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Study on the Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in the East Asia Region

Edited by

Kentaro Hayashi

Akihiro Kimura

Hiroki Kudo

ERIA

Economic Research Institute
for ASEAN and East Asia

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Economic Research Institute for ASEAN and East Asia (ERIA)
Sentral Senayan II 6th Floor
Jalan Asia Afrika No. 8, Gelora Bung Karno
Senayan, Jakarta Pusat 10270
Indonesia

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Preface

The occurrence of disasters and their damage have been exacerbated by the effects of climate change. In the Association of Southeast Asian Nations region, large typhoons have been hitting every year, causing unprecedented localised heavy rainfall and resulting in landslides. Additionally, earthquakes are on the rise. In response to these natural disaster risks, strengthening each country and region's national resilience is one of the main pillars of governments' disaster prevention and mitigation policies, and there are ongoing efforts by both the public and private sectors in terms of hardware and software. In the recovery and reconstruction from disasters, the soundness of public infrastructure and faster recovery are crucial, especially for energy supplies, such as of electricity, gas, oil, and water, which are essential for the speedy recovery of both residents and businesses.

To deal with the intensifying natural disasters, it is necessary to strengthen the energy supply system and facilities that can respond to hazards. The energy supply side is working on the seismic reinforcement of facilities and supply networks, damage suppression and secondary damage prevention measures, and advanced disaster prediction. It has reached a certain level, but there are variations amongst different countries and regions.

On the other hand, when looking at the demand side of energy, business continuity planning initiatives for disaster preparedness have become common activities for many companies, but the resilience of power facilities on the demand side varies depending on the company.

In such a situation, it is highly meaningful for countries and regions around the world and private companies to gather and share knowledge and experiences focusing on energy resilience, and for ERIA to disseminate information from countries and regions to the world. It is believed that the role of this programme will continue to grow in the future, and we look forward to future efforts. The project team would like to express our gratitude to everyone who has cooperated with ERIA's workshops so far, and we ask for continued support in building a resilient world where countries and regions can collaborate.

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We hope this study contributes to making energy resilient and developing a stable and solid economy for the ASEAN region and its countries.

List of Project Members

Hiroki Kudo, Board Member, Director, Electric Power Industry & New and Renewable Energy Unit, The Institute of Energy Economics, Japan (IEEJ), Japan

Akihiro Kimura, Senior Researcher, Electric Power Industry & New and Renewable Energy Unit, The Institute of Energy Economics, Japan (IEEJ), Japan

Kentaro Hayashi, Senior Researcher, Electric Power Industry & New and Renewable Energy Unit, The Institute of Energy Economics, Japan (IEEJ), Japan

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List of Abbreviations and Acronyms

3E+S	Energy Security, Economic Efficiency, Environment, and Safety
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
BCP	Business Continuity Planning
ERS	Energy Resilience Score
EWG	The Energy Working Group (APEC)
ERTF	The Energy Resiliency Task Force (APEC)
IDNDR	International Decade for Natural Disaster Reduction
ISO	International Organization for Standardization
SDGs	Sustainable Development Goals
TC	Technical Committee (ISO)
USAID	United States Agency for International Development
WCDRR	World Conference on Disaster Risk Reduction (United Nations)
WSSD	World Summit on Sustainable Development (United Nations)

Executive Summary

Introduction

Whilst there is a global need to promote energy policies that balance energy security, economic efficiency, the environment, and safety (3E+S), the frequency of large-scale natural disasters is increasing. In fact, there were at least 421 individual natural disasters in 2022, which was slightly above the average since 2000. Global economic losses caused by natural disasters were close to the 21st century average in 2022. Focusing on weather-related disasters only, total losses in 2022 were roughly 17% above the average since 2000.

Due to the increase in economic losses caused by natural disasters, in recent years, efforts by each sector to improve energy resilience must be appropriately evaluated and executed. To build a robust energy system in the future, stakeholders, such as governments, local governments, energy suppliers and consumers, solution providers, and the financial sector, should be recognise their roles and identify a standard system and management methods for enhancing energy resilience. It will also be necessary to establish an international forum for sharing examples of initiatives and best practices amongst countries and various stakeholders, including companies, as well as promoting efforts to enhance energy resilience not only in specific countries and regions but also worldwide.

In this project, the prototype quantitative energy resilience score (ERS) model was used to conduct an empirical energy resilience assessment. The results of the empirical energy resilience assessment and international efforts to strengthen energy resilience, including those of the Asia-Pacific Economic Cooperation (APEC), were shared and discussed at the workshops held in the three countries. This report provides an overview of international efforts to strengthen energy resilience against the background of APEC's efforts for energy resiliency enhancement and the content of the Energy Resiliency Principles and related guidelines. Since APEC's principles and guidelines raise the importance of evaluating indicators of energy resilience, and this report includes a review of similar indicators and describes the concept and evaluation of the prototype model. Finally, it provides summary reports of the three workshops with a conclusion and consideration for future work.

International efforts to address energy resilience enhancement

In recent years, the damage caused by natural disasters such as earthquakes and typhoons has become enormous, and, there is recognition of the socioeconomic threat from cyberattacks. Building energy systems that are resilient against natural and manmade disasters in the APEC region has been an emerging issue. Whilst the United Nations is considering promoting disaster prevention initiatives, APEC has launched activities to consider energy resilience.

The Energy Working Group (EWG) of APEC developed the APEC Energy Resiliency Principle with the great help of the Energy Resiliency Task Force (ERTF) and APEC member economies. The Principle, which was endorsed at EWG59 held in August 2020, is comprised of norms and concrete measures that stakeholders in each economy should voluntarily pay attention to and implement in order to improve energy resilience, rather than mandatory or compulsory documents. In the Principle, it is stated that the establishment of detailed guidelines to support the formulation of energy resilience enhancement plans in APEC member economies is one of the follow-up actions. In addition, the Principle is expected to contribute to the achievement of the Sustainable Development Goals (SDGs) worldwide through the expansion of an international track record through international standardisation, such as ISO, in the future.

The Principle identifies four main sectors that should be addressed for energy resilience: (a) governments, (b) energy supply industries, (c) industrial and general energy consumers, and (d) financial institutions. It is characterised by the fact that it places importance on financial institutions for resilience. Financial institutions are positioned as important stakeholders in the enhancement of energy resilience in the APEC economies. Assessment of, investment in, and financial support for financial institutions' efforts to strengthen energy resilience are recommended. In the effort to strengthen energy resilience, it is recommended to actively invest in disaster response and recovery and reduce risks to energy infrastructure. In order to make such investment decisions, it is essential to develop relevant indicators for appropriately evaluating the cost-effectiveness of investments, and it is essential to establish a system for disclosing established indicators and related information from private companies to financial institutions.

One of the action items identified in the Principle is to develop the APEC Energy Resiliency Guidelines to support the formulation of energy resilience enhancement plans in APEC member economies published in February 2023. The guidelines were developed based on best practices and recommendations gathered from participants from each workshop as well as literature research on relevant energy resilience efforts in the APEC region to reflect the regional diversity and variety of energy resilience challenges in the APEC region.

The guidelines address the need for multi-stakeholder knowledge sharing. Assessment of resilience knowledge gaps and capacity building needs may be conducted to facilitate knowledge sharing. The principle identified developing tools as follow-up actions based on the principle to better evaluate risk and vulnerability to disasters (for example, an energy resilience score to measure resilience performance as an APEC economy's resilience benchmark can be considered).

In response to the publication of the Energy Resiliency Principle, Japan submitted a new work item proposal for the development of ISO standards for ISO/TC292: Security and Resilience, which was approved in September 2022. The working draft of ISO 22366 was formulated with reference to the APEC Energy Resiliency Principle and discusses the structure required as an ISO standard.

Review of consideration for building an indicator relating to energy resilience enhancement

In recent years, in response to the frequent occurrence of extreme weather disasters around the world, governments, local governments, and companies have become increasingly aware of the need for resilience measures, and governments and insurance companies have introduced schemes to grant premiums for resilience improvement initiatives. In addition, as far as resilience to natural disasters associated with climate change is concerned, systems such as green bonds have also been started.

However, some in the financial world have pointed out that there are no indicators to quantitatively evaluate energy resilience, which hinders investment and loan decisions, and there are still barriers to funding, with the difficulty of quantitatively assessing benefits a core issue in terms of financing.

Chapter 3 provides an overview of previous research, especially in the United States, and existing consideration and development action being conducted in Asian countries (the Philippines, Thailand, and Indonesia) as references for further consideration of the development of a quantified energy resilience score system.

Prototype of a quantitative energy resilience scoring tool and the trial results

The prototype ERS system is intended to evaluate energy consumers in terms of their facilities' capability of maintaining a stable supply and operations under normal conditions and their preparedness in avoiding severe energy supply disruptions in the face of a disaster.

The ERS evaluates whether energy consumers can use energy stably, whether the energy facilities and systems can provide a stable supply and operations during normal times, and whether they are prepared to avoid severe energy supply disruptions during disasters. The score is quantitatively evaluated from three perspectives: (1) Regional Scoring, (2) Energy Supplier Side Scoring, and (3) Energy Consumer Side Scoring. These three evaluations are combined to calculate a comprehensive ERS.

The survey analyses energy resilience based on the status of disaster risks, energy supply side risks, and energy consumer side risks in the three regions where one energy company supplies energy using a prototype ERS evaluation method. The results of the survey, with detailed information provided by the energy supplier, give comparable regional energy resilience indicators. In the future, it is necessary to conduct and accumulate analyses in various regions using the same method to improve the qualification of the evaluation method and the accuracy and comparability of the derived ERS. Issues have been identified in the evaluation of energy resilience using this method, including issues related to the calculation methodology for energy resilience evaluation points.

Discussions at the workshops

For the purposes of this project, workshops were held in Japan, Thailand, and Indonesia. At the workshops, participants shared information on the impact of disasters on energy resilience and policy initiatives in each country and discussed the concept of the prototype ERS model and the results of the evaluation of the ERS demonstration.

In assessing energy resilience, it is important to consider the geographical characteristics of the target countries and regions since these impact the climate, disaster risk, and so on. Therefore, one continental country and one archipelagic country were selected as the target countries for the workshops, Thailand and Indonesia, which are located on the Pacific Rim and have suffered from large economic damage from natural disasters in the past.

Challenges to be addressed

An empirical evaluation of the ERS was conducted using the prototype ERS model. The concept and results were shared with the workshop participants, and discussions were held at the initial stage to consider the specific feasibility of application in each country. Through the demonstration evaluation using the prototype ERS model and discussions at the workshops, the challenges of the ERS model and the points for improvement for future use were clarified.

One of the challenges is refining the scoring to build a higher-level and more homogeneous platform for implementing the current scoring process in various countries and regions and across numerous infrastructures and companies. The second challenge is fine tuning depending on the country and region. The third challenge is the utilisation of private sector potential. Resilience assessments for energy resilience enhancement need to be used by the private sector, particularly in the financial sector, to expand their business. It is expected that the effective use of resilience assessments by the private sector will create several types of business opportunities to contribute to energy resilience enhancement.

Expected future work regarding the ERS

The prototype ERS system used in this project considers heavy rain, strong wind, earthquakes, and floods, which are key climate hazards in Japan. However, other hazards, such as drought, may be more significant in other regions. To accurately evaluate the resilience of energy infrastructure against hazards, the hazards that these systems will be most likely be exposed to should be considered.

To increase the availability of data collection, it is necessary to improve understanding of the content and significance of the ERS, as well as its benefits to consumers. It is necessary to increase the accumulation of empirical results using the ERS evaluation tool in many countries and regions and to continuously create opportunities for sharing and improve understanding of the ERS through discussions amongst stakeholders.

Scoring data need to be accumulated and analysed by one of the institutions or organisations. If there are a large number of organisations providing indicators, it is difficult to determine which organisation's indicators should be adopted, making it difficult to use them, especially from a business standpoint. Although scoring data may differ by country, region, and the subject to be evaluated, it is necessary to collectively manage, analyse, research, and disclose the data.

It is conceivable that the data on natural disasters and energy system vulnerabilities necessary for ERS assessment will be standardised, and reliable and comparable data can be collected by different countries, regions, and companies, etc. The collection of data based on common definitions and measures is expected to promote collaboration and cooperation amongst countries and regions to strengthen energy resilience.

Chapter 1

Introduction

Energy, such as fuel, heat, and power supply, is the foundation that supports all activities of society, including industrial activities and people's lives. A stable energy supply is a prerequisite for the sustainable development of nations and regions. Whilst there is a global need to promote energy policies that balance energy security, economic efficiency, the environment, and safety (3E+S), the frequency of large-scale natural disasters is increasing.

There were at least 421 individual natural disasters in 2022, which was slightly above the average since 2000.[1] In Japan, the importance of energy resilience was reaffirmed by the first-ever blackout caused by the Hokkaido Eastern Iburi Earthquake in 2018 and the large-scale power outages caused by Typhoon Faxai and other disasters in 2019 (Table 1.1). Similar natural disasters are becoming more severe in ASEAN countries in recent years.

[1] AON (2023), *Weather, Climate and Catastrophe Insight (January 2023)*.

