Renewable Energy Technologies (RETs) and Smart Grids: Potential areas for Indo-Korean collaboration

Rakesh Taori and Hokyu Choi

The primary goal of this article is:

(a) To introduce RETs and Smart Grids to the reader and
(b) Share authors' views[1] by means of specific examples on how India and Korea can collaborate in the area of RETs and Smart Grids.

We will begin with a short introduction to RETs and Smart Grids. We will then explore some areas of cooperation between India and Korea in these areas.

1. What is renewable energy?

Renewable energy is the energy generated from natural resources such as sunlight, wind and tide, which are naturally replenished. Contrast renewable energy with fossil fuels, which are non-renewable, i.e.; the latter draw on finite resources that will eventually shrink, resulting in them becoming too expensive or too environmentally damaging to retrieve. On the other hand, renewable energy resources are constantly replenished and will never run out.

2. Sources of renewable energy

Examples of renewable energy sources are solar power, wind power, bio fuels, hydrogen, tides and geothermal power.

The source of most forms of renewable energy, directly or indirectly, is the sun. To a layperson, sunlight, or solar energy, is the most obvious manifestation of energy from the sun. But how is wind created? The sun's heat drives the winds (which can be used to drive wind turbines). The winds and the heat cause water to evaporate. This water vapor turns into rain or snow and flows downhill into rivers or streams (which can be harnessed to generate hydroelectric power). Sunlight and rain cause plants to grow, which in turn are at the root of "Bio fuels." Hydrogen, the most abundant element on

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[1] The authors are not experts in the area of renewable energy technologies. Usage scenarios and example applications presented in this article are by no means claimed as "novel," any may not be feasible today.

earth, can be found in many organic compounds as well as water. Once separated (from compounds), hydrogen can be burned as a fuel or converted into electricity

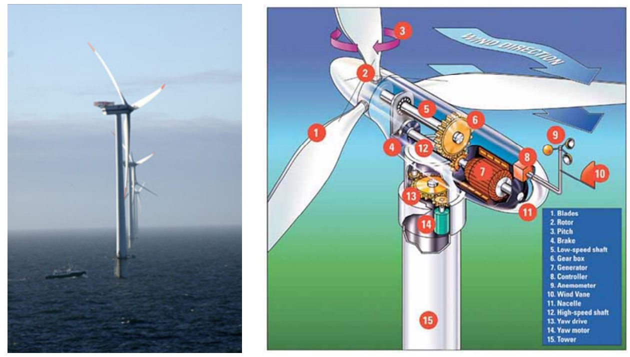
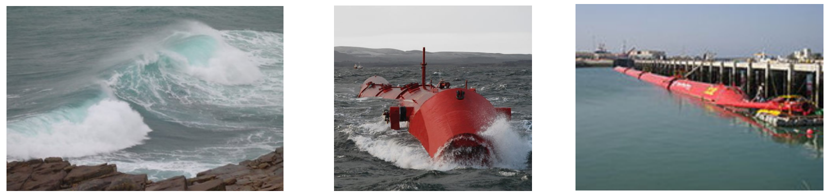


Figure 1: A turbine uses wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity. The electricity is sent through transmission and distribution lines to a substation, then on to homes and businesses. (Sources (i) http://www.hornsrev.dk/Engelsk/nyheder/nyh_dec_02/uk-dec_02.htm.; (ii): http://energiaeoliana.wordpress.com/)

Besides the sun, there are other sources of renewable energy. Geothermal energy, for instance, taps the Earth's internal heat. This could be from kilometers deep into the Earth's crust. It is expensive to build a power station, but operating costs are low resulting in low energy costs for suitable sites. Ultimately, this energy derives from heat in the Earth's core.

The energy of the ocean's tides comes from the gravitational pull of the moon and the sun upon the Earth. Moreover, there's the energy of the ocean's waves, which are driven by both the tides and the winds. A temperature difference, created by the fact that the sun warms the surface of the ocean more than the ocean depths, can be harnessed to produce electricity.



(i) Wave Energy

(ii) The Pelamis Wave Energy converter

(iii) Pelamis Wave Energy Converters in the harbor of Peniche, Portugal

Figure 2 : Wave Energy: it is technically possible to convert a sizeable fraction of wave energy into electricity.
(Source: http://www.pelamiswave.com/)

Technologies that will facilitate generation, distribution and consumption of clean energy based on the foregoing renewable energies are collectively studied under the term *renewable energy technologies* (RETs).

3. The RET landscape at the end of 2008

The renewable energy landscape looks very promising at the time of the writing of this article. According to the Renewable Energy Policy Network for the 21st Century (REN21) 2009 Update, an estimated US$120 billion was invested in renewable energy worldwide in 2008 alone. Table 1 lists several indicators of renewable energy, showing dramatic gains from 2004 until the end of 2008.

