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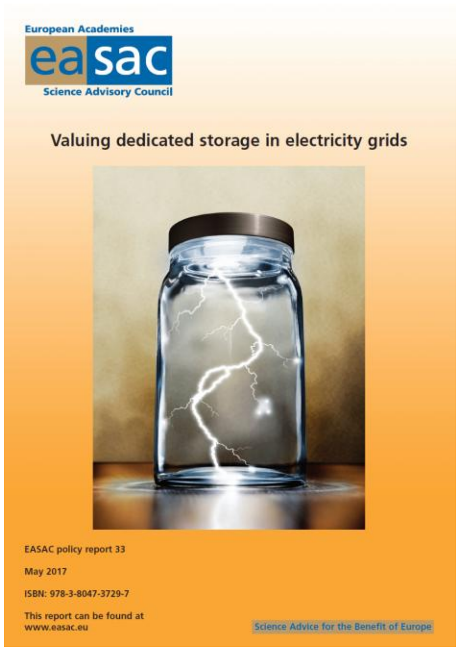
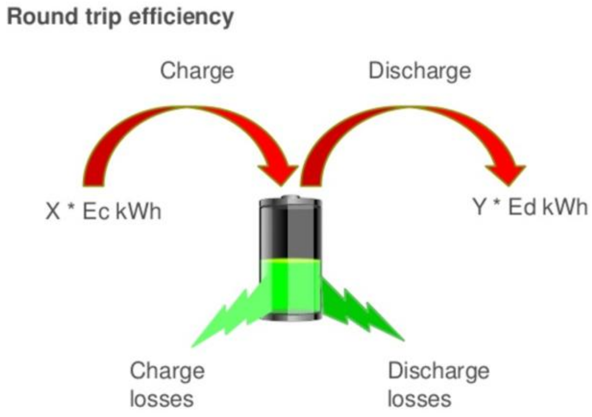
‘Valuing Dedicated Storage in Electricity Grids’



Mark O’Malley, McGill University, University College, Dublin & Royal Irish Academy
Dublin, 7th September 2017



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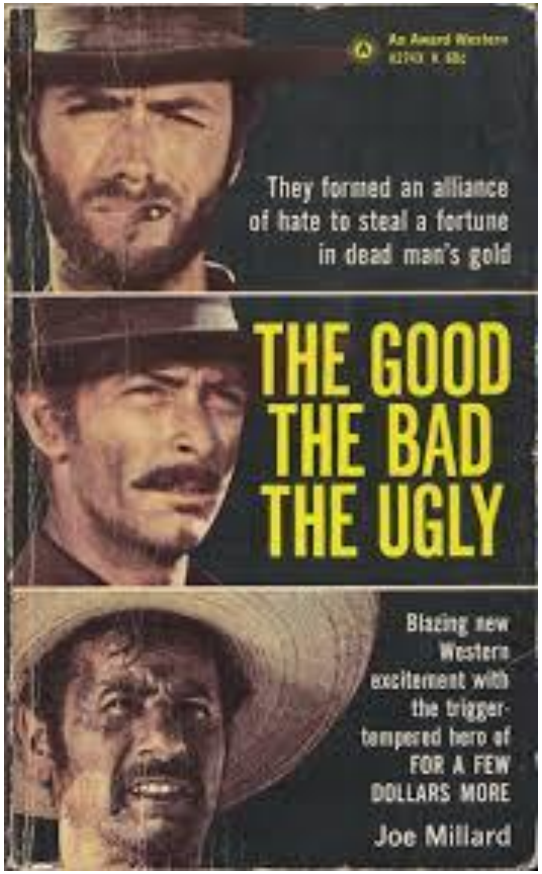

