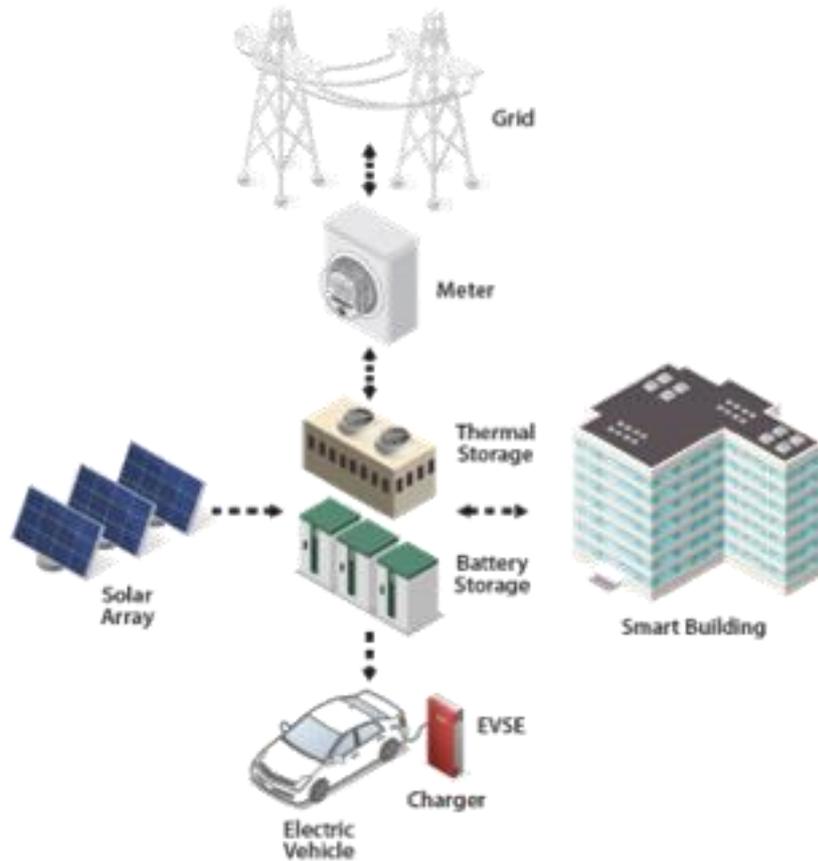


Dynamic and Interactive Energy Storage

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A Modern Grid Requires Energy Storage



What are the big trends in energy?

- **Renewables** are getting very cheap
 - Photovoltaics will be everywhere
- **Electrification**
 - Buildings are largest electrical load
 - Electric vehicles will be charged at buildings
- **Energy Storage** throughout the system
 - Electrochemical energy storage
 - Thermal energy storage

Question: What does this mean for thermal energy storage in buildings?

