Overview and State of Play on Energy Storage in Asia

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The suite of publications available on dnv.com
The energy transition and the need for flexibility
Energy transition will impact power flows and power quality

Energy transition will result in **larger fluctuations** in supply and load – mainly in electricity markets.

Large number of **inverters** (PV solar) will result in **voltage issues**.

Both developments put pressure on **reliability of electricity supply**.

Energy storage provides solutions for various players.
Storage is essential for the inclusion of variable renewables in electricity
Flexibility options

Causes
- Sudden failures
- Rapid changes in electricity demand
- VRES variability (local)
- VRES variability (regional, continental)
- Customer behaviour, working patterns
- Weather effects on electricity demand

Principal flexibility options
- Battery storage
- Pumped-hydro storage, compressed-air storage
- Heat storage
- Demand response
- Flexible generation
- Power-to-gas, Power-to-liquids
- Interconnection capacity

From: DNV GL Energy Transition Outlook, 2019
Customer Services
- Backup Power / UPS
- Increased self consumption
- Demand Charge Reduction
- Time-of-Use Bill Management
- Transmission Deferral
- Transmission Congestion Relief
- Power Quality Services
- Capacity Market
- Energy Arbitrage
- Black Start

Network Services
- Generation Firming
- Generation Shifting
- Power Smoothing
- Curtailment Mitigation
- Imbalance Reduction
- Oversizing Generation/ Reducing Connection Capacity
- Spinning/Non-Spinning Reserve
- Frequency Response
- Voltage Support

Ancillary/ Grid Services
- Network Services
- Ancillary/ Grid Services

Colocation Services
- TSOs/DSOs
- Utilities
- End users
  - Commercial & Industrial
  - Consumers
Energy storage technologies
Classification

Grid-connected energy storage (electrical output)

Electrical
- CAPACITOR
  - Capacitor
  - Supercapacitor
    - El. double-layer cap. (EDLC)
    - Li-ion capacitor
- SUPER CONductor
  - Superconducting magnetic energy storage (SMES)

Electrochemical
- ROOM-TEMPERATURE BATTERY
  - Lead-acid
  - Nickel-metal hydride
  - Lithium-ion (Li-ion)
- HIGH-TEMPERATURE BATTERY
  - Sodium-sulphur (NaS)
  - Sodium-nickel chloride
- REDOX FLOW BATTERY
  - Zinc-bromine
  - All-vanadium
  - Polysulphide-bromine

Mechanical
- POTENTIAL ENERGY IN STORAGE MEDIUM
  - Pumped hydro
  - Compressed air (CAES)
  - Liquid air (LAES)
- KINETIC ENERGY IN STORAGE MEDIUM
  - Flywheel

Chemical
- Power-to-gas

Thermal
- Sensible heat
- Latent heat (phase change materials)
- Sorption heat (thermochemical)
Energy Storage Applications

- Capacitor
- Flywheel
- Li-ion Batteries
- Flow batteries
- CAES
- Pumped Hydro
- Power-to-Gas Thermal

Power rating:
- 1 GW
- 1 MW
- 1 kW

Discharge duration:
- 1/100 Minute
- 1/10 Hour
- 1 Day
- 10 Days
- 100 Weeks
- 1000 Hours (Month)
Energy Storage Applications

- **Duration and frequency of power supply**

  - "Seconds to minutes" - Short term energy storage systems, C>2
    - E2P ratio: < 0.5h
    - Supercapacitors
    - Flywheels

  - "Daily storage" - Medium term energy storage systems, 2<C<0.1
    - E2P ratio: 2 - 10h
    - Batteries LiIon
    - Pumped hydro
    - Redox Flow

  - "Weekly to monthly" - Long term energy storage
    - E2P ratio: 50 - 500h
    - Power to Gas (H2)

- **Grid services**
- **Compensation for day-night load imbalance**
- **Peak shaving, valley filling, load shifting**
- **Correction of forecast errors of renewable producers**
- **Prevention of re-dispatch**
- **Opportunity of spot market price fluctuations**

- **Future application to bridge periods of low wind and photovoltaic generation**
- **Decarbonization of transport**
Energy storage technologies

