SYLLABLE TECHNOLOGY AND DESIGN

# UNDERGROUND PUMPED HYDROELECTRIC STORAGE

## REPORT SUMMARY, DRAFT 0.0.3

**Full report can be found here: github.com/syllable-hq/uphs-feasibility-study**

"We only get one home.
We only get one planet.
There's no plan B.

– President Barack Obama

# Underground Pumped Hydro Storage

We must stop climate change.
This requires renewable energy.
Which also requires energy storage...
Trillions of dollars of it.

Over 40 years, Underground Pumped Hydro Storage
could be 7-30 times cheaper than Li-ion batteries

# Climate change damage is escalating

Annual climate damage cost to the United States one decade from now:

**$360 billion a year**

(That's half of the expected growth of the economy)

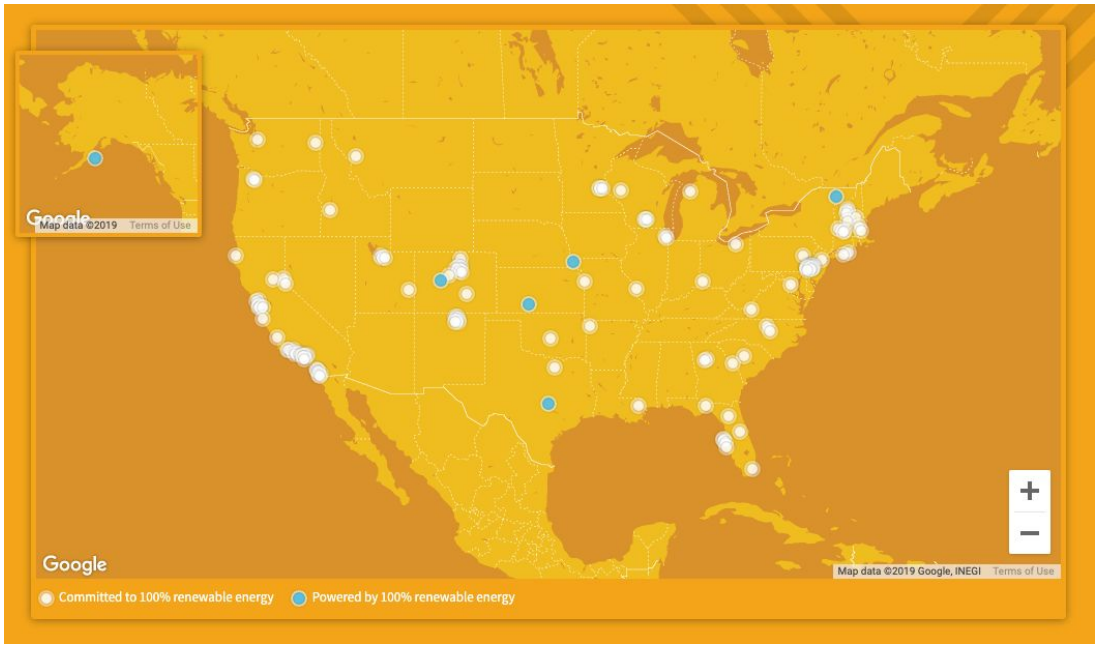
*https://feu-us.org/case-for-climate-action-us/*

# What are we doing about it?

U.S. cities have pledged to become carbon neutral by 2050.

But 100% renewable energy won't work without another key ingredient:

We also need enormous volumes of Energy Storage.




*https://thesolutionsproject.org/2018-impact-report/*

# Why do we need Energy Storage

The sun doesn't always shine & the wind doesn't always blow.

So, renewable energy increases our grid's supply variability…

which makes it hard to match our grid's real-time energy demands.

