Production, Properties, and Applications of Packaged Phase-Change Materials

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Topics to Discuss

- Localized versus distributed PCM
- Reasons for Using PCM
- Preliminary Evaluation
- Production
- Application
- Demonstration of Effect

Localized versus Distributed

Distributed

1. Can be added to thermal insulation
2. Readily installed
3. Location affects efficiency

Localized

1. Customized for optimum efficiency
2. Independent of insulation type
3. Incorporate more than one phase-change temperature

PCM PANEL – can contain organic or inorganic phase-change compound

A Heat-Flow Meter Apparatus can Be Used to Show Phase-Change Effect (an example)

Test assembly is initially isothermal at a temperature below the phase change temperature.

One boundary is ramped quickly to a temperature above the phase change temperature.

The heat fluxes in and out of the test specimen are monitored with time.

A comparison of heat flux data for specimens with and without PCM demonstrates performance.

Example of a Test Sequence

Test assembly (R-PCM-R) is initially near-isothermal with
bottom plate 69.8 °F top plate 70 °F

Bottom plate temperature is changed rapidly to a temperature above the phase change temperature.
bottom plate 69.8 °F to 120.2 °F

Record positive flux (into specimen) on the hot side and negative flux (out of specimen) on the cold side. (CHARGING)

Bottom plate temperature is returned to initial temperature after steady state is achieved and boundary fluxes are recorded. (DISCHARGING)

This procedure can be carried out for specimens with and without PCM.

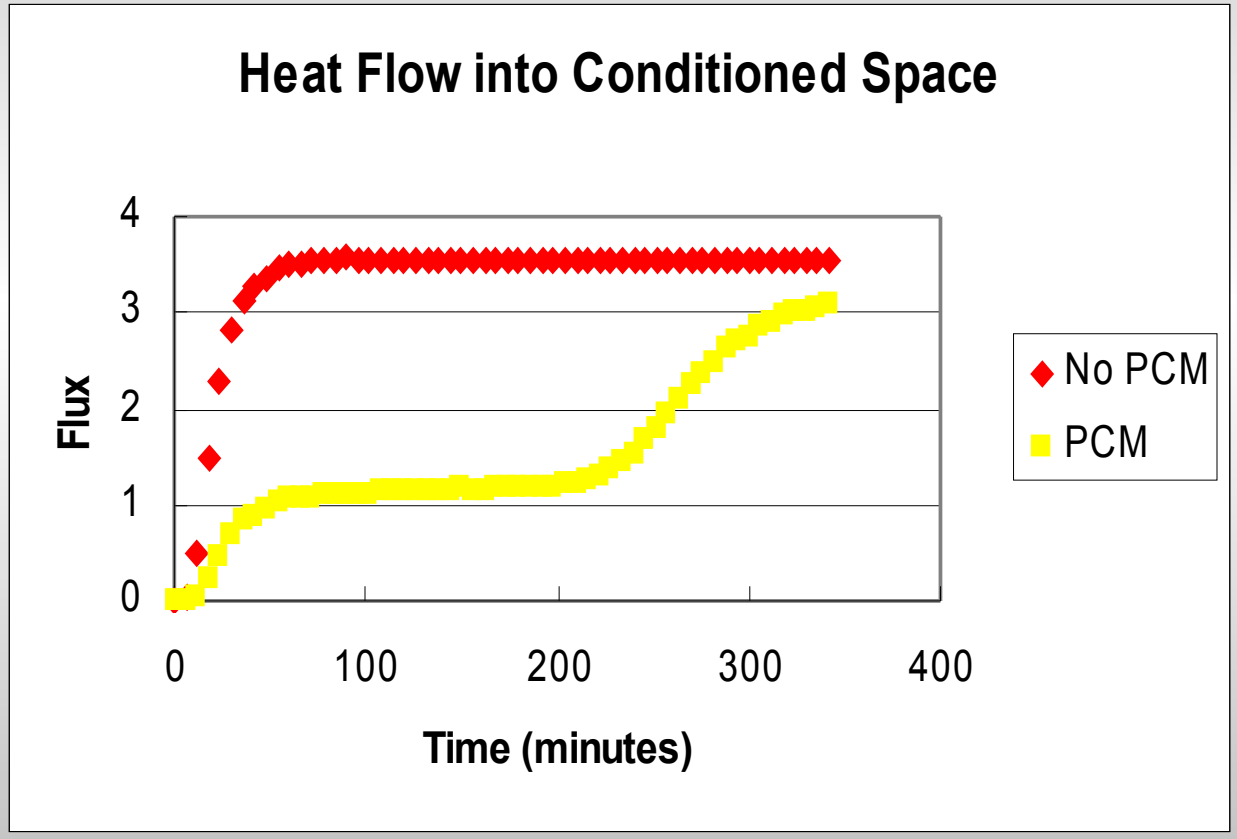
TEST ASSEMBLY

- Top Plate – cold (remains constant)
- Insulation above PCM R = 9 $ft^2 \cdot h \cdot °F/Btu$
- Layer of PCM
- Insulation below PCM R=5 $ft^2 \cdot h \cdot °F/Btu$
- Bottom Plate – cold ramps to hot (rapid)