Table 1.1. Major Typhoons, Torrential Rain, and Earthquake Disasters in Japan (Since FY2018)

(June 2018)	Northern Osaka Prefecture Earthquake	**Blackout**; Approximately 170,000 consumers **Disruption to town gas supply**; Approximately 110,000 consumers
(July 2018)	Heavy rain	**Blackout**; Approximately 80,000 consumers nationwide (Landslides occurred frequently)
(August 2018)	Typhoon No. 20	**Blackout**; Approximately 170,000 consumers nationwide
(September 2018)	Typhoon No. 21	**Blackout**; Approximately 2,400,000 consumers nationwide
(September 2018)	Hokkaido Eastern Iburi Earthquake	**Blackout**; Approximately 2,950,000 consumers
(October 2018)	Typhoon No. 24	**Blackout**; Approximately 1,800,000 consumers nationwide
(July 2019)	Heavy rain	**Blackout**; Largest 8,840 consumers in the Kyushu Electric Power Co, Largest 3,840 consumers in the Chubu Electric Power Co. srvice area
(September 2019)	Typhoon No. 15	**Blackout**; Largest 930,000 consumers in the Tokyo Electric Power Co. srvice area
(October 2019)	Typhoon No. 19	**Blackout**; Largest 520,000 consumers in the Tokyo Electric Power Co., Chubu Electric Power Co., and Tohoku Electric Power Co. srvice area
(September 2020)	Typhoon No. 10	**Blackout**; Largest 530,000 consumers nationwide
(September 2022)	Typhoon No. 15	**Blackout**; Total 119,000 consumers in Shizuoka prifecture area (Collapse of transmission towers)

Source: Ministry of Economy, Trade and Industry (Japan).

Global economics losses caused by natural disasters reached approximately $313 billion in 2022, close to the 21st century average on a price-inflated basis. Focusing on weather-related disasters only, total losses in 2022 were roughly 17% above the average since 2000. The upward trend in the amount of economic damage caused by natural disasters has also led to an increase in insured losses. Global insured losses in 2022 were $132, about five times higher than in 2000, and although they fluctuate, they are increasing year by year.[2]

Due to the increase in economic losses caused by natural disasters in recent years, efforts by each sector to improve energy resilience must be appropriately evaluated and executed. When evaluating and implementing such measures, it is necessary to consider them in conjunction with business and financial perspectives, given the importance of finance to advance energy investment that contributes to improving energy resilience under each country's circumstances.

In addition, to building a robust energy system in the future, stakeholders such as governments, local governments, energy suppliers and consumers, solutions providers, and the financial sector should recognise their roles and identify a standard system and management methods for enhancing energy resilience. To implement these, all actors need to work together, and standardising the principles and processes for resilience enhancement can be an effective measure.

It will also be necessary to establish an international forum for sharing examples of initiatives and best practices amongst countries and various stakeholders, including companies, as well as promote efforts to enhance energy resilience not only in specific countries and regions but also worldwide.

In this project, the prototype quantitative energy resilience scoring (ERS) model was used to conduct an empirical energy resilience assessment. The results of the empirical energy resilience assessment and international efforts to strengthen energy resilience, including those of APEC, were shared and discussed at the workshops held in the three countries. Regarding the results of the empirical energy resilience assessment, stakeholders in the host countries of the workshop discussed the concept and effectiveness of the model and tried to identify issues for the model to be applied to each country.

This report provides an overview of international efforts to strengthen energy resilience against the background of APEC's efforts for energy resilience enhancement and the content of the Energy Resiliency Principles and the related guidelines issued by APEC. Since APEC's Principles and Guidelines raise the importance of evaluating indicators of

[2] AON (2023), *Weather, Climate and Catastrophe Insight (January 2023)*.

energy resilience, this report includes a review of similar indicators, and describes the concept and evaluation of the prototype model. Finally, it provides summary reports of the three workshops, as well as a conclusion and consideration of future work.

In future, the strengths and weaknesses of resilience can be visualised by creating scores, which will lead to the financing and capital investment necessary to improve resilience, thereby contributing to building a stable and resilient economy.

Chapter 2

International Efforts to Address Energy Resilience Enhancement[3]

1. APEC Energy Resiliency Principle

1.1. Introduction

In recent years, damage caused by natural disasters such as earthquakes and typhoons has become enormous. The socioeconomic threat from cyberattacks has also been recognised, and the need to strengthen energy infrastructure against cyberattacks has been pointed out. Thus, building energy systems that are resilient against natural and manmade disasters in the APEC region has become an emerging issue.

The Energy Ministers of Member Economies of APEC affirmed the importance of energy resilience to promote energy security and achieve sustainable development in the Cebu Declaration at the 2015 APEC Energy Ministerial Meeting held in Cebu, the Philippines, with the theme of 'Towards an Energy Resilient APEC Community'. In addition, the Energy Ministers recognised the importance of quality energy infrastructure, energy supply diversity, energy efficiency, and energy access for promoting the energy resilience of the region.

In this narrative, the Energy Working Group (EWG) developed the APEC Energy Resiliency Principle[4] (hereafter, 'the Principle') with the great help of the Energy Resiliency Task Force (ERTF) and APEC member economies. The Principle, which was endorsed at EWG59 held in August 2020, is comprised of norms and concrete measures that stakeholders in each economy should voluntarily pay attention to and implement in order to improve energy resilience, rather than mandatory or compulsory documents. In the Principle, it is stated that the establishment of detailed guidelines to support the formulation of energy resilience enhancement plans in APEC member economies is one

[3] 'Resilience' and 'resiliency' have the same meaning, but it is thought that 'resilience' is often used internationally. For example, in a search of the Online Browsing Platform (OBP), an ISO search software, about 80 international standards define terms that include 'resilience', but there are no standards that define terms that include 'resiliency'. The APEC Energy Resiliency Principle uses the term 'resiliency' in its title and content. In this report, 'resiliency' is used to refer to the APEC Energy Resiliency Principle and related documents, and 'resilience' is used elsewhere.
[4] http://mddb.apec.org/Documents/2020/EWG/EWG59/20_ewg59_023.pdf

of the follow-up actions. In addition, the Principle is expected to contribute to the achievement of the Sustainable Development Goals (SDGs) worldwide by the expansion of an international track record through international standardisation, such as ISO, in the future.

1.2. Background and Purpose of the APEC Energy Resiliency Principle

1.2.1. International efforts against natural disasters

The beginning of growing international awareness of the need to strengthen energy resilience can be traced back to the United Nations' efforts in the 1970s regarding assistance and reconstruction assistance for disaster-stricken areas and disaster prevention and mitigation. At that time, the United Nations was providing relief efforts for damage caused by large-scale natural disasters around the world, such as earthquakes and droughts, which were becoming apparent. Subsequently, the United Nations General Assembly voted the 1990s as the International Decade for Natural Disaster Reduction (IDNDR), and United Nations-led international disaster prevention activities became prominent. At the first United Nations World Conference on Disaster Risk Reduction (WCDRR), held in Yokohama in 1994, the Yokohama Strategy and Plan of Action for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation (Yokohama Strategy) was adopted.

At the United Nations World Summit on Sustainable Development (WSSD) held in 2002, the Johannesburg Implementation Plan was adopted, which organised global issues for sustainable development. The document stated a number of disaster prevention-related issues and recognised the close relationship between sustainability and disaster prevention. In the Hyogo Framework for Action and the Sendai Framework for Disaster Risk Reduction, which were subsequently resolved at the WCDRR, international issues such as disaster prevention and poverty reduction were sublimated with the idea that they are all related within SDGs.

1.2.2. APEC energy resiliency principle

While the United Nations was promoting disaster prevention initiatives, APEC launched activities to consider energy resilience.

The Connectivity Blueprint, an action plan to strengthen connectivity in the APEC region, was adopted at the 22nd APEC Summit in 2014. APEC member economies are working together to promote the development of energy infrastructure, energy security, and efforts to enhance the resilience of energy infrastructure, and the focus is also on strengthening both the ‘hard’ infrastructure and the ‘soft’ side of finance. This is an important point for the discussion on energy resilience later.

A stable energy supply is essential for achieving the sustainable development of all economies and regions.

The region has been continuously challenged with natural disasters, ranging from earthquakes, volcano eruptions, tsunamis, mass movement, and hurricanes to heavy snows, posing massive risks and threats to human lives and economic security. Cyberattacks, terrorism, piracy and other manmade disasters also pose risks and threats to global energy supply chains. Energy resilience is the ability to secure a stable energy supply by effectively dealing with disasters (both natural and manmade disasters). APEC member economies have shared and discussed the experiences and knowledge of each economy at their EWG and ERTF. Since each economy is diverse in terms of geographical, environmental, economic, social and other aspects, the impacts of disasters significantly differ amongst economies. Each economy needs to investigate its economy-specific circumstances and consider tailored countermeasures in a holistic manner with all stakeholders involved. In the Cebu Declaration, energy resilience supports APEC member economies in achieving energy security and sustainable development, which includes economic prosperity and environmental sustainability. Originating from the Cebu Declaration, EWG activities aim to promote the three E's (economic growth, energy security and environmental sustainability) and safety as a prerequisite (3E+S). Thus, activities to promote energy resilience should be sufficiently in line with 3E+S.

Other global disaster risk reduction initiatives, including the Sendai Cooperation Initiative for Disaster Risk Reduction,[5] provide important insights and perspectives to improve energy resilience effectively. In addition to the EWG/ERTF discussions, the principle also refers to the other existing interregional initiatives.

1.2.3. Definition of energy resiliency

In order to build and implement initiatives to solve international issues, including cooperation between countries, such as APEC, it is necessary for countries to share a common view. One of the elements is the commonality of the definition of terms. Therefore, to build efforts to promote the enhancement of energy security, it is necessary to define and share resilience in energy infrastructure and systems. In practice, organisations are defining resilience in their energy policies individually and taking concrete measures. For instance, the United Nations Office for Disaster Risk Reduction (UNDRR) defines 'resilience' relating to power networks as follows:

[5] Sendai Cooperation Initiative for Disaster Risk Reduction (2015), 3rd UN World Conference on Disaster Risk Reduction, https://www.un.org/press/en/2015/iha1361.doc.htm

'The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.'[6]

Also, the National Association of Regulatory Utility Commissioners (NARUC; Australia) defines 'resilience' in its energy policy[7] as follows:

'The ability of the system to anticipate, absorb, recover from, and adapt to disruptive events, particularly high-impact, low-frequency events—is not yet incorporated into regulatory processes.'

On the other hand, the Cebu Declaration of the 2015 APEC Energy Ministerial Meeting, described above, defines 'energy resiliency' as follows:

'(we affirm the importance of energy resiliency in promoting energy security and sustainable development and providing access to the people. This includes in particular,) the ability and quality of energy infrastructure to withstand extreme natural and man-made disasters, to recover and return to normal conditions in a timely and efficient manner and to build back better.'[8]

Following the recommendations of the Cebu Declaration, the EWG/ERTF was discussed by member economies to strengthen energy resilience within the APEC region, and the APEC Energy Resiliency Principal agreed in 2020 set out the following definition:

'Energy resiliency, an important concept to promoting energy security and sustainable development and providing access, is the ability and quality that enables energy systems to withstand extreme natural and manmade disasters, to recover and return to normal conditions in a timely and efficient manner and to build back better, thereby securing a stable energy supply for society and reducing negative impacts on human lives and economic activities from energy supply disruption.'

In the future, efforts to strengthen energy resilience in the APEC area will be promoted based on this definition.

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[6] https://www.undrr.org/terminology/resilience

[7] https://www.naruc.org/cpi-1/critical-infrastructure-cybersecurity-and-resilience/resilience/

[8] https://www.ewg.apec.org/documents/Cebu%20Declaration%20and%20Instructions_APEC%20FINAL.pdf

1.2.4. The principle on the role of financial institutions and energy resiliency indicators

The content of the APEC Energy Resiliency Principle, as well as guidance on content, is provided in Appendix 1.

The Principle identifies four main sectors that should be addressed for energy resilience: (a) governments, (b) energy supply industries, (c) industrial and general energy consumers, and (d) financial institutions. It is characterised by the fact that it places importance on financial institutions for resilience. The role of financial institutions is defined as follows.

> (d) Financial institutions
>
> - *Financial institutions should implement initiatives, including positively evaluating investing and financing both public and private projects that contribute to the enhancement of energy resiliency of member economies.*

The characteristic of this principle is that financial institutions are positioned as important stakeholders in the enhancement of energy resilience in the APEC economies. Assessment of, investment in, and financial support for financial institutions' efforts to strengthen energy resilience are recommended.

In the effort to strengthen energy resilience, it is recommended to actively invest in disaster response and recovery and reduce risks to energy infrastructure. In order to make such investment decisions, it is essential to develop relevant indicators for appropriately evaluating the cost-effectiveness of investments, and it is essential to establish a system for disclosing established indicators and related information from private companies to financial institutions.

