BACKGROUND NOTE

Solving the Energy Trilemma through Innovation

Yongping Zhai and Yoonah Lee

DISCLAIMER

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In Asia and the Pacific, 350 million people do not have access to energy.[2] In addition, as climate change becomes a serious threat to many developing countries, the need to reduce greenhouse gas emissions increases in the region. Accordingly, universal energy access and expansion of renewable energy remain the region's priorities. To meet such multifaceted goals of economic growth, poverty reduction, and tackling climate change—known as the Energy Trilemma—in the energy context, innovative technologies are expected to play a key role.

Technology innovations have great potential to help developing countries address the Energy Trilemma and are expected to evolve toward the "4Ds": (i) decreasing demand by adopting energy-efficiency measures, (ii) decarbonization by expanding the use of renewable/clean energy, (iii) digitization by integrating information technology into the energy system, and (iv) decentralization through distributed energy systems.

(i) **Decreasing demand by adopting energy-efficiency measures.** Energy efficiency is beneficial to societies and the environment because it limits pollutant emissions, including greenhouse gases, reducing consumption of precious natural resources and improving energy security by reducing reliance on fossil fuel imports. Energy efficiency technology provides a virtual energy source that creates direct and indirect economic benefits, including avoiding the building of additional infrastructure.

(ii) **Decarbonization by expanding the use of clean energy.** For the past decade, renewable energy such as solar power and onshore wind has been playing a significant role in providing energy access and reducing greenhouse gas emissions. However, as global investment in existing renewable energy technologies has declined over the past two years, there is a growing need to develop new technologies. Advanced technologies will become available throughout the energy system on both the supply and demand sides, including renewable-based hydrogen, ocean energy (tidal, wave, and ocean thermal), and carbon capture and storage.

(iii) **Digitization by integrating information technology into the energy system.** As the world's data grow exponentially and become increasingly digitized, application of digital technologies such as artificial intelligence (AI) is expected to become more powerful. By providing accurate supply and demand forecasts, AI can optimize the operation of the energy system, particularly in the context of

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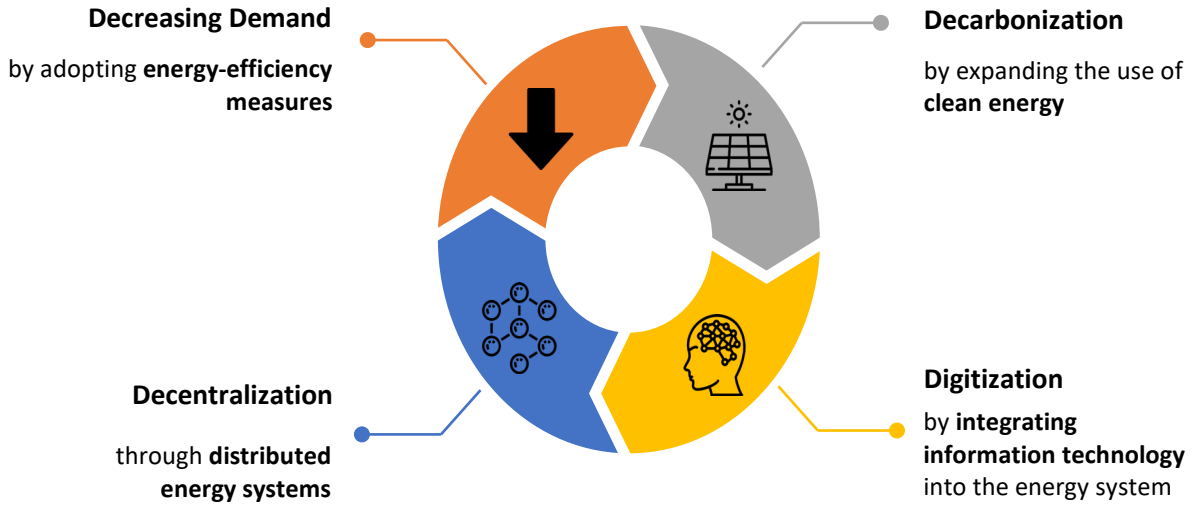
[2] International Energy Agency 2018.

decentralized systems based on renewable energy generation. AI can also help consumers optimize their energy management through advanced monitoring systems.