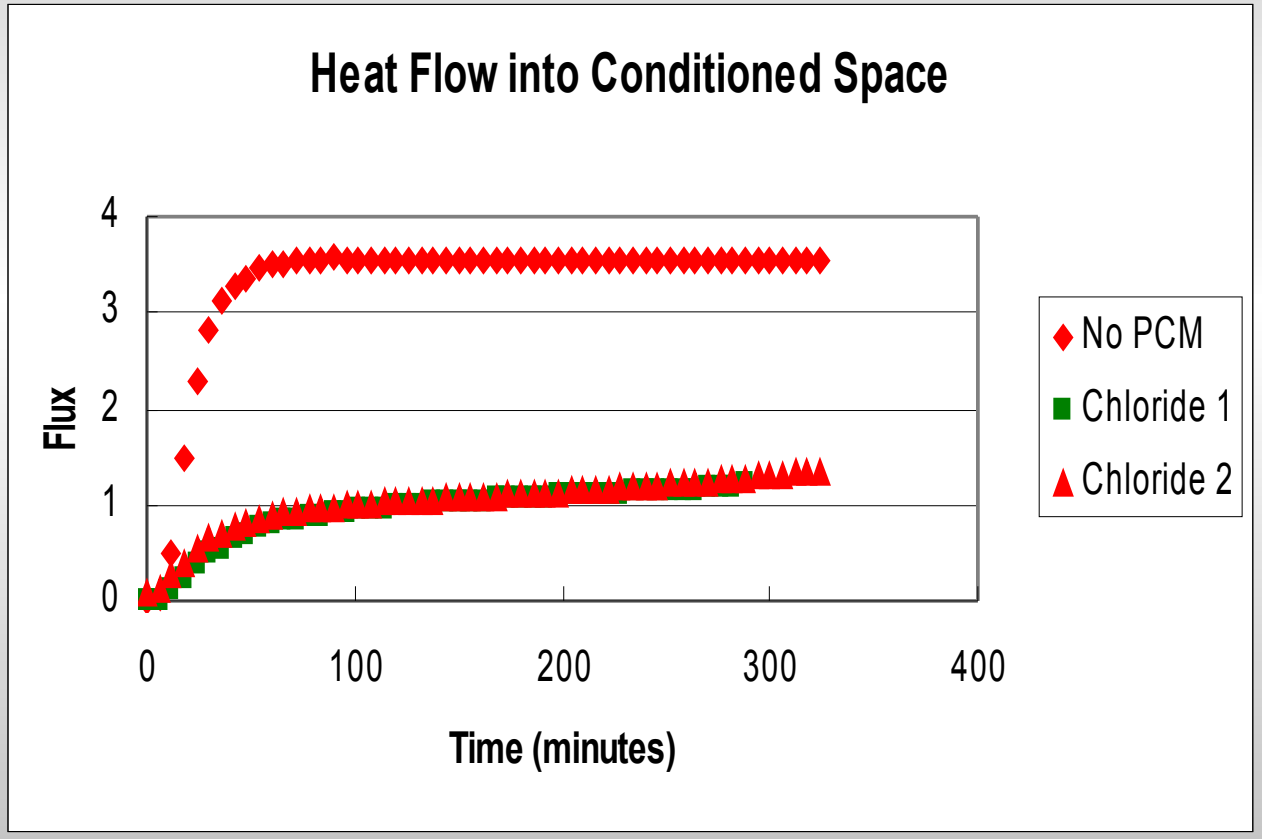
  steady state

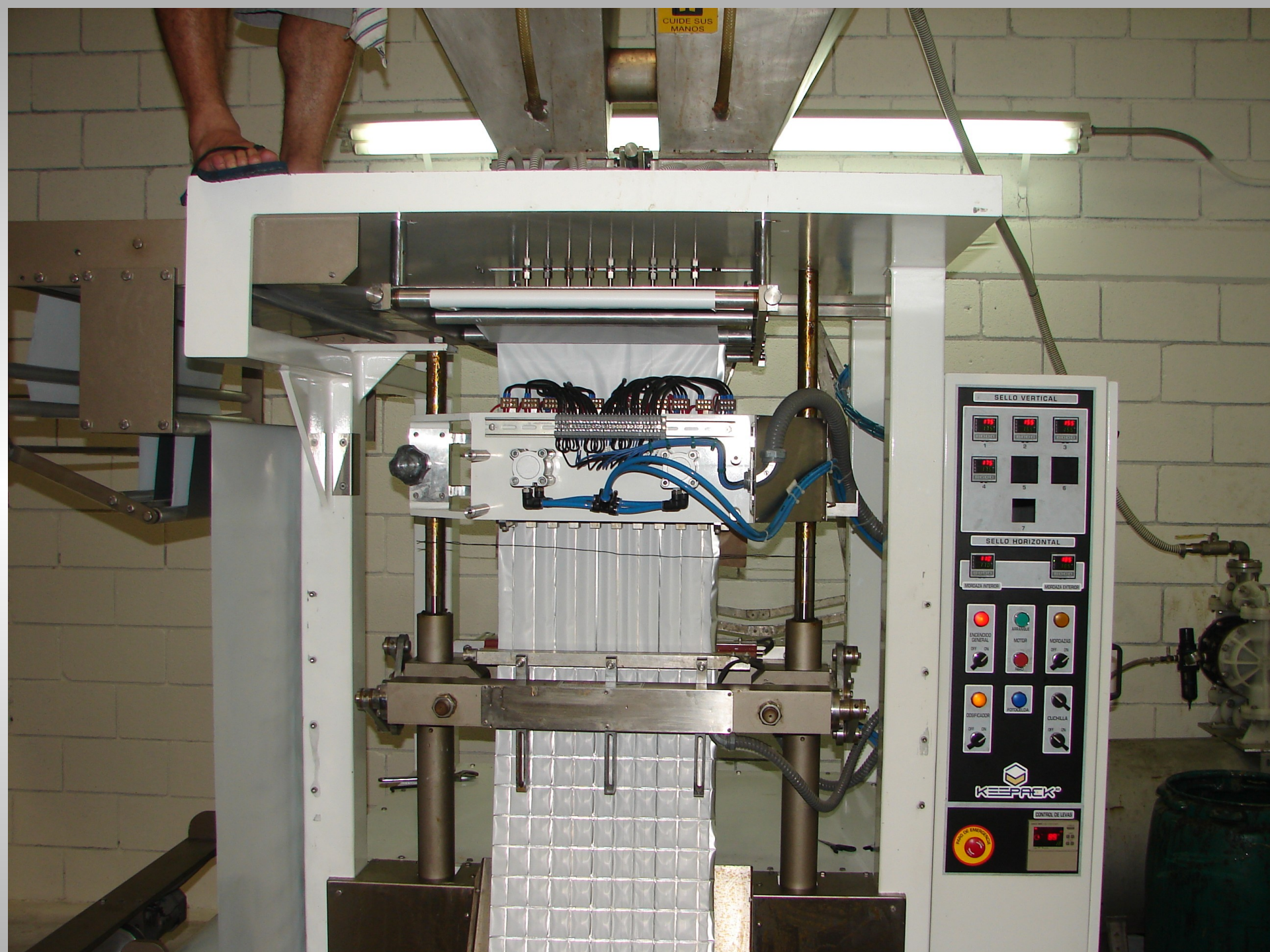
  hot ramps to cold (rapid)

A COMPARISON OF FLUX DATA FOR ASSEMBLIES WITH AND WITHOUT PCM DEMONSTRATES PERFORMANCE