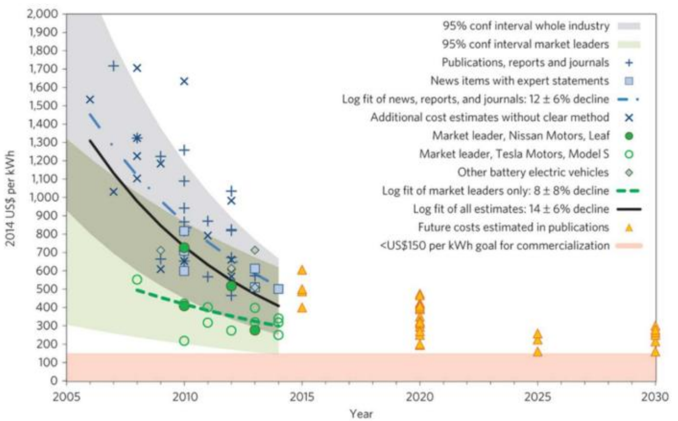

Source: Nature Climate Change 5, 329–332 (2015)

Graph 1. The cost evolution of vehicle batteries.

EASAC storage project timeline

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Project kick-off meeting London, April ‘15

2nd project meeting, Cologne, July ‘15

Open workshop and 3rd project meeting, Brussels, October ’15

Workshop and 4th project meeting, Dublin, March ’16

Report drafting, editing, peer review and finalisation.
Launch
19 June ‘17

Dedicated storage deployment (49 GW in 2016)
(Pumped Hydro, Compressed air, Flywheels, Batteries)

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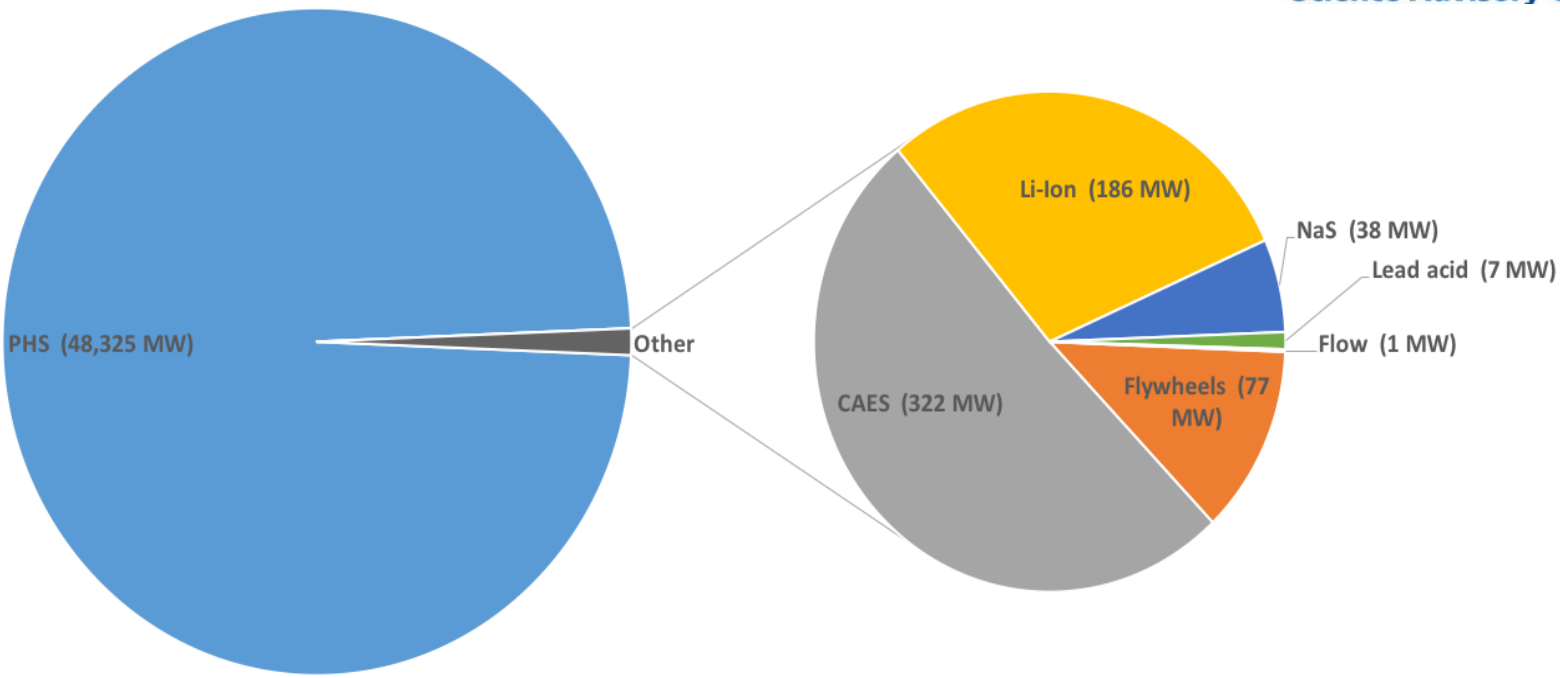