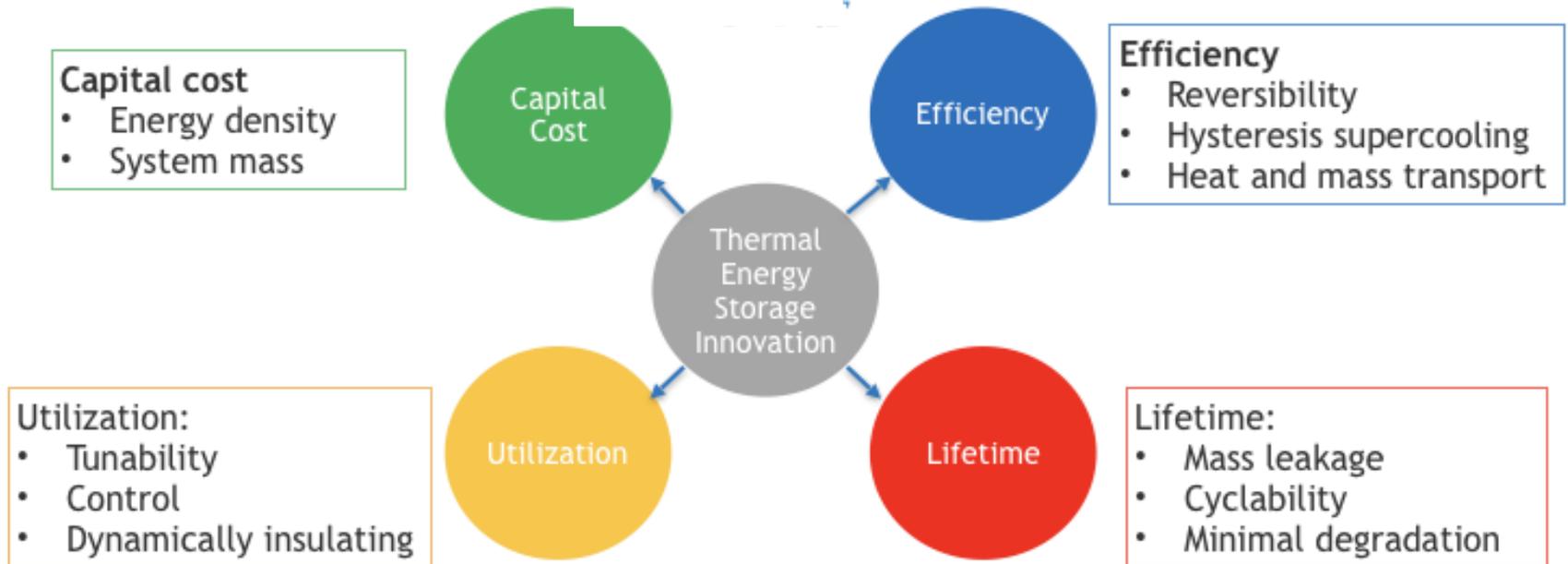
Current Status

Thermal Energy Storage is under utilized in buildings
Existing PCMs is active far less than 50% of the time

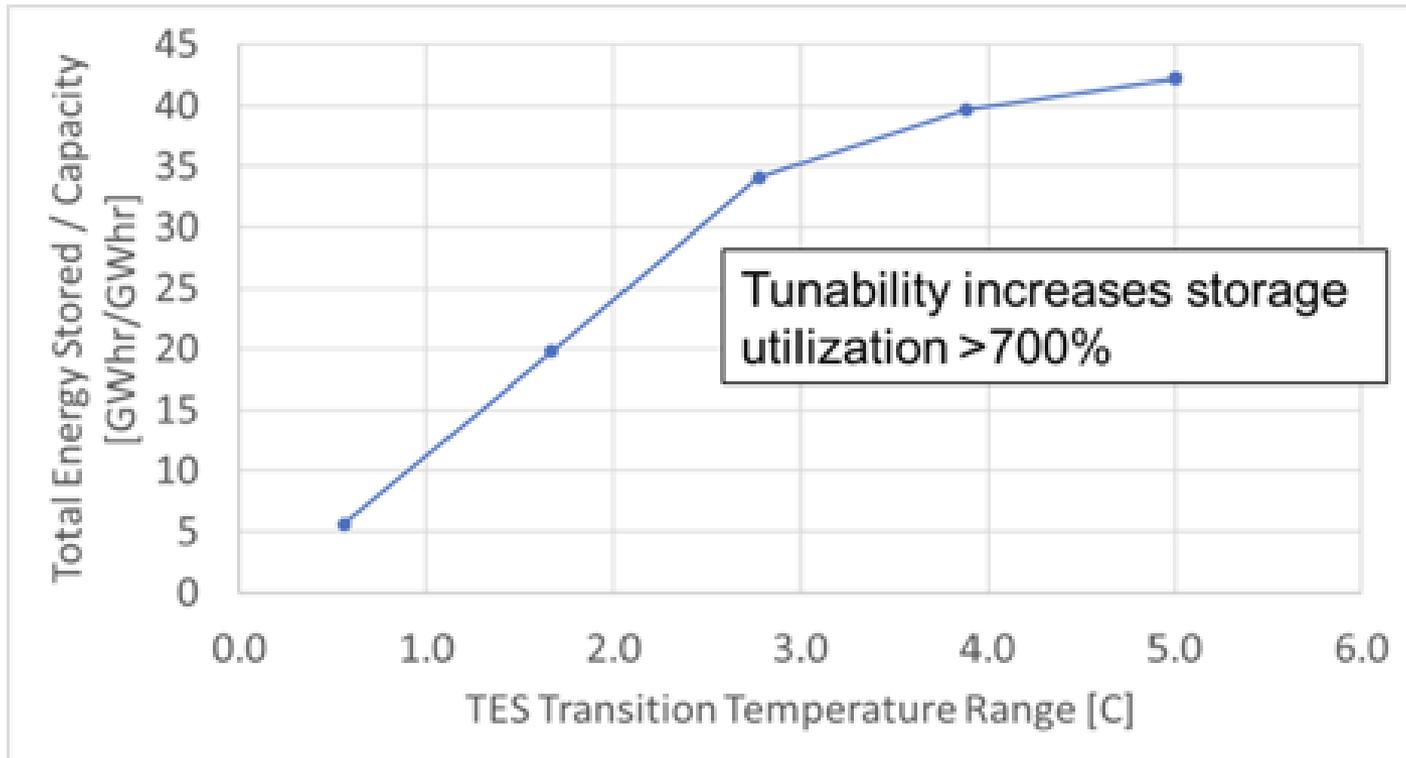


	South Wall		East Wall	
	Fully Active	Partially Active	Fully Active	Partially Active
Percent of Days out of Year	0%	36%	8%	36%