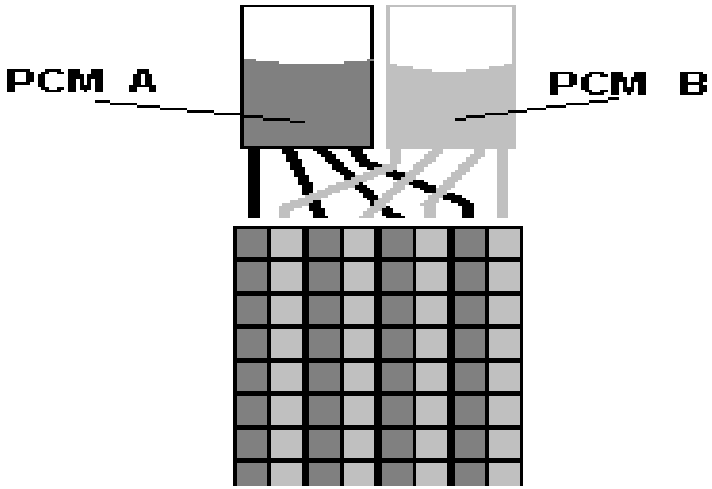
Heat Flux Data for Inorganic PCM




CUIDE SUS MANOS
SELLO VERTICAL
SELLO HORIZONTAL
KEEPACK

Equipment can be configured for multiple PCMs packaging

"Multiple Phase Change Temperature Blanket"

