Tokyo Institute of Technology: What Findings From the MIT-Japan Joint Study on the Future of Nuclear Power in a Low-Carbon World Tell Us About Flexibility

Prepared by Akira Omoto, Tokyo Institute of Technology, a university in Tokyo, Japan

An MIT-Japan study was carried out between early 2015 to early 2018 and resulted in the final report MIT-ANP TR171 (MITEI et al. 2018), released in September 2017.

The key messages of this report, which remain valid today, are:

1. Heat storage technologies can be coupled with nuclear reactors to provide reliable dispatchable electricity and are enabling technologies that support larger-scale use and sustained delivery of variable renewables;

2. It is vitally important to decarbonize the nonelectricity sectors by using nuclear energy, including heat storage and hybrid operation of nuclear power, for example, by Nuclear Air-Brayton Combined Cycle; and

3. Changes are needed in regulatory and other policies.

The study, which used MIT's GenX code as modeling tool, also revealed that decarbonization without using nuclear energy would result in unaffordable electricity prices and proposed an integrated energy network for intensive decarbonization (see Figure 1 and Figure 2).

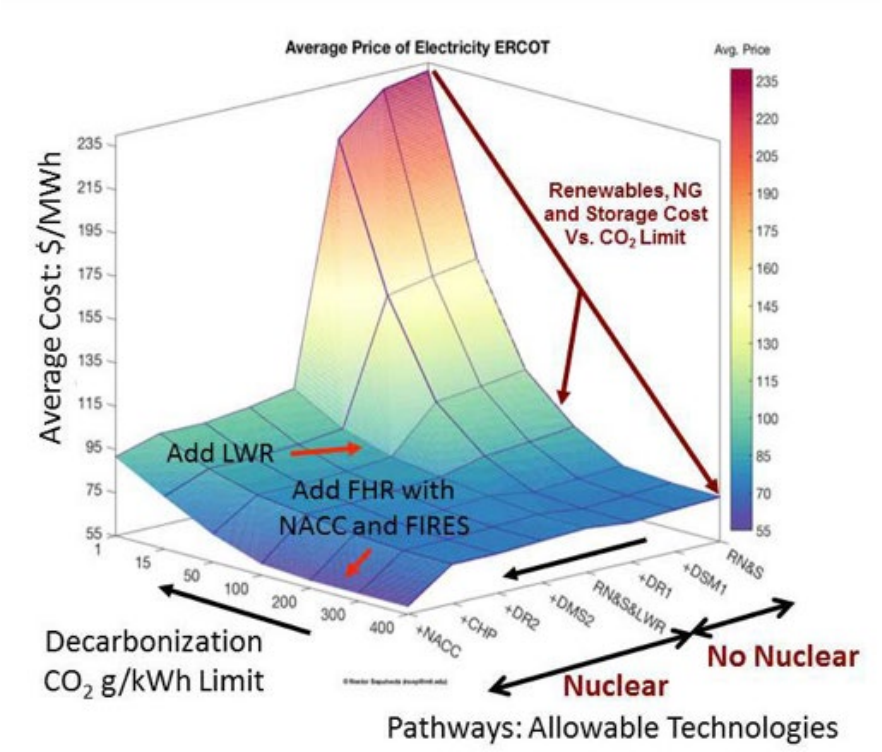

Figure 1. Cost of decarbonization with different technology portfolios as predicted by MIT study on decarbonization

