



CLEAN ENERGY
MINISTERIAL

Accelerating the Transition to Clean Energy Technologies

Energy Storage System : Challenges and Opportunities

Pre-Read for Public-Private Roundtable

Clean Energy Ministerial

12 May 2014

Grand Hyatt

Seoul, Korea

- 1. Objective**
2. Current Landscape
3. Barriers
4. Potential Solutions
5. Opportunities for Progress

OBJECTIVE

Fifth Clean Energy Ministerial (CEM5) Roundtable: Provides an important opportunity to synthesize the lessons learned from history, and to bring together practitioners and policymakers to cooperatively address the barriers faced today, including technical, regulatory, and policy issues.

Presentation: Provides background information on the current state of energy storage systems, and outlines challenges and potential solutions to further scaling-up energy storage systems as a key system of achieving universal energy access.

The information in this presentation is based on the work conducted by the Ministry of Trade, Business & Energy of Korea initiative and the Korea Battery Industry Association (KBIA), in collaboration with other institutions and organizations

Energy Storage Systems are a emerging system of technologies that can help ensure a stable supply of electricity and reduce power consumption

HISTORY OF ENERGY STORAGE SYSTEM

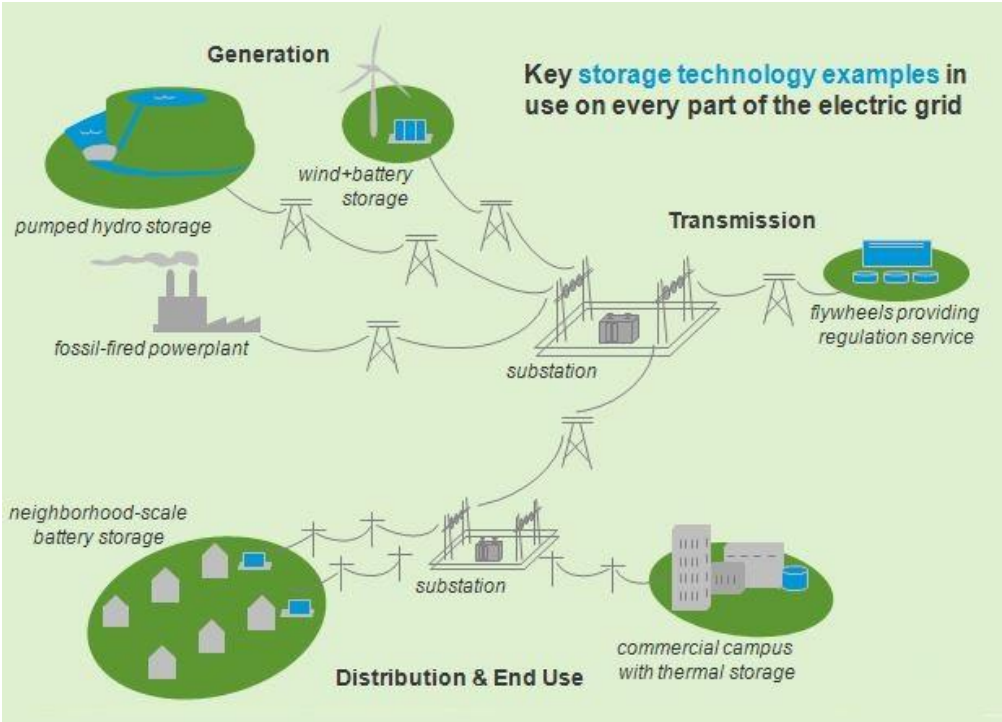


- Low carbon electricity is expected to play a major role in achieving emissions targets, with an increase in renewable generation partnered by electrification of heating and transport.
- Energy storage system became one option for providing flexibility in the energy system, which could reduce the need for new generation capacity and allow greater use of low carbon power.
- As important policy and investment decisions will be taken over coming years that have long-term effects on the energy system, it is timely for a high-level and strategic consideration of the role energy storage could play.

SCOPE OF ROUNDTABLE

An **energy storage system (ESS)** is a device that stores electricity when the demand is low and provides stored electricity when the demand is high. This improves energy efficiency and stabilizes operations of the electricity grid.

ESS are valuable components in most energy systems and could be an important tool in achieving a low-carbon future. And **energy storage deployment** is competitive or near-competitive in today's energy system.



Source : U.S. Energy Information Administration

CEM5 ROUNDTABLE CONCEPT

- The roundtable is focused on the how to develop sustainable energy strategies utilizing energy storage system. Participants will address key questions:
 - 1) What are the current status and the outlook of technology development for expanding the deployment of ESS?
 - 2) What are legal, institutional and technical challenges to the deployment of ESS in each nation? What can be done to meet these challenges?
 - 3) What are effective and efficient financing measures for the development and deployment of ESS?
 - 4) What challenges and opportunities arise in emerging economies through the expanded deployment of ESS?
 - 5) What areas require public-private coordination and what should be given priority?

