Hours to Years: A Review of Storage Use Cases

EPRI Work on Long Duration Energy Storage

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NMRETA: 500 Megawatts for 5 Days
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EPRI

PROFILE

Nonprofit

Chartered to serve the public benefit, with guidance from an independent advisory council.

Thought Leadership

Systematically and imaginatively looking ahead to identify issues, technology gaps, and broader needs that can be addressed by the electricity sector.

Independent

Objective, scientific research leading to progress in reliability, efficiency, affordability, health, safety, and the environment.

Scientific and Industry Expertise

Provide expertise in technical disciplines that bring answers and solutions to electricity generation, transmission, distribution, and end use.

Collaborative Value

Bring together our members and diverse scientific and technical sectors to shape and drive research and development in the electricity sector.

EPRI Approach to Addressing Energy Storage Needs

1 **EPRI Energy Storage Technology Database**

80+ technologies today (and growing)

2 **Technology Assessments**

Reviewing designs and vetting technologies

3 **Detailed Techno-Economic Studies**

Leverage from EPRI membership & government funding

4 **Energy Storage Benefits**

EPRI DER-VET™ / US-REGEN

5 **Pilots and Demonstrations**

Multiple pilot projects ongoing

6 **Technology Deployment Support**

Project planning underway

Energy Storage Evolution

As intermittent renewables increase, the duration of energy storage needed also increases

As storage duration increases, different types of energy storage are needed

Different durations of energy storage will be required

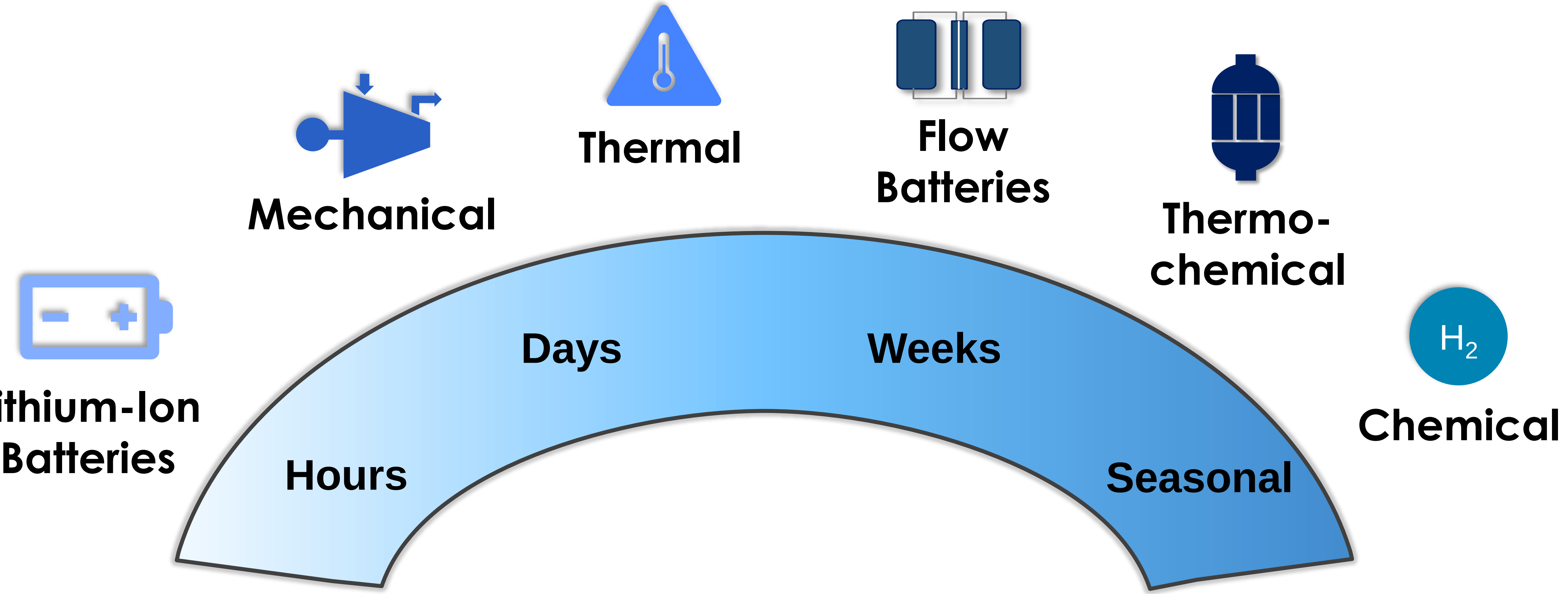
Energy Storage Types

Electrochemical	Thermal	Mechanical	Chemical
Reversible chemical reaction generates an electrical potential difference	Energy storage achieved by heating bulk media	Kinetic or potential (compression or gravitational)	Reaction produces product that can generate heat or power

