Event Summary Report

CAREC Knowledge Sharing Program on ICT for Energy



17-20 April 2017

Seoul, Republic of Korea

Prepared by Lux Research, Inc.

50 YEARS ADB 산업통상자원부 MINISTRY OF TRADE, INDUSTRY & ENERGY MOTIE KSGA Korea Smart Grid Association

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Introduction

On 17-20 April 2017, a Knowledge Sharing Program took place in Seoul hosted by the Asian Development Bank (ADB) and sponsored by the Korea Ministry of Trade, Industry, and Energy (MOTIE) and supported by the Korea Smart Grid Association (KGSA). The Program objective was to provide a platform to improve understanding of the role Information and Communication Technology (ICT) and other key technologies plays in the energy sector.

The Program gathered distinguished guests from Central Asia Regional Economic Cooperation (CAREC) countries. Additional participants included leading Korean corporations active in the ICT and energy sectors, representatives from strategic advisory firms, and ADB representatives. The three day program included informative presentations, lively panel discussions, extensive networking, and on-site visits to witness the successful implementation of ICT for energy.

This report highlights key themes that emerged from the Program and technology innovations and ICT applications enabling a distributed and renewable energy landscape.

Image: Group photo of the Program participants on Day 2 at K-Water's Integrated Water Management Center

Setting the Stage

Representatives from each CAREC nation shared insightful information on their countries' energy landscape and how it presented both opportunities and challenges at the same time. Several delegates spoke of their nations' abundant natural resources and the potential it has to play a key role in its energy landscape. Alternatively though, those opportunities faced common challenges including a lack of energy infrastructure and the distributed nature of its natural resources. Despite sharing similar geographies, economic stages of development, and similar opportunities and challenges, the program participants revealed that each country faces unique challenges, and a universal solution would not be an appropriate approach. However, even with such differences between the countries, three underlying themes were present throughout the opening panel discussion:

Three Major Themes of CAREC Nations' Energy Landscape

- **Improving and optimizing existing energy resources** – Inadequate infrastructure and underdeveloped energy management systems have left several countries facing the challenges of balancing its energy supply and demand, resulting in power shortages that continue to plague the country. Reducing energy loss, particularly due to theft, was another commonly mentioned theme for improving and optimizing the existing energy infrastructure.
- **Reducing dependence on energy imports** – Energy demand continues to increase and several nations around the world are striving for energy independence; CAREC nations are no different. Many rely heavily on the import of oil and gas to meet its energy demand needs, and with a volatile commodities market, economic and energy security risks are present. This is a risk all are trying to mitigate and ultimately eliminate in the future.
- **Increasing the share of renewable power generation** – Renewables are a major topic and will likely play a key role in the energy future of many CAREC nations. While ambitions shared by the representatives echoed many of the pledges laid out in the Paris Climate Agreement, worries about cost remained at the top of the list. Additionally questions about the suite of renewable technologies and ICT platforms that could enable widespread deployment created uncertainly for many of the program participants.

In this report we will discuss the technologies presented by industry experts as well as the technologies that attendees were able to see first-hand during the program. Most importantly, the following sections identify how these technologies address the three major themes impacting CAREC nations' energy landscape, and the ongoing innovations that will enable CAREC nations to improve and optimize existing energy resources. These innovations provide solutions to reduce dependence on energy imports and increase the share of renewables in their respective country's energy future.

Energy Management Systems: Digital Tools for Optimization

Managing a Reliable and Efficient Nationwide Power System

With inadequate infrastructure, the near-term development goals of CAREC nations focus on building and expanding nationwide power systems to provide power to the people. In addition to increasing up-time and availability, program participants have major concerns regarding reliability, efficiency, and the optimization of grid performance as national grids are developed. The deployment of energy management systems (EMS) plays a critical role in the success of a nationwide power system as explained by Jiyeon Park from KEPCO-KDN.

While EMS are comprised of several different components (see Figure 1), EMS implementations have seen measurable benefits of higher reliability and security and overall enhanced operational efficiency for the Republic of Korea's national grid. Utilizing Supervisory Control and Data Acquisition (SCADA) as the gateway to its EMS, KEPCO-KDN is able to leverage real-time data to maintain load frequency via Automatic Generation Control (AGC). AGC takes into consideration additional economic factors, such as fuel cost, through its Economic Dispatch (ED) algorithm, resulting in a cost efficient approach to balancing power demand and supply. Beyond operations, Network Analysis (NA) and Dispatcher Training Simulator (DTS), provide a platform to simulate various sequence of events and scenarios based on historical and real-time data that has been gathered via SCADA.

As two key challenges of CAREC nations are high reliability and security of the power grid, EMS will play a pivotal role as power infrastructure continues to expand in order to meet the ever growing energy demand from the population.