> Investment and financing for projects towards energy resiliency
>
> - *Stakeholders should actively invest and finance projects that contribute to enhancing energy resiliency in each economy. In addition to post-disaster response and recovery, prior investment to address underlying risk factors is essential in enhancing energy resiliency, as noted in the Sendai Framework for Disaster Risk Reduction 2015-2030 adopted at the 3rd United Nations World Conference on Disaster Risk Reduction in 2015.*
> - *Stakeholders should appropriately evaluate the contribution of invested and financed projects to energy resiliency in addition to projects' profitability. From that perspective, indices and matrices to properly measure levels of contribution to energy resiliency should be established as well as building mechanisms for private companies to disclose relevant information to financial institutions.*

1.2.5. Importance of multi-stakeholder knowledge sharing

All actions set out in this Principle are assumed to be implemented as voluntary measures (rules will not be set in APEC). It is recommended that effective examples of actual efforts contribute to improving energy resilience not only in the APEC area but also internationally. For example, it is possible to implement international standardisation in ISO, etc., by utilising guidelines created based on the Principle and best practices in APEC economies.

> ➢ *Stakeholders should take voluntary measures at all levels. Effective efforts are encouraged to be shared amongst stakeholders both within economies as well as globally.*

2. APEC's Future Perspectives of Energy Resiliency Enhancement

2.1. APEC Will Expand Its Activities to Enhance Energy Resiliency in the APEC Region

APEC leaders will clarify their stance on strengthening energy resilience in the APEC economy after the publication of the Principle and will continue to push for action. Specifically, in the political declaration (2020 Kuala Lumpur Declaration) of the 27th APEC Economic Leaders' Meeting, APEC positioned strengthening energy resilience as an important issue in the APEC economies (see Box (a)), and at the same time will plan and continue to implement projects (project number; EWG 07 2020A) to strengthen energy resilience amongst the APEC economies (see Box (b)).

> Box (a)
>
> 2020 Kuala Lumpur Declaration[9] (an extract)
>
> THE 27TH APEC ECONOMIC LEADERS' MEETING, 20 November 2020, Kuala Lumpur, Malaysia
>
> - APEC Putrajaya Vision 2040
>
> We proclaim the APEC Putrajaya Vision 2040, a new vision that primarily charts the future of our region. Our Vision is an open, dynamic, resilient and peaceful Asia-Pacific community by 2040, for the prosperity of all our people and future generations.

[9] https://www.apec.org/Meeting-Papers/Leaders-Declarations/2020/2020_aelm

- Driving Innovative and Inclusive Sustainability

We will collaborate to facilitate access to affordable energy, enhance energy resilience and energy security using the widest variety of fuels and technologies to support sustainable economic growth and promote transitions to cleaner energy as part of a strong and inclusive economic recovery.

We are hopeful that new technologies are available and accessible to allow us to handle resources and waste more sustainably, and in a holistic manner. We will promote economic policies and growth that support global efforts to tackle climate change, extreme weather and natural disasters, and strengthen emergency preparedness.

Box (b)

Workshop on Energy Resiliency Principle (Project Number; EWG 07 2020A)[10]

[Project summary]

APEC has been conducting energy efficiency and low-carbon measures until this point. However, in recent years, as the APEC region has been continuously challenged with large natural disasters, building energy systems that are resilient against disasters has become an emerging issue. In this narrative, the EWG has developed the APEC Energy Resiliency Principle with great help from ERTF and APEC member economies.

Considering the current situation, measures to enhance energy resiliency have become increasingly important with regard to the introduction of energy efficiency and conservation and new and renewable energy.

This project supports holding workshops in three or four APEC economies to provide an opportunity to promote the dissemination of the Principle for the capacity building of people in public and private organisations related to the energy sector from developing economies, and to discuss, exchange, and share attendees' experiences and views concerning the details and concrete measures of its guidelines in line with the situation in each economy.

[10] https://aimp2.apec.org/sites/PDB/Lists/Proposals/DispForm.aspx?ID=2717

2.2. APEC Energy Resiliency Guidelines[11]

2.2.1. Introduction

One of the action items identified in the Principle was to develop guidelines to support the formulation of energy resilience enhancement plans in APEC member economies, which were published in February 2023. To ensure the guidelines, reflecting the regional diversity and variety of energy resilience challenges in the APEC region, a total of three virtual workshops were planned to promote the dissemination of the APEC Energy Resiliency Principle for capacity building and facilitate discussions on energy resilience for the development of the Energy Resiliency Guidelines[12].

The guidelines were developed based on best practices and recommendations gathered from participants from each workshop as well as literature research on relevant energy resilience efforts in the APEC region. The guidelines reflect the perspectives of key stakeholders that play important roles in supporting energy resilience, including governments, energy supply industries, industry and general energy consumers, and financial institutions to ensure the guidelines promote a holistic approach with the involvement of all key stakeholders to enhance energy resilience.

2.2.2. Scope of the guidelines

The scope of the guidelines is described as follows:

> *In line with the APEC Energy Resiliency Principle, the guidelines aim to support APEC member economies to build energy systems that are resilient against both natural and human-induced disasters. The guidelines are intended to provide the general framework and best practices to enhance energy resiliency measures that can be applied to a wide array of disaster types. Natural disasters range from earthquakes to volcano eruptions, tsunamis, mass movements, hurricanes, tornados, and heavy snow and rain. Human-induced disasters may include cyberattacks, terrorism, piracy, and other disasters that pose risks and threats to global energy supply chains. It is recommended that each economy tailor its approach in consideration of economy-specific energy resiliency challenges. The guidelines are non-binding in nature. They provides best practices and energy resiliency approaches that may be implemented voluntarily by stakeholders, such as governments, energy supply industries, industrial and general energy consumers, and financial institutions, to*

[11] apec-energy-resiliency-guidelines.pdf (https://www.apec.org/publications/2023/02/apec-energy-resiliency-guidelines)
[12] apec-workshop-on-energy-resiliency-principle-project-summary-report.pdf (https://www.apec.org/publications/2023/02/workshop-on-energy-resiliency-principle-project-summary-report)

enhance energy resiliency efforts.

A feature of the Guidelines is that, based on the structure of the principles, they provide guidance on initiatives that can be used as a reference for APEC economies to consider how to develop and implement energy resilience enhancement plans tailored to their respective circumstances. Therefore, the guidance for each item that makes up the guidelines describes the general contents and introduces examples to better understand the contents. The selection of which cases to include is based on the information provided and the discussions at the workshop. The structure of the guidelines is designed in such a way that users can access more detailed information in the cases described and use it for their own consideration. In addition, the guidelines are a reference that include best practices for encouraging APEC economies' voluntary actions, and they differ from international standards in that they do not include requirements for users for their energy resilience enhancement actions.

2.2.3. Future action

Section 4.5 of the guidelines addresses the need for multi-stakeholder knowledge sharing. The specific description is as follows.

> *Every stakeholder in the energy industry may facilitate understanding for energy resiliency issues and contribute to knowledge sharing with stakeholders both within economies as well as globally. Stakeholders can better identify the most effective measures and approaches in line with the situations in each economy by sharing their experiences and best practices.*

The following items are listed as expected from multi-stakeholder knowledge sharing.

- Assess resilience knowledge gaps and capacity building needs: Assessment of resilience knowledge gaps and capacity building needs may be conducted to facilitate knowledge sharing. The principle identified developing tools as follow-up actions based on the principle to better evaluate risk and vulnerability to disasters (for example, an energy resilience score to measure resilience performance as an APEC economy's resilience benchmark can be considered).
- Cross-sectoral collaboration: Cross-sectoral collaboration is essential to facilitate the involvement of all stakeholders to enhance energy resilience. Cross-sectoral knowledge sharing can promote best practices and innovative technologies driven by both the public and private sectors.
- International collaboration for capacity building: Capacity building support may be provided through cross-economy learning, transdisciplinary working groups, and exchanges through conferences and seminars. Governments may partner with other

economies or international organisations for research and capacity building in energy resilience.

- Use of online platforms and tools for knowledge sharing: Online training platforms and online repositories may be established to make resilience best practice knowledge accessible to a wider range of stakeholders.

The energy supply and demand conditions and risks from natural disasters in each country are different, and APEC's efforts to build energy resilience take these circumstances into account. As a result, the APEC Energy Resiliency Principles and Guidelines reflect the APEC Energy Resiliency Principles' commitment to promote countries' voluntary efforts to build energy systems through ongoing information sharing and capacity building using common tools. Therefore, for the direction of future efforts, it is expected that efforts will continue to be made to formulate guidelines for areas where there is a shortage and to develop tools that can be used.

2.2.4. Energy resiliency enhancement project in 2023

Following the publication of the Energy Resiliency Principle and Guidelines, as well as the sharing of information through workshops, APEC will continue to implement the Energy Resiliency Enhancement Project[13] from the spring of 2023. The guidelines will focus on the energy supply sector, and a preliminary study will be conducted to establish indicators to review and understand the status of energy resilience in each country.

2.3. Development of ISO 22366: Security and Resilience – Energy Resilience – Framework and Principles[14]

In response to the publication of the Energy Resiliency Principle, Japan submitted a new work item proposal for the development of ISO standards for ISO/TC292: Security and Resilience, which was approved in September 2022. Subsequently, a WG was established under TC292/WG5 (Community Resilience), and experts from 16 countries participated in discussions for the development of the standard. The working draft of ISO 22366 was formulated with reference to the APEC Energy Resiliency Principle and discusses the structure required as an ISO standard (ISO 22366 is scheduled to be published in October 2025). The user benefits, scope, and structure discussed at the working draft (WD) stage through this standard are expected to be as follows.[15]

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[13] Asia-Pacific Economic Cooperation (APEC) (2022, Request for Proposal (RFP): EWG 09 2021 A– APEC Energy Resiliency Enhancement Project (August).

[14] https://www.iso.org/standard/83384.html?browse=tc

[15] As of June 2023.

User benefit

- National/local governments should support private stakeholders and communities in enhancing energy resilience and the formulation of energy resilience plans that may contain disaster prevention.
- Energy consumers should implement initiatives including formulating and implementing energy resilience plans.
- The residential sector can also obtain various benefits from the implementation of energy resilience enhancement.
- Financial institutions should implement initiatives including positively evaluating, investing, and financing for both public and private projects that contribute to the enhancement of energy resilience.
- Energy supply chain networks: All stakeholders and contributors to an energy supply chain network should use a common set of resilience principles and a standardised decision framework for enhancing energy resilience for the benefit of society.

Scope

- This document is intended to provide a framework and concept of 'energy resilience' to organisations to help reduce impacts and ultimately build back better from hazards, including natural and manmade disasters.
- The scope of this document includes broad resilience engineering and management principles applicable to a socio-technical energy supply chain but does not include guidance on the implementation of these principles for specialised engineering purposes.

Note: For example, engineering details about power generation systems, power grids and transmission systems, and backup generators are not included in the scope.

Contents

5. Relevant stakeholders and their roles in enhancing energy resilience
   5.1. General
   5.2. Government/local government
   5.3. Industries critical to maintaining the reliability and resilience of the energy supply chain
   5.4. Industrial and general energy consumers
   5.5. Financial institutions
6. Approaches for energy resilience enhancement
   6.1. General
   6.2. Identification of impact events (factors) for the energy system, including infrastructure
   6.3. Assess risks by impact events (factors) and kinds of energy resources for the organisation
   6.4. Design energy supply chains to be resilient
   6.5. Stability of energy supply
   6.6. Investment and financing for projects toward energy resilience
   6.7. Proper asset management
   6.8. Adoption of emerging technologies (including IoT and AI technology)
   6.9. Multi-stakeholder knowledge sharing
   6.10. Making an energy resilience plan
7. Criteria for an organisation's energy resilience plan
   7.1. General
   7.2. Structured internal/external communications
   7.3. Governance and resources for energy resilience (enhancement]
   7.4. Emergency response system, including energy management relating energy supply/usage risk
   7.5. Supply-chain management
   7.6. Financing for energy resilience enhancement
   7.7. Education and training

7.8. Consideration for achievement of building back better

8. Cooperative actions for improvement of social (regionwide) energy resilience

8.1. General

8.2. Develop tools (indicators) to better evaluate risk and vulnerability to disasters

8.3. Involvement of financial sectors

8.4. Promote expertise through social (regionwide) cooperation

8.5. Public (governmental) disaster management agencies and organisations

Chapter 3

Review of Consideration for Building Indicators Relating Energy Resilience Enhancement

1. Overview

Whilst interest in energy resilience is increasing, projects related to improving energy resilience are often seen as costs, so it is important for entities that are actively working to improve resilience to be able to raise funds smoothly.

At present, it has been pointed out in many research reports that it is difficult to secure financing for efforts to improve resilience.[16] Common reasons for this are that although economic benefits can be expected in the long term, the initial costs are large, it is difficult to quantitatively evaluate the economic benefits of improving resilience, and, in particular, it is difficult to estimate the benefits of avoiding damage caused by disasters. It is a point that benefits that are not familiar with quantitative evaluation may be included.

In recent years, in response to the frequent occurrence of extreme weather disasters, governments, local governments, and companies around the world have become increasingly aware of the need for resilience measures, and governments and insurance companies have introduced schemes to grant premiums for resilience-improvement initiatives. In addition, as far as resilience to natural disasters associated with climate change is concerned, systems such as green bonds have also begun.

