

Grid Decarbonization, Sector Electrification, and Long Duration Energy Storage

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We all understand that
we must Decarbonize Electricity,
we must change
to Renewable Energy!

And we have to do it soon!

At the same time
we must also Decarbonize
all other sectors:

Buildings, Transportation
Agriculture, Manufacturing

These sectors
need to be Electrified first
and then utilize
Decarbonized Electricity
(=Renewable Energy))

Renewable Energy
requires
Energy Storage

Storage of Various Durations will be Needed: Short, Medium, and Long

15 min – 4 hrs: smoothing renewables. Li-ion

4 – 12 hrs: day/night PV storage. Flow Batteries

12h – 3 days: bad weather backup. Thermal/Gravity

We will need some 1200-2300 GWh
of Energy Storage!

We have done well with Short Duration
Energy Storage and Li-ion Technology

Frequency Regulation
Smoothing Renewables
Demand Charge Reduction
Substation Upgrade Deferral

We have created Evaluation
and Planning Tools (e.g. Quest),
Developed viable Business Models

Lithium Dominates both
Stationary and
Vehicle applications

However,
with increasing Penetration
and Limited Resources
there will be competition
and increasing prices!

Vehicle Batteries
must have high Energy Density
while

Stationary Applications
must have Low Price

This will lead to
Resource Competition!

Unless domestic Li sources
in huge amounts
suddenly become available
Stationary Applications
will have to turn to new;
cheaper types of Batteries
Relying on more
Earth abundant Materials

Medium Duration Storage

4 – 12 hours

The next Wave!

Redox Flow, V, Zn, Fe,

Na-ion, L/A



Rongke Power: 100 MW / 400MWh
Dalian, China. Vanadium Flow Battery
Commissioned: Sep. 29, 2022

Vanadium Redox: not Flammable, Recycles at End of Life (30 years)



Invinity: Oxford 5 MWh
Commiss. July 5, 2022
Planned: Australia 8MWh
+6MWh PV ► 10GWh/year
Vanadium supply line!

CMBlue: Long Duration
Organic Electrolyte
120kW/1.2MWh system.
Debut planned 2023
California

Long Duration Storage

12h – 3 days

Mechanical, Thermal, Chemical
Energy Storage

Thermal Batteries using Phase Change Materials



Azelio: Heat stored at 600° molten, recycled Aluminium
Demos in Morocco, Egypt,
Planned 45MW in US



Highview Power: Liquid Air stored at -196° C
UK Demo: 50 MW/8hrs
Planned, Chile: 50MW/10h

Gravity Storage



Ares: Nevada Site Demo
5MW / 1.25MWh single track

Long Duration Energy Storage
is essential for the Development
of a Decarbonized, Reliable Grid

but it will require

New Technology, New Business Cases
and New Regulatory Frameworks!

And a lot of Funding
for Research, Development,
and Deployment!!

Current CEC Long Duration Projects – Grants Awarded

MW/MWh	Technology	Vendor	Expected Completion
400kW / 10hr X2	Vanadium Redox Flow Battery	Invinity Energy Systems	2023, 2024
400kW / 10hr X2	Zinc Hybrid Cathode Battery	EOS	2023, 2024
400kW / 10hr	Flywheel	Kinetic ES Corporation	2024
200kW / 10hr 50kW / 10hr	Aquifer Pumped Hydro	N/A	2024 2023
50kW / 10hr X2	Vanadium Redox Flow Battery	Invinity Energy Systems	2023
50kW / 10hr	Flywheel	Kinetic Energy Storage Corp.	2024

MW/MWh	Technology	Vendor	Expected Completion
10kW / 100hr X2	Iron Air	Form Energy	2023
10kW / 100hr X2	Zinc Air	E-Zinc	2023
10kW / 100hr	Thermal Storage	Antora Energy	2024

Grants in Development, Not Awarded yet

6MW / 10hr	Vanadium Redox Flow Battery	Invinity Energy Systems	2023
6MW / 10hr 8MW / 10hr	Zinc Hybrid Cathode Battery	EOS	2023 2023
5MW/100hr	Iron Air	Form Energy	2025

DOE /Sandia Support for CEC Projects through joint MOU

- Technical review of proposals
- Analysis of operational data
- Expertise on Fire / Safety issues
- Support of system commissioning

NYSERDA
LONG DURATION ENERGY STORAGE
TECHNOLOGY & PRODUCT DEVELOPMENT
PROGRAM OPPORTUNITY NOTICE (PON) 5179

Up to \$17 Million Available / 50% Cost Share

Product Development
Demonstration Projects
Federal Costshare Projects

DOE /Sandia Support for NYSERDA
Projects through joint MOU

Infrastructure Investment and Jobs Act (IIJA) of 2021. DOE Funding

IIJA Clean Energy Programs	IIJA Funding
Resilience – Utilities section 40101	\$5B
Resilience – States & Tribes section 40103(b)	\$5B
Resilience – Remote Areas section 40103(c)	\$1B
Grid Modernization section 40107	\$3B
Advanced Manufacturing section 40209	\$750MM
Clean Energy Projects on Mine Lands section 40342	\$500MM
Storage Demonstrations section 41001(a)	\$355MM OE/OCED
Long-Duration Storage Demonstrations section 41001(b)	\$150MM OE/OCED
TOTAL	\$15.755B

OE \$355 million

- **Validation:** “Demo Projects” for first-of-a-kind LDES utility scale demonstrations.
- **Piloting:** “Pilot Grants” to lower the barriers to storage deployments.

OE \$150 million

- **Demonstration:** “Demo Initiative” for innovative early-stage long duration technologies.
- **Resilience:** “Joint Program” for storage demos on DOE/ DOD facilities. \$30M Lab Call issued, Oct. 2022

A glimpse of the Future?

Controlled Nuclear Fusion
with positive Energy output
has now been demonstrated.

Teleportation of Energy
has been verified
in entangled quantum systems

We need much more Energy Storage!
And we need it bigger, and safer,
less expensive, and longer in duration.
And we need to apply it in equitable ways.
If we don't do this, we are in very deep Trouble.