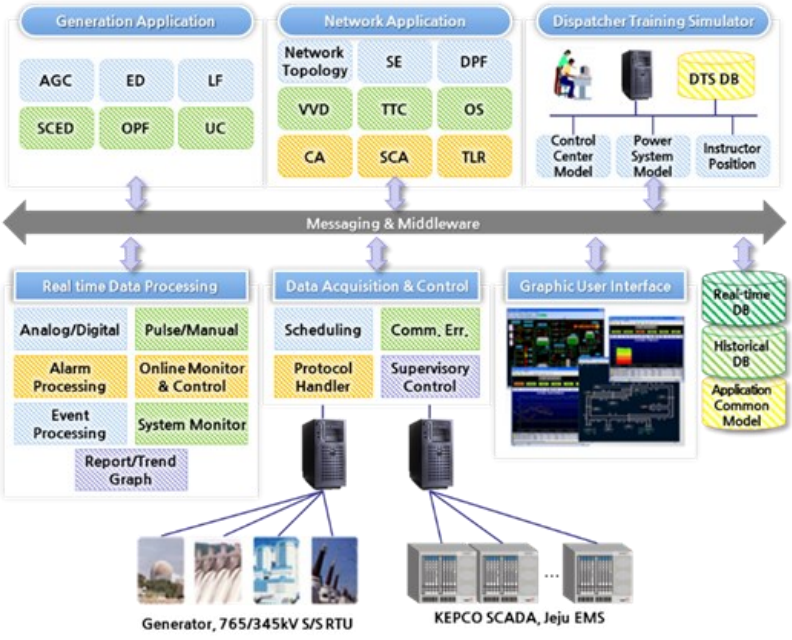

Figure 1: Schematic diagram of major functions of KEPCO-KDN's EMS for the Republic of Korea power grid (Source: KEPCO-KDN)

Utilities Are No Longer the Only Key Players in Energy with the Emergence of ICT

As digitization continues to occur in the energy landscape, a new group of players traditionally not involved in the energy space have entered and bring a new body of knowledge in ICT that has not been commonplace in the past. This industry trend presents unprecedented challenges for utilities and puts many of fundamental business models at risk. Utilities are finding ways to adapt and proactively seek assistance from outside its core industry, as seen with the presentation by Jundong Lee from Korea Telecom's Smart Energy Business Unit.

A telecom company at an energy meeting would not have been common-place in prior years. However, the ICT sector and energy sector are becoming more intertwined (see Figure 2) as big data and analytics capabilities developed in the ICT sector offer substantial value propositions for operators in the energy sector looking to evolve and grow its business.

Korea Telecom's Smart Energy Business Unit brings optimization to existing infrastructures through the deployment of sensors and meters for data collection. Korea Telecom then leverages its existing nationwide telecommunication network to transmit data to a centralized location so it can be visualized and analyzed in a user-friendly interface. This presents energy optimization opportunities at a very granular level, where devices such as lighting and heating and cooling systems can each be monitored individually. Combined with real-time data, advanced metering plays a key role in a smart and efficient energy infrastructure.

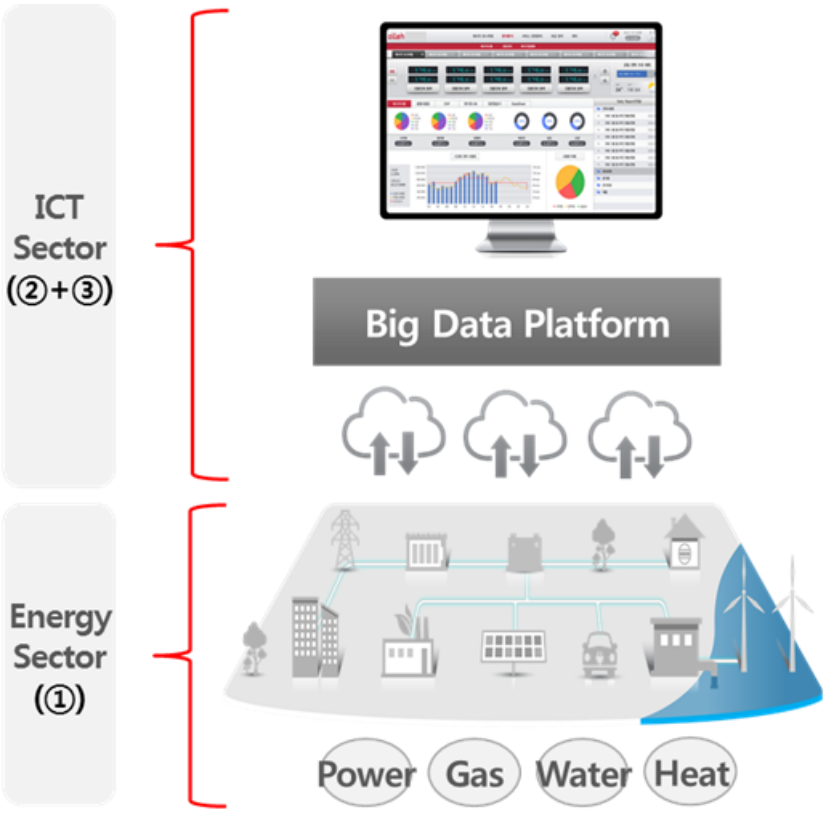

Figure 2: Big data and analytics from the ICT sector enables the evolution of the energy sector (Source: Korea Telecom)

Follow the Signal: ICT Solutions for Energy Needs Actionable Insight

ICT for energy falls under the category of the industrial Internet of Things (IIoT), which is the application of Internet of Things (IoT) tools in the industrial realm. IIoT is best defined by what is being connected, how and why it is connected, how the data is being used.

