An Essay on Integrated Understanding of Energy Security and Economic Efficiency of Energy

Kazutomo Irie*

When energy security is defined as securing enough quantity of energy with the condition of ″at an affordable price,″ it is necessary to distinguish it from economic efficiency of energy which means seeking lower energy price. This classification can be clarified by understanding that there is an inflection point in the demand curve of energy and the price elasticity of demand changes largely before and after that point. Estimating the demand at the inflection point makes it possible to calculate the stockpiling requirement for energy security.

The shape of the energy demand curve varies from economy to economy, depending upon economic development stages and natural and cultural conditions, and it can change historically even in the same economy. In the future when energy resource constraints become obvious, an inflection point will also arise in the supply curve of energy, and it is possible to predict a sharp price hike due to tightening of energy supply and demand.

Keywords ：Energy Security, Affordable Price, Economic Efficiency, Stockpiling Requirement

1. Introduction

In the beginning of this century, the author attempted to formulate the concept of energy security and pointed out as follows: though the aim of energy security is to seek the quantitative stability of energy supply, since quantity and price are correlated to each other, price stability must also be sought for energy security. Using recent terminology, energy security is defined as securing a sufficient quantity of energy with the condition of "at an affordable price."

In such a case, it is necessary to clarify the relationship between price stability in the context of energy security and another policy target, "low-priced supply" or "cost reduction" concerning energy (that is, the economic efficiency of energy), which is often juxtaposed with energy security. The author also argued that, for the purpose of such clarification, it would be effective to introduce the concept of supply-demand tightness.

That is to say, on the roughly L-shaped energy demand curve, the supply and demand of energy is tight on the left side of the inflection point X, which corresponds to the minimum energy requirement for the economy in question. On this side, the demand is less price-elastic and does not fall so much as would be expected in spite of the price increase, and the consumer's surplus shrinks greatly. The relative decrease in the consumer's surplus is large not only for the same rate of price increase (Figure 1) but also for the same magnitude of price increase (Figure 2). Attempting to control the price increase under these conditions means controlling the price stability in the context of energy security.

On the other hand, the supply and demand of energy is less tight on the right side of the inflection point X, and the demand is more price-elastic. The demand falls greatly because of the price increase, but the consumer's surplus does not shrink much. As before, attempting to control the price increase under these conditions is referred to as the "low-priced supply" or "cost reduction" concerning energy[1)].

The above discussion is within the boundary of conceptual thinking toward a systematic understanding of the various concepts concerned. However, in light of the subsequent development of energy security concepts, the author has come to realize that the idea of supply-demand tightness plays an important role when calculating the stockpile required for energy security.

* Senior Research Fellow, General Manager, Asia Pacific Energy Centre
The Institute of Energy Economics, Japan
Inui Bldg. Kachidoki, 1-13-1 Kachidoki, Chuo-ku, Tokyo 104-0054
E-mail:kazutomo.irie@aperc.ieej.or.jp

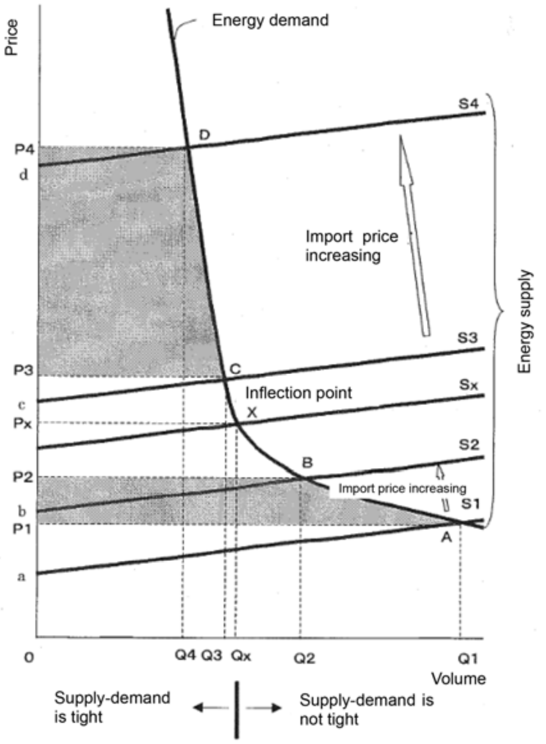

Figure 1: S-D Tightening and Price Increase

(Case 1: Rate of increase of import price is the same)

