BINGHAMTON UNIVERSITY | THOMAS J. WATSON COLLEGE OF ENGINEERING AND APPLIED SCIENCE

Continuous Casting of High-Temperature Micro-encapsulated Phase Change Materials for Industrial Decarbonization

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September 6, 2023

TES for Industrial Decarbonization/Electrification

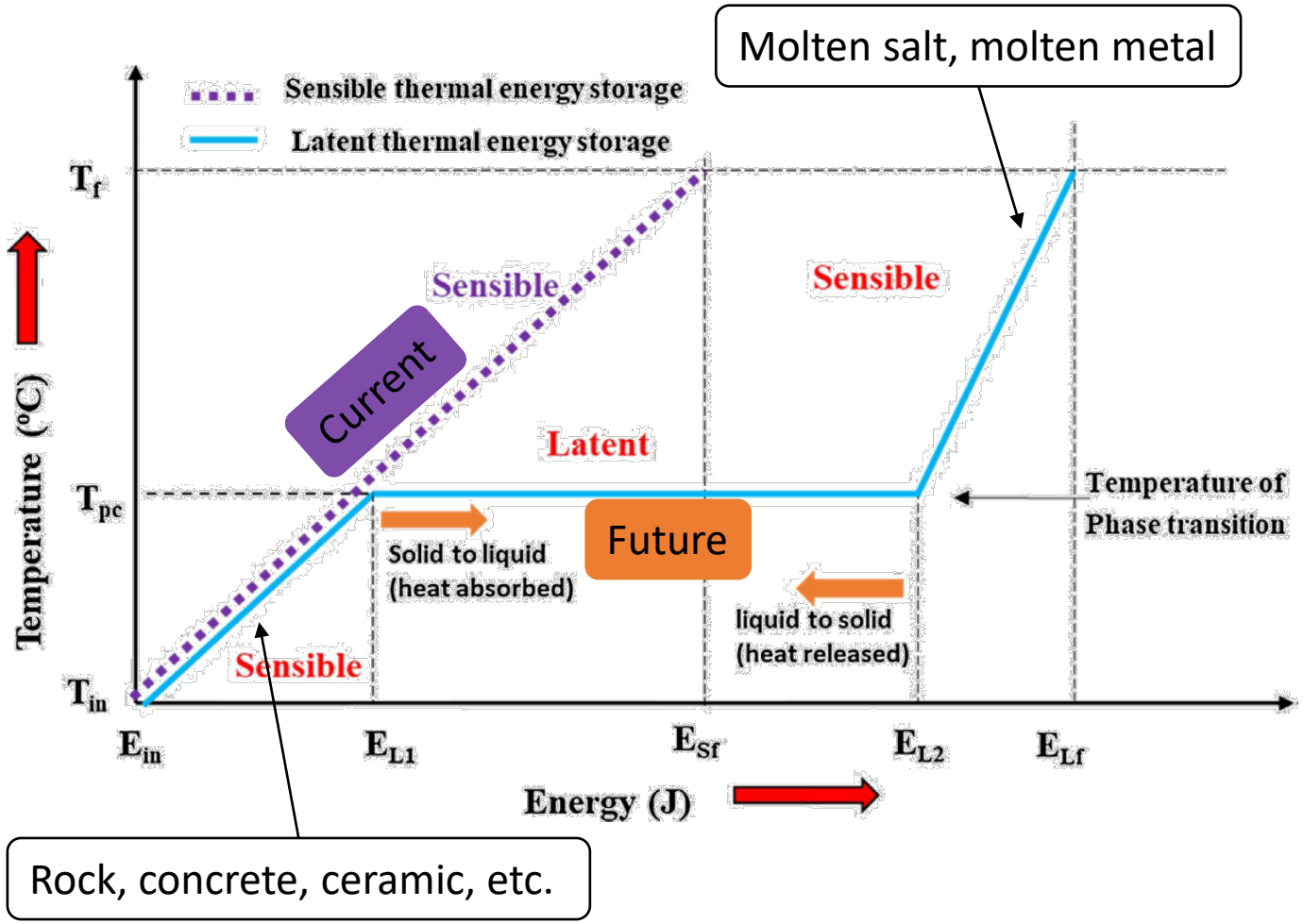
Thermal Energy Storage (TES) is the **key enabler** for **dispatchability**