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ESS ACROSS THE VALUE CHAIN

- Storage solutions for every step of the value chain

Production



Energy & Power

1 - 10MW

Renewables
Capacity Firming
Smoothing, Shaving

Transmission



High Power

10 – 50 MW

Ancillary Services
Frequency Control

Distribution



Energy & Power

100 Kw – 1MW

Load Management
Peak Shaving
Voltage Control

Consumption

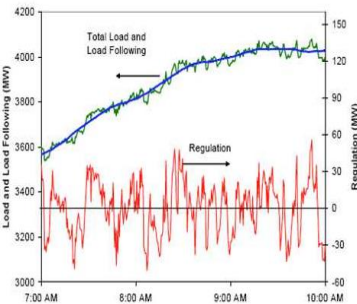


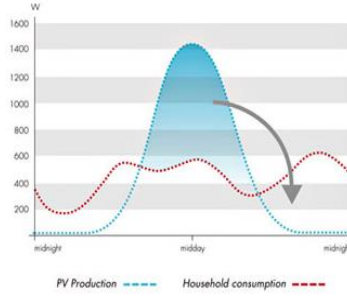
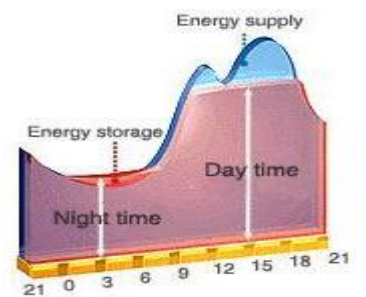


Energy

5 – 50 kW

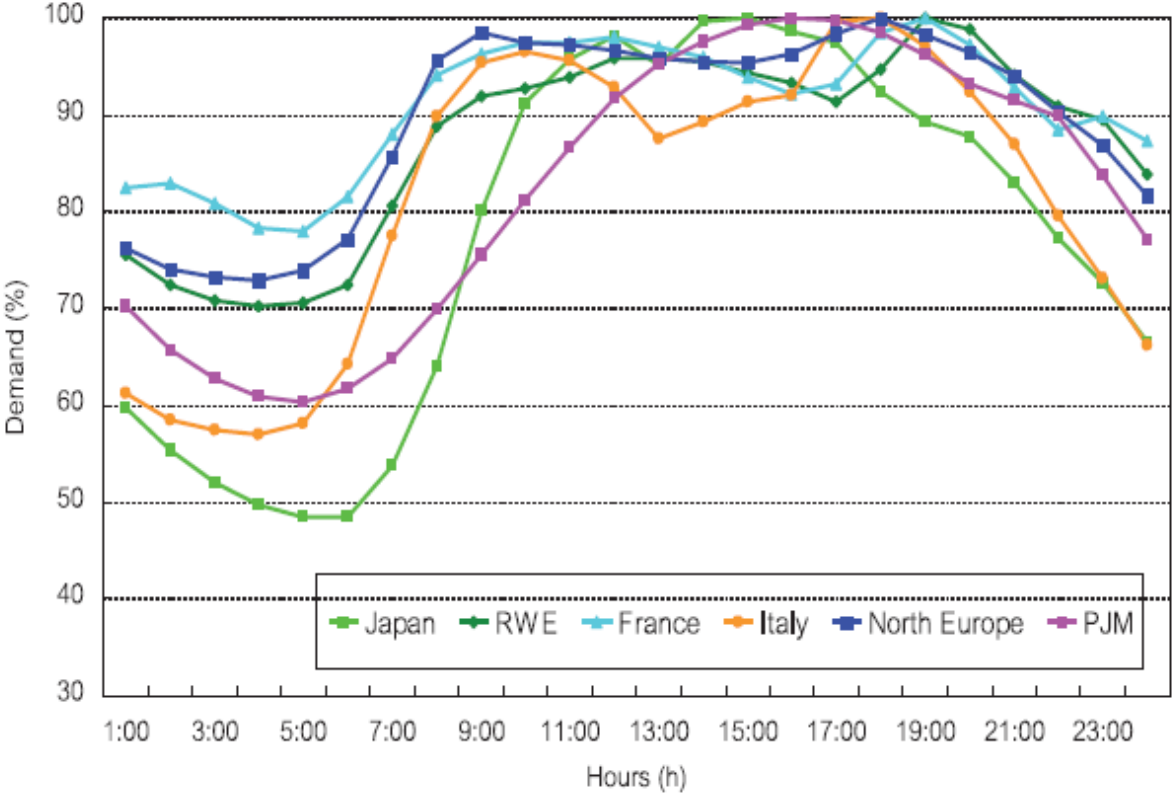
Time Shifting
Local Energy
Management

ESS UTILITY APPLICATIONS

Frequency Regulation	Community Energy Storage	Residential Energy Storage	Peak Shifting	Load Leveling
				
<ul style="list-style-type: none"> • Purpose <ul style="list-style-type: none"> - Maintain a constant grid frequency - Grid stabilized back-up power (spinning reserve) 	<ul style="list-style-type: none"> • Purpose <ul style="list-style-type: none"> - Neighborhood back-up - Local peak shifting - Power quality 	<ul style="list-style-type: none"> • Purpose <ul style="list-style-type: none"> - Residential back-up - PV integration 	<ul style="list-style-type: none"> • Purpose <ul style="list-style-type: none"> - Alternative to peaking gas power plant in urban areas - Renewable peak shifting 	<ul style="list-style-type: none"> • Purpose <ul style="list-style-type: none"> - Energy arbitrage - Renewable capacity firming