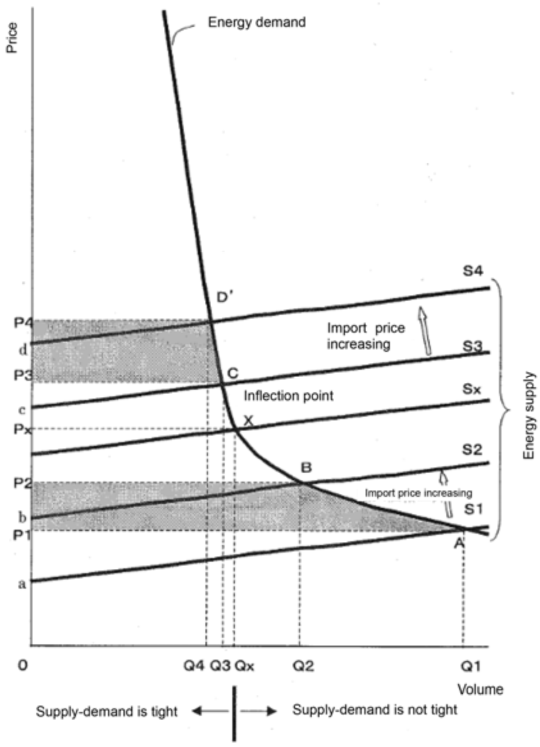

Figure 2: S-D Tightening and Price Increase

(Case 2: Magnitude of increase of import price is the same)

2. Supply-Demand Tightness and Stockpile Requirement

Energy security-related risks that should be considered used to be geopolitical risks associated with energy importation. To minimize the risk of suspension or interruption of imported energy supply, scenarios were constructed to estimate the duration of a possible import interruption of oil, which accounted for the majority of energy sources, and to calculate the oil stockpile required to deal with such emergencies.

After the first oil crisis in 1973, the International Energy Agency (IEA) was founded by developed countries, whereby all member countries were placed under an obligation to maintain a stockpile of 90 days' worth of their net oil import. The basis of the 90-day amount was not clear; however, it was effective in that it made it clear to energy exporting countries (especially, oil exporting countries) that any future interruption of oil supply as long as 90 days would not cause substantial troubles in the domestic energy supply markets of oil importing countries, thus deterring oil exporters from forming an international oil cartel again.

However, as discussed in a separate paper, since the turn of the 21st century, the risks associated with energy supply that should be dealt with in the context of energy security have increased in scope to include those of violent non-state actors (VNSA) such as terrorists, and the risk of damage that could be caused by natural disasters[2]. Moreover, as the relative importance of oil as the primary energy source declines, a stockpile of oil that is quantified in terms of the number of days' worth of net oil import has become less effective in providing energy security at times of emergency[3].

Regarding stockpiling, it is worth starting by directly estimating the minimum energy requirement of the economy in question, determining the number of days for which energy supply might be disrupted based on various risk assessments, and then calculating the magnitude of the stockpile commensurate with the number of days thus determined.

When doing so, one could use a method in which the locus of the inflection point X on the aforementioned L-shaped demand curve is determined, and then the minimum requirement for the economy in question corresponding to the inflection point X is estimated. Although it is not easy to collect and analyze data concerning the supply-and-demand of energy at times of emergency, which occur infrequently, it is worth attempting to use such a method.

In that case, it is not adequate just to think of energy in relative terms such as the total supply versus total demand of primary energy as in the case of the previous discussion. Instead, it is necessary to consider a supply-demand relationship for each of the energy sources. Furthermore, to prepare for an excessive supply-demand tightening for a certain energy source, it is also necessary to assess how far we would be able to compensate for the situation with another type of energy. A discussion of individual energy markets is beyond the scope of the present article; however, if we are to construct an energy stockpiling mechanism to cope with various risks, it will definitely be worth discussing such individual energy markets in future.

