Energy Storage Integrated With Fossil Power Generation

NETL's Advanced Energy Storage Project Review Meeting

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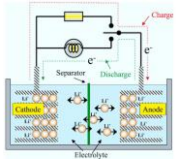
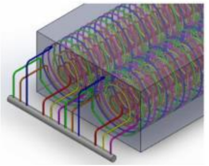
Energy Storage: Low-Carbon Tomorrow

- Variable renewable energy (VRE) is projected to grow significantly to reduce carbon
- Energy storage will be needed to provide power when renewables cannot and grid stability:
  - 1–6 hours duration: Lower VRE, fossil use prevalent



    - Batteries (in front and behind meter)
  - 6–48 hours duration: Medium VRE, some fossil backup



    - Largely non-battery types, which in many cases can be integrated to fossil assets
  - Weekly or seasonal duration: High VRE

    - Low-carbon fuels, e.g., hydrogen
- Dispatchable, reliable, safe, and cheap—and preferably synchronous

Future modes of energy storage will be different

Comparison of Energy Storage Technologies

Low (Low)	Not as good
Medium (M)	OK
High (H)	Good

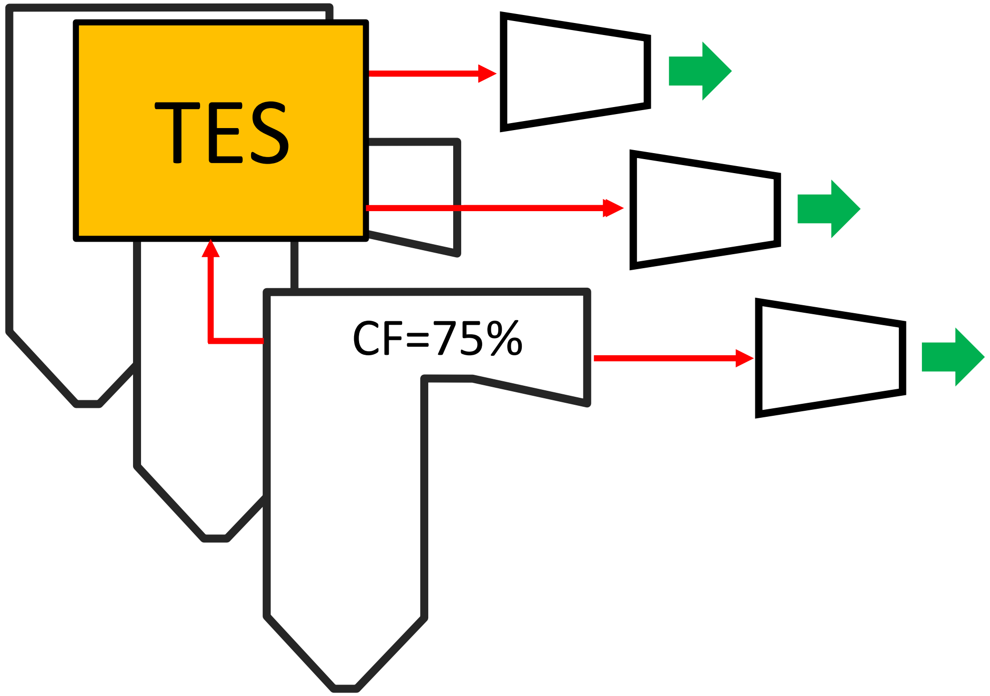
Type	Batteries		Thermal				Mechanical				Chemical	
Factor	Li-ion	Flow	Concrete	Molten-Salt	Pumped Heat	Sand	Compressed Air	Gravita-tional	Liquid Air	Pumped Hydro	Ammonia	Hydrogen
Cost	M	L	H	M	H	H	M	M	H	H	L	L
Duration	L	M	M	M	M	M	M	M	M	H	H	H
Efficiency	H	M	L	L	M	L	M	H	M	H	L	L
Environmental	L	L	M	M	H	H	H	H	H	L	H	H
Footprint	M	H	H	H	H	H	M	M	H	L	M	L
Inertia	L	L	H	H	M	H	H	L	H	H	H	H
Integrates with Fossil	L	L	H	H	L	H	L	L	M	L	M	M
Maturity	H	L	M	H	L	L	H	M	M	H	L	L
O&M	L	L	H	M	M	H	L	H	M	M	L	L
Response Time	H	H	M	M	M	M	M	H	M	M	L	L
Safety	L	L	H	M	M	H	M	H	H	M	L	L
Scalability	L	M	H	H	H	H	H	M	H	H	H	H