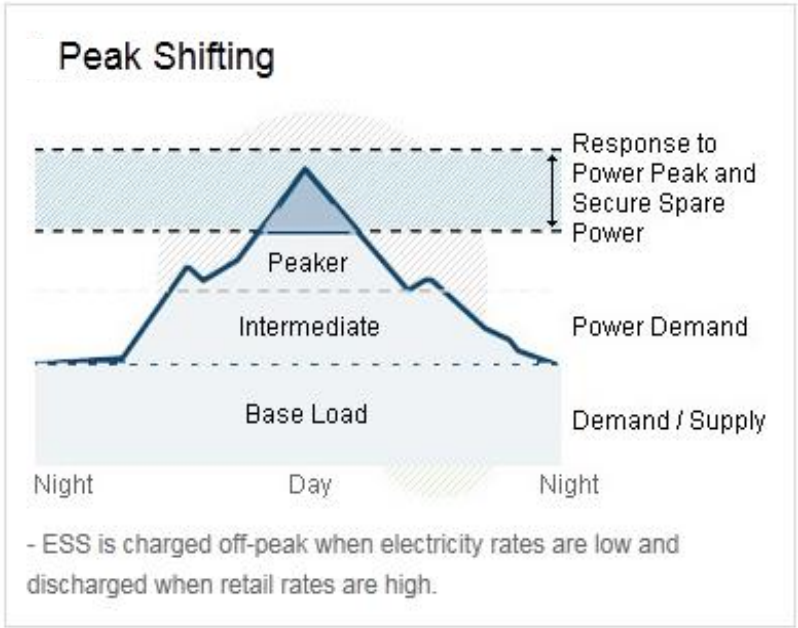
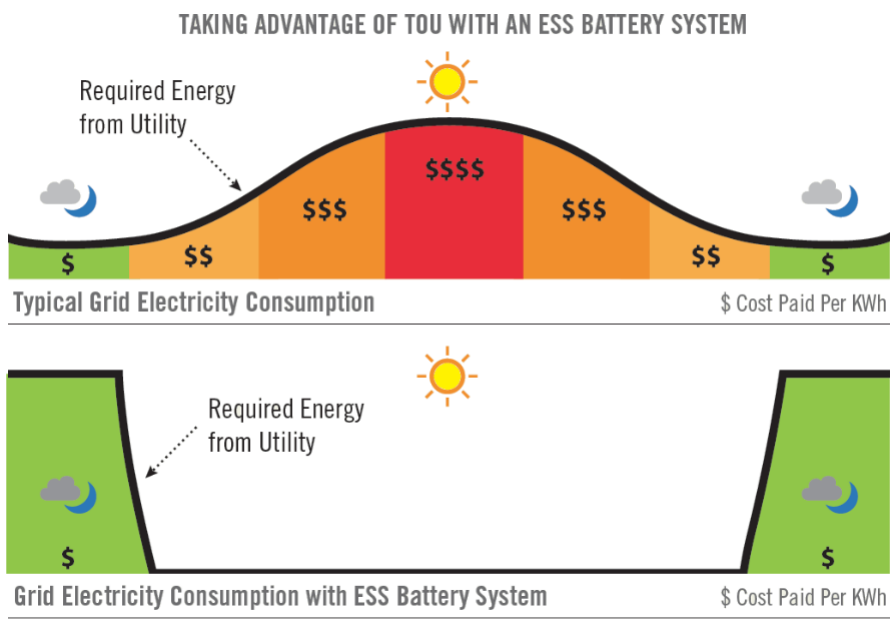
TYPICAL UTILITY LOAD CURVES

- The IEC, in its “Comparison of daily load curves,” states: **Power demand varies from time to time, and the price of electricity changes accordingly.** The price for electricity at peak demand periods is higher and at off-peak periods lower. This is caused by differences in the cost of generation in each period.



POTENTIAL ESS IMPACTS ON PEAK DEMEND

- **Energy storage system (ESS)** is a new technology that helps ensure a stable supply of electricity and reduces power consumption by **lowering peak electricity demand**, while complementing the shortcomings of renewable energy, including wind power and PV



POTENTIAL BENEFITS OF ESS

• **Energy storage system** offer possibilities for improved energy generation and access

- Displace expensive and emissions-intensive diesel-based generation
- Improve efficiency and profit of existing generating assets
- Reduce overall emissions
- Increase adoption and profitability of renewable energy
- Create local jobs
- Provide environmental benefits

