Electricity Demand Drops Down Due to COVID 19 Virus: Opportunities for Long-term Energy Storage in a Highly Renewable Electricity System

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With the outbreak of novel coronavirus (COVID-19), economic activities have been slowed down across the world. In the power sector, the most profound impact is the dramatic fall in electricity demand in many countries. For instance, China's electricity demand for the industry is estimated to decline by 73 billion kWh in 2020 [1], roughly the same as the annual electricity consumption in Austria. Other analyses have also shown an apparent decrease in electricity demand in Italy, Spain and France [2, 3]. The fast decline in demand has pushed down the electricity price in the wholesale market to multi-year lows and has led to large-scale curtailments of variable renewable energy (VRE). Recently, the combined systemwide solar and wind curtailments in California have spiked over 13,000 MW [4].

Due to political goals and decreasing costs for wind and solar, the share of VRE is increasing rapidly in the electricity system. A highly renewable electricity system is less capable of load-following due to the intermittency of VRE as compared with the conventional electricity system based on dispatchable power plants [5]. Therefore, renewable energy is curtailed to keep the real-time balance between electricity load and generation in the power system, and the curtailment is further enhanced with the outbreak of the coronavirus. Significant curtailment of renewable energy is not desirable, as cost-free and emission-free energy has to be wasted. In addition, the effective capacity factor for renewable power is reduced due to curtailment. How to utilize curtailed energy remains a challenge in the electricity system. One potential solution to this question is long-term energy storage.

Plenty of studies [6-9] in literature have investigated the role of energy storage in dealing with electricity curtailment, and the main functions of storage can be summarized as: (1). Temporally shifting electricity generation from congested periods; (2) Providing flexibilities back to the grids when there is little output from VRE power plants. Energy storage serves as an option to store renewable energy during periods of surplus generation and discharging during periods of limited output. A large amount of storage is adopted for studies on long-term investment planning of the future renewable electricity system. However, the invested storage is dominated by short-term battery storage to deal with the daily mismatch of renewable supply and electricity demand. Long-term storage, on the other hand, seems to be less attractive. This is mainly because many studies limit the system boundary to electricity system only without sector coupling, which neglects the potential contributions from long-term storage to other sectors, such as heating, transportation and industry. Studies considering sector coupling usually linearly scale up the historical demand profile to a new value for the future electricity demand. Despite the fact that the annual electricity consumption change is considered, the intertemporal pattern of the demand profile is assumed to remain the same. Therefore, the electricity consumption patterns for other sectors are not well represented, which leads to an underestimation of the peak demand and flexibility requirements for the electricity system. Besides, the curtailment of renewables is modest both in volume and temporal duration. Last but not least, the investment cost is high for some infrastructures such as hydrogen electrolyzer, the key equipment to produce green hydrogen from water.

With the on-going quarantine policy, shutting down of industrial production and offices, we are facing an unusual "disruption" in the electricity system: continuous low electricity demand for a long period. So far, it is still not clear how long this epidemic will last. One implication out of this contingency for the planning of future electricity system is to take into account the plausible scenarios with long-term low electricity consumption. The continuous electricity curtailment in such scenarios would make the investment in long-term storage appealing. In addition, the cost of long-term energy storage technology has been decreasing over time. One ample example relates to the electrolyzer, the cost for which has fallen by 40% in the last five years [10]. The future decrease in cost can be expected with more deployment and continuous policy support.

In reality, to achieve the ambitious goals set by the Paris Agreement, the power sector is expected to mitigate nearly all its CO_2 emissions and meanwhile contribute to carbon reduction in the transport and heating sectors. The energy demand for transportation has a typical diurnal variation. In stark contrast, energy demand for heating has an evident seasonal variation, with most of the consumption concentrated in winter. Considering the intensive diffusion of both electric vehicles and electric heating, the winter peak demand will grow significantly. Regarding such a large seasonal variation in electricity demand, long-term storage technologies such as thermal energy storage, power to hydrogen are good options to tackle the seasonal mismatch between electricity demand and VRE generation. For example, thermal energy stored in summer and autumn with favorable solar irradiance can be used to deal with the high heat demand in winter when there is little output from wind and solar. This will largely decrease the investment in other back-up capacities. By comparison, green hydrogen can not only provide flexibility back to the grids but also help to decarbonize some hard-to-abate sectors such as the steel industry.

The coronavirus has spread over 210 countries and territories and resulted in more than 140,000 deaths. This is a worldwide tragedy for the current generation. While we are mourning the great losses, opportunities are approaching us. Long-term energy storage is a potential option to be adopted in such opportunities to shift renewable energy generation over time to guarantee the security of electricity supply and mitigate CO_2 emission at the same time. Nevertheless, policy is essential for long-term energy storage to gain use. This relates to policies to foster sector coupling; policy supports for scaling up hydrogen production and investment in supply networks; Besides, emission policies are important to motivate the shift from energy production with fossil fuels to long-term energy storage.

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