Current deployment of grid connected electricity storage in EU28+NO+CH

Note: Data were exported from DOE database in September 2016. Specialised applications of high power flywheels in UK and German fusion research labs and the RWE Adele Compressed Air Energy Storage (CAES) plant (which is not operational) were excluded.

Potential for cost reductions in dedicated storage technologies

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Technology	Potential for future cost reductions
Pumped Hydroelectric storage (PHS)	Low
Compressed air energy storage (CAES)	Medium
Flywheels	Medium
Lead acid batteries	Low
Li-ion batteries	High
Sodium ion batteries	High
Redox flow batteries	Medium / High
Sodium sulphur batteries	Medium
Super capacitors	Medium
Power to gas to power (P2G2P)	Medium
Cryogenic energy storage (CES)	Medium

Projected cost reductions for Lithium ion batteries (cell price)

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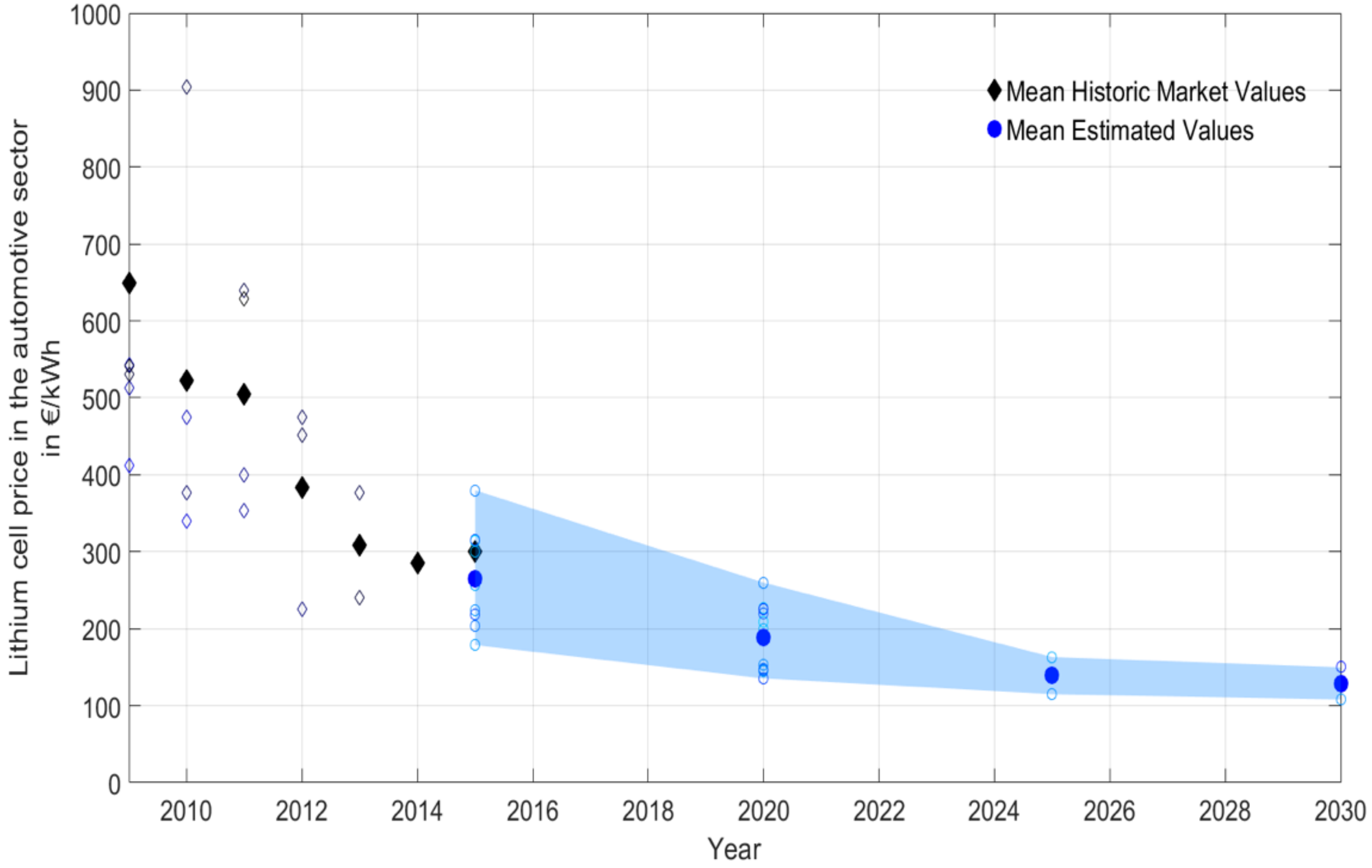

