The Opportunities for Battery Storage System in Demand Side

8 May 2018

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Materials for Energy Research Unit (MFERU)

National Metal and Materials Technology Center (MTEC)


NSTDA


BIOTEC
a member of NSTDA
MTEC
a member of NSTDA
NANOTEC
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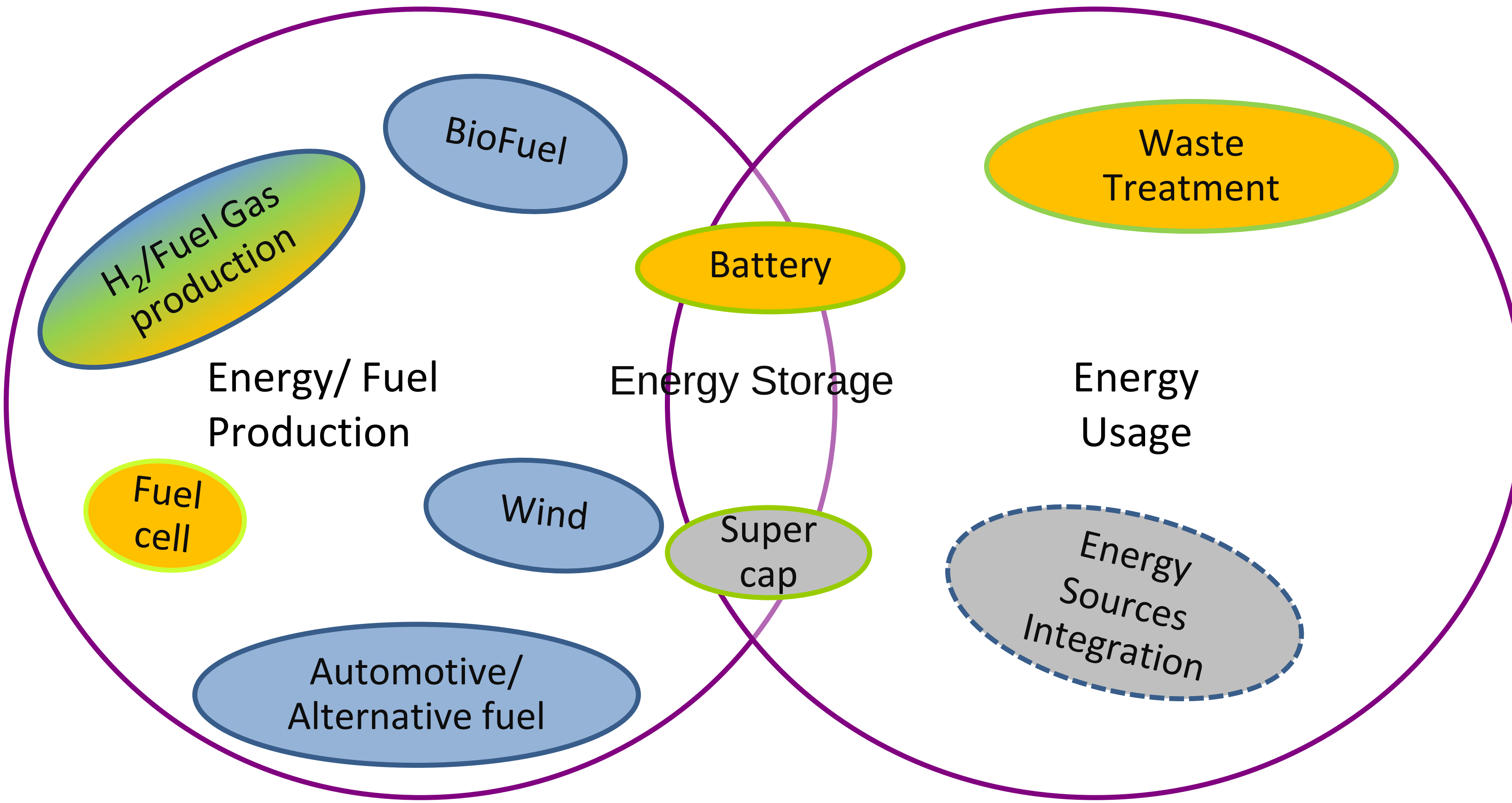
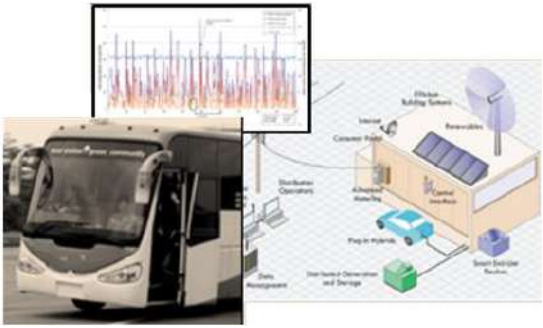
NECTEC
a member of NSTDA
TMC
a member of NSTDA

Materials for Energy Research Unit (MFERU)

Research Unit Focus

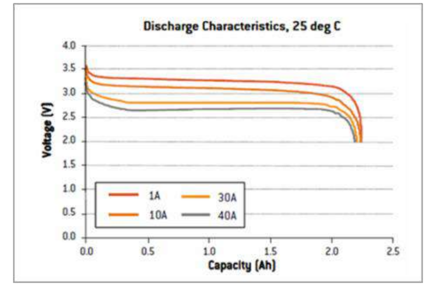


Energy Storage Materials and System Lab



Pack/system integration/optimization

Cell/Pack Development+ Performance evaluation/testing



Safety and Performance Standardization

MTEC/NSTDA

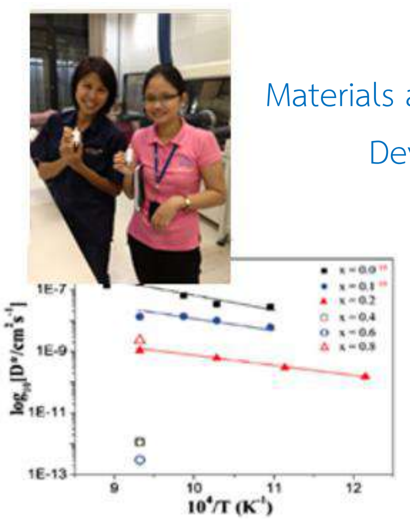
+

Governance sectors & Universities

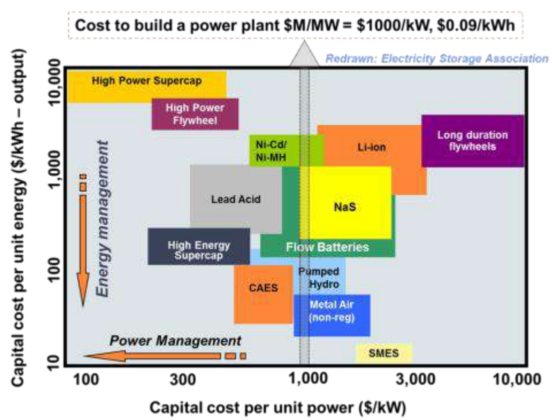
& Private sectors

(Thai and International)

End of Life Handing

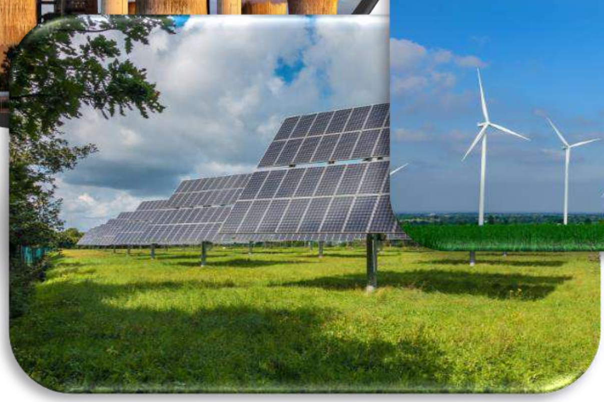


Materials and Cell Structure Development



www.mtec.or.th

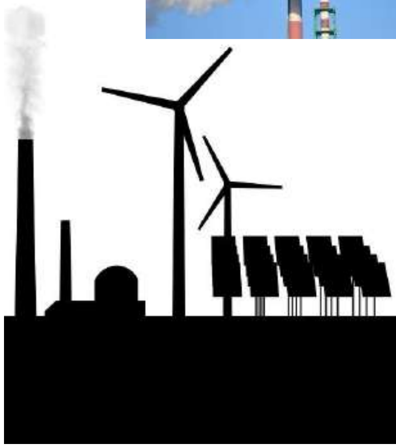
Era of energy transition



Era of power grids transition

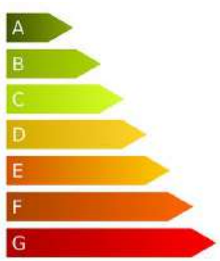
Resource transition

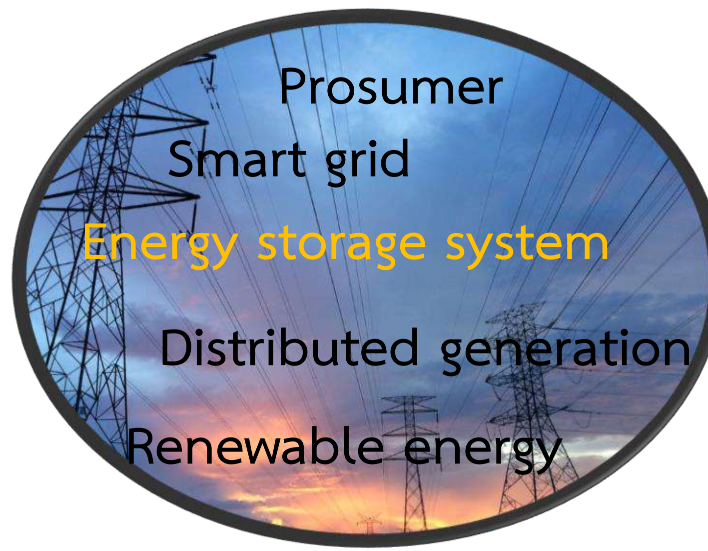


Digitization

Consumer Participation



Trendy technology

- Top 20 Green Tech Ideas, by Times Magazine DEC,2010
- Top 10 Emerging Technologies That Could Transform Our Future / Emerging Energy Technologies That Will Change The World in 2014-2015
- Why?
  - Global warming => Renewable energy and clean technology
  - Price reduce
  - Characteristics improve