Table 1. Gains from Exemplary Renewable Energy
(Source: REN21 Global Status Report, 2009 Update)

Renewable Energy	Gain (2004 - 2008)	Absolute Value (end of 2008)
Annual renewable energy	4 times	US$120 Billion
Solar photovoltaic	6 times	16 GW
Wind power	250%	121 GW
Total power capacity (RE)	75%	280 GW
Solar heating capacity	2 times	145 GW thermal
Biodiesel production Ethanol)	6 times	12 Billion Liters

According to the REN21 2009 update, India and Korea ranked third in "capacity added in 2008" for wind power capacity and grid-connected solar photo-voltaic capacity, respectively. In 2008, India and Korea ranked fifth in the existing capacity of wind power and solar PV, respectively.

4. RETs – An obvious solution for alleviating poverty in developing countries

Developing countries such as India and Africa are significantly energy-starved. At the same time, they are also some of the most populous countries in the world. This combination leads to a tremendous hunger for energy. Renewable energy can be particularly suitable in such a setting. In rural and remote areas, the transmission and distribution of energy generated from fossil fuels can be difficult and prohibitively expensive. Producing renewable energy locally can offer a viable alternative, and directly contribute to alleviating poverty by providing the energy needed for creating businesses and employment. Renewable energy technologies can also make indirect contributions to alleviating poverty by providing energy for cooking, space heating and lighting. Renewable energy can also contribute to education by providing electricity to schools. For an investment of as little as $100, a solar panel can be used to charge a car battery, which can then provide power to run a fluorescent lamp or a small television for a few hours a day [1].

At the other end of the spectrum, in developing countries, there is a burgeoning segment of the population that can afford multiple vehicles per family and several air conditioners in a house. This segment of the populace has succeeded in creating what seems like a bottomless pit for energy.

As they modernize, developing countries can select better technologies and in so doing surpass the typical levels of efficiency of industrialized countries.

5. Smart Grid and RETs

In its most glamorous form, the smart grid represents a major paradigm shift from the 20th century power grids that "broadcast" power from a few central power generators to a *bi-directional flow of power and information*, fundamentally transforming the way in which power will be generated and distributed.

In contrast to the conventional grid, which broadcasts power to a large number of users, the smart grid is visualized as having the ability to <u>*route*</u> power in optimal ways to respond to a very wide range of conditions and to charge a premium to those who use energy at peak hours. A smart grid is visualized as delivering electricity from suppliers to consumers using two-way digital technology to control appliances at consumers' homes to save energy, reduce costs and increase reliability and transparency. Such a modernized electricity network is being promoted by many governments as a way of addressing energy independence, global warming and emergency resilience issues.

Generally, bidirectional flows of power and information are part of the vision of a modernized grid that supports RETs, energy efficiency, market efficiency, electric-vehicle readiness, improved power reliability and improved power quality. Smart-grid advocates hope to address these challenges via a new transmission and distribution infrastructure that integrates information and communication technology.

6. Potential for Indo-Korean collaboration on RETs and Smart Grid

Faced with crippling electricity shortages, the Ministry for New and Renewable Energy in India has recently unveiled an ambitious plan for solar energy under the brand name "Solar India" – expected to lead to an installed capacity of some 20GW by 2022. Noting that "the next three to four years will be critical," the Indian Cabinet has approved 1,100MW of grid-connected solar power and 200MW of off-grid installations using both solar thermal and photovoltaic technologies. The mission also includes a major initiative for promoting rooftop solar PV applications. The mission is setting an ambitious target for ensuring that domestic and industrial applications below 80°C are solarized, among other measures making solar heaters mandatory, through building bylaws and incorporation in the National Building Code. In the off-grid sector, the solar mission has set a target of 1,000MW by 2017, but plans to provide solar lighting systems under the ongoing remote village electrification program to cover about 10,000 villages. Some 20 million solar lighting systems are to be deployed in rural areas by 2022. A number of concentrating solar power (CSP) demonstration projects are also planned. In launching India's National Action Plan on Climate Change on June 30, 2008, Prime Minister Dr. Manmohan Singh stated: "Over a period of time, we must pioneer a graduated shift to renewable sources of energy. In this strategy, the sun occupies center stage, as it should."

As mentioned earlier, according to the REN21 2009 Update, South Korea ranked third in the "grid-connected Solar PV" additions in 2008. South Korea is also well on its way to establishing itself as a pioneer in *solarizing* its cities. Daegu Metropolitan City was selected as “Solar City” at the Climate Change Workshop in 2008 [2]. With such expertise under its belt, South Korea could potentially serve as a partner to the Indian government in bringing “Solar India” to fruition. This could be achieved either by means of government backed programs or private-public partnerships in both the countries.