Advancements in sensors and chips, combined with cloud infrastructure and analytics forms the IIoT value chain. While several companies specialize in various parts of the value chain, larger players such as GE, Amazon, and IBM offer broader platforms via partnerships and acquisitions of smaller players. CAREC nations interested in IIoT for energy are advised to seek collaboration with corporations outside of the energy sector as core expertise in implementation and successful execution will rival that of any developed internally by utilities.

Lastly, regardless of the components or the provider of the IIoT solution, the key to successfully leveraging ICT in energy is to "follow the signal". The key question and the ultimate goal of the system design is in the final step, "Act: How do I act on this insight?" (see Figure 3).

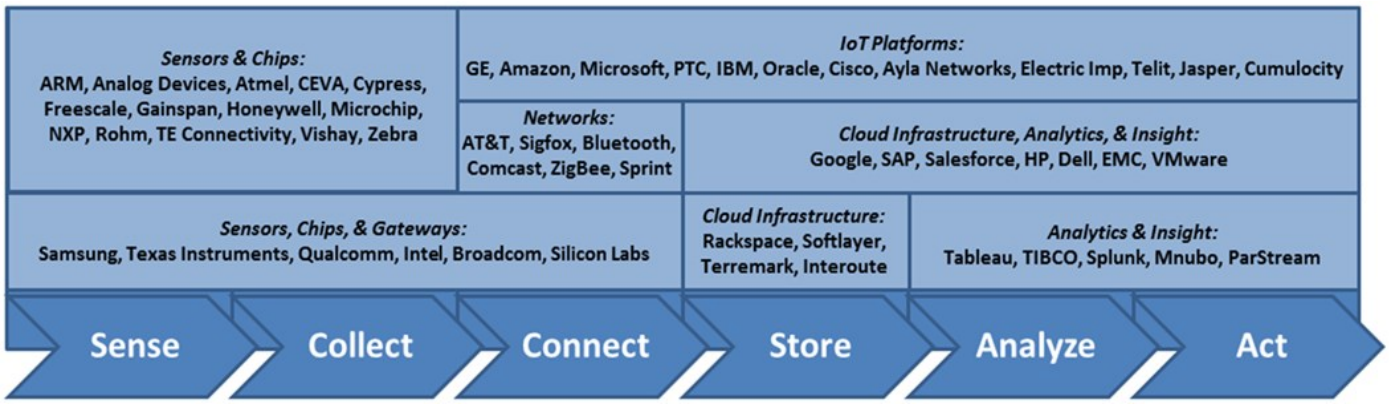

Figure 3: Following the signal of the IIoT toolbox illuminates patterns in system design with players both big and small involved in the emerging IIoT value chain (Source: Lux Research)

Site Visit Spotlight: *K-Water's Integrated Water Management Center*

On Day 2, Program participants visited K-Water's Integrated Water Management Center in Daejeon, Republic of Korea. Established in 1982, K-Water has evolved its capabilities and expanded the role of its Water Management Center for weather forecasting, hydrological data acquisition, water supply management, flood control operation and management, hydroelectric power, and continued development of ICT capabilities for further process and operational optimization.

During the visit Program participants viewed the history of The Center as it transformed from a paper-and-pen operation to a real-time data center monitoring and controlling the Republic of Korea's water infrastructure.

Find out more at K-Water's official website.

Image: Program participants viewing history of K-Water's Integrated Water Management Center and witnessing the implementation of ICT solutions in optimizing nationwide water infrastructure on Day 2