Outline

- Introduction to Energy Storage System
  - Types
  - Applications
- Battery storage system applications at demand side

Definition

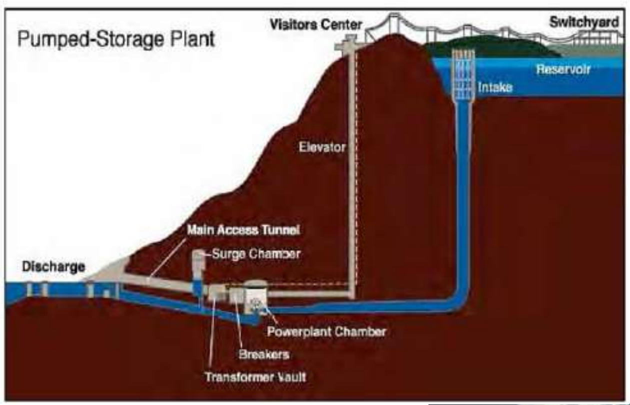
Storing / Charge:

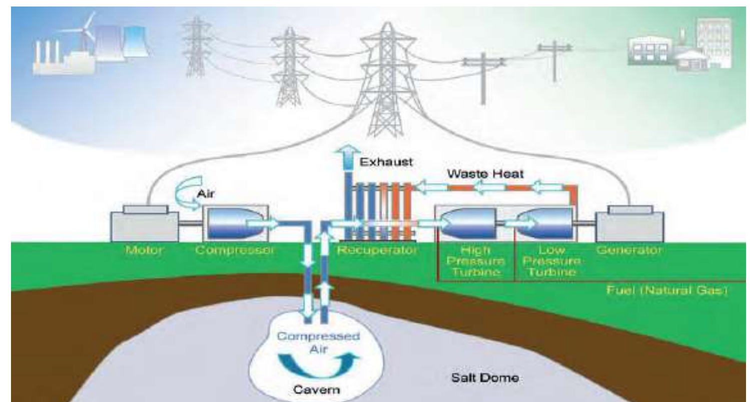
One form of energy

Energy storage system

Supply/Discharge:

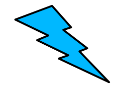
Electrical energy





Available Technologies

4 Groups (by storing form of energy)



Mechanical energy storage
- Pump Hydro
- Compressed Air (CAES)
- Flywheel

Electrochemical /Chemical ES
- Battery
- Fuel Cell
- Synthetic Natural Gas (SNG)

Electrical energy storage
- Supercapacitor
- Superconducting Magnet (SMES)

Thermal energy storage
- Superheated liquid
- Phase changed mat.
- Adiabatic CAES

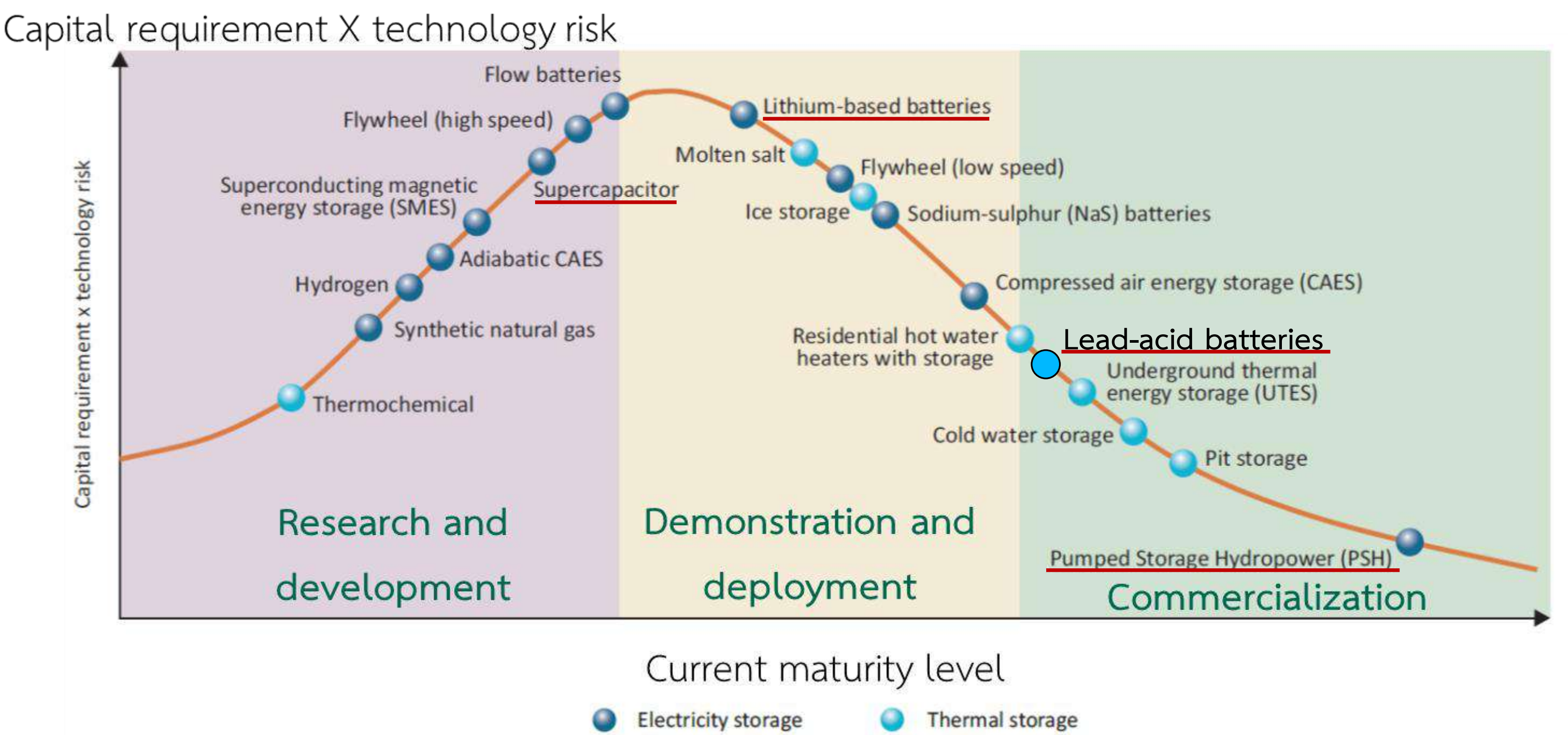
- All these technologies have been around for ages. Some over 150 years!

Technologies of energy storage: Comparison (1)

1. Maturity of energy storage technologies

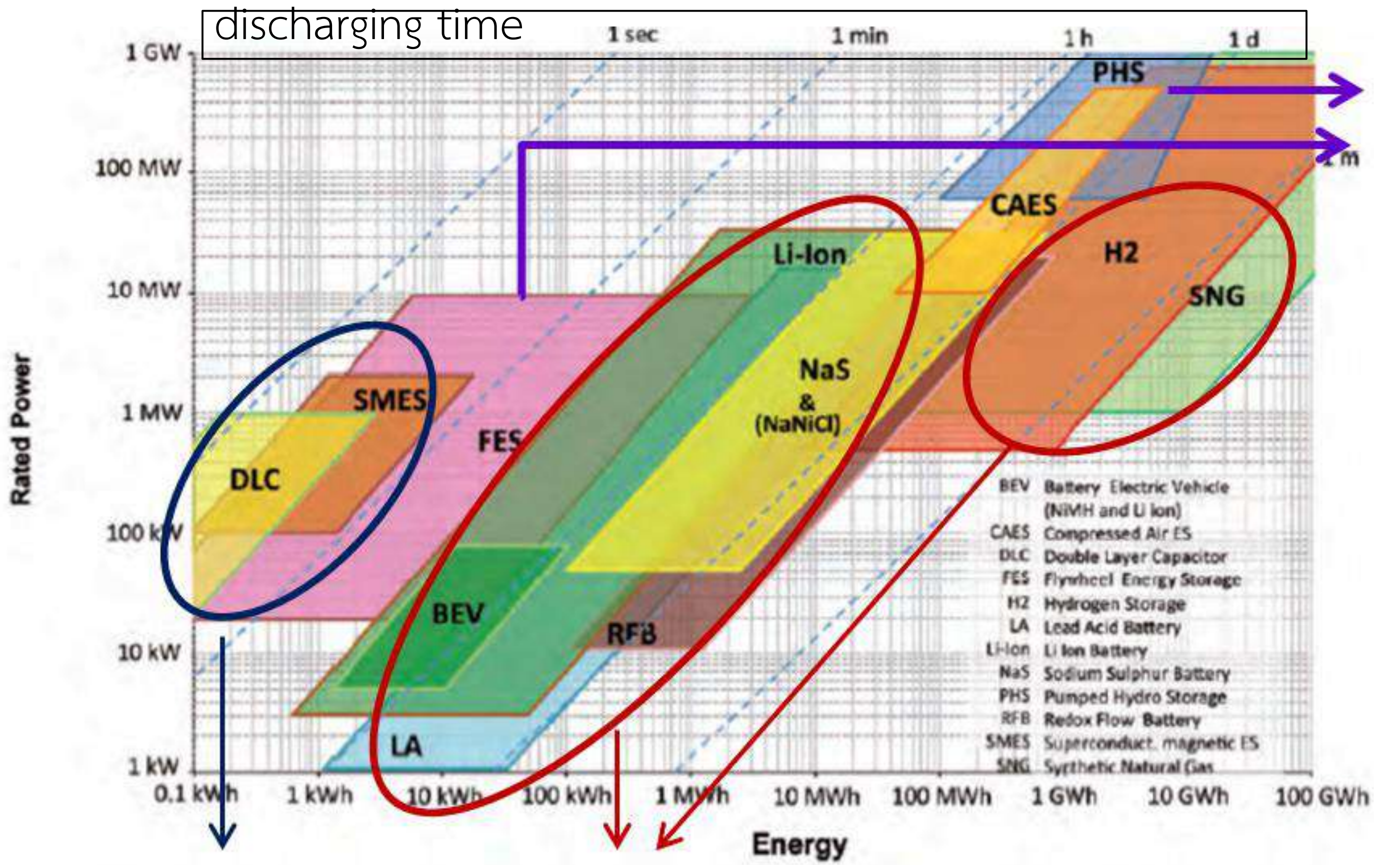
- Mature technology: Pumped Hydro Energy Storage (First start up in 1909) and Thermal Energy Storages

- Lead-acid batteries: the most mature technology of secondary batteries



Source : Technology Roadmap: Energy storage, IEA

2. Power to energy ratio and discharging time



Mechanical ES:

