

# ELECTRICITY MARKET DESIGN AND PROFITABILITY OF NUCLEAR ENERGY

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## Overview

Recently not a few countries regard nuclear energy as an important option for their decarbonization. However, profitability of nuclear power plants (NPPs) under liberalized electricity markets in some developed economies is affected by the extremely low marginal price of rapidly expanding renewable electricity (wind and solar PV). Firstly, this research conducts case studies to show current situation and profitability of NPPs in the developed economies. Secondly, quantitative analysis is conducted to understand the profitability of NPPs in the economies where wholesale electricity market is liberalized and simulates the effect of increased renewable electricity to the market price. And finally, other case studies show unique methods of the developed economies to ensure necessary investment to sustain their electricity system. Implications drawn from the study would provide meaningful lessons toward the future market design in many countries in Asia and Oceania that aim ambitious climate policy targets and that is considering whether they should begin using nuclear energy to achieve the targets.

## Methods

This study conducts case studies through literature survey, as well as the analysis on disclosed data and documents in each economy. The economies treated here include the U.S. (PJM area), the U.K. and Canada (Ontario). The analysed cases include (1) the advanced electricity market liberalization, in the world and (2) the those governments that clearly states that nuclear energy is their important clean energy source for decarbonization.

This research also conducts quantitative analysis on the effect of massive deployment of variable renewable electricity (VRE) on wholesale electricity price. Simulation analysis is conducted to divide the U.S. electricity markets divided into eight areas. The simulation is based on the linear programming method, and calculates market values regarding the shadow prices of demand constraints as proxy for wholesale electricity prices.

## Results

Profitability of NPPs affected by the current market design of the developed economies. Fig.1 shows the profitability of NPPs located in PJM area of the U.S. All of the existing plants become (and are expected to become) less economically profitable, and some of them even cause a deficit for the operator. Actually, Davis Besse and Perry NPPs are announced to be closed respectively by 2020 and 2021 unless they couldn't receive any financial support, and Three Mile Island NPP is decided to be closed in 2019.

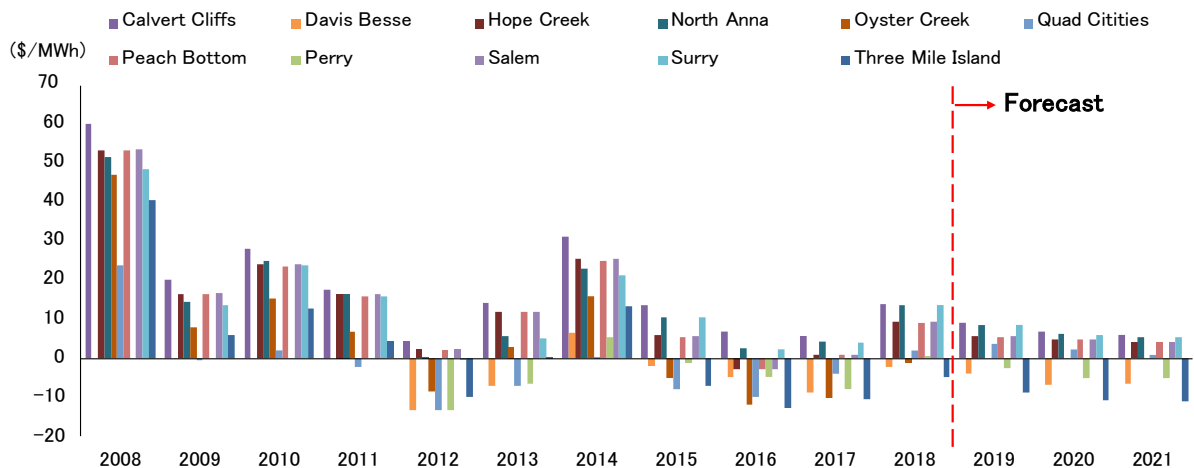


Fig.1 Annual Profitability of NPPs in PJM area  
Source: Monitoring Analytics (2019) [1]

The situation is similar in the U.K. Fig.2 is the result of calculation of profitability being based on the Consolidated Segmental Statement (CSS) of each NPP operator. It is clearly decreasing year by year. Compared with the profitability of renewable power generation (According to the CSS of 5 large operators, it was 37-54% in 2017.), the serious situation of NPPs becomes clearer.

