Use All the Zero Carbon Energy Options

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*By Matt Bowen and Steve Brick**

The world continues to fail to address climate change, as carbon emissions rose again in 2018. A recent report indicates that global temperatures could rise 3.2 degrees Celsius by the end of the century.[1] The carbon reductions now required to limit warming to 1.5 degrees Celsius or even 2 degrees Celsius are daunting. The United States and the Republic of Korea (ROK) continue to depend on fossil fuels for their electricity supply (see Figure 1) as does the rest of the world.[2]

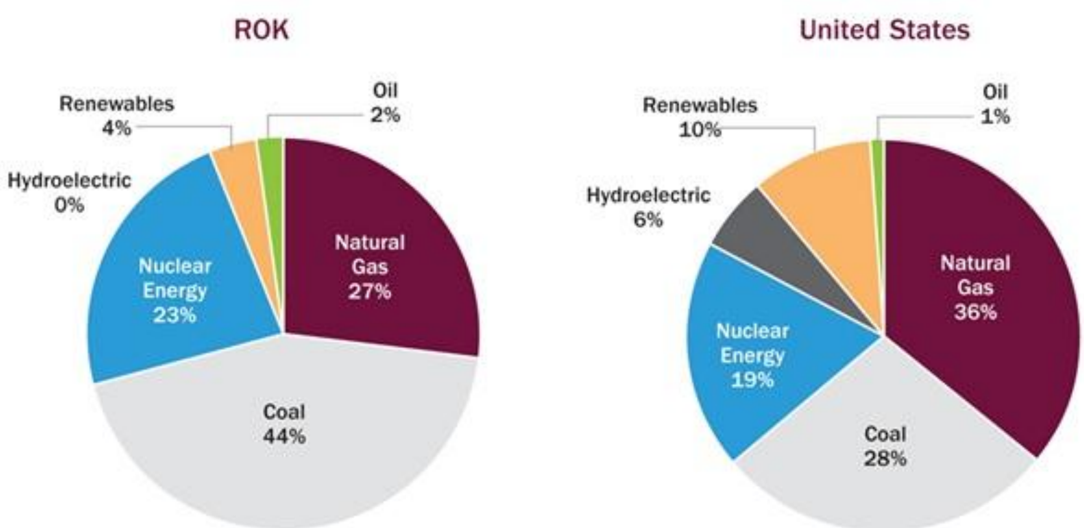

Figure 1. ROK and U.S. electricity supply by fuel
Source: BP Statistical Review of World Energy 2019

There have been some positive developments in recent years. The Paris Agreement in 2015 represented a consensus from the world's governments that warming should be limited, and coming out of that agreement, countries announced their own Intended Nationally Determined Contributions to reduce greenhouse gas emissions. Even though the United States has announced that it is leaving the Paris Agreement, individual states (e.g., California, New York, New Mexico) have passed clean energy standards to decarbonize their power sectors and individual utilities have announced plans to eliminate carbon emissions from their generating portfolios.

The falling costs of solar and wind energy have also been a positive development for efforts to address climate change. However, these falling costs should not be extrapolated to mean that decarbonization using solely wind and solar energy will be inexpensive. For example, the low levelized cost of electricity (LCOE) for a new solar or wind energy generation plant can be misleading when used in isolation. When a utility adds a solar or wind plant to its generation portfolio, it does not mean that its customers immediately begin paying electricity bills at that LCOE. Rather, the electricity bill rates are determined by the total system required to reliably deliver electricity to the customers. If a dispatchable natural gas plant is required to run when the sun is not shining and the wind is not blowing, the operational, maintenance, and fuel costs from the natural gas plant also factor into the price that utility customers see. This reasoning also applies to energy storage facilities, and Clean Air Task Force analysis in the past has suggested that a portfolio based solely on solar and wind resources, using energy storage to even out the deficits and surpluses in generation (see Figure 2 for an example of this type of generation and demand mismatch in the United States) would introduce dramatic cost increases.[3] This is true even if storage costs decline greatly compared with the technologies available today.