However, some in the financial world have pointed out that there are no indicators to quantitatively evaluate energy resilience, which hinders investment and loan decisions, and there are still barriers to funding and the difficulty of quantitatively assessing benefits is a core issue in terms of financing.[17]

This chapter provides an overview of previous research, especially in the United States,

[16] For example: USAID and NREL (2019), 'Finance for Power Sector Resilience', December (https://www.nrel.gov/docs/fy20osti/74289.pdf); Global Facility for Disaster Reduction and Recovery (GFDRR) (2015), 'Investing in Urban Resilience' (https://www.gfdrr.org/sites/default/files/publication/Investing%20in%20Urban%20Resilience%20Final.pdf).

[17] The Institute of Energy Economics, Japan (IEEJ), (2020), 'Research and Analysis on Energy Resilience' (Japanese only, title is provisional translation), March.

and existing consideration and development actions are being conducted in Asian countries (the Philippines, Thailand, and Indonesia) as references for further consideration of the development of a quantified energy resilience score system.

2. RAND Corporation's Study[18]

A 2015 report by RAND Corporation was commissioned by the Department of Energy (USDOE) to conduct a literature review of quantitative indicators of resilience in energy supply systems. USDOE asked RAND to develop a framework for measuring the resilience of energy distribution systems and summarise the state of metrics for the resilience of electric power, refined oil, and natural gas distribution systems. This report summarises the concepts addressed by measures of resilience, describes a framework for organising alternative metrics used to measure the resilience of energy distribution systems, and reviews the state of metrics for the resilience of energy distribution systems.

To better understand how industry, governments, and communities measure the resilience of energy systems, the authors reviewed 58 published reports and peer-reviewed journal articles published between 1997 and 2014. The report also suggests recommendations that could improve the metrics available to support energy policy, and the key findings are follows.

(1) A framework for measuring energy system resilience

- The building blocks of resilience are inputs, which define what is available to support resilience. At the input level, metrics tend to describe the amount of energy produced, transmitted, or stored or the number of people, facilities, or equipment available to support this.
- The ways in which inputs are organised to support resilience are called capacities. Metrics describe the existence and extent of systems, policies, and organisations in place to support energy capabilities.
- Capability metrics reflect how well capacities can serve a system when they are needed.
- Performance metrics describe what is produced by an engineered system. Metrics describe the quality, amount, and efficiency of the services being provided.
- In the end, the performance of energy systems depends on how the systems

[18] Willis, H. H. et al. (2015), 'Measuring the Resilience of Energy Distribution Systems', RAND Corp. (https://www.rand.org/pubs/research_reports/RR883.html).

generate the outcomes that society is seeking to achieve. At the outcome level, metrics describe how energy influences aspects of societal welfare through health, safety, and the economy.

(2) The state of energy system resilience metrics

- The metrics present a complex picture of how resilience is managed and measured in energy systems. Whilst many metrics exist, there is no single metric or set of metrics for each purpose.
- The literature reviewed pays more attention to metrics for the more detailed levels of facilities and systems.
- The regional and national metrics identified focus more on aspects of performance and outcomes.

(3) Recommendations

- Improve the collection and management of data on inputs and capacities at the facility and system levels.
- Develop better measures of capabilities at the system and regional levels.
- Improve understanding of how capabilities and performance translate to outcomes at the regional and national levels.

The RAND report illustrates the components that can be used to quantify resilience but **notes that much of the data are internal information for businesses, making it difficult to collect and analyse the data**, and that it is difficult to measure the ability to respond to and recover from rare catastrophic events. For this reason, **resilience assessment is still at the stage of deepening our understanding of capability and exploring how it can be quantitatively assessed.**[19]

3. Argonne National Laboratory's Study[20]

Enhancing the resilience of critical infrastructure requires its owners/operators to determine the ability of the system to withstand specific threats, minimise or mitigate potential impacts, and to return to normal operations if degradation occurs. Thus, a resilience methodology requires a comprehensive assessment of critical infrastructure systems/assets, from threat to consequence. The methodology needs to support decision-making for risk management, disaster response, and business continuity.

[19] See footnote 16.
[20] Petit, F.D., et al (2013), 'Measuring the Resilience of Energy Distribution Systems', Argonne National Laboratory, April (https://publications.anl.gov/anlpubs/2013/07/76797.pdf).

Argonne National Laboratory, in partnership with the Protective Security Coordination Division of the U.S. Department of Homeland Security (DHS), has developed an index, the Resilience Measurement Index (RMI), to characterise the resilience of critical infrastructure.

The RMI was developed as an index to identify the most vulnerable areas of various facilities and to promote facility resilience measures. In preparing the RMI, the first step was to collect the various actions included in the four phases of resilience (preparedness, mitigation, response, and recovery) through a literature review and classify them into hierarchies. The preparatory stage is divided into (1) the 'awareness' stage, which includes the collection of information and risk assessment of disasters, and (2) the 'planning' stage, which involves formulating countermeasures.

Mitigation consists of (1) 'design' to increase the resilience of facilities against disasters, (2) business continuity using 'alternative bases' (damage control), and (3) 'mitigation measures' in the event of disruption of resources essential to business continuity.

The post-incident response is (1) an on-site response that can be implemented as an initial response without external support in the event of a disaster, (2) an off-site response that can be implemented through cooperation with external support organisations, such as the police, ambulance, and fire departments and resource providers, and (3) the ability to compile and manage information on activities for disaster response, recovery, and service continuity, including on-site and off-site.

Recovery mechanisms are activities to efficiently restore the activities of damaged entities to an acceptable level after a disaster, etc. and can be divided into (1) activities based on prior agreements with external resource providers, including suppliers of parts and services necessary for the restoration of facilities/equipment, and (2) activities until the activities before the occurrence of the disaster are fully restored.

Table 3.1. Classification of Components of Resilience in the RMI

Preparedness	Awareness	Resilience operations
		Information sharing
	Planning	New planning measures
		Business continuity plan
		Emergency operation/emergency action plan
		Cyber plan
Mitigation	Mitigating construction	Natural hazards
		New mitigation measures
		Standoff distance
		Significant asset/area mitigation
	Alternate site	
	Resource mitigation measures	Electric power
		Natural gas
		Communications
		Information technology
		Transportation
		Critical products
		Water
		Wastewater
Response	On-site capabilities	New response measures
		Incident management capabilities
	Off-site capabilities	First prevention/responder interaction
		Resource service level agreements
		Equivalent number of dependencies
	Incident management and Command centre characteristics	Local emergency operation centre involvement
		Facility incident management and command centre characteristics
Recovery	Restoration agreements	Information sharing
		Resource restoration agreements
	Recovery time	Significant asset/area recovery
		Resource recovery

Source: Petit, F.D., et al. (2013), 'Measuring the Resilience of Energy Distribution Systems', Argonne National Laboratory (https://publications.anl.gov/anlpubs/2013/07/76797.pdf).

The RMI is defined by the aggregation of its six levels of information. For each component, an index corresponding to the weighted sum of its components is calculated. This process results in an overall RMI that ranges from 0 (low resilience) to 100 (high resilience) for the critical infrastructure analysed.

It is important to note that the RMI is a relative measure. A high RMI does not mean that a specific event will have minimal consequences. Simply stated, the RMI index allows comparison of different levels of resilience of critical infrastructure. Determining a facility's RMI and how different options affect the RMI can be used to determine the most effective ways to improve a facility's overall resilience.

The RMI by the Argonne National Laboratory is said to be excellent in that it can evaluate the resilience of all risks, not just natural disasters, not only for energy but also for all critical infrastructure, but there is room for further improvement in the training and hearing procedures of evaluators in order to interject evaluators' value judgments in the process of quantitative evaluation. In addition, it has been pointed out that although it is useful for facility-level resilience assessment, it is not suitable for regional and industry-level resilience assessment.

4. Sandia National Laboratory's Study[21]

Sandia National Laboratories' report on resilience indicators for power supply systems is considered for indexing in six areas: reliability, flexibility, sustainability, affordability, security, and resilience.

The report defines resilience as the deterioration and recovery of power supply services in the event of a rare and large loss event and treats conventional supply reliability separately. The index is divided into two types: a method that classifies and scores assets and measures that increase resilience and evaluates endurance and resilience to future events, and a method that estimates based on performance, that is, actual data at the time of disaster. Performance-based methods are more useful for estimating the cost-effectiveness of capital investment to improve quantitative resilience, but they are complex and require a lot of data.

Specifically, it is recommended to consider resilience indicators in accordance with the following procedures.

- Step 1: Define resilience goals

[21] Vugrin, E., et al. (2017), 'Resilience Metrics for the Electric Power System: A Performance-Based Approach', Sandia National Laboratory, February (https://www.osti.gov/servlets/purl/1367499).

- Step 2: Define consequence and resilience metrics
- Step 3: Characterisation hazard
- Step 4: Determine level of disruption
- Step 5: Collect data via system model or other means
- Step 6: Calculate consequence and resilience metrics

The report concludes that it is impossible to create a uniform resilience measure based on an analysis based on this risk assumption because the events that may occur in reality differ from region to region and points out that specific analysis should be left to the region. However, the specific steps of indexing presented in this report are considered to be a reference case for the development of an energy resilience score system in the future.

Figure 3.1. The Resilience Analysis Process

Source: Petit, F.D. et al. (2013), 'Measuring the Resilience of Energy Distribution Systems', Argonne National Laboratory, April (https://publications.anl.gov/anlpubs/2013/07/76797.pdf).

Table 3.2. Examples of Consequence Categories for Consideration in Grid Resilience Metric Development

Consequence Category	Resilience Metric
Direct	
Electrical service	• Cumulative customer-hours of outages • Cumulative customer energy demand not served • Average number (or percentage) of customers experiencing an outage during a specified time period
Critical electrical service	• Cumulative critical customer-hours of outages • Critical customer energy demand not served • Average number (or percentage) of critical loads that experience an outage
Restoration	• Time to recovery • Cost of recovery
Monetary	• Loss of utility revenue • Cost of grid damages (e.g. repair or replace lines,

	transformers) • Cost of recovery • Avoided outage cost
Indirect	
Community function	• Critical services without power (e.g. hospitals, fire stations, police stations) • Critical services without power for more than *N* hours (e.g. *N* > hours of back up fuel requirement)
Monetary	• Loss of assets and perishables • Business interruption costs • Impact on Gross Municipal Product (GMP) or Gross Regional Product (GRP)
Other critical assets	• Key production facilities without power • Key military facilities without power

Source: Petit, F.D., et al (2013), 'Measuring the Resilience of Energy Distribution Systems', Argonne National Laboratory, April (https://publications.anl.gov/anlpubs/2013/07/76797.pdf).

5. Consideration for Development of ERS in Asian Countries

5.1. Philippines

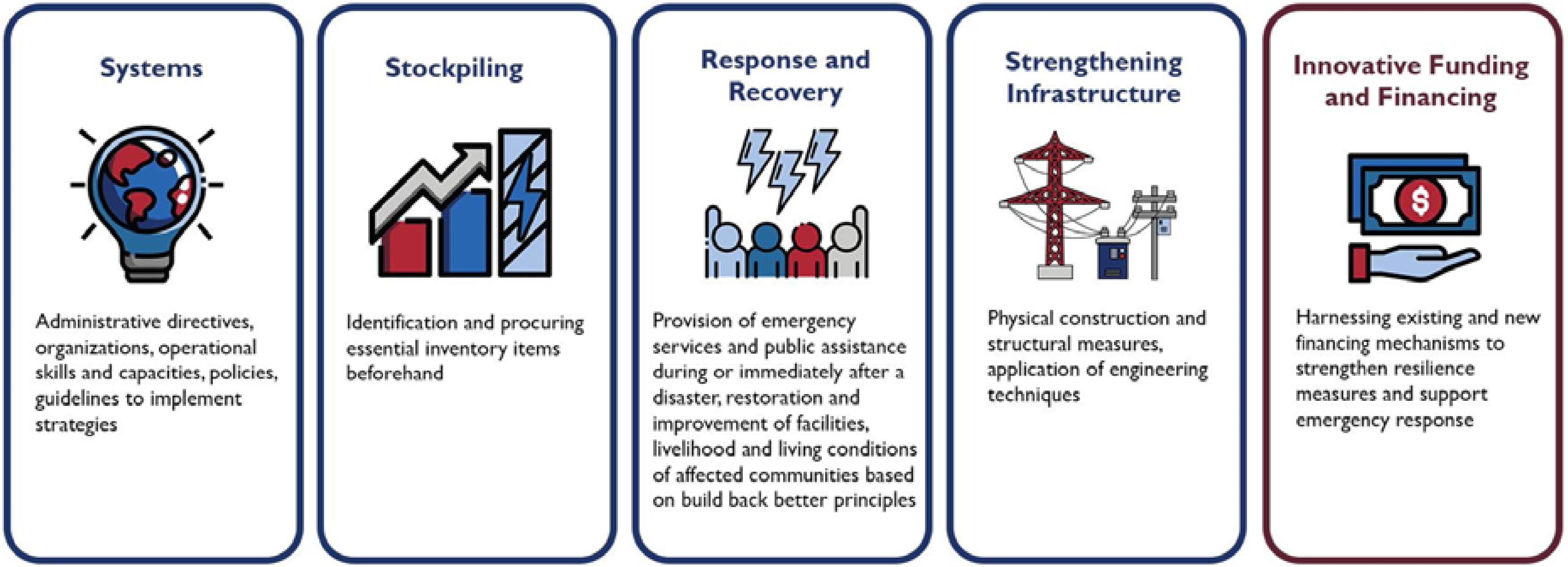
The Philippine Department of Energy (PDOE) and the US Agency for International Development (USAID) are now working together to create the Energy Resilience Scorecard.[22] The scorecard will depict broader risk modelling and help capture the actual readiness of the government and utilities. The scorecard will provide evidence-based information that guides decision-making and resource allocation, including financing for readiness and resilience strengthening.

