STUDY ON TAIWAN ENERGY SECURITY RISK INDEX

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Overview

The study establishes the risk indexes for Taiwan's energy and electricity security to investigate the energy conditions in the history; then, by the risk quantification, the energy issues can be found and the policy suggestions can also be proposed correspondingly. In the paper, 25 indexes are proposed totally, and they can be divided into four categories: Electricity, Energy, Environment and Economy. The raw data required for each index are obtained from government agencies for accuracy and credibility. By the definition of the risk indexes, the raw data are converted into the index data and then converted into risk scores according to the highest and lowest values of the index data in the duration. According to the results, the near-term risks of the four categories and the indexes with high risk score can be studied. Regarding the concerns of the public recently, the study addresses some issues including: electricity supply and demand, liquefied natural gas (LNG) supply security, carbon dioxide emission, and the concentration on electricity generation and imported fuels; the risks for those indexes are examined in detail and the policy suggestions are proposed respectively.

Methods

The energy and electricity security indexes and the corresponding categories proposed in the paper are listed below: The **Electricity** includes: (1) Electricity Reserve Capacity Rate, (2) Low Electricity Operating Reserve for Days, (3) Annual Minimum Value of Electricity Operating Reserve, (4) Ratio of Electricity Transmission Across Grid Areas, (5) Load Factor, (6) Annual Outages, (7) Electricity Generation Concentration, (8) Electricity Consumption Per Capita, and (9) Electricity Consumption Share of High Electricity Comsumming Industries. The **Energy** includes: (10) Turnover Rate of Liquefied Natural Gas – Gas-Fired Generation Share, (11) Concentration of Oil Import, (12) Concentration of Natural Gas Import, (13) Concentration of Coal Import, (14) Dependence on Energy Import, (15) Energy Intensity and (16) Energy Consumption Per Capita. The **Environment** includes: (17) CO_2 Emissions Trend, (18) CO_2 Emission Intensity, (19) CO_2 Emission Per Capita, (20) Non-carbon Generation, and (21) Renewable Electricity Generation. The **Economy** includes: (22) GDP Per Capita, (23) Retail Electricity Price, (24) Energy Import Expenditure Intensity, and (25) Energy Import Expenditure Per Capita. The highest and lowest values of the raw data are designated as the risk scores from 0 to 1000, and the risk for each index is calculated by linear interpolation.

Results

Based on the results, the indexes with high risk include: Low Electricity Operating Reserve for Days, Annual Minimum Value of Electricity Operating Reserve, Electricity Consumption Per Capita, Electricity Consumption Share of High Electricity Comsumming Industries, Turnover Rate of Liquefied Natural Gas - Gas-Fired Generation Share, Concentration of Coal Import, Dependence on Energy Import, Energy Consumption Per Capita, CO_2 Emissions Trend, CO_2 Emission Per Capita, and Non-carbon Generation.

Besides, the study addresses the issues of public concern currently, and provides suggestions respectively. In the power supply and demand issue: The analysis shows that the rapid growth of electricity consumption in the electronics industry recently has a significant impact on the overall power consumption in Taiwan. However, the influence of electronics industry on Taiwan's economic is still significant, and thus it is necessary to maintain the stable electricity supply for the industry. In the index of Renewable Electricity Generation, the share of wind power and solar photovoltaic generation was only 1.2% in 2017, and the growth of conventional hydropower and waste-to-energy electricity generation had been unobvious; that results in the high risk in the index of Renewable Electricity Generation. Finally, gas-fired power generation is limited by the shortage of LNG storage tanks and the expansion of the gas-fired power plant is not as expected; hence, the risk of Turnover Rate of Liquefied Natural Gas increases correspondingly. According to the results mentioned above, the suggestions are proposed as: (1) reserving the old available coal-fired power plants for backup, and (2) retaining operation-license-expired nuclear power units under off-commissioning status for possible life extension in the future. As the development of wind power, solar photovoltaic, the energy storage facilities and power grids are as expected: 20% renewable power up to 2025, the operation-license-expired nuclear power plants can then be decommissioned.

Concerning the LNG supply security issue: Tatan Power Plant is the largest gas-fired power plant in Taiwan, where the natural gas supply comes from the Taichung LNG receiving terminal via submarine pipelines. The study recommends the land pipelines are also required to diversify risks. Besides, the major LNG import

countries of Taiwan include: Qatar, Indonesia and Malaysia. A great diversity of LNG import countries is the suggestion for reducing LNG supply interruption risk.

Concerning the CO_2 emissions issue: After the efforts in recent years, various CO_2 reduction measures have been adopted, such as increasing gas-fired power generation, decommissioning of old coal-fired power plants, and adoption of new ultra-supercritical coal-fired power plants. However, the trend of CO_2 emission does not reduce notably due to the decrease of nuclear power generation, and low share of wind and solar photovoltaic power generation. It implies that if the nuclear power generation kept constant, and correspondingly the coal-fired generation was reduced, the CO_2 emission should be lowered in 2017, and the chance to achieve the reduction goal announced in "The Greenhouse Gas Reduction and Management Act" is increased; meanwhile, the promise of international reduction can also be fulfilled. Nuclear power generation and renewable energy are not in conflict. A reasonable electricity portfolio of nuclear energy, coal-fired, gas-fired and renewable energy is necessary to ensure both carbon reduction and power supply stability.

Concerning the energy price issue: Since 2014, because shale oil and shale gas have been massively extracted, the oil prices have fallen sharply. Accordingly, the index of energy expenditure per capita risk has dropped sharply. The energy price has rebounded slightly in 2017, and the energy expenditure per capita risk has also increased. According to energy price projection of the International Energy Agency, the natural gas price and coal price are expected to increase slightly in 2040. At present, Taiwan is actively promoting solar photovoltaic and wind power generation. The influence of investment in renewable energy facility construction and grid connection costs on electricity prices will be an issue in the future .

Finally, concerning the concentration issue: The power generation is over-concentrated on coal and gas. It is recommended that the share of nuclear power generation can be moderately increased before renewable power generation rises significantly. Oil imports are relatively concentrated on Saudi Arabia and Kuwait. It shows that the concentration of oil imports and the corresponding risks are relatively low with sufficient import countries. It is recommended that some oil can be imported from the United States to further reduce the concentration risk. The import of natural gas is concentrated on Indonesia, Malaysia and Qatar. The share of gas-fired generation is higher than the other generation technologies, but the LNG storage capacity is insufficient. Therefore, it is recommended that some LNG can be imported from the United States to reduce concentration risk. Coal imports are also over-concentrated on Australia. It is recommended reducing the proportion of imports from Australia to maintain a low coal import concentration risk.

Conclusions

In the policy of nuclear-free homeland, Taiwan actively buildes renewable energy facilities and gas-fired plants to compensate the electricity loss from nuclear generation. Due to the intermittent nature of renewable energy, it needs to install sufficient energy storage facilities and more backup electricity with fast ramping capability, such as gas-fired power plants and ultra-supercritical coal-fired power plants. Hence, the sufficient storage capacity of LNG and enlarging the current receiving terminals is required to ensure the stable supply of LNG. In addition, the old available coal-fired power plants can be as the backup power as the supply of gas-fired generation is interrupts suddently. Finally, each generation technology has inherent advantage and disadvantage, and how to plan a reasonable electricity portfolio for Taiwan's situation to ensure emission reduction and power supply stability will be the challenge for Taiwan.

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