Different technologies for different purposes

Energy Storage Spectrum

More than 100 different technologies



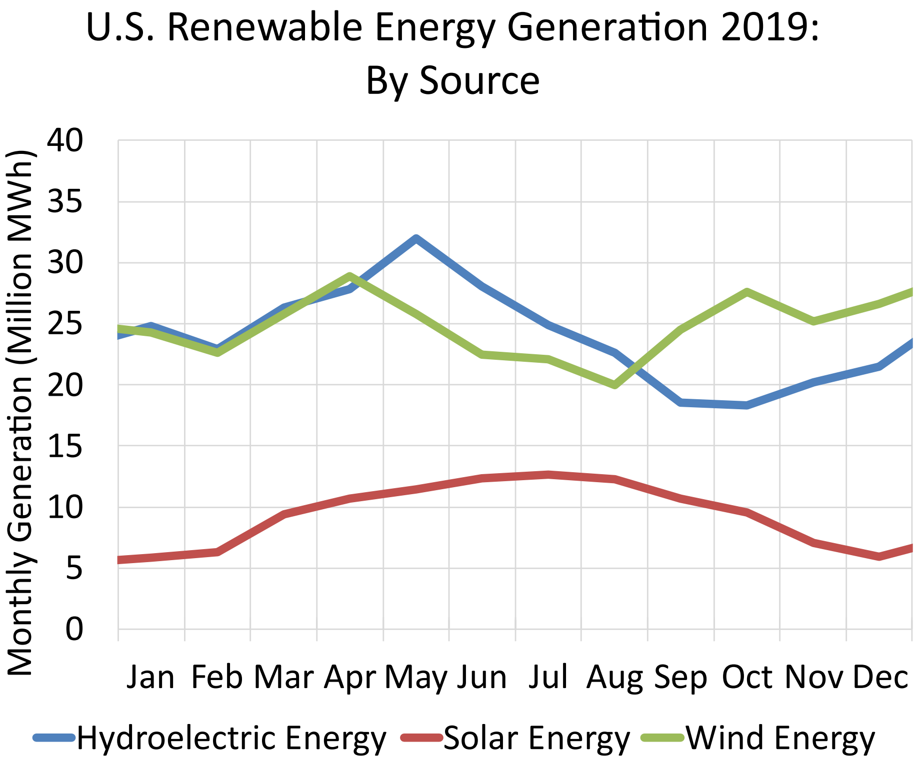
A range of energy storage technologies will be needed

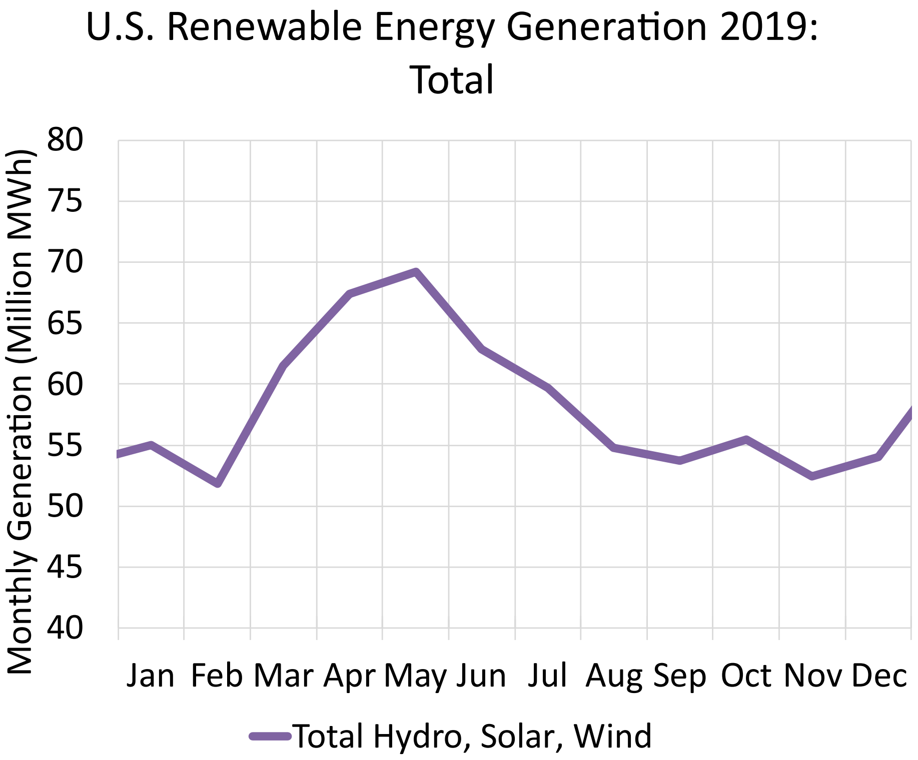
Seasonal Energy Storage

Use Case: Seasonal (U.S. Example)