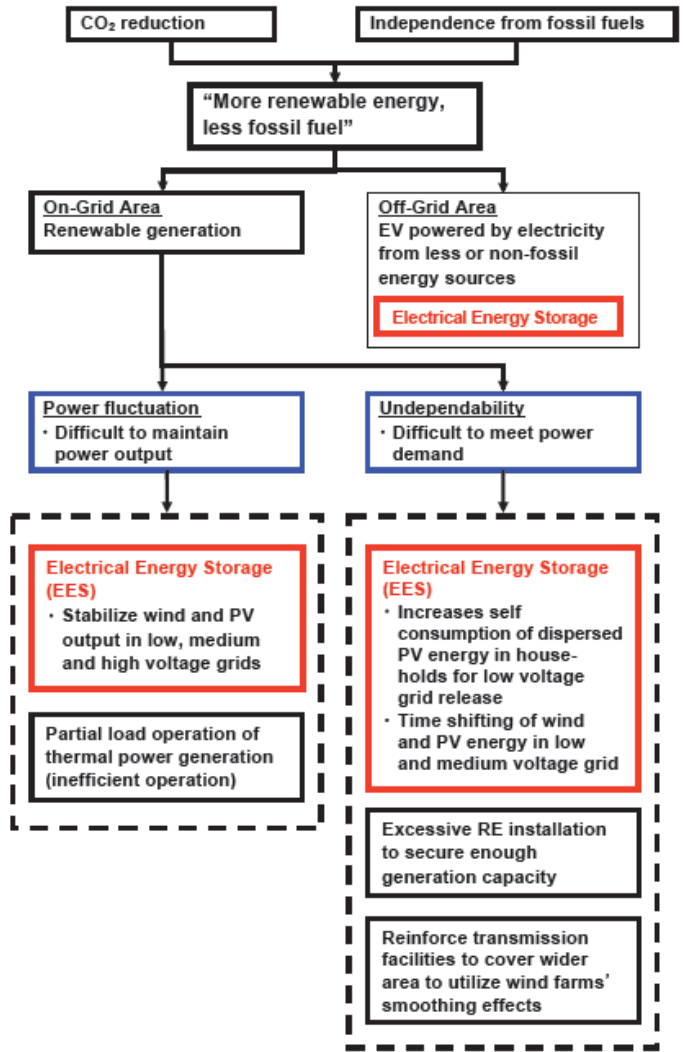
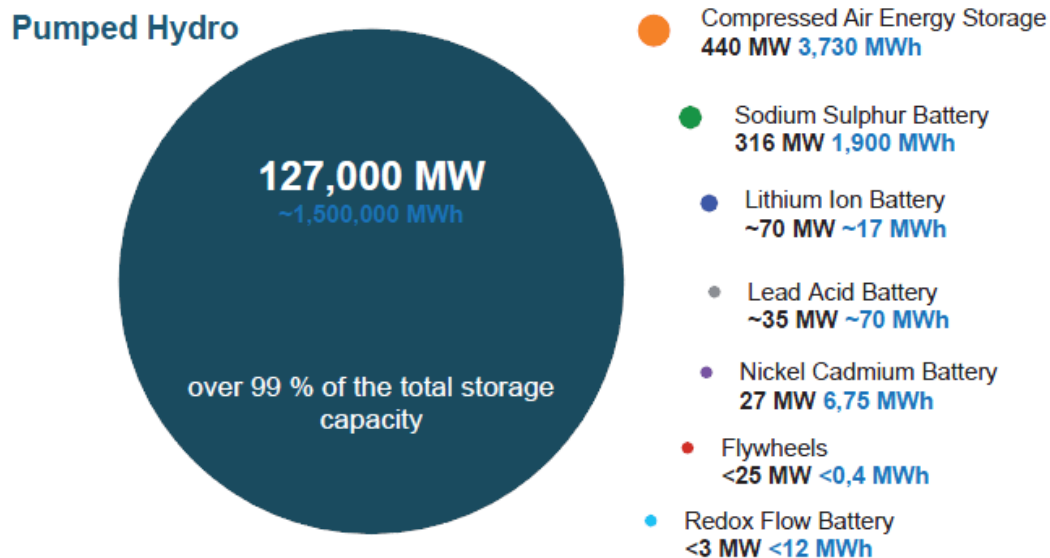


Figure 1-2 – Problems in renewable energy installation and possible solutions (TEPCO)

CURRENT LANDSCAPE

- The Current Landscape for Energy Storage**

Worldwide installed storage capacity for electrical energy



- Chart provides capacity of ESS systems used in electricity grids
- **Pumped Hydro Storage (PHS)** power plants, with over 127GW, represent 99% of total ESS deployed
- Currently, ESS represents 3% of global generation capacity

Source : Fraunhofer Institute.

EPRI, Electricity Energy Storage Technology Options, 2010.

CURRENT LANDSCAPE

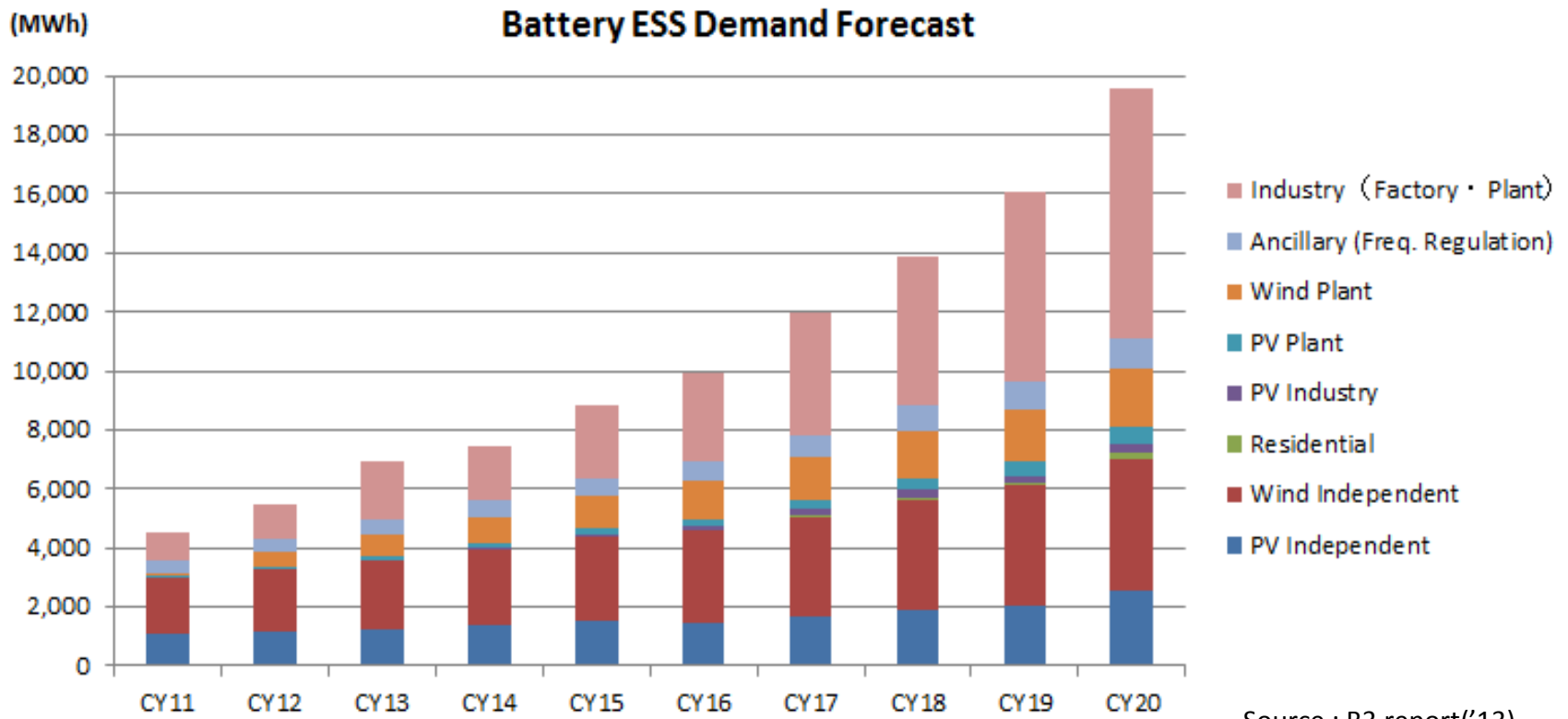
- The Current Cost & Efficiency of Energy Storage**