Pumped Hydro,

Compresses air, Flywheel

Electrical ES:

Supercapacitor

Electrochemical ES:

Secondary Batteries => Pb, Li-ion, NiMH

Flow batteries => Redox-Flow

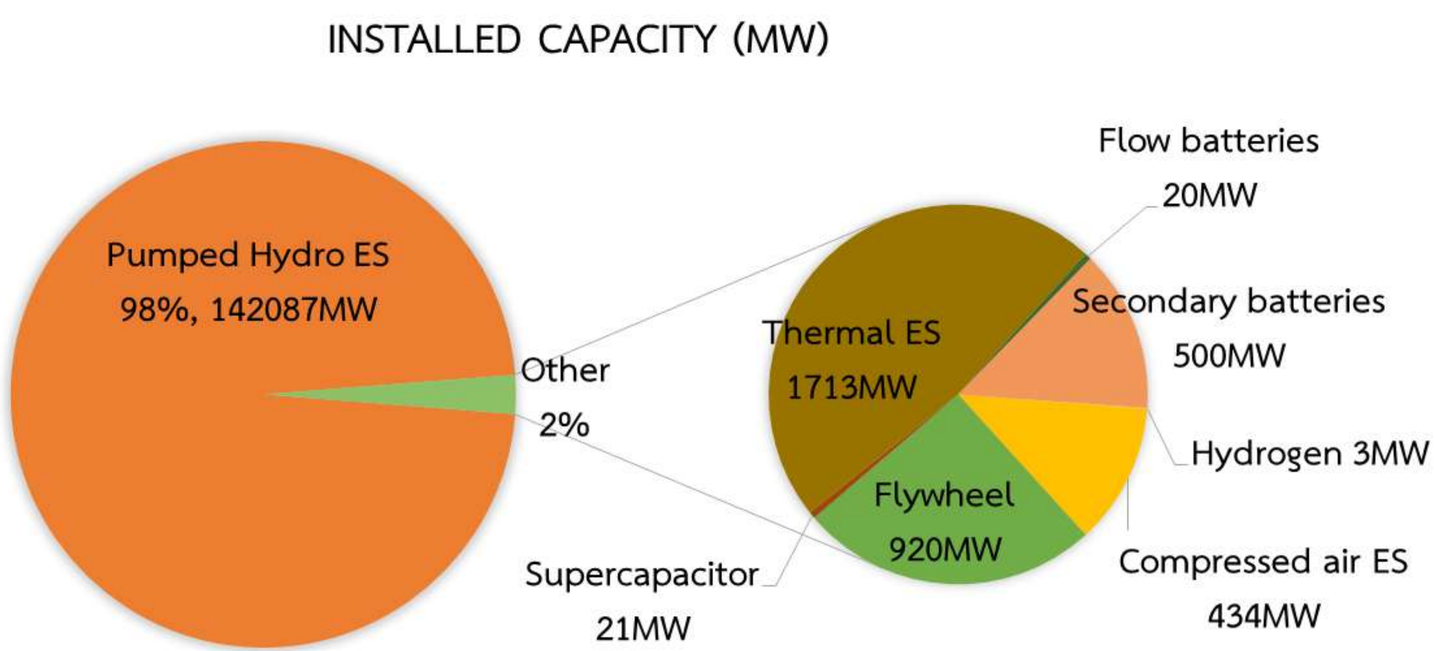
Fuel cell

Source : Electrical energy storage, IEC

Current Technologies of energy storage for grid

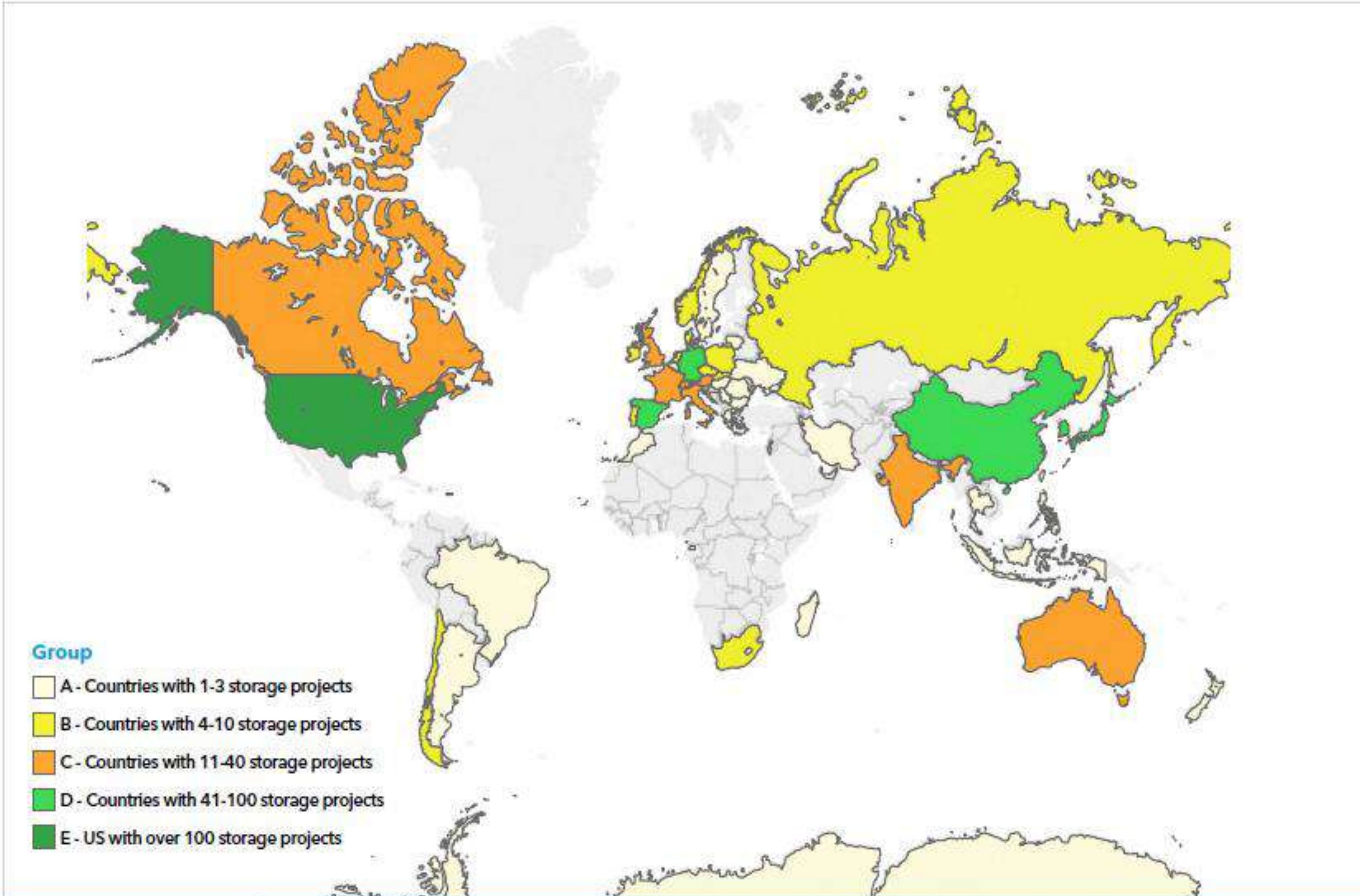
Installed capacity of energy storage (Worldwide operational project)

- Majority part 98% => Pumped hydro energy storage
- Others technologies 2% => Thermal ES > Flywheel > Secondary batteries
- Secondary batteries (500MW) => Li-ion (320MW) > Na based (101MW) > Pb (49MW) > Nickel based (30MW)



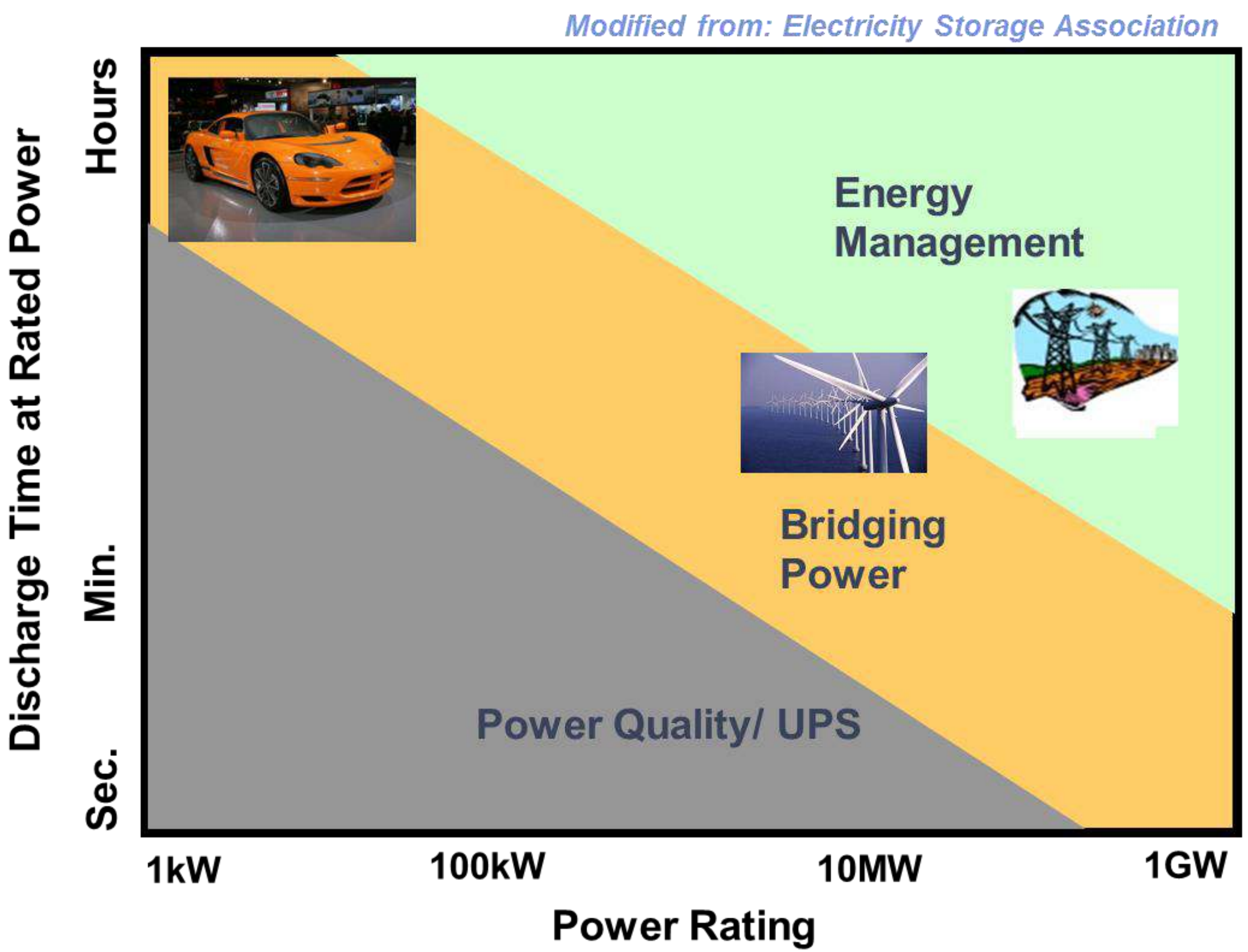
Source : Chart made from DOE database (operational case), www.energystorage exchange.org