Waste Heat Recovery

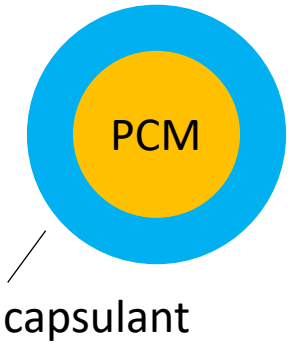
Solar Heat for Industrial Processes

Solar Heat for Power Generation

Micro-encapsulated PCM for HT-LHTES (>300 °C)



Micro-encapsulated Phase Change Material (PCM) for High Temperature Latent Heat Thermal Energy Storage (LH-TES)

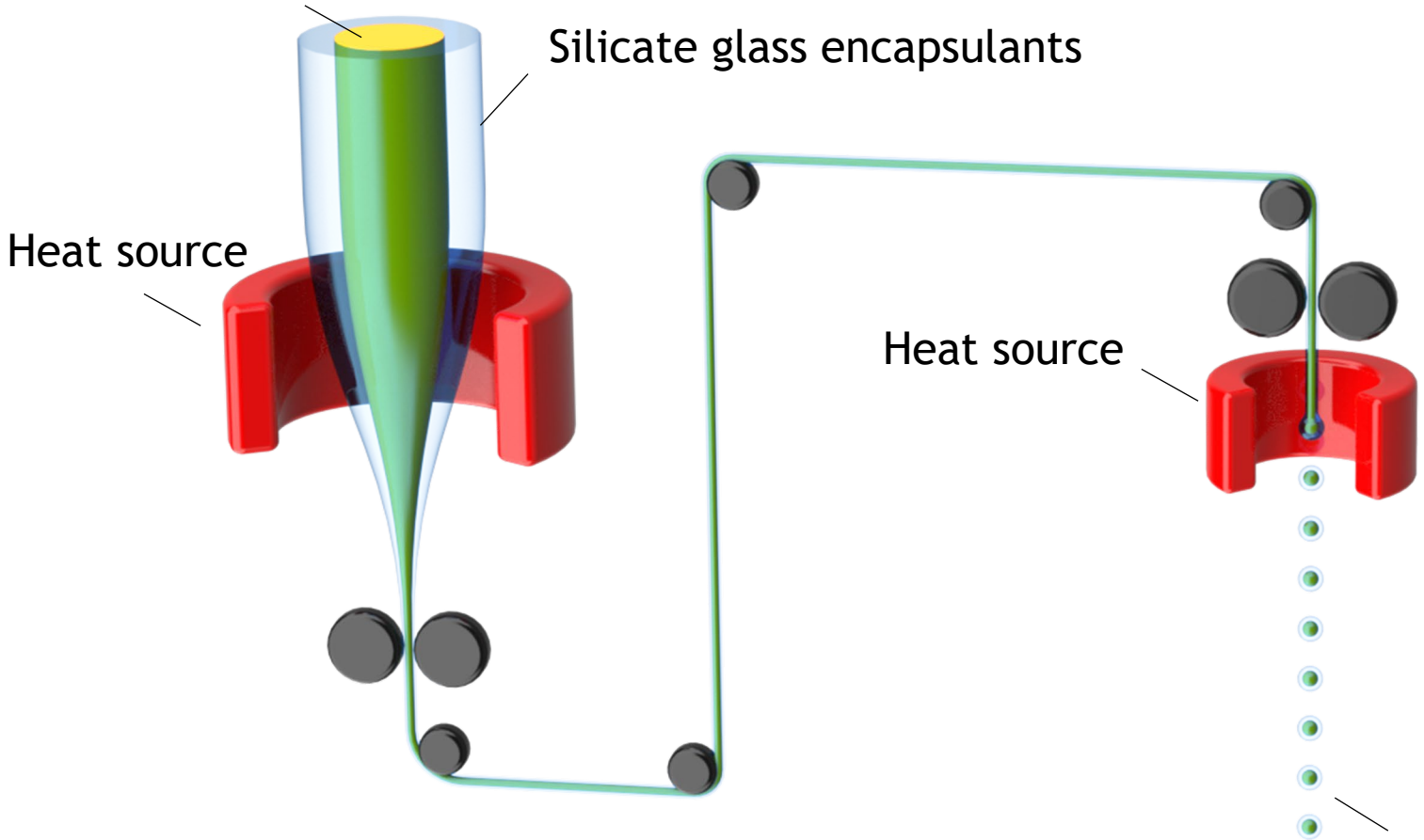


Challenges:

- Energy and power density
- Durability (>10,000 thermal cycles)
- Manufacturing cost ($1/kg)

Continuous Casting of Micro-encapsulated Phase Change Materials

High Temperature-Phase Change Materials (HT-PCMs)



- Tunable melting point (wide applications)
- Minimal thermal expansion mismatch (better durability)
- Low undercooling (higher efficiency)
- Encapsulation while production (lower cost)

Development Goals

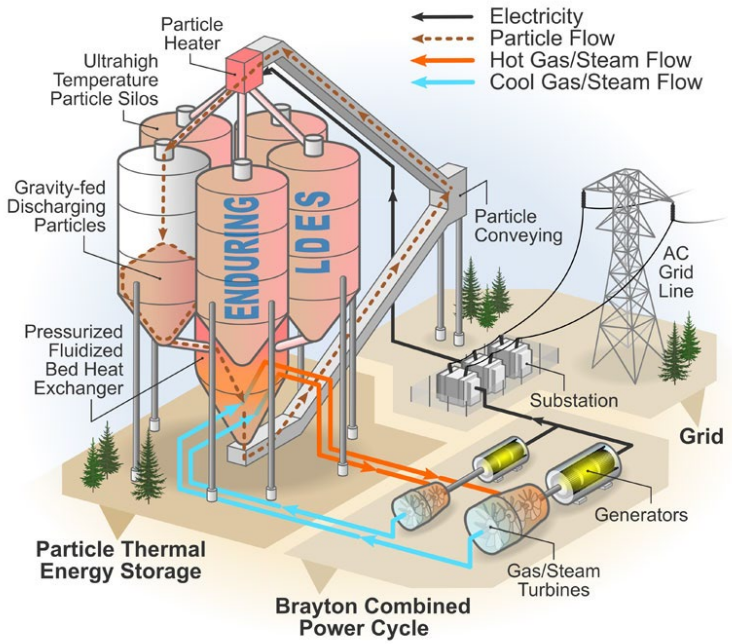
Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance/Cost
Improved range of melting point	°C	230 °C ~ 1200 °C	230 °C ~ 1500 °C	232 °C
Increased energy density of storage component by weight	J/g	800	1400	60
Increased energy density of storage component by volume	J/cm^3	**1700 (Cu)**	2700 (Si)	439 (Sn)
Increased lifetime of storage component	# of charge-discharge cycles	8000	10000	3000
Increased throughput (Reduced cost of production)	g/hr	100	1000	0.01
Reduced undercooling (Improved reversibility)	% of absolute melting temperature	10%	5%	20%
Improved thermal conductivity (Improved charge-discharge rate)	W/m-K	100	200	33

Volumetric energy density of Li-ion Battery by 2020: **1620** J/cm^3

Muralidharan, Nitin, et al., *Transition Metal Oxides for Electrochemical Energy Storage* (2022): 33-53.

Scientific and Social Impact

- Capillary break-up of coaxial fluid interfaces in the presence of a steep temperature gradient
- Key enabler for the future success of TES systems
- Drop-in replacements for particle-based TES systems
- New miniaturized HT-TES systems for industrial electrification
  - Comparable or higher volumetric energy density than LIB
  - Reduced capital investments
  - Accelerated adoption



DOE ENDURING Project @ 900 °C

Acknowledgements

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
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MASSACHUSETTS CLEAN ENERGY CENTER®

NSF National Science Foundation

The Massachusetts Technology Transfer Center

University of Dayton

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