Technology	Power subsystem cost \$/kW	Energy Storage Subsystem Cost \$/kW	Round-trip Efficiency %	Cycles
Advanced Lead-acid Batteries (2000 cycle life)	400	330	80	2000
Sodium/sulphur Batteries	350	350	75	3000
Lead-acid Batteries with Carbon-enhanced Electrodes	400	330	75	20000
Zinc/Bromine Batteries	400	400	70	3000
Vanadium Redox Batteries	400	600	65	5000
Lithium-ion Batteries(large)	400	600	85	4000
CAES	700	5	N/A (70)	25000
Pumped hydro	1200	75	85	25000
Flywheels(high speed composite)	600	1600	95	25000
Supercapacitors	500	10000	95	25000

Source : Sandia National Laboratories

ANOTHER ESTIMATE OF RAPID ESS MARKET GROWTH

The worldwide market for **Battery ESS demand** is forecast to grow rapidly to reach **19,000MWh in CY20**



Source : B3 report('13)

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ANOTHER LOOK AT THE CURRENT STATUS OF ESS

- The role for energy storage is poorly described in many pathways to a low-carbon economy.
- It is a complex technology covering timescales from seconds to months, which needs detailed analysis of systems and sub-systems to identify the economic and environmental benefits that it may bring.
- New energy storage technologies are unlikely to be deployed on a large scale under current market and regulatory conditions.
- Demonstration of energy storage technologies needs to be scaled-up to show the impact they can have and to guide further underpinning R&D to reduce costs and improve performance.
- Energy storage is an enabling technology; its potential role will be defined by developments across the energy system.

TECHNICAL BARRIERS

Cost-competitive energy storage technologies

- Despite its promising future from a technical perspective, the primary barrier to implementation of energy storage projects is the high cost of available technologies.

Diesel engines are the primary power source for many rural communities due to a lack of technical expertise in other technology opportunities.

- Renewable energy and other power resources are often ignored for traditional, familiar diesel systems.

Operation and Maintenance (O&M) pose a challenge and can threaten the continuity of the operation and the reliability of power supply.

- Energy storage system is utilized to improve the reliability of power generation, but add complexity and cost to the system.

Uncertainty on how storage technology will be used in practice and how new storage technologies will perform over time in application

- Systems operators have limited experience using deployed storage resources.

ECONOMIC BARRIERS

Lack of markets

- The lack of markets and market prices makes it difficult and sometimes impossible, depending on the situation, for an energy storage developer to consider a resource to provide these services.

Lack of price signals

- Difficulty in determining market prices for ancillary services makes it challenging for independent developers to consider energy storage resources and compete against other resources in procurement calls.

The total cost of storage systems, including all the subsystem components, installation, and integration costs need to be cost competitive with other non-storage options available to electric utilities.

- While there is a strong focus on reducing the cost of “storage” components, such as batteries or the flywheel, the storage component still constitutes only 30% to 40% of the total system cost.
- The focus needs to be on the entire system.

POLICY BARRIERS

A shortage of information in the public issues, and a lack of consumer awareness and access to information.

- Information is needed for both large global corporations and very small local players to evaluate entering the market.

Subsidy policies, such as capital subsidies, are aimed at short-term performance.

- Short-term subsidies are not effective or efficient in promoting long-term performance.

A lack of government support for rural electrification institutions or programs

- Countries lack institutions that fully understand the electricity needs of rural and remote populations. Many state-level governments lack the capacity to properly address rural electrification needs.

REGULATORY BARRIERS

Administrative delay in the implementation of new regulations to address barriers to energy storage deployment itself presents a barrier to deployment.

- Slow adoption of pay for performance requirements by many ISOs/RTOs
- Slow modification to market participation rules to allow limited duration energy storage resources to participate in ancillary service markets

No international standard operating procedures, quality standards, or safety standards exist for setting up ESS.

- The lack of standards results in a high-risk perception that discourages private investment, which limits funding opportunities.
- Demand for ESS decreases due to uncertainty about the quality and safety.

PERFORMANCE AND SAFETY

The process for evaluating and reporting the performance of existing storage systems on a unified basis needs to be created.

- This combined with industry accepted codes and standards to specify desired performance parameters for each storage service, will lead to a wider acceptance of energy storage system.
- For example, the usable life of batteries, the length of time

The operational safety of large storage systems is a concern and will be a barrier its deployment in urban areas or in proximity of other grid resources such as substations.

- Design practices that incorporate safety standards and safety testing procedures for the different storage technologies need to be developed and codified.