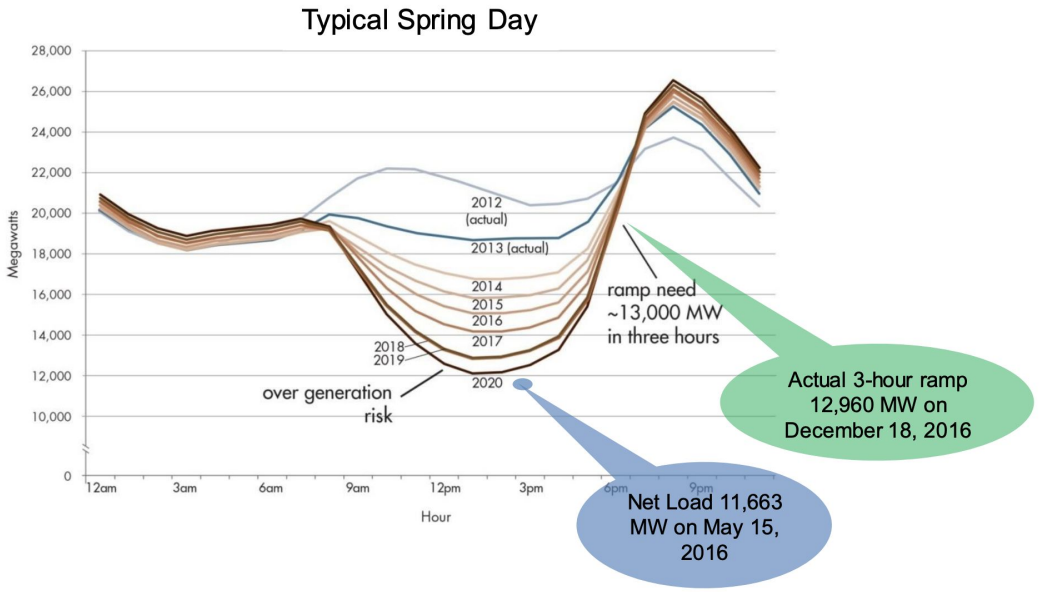



Figure 3. CAISO duck chart (source: CAISO)

*https://www.caiso.com/Documents/UsingRenewablesToOperateLow-CarbonGrid.pdf*

# How much energy storage do we need?

Getting to 100% wind and solar energy requires enormous volumes of energy storage.

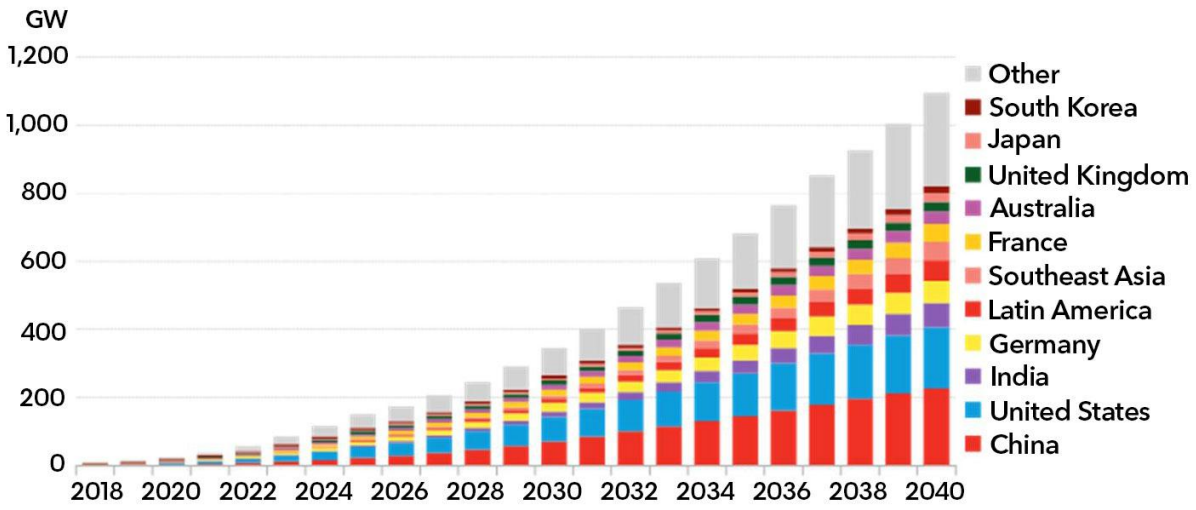
Exponential growth is expected for the market.