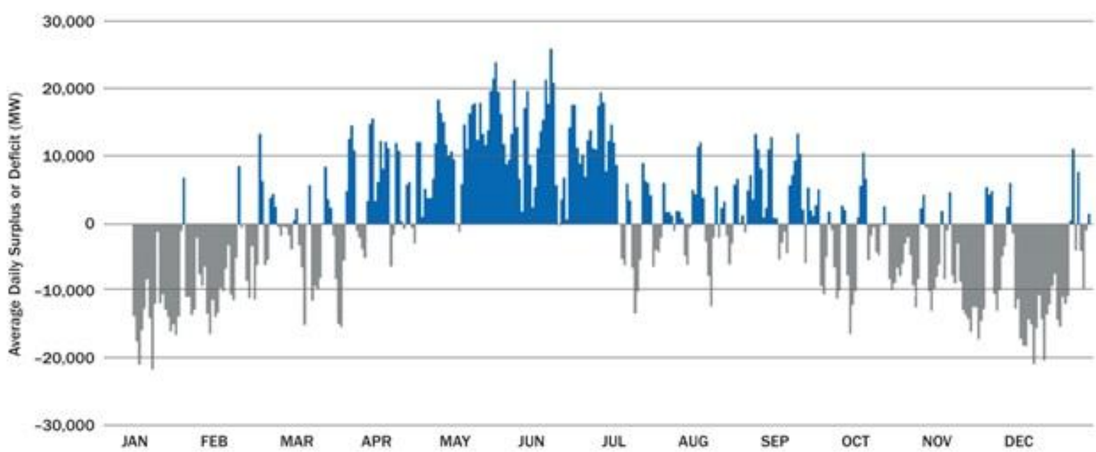

Figure 2. Mismatch in generation and demand for solar and wind energy each scaled up to meet 50% of total California electricity demand
Source: Clean Air Task Force

Another problem with defining one LCOE for each energy generation technology is that energy generation can have a regional dependence. For example, a solar plant in Arizona will produce energy at a lower LCOE than the exact same plant in Alaska owing to the smaller amount of solar radiation incident on the latter during the course of the year. The value difference is even more pronounced in that Arizona's peak demand during the year tends to be during the day and during the hot summers, when solar radiation is in abundance, whereas Alaska receives comparatively very little solar radiation during its cold, dark winters.

Quite separate from electricity generation, the industrial sector encompasses a set of activities that appear more difficult to decarbonize than the power sector, and it is even less clear what the best options will be. Zero-carbon high-temperature process heat (in some cases, over 2000 degrees Celsius) appears to be needed to replace the fossil energy currently used for manufacturing cement, steel, glass and other products. Nuclear energy and/or fossil energy with carbon capture and sequestration may turn out to be the more affordable pathway for decarbonizing heavy industry than renewable energy.[4]

All of the arguments above advocate against conflating "100% renewable energy" with "fighting climate change." Analyses within the United States have made clear the challenge that would be entailed with trying to decarbonize the electricity sector alone with solely renewable energy.[5]

A recent Nuclear Innovation Alliance (NIA) report outlines an opportunity in the ROK to eliminate coal generation in the ROK power sector with a combination of increased energy efficiency, renewable and nuclear energy usage, and natural gas.[6] The ROK's 8th Basic Plan for Long-Term Electricity Supply and Demand incorporates increased energy efficiency and renewable usage to achieve a relatively modest decrease of 5% carbon emissions from the power sector by 2030 ("Target 2030") compared with 2017 emission levels.

However, the NIA report identifies four additional technical pathways would appear to enable the ROK to reduce its power sector emissions by 77% relative to 2017 emission levels:

1. 90CF: Operate nuclear reactors at 90% capacity factor, which has been achieved in the past
2. 60LE: Extend reactor operation licenses to 60 years
3. 88NB: Reinstate 8,800 MW of cancelled reactor projects, which were scheduled to be added in the ROK's 7th Basic Plan for Long-Term Electricity Supply and Demand
4. VLC ("very low carbon"): Eliminate remaining coal operation using additional liquefied natural gas use

Figure 3 illustrates the potential emissions reductions possible by 2030 from these four pathways. This would not appear to be a costly approach: $2.6/MWh on a total system basis. Pursuing only the first two pathways--operating reactors at a 90% capacity factor and extending reactor lifetimes--would reduce power sector emissions by 40% and at a net cost savings to the ROK. In addition, not only would the ROK avoid the costs of climate change associated with the carbon emissions from coal plants, but also eliminate the negative health impacts of traditional air pollution.

