

Electric Energy Storage in Batteries Platon Baltas Athens 16 October, 2018



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- Energy Storage has always been a desired option. Pumped hydro plants represent over 95% of existing energy storage worldwide, however:
 - Round trip efficiencies around 70%
 - Environmental issues
 - Capital intensive costs depend on location
 - Centralized storage not dispersed
 - LIMITED POTENTIAL FOR GROWTH
- Compressed air energy storage efficiencies around 50%
- Need to introduce more renewables in the mix implies need for new storage options to accommodate this. Renewables have lower cost and this may economically justify the use of storage.
- Progressive Electrification (electric vehicles, heat pumps, etc.) implies changes in load profiles and need for flexibility
- Advancements in electrochemical storage technologies are promising low cost solutions









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Enabling Storage Technologies

- Lead Acid Lead Carbon
 - Mature technology no great potential for performance improvement and drop in cost
 - Environmental restrictions
 - Cost depends on cost of Lead
 - Heavy batteries cannot be used for electric vehicles
- NaS
 - High cost
 - Very few companies produce it (NGK)
 - High temperature complicated system
- Flow batteries
 - High cost
 - Not mature technology
 - Cannot be used for mobility
- Li Technologies
 - Use in mobile phones and hybrid vehicles resulted in technology advancement and cost drop
 - Today, kWh cost of battery is 3.5 times of Lead acid but more than 3,5 times the cycling
 - Low weight battery can be used for electric vehicles











Cost of storage –rough calculations

- Lead Acid Batteries
 - (OPzV)
 - 100 €/kWh
 - 1200 cycles
 - 80% efficiency
 100 €/kWh / 1200 + 20% of the cost of electricity =
 = 100 €/MWh
 - (Lead Carbon)
 - 150 €/kWh
 - 3000 cycles
 - 80% efficiency
 150 €/kWh / 3000 + 20% of the cost of electricity =

= 67 €/MWh

- Li Batteries
 - (LFP or NMC)
 - 250 €/kWh
 - 6000 cycles
 - 90% efficiency

250 €/kWh / 6000 + 10% of the cost of electricity = = **50 €/MWh**

- (near future)
 - 150 €/kWh
 - 8000 cycles
 - 90% efficiency

150 €/kWh / 8000 + 10% of the cost of electricity =

= 27 €/MWh



Usages of Energy Storage / Classification

Primary Frequency regulation

- Helps electricity grid cope with quick changes in load / power generation
- Battery storage can be used in conjunction with power plants and improve their response characteristics. Power can be stored/released within few hundreds of milliseconds into the grid
- Real value for small power systems (e.g. island grids)
- Allows integration of more renewables when grid stability issues dictate to switch-off renewables
- Storage capacity can be from few minutes to a couple of hours
- Potential applications in SE Europe: Greek islands

Grid upgrade deferral

Storage elements help shave the peak loads in transmission / distribution lines (congestion management)

Applicability

- Countries with old distribution networks who need upgrade
- Countries with "weak" transmission and distribution systems (mainly in Africa)

Peak Load Shifting to allow for more renewables



Generation mix today





More PV implies need for storage





"Behind the Meter" storage

House and small business systems utilizing net-metering

- Electricity is stored and consumed at a later time so consumers do not have to feed the grid
- Economic viability depends on net metering regulations and price rates
- Germany is the leading country (subsidy)
 - 20,000 residential energy storage systems installed in 2016 and 30,000 in 2017.
 - 85,000 energy storage systems in operation.
 - Market size is 490 M€
 - Installed power expected to rise to 385 MW by end of 2018



Batteries as household appliances





Batteries as household appliances





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Towards grid defection?

Low cost mass housing in Philippines

- 1 kW PV
- 3+3 kWh Li storage
- Connection to the grid



NO net-metering

Homeowners are not allowed to sell to the grid. They use their own electricity and they buy from the grid in rare cases.



Containerized Systems





- ✓ Thermal Insulation Systems
- ✓ Fire-Extinguishing System
- ✓ Energy Management System



Bidirectional PCS



Storage plants at the substation level

<u>USA</u>

- Largest world market Over 650 MW
- Landmark projects
 - 100 MWh in SCE territory
 - 10 MW / 40 MWh if Florida

<u>Korea</u>

- 500-megawatt frequency regulation energy storage procurement plan (KEPCO)
- Already installed:
 - 24-MW (9-MWh) Lithium NMC
 - 16-MW (6-MWh)
 - 16-MW (50-MWh) Lithium Titanate Oxide

<u>China</u>

- Largest battery storage plant under construction in Dalian China (expected end of 2019) is 200 MW / 800 MWh – Rongke Redox flow battery
- 300 MW under construction

Australia

- 129 MWH coupled with wind farm
- Planed 250 MW "virtual plant" (50.000 homes)

<u>Japan</u>

• Large number of subsidies projects to support the government goal of Japan controlling 50% of the global market share by 2020



Σταθμός παραγωγής 300 MW σε λίγους μήνες







World markets

Electricity storage is needed to:

- Improve service to customers connected to bad grids (market needs TODAY)
 - Batteries and coupled with photovoltaics to replace diesel generation in households and businesses
 - Distribution network storage systems to help extend electrification hours in areas connected to congested transmission grids
 - Photovoltaic battery systems (at household or community level) to provide daytime electricity to diesel powered island grids.
- Implement mini-grids in non-electrified areas for:
 - Telecom and internet services
 - Village electrification

The mode of electrification in many areas will soon switch from diesel to photovoltaic – battery.



Big mini-grid demos in China

Zhangbei

60 MWh lithium and 12 MWh lead-acid battery, it is the largest wind + solar + storage demonstration project in China.

• Qinghai

9 MWp PV, 3 MWh lithium battery and 28 MWh lead-acid battery





Electric Vehicles

- The biggest controllable load ever to be introduced in the grid
- Questionable is feasible to utilize EVs to retrieve energy
- Second life batteries (used) could be an option, depending on new battery cost and battery management costs

