

Adding Energy Storage to the Grid

How can adding storage help a utility

Allows up to 100% solar, wave, tidal or wind generation

Can allow diesel engines to operate continuously at top fuel efficiency

Can improve voltage regulation at the far ends of the grid

Very rapid response to load changes

Where to install storage

Not a critical issue, with remote monitoring and control, storage can be distributed and placed almost anywhere on the grid.

Major Types of Energy Storage

Mechanical (flywheels)

Pumped water storage

Compressed air

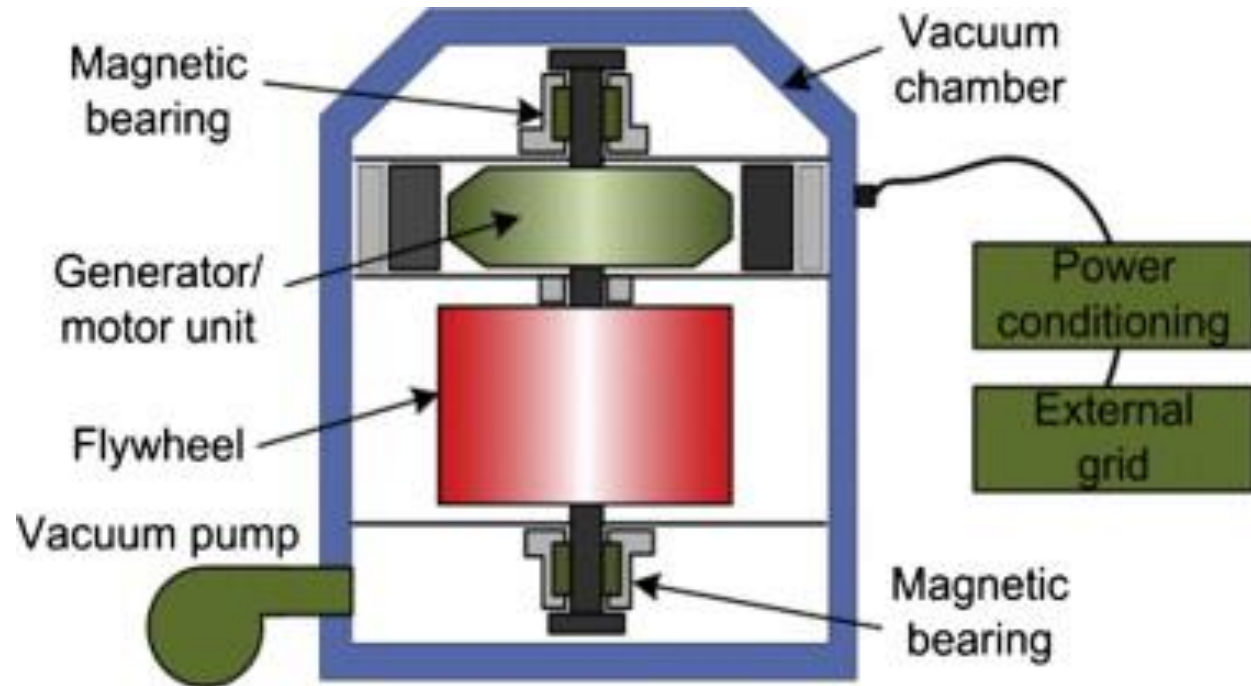
Heat storage

Capacitors

Flow batteries

Static Batteries

Flywheel Storage



Spinning at over 16,000 RPM and weighing over 1.5 tons, the flywheel is brought to speed by the motor using surplus electricity and energy is taken out by tapping that high kinetic energy using the generator to make electricity when needed to fill in gaps in generation

