QoEn™ Approach – A Quantitative Index that Can Suggest the Direction toward High-quality Energy Infrastructure Based on the Three Aspects of Society, Economy and the Environment

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In line with accelerating international initiatives for climate change such as the reduction of greenhouse gas emissions and the realization of sustainable development, we are working on the development of an index called QoEn™ as a quantitative index of how high-quality energy infrastructure should be defined. Our goal is to propose to urban development planners and investors, from the project planning stage, the energy infrastructure that is suitable for the area's energy needs and that can support its sustainable development. We aim to achieve this goal by quantitatively assessing the impact of the project on the area in terms of social, economic and environmental aspects.

This report gives an overview of QoEn™ and summarizes the joint development research conducted with the University of New South Wales in Australia.

1. Introduction

Environmental awareness has grown further since the adoption of the "Paris Agreement" as an international framework to reduce greenhouse gas emissions in 2015, accelerating the "penetration of clean energy such as renewable energy" and the "promotion of digitalization" along with "technological innovation" in the field of energy infrastructure. At the United Nations Summit in 2015, Sustainable Development Goals (SDGs) were adopted to realize a "sustainable society with diversity and inclusion," in which issues related to climate change were also addressed.

Following this SDG approach, ESG (Environmental, Social and Governance) investment is becoming the mainstream and companies paying attention to environmental, social and governance issues are prioritized/selected for investment. An increasing number of companies have started using renewable energy to reduce CO_2 emissions or have set the goal of operating their businesses only using renewable energy. As such, the importance of renewable energy is expected to further increase.

On the other hand, the amount of electricity generated by renewable energy is characteristically and considerably dependent on climatic conditions and topography. As shown in **Figure 1**, the existing energy infrastructure is influenced by renewable energy in various ways.

(1) Increase of public financial burden due to subsidies, incentives, etc., to promote the introduction of renewable energy

(2) Shutdown or discontinuation of existing thermal power plants
(Lowered availability and economy, and increased gap between installed capacity and the peak demand)

(3) Mismatch between supply and demand due to variable power generation
(Necessity of regulated power supply and additional investment in energy infrastructure)

(4) Limitations on investment in new energy infrastructures (thermal power plants)

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Energy infrastructure is essential in underpinning the economic growth of a region. The energy mix, in which various energy sources including renewable energy are combined for effective use, will be of increasing importance for the realization of a stable energy supply.

