

Long Duration Energy Storage at Grid Scale.

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Energy Storage provides Energy

when it is needed

just as Transmission provides Energy

where it is needed

But while the Transmission Grid
Spans the Continent
Storage only covers
rather Modest Durations

15 min -- 1hr – 4hrs

e.g. 2020 Q3: 476 MW / 764MWh
1 ½ hours!

Many Applications have been identified,
Valuation Models have been developed.
Business Cases with multiple
Benefit Streams have been established.

Global Energy Storage Data Base
at Sandia.gov/ess

Big Storage!

250MW / 1hr, Gateway, CA

300 MW / 4hr, Moss Landing, CA

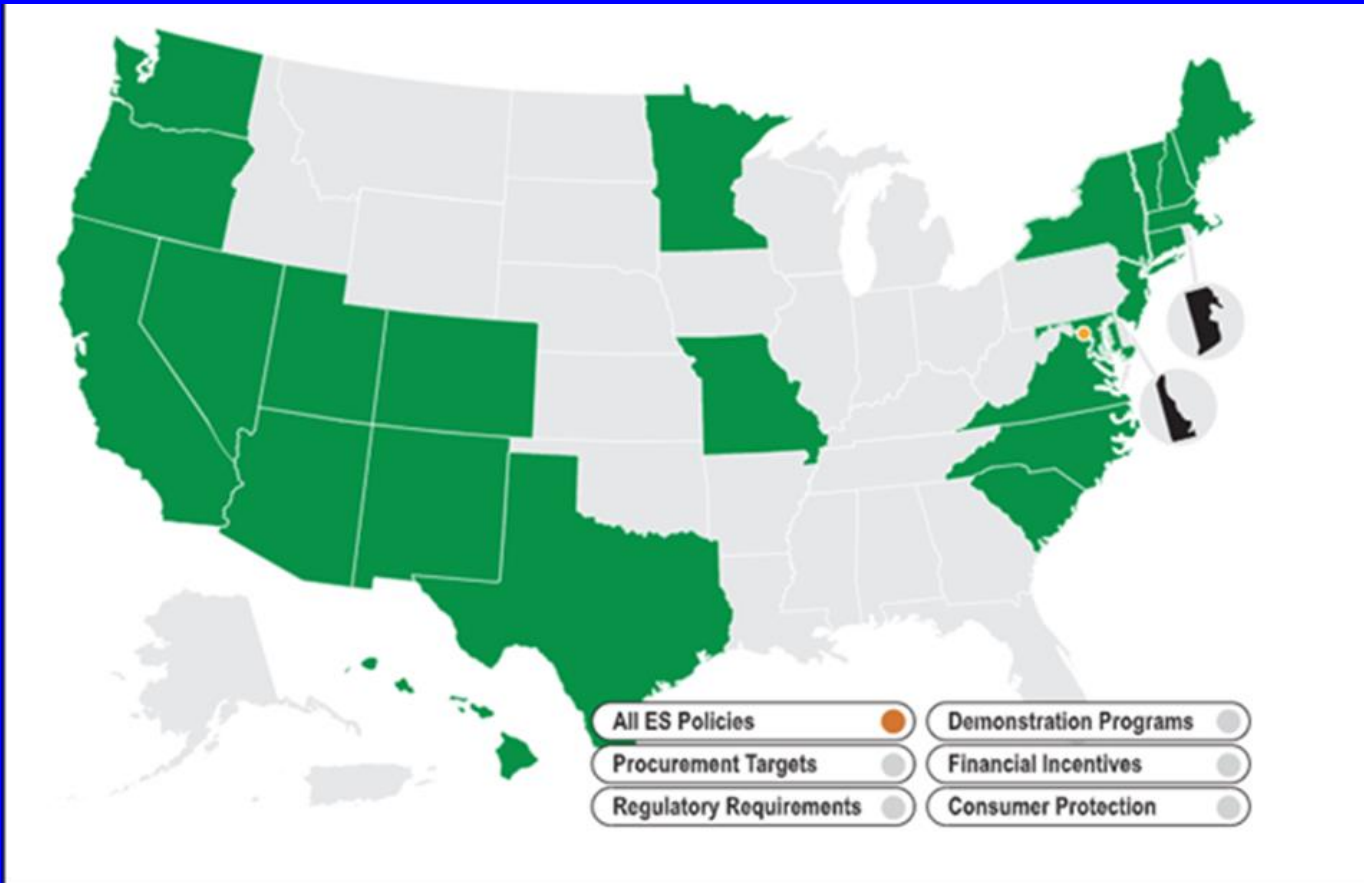
700MW / 4hr, NSW, Australia (announced)

1200MW / 4hr, Hunter, NSW, AU (announced)

510MW / 6hr, Quarzazat, Thermal Salt

110MW / 26hr. Hundedorf, CAES

From ES Policy Data Base



<https://energystorage.pnnl.gov/regulatoryactivities.asp>

Issues:

- Safety
- Social Equity
- Sustainability

Incumbent Lithium-Ion Technology: Sourcing, Ecological, and Sociological Issues Safety, Reliability, Re-Use, Recycling, Disposal



To achieve real Sustainability
we would Ultimately like
to have a Circular Technology
Based on
Earth Abundant and Inexpensive
Materials!