20 MW Flywheel Energy Storage Facility in the USA (100 kW per unit)



Advantages

- Very fast response time for load changes

Disadvantages

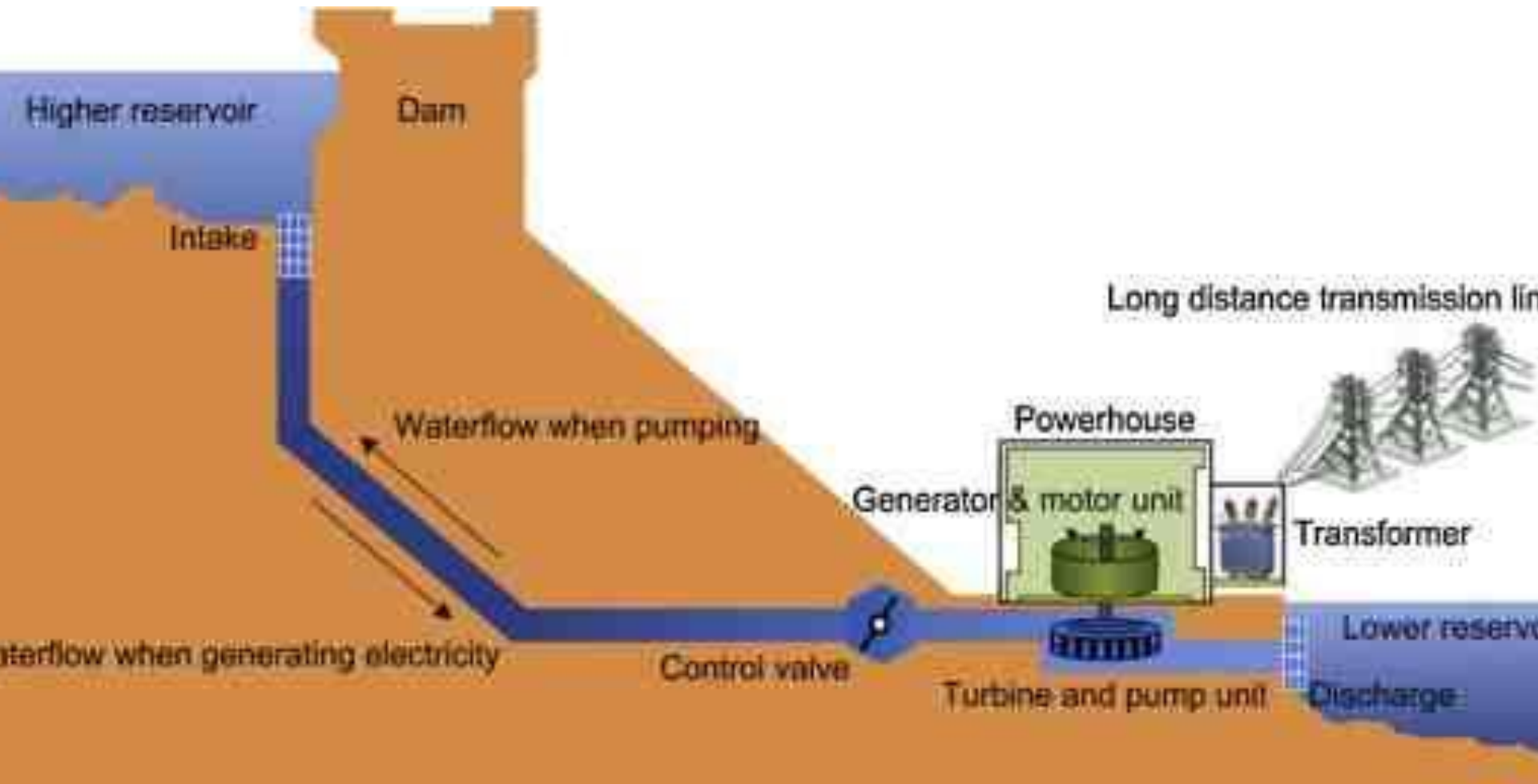
- High cost

- Best to manage rapid variations from solar, not good for long term (multi day) storage