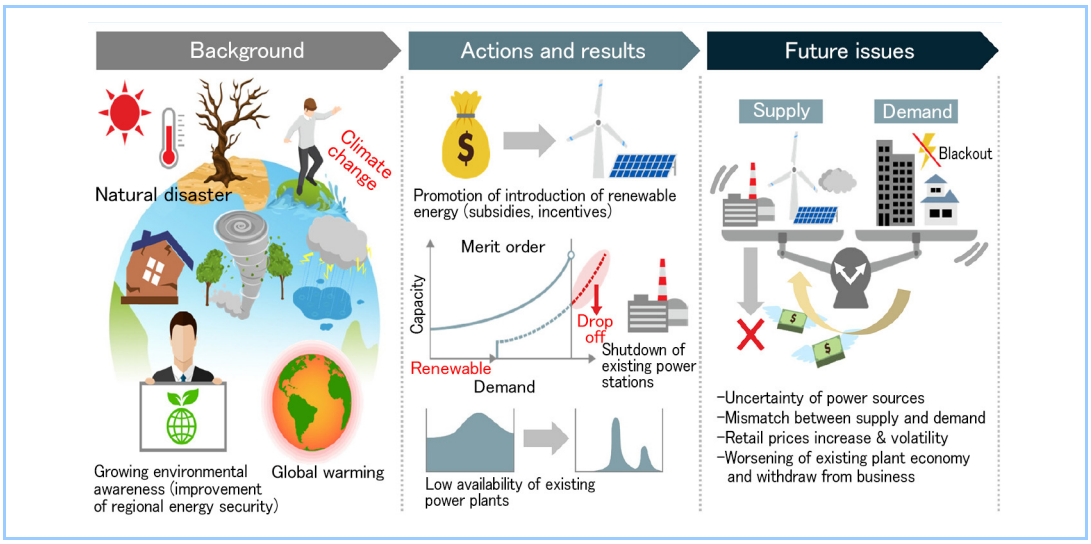

Figure 1 Energy transition surrounding energy infrastructure

2. Our future direction

To supply energy in a stable manner, Japan has adopted and aims to fulfil the basic energy policy of S+3E: safety as a prerequisite (Safety), stable supply (Energy security), improvement of efficiency from an economic perspective (Economic efficiency) and environmental compatibility (Environment). It is important to realize a balanced energy mix without depending on only a certain energy source.

For the realization of sustainable development, it is also important to take the same stance on energy security, economic efficiency and the environment as with the case of energy infrastructure. For example, as described in Section 1, the penetration of renewable energy can considerably contribute to "environmental performance." It can also lower the "economic performance," however, because additional investment may be necessary to balance the supply and demand, or it can also lower the "social performance" due to the installation/operation of facilities required to use renewable energy, etc. It therefore cannot necessarily be said that every case is sustainable.

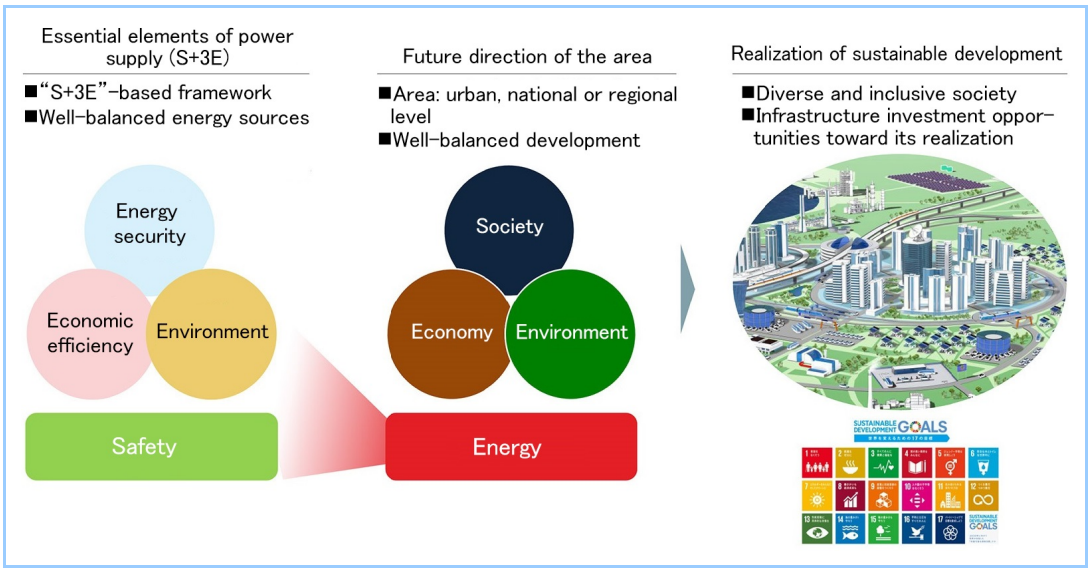

Figure 2 Our future direction

To realize sustainable development, our society has to grow while maintaining the area's balance of (1) society, (2) economy and (3) the environment. Mitsubishi Heavy Industries, Ltd. (MHI) therefore proposes that energy sources that can balance these three aspects are defined as

"high-quality energy infrastructure." Furthermore, we also consider that it is our social responsibility to present suggestions in a simple, quantitative manner to energy infrastructure planners and investors regarding how these aspects can be balanced or how the infrastructure should work **(Figure 2)**.

3. Proposal of our new approach: QoEn™ (pronounced as "*ku-won*")

At the planning stage of a project such as urban development, the topics that are mainly considered include (1) what kind of society should be created, (2) in what way investment can be attracted and (3) what kind of energy infrastructure should be applied. As shown in **Figure 3**, we are developing an assessment tool to quantify indices in terms of the three aspects of society, economy and the environment using public data of the region concerned. With this tool, we will be able to assess how new energy infrastructure, if introduced, can contribute to the area by quantifying and showing the gap between current indices and future indices.