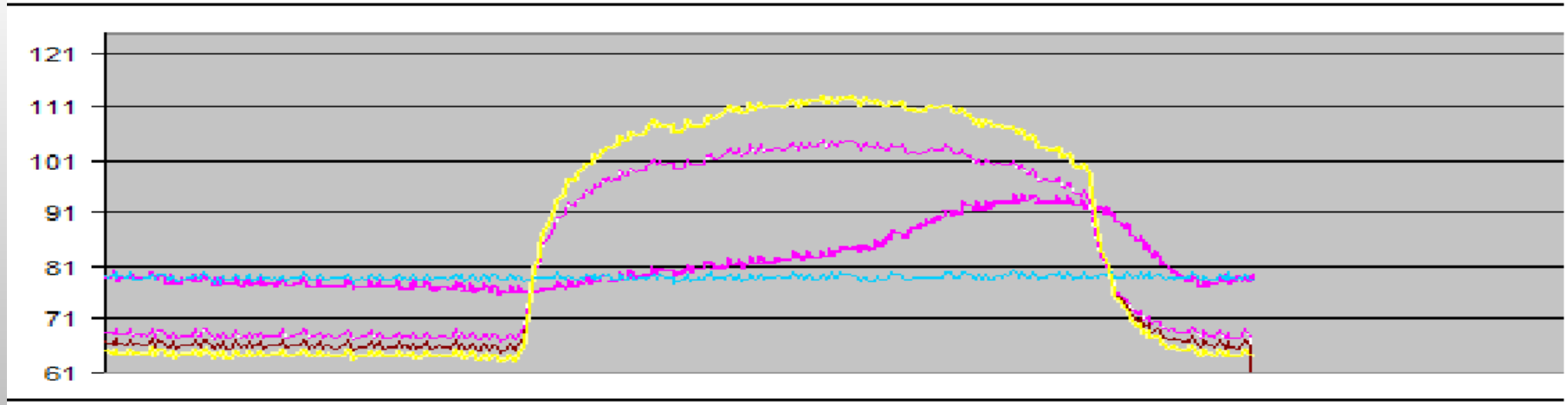


It has been discovered that a multple temperature PCM blanket has an advantage over a single temperature PCM blanket. Above PCM B changes phase at about 85 degrees F., PCM A changes phase at 80 degrees F. Winter to Summer temps vary enough that one PCT may not be within the diurnal cycle temps. of both seasons. This means that one perfect for summer may not be perfect for winter. If two different Phase change temps (PCT) are combined both winter and summer can be optimized, then a more efficient system can be achieved.

Application of PCM panel in wall when insulation is installed.

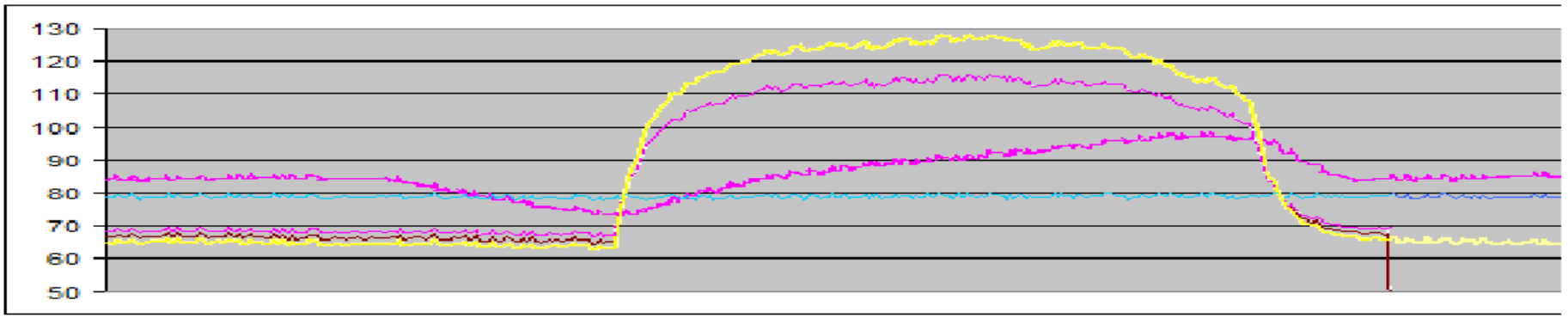
Temperatures show presence of PCM in finished wall

		Heating	161.8	Cooling=	57.5	Heat Saved	Cool Saved		59.46	(equiv R)	20	
		No PCM	No PCM	PCM	PCM	88.7%	66.4%		176.8	Upper R	5	1.681323
		Heat	Cool	Heat	Cool	btus in pcm	btus out	From HVAC Units		HF UP	2	2
		8.142	16.451	0.920	5.532	51.83	-37.44	0.92	-5.53	Lower R	15	3 inches
			Electricity used			Heat Saved	Cool Saved	Totals BTUs in and out				
		8.126	16.451	0.760	5.017	90.6%	69.5%	52.75	-42.97			
						Heat stpt.	Cool stpt.			BTUs NO PCM		BTUs w
Poteet			Adj to deduct heat flows			75	78		R=L2+L4	heat	cool	heat
		inner wall 1	PCM 8	outer wall 4	iner wal 12	middle 9	outer wall 5	14	WOPCM	122.135	-246.8	13.80667
TIME	"OF	"F"	"F"	"F"	"F"	"F"	"F"	"F"				
11/9/2010 0:59	0	79.2	79	65	79.2	68.55	65	1	68.55	0.71	0	0.013333