- Solar, wind, and hydro typically peak in late spring and summer
- Solar and hydro reduce substantially in the winter

- Total renewable energy generation is highly seasonal
- Problem will be exacerbated at high VRE penetration
- Effect in Asia, Europe, and other regions will vary

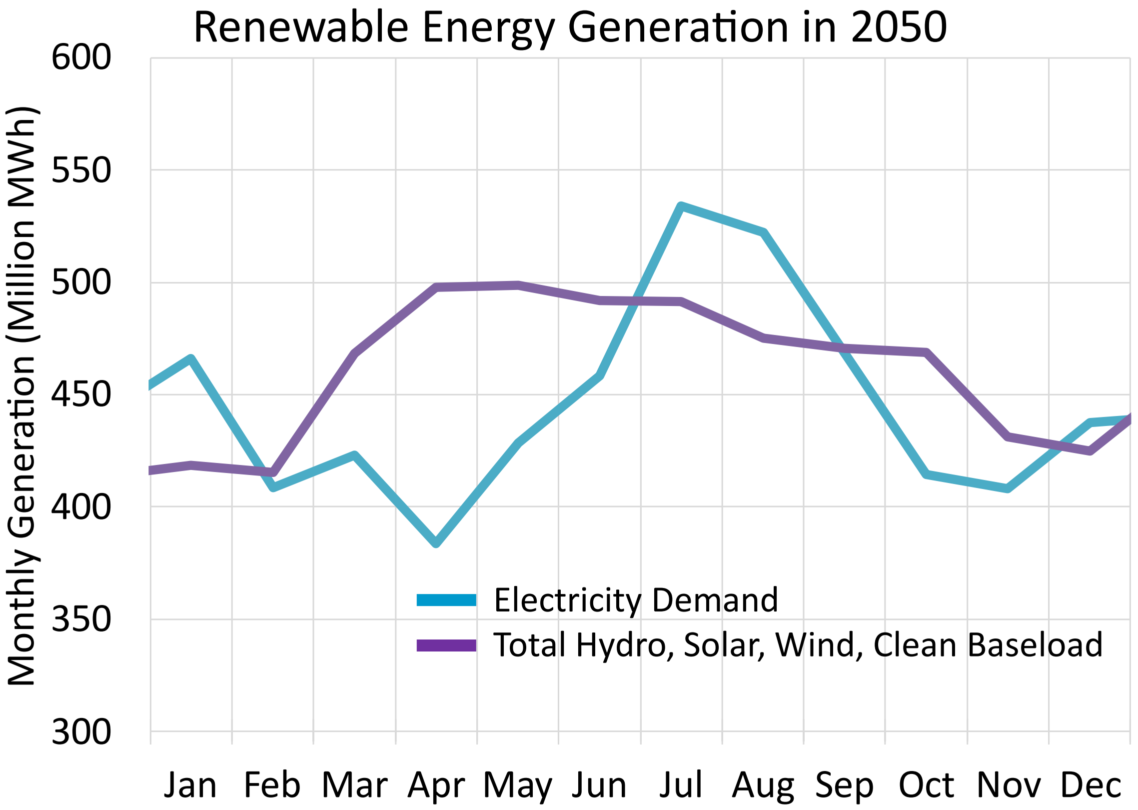




Seasonal variation in VRE becomes a critical issue

Need Seasonal Energy Storage to Fill Gaps

- **<u>Severe overgeneration in spring and fall and shortfall in summer and winter</u>**
  - Projected total U.S. electricity demand in 2050 assuming 1% growth rate from 2020 onward
  - Projected total U.S. clean energy generation in 2050
  - Assumes 12x current solar generation, 4x wind, and clean baseload