~ 14x by 2024
~ 122x by 2040 *

* Not even including pumped hydro installations

*https://bnef.turtl.co/story/neo2019*

Global cumulative energy storage installations




*Source: BloombergNEF*

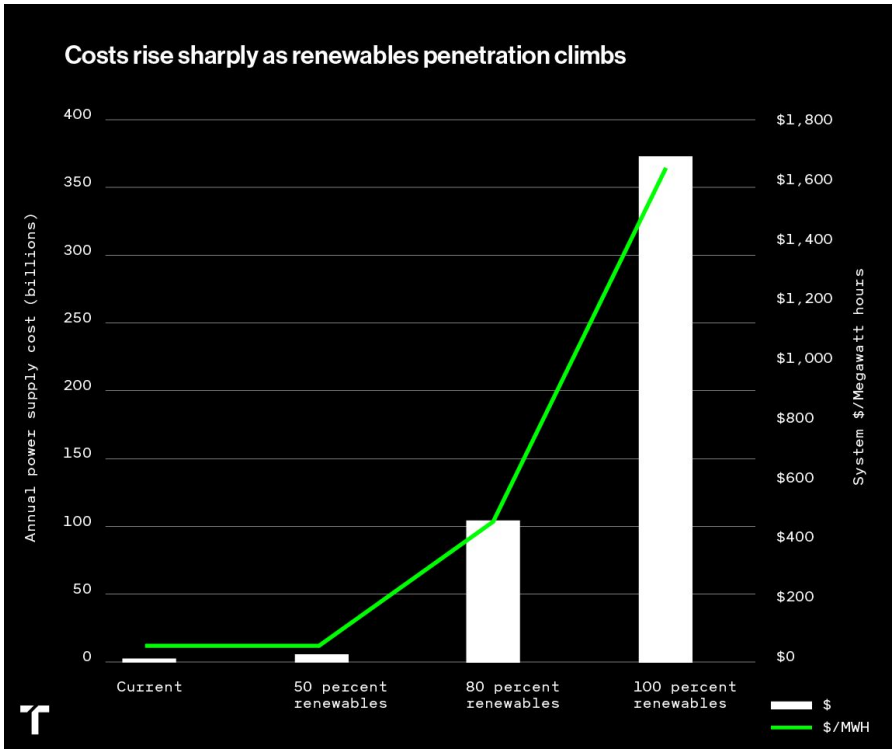
# How much will this cost?

We need way more energy storage. Our current capacity is only 2.5% of our overall energy supply.

Li-ion batteries + 80% renewable energy sources would cost too much. How much?

$2.5 Trillion ∧. Just for California.

We need something cheaper...



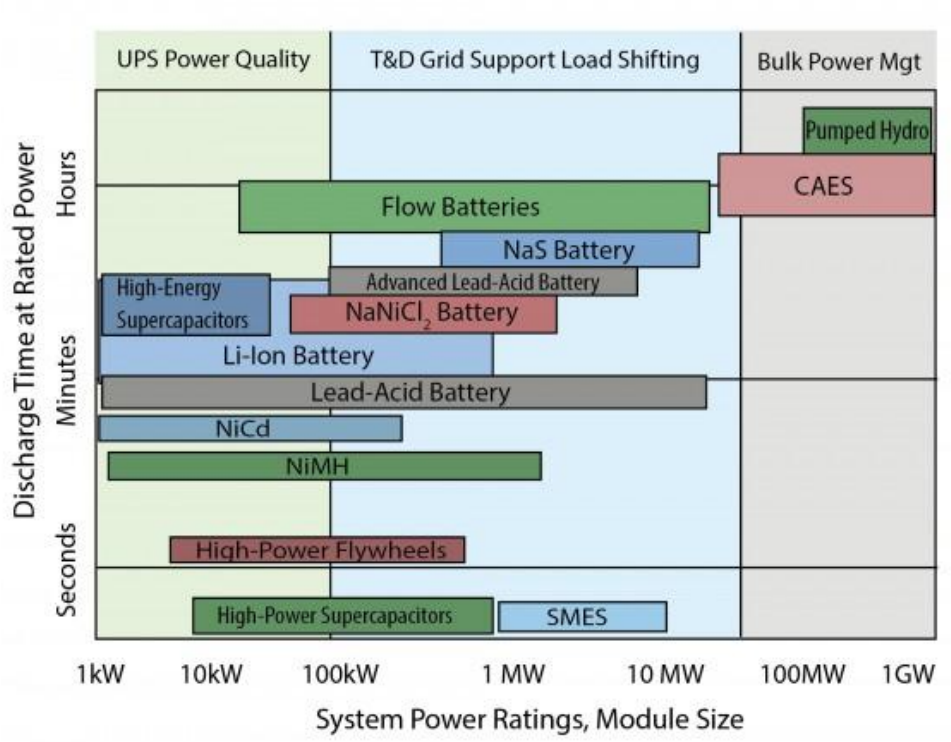

*https://www.technologyreview.com/s/611683/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/*

# How can we build this energy storage?

There is only one cheap, proven, carbon-free, solution for bulk power management:

**Pumped Hydro Energy Storage**

Chemical battery solutions are not suitable for grid-scale storage.