Energy storage installations by April 2016



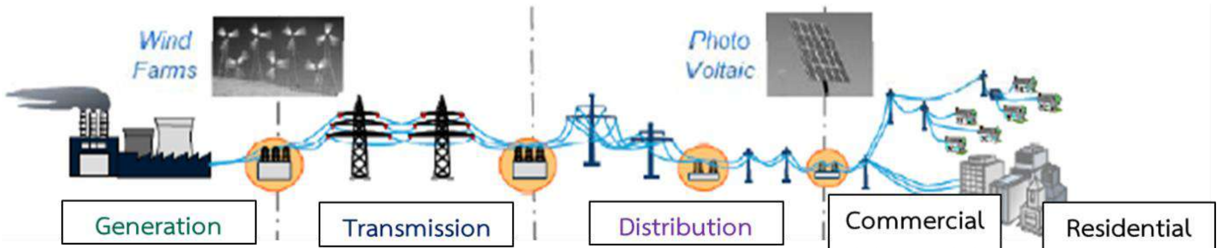
Source : DNV-GL

Energy Storage Application – Example



Applications of energy storage in power system

For large grid:



Source : Electrical energy storage

	Short duration < 2 min	Medium duration 2 min – 1 hour	Long duration > 1hour
GENERATION SIDE	Provide frequency regulation services	Provide spinning & non-spinning reserves	Provide replacement reserves Provide black-start services Firm renewable output Perform price arbitrage Avoid curtailment
TRANSMISSION GRID	Smooth intermittent resource output Provide system inertia	Improve system reliability	Defer upgrades
DISTRIBUTION GRID	Improve power quality	Mitigate outages Integrate distributed variable renewable generation	Defer upgrades
END-USER SIDE	Maintain power quality	Provide uninterruptible power supply	Optimize retail rate

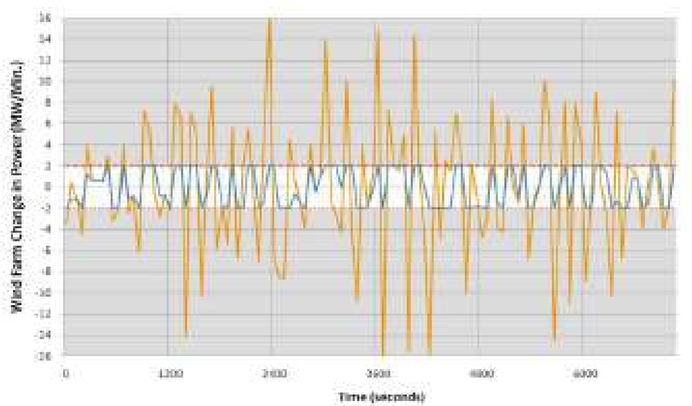
**** Smart Grid ****

**** Microgrid ****

Energy Storage for Grid: Applications

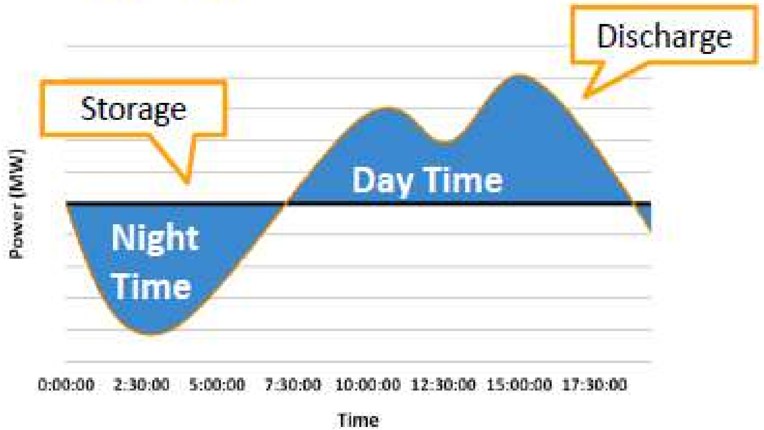
Power	Energy

Power Applications:



- Regulation
- Spinning Reserve
- Renewable Integration
  - Ramp Management
- **Requirements:**
  - Very high Charge/Discharge Rates
  - Short Duration (<1hr)
  - Many cycles (100s per day)
  - Continuous use

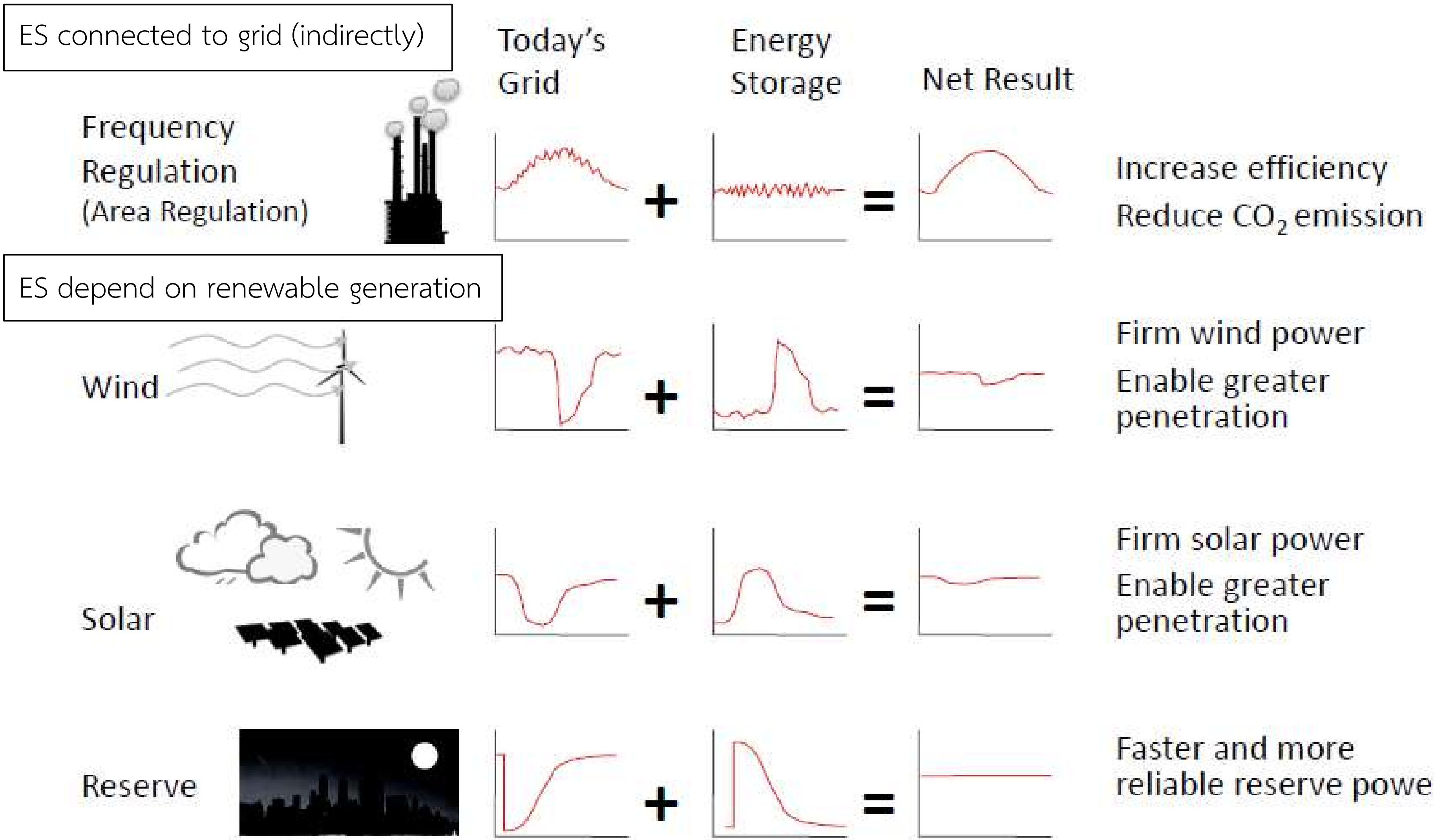
Energy Applications:



- Peak Load Shifting
- Renewable Integration
  - Firming, Shifting & Curtailment Recovery
- Arbitrage
- T&D Asset Deferral
- **Requirements:**
  - Long Duration (1+ hrs)
  - 1-2 cycles per day