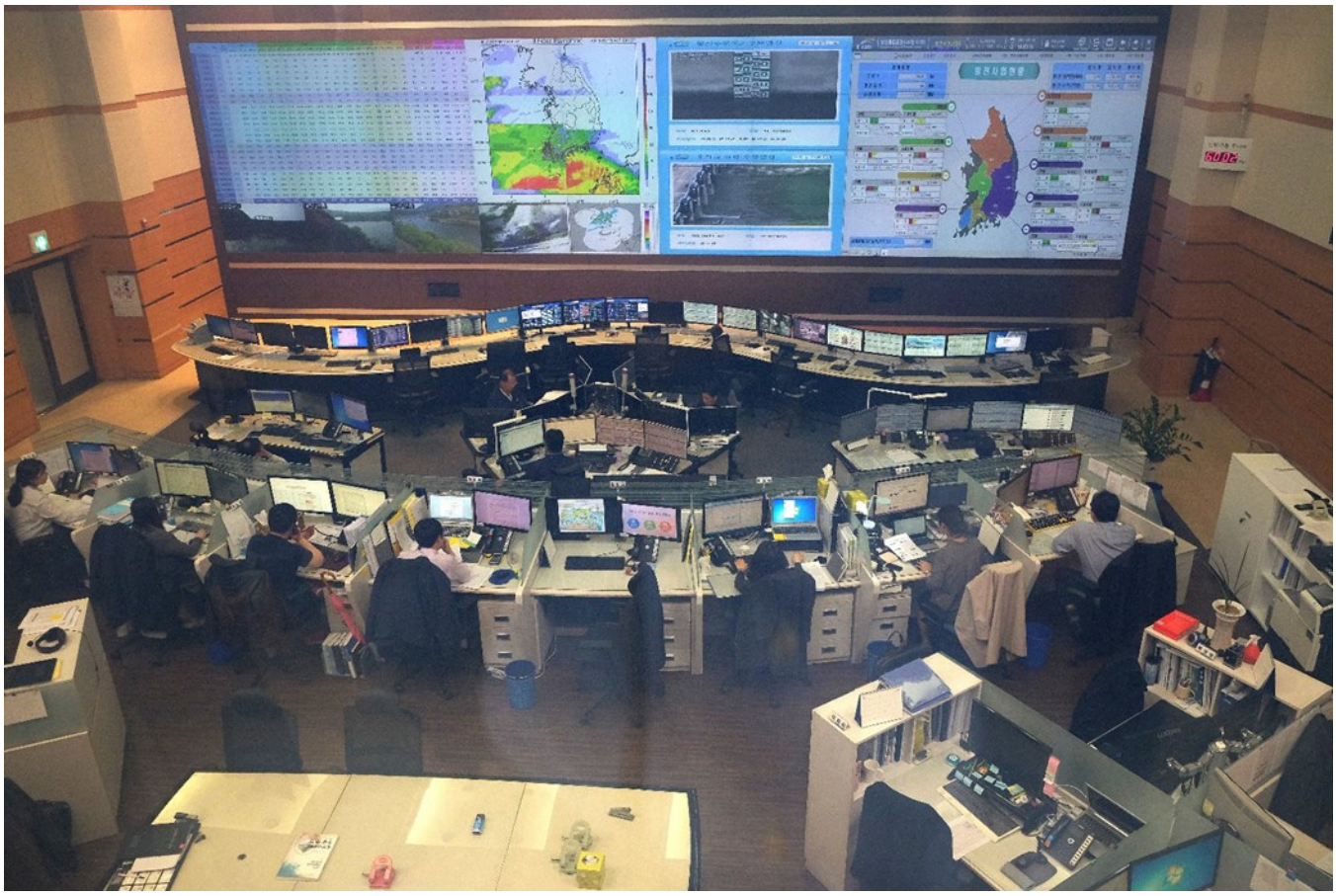

Image: Overhead view of K-Water's Integrated Water Management Center all-source situation room

Micro-grids: Distributed Energy Solutions for CAREC Nations

Micro-grids in the Context of CAREC

ADB's Dae Kyeong Kim provided a lasting snapshot on the current status of the energy sector in CAREC nations. Of the nine countries, only two, Azerbaijan and Turkmenistan, had a power surplus while the rest of the nations suffered from power deficits and faced seasonal and regional imbalance. This status presented a vivid picture of the various issues impacting CAREC nations, such as old and lacking infrastructure, poor electrification rates, and low reliability of supply.

Due to these issues, micro-grids offer a promising solution, addressing a wide range in scale (from less than 1 kilowatt (kW) upwards to the gigawatt (GW) scale) as well as applications in both rural and urban environments.

Another important consideration for CAREC nations is the availability and access to various funding mechanisms to deploy micro-grids in their countries. Fortunately, several financial institutions offer micro-grid specific funds, such as the Green Climate Fund (GCF), Global Environmental Facility (GEF), Multilateral Development Bank (MDB), and Climate Investment Funds (CIF), amongst several others.

It remains pertinent that CAREC nations receive not only government support for energy projects, but also funding from international sources as well.

Micro-grid Deployment Coincides with the Expansion of Renewables plus Storage

Again, as CAREC nations seek solutions to address the three main themes of their energy future, micro-grids offer power system reliability, energy efficiency, and energy security, especially when deployed with renewables, energy storage, and operated via an ICT platform as explained by Jinho Lee, Ph.D. from LSIS.

In its simplest form, a micro-grid has two components: a supply-side, such as microgeneration, and demand resource management for flexible load. This basic micro-grid system, while useful in rural and remote areas, typically consists of a diesel generator, which is costly due to fuel transportation needs. However, with the introduction of renewables, generation cost is reduced but the system also faces stability issues with the higher penetration of intermittent renewables. Ultimately, with energy storage, the concerns of stability are addressed (see Figure 4).