Theoretically, if the energy supply-and-demand situation becomes extremely tight, one may consider the possibility of overcoming the shortage of energy by making changes involving other production factors. Japan has already experienced such changes; when faced by the oil crises in the 1970s, it abandoned domestic aluminum production and chose to rely on imports for aluminum products. In such cases, the shape of the energy demand curve may be affected. However, with great progress in energy-saving technologies after experiencing two oil crises, there are fewer opportunities for any shortage of energy to be compensated by other production factors.

3. Economic Growth and Supply-Demand Tightness

So far, we have been concerned with analysis at one point along the time line of a certain economy. However, if we are to exercise diachronic thinking, unless economic growth and energy consumption can be decoupled, the energy demand rises as the economy grows, and the L-shaped demand curve shifts to the right (see Figure 2).

In such a case, assuming the supply curve remains the same, energy supply-demand tightening, with the supply curve crossing the demand curve at the inflection point X, becomes reality. In other words, the risk of energy supply-demand tightening due to short-term shifting of the supply curves increases.

Hence, the economy in question must minimize the rightward shifting of the demand curve through energy-conservation and energy-saving efforts.

From a synchronic perspective, the demand curve D1 of a developed country with a mature economy lies to the right of the demand curve D2 of a developing country, calling for the further implementation of energy security measures. Since the position of the demand curve can be influenced by the size of a country's population, one might need standardization methods such as drawing per capita energy demand curves to make comparisons between countries; however, the general tendency will be as described here.

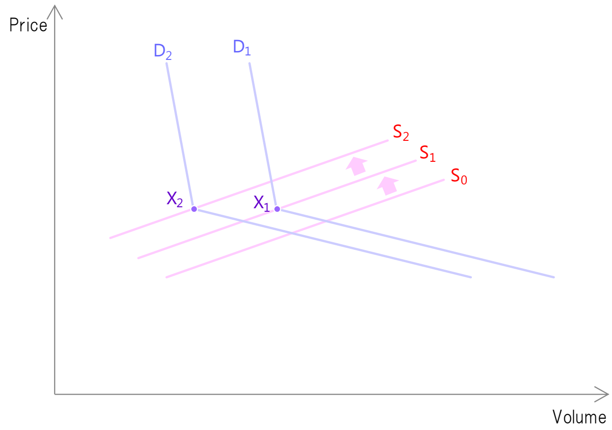

Figure 3: Economic Growth and Supply-Demand Tightness

4. Energy Resource Constraints and Supply-Demand Tightness

When we consider the supply-and-demand relationship of energy, we need to take into account not only the increase in energy consumption seen from the demand side but also the energy resource constraints seen from the supply side. For fossil fuels, the finite nature of natural resources is clear. Likewise, in the case of renewable energy, which is often regarded as being infinitely exploitable, its finite nature cannot be totally dismissed because available geographical locations suitable for developing various forms of renewable energy such as wind power, solar power, and geothermal energy will become fewer as their exploitation expands.

Therefore, the inflection point Y does exist for the supply curve too, which leads to an anti-L-shaped supply curve. It should be obvious from Figure 4 that severe energy resource constraints are likely to result in tight energy supply and demand, where even a short-term change in the demand may lead to a sudden increase in the price.

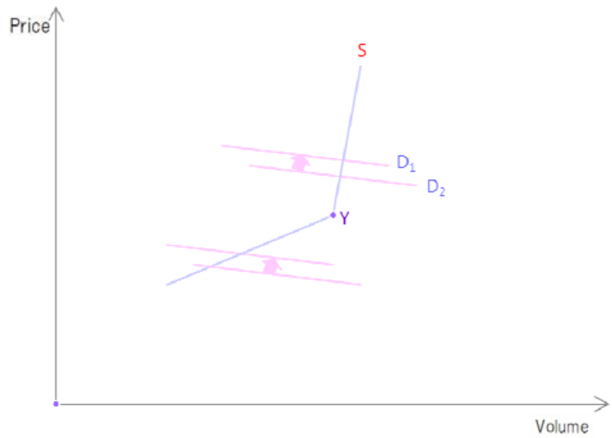

Figure 4: Energy Resource Constraints and Supply-Demand Tightness (Short-term)

From a long-term perspective, one can assume that the supply gradually becomes price-inelastic as energy resource constraints manifest themselves (see Figure 5). In Figure 5, the supply curve shifts from S to S', and the slope becomes steeper.