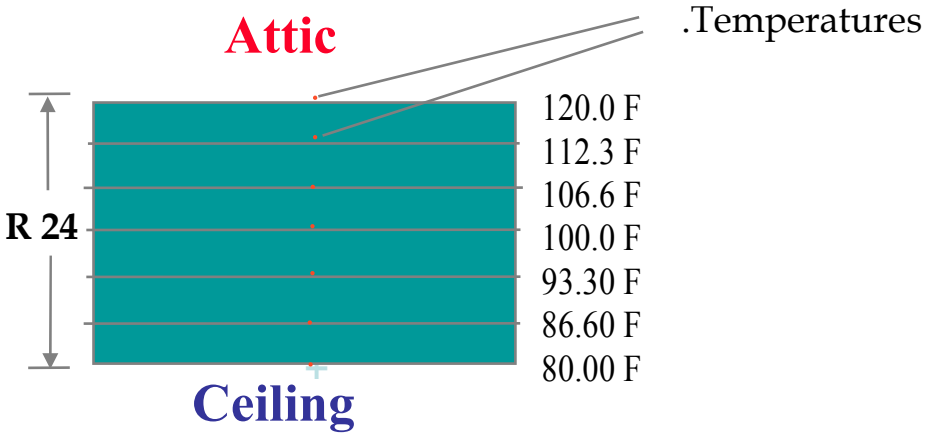


Higher Phase Change Temperature

		Heating	206.6	Cooling=	38.5	Heat Saved	Cool Saved		40.50	(equiv R)	20	
		No PCM	No PCM	PCM	PCM	91.0%	50.6%		221.6	Upper R	5	2.468474
		Heat	Cool	Heat	Cool	btus in pcm	btus out	From HVAC Units		HF UP	2	2
		7.893	24.248	0.712	11.971	72.50	-49.55	0.71	-11.97	Lower R	15	3 inches
			Electricity used			Heat Saved	Cool Saved	Totals BTUs in and out				
		7.847	24.248	0.462	8.689	94.1%	64.2%	73.21	-61.52			
						Heat stpt.	Cool stpt.			BTUs NO PCM		BTUs w
			Adj to deduct heat flows			75	78		R=L2+L4	heat	cool	heat
								14	WOPCM	118.39	-363.7	10.67333
					"F"	"F"	"F"	"F"				
11/22/2010 23:04	0	78.8	83.8	64.8	78.8	68.3	64.8	1	68.3	0.7	0	0



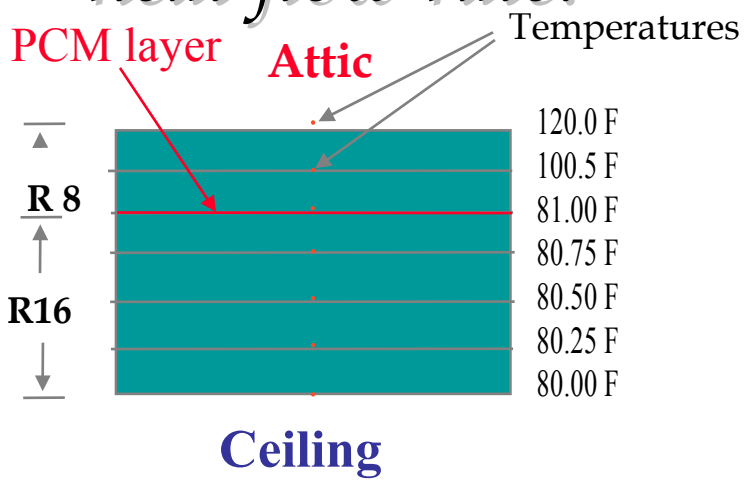
PCM Panels can be used to reduce heat transfer between attic space and conditioned space. The sketch shows situation without PCM



Temperature distribution is linear (steady-state)

Heat flow into ceiling is 1.7 BTU/ ft²·h under these conditions.

Addition of a layer of PCM changes the heat flow rate.



PCM layer is 0.125 inch thick and can be designed to maintain 81 °F for a diurnal cycle.

Heat flow into ceiling is 0.0625 BTU/ft $^{2}\cdot$ h

(1.7 without PCM)