Non-dedicated storage options

- **Power to heat** – a low cost alternative to curtailment, but not usually possible to revert to electricity. Typically the heat is used in buildings where its value may be low because of competition with other low cost options.
- **Power to gas** – already technically feasible and being studied in demonstration projects for transport and industry applications.
- **Battery electric vehicles** – an application of growing interest where owners of electric vehicles can use their batteries also to contribute to self consumption at home or at work.

Storage technologies in EU electricity grids

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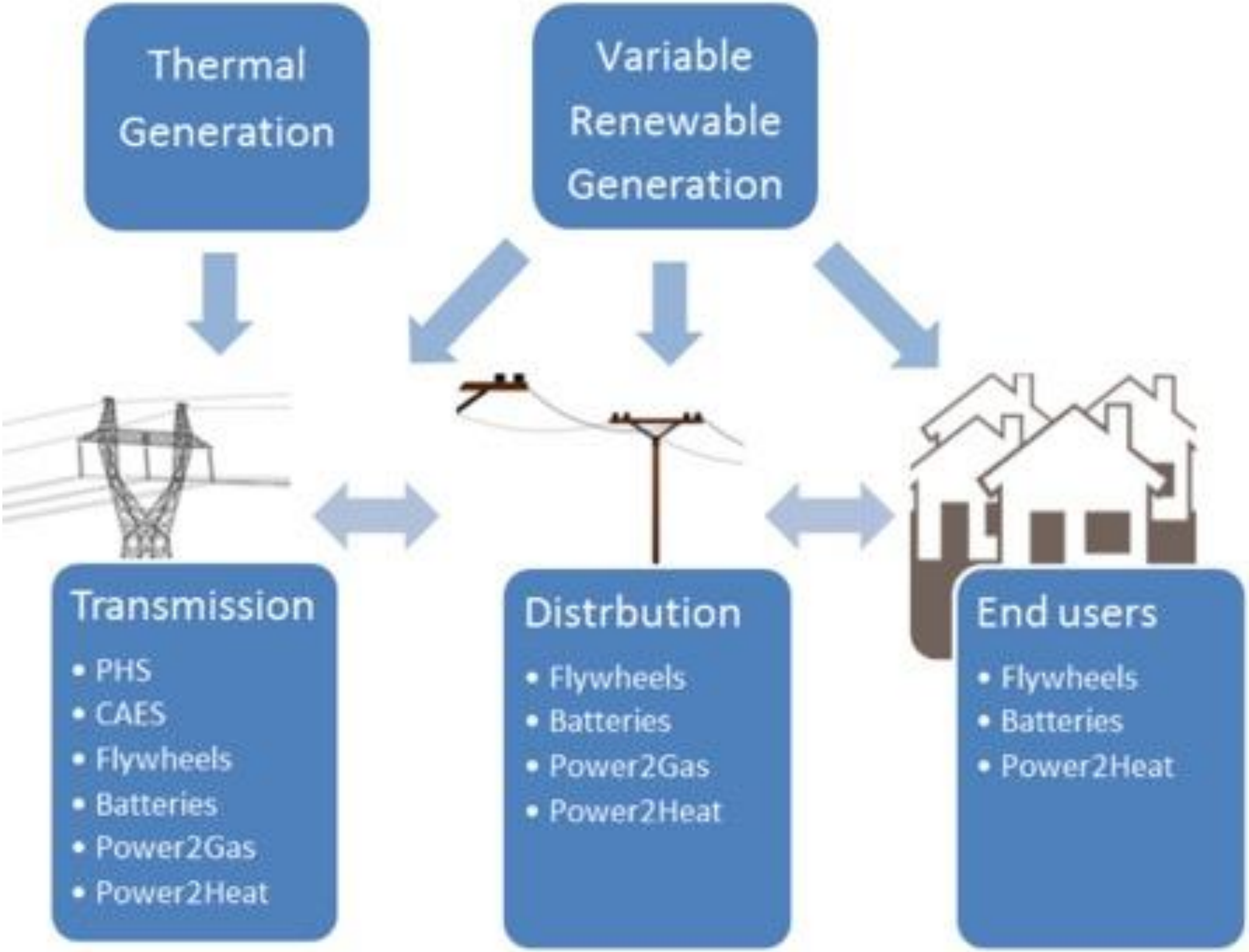