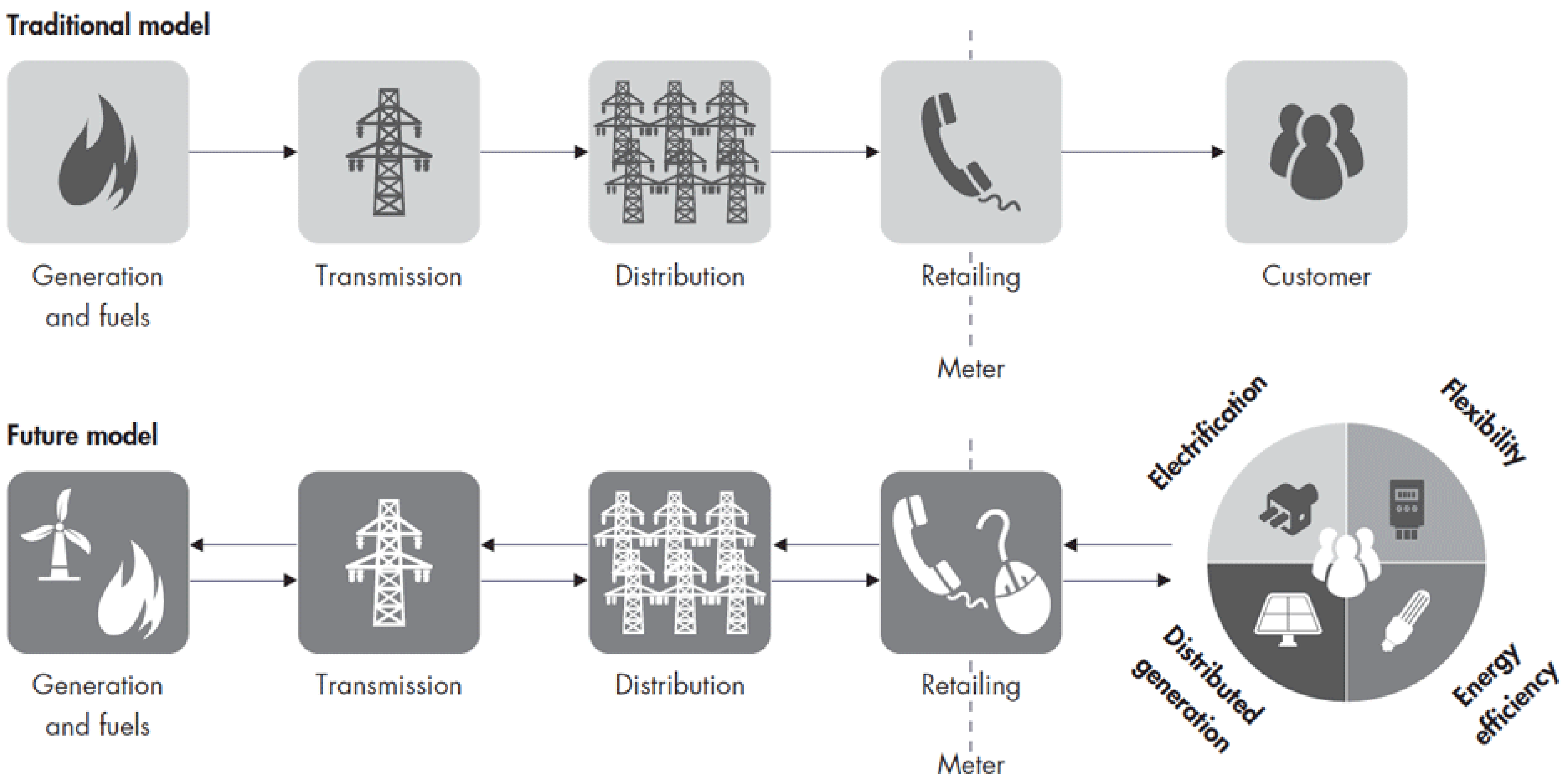
Source: Courtesy of 24M Technologies

Application of energy storage in power system



At demand side…

New business and investment opportunities are emerging closer to the customer



Sources: Commonwealth Scientific and Industrial Research Organisation, 2013; "New Business Models for the Distribution Edge," eLab, 2013

Source: http://www.bain.com/publications/articles/business-and-investment-opportunities-in-a-changing-electricity-sector.aspx

Integrated demand side management

- Integrated DSM = new Energy Efficiency
- 6 Solutions should be considered together
  - Energy Efficiency
  - Demand Response
  - Distributed Generation
  - Storage
  - Electric Vehicle
  - Price structure

Lighting Systems & Control

Battery Storage

Energy Management & Control System

EV

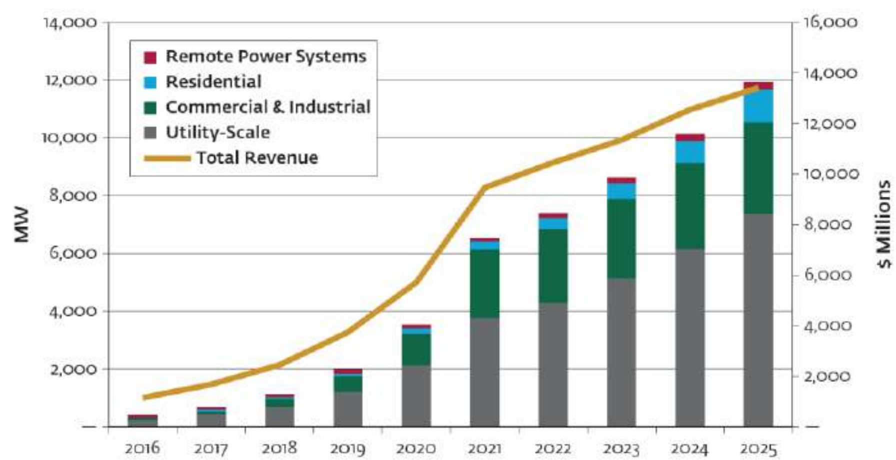
Source: Lawrence Berkeley National Laboratory, *Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management*, November, 2017

ESS at demand side

ESS market segments

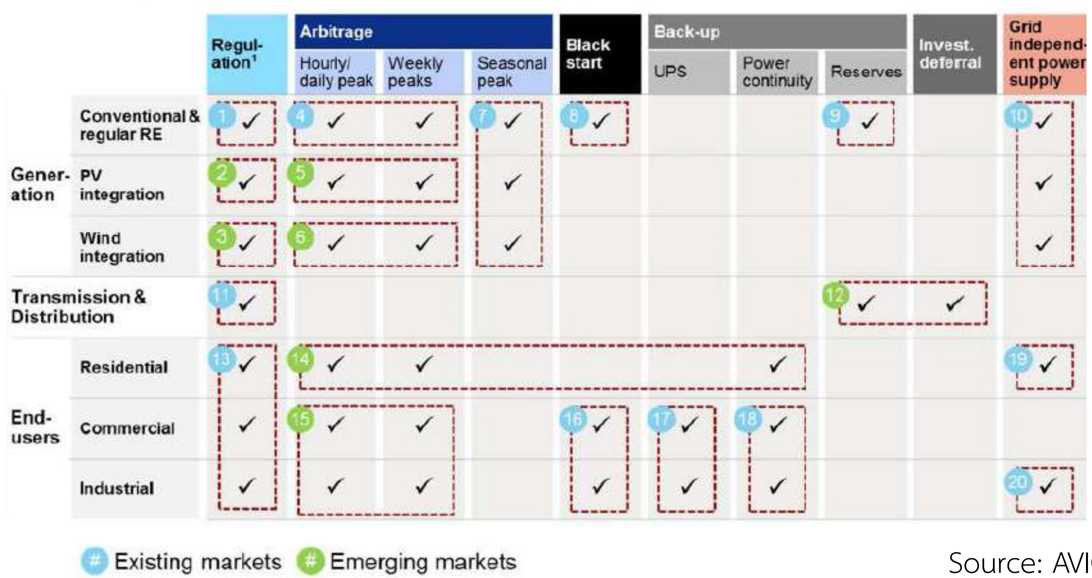
- Utility scale
- Behind the meter
- Isolated grid

Chart 3.3 Projected Annual Stationary Energy Storage Deployments, Power Capacity and Revenue by Market Segment, East Asia & Pacific: 2016–2025



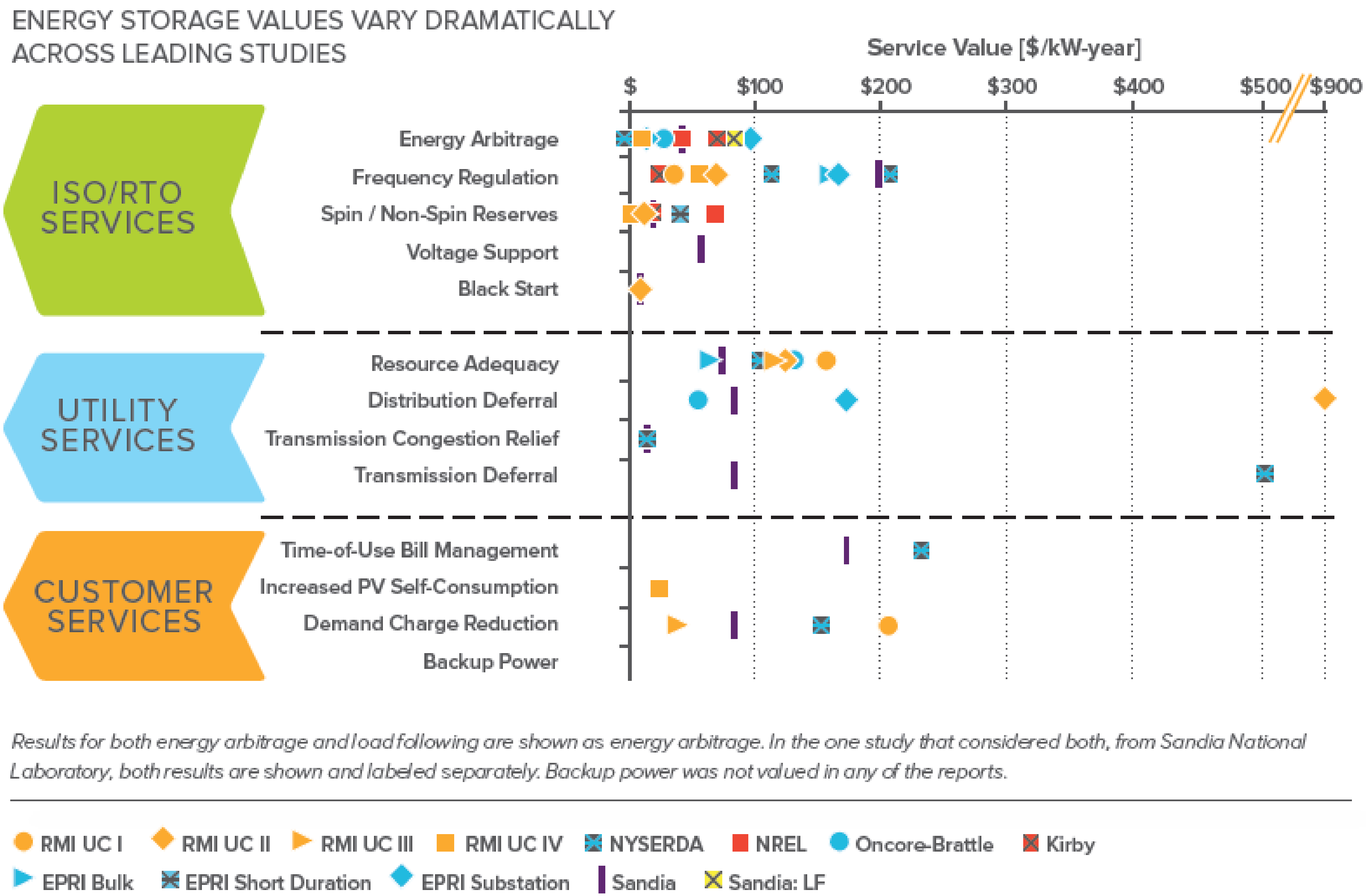
Source: Navigant Research

Stationary Energy Storage - Potential segmentation



Source: AVICENNE ENERGY, 2016

Where? Which services?