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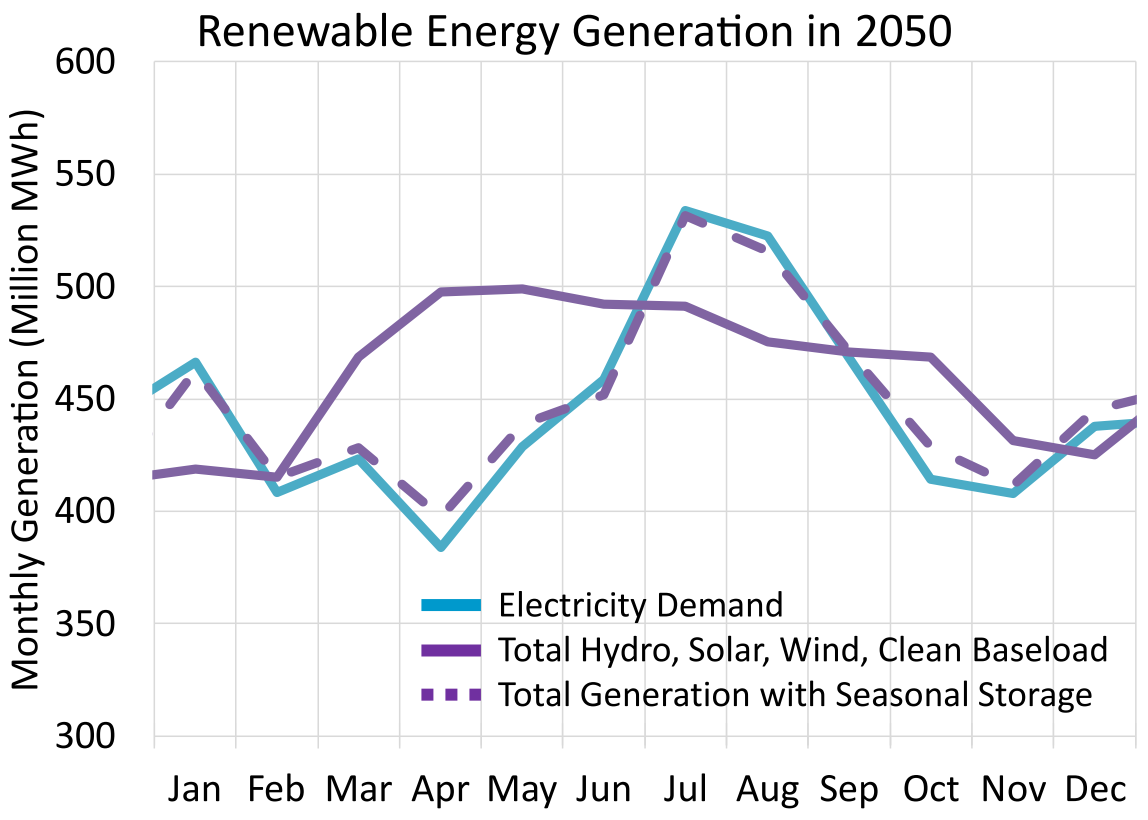
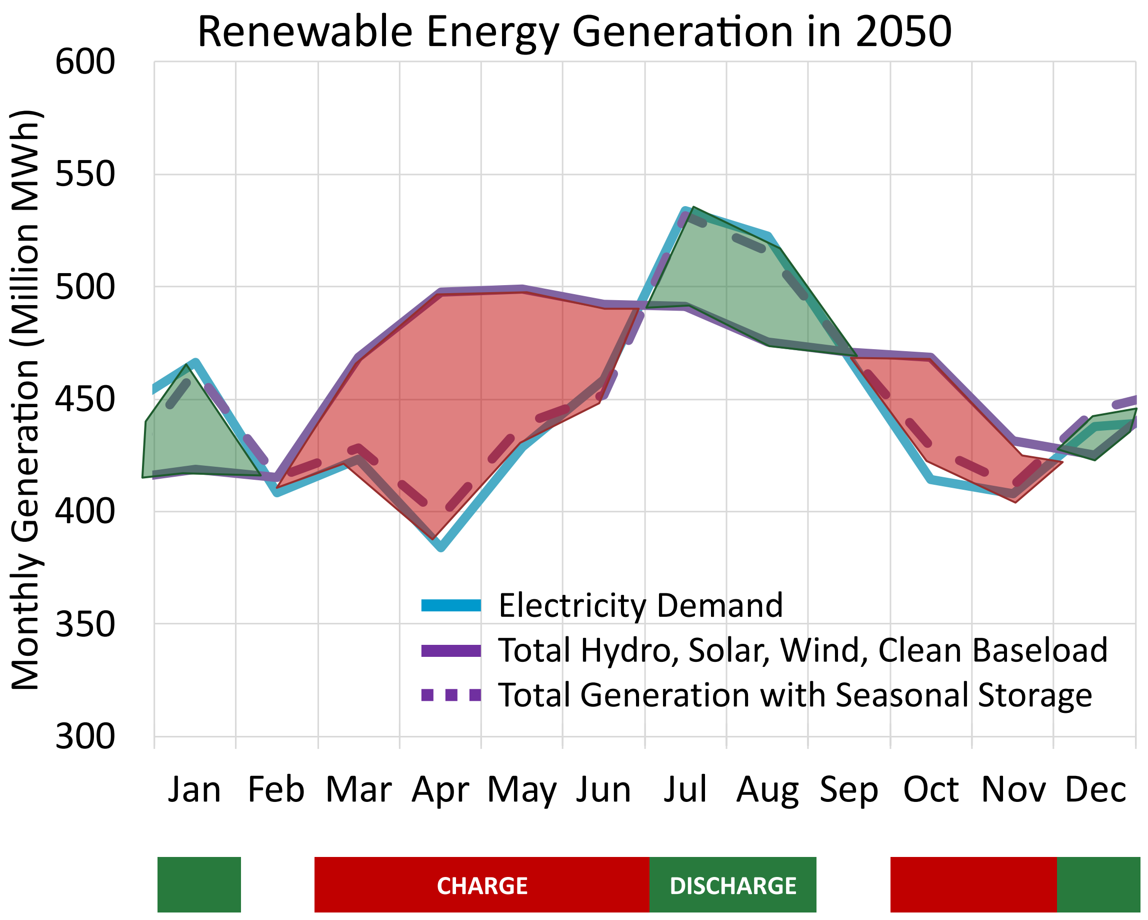
- Add in seasonal energy storage
- Sculpt generation profile to match load