Services offered by storage to electricity markets

- **Energy arbitrage**
- **Ancillary services**
  - Reserves (frequency control and balancing).
  - Voltage control
  - Black start
- **Grid adequacy** (for congestion control and up-grade deferral)
- **Generation adequacy**
- **End user and consumer needs**
  - Power control / local back-up
  - Self consumption (PV + battery)
- **Operation in multiple roles and markets**

Modelling and assessing values of storage

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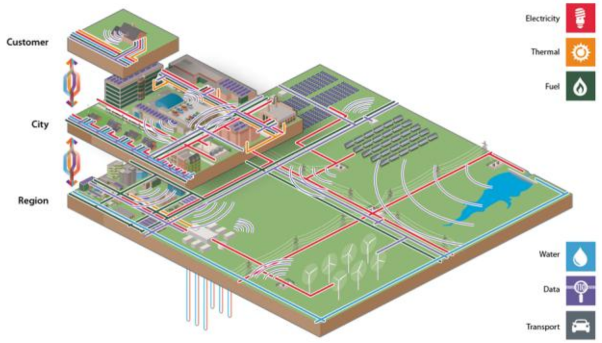

- **Modelling methodologies reviewed**
  - **System models**
  - **Storage-centric models**
- **Findings from peer reviewed modelling assessments**
  - Storage to reduce variable renewable electricity curtailment
  - Storage for multiple uses
  - Marginal value of additional storage
  - Value of storage depends on services provided
  - Value for isolated systems and weak interconnected areas
  - Competitiveness of storage
  - Expected deployment
- **Gaps and priorities for further research**

Conclusions
What is the value of storage?

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1) The value of dedicated storage is system dependent and it has many competitors
2) Dedicated storage in grids is expensive today, but its costs are falling (notably Li-ion batteries) and its value is improving
3) Storage adds value by providing flexibility (e.g.: congestion management)
4) Storage also adds value through balancing, reserves, capacity, and generation adequacy
5) Batteries are valued by consumers for self-consumption (prosumers)
6) Storage is particularly valuable in isolated systems and grids

Conclusions
What are the limits of storage?