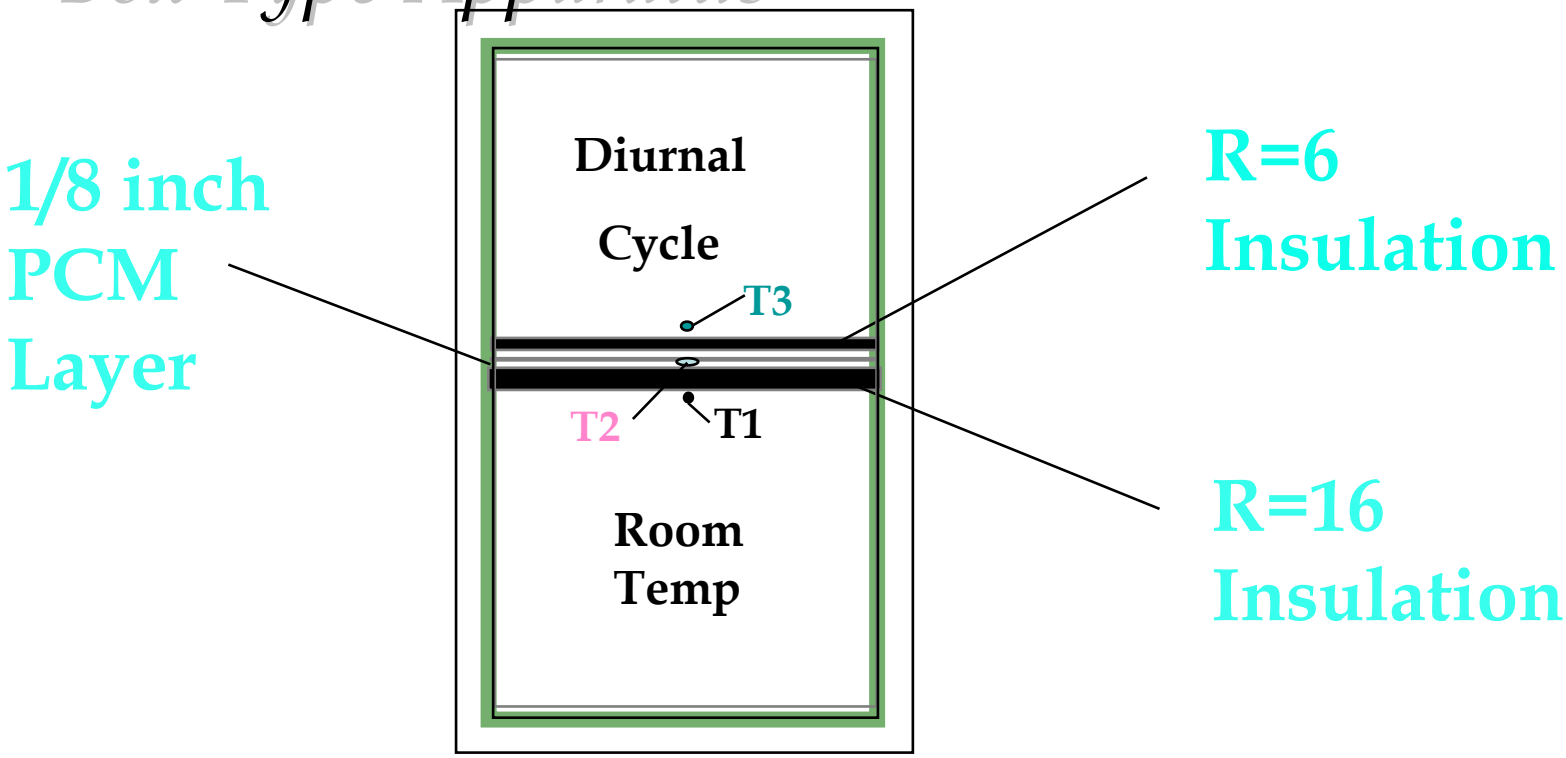
PCM in Attic Space can reduce heat flow to near zero during active period.

PCM temperature change near the conditioned space set temperature.

Saving during period that PCM is absorbing energy.

The discharge period must be analyzed to determine actual savings.

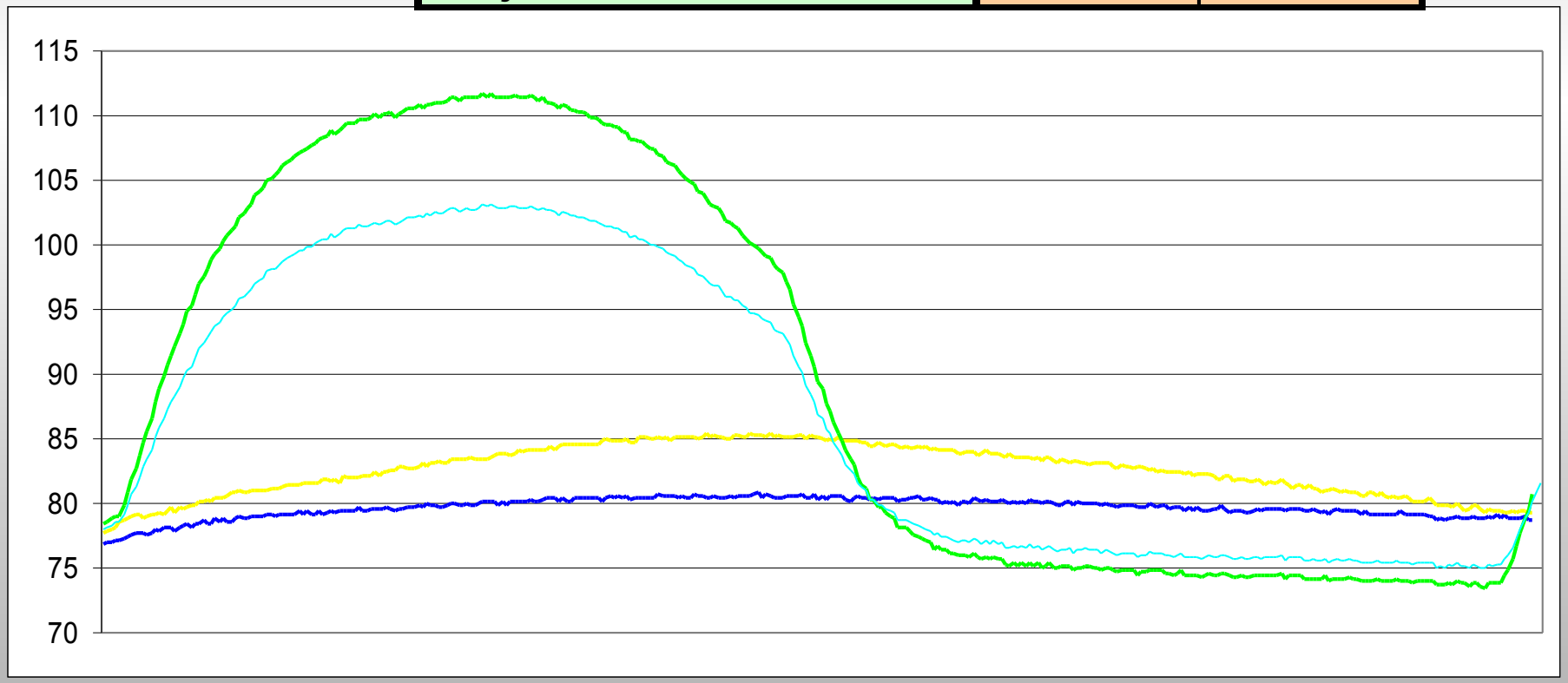
Demonstration Implemented with a Hot-Box Type Apparatus