The scorecard is useful as it enables governments, businesses, and utilities to measure performance against domestic and global resilience benchmarks. It also facilitates the institutionalisation of standards and facilitates data visualisation, gathering, use, and sharing. This tool is also effective in conducting targeted training to strengthen resilience and can serve as a valuable guide for policy formulation.

Innovative funding and financing could be a component of the Energy Resilience Scorecard. PDOE and USAID will continue to explore potential applications of the scorecard in designing incentives for innovative finance in the future.

[22] See footnote 10.

Figure 3.2. Five Pillars of Resilience Scorecard[23]



Source: United States Agency for International Development (USAID).

[23] Presentation material by John Aaron Edgar, Office Director for Environment, United States Agency for International Development-Philippines in the Workshop on Energy Resiliency Principle (16 February 2022, the Philippines).

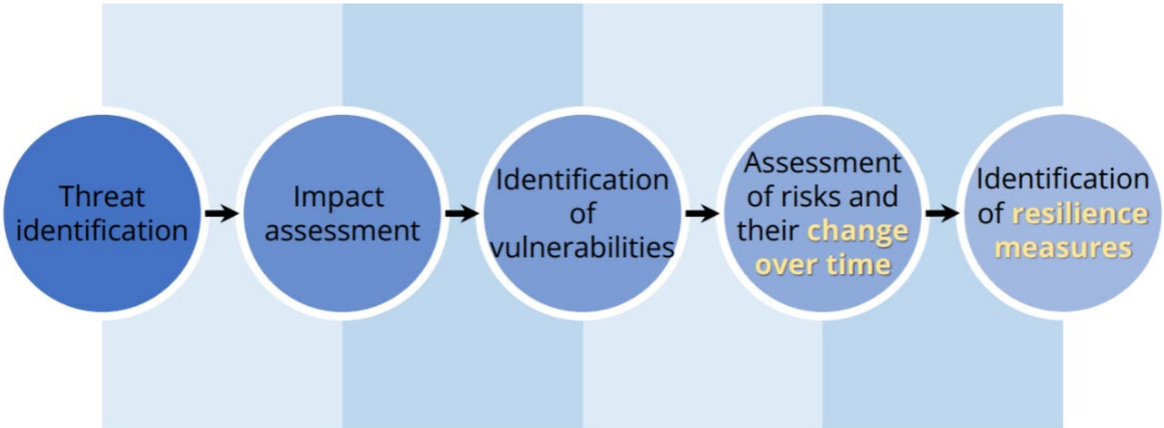
5.2. Thailand

In Thailand, the Energy Resilience Assessment system is in operation, which evaluates the energy resilience of newly constructed renewable energy power plant plans and considers measures to reduce the risk of disasters at the planning stage, assuming the natural disaster risks and vulnerabilities of planned power plants. As the introduction of renewable energy is promoted as a measure against climate change, the study was conducted to balance climate change countermeasures and secure the energy supply by reducing the risk of natural disasters.

This system was developed and operated by the National Energy Technology Center (ENTEC), which was established in 2020 and is working to promote the use of the ASEAN Energy Resilience Assessment Guideline published in 2022 in the ASEAN region.

The Energy Resilience Assessment system can be broadly divided into five review steps.

Figure 3.3. Energy Resilience Assessment



Source: Silva, K., et al. (2023), 'Overview of Energy Resilience and Putting it in the Thai Context', 2nd Workshop Meeting for Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region, 20 April.

(1) <u>Threat identification</u>: The risk of natural disasters at the site where the power plant equipment is planned to be built is identified. At that time, a five-point score is created based on the frequency of the expected natural disaster risk (Figure 3.4).

(2) <u>Impact assessment</u>: The vulnerability of power generation facilities planned for construction to natural disasters will be assessed. The impact of expected natural disasters on the frequency and intensity of natural disasters on power generation facilities and operations will be reviewed.

(3) <u>Identification of vulnerabilities</u>: Vulnerabilities are assessed based on the results

of the impact assessment. Vulnerability to the impact of possible natural disasters is assessed on a five-point score, considering the characteristics of the planned power plant (Table 3.3).

(4) <u>Assessment of risks and their change over time</u>: Vulnerability assessments are conducted over time from the onset of the impact of natural disasters to recovery.

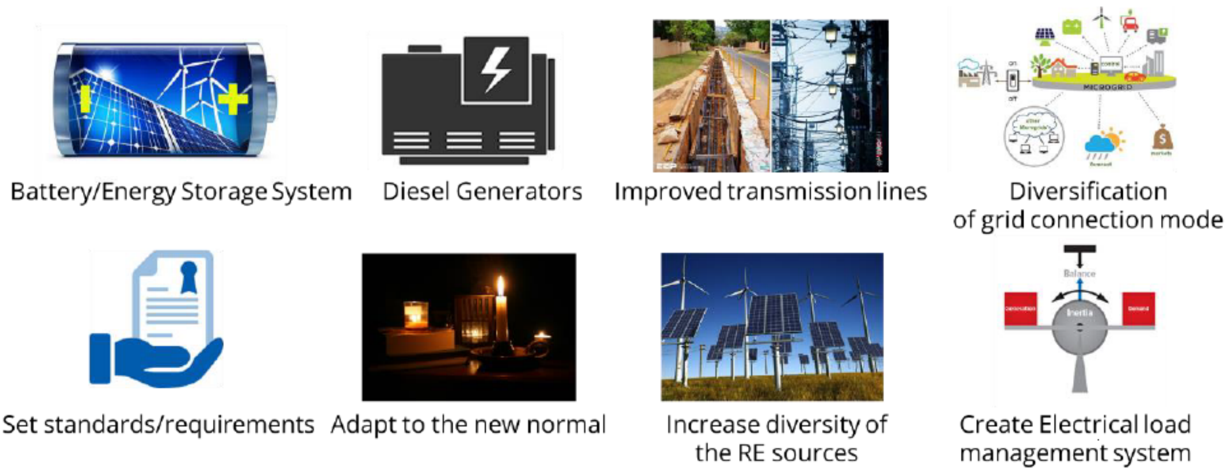
(5) <u>Identification of resilience measures:</u> Based on the results of the evaluation so far, the measures that should be implemented to build a more resilient energy system are discussed (Figure 3.5).

The Energy Resilience Assessment system was developed with the assumption that it would be evaluated for new renewable energy power generation facilities, but it is also possible to apply it to the resilience of existing facilities in the future.

Figure 3.4. Threat Likelihood Score

Source: ENTEC (2022), 'ASEAN Energy Resilience Assessment Guideline'.

Figure 3.5. Examples of Resilience Solutions



Source: ENTEC (2022), 'ASEAN Energy Resilience Assessment Guideline'.

Table 3.3. Vulnerability Severity Score

	Effect	Power sector	Financial	Score
High	Highest magnitude of consequence.	Entire power system would be impacted.	Extreme financial impacts would exist.	9
Medium-High	Significant consequences to the organization.	Majority of population would be impacted. Staff tasks would be switched to emergency/critical operations.	Significant financial impacts would exist.	7
Medium	Medium magnitude of consequence.	The organization would be somewhat affected. Specific systems or functions would be substantially interrupted, but not all.	Financial impacts would be expected to change budgeting plans or require reallocation of funds.	5
Low-Medium	Slightly elevated consequence to the organization.	The power sector may need to temporarily transition operations to backup systems to resolve failure.	Limited financial impacts may become apparent.	3
Low	Lowest magnitude (or severity) of consequence to the organization	The power sector would experience little to no affect	The Financial would experience little to no affect	1

Source: ENTEC (2022), 'ASEAN Energy Resilience Assessment Guideline'.

5.3. Indonesia

Indonesia's National Energy Policy (Government Regulation No. 79/2014) and its targets are focused on reducing the use of fossil fuels, including petroleum, whilst forecasting an increase in energy supply.

As part of the efforts to achieve the target, the four aspects of availability, accessibility, affordability, and acceptability have been established, and multiple index items are set for each aspect to calculate the score as a country. Each indicator is scored on a scale of 1 to 10, and the scores are calculated annually and the results reviewed.

Table 3.4. Energy Resilience Aspects and Indicators (Indonesia)

Aspects	Indicators
A. Availability	A.1 Fossil energy reserves and productivity
	A.2 Energy import
	A.3 National energy reserves
	A.4 Domestic energy supply
B. Accessibility	B.1 Electricity supply and service
	B.2 Fuel supply and service
	B.3 Supply and service of natural gas and LPG
C. Affordability	C.1 Energy price disparity
	C.2 Ratio of energy expenditures to income
	C.3 Energy subsidy
D. Acceptability	D.1 NRE's percentage on energy mix
	D.2 Energy intensity
	D.3 Carbon emission on energy sector

Source: Ir. Sujatmiko (2023), 'Comment at the 3rd Workshop Meeting for Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region', 24 May.

The score calculated is an evaluation of the country as a whole, but on the other hand, since Indonesia is a country formed by many islands, it is difficult for the score evaluation of the country as a whole to represent the situation of the diverse islands. Therefore, the key to the development of the Energy Resilience Score in the future is to increase its applicability to regional assessments and contribute to the consideration of effective efforts to achieve energy policy objectives.

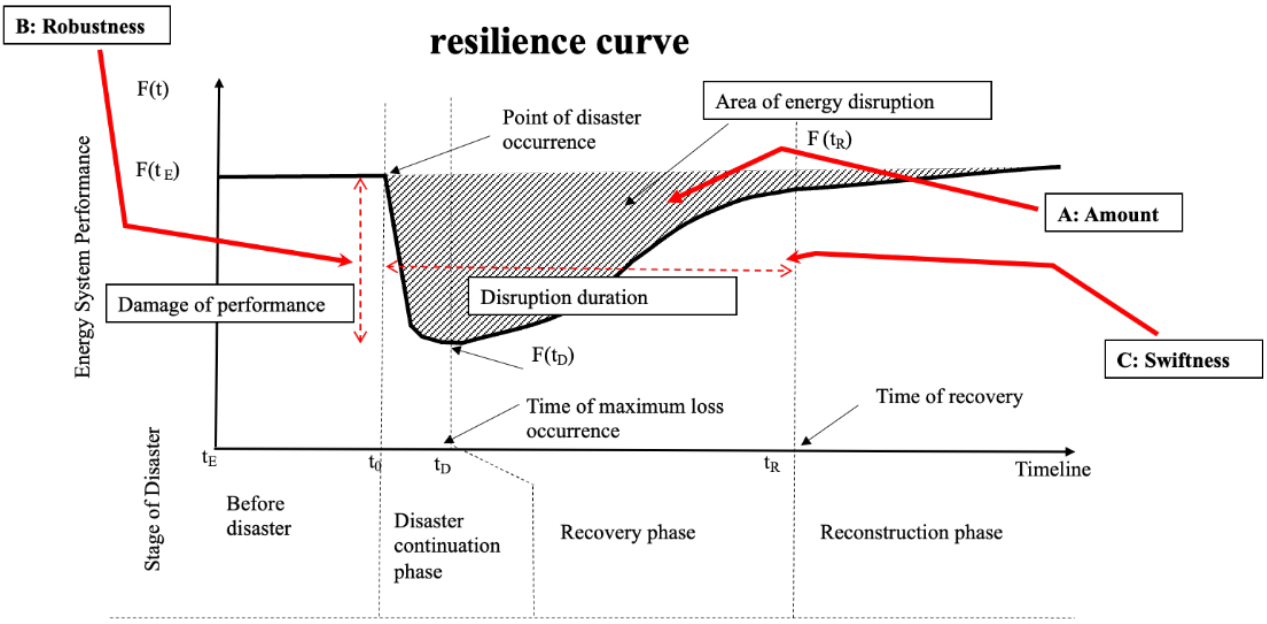
Chapter 4

Prototype of a Quantitative Energy Resilience Scoring Tool and the Trial Results

1. The Need for Improved Trial Energy Resilience Scoring

There have been attempts to quantitatively evaluate efforts to improve energy resilience, but most of them have been 'output indicators' that focus on what the energy suppliers have done. There has been a lack of consideration on how these efforts contribute to the value enhancement of companies and society, including the perspective of end users.

Figure 4.1. Resilience Curve



Source: Created by The Institute of Energy Economics, Japan (IEEJ) by referencing Henry, D., and J.E. Ramirez-Marquez (2012), 'Generic Metrics and Quantitative Approaches for System Resilience as a Function of Time', *Reliability Engineering & System Safety*, 99, pp.114–22.