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TECHNICAL SOLUTIONS

- Accelerate R&D efforts focused on optimizing the integration of energy storage technologies in the energy system.
- Improve battery assembly design to improve system reliability and performance.
- Improve operation management of battery systems, both centralized and distributed.
- Improve the efficiency of energy storage system and document technology performance through testing and demonstration.
- Document and more effectively communicate the cost and performance of energy storage systems for applications and best practices for installation and operation.

ECONOMIC SOLUTIONS

- Define a fair market design for all services provided by energy storage
- Support needed market integration
- To ensure long-term viability, preference market solutions for storage applications in both regulated and non-regulated parts of the system
- Streamline the financing process for large-scale storage systems, with clear guidelines on documentation requirements
- Incentivize the co-financing of distributed electricity generation technologies with integrated storage after assessing the risks and benefits of this approach
- Explore new business models to overcome the barrier of high upfront costs of innovative and efficient energy storage solutions
- Standardization is a key requirement for cost reduction
 - Standardization can lead to lower transaction costs in the economy as a whole, as well as to savings for individual businesses.

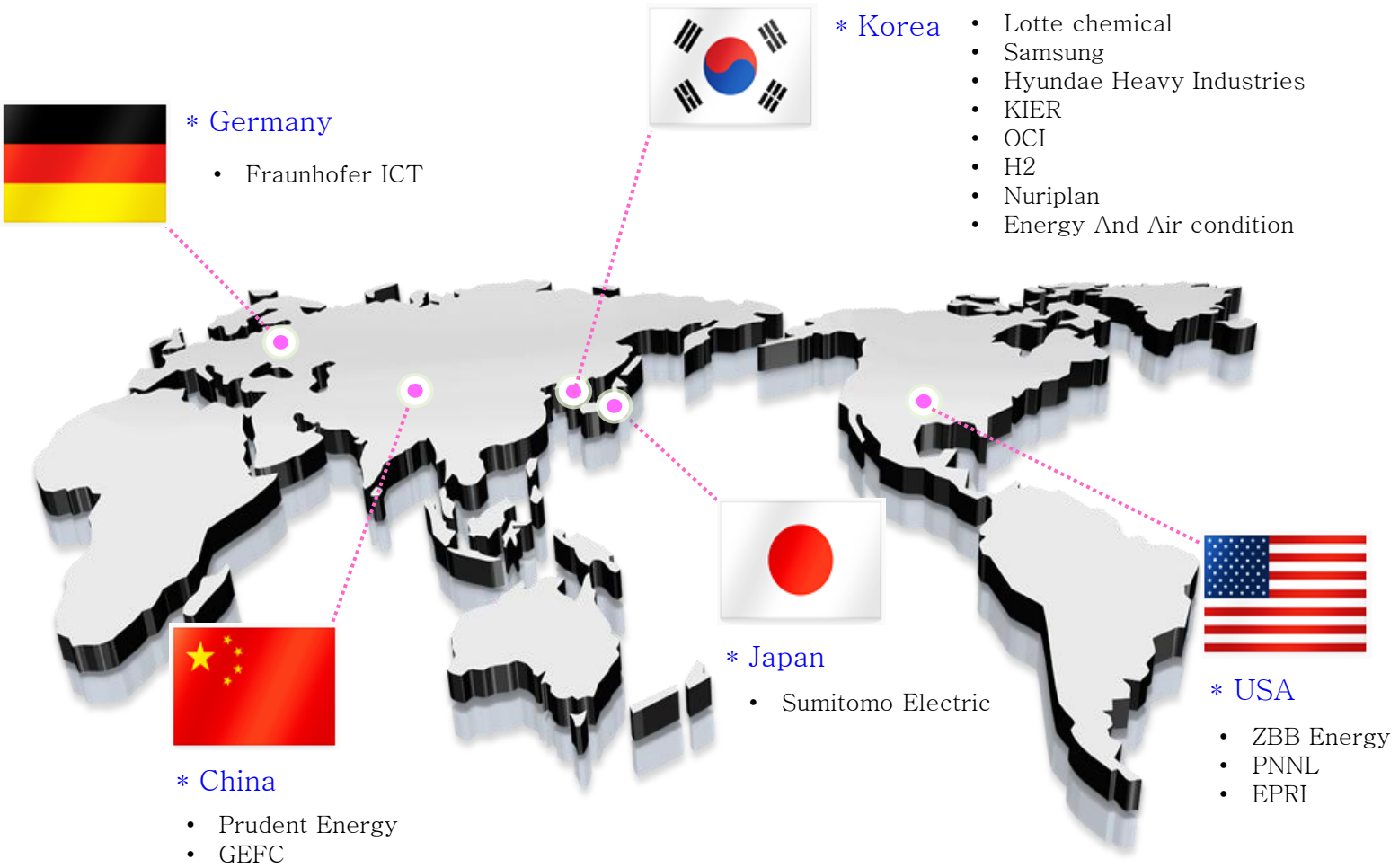
POLICY SOLUTIONS

- Governments – Set out long-term policy directions for energy
- Regulators – Ensure uniform or at least non-conflicting treatment and ensure, where possible, coherent, comprehensive, and equitable regulatory treatment
- Funders of energy innovation -- Set out strategies for the analysis and innovation of energy storage technologies, coordinating support and integrating the analysis of potential benefits with technology innovation.
- All – Work cooperatively to ensure an efficient transition to low carbon solutions that energy storage could help enable.
- All – Fund further analysis of the potential role of storage.
- All – Support whole system and subsystem modeling, incorporating the full range of energy storage options across time and energy scales.