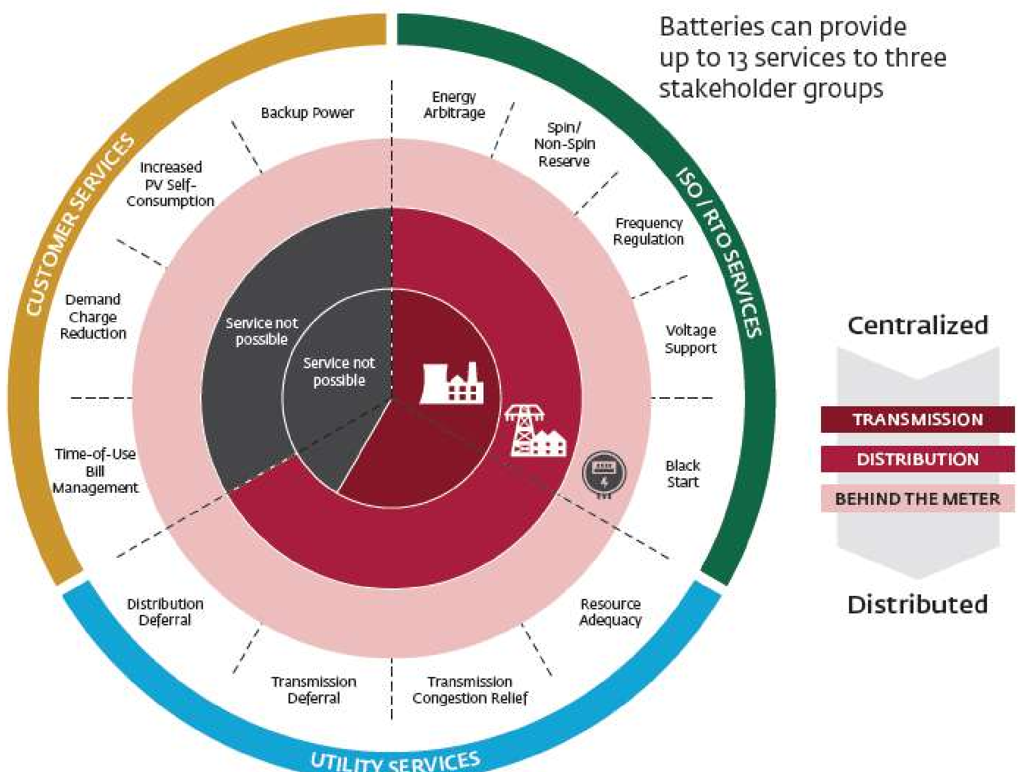
Source : Rocky Mountain Institute, The Economics of Battery Energy Storage

Value of ESS

Where? => Behind the meter

Which services?

- Back up power
- Demand Charge Reduction
- Time-of-Use Bill Management
- Increased PV Self-Consumption

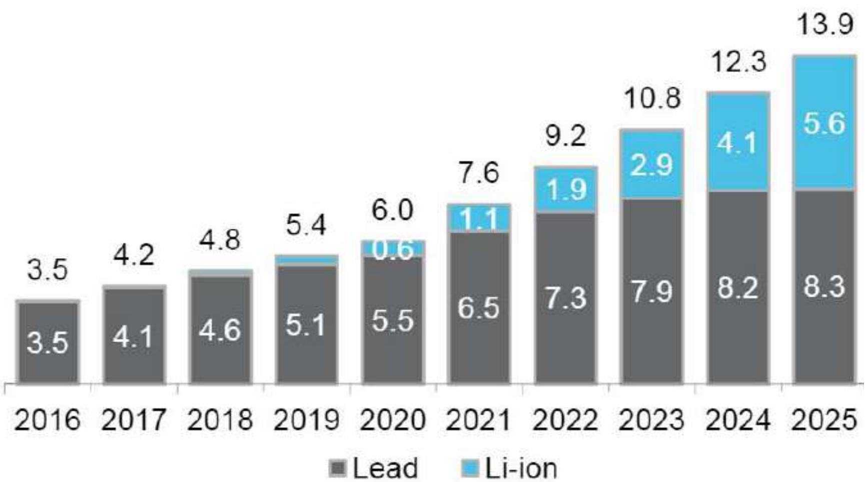


Source : Rocky Mountain Institute, The Economics of Battery Energy Storage

Uninterrupted power supply/Back up power

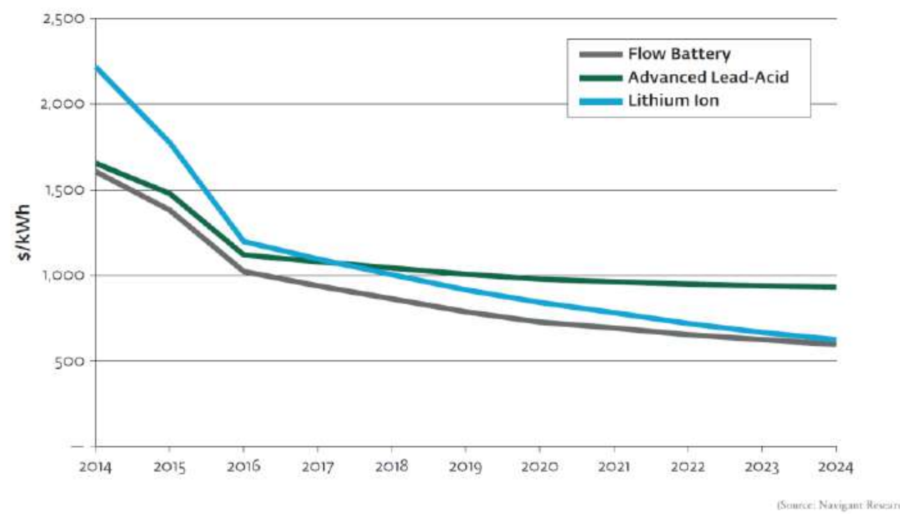
- High value
- Short payback period
- Current tech. in market => Diesel generator / Lead batteries
- Emerging technologies = Lithium ion battery because of cost reduction and better performance

Annual data center lithium-ion penetration in North America and Europe, 2016-25 (GWh);



Bloomberg New Energy Finance

Behind-the-Meter Energy Storage System Cost Trends by technology, Global Averages 2014-2024

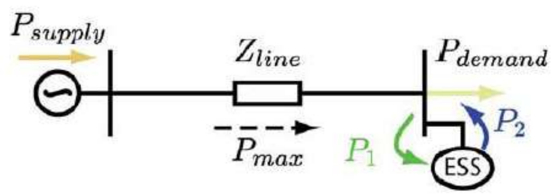


Source: Navigant Research

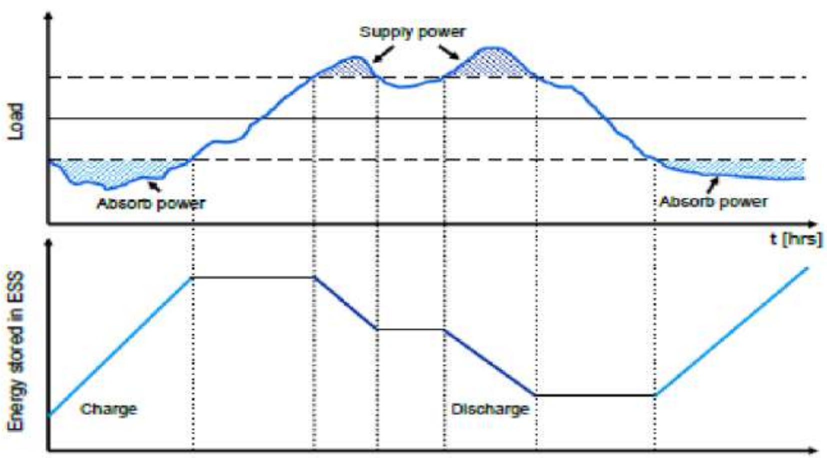
Electric bill management

⟹ To reduce electricity expense: energy cost + demand charge

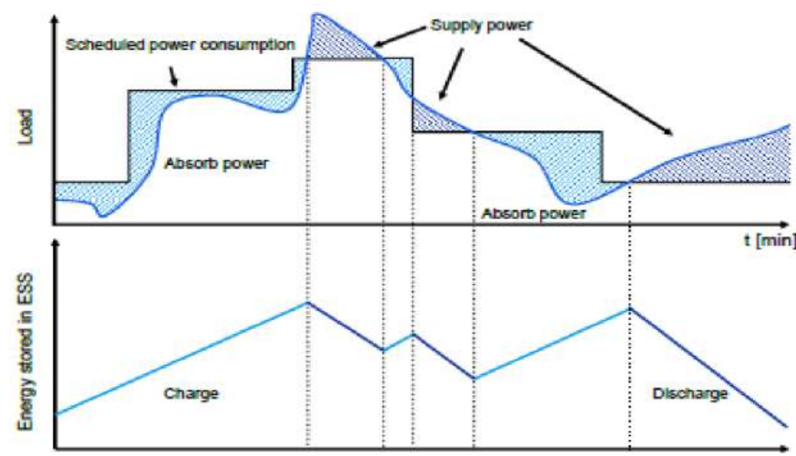
A. Demand Charge Reduction => Try to reduce maximal power over a period ranging (15-60 minutes)



Load levelling:



Peak shaving:



Source :