Figure 4.1 illustrates the performance of the energy system from pre-disaster to recovery. The vertical axis shows the performance of the energy system, and the horizontal axis shows the stages from disaster occurrence to recovery. In the figure, 'A' shows the total amount of energy system failure due to the disaster, 'B' indicates the amount of the energy system that does not function per unit of time, and 'C' indicates the disruption duration of the energy system.

To improve energy resilience is to reduce 'A' in the above figure, and to do so, 'B' or 'C' needs to be reduced. To make indication of the improvement in 'B' and 'C', it is necessary to establish an evaluation method based on performance indicators that concretely and quantitatively show the benefits to the end users who bear the investment costs.

It is necessary to move beyond theoretical discussions and establish a system that updates the content based on actual cases and data every year.

In Japan, an expert committee on the quantitative assessment of energy resilience was set up in 2019. At the committee meetings, expert representatives from government agencies, power companies, gas companies, oil companies, banks, insurance companies, and other related organisations gathered to discuss processes, methods, and issues related to the quantitative assessment of energy resilience.

In parallel, a private sector study group on energy resilience was established. Experts from multiple energy companies, insurance companies, and research institutes gathered to discuss business applications of energy resilience assessment. In 2022, the Energy Resilience Council[24] was established under the leadership of the private sector as a successor to the Energy Resilience Study Group, and a prototype of the quantitative energy resilience assessment (scoring) has been developed.

2. Detail of the Prototype of the Energy Resilience Score System

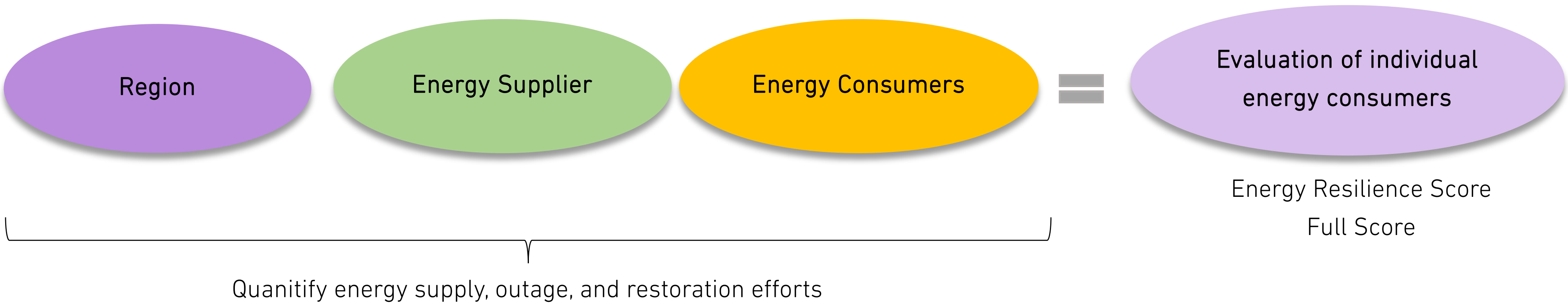
2.1. Concept of an Energy Resilience Score (ERS)

The prototype energy resilience score (ERS) system is being developed under the following concept:

- The quantitative evaluation indicators to be adopted in the ERS system should be **easy to understand** and **can be as an index with published data**.
- An ERS should be capable of expressing the degree of resilience improvement.
- An overall ERC is calculated by quantifying local hazards and the efforts of suppliers and energy consumers that affect stable energy supply and rapid post-disaster recovery.

[24] The main expert members are made up of electric power companies, weather companies, risk management companies, resilience consulting firms, automobile manufacturers, super general contractors, global risk organisations, and research institutes.

Figure 4.2. Energy Resilience Score System



Source: The Institute of Energy Economics, Japan (IEEJ).

2.2. Overview of the ERS

The prototype ERS system is intended to evaluate energy consumers in terms of their facilities' capability of maintaining a stable supply and operations under normal conditions and their preparedness in avoiding severe energy supply disruptions in the face of disaster.

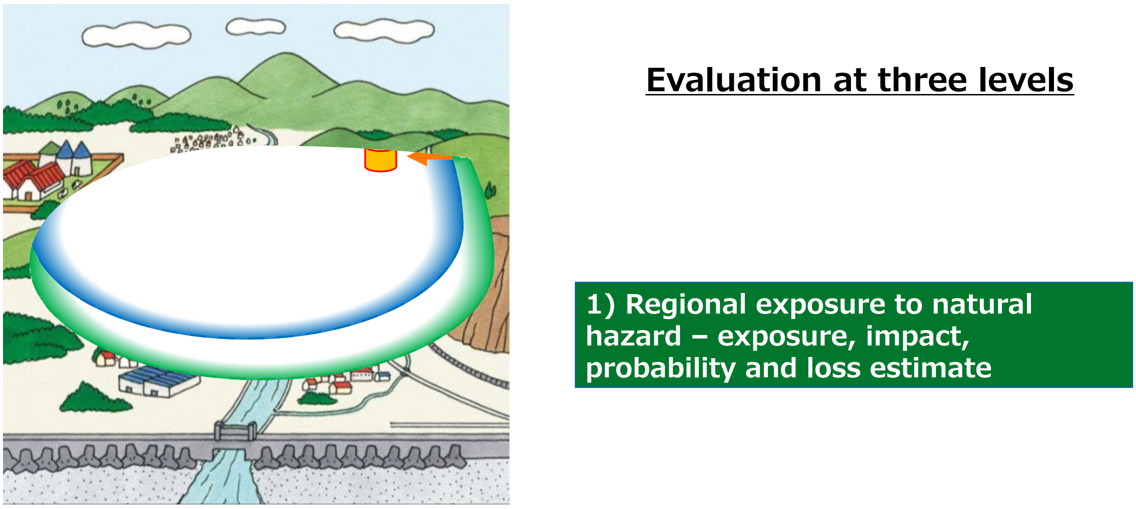
The calculation of the ERS is carried out in the following steps.

Step 1: Assess the disaster risk of the region where the energy consumers (business occupancy) are located (make assessments based on the impact and likelihood of disasters).

Step 2: Check whether the region's energy supply (electricity, gas, oil, water, etc.) has been designed to increase resilience in response to local disaster risks, and whether stable supply is maintained under normal conditions.

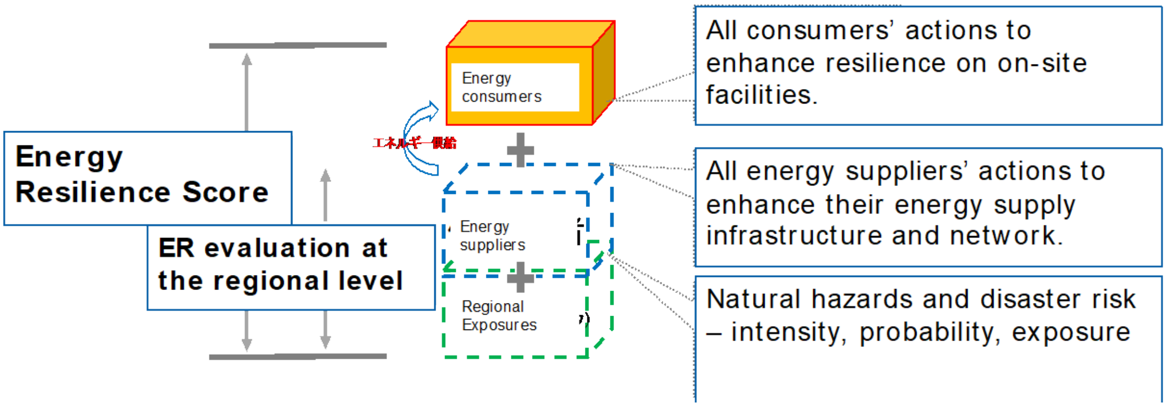
Step 3: Evaluate energy consumers' energy resilience efforts to calculate an overall score.

Figure 4.3. Assessment Levels for ERS Evaluation



Source: The Institute of Energy Economics, Japan (IEEJ).

Figure 4.4. Structure of ERS Calculation



Source: The Institute of Energy Economics, Japan (IEEJ).

2.3. Approach to calculating the ERS

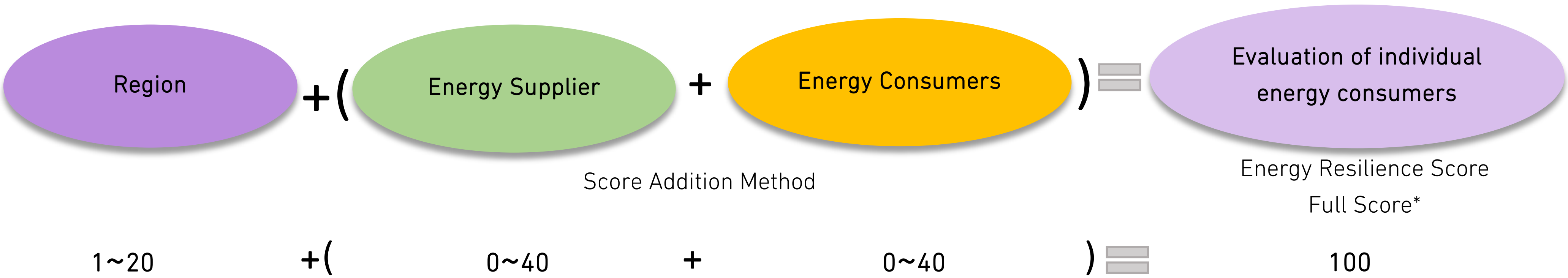
The ERS evaluates whether energy consumers can use energy stably, whether the energy facilities and systems can provide a stable supply and operation during normal times, and whether they are prepared to avoid severe energy supply disruptions during disasters. The score is quantitatively evaluated from three perspectives: (1) regional scoring, (2) energy supplier side scoring, and (3) energy consumer side scoring. These three evaluations are combined to calculate a comprehensive ERS. The requirements for assessment of the three evaluations in the calculation of the ERS are as follows.

<u>Regional score</u>: Each country, city, or region differs in terms of its risk level; therefore, efforts to address that risk level must be appropriately evaluated. For this purpose, the risk level of the region is organised as a basic score.

<u>Supply score</u>: The energy resilience of each energy type is different in each region; therefore, the system will be designed to allow evaluation of different energy types depending on the energy consumer.

<u>Score for energy consumers</u>: The evaluation is based on a score addition method, considering the measures taken for each energy type.

Figure 4.5. Concept of ERS Calculation



Note: A full score represents the situation with very low possibility of supply interruptions during normal and emergency situations.

Source: The Institute of Energy Economics, Japan (IEEJ).

2.4. Detailed Explanation of the Three Evaluations

2.4.1. General

When selecting indicators to quantitatively evaluate energy resilience, we anticipate several necessary elements. To promote the widespread adoption of the quantitative evaluation of energy resilience in society, it is required to avoid overly detailed and complex evaluation items and provide simple and easy-to-understand indicators as much as possible. As for the indicators used for quantitative evaluation, publicly available data, including data reported to administrative agencies, should be used as much as possible, and the improvement of energy resilience must be quantifiable.

Moreover, evaluating efforts to improve the resilience of suppliers and consumers, and contributing to measuring the degree of improvement in energy resilience of regions and cities is necessary for evaluating energy resilience. Regarding the evaluation of regional resilience, it is essential to use evaluation indicators suitable for each country and region because meteorological and geographic conditions can vary greatly depending on the region. Conditions to be considered are economic progress, culture and customs, major industries, and whether it is a continental country or archipelagic country, etc. However, the basic evaluation concept of whether or not energy could be supplied at the energy supplier side and whether or not energy could be used at the energy consumer side should be common.

2.4.2. Region

Since countries and regions have different environments regarding culture, customs, economic development, industrial structure, geographic challenges, climate, ways of living, and economic activities, the types and frequency of risks, as well as the magnitude of occurrence, naturally differ. From the perspective of minimising business interruptions and improving early recovery in the event of disasters, it is necessary to properly evaluate initiatives that are adapted for resilience management. However, for numerous challenges, particularly political risks, it is difficult to predict the probability of their occurrence and the level of risk if they do occur. Therefore, as a starting point, the evaluation focuses on natural disasters. For each region, past occurrences of natural disasters are used as the basis for evaluating its score, and in some regions, future climate change is also predicted and organised as a regional score. This regional score naturally differs in urban and depopulated areas, but it is appropriate to first evaluate urban areas where economic activity is carried out since those are the areas that will impact society most when hit by a natural disaster. Additionally, it is necessary to assess the regional score for administrative units, such as a city.

The region score is assessed based on the probability of natural disasters, such as earthquakes, typhoons, and floods, that are likely to occur in the country or region. It is also evaluated based on the probability of occurrence and the damage conversion factor (degree of impact of hazardous events on the environment).

2.4.3. Energy supplier

For the supply side, an assessment is required to determine which energy type consumers depend on the most. The energy resilience of each energy type varies by region. Therefore, the supply scores should be combined to create a system that allows energy consumers to evaluate the energy types they need.

Publicly available data, including data submitted to the national and local governments, will be adopted in accordance with relevant laws and regulations.