- No experience with small utility storage

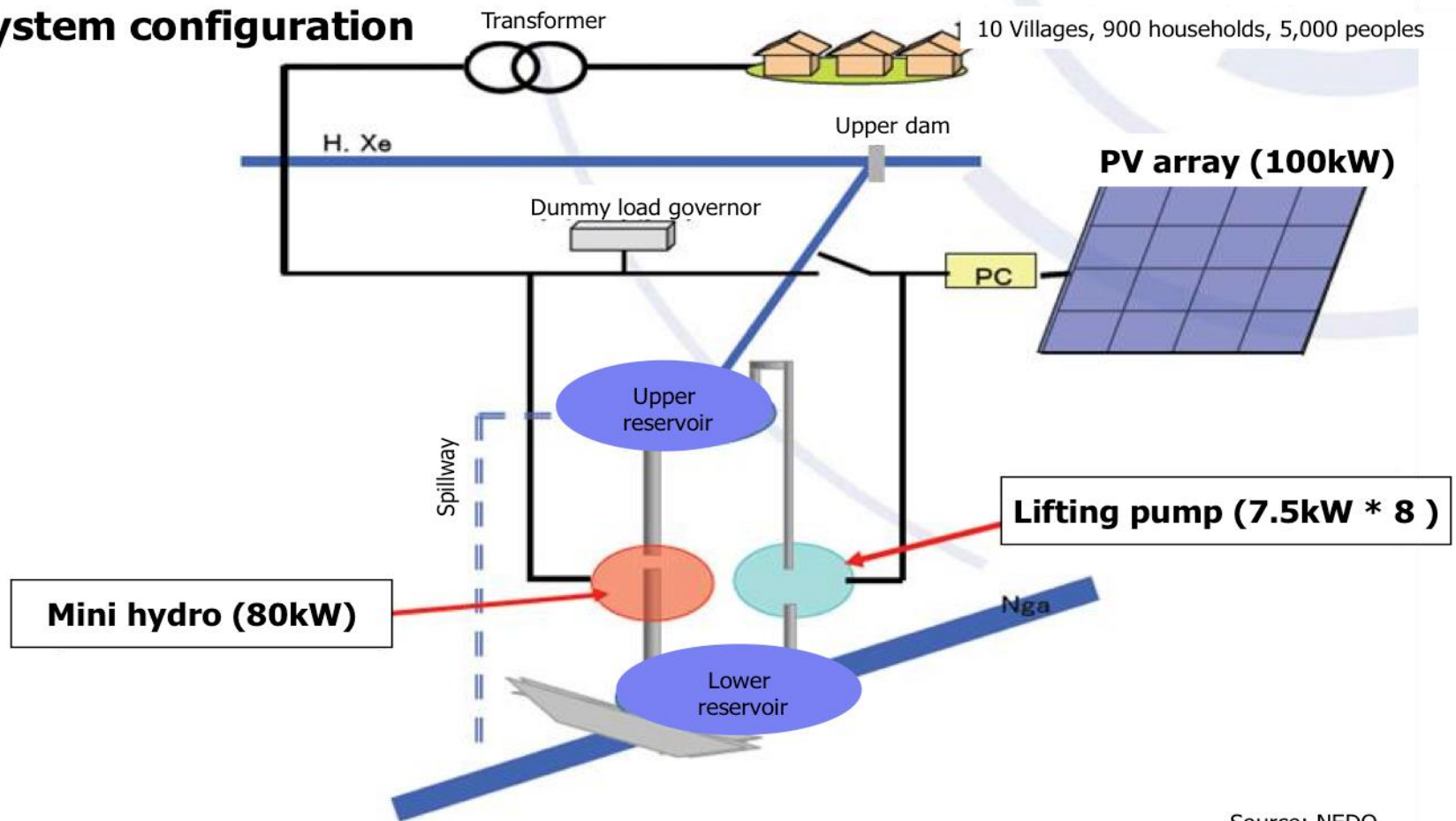
- High maintenance

Pumped Water Storage



NEDO Solar and Pumped Hydro Project in Laos

System configuration



Source: NEDO

Laos 100 kW Solar With Pumped Storage



Advantages

If topography is good, can be relatively cheap and reliable storage

Well tested technology

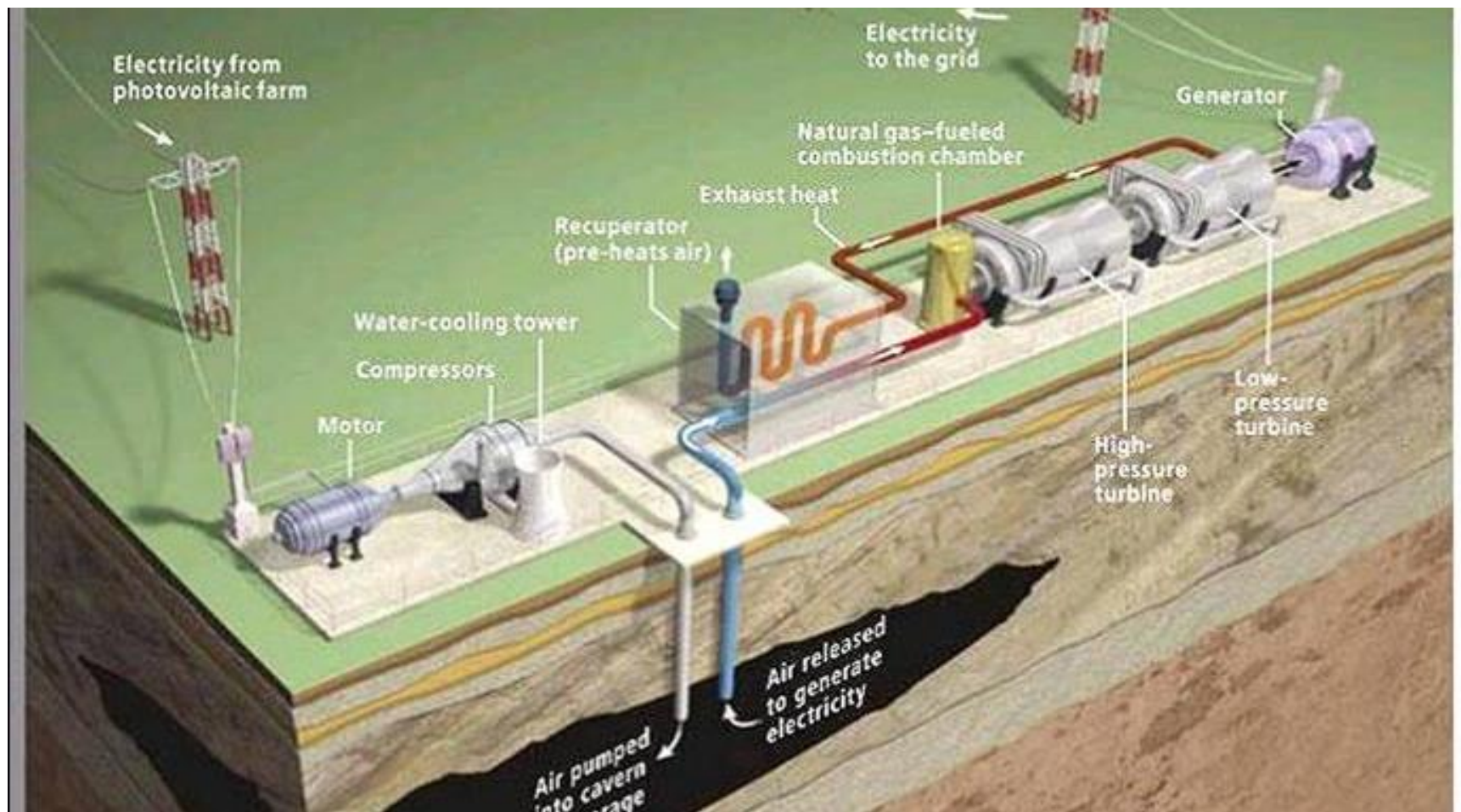
Disadvantages

Perfect topography is rare

Land issues both for the pond and for the delivery pipe

Relatively high losses

Compressed Air Energy Storage



Advantages

- Can provide long term storage

- Uses commercial mechanical technology

Disadvantages

- Hard to find a suitable underground chamber

- Relatively high losses

- Complex and expensive

- High maintenance

- Little real world experience

- Not a good match for small utilities

Thermal Energy Storage

Stores heat in a special salt or in water and runs a low temperature turbine to generate electricity

Only suitable for thermal type solar generators (power tower and concentrating collector systems) which are very unlikely to be used in the Pacific