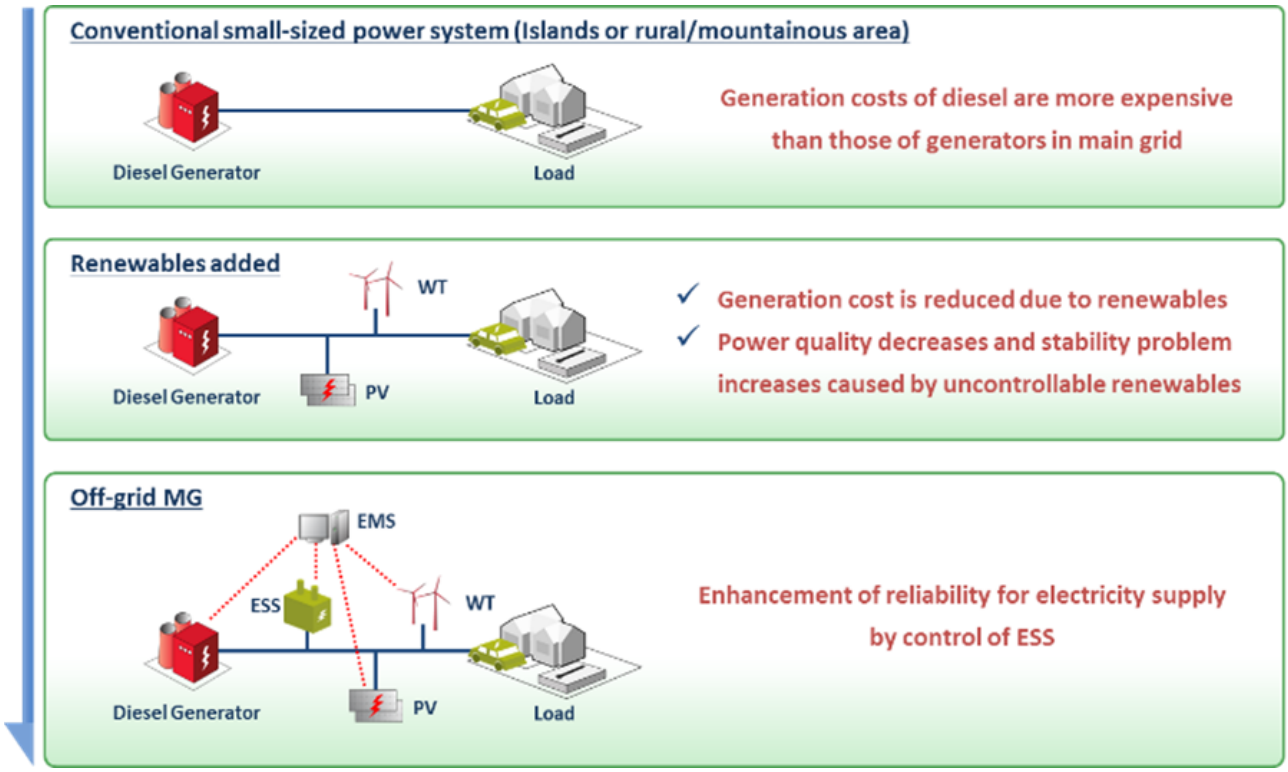

Figure 4: Deployment of renewables plus storage for micro-grids reduces dependence on fossil fuels and increases power stability (Source: LSIS)

Storage Enables Global Expansion of Solar

There is no question that energy storage can help solar installations be more resilient and more useful, and prevent them from placing undue stress on the grid. It has also become clear that there are several benefits from use cases such as "self-consumption."

As a result, CAREC nations must be aware that the implementation of storage will eventually drive demand for an additional 25 GW annually of distributed solar compared to a scenario without the presence of energy storage (see Figure 5).

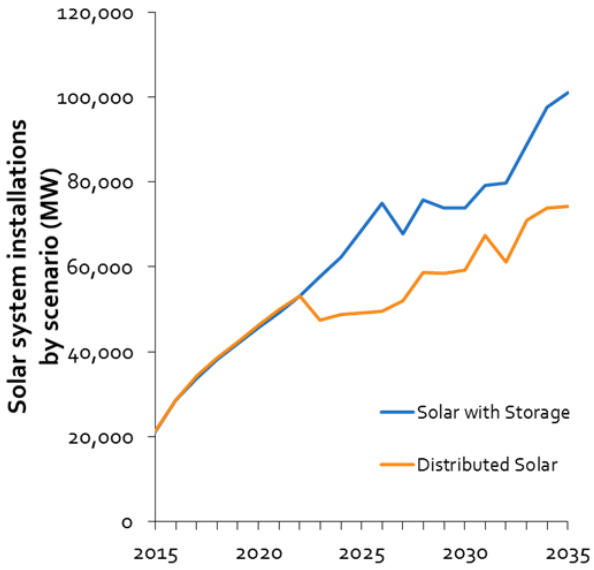

Figure 5: Around 2023 the economic case for solar-plus-storage arises (Source: Lux Research)

Site Visit Spotlight: *2MW Floating Solar Power Plant*

On Day 2, Program participants visited an ADB funded 2MW floating solar power plant. The USD$5.6 million project took six months to complete, officially beginning operations in March 2016. With a capacity of 2MW, the floating power plant produces 2,781 MWh per year and occupies approximately 13,200 m^2 per MW.

Through prefabrication and modular units, the project was able to reduce construction cost by 30% and construction time by 70% compared to earlier pilot studies. Additionally, solar modules were optimized for temperature and moisture resistance, structurally configured for peak buoyancy, and mooring devices to keep the solar panels at water level despite inclement weather conditions. Through these advancements, the project has shown to perform nearly 10% better in terms of energy generation than identical

Image: Mr. Jung-Kyoon Han, ADB CWEN Energy Specialist, explains how prefabrication and modular solar units offer distinct advantages in efficiency and low-cost deployment of floating solar farms in land constrained regions.

Image: Distributed renewable sources come in all forms including floating solar panels for applications in land constrained regions. Program Participants viewed the floating solar panels on Day 2.

Energy Storage: Batteries for a Renewable Future

Cost Reduction, Power Quality, and Improving Reliability through Frequency Regulation

Energy storage systems (ESS) currently have three key use cases: frequency regulation, stabilization of renewables, and peak shaving. With an archaic power infrastructure, CAREC nations will find near-term opportunities in deploying ESS to maintain power frequency caused by imbalance of supply and demand, as presented by Namgil Paik from KEPCO.

