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Significance of an Optimization Concept for Energy Transition

Ken Koyama, PhD
Chief Economist, Senior Managing Director
The Institute of Energy Economics, Japan

Every country in the world is taking initiatives to structurally change energy supply and demand in pursuit of carbon neutrality and energy security enhancement. These initiatives seek to transform the present energy supply and demand structure, and infrastructure and supply chains for supporting the existing structure into entirely different ones to address carbon neutrality and energy security. This transformation, or energy transition, is a great challenge for the world.

At present, before the energy transition, the world depends on fossil fuels such as oil, coal and natural gas for some 80% of total energy supply. Non-fossil energies such as renewables and nuclear account for the remaining 20% or less. This picture has resulted from decisions accumulated by stakeholders in energy consumption, distribution, transportation, production, development and other stages. Such stakeholders' choices and decisions have formed the present energy supply and demand structure, and infrastructure and supply chains for supporting the structure. Given the long service lives and stock effects of infrastructure and supply chains, the energy transition turns out to be a difficult challenge.

Another important point is that while stakeholders' choices and decisions have been accumulated to form the present supply and demand structure, and infrastructure and supply chains, the biggest factor that has exerted great influence on such choices and decisions have been the extent of overall attractiveness including competitiveness, economy and convenience. Attractive options have been chosen to create the present supply and demand picture. In this sense, a big issue is whether or not natural choices can be expected to realize global carbon neutrality and enhance energy security fundamentally.

How to respond to climate change and address energy security represents how to face market externalities. This is not a problem that can be resolved by natural choices. Rather, the problem can be resolved by intentional or strategic deviation from natural choices to go in the direction of a desirable future picture in policy or strategic perspectives. Additional costs may thus be required for energy transition. Additional costs may be accepted for innovations to create a desirable future picture.

Nevertheless, the current Ukraine crisis has clarified that society, economy and politics even in developed countries are vulnerable to energy cost hikes that cannot be left untouched. Even in developed countries, various market intervention measures such as energy subsidies have been taken. In lower-income developing countries, energy cost hikes are an even more serious problem. Important here is how to reduce or minimize costs (or cost hikes). While everyone recognizes that it is important to create a desirable world, the most important point is the minimization of costs for the creation. Here, the promotion of energy transition through optimization or cost minimization becomes significant.

When cost minimization regarding energy transition is discussed, power generation costs

may be taken up most frequently. The basic prescription for decarbonization calls for promoting electrification and achieving a zero-emission power generation sector. As electricity grows more important for decarbonization, power generation costs attract attention naturally.

When power sources are selected, priority is given not only to short-term variable and marginal costs but also to the levelized cost of electricity (LCOE) covering construction and other capital costs as well as operation and maintenance, and fuel costs. In a sense, it is natural for more cost-competitive power sources to be selected. As a matter of course, environmental loads, social acceptability and other important factors also exert influence on the selection. In the meantime, renewable energy power generation costs have declined remarkably. In some regions, renewable energy projects have achieved extremely high competitiveness in terms of power generation costs including the LCOE. As far as renewable energy is domestic energy emitting no CO_2 for power generation and cost-competitive, it is natural for the diffusion of renewable energy to accelerate.

Meanwhile, it is growing more important to apprehend optimization from a wider perspective. Regarding solar and wind power generation, whose supplies can be intermittent, for instance, additional measures are required to make up for intermittency and stabilize the electricity system. Costs are required to develop power storage systems, use fossil fuel power generation for complementing the electricity system and increase interconnection lines. They are called integration or system costs. As intermittent energy sources' share of power generation expands, integration costs increase naturally. From the viewpoint of the overall electricity system, it is important to optimize the total cost including integration costs, as well as the LCOE and other power generation costs.

Recently, a viewpoint that broadens the scope of optimization further has attracted attention. The viewpoint sees energy option choices as going beyond energy sources and leading to security costs regarding relevant resources and raw materials. This viewpoint is typical for critical minerals that have become a global matter of concern. Attention is paid to the tighter supply-demand balance and price hikes for critical minerals that may come as the promotion of batteries, electric vehicles and renewable energy is substantially accelerated. Dependence on certain supply sources for critical minerals is also attracting attention. These matters are linked to economic security costs. In this respect, the Western bloc has become conscious of China's growing presence as a dominant critical mineral supplier. The risk of heavy dependence on certain supply sources for strategically important materials/goods represents a lesson learnt from the oil crisis 50 years ago and the current Ukraine crisis. The significance of optimization covering economic security costs is growing as the division of the world deepens.

The so-called best energy mix can be viewed as the optimized one. When the best energy mix is considered in Japan, the 3E's – energy security, environment and economic efficiency – are required to be optimized finally. Then, it may be important to consider not only superficial costs but also costs accompanying externalities such as energy security and climate change countermeasures. Amid the division of the world, however, economic security costs as well may be considered. In this way, priority may be given to broader optimization. How to sort out the concept of optimization as a key milestone for energy transition may become a globally important issue.

Contact: report@tky.ieej.or.jp