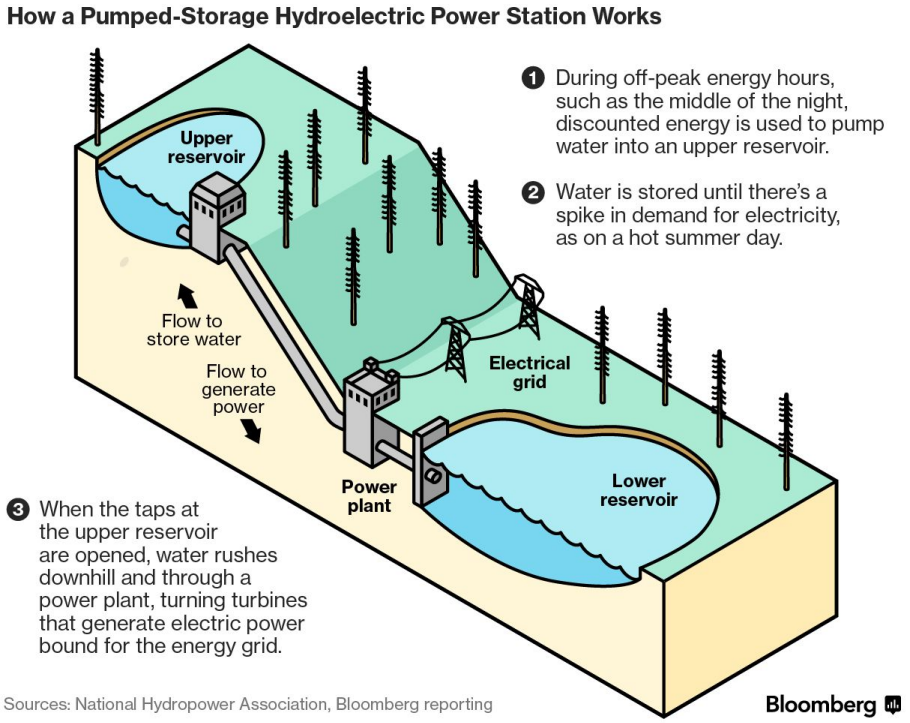

*http://css.umich.edu/sites/default/files/U.S._Grid_Energy_Storage_Factsheet_CSS15-17_e2018.pdf*

# What is Pumped Hydro?

Pumped Hydro Energy Storage is simple. We just pump water up and down a hill.

This is how we generate almost all of our energy storage.

Pumped hydro supplies 94% of our stored energy.




*https://www.bloomberg.com/news/articles/2019-06-06/in-quest-for-bigger-batteries-california-mulls-century-old-idea*

# Why not Pumped Hydro?

Pumped Hydro Energy Storage is beautiful, simple, and efficient. But it has disadvantages:

- New dams harm ecosystems
- Construction time is long
- Limited viable locations

New Pumped Hydro permits have spiked, but projects are being delayed by eco concerns.

*https://www.bloomberg.com/news/articles/2019-06-06/in-quest-for-bigger-batteries-california-mulls-century-old-idea*

# A clever work around: go underground

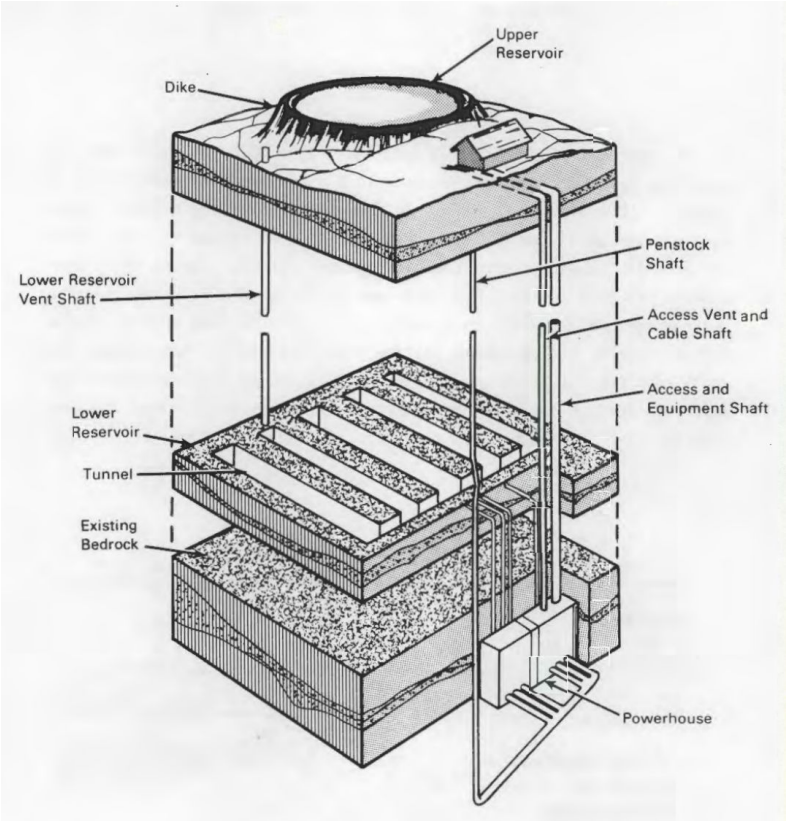
Introducing: Underground Pumped Hydroelectric Storage (UPHS)