There are four main types of ESS – pumped hydro, flywheel, compressed air, battery – each with their own strengths and weaknesses. Batteries have emerged as one of the best potential solutions due to its high efficiency and no geographical limitations. However, it is also the least commercially tested to date as widespread commercial deployment has yet to be seen.

Despite battery-based ESS being relatively new to the industry, it displays promising attributes such as cost reduction due to no fuel inputs, quick response times to regulate frequency variability, and flexibility and speed in ramp up compared to conventional methods. With global leaders in battery technology such as LG Chem and Samsung SDI leading in technology advancements, CAREC nations should strongly consider ESS as an addition to its existing power grid as a frequency regulator amongst several other potential applications.

Batteries are Not Only Important, but Necessary with Increasing Renewables Penetration

With strong pledges to reduce carbon emissions, CAREC nations will continue to increase renewables in its energy mix. Several countries, such as Azerbaijan, Kazakhstan, and Kyrgyzstan have pledged to limit or reduce their carbon emissions upward to 35% in the Paris Climate Agreement. With economic growth projected to continue at a rapid pace in CAREC nations, the only solution will be the deployment of renewables which requires battery energy storage systems (BESS), according to Jeong Min Lee from Hyosung.

Due to the intermittent nature of renewables such as wind and solar, BESS improves power quality, regulates frequency, and also provides constant power generation during times when the sun is not shining or when the wind is not blowing (see Figure 6).

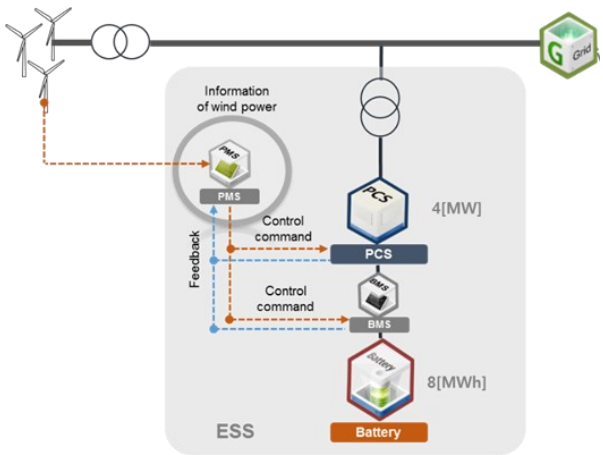

Figure 6: Schematic diagram of renewables integration with large-scale BESS (Source: Hyosung)

Participants in the Program were fortunate to visit Hyosung's 46 MW wind power ESS commercial project where Hyosung supplied the power conditioning system (PCS) and power management system (PMS) and LG Chem supplied 16 MWh lithium-ion

Decreasing Capacity Credit[1] of Renewables Increases Value Proposition of Batteries as Renewables Rise

At today's low penetrations of solar and wind, the issues with reliability and managing fluctuating supply are yet to really be seen. But as renewables continue to dominate new capacity additions technology innovation, specifically in the reduction of battery costs, will be critical for reaching high intermittent renewables penetration. In addition to batteries, the implementation of ICT platforms will also play a critical role with big data and analytics enabling real-time monitoring, analysis, and optimization.

While the implications of high penetration renewables is far off for the CAREC nations, it remains important for countries to identify the potential scenarios that may arise in the long-term. Additionally, CAREC nations have the opportunity to completely avoid renewables integration issues altogether as existing grid infrastructure could potentially be replaced by micro-grids.

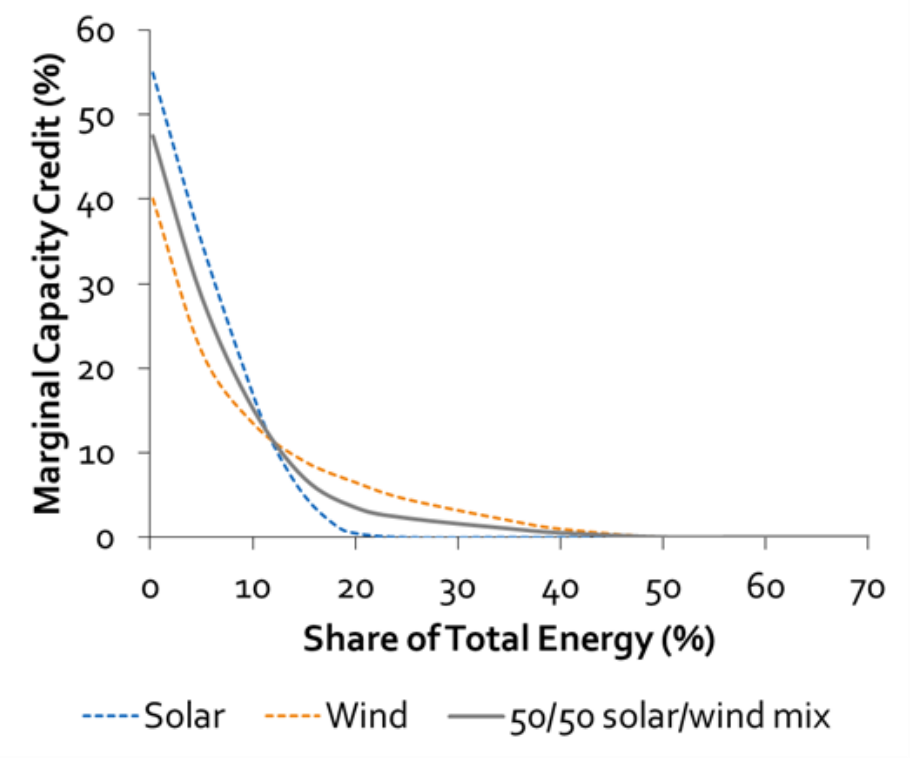

Figure 7: The capacity credit of renewables depreciates precipitously and drops to nearly 0% with renewables penetration of 25% (Source: Lux Research)