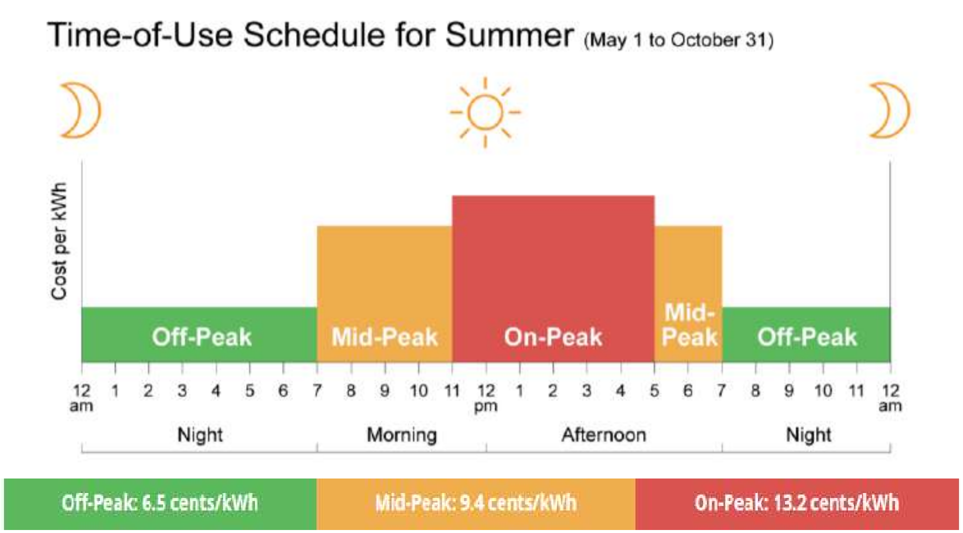
- Energy Storage Systems for Transport and Grid Applications, IEEE Trans. on Industrial Electronics, Vol.57 No.12
- ABB

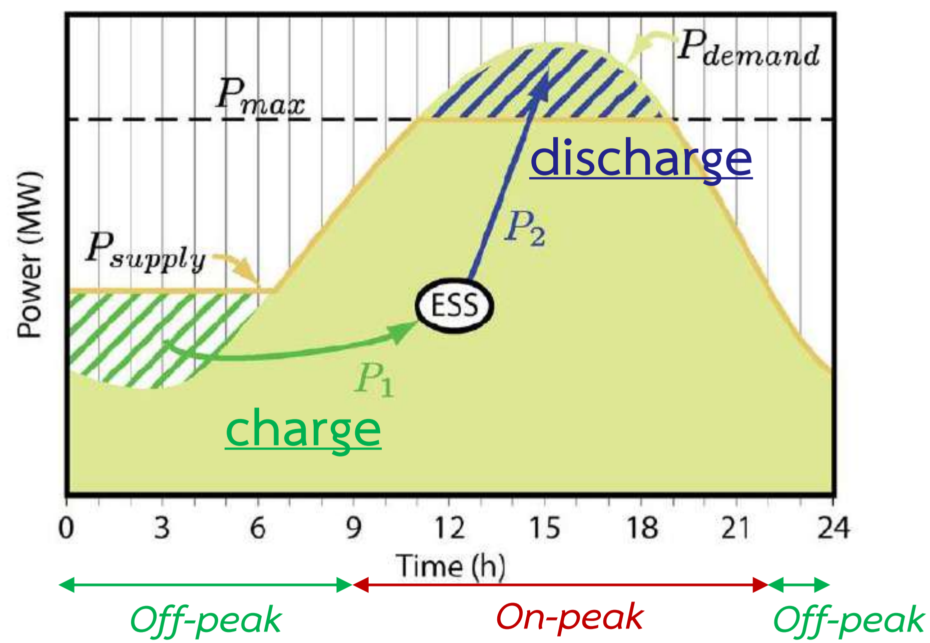
Electric bill management

⇒ To reduce electricity expense: energy cost + demand charge

B. Time-of-Use Bill Management => TOU rate, Reduce energy use => During low demand or off-peak period (low price of electricity), energy storage is charged and it is used during peak demand or on-peak period (high price of electricity)

<u>Load shifting:</u>





Different tariff by season and country

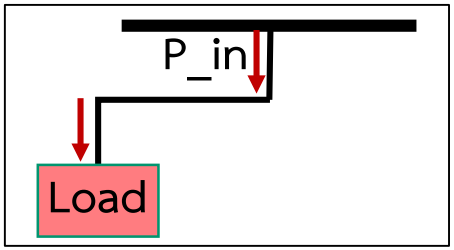
Source : Energy Storage Systems for Transport and Grid Applications, IEEE Trans. on Industrial Electronics, Vol.57 No.12

https://hydroottawa.com/accounts-and-billing/residential/time-of-use

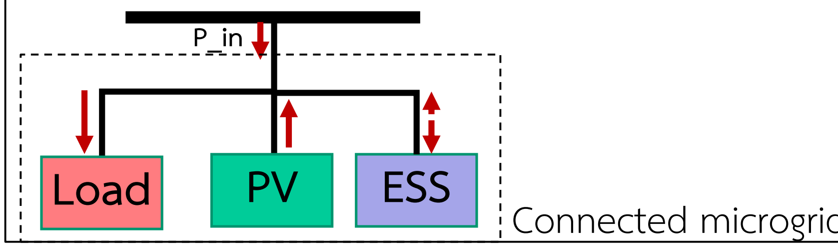
Self consumption/PV-Storage

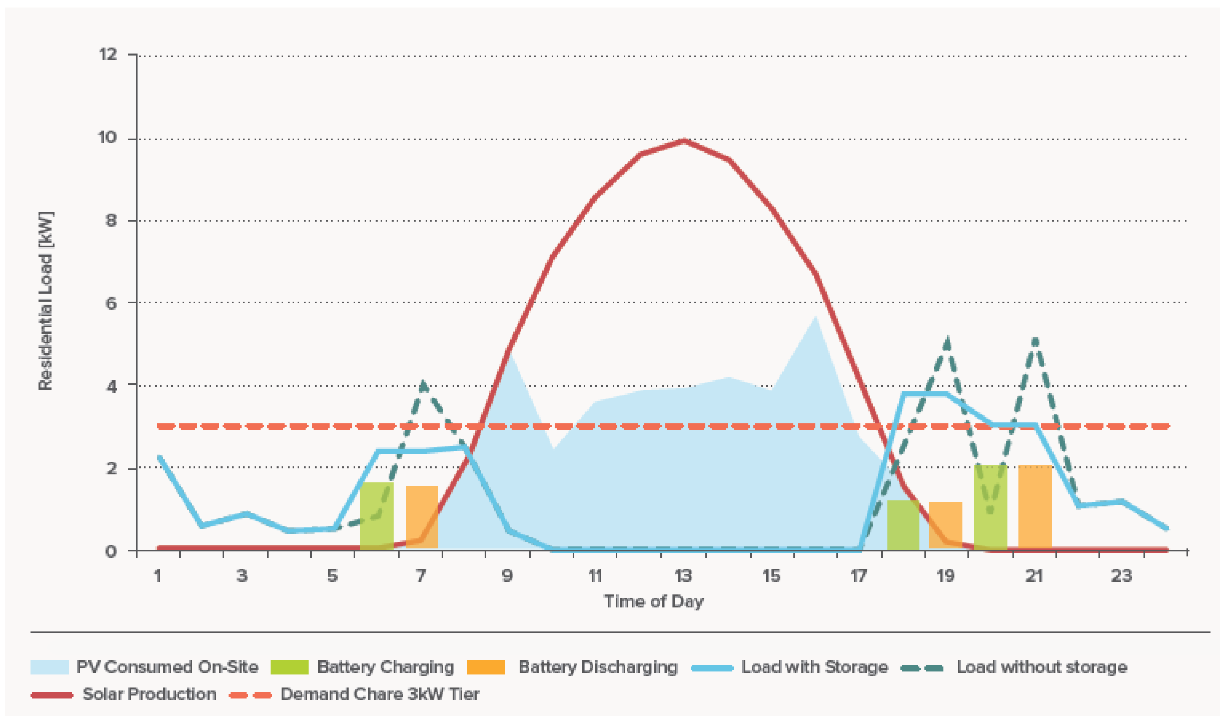
⇒ Net-zero energy building/community => Residential bill management

Initial



Proposed; Try to minimize P_in

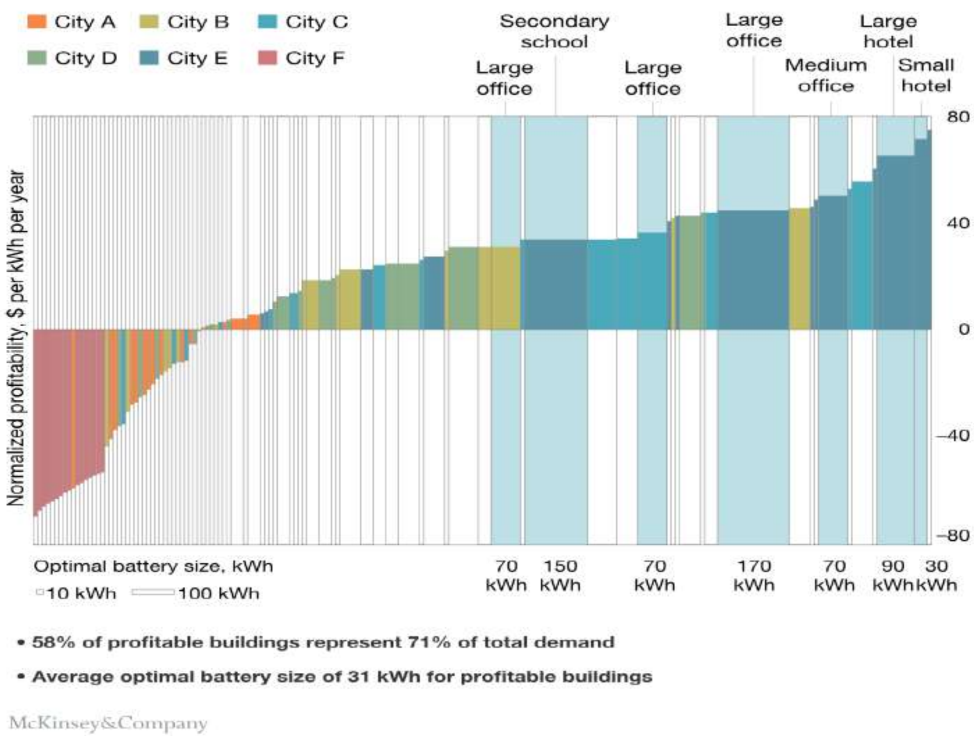




Source: Rocky Mountain Institute, The Economics of Battery Energy Storage

ESS at behind the meter - Challenges

- Mostly cost-effective for commercial and industrial customer
- Challenges:
  - Still high upfront cost
  - Cost-effective for specific customer/load behavior
  - Depends on tariff and regulation
  - Lack of data/load profile