One Diurnal Cycle (24 Hrs)

	Btus Consumed			Heat Saved	Cool Saved
No PCM	No PCM	PCM	PCM	100.0%	67.2%
Heat	Cool	Heat	Cool	btus in pcm	btus out
2.29	13.30	0.00	4.36	41.83	-16.02

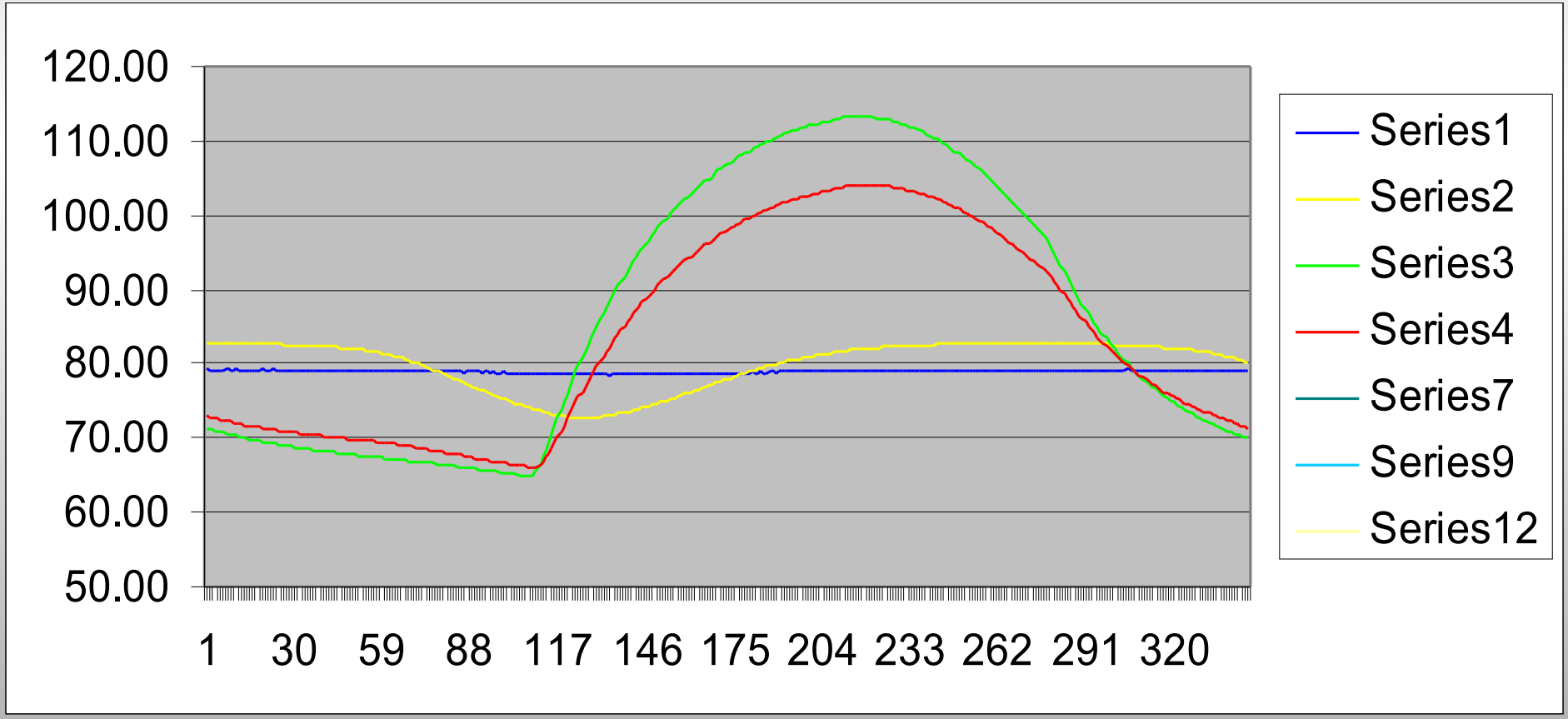
	Electricity used			Heat Saved	Cool Saved
2.20	13.30	0.00	2.94	100.0%	77.9%
				Heat stpt.	Cool stpt.
	Adj to deduct heat flows			77	77