1) **Storage will not greatly reduce EU needs for back-up generating capacity**
   a) Storage adds capacity (e.g. for peak loads) and can displace some back-up generation, but cannot deliver rated power for more than ~10 hrs
   b) There can be periods of several days with little wind and solar generation
   c) Sufficient dispatchable generation and/or interconnections are needed

2) **Seasonal storage technologies are being developed**
   a) Power to gas (P2G) options could soon be ready to limit curtailment
   b) Seasonal storage will not be needed until more renewables are on line
   c) P2G2P systems are too costly and their efficiencies too low – they are unlikely to be ready for deployment as seasonal storage before ~2050.

Conclusions: what should be done to ensure that storage is used effectively? (1)

1) **Electricity market design should deliver price signals (locational and temporal) which encourage investments in cost-efficient flexibility options on both transmission and distribution grids.**
   a) Tariff structures should focus more on costs per kW (less on costs per kWh), to make the values of efficient flexibility and congestion management more visible to potential investors.
   b) Re-organisation of bidding zones (make them smaller) is needed to deliver a cost efficient mix of flexibility options.
   c) Investors need transparency on future plans for flexibility management (Marginal value of adding flexibility decreases as more is deployed)
   d) It is too early to assess the values of recent storage incentives, targets or demonstration programmes.

Conclusions: what should be done to ensure that storage is used effectively? (2)

2) **Electricity market design should address PV plus battery systems on distribution grids.**
   a) Consumers want self production, but the costs of grid infrastructure should be shared fairly across all users, and any additional costs of congestion management should be attributed to those who create them.
   b) Benefits for distribution system management, resulting from the use of (aggregated) household storage systems, should be fairly shared between those who provide them.
   c) Time-of-day tariffs and smart meters will be needed to address these issues.

Conclusions: what should be done to ensure that storage is used effectively? (3)

3) **Electricity market design should not create barriers to the deployment of potentially valuable systems and technologies (including storage).**
   a) All system assets and technologies for providing flexibility to the grid (including storage) should be defined and accommodated.
   b) Minimum bid sizes, lack of provision for aggregator involvement, and double taxation (tax on energy coming into and out of storage) currently limit participation of storage in some markets.
   c) Storage owners or aggregators should be permitted multiple use with value stacking, eg for regulated functions when contracted by system operators, and in competitive markets at other times.
   d) EU funds (eg: CEF, EIB) should give equal treatment to all options for grid flexibility, including interconnections and storage.

Conclusions: Policy for science

More research and development is warranted with a focus on:

1. Continuing to reduce the costs of storage
2. Pursuing continued technological advances for dedicated grid connected (stationary) applications, which are not necessarily well matched to those needed for transportation (e.g. energy density and cycle life requirements can differ significantly).
3. Studies and analysis (including modelling) of transmission and distribution systems and markets, including socio-economic monitoring of storage demonstrations and innovation programmes, and of prosumer markets, as the market design evolves.

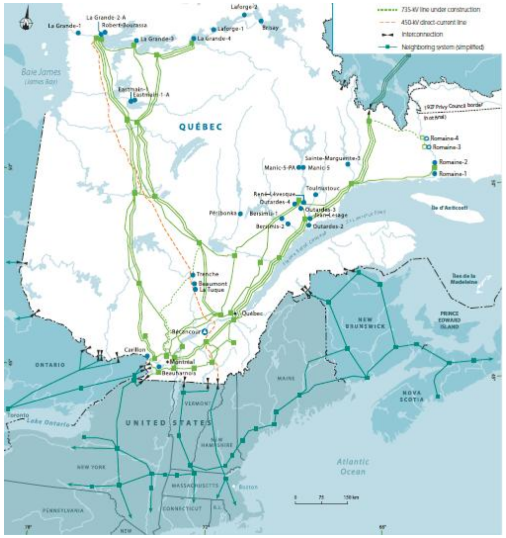
Real Storage

≈40 GW

27 large reservoirs

***176 TWh** of storage*

2,000,000,000



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Acknowledgements

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