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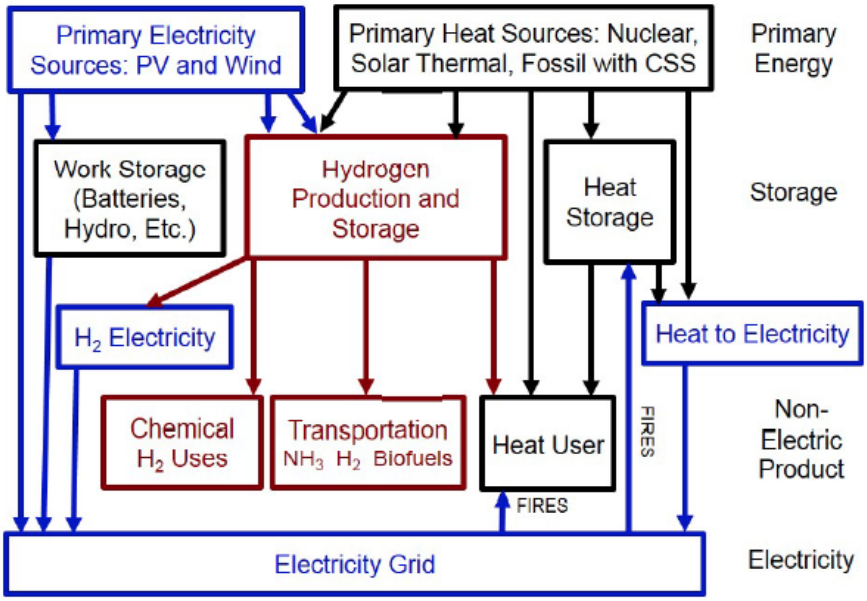

Figure 2. Hybrid energy systems energy flows to enable electricity and hydrogen production, heat and electrical storage, and chemical processing

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GenX was used to model the electric sector of different independent system operators (specifically, the Texas electricity grid that has high-grade wind and solar resources) in the United States in 2050. The details of the assumptions and data can be found in the report and a report by Sepulveda (Sepulveda 2016). The results of similar study in different jurisdictions and used data are available in MIT's report (MITEI et al. 2018), released in September 2018.

The study was conceived in the middle of 2014 by the government (DOE/METI) and academia (MIT/Titech) to vitalize the future of civilian nuclear energy. From among the candidate topics, the topic of integration of nuclear and renewables was chosen, and a Statement of Work was agreed upon in late 2014. Participating researchers, besides MIT and the Tokyo Institute of Technology (Titech), were the University of Tokyo, the JAEA, and so on.

Continuation of the MIT-Japan study was suspended in 2018 due to financial reasons. On the part of Japan, a limited scope study is currently being carried out by Toshiba/University of Tokyo/Titech on the topic of viability of LWR heat storage to find an appropriate level of LWR heat storage as a function of the share of variable renewables in the grid, economic viability of the system, and supporting approaches for storage.

Given the current situation that: (a) energy accounts for ~70% of GHG emission; and (b) the aggregated results of Nationally Determined Contribution falls far short of the goal set out by the Paris Agreement as a global action plan to limit global warming to well below 2° C and to aim to limit to 1.5° C (UNEP 2019), it is clear that clean nuclear energy needs to expand significantly and go beyond just producing electricity.

As for nuclear energy's relationship with variable renewables, the public may think that nuclear is not compatible with solar or wind; however, both nuclear and variable renewables are important to reduce GHG emission, and both are capital-intensive, meaning high capacity factor is necessary for economics. The MIT-Japan report points out that both are compatible, and nuclear power can help electricity production from solar or wind, while the capacity factor of nuclear is maintained. For example, cases of curtailment of electricity supply from solar power (when its supply is beyond demand) is reduced if nuclear reactors reduce electricity generation then and a part of their heat is stored or used for hydrogen production. In this chapter, "variable" means, in the case of PV, changes of electricity supply by clouds, nights and seasons, whereas "dispatchable" means that supply is controllable, depending on demand situation, from load dispatching center to vary supply from controllable power source such as nuclear or fossil power plants.

Also, a comparative study of selected European countries shows that countries with a high share of dispatchable energy (nuclear and hydro) translates to low electricity prices and low value in terms of gCO_2/kWh. Energy policy and institutional arrangements play an important role in securing dispatchable energy. What matters is how to achieve decarbonization with a minimum burden to society, a consideration that was a driving force behind the MIT-Japan study and still is valid today.

1.1 References

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