Based on interviews and exchanges of opinions with suppliers, the evaluation indicators were subdivided to enable the evaluation of industry-specific initiatives in the categories of 'alternative energy procurement', 'innovation and capital investment', 'supply network resilience', and 'emergency response'.

2.4.4. Energy consumers

Considering that measures are taken for each energy type, a score addition method will be used for evaluation.

In addition to indexing energy consumers with publicly available data, we decided to use an index that surveys and evaluates the presence or absence of energy consumer initiatives in the target region.

The score on the consumer side will be based on whether the energy consumers cooperate with the energy suppliers in the region where the energy consumer is located to maximise the use of multiple energy sources (including renewable energy) in the event of a disaster.

The evaluation will also include efforts on the part of energy consumers to keep business facilities in operation or to shorten the time during which facility operations are suspended in the event that the energy supply is disrupted due to a disaster.

Furthermore, since a company's ability to secure multiple energy sources, prepare its own facilities, implement business continuity planning (BCP), and offer contingency plan training are important elements in preparing for energy disruptions, and these points are given special emphasis in the evaluation.

3. Trial Analysis with Prototype ERS system

3.1. Target Consumer (Facility)

In this study, three facilities of Tokyo Toshi Service Corporation[25] located in Tokyo and near Tokyo agreed to provide information and conduct an ERS assessment were selected as the subjects for the evaluation of the ERS.

Tokyo Toshi Service Co., Ltd. is a Japanese company that provides heat supply services; sales, leasing, installation, operation, and maintenance of facilities that contribute to efficient energy use and the environment; contracted operation of heat supply facilities; contracted management and operation of buildings and ancillary facilities; consulting on energy use in buildings and industry; sales of water treatment facilities; and lease, installation, operation, and maintenance of facilities that contribute to energy efficiency and the environment. The company's main business activities are sales, lease, installation, operation, and maintenance of water treatment facilities, sale of treated water, and supply of electricity, gas, and oil, etc. In conducting the evaluation, cooperation was obtained not only from the consumer side but also from the energy supply side.

The target regions for energy resilience assessment were Tochigi Prefecture (Utsunomiya City), Kanagawa Prefecture (Yokohama City), and Tokyo (Shinagawa Ward), where the consumers to be assessed were located. In evaluating these areas, information was collected on 1) the status of disaster risk in the areas under evaluation, 2) the energy supply situation in the areas under evaluation, and 3) the current status of consumers in the areas.

Details of the districts to evaluated are as follows.

[25] Tokyo Urban Services Corporation, https://www.tts-kk.co.jp/company/gaiyou.html (accessed 29 November 2022).

Table 4.1. Facility Locations of Tokyo Urban Service Corporation (Three Regions)

Tochigi prefecture (Utsunomiya City)	Kanagawa prefecture (Yokohama)	Tokyo Metropolitan area (Shinagawa Ward, Tokyo)
➢ Date of commencement of supply: 1991 February ➢ Total floor area supplied: 139,000 m^2 ➢ Supply facilities: Public facilities (government buildings, halls), business facilities	➢ Date of commencement of supply: February 2020 ➢ Total floor area supplied: 185,000 m^2 ➢ Supply facilities: Public and business facilities	➢ Date of commencement of supply: January 1999 ➢ Total floor area supplied: 318,000 m^2 ➢ Supply facilities: Business facilities, commercial facilities, residential facilities, public facilities

Note: The source of the information and evaluation method are summarised in Tables 4.2, 4.3, and 4.4.

Table 4.2. Evaluation Indicators and Methods for the Facility in Utsunomiya City

Classification		Evaluation Indicators and Methods
Disaster risk		Assessment of disaster risk in the central Utsunomiya area using quantitative evaluation indices for heavy rain, strong winds, floods, and earthquakes
Supply side	Electric power	Using information from Tokyo Urban Service Co.
	Gas	Using information from Tokyo Urban Service Co.
	Petroleum	Using information from Tokyo Urban Service Co. Not evaluated (not used as a consumer)
	Administrative facilities (water supply, roads, etc.), sewerage	Using information from Tokyo Urban Service Co.
Demand side		Evaluation based on information from Tokyo Urban Service Co.

Table 4.3. Evaluation Indicators and Methods for the Facility in Yokohama City

Classification		Evaluation Indicators and Methods
Disaster risk		Assessment of disaster risk in the Yokohama city area using quantitative evaluation indices for heavy rain, strong winds, floods, and earthquakes
Supply side	Electric power	Using information from Tokyo Urban Service Co.
	Gas	Using information from Tokyo Urban Service Co.
	Petroleum	Using information from Tokyo Urban Service Co. Not evaluated (not used as a consumer)
	Administrative facilities (water supply, roads, etc.), sewerage	Using information from Tokyo Urban Service Co.
Demand side		Evaluation based on information from Tokyo Urban Service Co.

Table 4.4. Evaluation Indicators and Methods for the Facility in the Osaki Area

Classification		Evaluation Indicators and Methods
Disaster risk		Assessment of disaster risk in the Osaki area using quantitative evaluation indices for heavy rain, strong winds, floods, and earthquakes
Supply side	Electric power	Using information from Tokyo Urban Service Co.
	Gas	Using information from Tokyo Urban Service Co.
	Petroleum	Using information from Tokyo Urban Service Co. Not evaluated (not used as a consumer)
	Administrative facilities (water supply, roads, etc.), sewerage	Using information from Tokyo Urban Service Co.
Demand side		Evaluation based on information from Tokyo Urban Service Co.

3.2. Current Status of Disaster Risk in the Assessed Areas

Table 4.5. Disaster Risk in the Assessed Areas

Weather Elements	Risk	Usage Data	Analysis Period	Spatial Resolution	Methodology/Source
Heavy rain	Landslide Probability Index	Radar AMeDAS 1 km mesh analysis rainfall Notes: 1988–2001: 5 km mesh 2001–2005: 2.5 km mesh	1988–2020 Notes: If 15 years after 2006 is sufficient, do not use before 2006	1 km mesh	Japan Meteorological Agency (JMA) landslide warning compliant
Strong winds	Storm Entry Rate Index	JMA best track data	1977–2020	1 km mesh	WNI[26]
Flood	Flood Damage Probability Index	Flooding Navigation (Ministry of Land, Infrastructure, Transport and Tourism)	-	1.7 km mesh	5: No flooding 4: Inundation under floor less than 0.5 m 3: Flooding above floor level of 0.5 m or more but less than 1 m 2: 1 m or more but less than 2 m 1: 2 m or higher, first floor ceiling height 2.4 m
Earthquake	Index of probability of occurrence	Headquarters for Earthquake Research	-	1 km mesh	Probability of occurrence data corresponding to the seismic intensity of

[26] Weathernews Inc. (https://jp.weathernews.com/corporate-outline/).

Weather Elements	Risk	Usage Data	Analysis Period	Spatial Resolution	Methodology/Source
	of seismic intensity 5 or higher	Promotion, Original Data for Probabilistic Earthquake Motion Prediction Map (250 m mesh)			the Headquarters for Earthquake Research Promotion

Note: AMeDAS is the Automated Meteorological Data Acquisition System, developed and operated by Japan Meteorological Agency (JMA).

The regional disaster risk assessment indicators are based on the typical natural disasters (heavy rainfall, strong winds, floods, and earthquakes) encountered in Japan, and the regional risk assessment is performed by multiplying the ‘likelihood of occurrence’ and ‘degree of impact (degree of severity and scale due to hazard)’ of each disaster assumed in the area to be assessed. In this assessment, the possible risks to the target area are evaluated based on data from the past decades, based on recent changes in weather conditions and meteorological data. In doing so, the evaluation was able to predict the extent of the damage in the target area (i.e. the extent of damage to buildings and roads in the area) according to the results of the disaster risk assessment so that the evaluation could be used for countermeasures by suppliers and consumers. Detailed studies will be required for the calculation method of disaster risk assessment in the region, but the indicators shown in Table 4.6 were used in this project.

Table 4.6. Disaster Risk in the Assessed Areas

<table>
<tr><th>Weather Elements</th><th>Risk</th><th>Rank</th><th>Score</th><th>Evaluation Details per Score</th></tr>
<tr><td>Heavy rain</td><td>Landslide Probability Index</td><td rowspan="4">360,000 mesh, rated in five ranks per location</td><td>1–5 points</td><td rowspan="4">Comparison in Japan
1: Relatively dangerous
2: Relatively somewhat dangerous
3: Relatively medium
4: Relatively somewhat safe
5: Relatively safe</td></tr>
<tr><td>Strong winds</td><td>Storm Entry Rate Index</td><td>1–5 points</td></tr>
<tr><td>Flood</td><td>Flood Damage Probability Index</td><td>1–5 points</td></tr>
<tr><td>Earthquake</td><td>Index of probability of occurrence of seismic intensity 5 or higher</td><td>1–5 points</td></tr>
<tr><td colspan="3">Disaster Risk Assessment</td><td>4–20 points</td><td></td></tr>
</table>

Source: The Institute of Energy Economics, Japan (IEEJ).

The evaluation results for the three regions of the study using the above evaluation criteria are as follows (Tables 4.7 and 4.8).

Table 4.7. Disaster Risk in the Assessed Areas

Weather Elements	Risk	Tochigi Prefecture	Kanagawa Prefecture	Tokyo Metropolitan Area
		Utsunomiya	Yokohama	Osaki
Heavy rain	Landslide Probability Index	3 points	5 points	4 points
Strong winds	Storm Entry Rate Index	4 points	4 points	4 points
Flood	Flood Damage Probability Index	5 points	5 points	5 points
Earthquake	Index of probability of occurrence of JMA seismic intensity 5 lower or above	1 point	1 point	1 point
Disaster Risk Assessment		13 points	15 points	14 points

Source: The Institute of Energy Economics, Japan (IEEJ).

Table 4.8. Disaster Risk in the Assessed Areas

Location	Factor	Result	Unit	Point assigned	Total
Utsunomiya	Rain and sediment disaster	0.001	%	3	13
	Typhoon / strong wind	0.5	times / year	4	
	EQ - Intensity 5 lower, or above per JMA	93.8	%	1	
	Heavy rain / Flood	No inundation	m	5	
Yokohama	Rain and sediment disaster	No information	%	5	15
	Typhoon / strong wind	0.6	times / year	4	
	EQ - Intensity 5 lower, or above per JMA	99.9	%	1	
	Heavy rain / Flood	No inundation	m	5	
Osaka	Rain and sediment disaster	0.004	%	4	14
	Typhoon / strong wind	0.6	times / year	4	
	EQ - Intensity 5 lower, or above per JMA	99.9	%	1	
	Heavy rain / Flood	No inundation	m	5	

Source: The Institute of Energy Economics, Japan (IEEJ).

3.3. Survey of the Supply Side

The evaluation indicators for suppliers will be based on publicly available data, data submitted to the national and local governments in accordance with relevant laws and regulations, and indicators that are used to survey and evaluate suppliers in the evaluation target areas to determine whether they are making efforts. The indicators are as follows (Tables 4.9, 4.10, 4.11, and 4.12).

Table 4.9. Disaster Risk in the Assessed Areas (Electric Power)

Alternative energy procurement	Availability of power portfolio formation with multiple energy sources	
	Regional distribution of energy sources (Pacific Ocean side and Sea of Japan, Eastern and Western Japan, etc.)	
	Availability of measures to cope with supply-demand crunch and emergency power demand: availability of reserve capacity and adjustment capacity for supply-demand adjustment and effectiveness of control. (including whether or not other power sources are purchased)	
	Cooperation with other electric power suppliers, etc.	
Innovation and capital investment	Capital investment for stable energy supply, introduction of new systems (expansion of distribution automation equipment, digital substations, etc.)	
	Availability of training to operate equipment in the event of a disaster	
	With training	Number of trainings
Strengthening of the distribution network	System Average Interruption Duration Index (SAIDI): average outage duration per consumer	
	System Average Interruption Frequency Index (SAIFI): average number of outages per consumer	

	Disaster preparedness (e.g. earthquake-proofing facility, flood control, etc.)	
Emergency preparedness	BCP and disaster countermeasures manual in place	
	Availability of training to enhance effectiveness of BCP and disaster preparedness manuals	
	Training for an emergency	Number of trainings
		Training
		Number of institutions participating in training (including participation at the request of other institutions, etc.)
	Whether or not a third-party evaluation of the BCP has been conducted (including whether or not standards within the electric power industry have been followed)	

Source: The Institute of Energy Economics, Japan (IEEJ).