No energy storage technology is one-size fits all

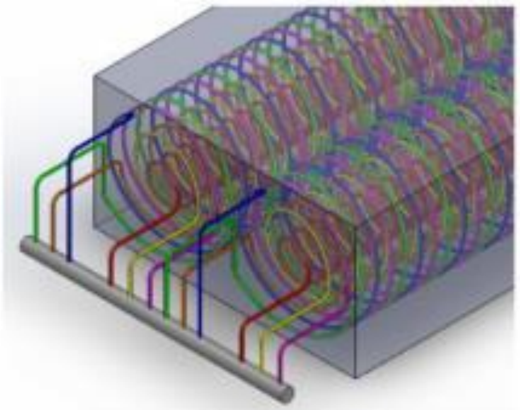
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Concrete Thermal Energy Storage (TES)

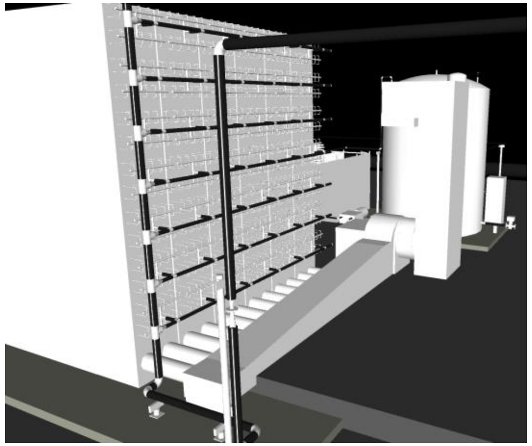
- Solid ‘thermocline’ structure used to store thermal energy
- Modular system (12.5 m in length)
- Low-cost material: $68/tonne
- $687/kWe with $400/kWe attainable



- Steam tubes embedded into concrete monoliths as coils—conduction only
- No moving parts
- Road/rail transportable
- DOE-funded 10-MWhe pilot demo led by EPRI at Southern’s Plant Gaston



Tube internal arrangement

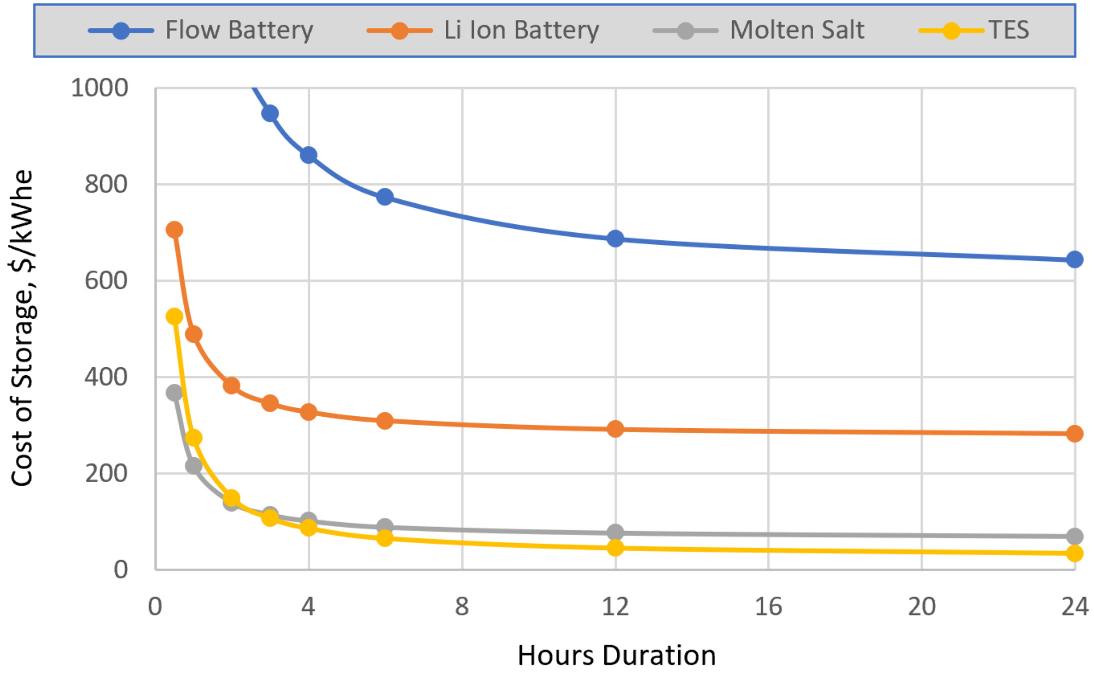


10 MWh-e pilot unit

Bright Energy ***Images courtesy of Bright Generation Holdings***

Costs and Benefits of Mid-Duration Energy Storage

- <u>#1 Question Asked by Industry:</u> Will there be value for energy storage?
- For fossil-integrated energy storage, durations are up to 24–48 hours
- Costs for TES are much lower for these mid-durations compared to batteries—most of the cost is adding more cheap thermal media



- EPRI is currently performing benefit assessments, which show value for mid-duration energy storage if there is an ancillary services market (e.g., non-spinning/spinning reserves)—arbitrage alone is not enough

As markets evolve (e.g., carbon pricing), value will continue to grow

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