Capacitor Storage

Advantages

- Very fast response

- long life

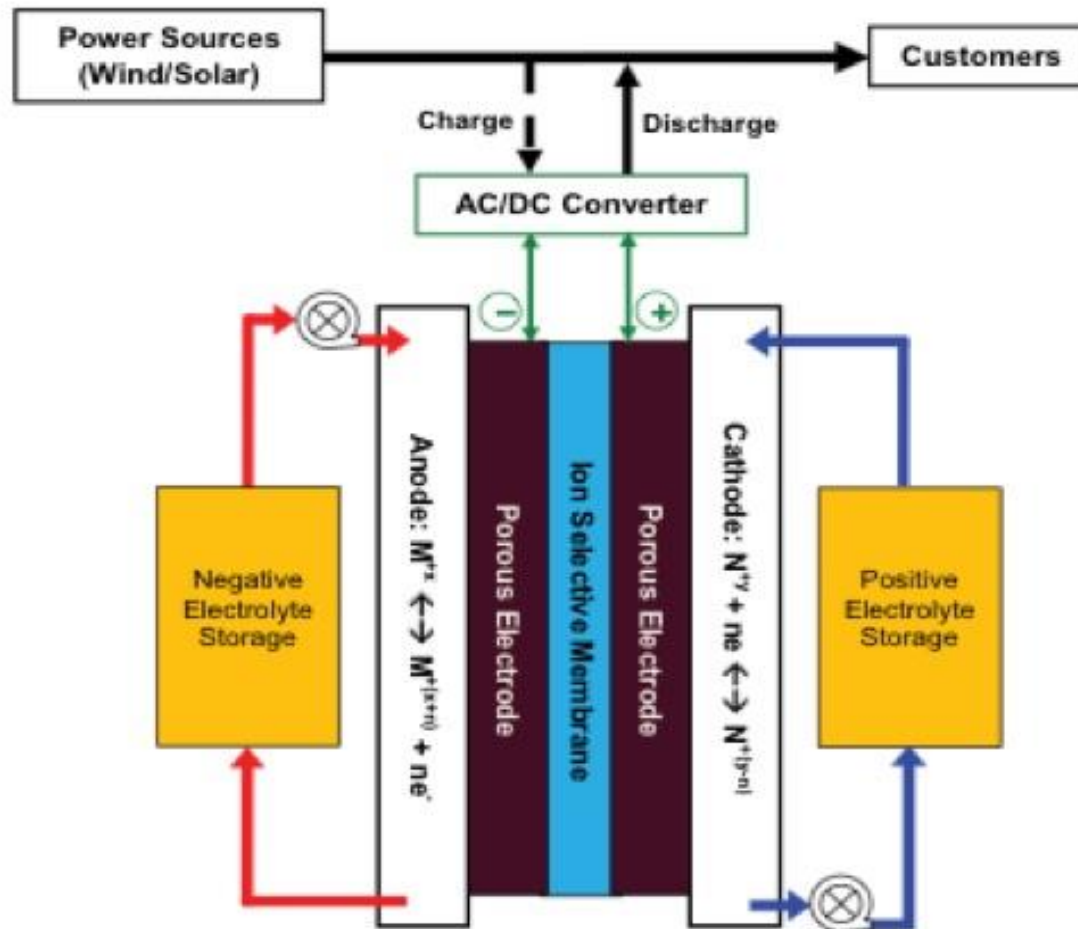
- Charge rapidly

Disadvantages

- Very expensive

- Suitable mainly for rapid delivery of energy to offset solar variations, not practical for long term storage