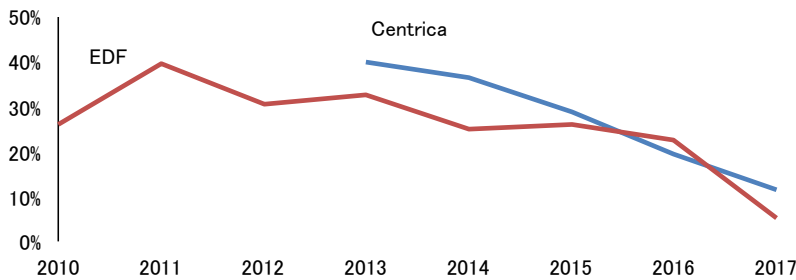


Fig.2 Annual Profitability of Nuclear Power Segment of the Plant Operators in the U.K.

Note: Calculation is based on Earning before Interest and Taxes (EBIT)

Source: CSS of each operator in each year

In addition to the results from case studies, quantitative analysis results show that profitability of NPPs is quite low in the electricity systems where massive VRE is deployed, even though flexible operation of NPPs would increase the value of their electricity.

Despite the serious situation, in those countries that promote nuclear energy as an important clean energy option for the future, they are making policy efforts to keep its profitability and to ensure the profitability of NPP operators. In some state governments of the U.S. grant Zero-Emission Credits (ZEC) to maintain their NPPs. Production Tax Credit (PTC) of the U.S. federal government and Contract for Difference (CfD) scheme of the U.K. has proven their effectiveness in deployment of renewable energy and are currently applied to nuclear energy. CfD is criticized for the high “strike price” for Hinkley Point C project, and the U.K. government is currently considering Regulated Asset Base (RAB) model for the following projects. If RAB model would be applied, the investors can correct their investment via electricity bill even before the operation [2]. Construction period is recently becoming longer, and CfD doesn’t cover this period. RAB model is expected to reduce such uncertainty. Reduced uncertainty means the necessary support level that should be

guaranteed for the NPP operators will be lowered and the economic burden on the people will be reduced. Another interesting case is Ontario. Like other cases, wholesale price is becoming lower in Ontario. But the Independent Electricity System Operator (IESO) of Ontario adds Global Adjustment (GA) on the electricity bill to secure enough funding for new construction of the generation facilities, maintenance of existing ones, Feed-in Tariff (FIT) payment for renewable energy, and so on. As Fig.3 shows, the amount of GA is increasing as the wholesale price is decreasing.

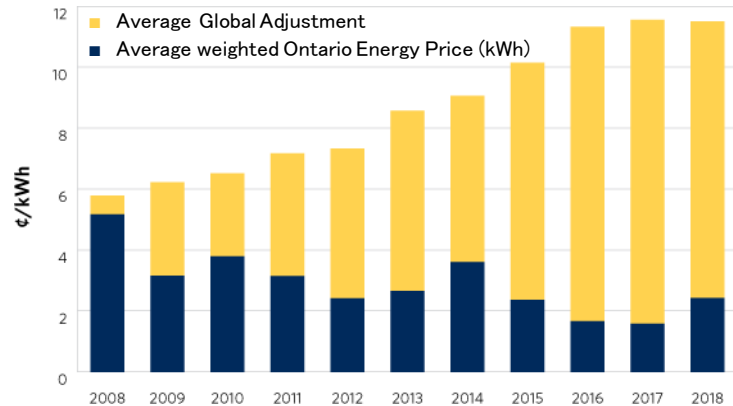


Fig.3 Average Ontario Energy Price (HOEP) plus Average GA

Source: IESO website [3]

## Conclusions

The case studies shows that profitability of NPPs is weakened in a liberalized wholesale market with the massive deployment of VRE, and the quantitative analysis confirms the case studies’ results. Nevertheless, the developed economies are taking policy measures to maintain their clean power sources for the future. Certainly, market liberalization is a recent global trend, but energy policy requires long-term perspective and decarbonization requires strategic plans. If any country is considering nuclear energy utilization, policy needs to be carefully crafted to balance between short-term as well as long-term energy policy objectives, and consider to what extent market mechanism is utilized and how such market is regulated.

## References

- [1] Monitoring Analytics, *2018 State of the Market Report for PJM*, vol.2, 2019.
- [2] BEIS, *RAB Model for Nuclear: Consultation on a RAB model for new nuclear projects*, 2019.
- [3] IESO website (<http://www.ieso.ca/en/Power-Data/Price-Overview/Global-Adjustment>)