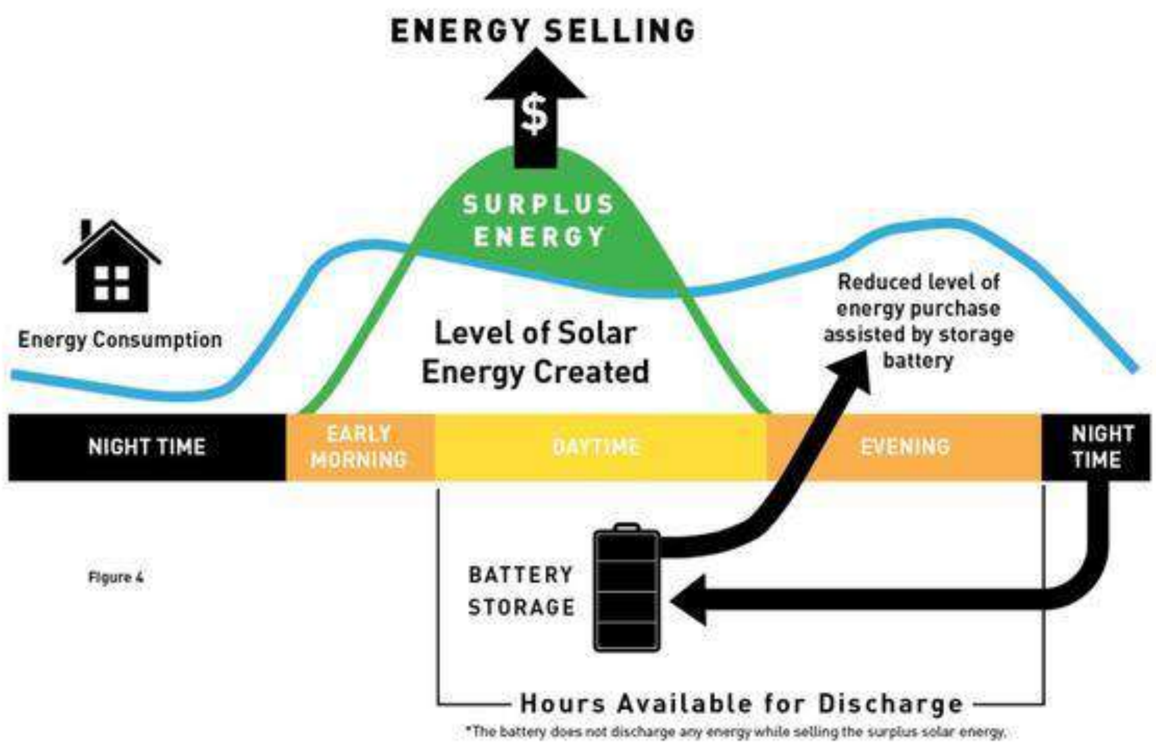
Home/Small building

Industrial/Community/ Large building

Source: https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/the-new-economics-of-energy-storage

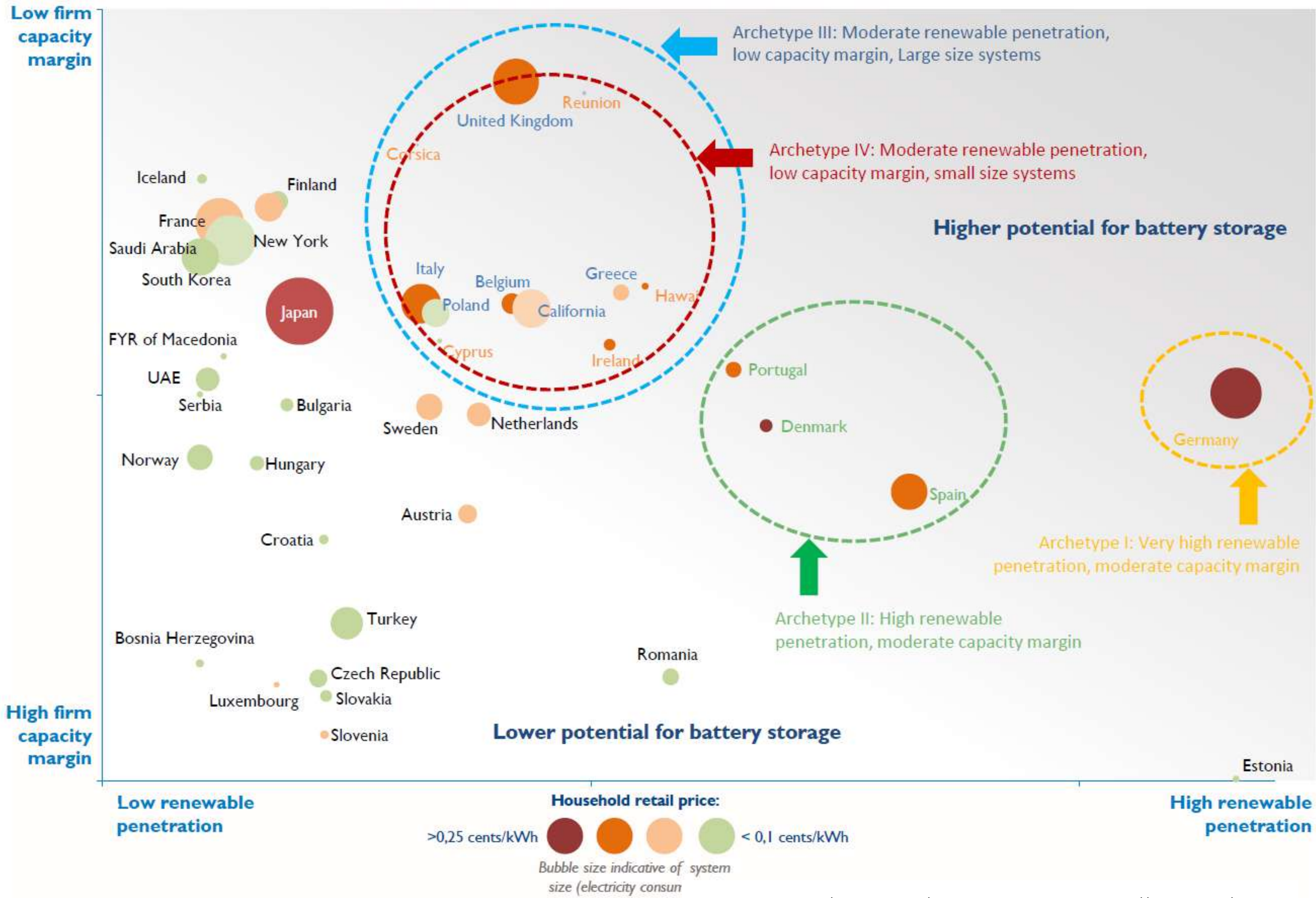
ESS at behind the meter - Challenges

- In some country, Energy selling from surplus PV > Electricity tariff => Discourage ESS implementation
- Reduce amount purchased energy from grid => Opposed by some utilities => Restrictive regulation



Source: ESS magazine, Utility Scale Battery Electrical Energy Storage System – Its Time Has Come in India

Single application VS Stack application

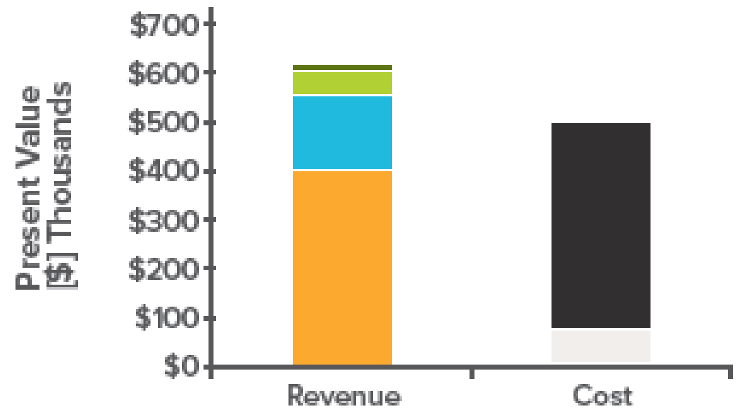


Source: Arthur D. Little, Battery storage: Still too early?

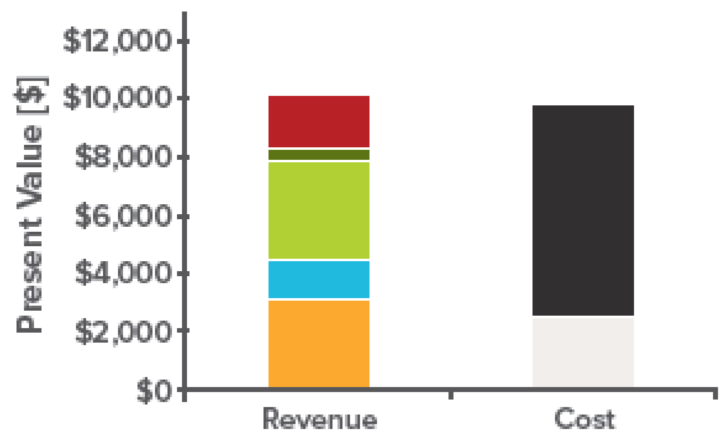
Single application VS Stack application

Because of high capital cost, ESS should support more that one services in order to increase values.

USE CASE I. Commercial demand-charge management in San Francisco. Primary service: commercial demand-charge management. **Secondary services:** frequency regulation, resource adequacy, and energy arbitrage.



USE CASE III. Residential bill management in Phoenix. **Primary service:** time-of-use optimization / demand-charge reduction. **Secondary services:** a suite of ISO / RTO services and resource adequacy.



ISO/RTO SERVICES: Load Following, Frequency Regulation, Spin Reserve, Non-Spin Reserve, Black Start

UTILITY SERVICES: Resource Adequacy, Dist Deferral CUSTOMER SERVICES: TOU, Self-Consumption, Demand Charge Reduction

COSTS/TAX: Capital Cost, O&M & Charging, Tax Cost, Tax Benefits

Source: Rocky Mountain Institute, The Economics of Battery Energy Storage

To summarize

- Energy storage have opportunity in behind the meter market
    - Demand charge reduction
    - PV self consumption
- ESS will be cost-effective in near future without subsidize because of cost reduction of battery
- However, need changes in tariff structures, policy and regulation

Thank you