Footnote:

1 - As the share of renewable energy increases, one needs to add more backup capacity to the grid to prepare the time when the wind is not blowing and there is no sun. This requirement is accounted for by the term "capacity credit". If capacity credit is 100%, it means you can add renewable energy capacity to the grid without adding backup capacity. At a capacity credit of 0%, one must add equal amounts of backup capacity and renewable energy. This is where private investments have a trouble in investing on renewable energies. They are forced to add lots of backup capacity to maintain grid stability but it is probably not economically viable.

Site Visit Spotlight: *KOEN's 4 MW Wind Power ESS Commercial Project*

On Day 1, Participants visited KOEN's energy storage system (ESS) project dubbed Yeong Heung Wind Power Complex ESS. The 4MW-16MWh wind complex is supported by two ESS complexes consisting of 2MW PCS-8MWh Li-ion batteries supplied by Hyosung and LG Chem. The USD$8.5 million project took six months to complete, officially beginning operations in November 2015.

Using Hyosung's technical expertise, each ESS complex is able to control power inflow and outflow between LG Chem's batteries and the power grid. Concurrently, compensating power quality, synchronizing the grid, and protecting the grid. All is controlled in the situation room as the battery management systems, energy management systems, and power generating wind turbines all seamlessly communicate via the implementation of ICT technologies.

Image: Situation room for KOEN's 4MW wind power ESS commercial project with dashboard monitoring of individual wind turbine health and status.

Image: Participants visiting KOEN's 4MW wind power ESS commercial project on Day 1

Paving the Way for the Future of Energy

On Day 1 participants witnessed a traditional coal plant at KOEN's power generation site juxtaposed with 12.6 MW of tidal power, 46 MW of wind power, 8 MW of solar, and a 28 MWh energy storage system. While the incumbent coal plant's capacity far surpassed that of its renewable counterparts, it was a visual representation of the current state of the energy landscape. Cheap, carbon-intensive processes with scale, and innovations enabling low-carbon processes to compete on cost and eventually contribute a significant supply of the energy demand.

Arij van Berkel from Lux Research, presented the transition of the energy landscape, starting with current status of renewables making up approximately 20% of the electricity mix and eventually reaching more than 80%. Along this paradigm shift, it is evident that the energy transition is a complex, non-linear process. From the emergence of non-electric energy storage options to the critical implementation of ICT-based platforms to utilize growing battery capacity. In closing, it was clear that technology innovations are advancing while governments controlled the pace in which the transition occurred.

Key Takeaways and Outlook

The Program offered solutions and displayed successful projects that would greatly benefit the CAREC nations. Enabled by technology innovations and ICT platforms, CAREC nations are now presented with a suite of potential technologies to address their countries' main energy opportunities and challenges that were laid out at the start of the Program. As discovered on the very first day, no two countries will have the same approach. With the wealth of information that was presented during the Program, the participants will return to their home countries with actionable advice and strategic foresight. Upon reviewing and understanding the key themes of the Program and incorporating the wealth of knowledge that was shared between all delegates, three key next steps are advised for participants:

- Educate the public on the advancements of emerging technologies – Knowledge transfer is one the greatest values of the Program. Several delegates were able to observe and learn first-hand about new technologies that were not well understood. So, it is now important that they educate their fellow colleagues, industry stakeholders, and government officials in their home country about these technology advancements. Without a better understanding of emerging technologies, it remains difficult to make well-informed strategic decisions.
- Collaborate with neighboring countries and corporations – CAREC offers an extremely beneficial platform for neighboring countries to collaborate and implement projects that not only benefit their own countries, but the entire region. Financial support is a critical aspect of the development of the energy landscape in CAREC nations with several available funding mechanisms to assist in infrastructure development. Private corporations will also play a key role as several are seeking opportunities to enter emerging markets.
- Act swiftly with strategic foresight – With sharing and collaboration, all will go to waste without action. However, action should not be taken without proper strategic foresight. Given the unique situation of CAREC nations, it remains critical to identify and prioritize the challenges before aligning technology solutions to address them in the near- to long-term. Given the long payback period and lifetime of energy infrastructure, decisions made today should reflect the energy outlook 15 to 20 years later.