UPHS is just regular pumped storage, but the lower reservoir is dug out of bedrock.

*"The UPHS concept is technically feasible and economically viable."*

*-- A U.S. Dept of Energy report from the 1980s*

*https://www.osti.gov/biblio/6517343*

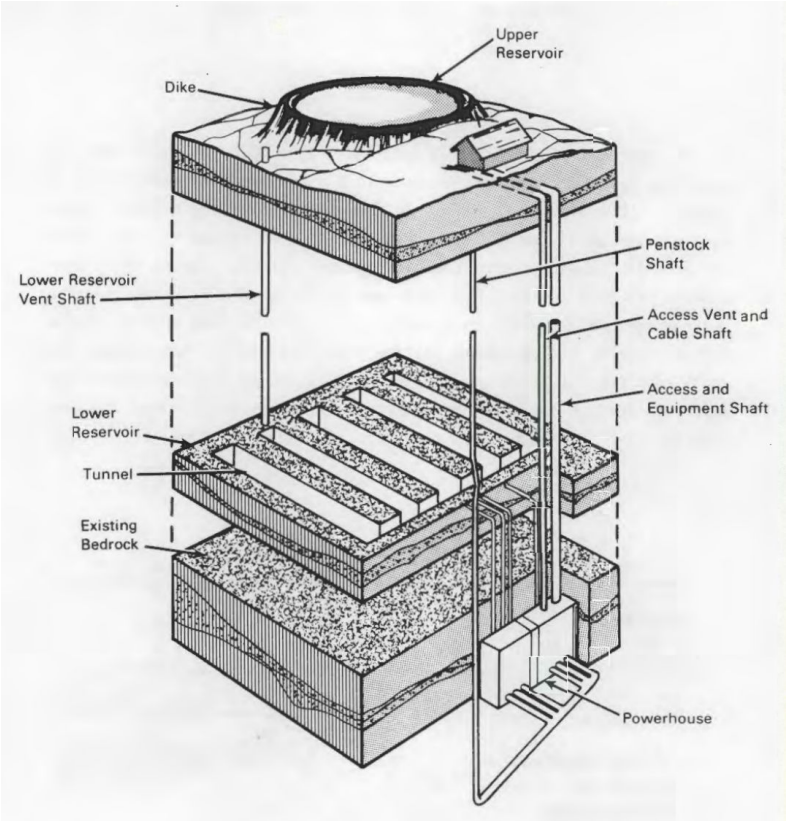


# UPHS to the rescue?

A U.S. DOE report from 1984 determined that UPHS costs about the same as traditional pumped storage.

Today, it might even be 4x cheaper.
(better technology + better market conditions)

And adding UPHS to existing dams avoids environmental concerns.




*https://www.osti.gov/biblio/6517343*

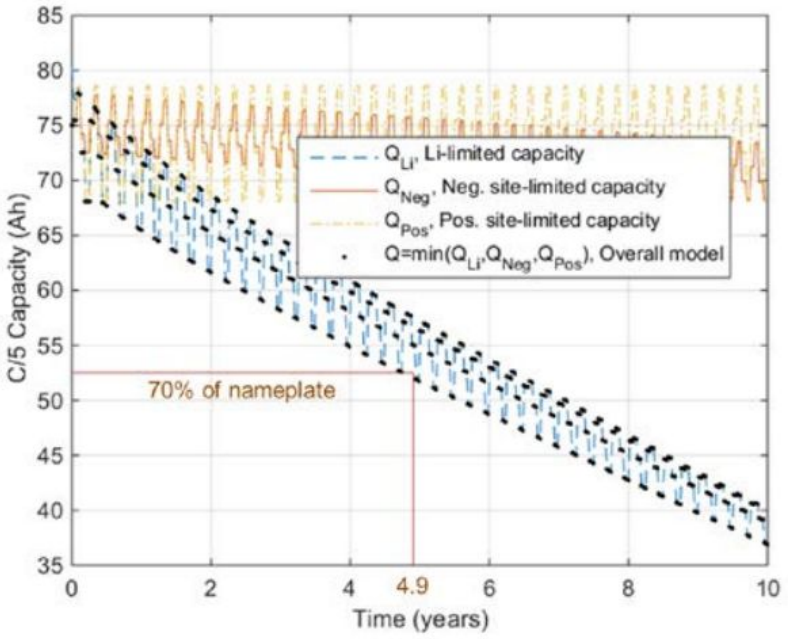
# UPHS is cheaper than Li-ion batteries?