Flow Batteries



Advantages

- Very long life of components

- Good conversion efficiency

Disadvantages

- Still under development

- More expensive than Li-ion units

- Typically operate at high temperatures

- Generally not cost effective for small utilities

Static Batteries

Commercially available batteries for small utility scale storage

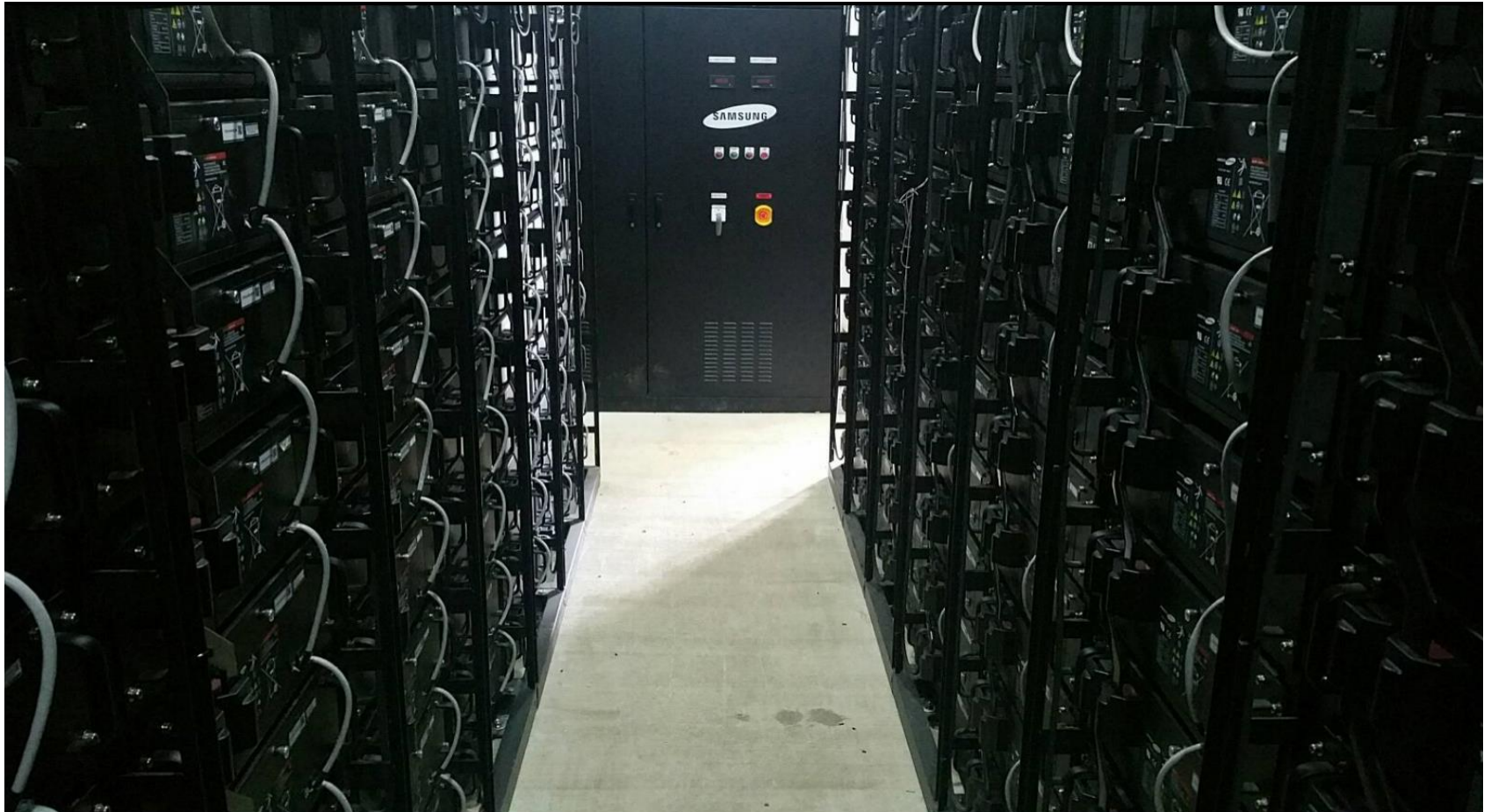
Lead-Acid

Lithium-ion

Small Li-ion Batteries - Niue (For Power Stabilization Only)



Large Li-ion Battery Bank (2MWh storage) Iririki Island, Port Vila, Vanuatu



Advantages of Li-ion batteries

Much lighter than lead-acid

Longer life than lead-acid

Not sensitive to deep discharging

Disadvantages

Still more costly per kWh than lead-acid batteries

Potential fire hazard

Sealed Lead Acid Batteries



Advantages of sealed lead-acid units

- Can be stacked or mounted in any position

- No maintenance

- Shipping while charged is ok

- Readily available

Disadvantages of sealed units

- More expensive

- Must not be overcharged

- No maintenance possible

- Very heavy

- Must be kept at full charge if in storage more than two months

Open Cell Lead-Acid Battery



Advantages of open cell lead-acid batteries

- Cheapest per kWh storage

- Not sensitive to overcharging

- Readily available

- Longer life than sealed batteries

- Can be shipped cheaply 'dry' then filled with electrolyte on site

- More forgiving of abuse than sealed batteries

- Equalization charging is practical to reduce sulphation

- Spares can be stored 'dry charged' for years without degradation

- Usually have transparent cases so the 'guts' are visible

Disadvantages

Require adding distilled water about twice a year

Shipping charged batteries is very expensive

Very heavy

Must be transported upright

What is the main disadvantage of all energy storage technologies?

Loss of 15% to over 40% of grid energy in the conversion to stored energy and back to delivered energy

TANSTAAFL

DISCUSSION