Supply Chain and Waste Stream
Must be part of the design!

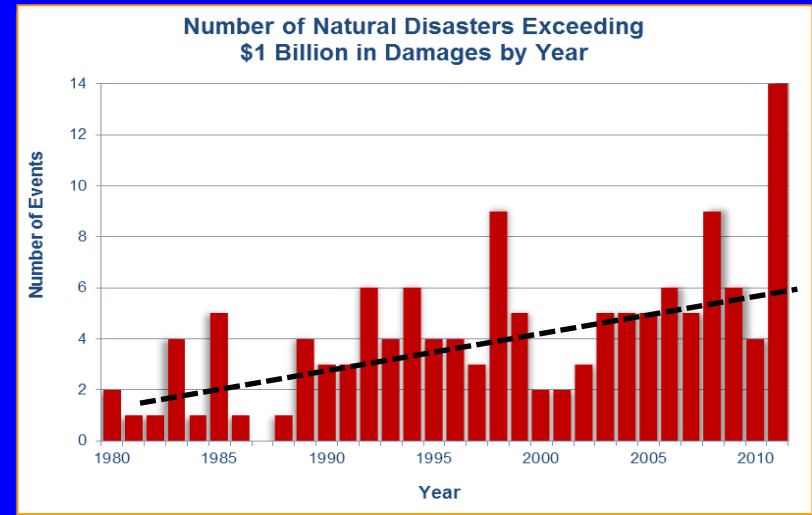
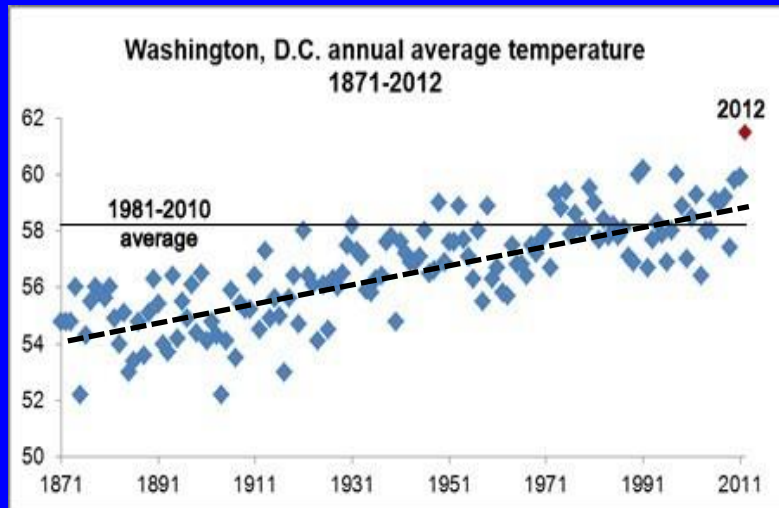
Sustainability: Global Warming is real!



Florida, Harvey, 2017



Now! Worst Drought for 400 years



Global Warming has Emerged
as a Paramount Issue - World Wide!

We must Decarbonize,
we must change to Renewable Energy!

An Urgent Situation!

30 states, Washington, D.C., and 3 territories
have adopted Renewable Portfolio Standards:

CA 100% by 2045, CO 100% by 2050

DC 100% by 2032, HI 100% by 2045

NM 100% by 2045, NY 100% by 2040

VT 75% by 2032, WA 100% by 2032

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As Penetration of Renewable Generation
Continues to increase,
Incremental Solutions
will no longer be sufficient

Longer Duration Storage
is urgently required!

8 Hours – 12 Hours – Days – Seasons

Respectable Storage Goals!

NJ— 600 MW by 2021; 2,000 MW by 2030 (Goal)

NY—1,500 MW by 2025; 3,000 MW by 2030 (Target)

CA – 1,325 MW by 2020 (Target)

OR – > 10 MWhr, up to 1% peak load by 2020 (Mandate)

MA – 200 MWhr by 2020; 1,000 MWhr by '25 (Mandate)

VA – 3,100 MW by 2035 (Mandate)

NV—1, 000 MW by 2030 (Target)

Cost Goals for Focus Technologies

Manufactured at scale

Li-ion Batteries (cells) \$100/kWh

V/V Flow Batteries (stack+PE) \$300/kWh

Zinc Manganese Oxide (Zn-MnO₂)
2 Electron System \$ 50/kWh

Low Temperature Na / Na-ion
based Batteries \$ 60/kWh

Aqueous Soluble Organic (ASO)
Redox Flow Batteries (stack+PE) \$125/kWh

Advanced Lead Acid \$ 35/kWh

On the Horizon:

“Better” Lithium: Innolith (Alevo) / Non-Lithium Technologies
Vanadium Redox, Zinc-Bromine, Zinc-Manganese,
Iron-Chlorine (ESS), Ambri, Sodium (NGK), Lead

Vehicle to Grid – Fleets: School bus, Postal, Military

Non-Battery Technologies:

Cement Blocks, Rail Systems, CAES, Pumped Hydro
Thermal Systems (Ice, PCMs, Aesthus, Malta, Liquid Air)

Chemical Systems: Hydrogen, Ammonia, etc.

But what
is the Business Case
for effecting
widespread LDS??

100% Decarbonization
by 2050 ?

It will need a
Deep Transformation
of the entire
Energy Industry!!