Final Program

CAREC Knowledge Sharing Program on ICT for Energy
17-20 April 2017
Seoul, Republic of Korea

Day 1 – 17 April 2017 (Monday)	
Opening Session	
9:00 – 9:30	**Welcoming Remarks** **Mr. F. Cleo Kawawaki**, *Director*, CWRD/ADB **Opening Remarks** **Mr.Koo Ja-Kyun**, *Chairman*, Korea Smart Grid Association
Setting the Context	
9:30 – 10:30	**Presentation on CAREC Energy Program** **Mr. Sohail Hasnie**, *Principal Energy Specialist*, ADB **Panel Discussion with CAREC Members**
10:30 – 11:00	**Networking Break**
Energy for All and Micro-Grid	
11:00 – 12:00	**A Consideration of Off-Grid Micro-Grids** **Dr. Jinho Lee, Ph.D.,** *Team Leader/Principal Research Engineer*, LSIS **Introduction of EMS** **Mr. Jiyeon Park,** *Associate*, KDN
12:30 – 13:30	**Lunch**
Site Visit	
13:00 – 15:00	**Transport to Site Visit**
15:00 – 16:30	**Site Visit: Wind Farm Energy Storage System**
16:30 – 18:30	**Return to Hotel**
Welcome Dinner at Plaza Hotel	

Day 2 – 18 April 2017 (Tuesday)	
Moring Site Visit	
7:30 – 11:00	**Transport to Site Visit**
11:00 – 12:30	**Site Visit: Floating Solar Power Plant**
12:30 – 14:00	**Transport to Lunch**
14:00 – 15:00	**Lunch**
Afternoon Site Visit	
15:00 – 16:30	**Site Visit: K-Water Integrated Water Management Center**
16:30 – 18:30	**Transport to Dinner**
Dinner	

Day 3 – 19 April 2017 (Wednesday)	
Energy Efficiency	
9:00 – 10:30	**Shifting Paradigms in Energy and Industry** **Dr. Arij van Berkel, Ph.D.**, *Research Director*, Lux Research **Micro-Grid Strategy for CAREC** **Mr. Dae Kyeong Kim**, *Senior Energy Specialist*, SDSC-ENE/SDCC
10:30 – 11:00	**Networking Break**
Energy Management System and Energy Storage System	
11:00 – 13:00	**Energy Through ICT** **Mr. Jundong Lee,** *General Manager*, Korea Telecom **Large-Scale Energy Storage System for Renewable Energy** **Mr. Jeong Min Lee,** Hyosung **KEPCO's ESS Projects for Frequency Regulation** **Mr. Namgil Paik,** *General Manager,* KEPCO
13:00 – 14:00	**Lunch**
Group Discussion	
14:00 – 14:45	**Group Discussion**
14:45 – 15:00	**Networking Break**
15:00 – 15:30	**Wrap-Up & Closing**
Closing Dinner	

List of Participants

COUNTRY	DELEGATE
Afghanistan	Mr. Qudratullah Delawari, CEO, DABS
Azerbaijan	Ms. Zamina Aliyeva – Deputy Director of State Programs Preparation and Execution Control Department, Ministry of Energy
People's Republic of China	Mr. Qi Zhixin, Deputy Director, Science and Technology Department, National Energy Administration
Georgia	Mr. Davit Sharikadze, Head of Energy Department
Kazakhstan	Mr. Talgat Abylgazy - Deputy Director, Electricity Department, Ministry of Energy
Kyrgyz Republic	Mr. Aibek Dzhunurov, Head of Fuel and Energy Complex and Mining Division, Parliament of the Kyrgyz Republic (Jogorku Kenesh) Ms. Gulbarchyn Karymshakova, Chief Specialist, Renewable Sources of Energy and Energy Saving Department, State Committee on Industry, Energy and Mining Ms. Elvira Musaeva, Specialist, Electric Power Management Department, State Committee on Industry, Energy and Mining
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Pakistan	Mr. Hammad Raza, Section Officer, Ministry of Water and Power
Tajikistan	Mr. Saulat Ali, Section Officer, Ministry of Water and Power Mr. Alisher Makhsumov, Leading Specialist of Energy Department Ms. Muneeza Hamid, Section Officer , Economic Affairs Division
Turkmenistan	Mrs. Tahmina Burhonaddinova, Senior Specialist of Economic and Forecast Department Mr. Berdiniyaz Batyrov, Head of Energy, Chemistry and Other Industries Development and Analysis Division, Ministry of Economy and Development
Uzbekistan	Mr. Abdyrashid Mirzaev, Head of National Dispatching Center, JS Uzbekenergo Company. Mr.V.Vasilyev, Head of the Development and Maintenance of Software and Energy, JS Uzbekenergo Company. Ms. F.Mirkasimova, Leading Specialist of the Department of Informational Technologies, JS Uzbekenergo Company.

List of Resource Speakers

Session	Name
A consideration of off-grid micro-grids	Jinho Lee, PhD Packaged S/W Platform Research Team
Introduction to Energy Management System	Jiyeon Park EMS specialist, KEPCO Knowledge, Data & Network Co.Ltd
Shifting paradigms in energy and industry	Arij van Berkel, PhD Research Director, LuxResearch
Microgrid for CAREC	Dae Kyeong Kim Senior Energy Specialist, ADB
Energy through ICT	Jundong Lee General Manager, KT Smart Business Unit
Large-Scale Energy Storage System for Renewable Energy	Jeong Min Lee Hyosung Corporation
KEPCO's ESS Projects for Frequency Regulation	Namgil Paik Director General, KEPCO