UPHS is cheaper than Li-ion batteries. Especially in the long term, because:

Li-ion batteries only last 10 years

But UPHS lasts 80+ years. So,

**Over 40 years, Li-ion could be 7-30 times more expensive than UPHS**




*https://github.com/syllable-hq/underground-pumped-hydroelectric-storage-feasibility-study*

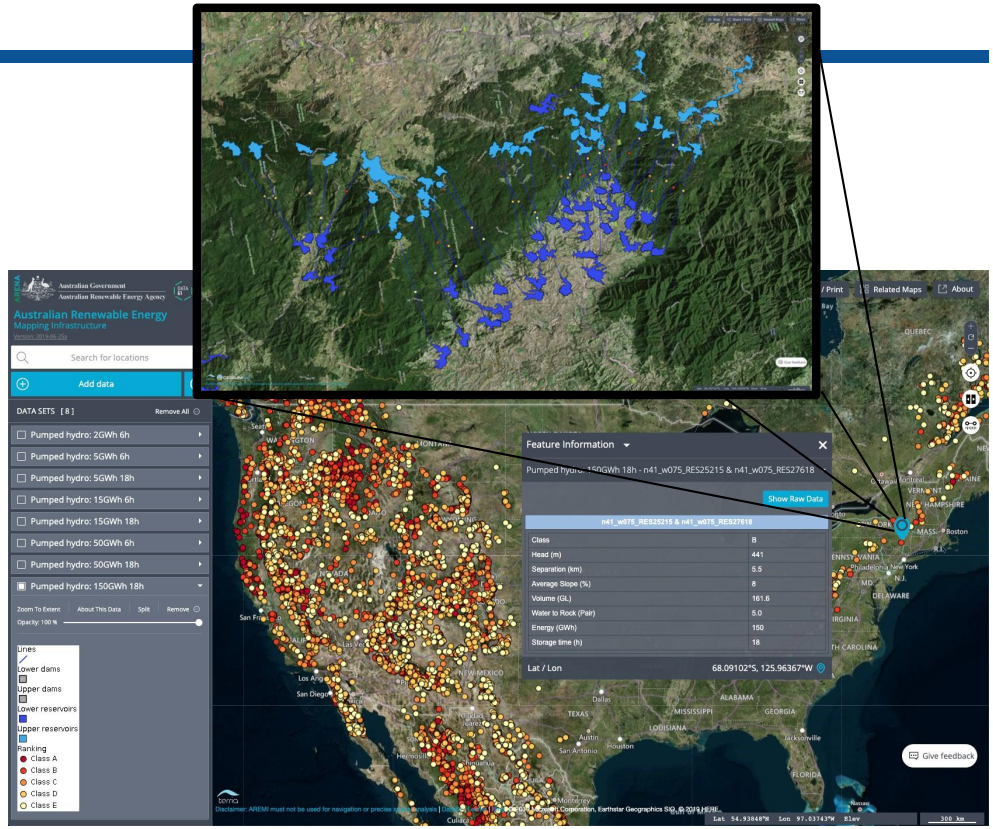
*Li-ion battery capacity over time: https://www.nrel.gov/docs/fy17osti/67102.pdf*

# So what's next?

What's next?
We need to do more research

We can use mapping tools to discover optimal sites for pumped storage, including underground pumped storage.

We should immediately test and develop this promising technology.




*http://re100.eng.anu.edu.au/global/*

“

**We’re the first generation to feel the impact of climate change.**

**We’re the last generation that can do something about it.**

**– President Barack Obama**

# Thanks

**For the full report, visit:**
**github.com/syllable-hq/uphs-feasibility-study**