 1/10 th the R-value		

Figure A – The total R Value for the Thermal Energy Storage Cell is only R1, the convective boundary layer resistance.

Figure B – The total R Value for typical frozen food product, where R1, R3, & R4 are convective boundary layer resistances, and R2 is the resistance of corrugated cardboard.

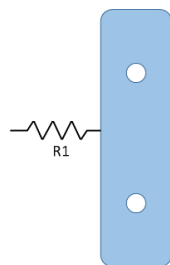


Figure A – TES Cell

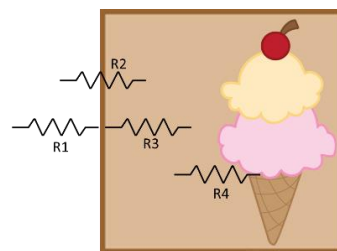


Figure B – Frozen Food in Packaging

Surface Area	7,300 sqft	66,000 sqft
TES modules have 15 times the surface area per lb		

Heat transfer rate (Q̇)	63,000 BTU / hr	12,000 BTU / hr
TES modules are 5 times more heat absorbent		

Equipment Runtime Time required to change the total thermal mass by 1°F with an evaporator outlet ΔT of 10°F	Combined Product and PCM 8.7 hrs	Product Thermal Mass Only 39 hrs
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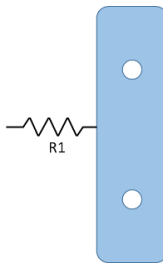
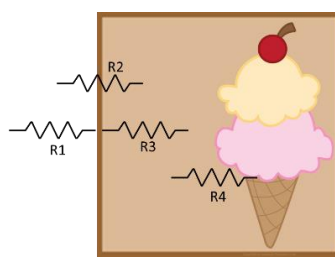
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Analysis for a typical 930 square meter frozen storage warehouse

	Thermal Energy Storage (TES) Cells	Frozen Product
Thermal Mass	350 Cell Modules 46x112x10 cm module size; 1 module per 2.8 m ² 11 kg PCM per cell module 3,850 kg total PCM PCM is < 1% of the total thermal mass in the room	900 Pallet Positions 107x122x122 cm pallet size; 90% occupied 680 kg product per pallet 550,000 kg total product
Thermal Capacity	300 kJ/kg (Latent heat) PCM has 325 times the thermal capacity per kg per 0.5°C	1.674 kJ/kg/K (Specific heat)
Thermal Energy Storage (of 0.5°C temp delta)	1,155,000 kJ PCM can store 2.3 times more thermal energy	506,380 kJ
Thermal Resistance (Surface)	0.10 m ² -K/W (see figure A below) Thermal Energy Cells have 1/10th the R-value	0.944 m ² -K/W (see figure B below)
<div> <div> <p>Figure A – The total R Value for the Thermal Energy Storage Cell is only R1, the convective boundary layer resistance.</p> <p>Figure B – The total R Value for typical frozen food product, where R1, R3, & R4 are convective boundary layer resistances, and R2 is the resistance of corrugated cardboard.</p> </div> <div>  <p>Figure A – TES Cell</p> </div> <div>  <p>Figure B – Frozen Food in Packaging</p> </div> </div>		
Surface Area	678 m ² TES modules have 15 times the surface area per kg	6,132 m ²
Heat transfer rate (Q̇)	18.5 kW TES modules are 5 times more heat absorbent	3.5 kW
Equipment Runtime Time required to change the total thermal mass by 0.5°C with an evaporator outlet ΔT of 5.5°C	Combined Product and PCM 8.7 hrs	Product Thermal Mass Only 39 hrs