In a modern, highly developed economy such as South Korea, a smart grid deployment is likely to include (a) an intelligent monitoring system that keeps track of all electricity flowing in the system, (b) incorporating the use of superconductive transmission lines for reduced loss of power, (c) the capability of integrating alternative sources of electricity such as solar and wind and (d) a smart grid could turn on selected home appliances such as washing machines or factory processes that can run at arbitrary hours when power is least expensive, while turning off selective appliances at peak times to reduce demand.

Korea is quickly moving to nurture smart grid technology as a growth engine of the national economy in the next two to three decades. On Aug. 20, 2009, the South Korean Government inaugurated the tentatively named “Smart Grid Business Corps,” charged with initiating collaboration among industry, academia and research circles in building smart grid infrastructure. In another development, the South Korean Minster of Knowledge Economy joined some 200 business representatives and local residents on Aug. 31, 2009 to celebrate the establishment of a test bed for "smart grids" on Jeju Island. Under the government-led project, 6,000 households in the northeastern region of Jeju Island will have the opportunity to test smart grid technology. The purpose of this pilot project is to address energy and environmental issues, promote new growth engines and encourage low-carbon green growth.

Many of the above concepts, which could first be tested and applied in South Korea, can readily be applied in the urban pockets of metropolitan Indian cities such as New Delhi, Mumbai and Chennai – in fact, the two countries could work together.

With smart grids and RETs, both of which target efficient and green energy generation, distribution and consumption can have a symbiotic relationship when it comes to Indo-Korean collaboration. Both the Korean and Indian governments seem committed to the development of RETs and smart grid technology as part of their efforts to go green.

Provided below are some of the collaboration scenarios that the authors envisage:

- One vision of RET encompasses large scale bi-directional flows of electricity to and from regions that have abundant renewable resources. When applied to India, the northwestern deserts in Rajasthan could supply abundant solar energy to Delhi and Mumbai during the day, but could be a net consumer during the night. South Korea has pioneered large-scale infrastructure projects in Southeast Asia and the Middle East, and can play a pivotal role in making the vision of the scorching heat of Rajasthani deserts powering Mumbai and Delhi during the day come true.

- In another example, smart grid and RETs can work together to meet climate change and greenhouse gas emissions reductions. The smart grid addresses climate changes by supporting efficient power transmission, delivering information about consumption that helps customers make wise decisions about energy, enabling the remote control of appliances by customers, and enabling direct load control by utilities companies to reduce consumption during peak demand. This kind of "peak shaving" reduces the need for new power plants and more importantly reduces the need for some of the dirtiest older plants, many of which are there to primarily provide generation capacity to handle peak demand periods. This kind of smart energy management requires software that resides in a smart meter as well as communication protocols for switches that reside between a home and electrical grid. Large-scale software development projects involving Indian Software development engineers and infrastructure expertise pioneered by Korean firms can be effectively used to bring the above vision from concept to reality.

- The international transmission of power generated by RETs could be constructive for geopolitics pertaining to both nations. A case in question is South and North Korea on the one hand, and India-China, India-Pakistan, India-Bangladesh and India-Nepal, on the other. South Korea's KEPCO is already involved in providing energy to their northern neighbor. However, if looked at from an RET perspective, the neighbors to India and Korea have abundant renewable energy resources (most notably water), and offer the opportunity to depart from today's asymmetrical buyer-seller relationship to a relationship that yields mutual dependence and alliance. Nations might exchange electricity that derives from various kinds of renewable sources during various parts of the day.

7. Obstacles to RETs and Smart Grid deployments

Smart Grid and RET investments promise to pay off through the years, but initial costs can be high. Both RETs and smart grids will require new practices at utility companies, whose business processes have hardly changed through the decades. In both countries, political will and drive is essential to turn this opportunity into something real. And despite the enthusiasm of technology advocates, both RETs and smart grids face uncertainty with retail customers who may need to change their behavior to adopt new technologies. South Korea can boast speedy technology adoption, but the Indian consumer is a very cost conscious one and poses a real challenge for the adoption of these clean technologies unless immediate financial benefits can be shown.

The largest challenge of all will be to come up with a coherent vision in which these technologies should be driven. Will grid modernization mainly support large capacity projects – large scale wind farms, huge solar arrays spread across large parts of deserts? Or will it be possible to support a large number of small generators to provide a single virtual generator?

8. References

[1] D. M. Kammen, "The rise of renewable energy", Scientific American, pp. 85-93, September 2006.

[2] Ju-Young Kima, Gyu-Yeob Jeona and Won-Hwa Hong, "The performance and economical analysis of grid-connected photovoltaic systems in Daegu, Korea", Applied Energy Volume 86, Issue 2, Pages 265-272, February 2009.