In the long run, the demand increases, causing the demand curve to shift from D to D', and the new supply-demand equilibrium point E' comes close to X' and Y', the inflection points of the demand curve and the supply curve respectively, increasing the risk of supply-demand tightening.

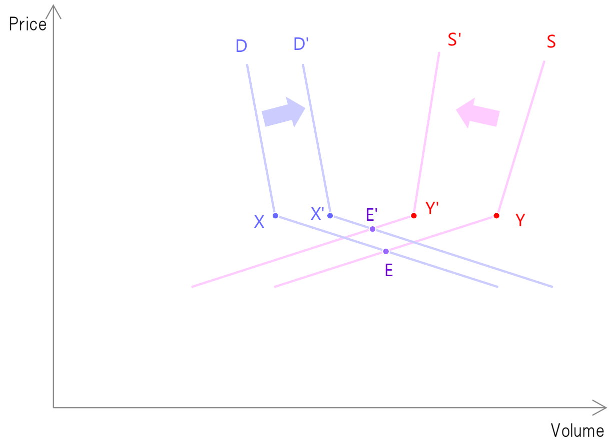

Figure 5: Energy Resource Constraints and Supply-Demand Tightness (Long-term)

In a situation where the demand increases and energy resource constraints are likely to manifest themselves, a short-term decrease in the supply can result in a sudden steep increase in the price (Figure 6). In Figure 6, even if the energy supply and demand becomes tight due to the short-term supply change, if the supply-demand equilibrium point E moves to E', the intersection of the supply curve S' and the demand curve, the energy supply is still price-elastic, and the corresponding price increase is small. However, if the supply-demand equilibrium point moves further from E' to E'', the intersection of the supply curve S'' and the demand curve, the energy supply becomes price-inelastic because of the energy resource constraints, and the corresponding price increase becomes large.

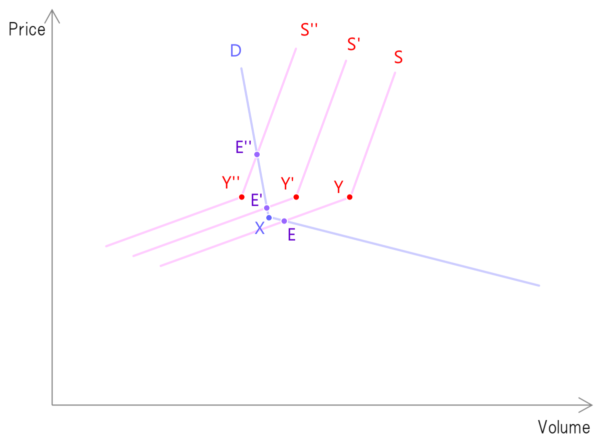

Figure 6: Price Increase under Energy Resource Constraints

To prevent such critical situations from becoming a reality, we need to facilitate the rightward shifting of the energy supply curve by making efforts to develop new energy resources and innovative technologies from the supply perspective, in addition to demand-side efforts such as promoting energy-conservation and energy-saving measures.

5. Conclusion

In this study, we reviewed the conceptual differences between the energy security and the economic efficiency of energy based on a relatively simple supply-demand analysis model with an inflected energy demand curve. We showed that this framework is beneficial for estimating the required energy stockpile considering the recent evolution of energy security concept.

Using this framework, it was shown that economic growth and energy resource constraints would lead to a heightened risk of supply-demand tightness in the long run. This framework is expected to be useful for further quantitative analyses in the future.

Acknowledgement

I sincerely thank my colleagues at the Institute of Energy Economics, Japan, for writing this article, and offer special thanks to Mr. Yuhji Matsuo for inspiration and encouragement.

References

1) K. Irie, K. Kanda, "Study on the Conceptualisation of Energy Security," Energy Policy Study, 1, 1 (2002), 1-57
2) K. Irie, "The Evolution of the Energy Security Concept and APEC Energy Cooperation," IAEE Energy Forum, 26, Singapore Issue 2017 (2017), 38-40.
3) K. Irie, "Transformation of World Energy Governance: A Brief Overview Focusing on Energy Security," IAEE Energy Forum, 26, Fourth Quarter 2017 (2017), 33-35, 41