Example flywheel project: US – 20MW/5 MWh plant – 200 flywheels

Source: http://beaconpower.com/stephtown-new-york/
Energy Storage in Conventional Power Systems

• Traditional Power Systems have a very limited energy storage system
  • Kinetic Energy in Rotating Generators
  • Pumped Hydro

• Consequence of near “zero” storage:
  • Overcapacity
  • Lower asset utilization
  • Reduced operational efficiency
  • Reduced “Hosting Capacity” for “Variable Energy Resources” (PV, Wind…)
Ideal system characteristics for storage

- High Penetration of Renewables
- System Flexibility required to align supply and demand
- High usage of peaking diesel generators
- Off-Grid Systems
- Weak electrical networks and networks requiring upgrades
- Ability to maximise cheap grid connection potential

Policy and Regulation
Levelized Cost of Storage (LCOS) as a Comparison Index

- LCOE is typically used to assess the cost of electricity from different power plant types. In this analysis it has been transferred to storage technologies and therefore the term LCOS is used.

- It enables comparison between different types of storage technologies in terms of average cost per produced/stored kWh.

\[ LCOS = \frac{I_0 + \sum_{t=1}^{n} A_t / (1+i)^t}{\sum_{t=1}^{n} M_{el} / (1+i)^t} \]

<table>
<thead>
<tr>
<th>Input Variables</th>
<th>Elements</th>
<th>Example values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment costs [$]</td>
<td>Specific cumulative investment cost * rated power</td>
<td>700 - 1500 $/kW * rated power</td>
</tr>
<tr>
<td>Annual total costs in year t [$]</td>
<td>Operational costs (in %) * Investment costs</td>
<td>2% * Investment costs</td>
</tr>
<tr>
<td>Produced electricity in each year [kWh]</td>
<td>Rated power * Equivalent full-load hours * Efficiency</td>
<td>Rated power *1,460 h/a * 80%</td>
</tr>
<tr>
<td>Technical lifetime [years]</td>
<td>Technical lifetime</td>
<td>50 years</td>
</tr>
<tr>
<td>Interest rate (WACC)</td>
<td>Discount rate</td>
<td>8%</td>
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</tbody>
</table>
• As the power system evolves and the role of storage changes over time, other technologies could have new opportunities if they can compete with lithium-ion battery prices.

• Long-duration energy storage can significantly enhance the utilization of renewable energy sources.
From the 2021 results, the gaps between LCOS values across technologies except for lead acid narrow as the duration increases from 2 to 10 hours.
By 2030, as duration increases, LCOS for all technologies are estimated to decrease to their minimum at ~ 10 hours.
## ESS Overview in Asia – Pacific excl. ASEAN

<table>
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<tr>
<th>Country</th>
<th>ESS capacity as of 2020</th>
<th>ESS Targets by 2030</th>
<th>Incentives</th>
<th>Business Models</th>
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</thead>
<tbody>
<tr>
<td>Mainland China</td>
<td>33.1 GW of ESS</td>
<td>~120 GW for ESS and 47 GW for battery-specific</td>
<td>Government and province-level subsidies and grants. Priority status to storage + RE projects at permitting stage.</td>
<td>Energy Arbitrage, Frequency Reserve; Contingency Reserve</td>
</tr>
<tr>
<td>Australia</td>
<td>3.2 GWh</td>
<td>6 GWh</td>
<td>Rebates and subsidies for residential and small installations</td>
<td>Energy Arbitrage in NEM; Frequency response; contingency reserve</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td>In January 2023, Japan announced 17 billion Japanese Yen worth of subsidies for BESS installations and water electrolysers via an application process</td>
<td>Supply-Demand Adjustment Market, wholesale electricity market, capacity market and via individual trading</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>New installations of 1MW and above capacity</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>Build-Operate-own (BOO)/ Transfer (BOOT): SEI floated and awarded the first 500MW/1GWh BESS in the Rajasthan region. NTPC awarded a 3GWh tender to Pumped hydro storage on a 25-year basis Funding for 4GWh of grid-scale batteries in its 2023-2024 annual expenditure budget</td>
<td></td>
<td></td>
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<tr>
<td>South Korea</td>
<td>8.6 GWh</td>
<td>25GW/127GWh storage target by 2036. Plans to increase ESS capacity for grid stability and demand response.</td>
<td>(1) Higher-weighted renewable energy certificates (RECs) for ESS projects; (2) Peak-shaving ‘special tariff plan’ for ESS installed behind the meter</td>
<td>KEPCO announced utility-scale ESS services such as ancillary services, power line deferral services, and transmission line congestion controls.</td>
</tr>
</tbody>
</table>