One Diurnal Cycle (24 Hrs)

0.25 lb/ft² of n-octadecane

Heat saved	2.63	**63.64%**
Cool saved	5.37	**65.04%**

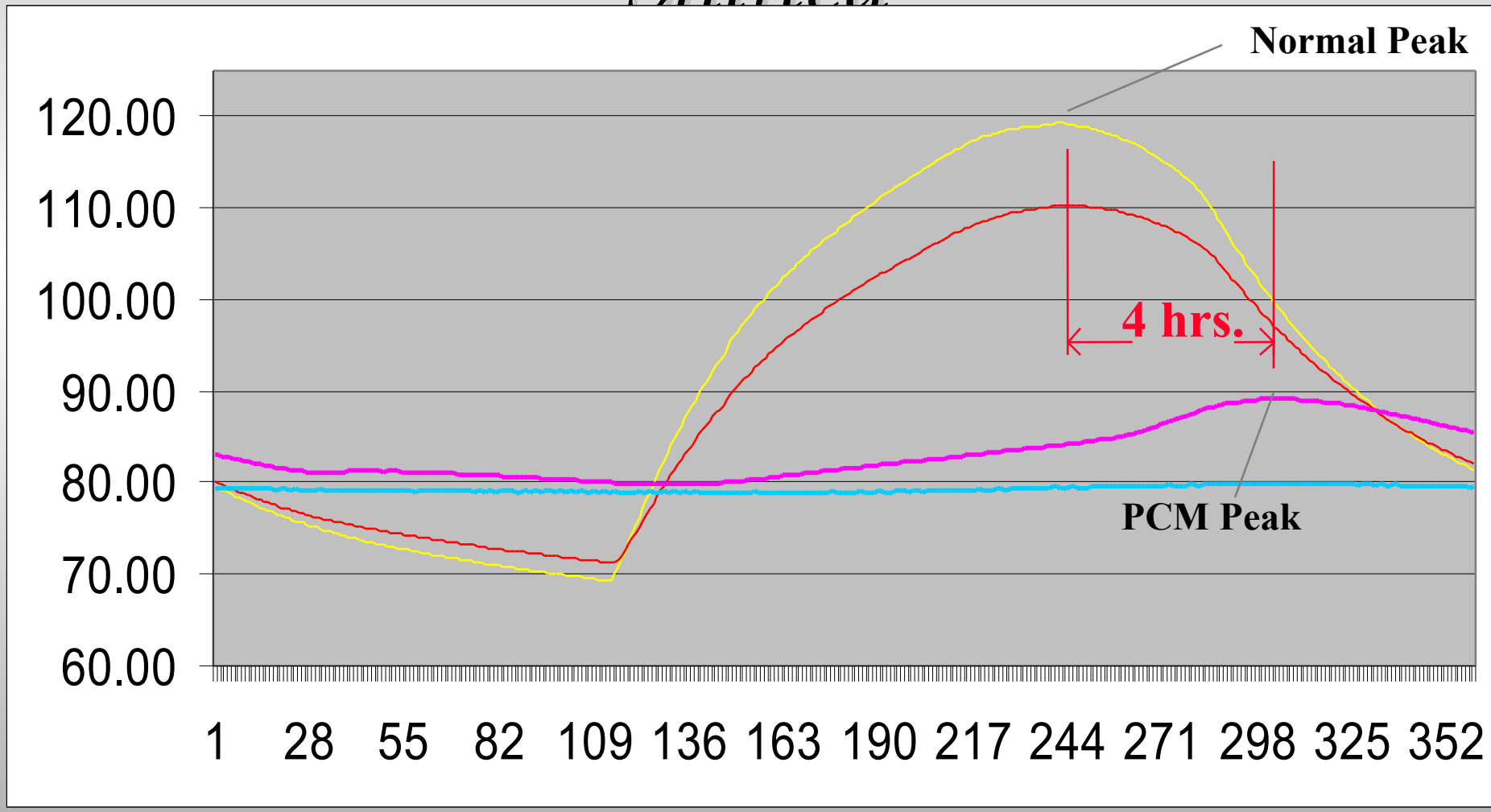


Some Power Companies Charge More for Energy at Peak Times.

Consumers can benefit by using PCM Enhanced Insulation. Delaying and spreading their energy demand over time saves them money.

Power companies benefit from reduced peak loads.

Peak Load on Power Grid is Shifted



Low Space Requirements

- A 0.125 in. thick layer of PCM (0.5 lb) with thermal resistance on both sides can last for a complete diurnal cycle.

Summary

PCM panels are in production.

Laboratory data demonstrates savings potential.

Hot-box type data shows savings for complete cycles or extended time periods.

Specific applications are being studied.