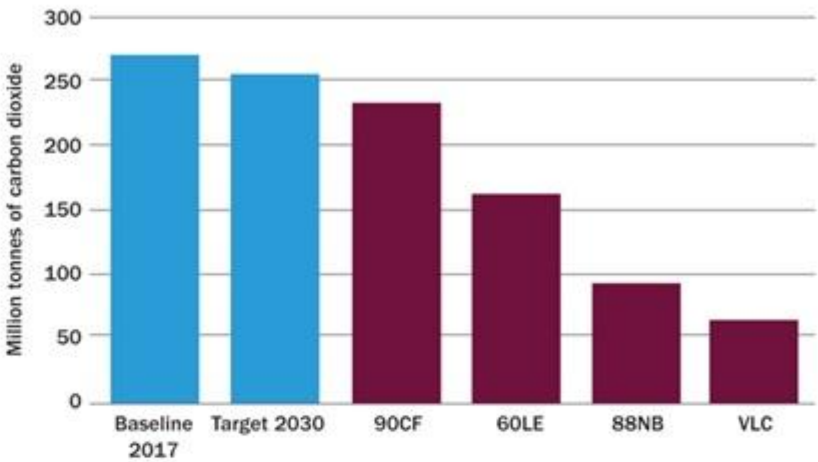

Figure 3. Possible reductions in carbon emissions in 2030 from the ROK power sector compared with 2017 levels

Source: Nuclear Innovation Alliance, "U.S.-ROK Cooperation on Nuclear Energy to Address Climate Change," November 2019

Similar to the United States, there are challenges the ROK would face in trying to decarbonize its power sector using only renewable energy. Using the 2030 targets for renewable energy in the 8th Basic Plan for Long-Term Electricity Supply and Demand, about 4.3% of the energy would be surplus and would have to be either stored or wasted. As ROK electricity system operators have to balance energy demand and generation, the addition of more variable renewable energy generation also means that operators will at times have to turn more power plants on and off faster to account for the increased variability and to maintain system reliability. Specifically, at the levels of renewable energy outlined in the 8th Basic Plan, the NIA report projects that the maximum hourly system ramp rate would double from around 9,300 MW per hour to 19,700 MW per hour. Bringing that much power on and off the ROK electricity grid in the same amount of time would be an increased challenge to system operators.

If the ROK were to then double wind and solar to be 30 percent of system energy, and if coal generation is backed down by an equivalent amount, system surplus energy is projected to grow to 37%. The maximum hourly system ramp rate would grow to more than 37,000 MW per hour. It is unclear if the anticipated composition of the ROK power system in the future would be able to accommodate these large ramp rates.

Germany presents an example of a wealthy, industrialized nation that decided to phase out nuclear power and decarbonize using solely renewable energy. However, Germany has failed to meet its own climate goals, and German consumers now pay some of the highest power bills in the European Union--nearly 50% over the EU average.[7] Germany has also retained its dependence on coal, which means that its citizens are still breathing in polluted air from these plants.

Mainstream analysis, from the Intergovernmental Panel on Climate Change to the International Energy Agency, continues to show the importance of utilizing all zero-carbon energy sources, including nuclear power, as part of efforts to decarbonize.

Both the ROK and the United States should heed this observation in pursuing technology-neutral policies for reducing greenhouse gas emissions.

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[1] U.N. Environment Programme, "Emissions Gap Report 2019."
[2] BP Statistical Review of World Energy 2019.
[3] Presentation by Clean Air Task Force to the California Public Utility Commission, "Deep Decarbonization of the Electricity Sector: The Challenge of Variability and Storage," April 4, 2018.
[4] Julio Friedmann, Zhiyuan Fan, and Ke Tang, "Low-Carbon Heat Solutions for Heavy Industry: Sources, Options, and Costs Today," Columbia SIPA Center on Global Energy Policy, October 2019.
[5] Energy and Environmental Economics, Inc., "Resource Adequacy in the Pacific Northwest," March 2019.
[6] Nuclear Innovation Alliance, "U.S.-ROK Cooperation on Nuclear Energy to Address Climate Change," November 2019.
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