REGULATORY AND STANDARD

- Recognize the potential benefits of increased energy storage explicitly in electricity Market Reform and regulatory approaches
- Avoid adding barriers in the way of future ESS deployment, either directly or as an unintended consequences of other policies, despite the underpinning analysis to define ESS' potential role not being fully developed to date.
- Take note of emerging environmental and economic cases for incentivizing deployment of such technologies
- Implement testing programs to document the safety and performance of energy storage technologies, based on published standards and protocols.
- Work with standard-setting organizations and governments to develop performance-based labelling of energy storage.

INDICATIVE ESS DEMONSTRATION PROJECTS*



**This is a indicative list of projects. It is not meant to capture all of the active ESS demonstration projects in any of the countries listed or globally.*

DEMONSTRATION

Zhangbei National Wind PV Energy Storage Project (China)

Hybrid Wind Power + Solar PV Generation + Lithium-ion Battery Energy Storage : 216 MW



*As of completion in 2011, the Zhangbei National Energy Storage and Transmission Demonstration Project is the world's first and, to date, only utility-scale hybrid renewable energy plant to **integrate utility-scale wind and solar PV generation with large scale lithium-ion battery energy storage***

- **Location :** Zhangbei County, Hebei Province, China
- **Project Status :** Commissioned : 2011
- **Rated Capacity :** Total 216MW (wind 100MW, solar PV 40MW, Battery storage 20-36MW)
- **Owner :** State Grid Corporation of China(SGCC)
- **Cost :** \$1.88billion(first phase investment : \$550 billion)

DEMONSTRATION

Laurel Mountain Plant (U.S.)

Wind farm + Lithium-ion Battery Energy Storage



*Providing energy storage for a **98MW** wind farm, the **AES Laurel Mountain Plant 32MW lithium-ion battery storage** facility is the largest such energy storage facility in the United States*

- **Location :** Randolph and Barbour Counties, West Virginia
- **Project Status :** Commissioned : 2011
- **Rated Capacity :** 32MW in 15 minute increments(short term smoothing), wind : 98MW
- **Owner :** AES Corporation
- **Cost :** AES declines to share cost figures

DEMONSTRATION

AES Projects (Japan)

Wind Power + Solar PV Generation + NaS battery Energy Storage : 85 MW



*The Rokkasho-Futamata Wind Farm is the largest and first combined **wind generation(51 MW) plus battery energy storage(34MW) facility in Japan** and one of the world's largest sodium sulfur(NaS) battery assemblies*

- **Location :** Rokkasho, Aomori, Japan
- **Project Status :** Commissioned : 2008
- **Rated Capacity :** Total 85MW (wind 51MW, Battery storage 34MW)
- **Owner :** Japan Wind Development Company, Ltd.
- **Cost :** No available

DEMONSTRATION

AES Projects (Germany)

Compressed Air Energy Storage(CAES) : 321MW



*Germany's Huntorf Compressed Air Energy Storage Plant is the **world's first and still the largest utility-scale, commercial compressed air energy storage plant** (as of April 2012)*

- **Location :** Huntorf, Germany
- **Project Status :** 1978(upgraded from 290 MW to 321 MW in 2006)
- **Rated Capacity :** 321MW over 2 hours
- **Owner :** E.O Kraftwerke GmbH(BBC Mannheim designed the plant)
- **Cost :** Unknown

DEMONSTRATION

AES Projects (U.S.)

Compressed Air Energy Storage(CAES) : 110MW



*The world's first and only utility-scale compressed air energy storage facility in the United States. Along with Huntorf CAES in Germany, the **only operational commercial CAES** plants in the world*

- **Location :** MacIntosh, Alabama, U.S.
- **Project Status :** 1991
- **Rated Capacity :** 110 MW over 26 hours
- **Owner :** PowerSouth Energy Cooperative(designed by Energy Storage Power Corporation)
- **Cost :** \$65million