Accordingly, we aim to suggest the direction toward high-quality energy infrastructure to planners and investors. The term QoEn™ ("*ku-won*") will be used to collectively refer to this kind of assessment tool, and we are proceeding with its trademark registration. (Based on the phrase Quality of Energy, the term QoEn™ was also coined to sound like the Japanese word "久遠 (*Ku-on*, which means eternity).")

We intend to make this assessment tool publicly available in the future, allowing for its use by third parties with public data.

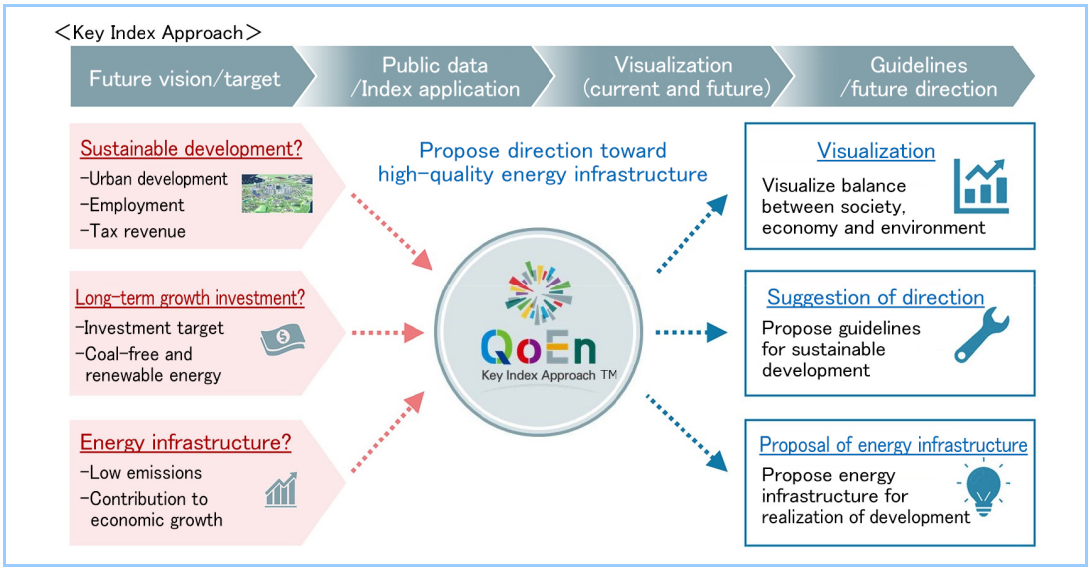

Figure 3 Our proposal of new, key index approach: QoEn™

4. QoEn™ overview and application concept

QoEn™ is characterized by its capability of visualizing the current status through the three quantified indices of society, economy and the environment based on public data such as the statistical data of the region concerned. The development or growth goals of the area, for example, are calculated and regarded as target indices. By comparing these two types of indices (i.e., current status and future), QoEn™ can reveal any discrepancies.

Furthermore, the use of a triangular radar chart to plot the three quantified indices can provide immediate comprehension in terms of the balance of the three indices and a comparison with other areas. **Figure 4** is a conceptual illustration of the application of the tool, and the application phases are summarized below.

Phase I: Select indicators such as electricity price and CO_2 emissions to estimate social, economic and environmental indices

Phase II:
- Estimate and visualize the current status of each index (as shown by a red triangle tagged as Current status)
- Estimate and visualize the development or growth goals as future indices (as shown by a green triangle tagged as either Current status or Future)

— Design new energy infrastructure and simulate its impact on the current status (as shown by a red triangle tagged as Future)

Phase III: Assess the simulation results from the perspective of the balance between society, economy and the environment, and propose the direction for new energy infrastructure based on the assessment results

The application of QoEn™ thus enables us to evaluate the current status in the context of the development or growth goals of the area and quantify/visualize the impact of introducing new energy infrastructure in terms of how much this introduction can bring the current status closer to the future indices.