(iv) **Decentralization through distributed energy systems.** A global shift is occurring from a highly centralized power system to smaller-scale, localized systems that optimize power demand, consumption, and management by offering tailor-made energy supply solutions at the consumer level. Micro grids are emerging as one of these decentralizing technologies. A combination of clean technologies such as distributed generation, batteries, and renewable resources will help organizations operate autonomously from the traditional electrical grid.[3]

Figure 1: Future Energy Systems



Source: Authors.

As the next breakthrough, there are a few rising innovative technologies that are expected to boost the expansion of 4Ds: hydrogen, blockchain-based energy systems, AI in micro grids, and ocean energy.

A. Hydrogen Energy

Hydrogen is the most abundant chemical element in the universe. It has the potential to decarbonize electricity generation, transport, and heat, which ultimately contributes to a cleaner environment. That is because when produced by electrolysis—using electricity to split water into hydrogen and oxygen—hydrogen does not produce any pollutants. Fuel cell electric vehicles, which run on hydrogen, avoid concerns about the range and the time it takes to recharge. Hydrogen used to heat our homes could be blended with natural gas, which would

[3] https://www.iea.org/digital/.

avoid the grid costs associated with greater electrification of heat. Hydrogen could also act as a short and long-term energy store.

In Japan, as part of its "3E+S" (energy security, economic efficiency and environmental protection, plus safety) energy policy, the government formulated the world's first 21st century hydrogen strategy in December 2017, with the aim of establishing a "hydrogen economy" by 2050.

B. Blockchain-Based Energy Systems

Blockchain has the potential to disrupt the energy industry. Blockchain is used to decentralize the distribution, sale, and transfer of energy through micro-transactions of data sent to the system, validated, and retransferred to the contributor's network to secure payment. In other words, blockchain allows peer-to-peer trading for "prosumers" (production by consumers). It is compelling as an enabling technology for scaling energy systems powered by renewable energy and responsive distributed energy resources. This technology will enable many individual prosumers to get returns from directly investing in renewable energy installations, and help a great share of renewable energy get integrated into electricity grids.

The pilot project in the center of Bangkok, Thailand's capital, is one of the world's largest peer-to-peer renewable energy trading platforms using blockchain. Commercial operation started in the fourth quarter of 2018, generating capacity of 635 kilowatts that can be traded via Bangkok city's electricity grid between a hospital, a school, a mall and an apartment complex. The project is expected to encourage increasing numbers of people to switch to renewable energy as the cost is offset by selling excess energy.

Artificial Intelligence (AI) in Micro Grids

AI helps compress and analyze the massive amounts of data that the energy industry produces every day and turn them into insights that can improve energy efficiency. Modern power grid gather energy from multiple energy sources, such as wind and solar which are variable. As more and more community level renewable generation are put in the grid, the challenges of balancing energy flows within that grid is getting more acute. AI increases efficiency and stability to these energy sources through its ability by analyzing large sets of data. AI can also be used to monitor the energy consumption behavior of individuals and businesses.
Many AI-based startups are now offering practical solutions to optimize this energy usage, such as a system that can reduce energy consumption by adapting to user behavior.

Ocean Energy

The ocean covers more than 70% of earth's surface. We can use ocean energy to produce electricity. This can be harnessed in several ways, but the resources that have the most immediate potential in terms of energy production are tides and waves. Although it is still in the early stage of development and a lot of barriers need to be overcome to make it commercially

viable, ocean energy is expected to have a significant role for the future energy system that contributes to carbon emission reduction in coastal areas, because it emits no harmful gases into the atmosphere.

The world's first large-scale tidal power plant is located in La Rance, France, with a capacity of 240 megawatts. The Sihwa Lake Tidal Power Station is another tidal power plant located in the Republic of Korea which claimed the title of world's largest tidal power plant in 2011 with 254 megawatts installed capacity.