Source: DNV White Paper titled “Energy storage systems in the Asia Pacific region”
First Utility Scale Flow Battery 2022

- Commissioning has taken place of a 100MW/400MWh vanadium redox flow battery (VRFB) energy storage system in Dalian, China

- The biggest project of its type in the world today, the VRFB project’s planning, design and construction has taken six years.

https://www.energy-storage-news/first-phase-of-800mwh-world-biggest-flow-battery-commissioned-in-china/
ASEAN grid connections plan signals more ESS opportunities

ESS opportunities in Asia receive a medium-to-long-term boost under the ASEAN Plan of Action and Energy Cooperation (APAEC) Phase II: 2021–2025

**Malaysia:** 500 MW (100 MW planned to be installed annually from 2030–2034) - Investment incentives for ESS include Green Investment Tax Allowance (GITA) and Green Income Tax Exemption (GITE)

**Vietnam:** FiTs for solar and wind were revised in 2020, but ESS still lacks an incentive. RE projects face curtailment issues, so it is possible that the policy/regulatory environment will change to support ESS in the next few years.

**Philippines:** Island nation favourable for microgrid applications for congestion management through frequency regulation/energy shifting applications.

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## ASEAN overview

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<td>Singapore</td>
<td>200 MW</td>
<td>1 GW</td>
<td>EMA's Intermittent Pricing Mechanism (IPM) is a potential driver for ESS uptake</td>
<td>Energy arbitrage through time-of-use (ToU) tariffs; primary and contingency regulation reserve; and demand-side management.</td>
</tr>
<tr>
<td>Thailand</td>
<td>The first private sector initiative in the country to integrate utility-scale wind power (10 MW) generation with a BESS (1.88 MWh) was led by BCPG subsidiary, Lom Ligor, and was supported by the Asian Development Bank (ADB). A second storage initiative was sponsored by Blue Solar, a solar-focused Thai renewable energy company which deployed a 42 MW DC solar + 12 MW / 54 MWh ESS hybrid system. Under contract to provincial electric utility PEA, third-party developers are installing a few standalone BESS systems to support grid-constrained locations.</td>
<td>All ancillary services are procured by Taiwan Power Company through bilateral contracts.</td>
<td>Fast response; regulation reserve; spinning reserve; supplemental reserve</td>
<td></td>
</tr>
<tr>
<td>Taiwan</td>
<td>Mainly pumped hydro and ~10 MW electrochemical ESS</td>
<td>Demand for ~600 MW by 2025 related to ancillary services</td>
<td>All ancillary services are procured by Taiwan Power Company through bilateral contracts.</td>
<td></td>
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Source: DNV White Paper titled “Energy storage systems in the Asia Pacific region”
Example from Thailand: Transmission deferral with ESS
Example from the Philippines:
Romblon 16MW Microgrid (Solar PV+ BESS+ Diesel)

- The Isnad of Tablas has 150000 inhabitants.
- New hybrid system allowed the island to have stable energy and less dependency from Diesel.
Developments and Trends

• Asia Pacific (APAC) maintains its lead in building on a power capacity (gigawatt) basis, representing 44% of global additions in 2030. China leads in deployments in the region, driven by local targets and compulsory renewable integration policies.

• Customer-sited batteries – both residential and commercial and industrial (C&I) – are also expected to grow at a steady pace. Australia is leading currently with Japan having a sizeable market.

• Pumped hydro makes a comeback attracting more investment than other long-duration storage technologies – India and Thailand with their capacity additions.

• Co-located renewables-plus-storage projects, in particular solar-plus-storage, are becoming commonplace globally.

• Ability of storage to provide firm capacity and time-shifting is a primary cost driver for cost-effective deployments.
Thank you!

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