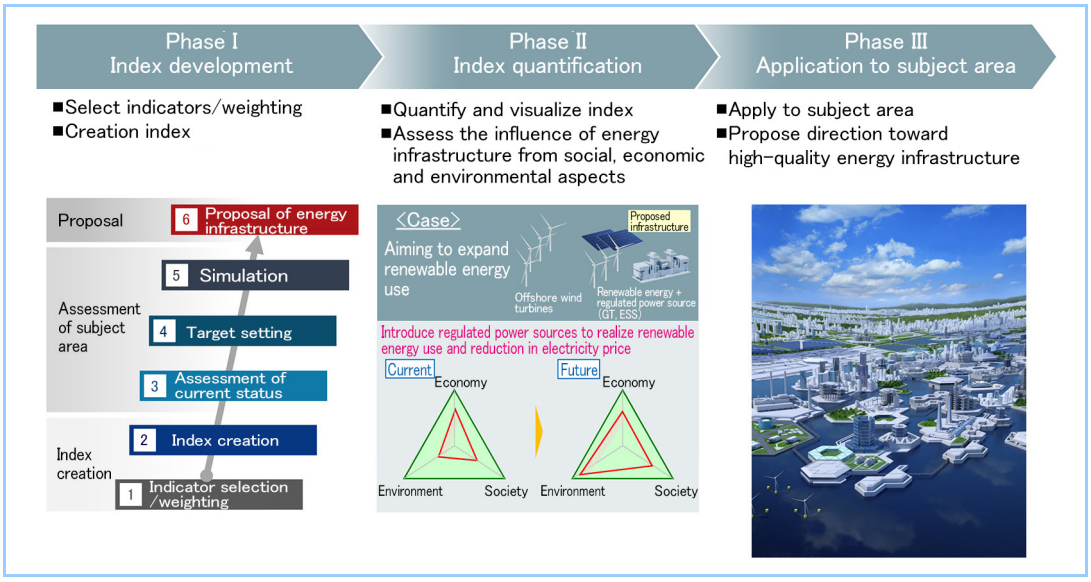

Figure 4 QoEn™ overview and application concept

5. Application to urban development project in Australia

In October 2018, MHI signed a Memorandum of Understanding (MOU) with the Government of New South Wales in Australia to cooperate in providing energy management solutions, etc., for the comprehensive development plan of the Western Sydney region.

Figure 5 Outline of development plan for Western Sydney region(1)

As a joint project by Government of New South Wales with the Australian Federal Government and the eight municipalities in the Western Sydney region, our areas of focus were the Second Sydney Airport (scheduled to begin its operation in 2026) and the surrounding areas as shown in **Figure 5**. The New South Wales Government, which is coordinating infrastructure development for the region, formulated a plan to decentralize city functions by creating several

central business districts in the Sydney metropolitan area. In addition to these central business districts in Sydney, the government has started a second program to develop other central business districts, which was initiated by the relocation of state government agencies to suburban areas. Other organizations such as leading companies, universities and research institutions have also participated in this program.

To make QoEn™ applicable to the Western Sydney region, we are conducting joint development research with the University of New South Wales in Australia, taking into consideration access to Australian public data and securing index transparency. We will publish the research outcomes including the application results for the Western Sydney region.

6. Conclusion

While the requirements for an energy infrastructure vary depending on the region of the world, it is important to propose high-quality energy infrastructure that suits the needs and characteristics of the region and can support the realization of sustainable development. We will apply QoEn™ to propose, from the planning stage of a project such as urban development, the optimal energy infrastructure that can realize both reduced environmental impact and economic growth, thereby contributing to the realization of sustainable development in accordance with the characteristics of each region.

In addition to a stable energy supply under normal circumstances, it is also becoming necessary to take the recent viewpoint of maintaining/improving “energy resilience” (i.e., resistance to emergencies such as natural disasters) into account for energy infrastructure. We will take on the challenge of making such assessment possible.

References

(1) NSW Government, Delivering The Western Parkland City, April 2019