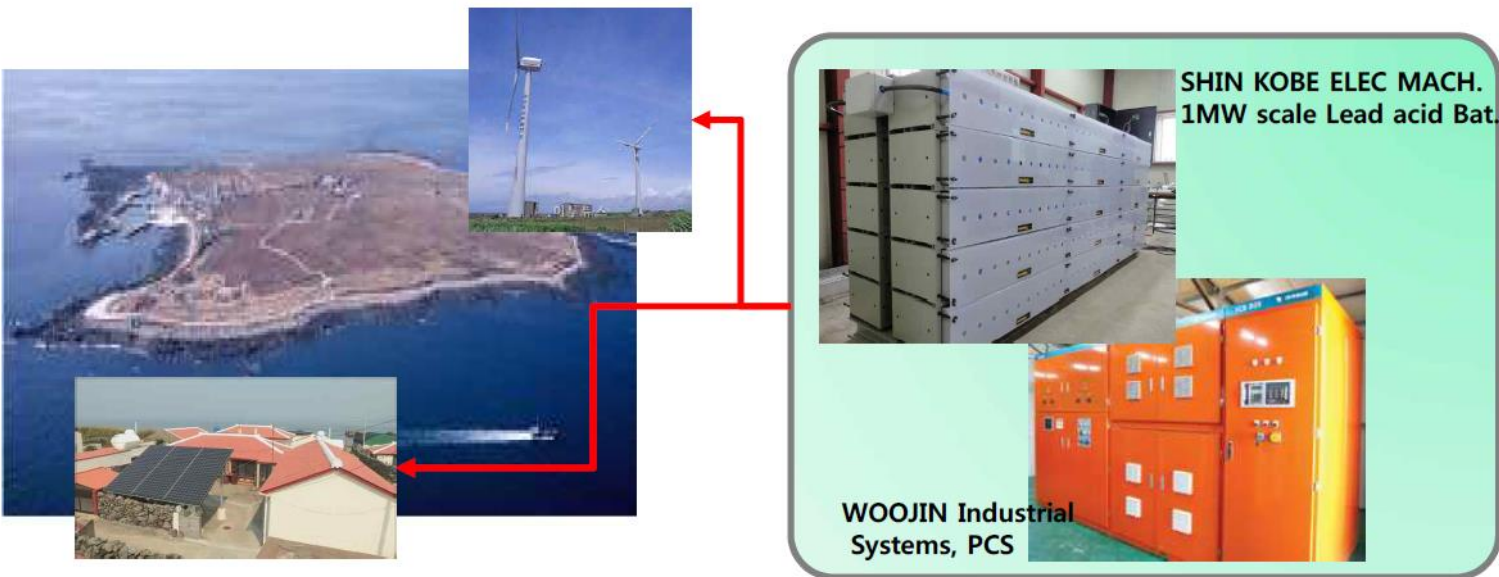
CASE STUDIES

Carbon free island GAPA-DO (Korea)

KEPCO : Smart grid system control(193 families)

KOSPO(Nambu Genco) : Wind Power (250kW, 2EA)

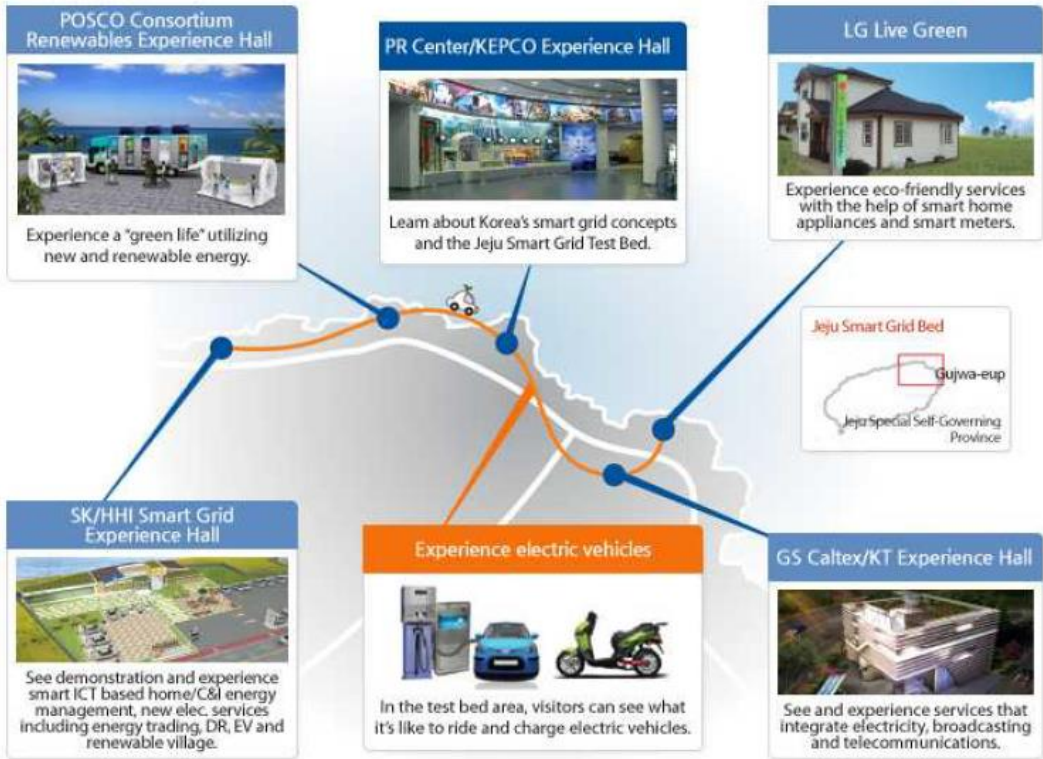
KRE(Korea Renewable Energy) : ESS & PCS



DEMONSTRATION

Jeju Smart Grid Demonstration Project (Korea)

• 8 MWh ESS LiB will be demonstrated at the Jocheon substation in Jeju



Demonstration



POSCO ICT 2MW scale BESS system
- System operation
LG Chem. Li battery supply



Samsung SDI ESS system – Plan to demo. at the Jocheon substation

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IEA's KEY ACTIONS FOR THE NEXT 10 YEARS*

- **Determine** where near-term **cost effective niche markets** exist and support deployment in these areas, sharing lessons **learned to support long term development**
- **Incentivize** the **retrofit** of existing storage facilities **to improve efficiency and flexibility.**
- **Develop marketplaces** and **regulatory environments** that enable accelerated deployment, in part through **eliminating price distortions** and enabling benefits-stacking for energy storage systems, allowing these technologies to be compensated for providing multiple services over their lifetime.
- **Support** targeted **demonstration projects for more mature**, but not yet widely deployed, energy storage technologies to document system performance and safety ratings. **Share information** collected including lessons learned widely through storage stakeholder groups.

IEA's KEY ACTIONS FOR THE NEXT 10 YEARS*

- **Support investments** in **research** and **development** for early stage energy storage technologies **to maximize resource use efficiency**.
- **Establish** a comprehensive set of **international standards** in a manner that allows for incremental revisions as energy storage technologies mature
- **Evaluate** and **broadly disseminate** the **learning** and **experience** from established installations. Information should include data on both technical aspects (e.g. generation, cost, performance) and contextual details (e.g. market conditions, energy pricing structures) specific to a region/market.
- **Establish** international and national **data co-operation** to foster research, monitor progress and assess the research and development (R&D) bottlenecks.

THANK YOU