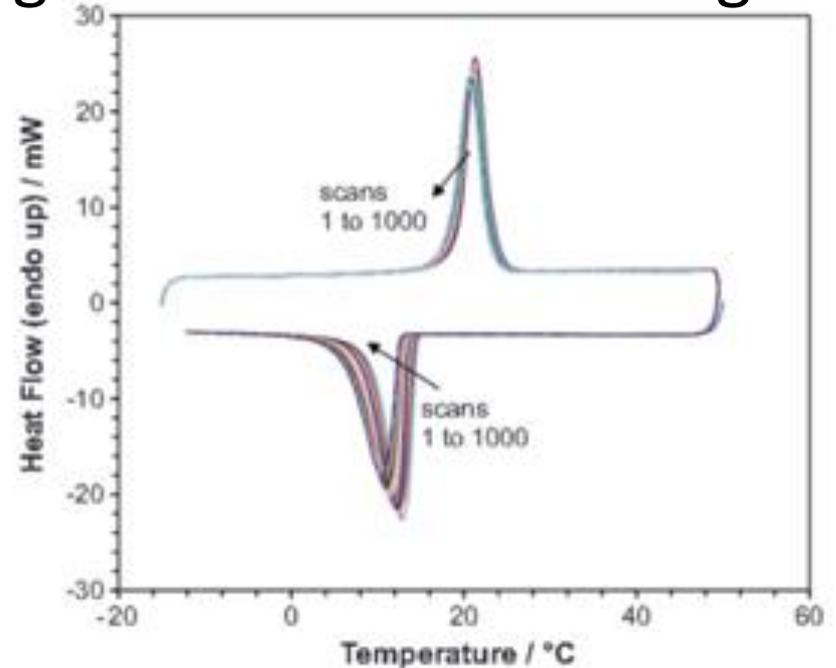
R & D Opportunities



Tunable PCMs can provide a 7x improvement in annual energy storage utilization



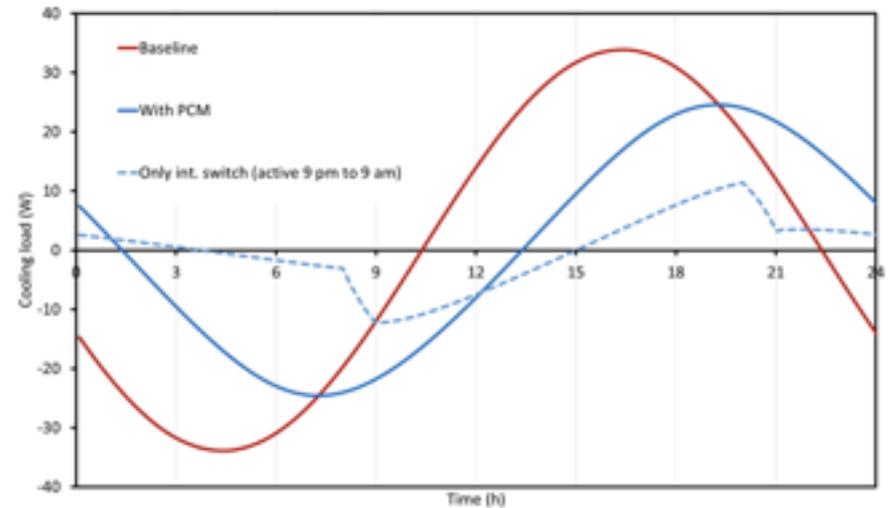
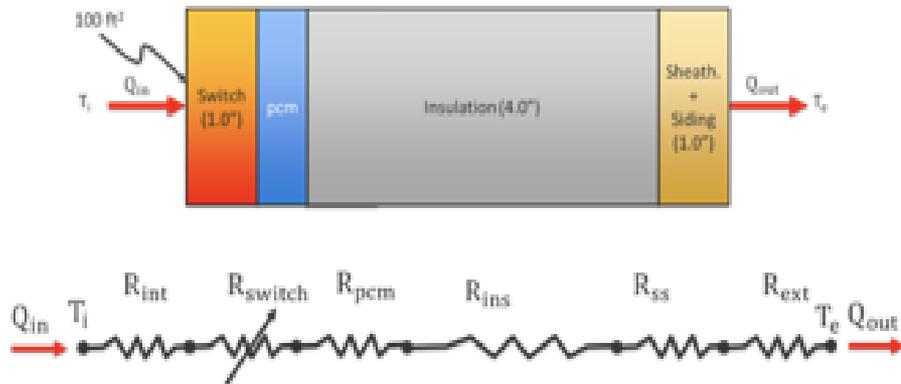
Solid-Solid Tunable Phase Change materials for building envelope.



Example: Energy density 80J/g. Stable after 1000 cycles.
C. Whitman et al., *Thermochimica Acta*, 2012, 531, 54

No encapsulation required

What if we have non-linear thermal devices such as a thermal switch?





Thank You!