Need Seasonal Energy Storage to Fill Gaps

- Example dispatch profile absorbs excess generation in spring and fall, and serves peak loads in summer and winter
  - Charge in March–June and Oct–Nov
  - Discharge to meet summer peak in July–Aug and winter loads in Dec–Jan
- Energy storage must be capable of delivering output over the course of several months without recharging
- **Will require rated output durations of 500+ hours**



EPRI

What Could Be Deployed to Provide a Solution?

- Prospective technologies should have low costs (potentially <$10/kWh*) and low standby energy losses
- Round-trip efficiency is less important than capital cost
- Lithium-ion batteries are too expensive
- Potential candidates:
  - Hydrogen
  - Ammonia
  - Geo-thermal energy storage (TES)
  - Thermochemical
- Must quantify costs and performance of each prospective technology and assess its benefits

** Sepulveda et al., "The design space for long-duration energy storage in decarbonized power systems," Nature Energy, vol. 6, 2021.*

Hydrogen Energy Storage

- **Site**
  - Intermountain Power Project in Delta, Utah
  - $505 million DOE loan guarantee plus $650 million equity
- **Use Case**
  - Seasonal energy storage
  - Serves demand in Los Angeles via HVDC transmission line
- **Storage Technology**
  - Electrolyzers generate clean hydrogen, which is stored in salt cavern during charging
  - To discharge, the hydrogen is burned in a combined cycle system capable of up to 100% hydrogen fuel (by 2045)
  - Mitsubishi Power will provide the hydrogen equipment
  - Black & Veatch is EPC
- **System Size Profile**
  - Discharging power: 840 MW
  - Storage capacity: 165,000 MWh (~200 hours)
  - Charging capacity: 220 MW

Thermochemical Energy Storage

- **Stores energy at ambient conditions as a solid fuel**
- SaltX is developing thermochemical energy storage using calcium oxide (CaO)

$$CaO + H_2O \rightarrow Ca(OH)_2 + 1.9\ MJ/kg$$

- Charging system is an adapted calciner (partner with Calix)
- Storage done with silos holding CaO
- Discharging system is a fluidized-bed reactor (partner with Foster Wheeler)
- Each subsystem can be sized independently

Commercial Barriers to Seasonal Storage

- Must develop business case to make projects financeable
  - Need bankable project revenues with secure offtake agreements
  - High capacity payments ($/kW-mo) or energy payments ($/MWh) needed
- Quantify dispatch strategy, energy sales, inertia, and other grid benefits
- Need stakeholder engagement to successfully deploy seasonal energy storage:
  - Investors and debt providers
  - Project developers
  - Regulatory bodies
  - System operators
  - Technology developers
  - Utilities

Seasonal storage is both a technical and financial/economic challenge

What’s Next?

- Upcoming EPRI **white paper** on seasonal energy storage
  - “Seasonal energy storage: A technical and economic framework,” EPRI 3002025178, in publication, 2022.
- **One day virtual** **workshop** on seasonal energy storage scheduled for November 9, 2022
  - Free and open to all
- Then, seasonal energy storage **technology roadmap** report to be published in 2023
- Later, pilot projects, commercial demos, competitive RFPs, oh my!

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Thank you!
Any questions?


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