Table 4.10. Disaster Risk in the Assessed Areas (Gas)

Alternative energy procurement	**Natural gas, LP gas** Diversification of LNG suppliers and flexible procurement system	
Innovation and capital investment	**Natural gas** Whether or not smart energy networks are being deployed * The introduction of facilities that can handle power outages (‘EneFarm’, cogeneration) and distributed energy facilities (concepts such as power generation on the customer's side) are mentioned	
Strengthening of the distribution network	**Natural gas** Durability of gas pipelines, availability of disaster countermeasures for LNG terminals (earthquake-proofing, typhoon and tsunami countermeasures)	
	Natural gas, LP gas Existence or non-existence of facility redundancy initiatives Example: Redundancy in production facilities includes the possession of spare units, and redundancy in supply facilities includes looping of the pipeline network (although not throughout the entire service area) and the availability of temporary supply	
	Natural gas Availability of blocked supply areas	
	LP gas Storage facility countermeasures (earthquake and flood countermeasures)	
Emergency preparedness	**Natural gas, LP gas** Disaster countermeasure manuals are in place	
	Natural gas Whether or not actions are taken in accordance with the Guidelines for Coordination and Cooperation amongst Gas Utilities to Ensure Safety	

	Natural gas Emergency drills to enhance the effectiveness of BCP and disaster response manuals.	
	Natural gas, LP gas Training	Number of trainings
		Training
		Number of institutions participating in training (including participation at the request of other institutions, etc.)
	Natural gas, LP gas BCP third-party evaluation	

Source: The Institute of Energy Economics, Japan (IEEJ).

Table 4.11. Disaster Risk in the Assessed Areas (Petroleum)

Alternative energy procurement	Ratio of domestic production to domestic consumption (* The index excluding naphtha, which is mainly imported even in normal times, is used as an indicator.)	
	Number of stockpiling days relative to domestic consumption	
Innovation and capital investment	Whether artificial intelligence (AI) capital investment, energy cost reduction initiatives, manpower saving, etc. (e.g. refinery operations, maintenance-related activities, transformation of the entire supply chain, mechanisation to reduce the number of workers at	

	refineries in light of corona infection control, etc.)	
Strengthening of the distribution network	Percentage of refineries and depots equipped with emergency power sources	
	Percentage of gas stations equipped with emergency power supply	
	Earthquake (magnitude of seismic motion) assumed in implementing measures for seismic strengthening and liquefaction resistance of refineries, etc.	
Emergency preparedness	Whether affiliated BCP and disaster countermeasures manuals have been established or not	
	Availability of training to enhance effectiveness of BCP and disaster preparedness manuals	
	Emergency training	Number of trainings
		Training
		Number of institutions participating in training (including participation at the request of other institutions, etc.)
	Whether or not a third-party evaluation of the BCP is conducted	
	Participation in Disaster Oil Supply Coordination Plan	
	Number and type of earthquakes and other disasters (flood, wind, snow, etc.) to be anticipated	
	Time required to restore oil supply (time required to restore to 1/2 of normal incoming/outgoing shipment volume)	

Source: The Institute of Energy Economics, Japan (IEEJ).

Table 4.12. Disaster Risk in the Assessed Areas (Administrative Facilities, Sewerage)

Administrative facilities (water supply, roads, etc.), sewerage	Emergency preparedness (administrative facilities (water supply, roads, etc.))	Whether or not the municipality has established a BCP and disaster countermeasures manual (whether or not measures are taken for administrative facilities (water supply, roads, etc.))	
		Availability of training to enhance effectiveness of BCP and disaster preparedness manuals	
		Emergency training	Number of trainings
			Training
			Number of institutions participating in training (including participation at the request of other institutions, etc.)
	Emergency preparedness (sewerage)	BCP and disaster preparedness manuals for sewage systems (prefectural, municipal, etc.)	
		Availability of training to enhance effectiveness of BCP and disaster preparedness manuals	
		Emergency training	Number of trainings
			Training

			Number of institutions participating in training (including participation at the request of other institutions, etc.)

Note: Administrative facilities include water supply, roads, etc.

Source: The Institute of Energy Economics, Japan (IEEJ).

The results of the supply-side evaluation of the evaluated areas are as follows (Table 4.13).

Table 4.13. Results of the Evaluation of Supply-side Indicators for the Evaluated Regions

	Tochigi Prefecture	Kanagawa Prefecture	Tokyo Metropolitan Area
	Utsunomiya	Yokohama	Osaki
Electric power	3.6 points	4.2 points	3.6 points
Gas	-	3.3 points	-
Petroleum	-	-	-
Administrative facilities (water supply, roads, etc.), sewerage	1.1 points	1.1 points	1.1 points
Supply side total	4.7 points	8.6 points	4.7 points

Source: The Institute of Energy Economics, Japan (IEEJ).

3.4. Survey of the Consumer Side

The score for the consumer side is based on whether the company is making efforts to maximise the use of multiple energy sources (including renewable energy) in the event of a disaster in cooperation with local energy providers in the area where the company is located. In addition, the evaluation was based on the efforts of consumers to continue to use the energy provided by the supplier in the event of an emergency and to shorten the time that business activities are suspended as a result of energy supply disruptions.

In particular, weight was given to whether the company is considering securing multiple energy sources, as well as its own facilities, BCP, training, and other measures, as these are important elements in preparing for energy disruptions.

Table 4.14. Demand-side Indicators

Consideration of securing multiple energy supply sources	A risk assessment of energy security is being conducted with knowledge assistance from energy suppliers.
Electric power	Seismic retrofit of power-receiving facilities, and availability of distributed power sources such as renewable energy, batteries, and EVs. Equipment prepared for power outages ('EneFarm', cogeneration) are installed. Safety measures for on-premises private power facilities are planned in consultation with the power supply side.
	Understanding of number of days of continuity by in-house alternative means in the event of a power supply outage.
	Mutual assistance agreement with the supply side in the event of a disaster (e.g. signing of a disaster response agreement, etc.).
Gas	Use of medium pressure natural gas pipeline.
	Seismic gas supply pipelines, measures to prevent LP gas containers from tipping over, etc. Countermeasures are planned in consultation with supply side.
	Number of days of continuity by in-house alternative means in the event of gas supply outage (e.g. emergency use of LP gas as an energy source in the event natural gas supply is stopped).
	Existence or non-existence of a cooperative system with the supply side in the event of a disaster (e.g. signing of a disaster response agreement, etc.).
Petroleum	Seismic retrofit of the storage facilities. Countermeasures are designed in consultation with the supply side.
	Rules to fill up a car when the fuel gauge is about half full.
	Availability of self-defence stockpiles of oil (for how many days).

	Mutual assistance system with the supply side in the event of a disaster (e.g. signing of a disaster response agreement).
Water supply	Seismic retrofit of water supply lines on the premises. Measures are introduced in consultation with the supply side.
	Availability of water supply for self-defence (for how many days).
Facilities, BCP, training, etc.	Vulnerability assessment of facilities and equipment in preparation for earthquakes, floods, etc.
	Physical countermeasures of key facilities and equipment prepared for earthquakes, floods, etc.
	BCP and disaster countermeasures manual are in place.
	Availability of training to enhance effectiveness of BCP and disaster preparedness manuals.
	Training programmes (frequency of training; education and training programmes collaborating with energy suppliers and local governments)
	Availability of financial protection (insurance, etc.)
	A third-party evaluation of BCP is conducted

Source: The Institute of Energy Economics, Japan (IEEJ).

3.5. Results of the Evaluation

This survey analyses energy resilience based on the status of disaster risks, energy supply side risks, and energy consumer side risks in the three regions with the same energy supplier, using a prototype ERS evaluation method. The results of the survey, with detailed information provided by the energy supplier, give comparable regional energy resilience indicators.

In future, it is necessary to conduct and accumulate analyses in various regions using the same method to improve the qualification of the evaluation method and the accuracy and comparability of the derived ERS.

Table 4.15. Results of the Evaluation

Category/segment	Hazard / Energy type	Utsunomiya Central District		Kitanakadori Minami District, Yokohama City		Osaki 1-chome District	
Region	Sediment-related disaster	3	/5	5	/5	4	/5
	Floods	5	/5	5	/5	5	/5
	Typhoon	4	/5	4	/5	4	/5
	Earthquake	1	/5	1	/5	1	/5
	Subtotal	13	/20	15	/20	14	/20
Energy Supplier (supply side)	Electricity	3.6	/10	4.2	/10	3.6	/10
	Gas	-	/10	3.3	/10	-	/10
	Coal	-	/10	-	/10	-	/10
	administrative facility	1.1	/10	1.1	/10	1.1	/10
	Subtotal	4.7	/40	8.6	/40	4.7	/40
Energy consumers (Demand side)	Multiple energy security	8.0	/8	8.0	/8	8.0	/8
	Electricity	1.7	/10	5.0	/10	1.7	/10
	Gas	-	/5	0.7	/5	-	/5
	Coal	-	/5	-	/5	-	/5
	Water	0.0	/4	0.0	/4	0.0	/4
	Equipment/BCP/Training	4.4	/8	3.6	/8	4.4	/8
	Subtotal	14.1	/40	17.3	/40	14.1	/40
Total		31.8	/100	40.9	/100	32.8	/100

Source: The Institute of Energy Economics, Japan (IEEJ).

On the other hand, the following issues have been identified in the evaluation of energy resilience using this method.

(a) Improvement points in resilience evaluation items

- It is necessary to consider detailed evaluation methods for converting the responses obtained for each evaluation item into points, including how to interpret qualitative comments when converting them into quantitative scores, AI analysis of text data, evaluation methods by experts.
- Items including electricity (lighting, PCs, home appliances, etc.), air conditioning, hot water, kitchen, heat need to be categorised and sorted out into evaluation items.
- It is necessary to consider evaluation methods for cases (electric power outage, supplement with gas, etc.) in which customers take measures for business continuity using multiple types of energy.
- It is necessary to consider evaluation methods for the supply side that consider the recovery time once the system is shut down due to a disaster, etc.

(b) Issues related to the calculation methodology for the energy resilience evaluation points

- It is necessary to consider of evaluation weighting method that considers the energy use ratio of consumers (electricity, gas, oil, and water), in association with,
  - it is necessary to consider of evaluation using CO_2 emission data.
  - It is needed to reflect the energy use ratio in the supply-side evaluation.
  - It is needed to consider how to calculate evaluation points for the supply side and the demand side (e.g., multiplying by energy use).
- It is necessary to study on how to assign evaluate points for energy that is not used by the customer in the project.
- For resilience evaluation, it is also necessary to consider the evaluation of business continuity measures for the supply side (electricity, gas, and oil) (business shutdown time and number of operations to be shut down in the event of a disaster) and for the demand side (business shutdown time and number of operations to be shut down in the event of a disaster).

(c) Data availability

- When evaluating general consumers (applying to various countries and regions) in the future, it may be difficult to collect evaluation information from publicly available data on the supply-side companies (electricity, gas, oil) used by such consumers, and it is necessary to consider how to collect data for evaluating ERS (publicly available information is available for publicly managed infrastructure such as water and sewage systems, making basic evaluation possible) even though basic evaluation is possible for publicly available information on publicly managed infrastructure such as water and sewage systems.

Chapter 5

Discussions at the Workshops

1. General

For the purpose of this project, workshops were held in Japan, Thailand, and Indonesia. At the workshops, participants shared information on the impacts of disasters on energy resilience and policy initiatives in each country and discussed the concept of the prototype ERS model and the results of the evaluation of the ERS demonstration.

In assessing energy resilience, it is important to consider the geographical characteristics of the target countries and regions since they impact the climate, disaster risk, and so on. Therefore, for the workshops, one continental country and one archipelagic country were selected as the target countries (Thailand and Indonesia), being located in the Pacific Rim and having been affected by large economic damage from natural disasters in the past.

2. Current Status of Disaster Risk in the Three Countries

2.1. Japan

Japan is prone to various types of disasters due to its natural conditions and topology. Natural disasters such as floods, landslides, earthquakes, and tsunamis occur year after year. In recent years, the Great East Japan Earthquake in 2011, Kumamoto earthquake in 2016, torrential rain in July 2018, East Japan typhoon in 2018, and torrential rain in July and August 2020 caused severe damage. An earthquake centred in the northwestern part of Chiba Prefecture occurred on 7 October 2021, and an earthquake centred off the coast of Fukushima Prefecture occurred on 16 March 2022. The heavy rains that started on 1 July 2021, caused mudslides and debris flow in Atami City, Shizuoka Prefecture, as well as damage to homes and public utilities in several prefectures.

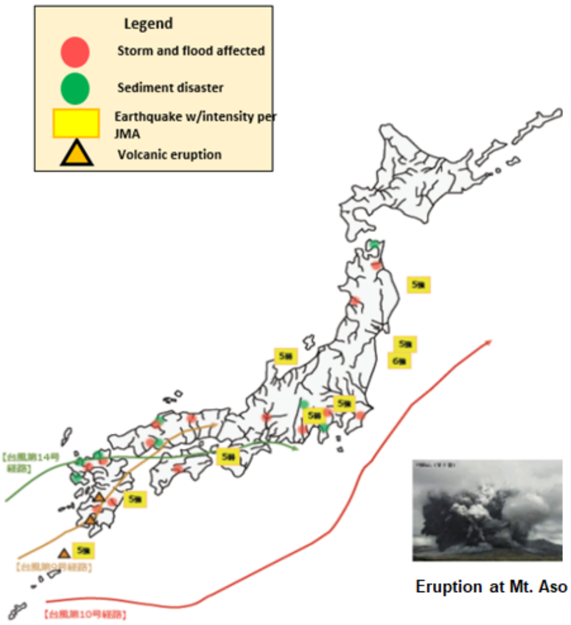
Figure 5.1. Major Disasters in Japan in FY2021[27]

Storm and Flood		
Event	Month	Affected Prefecture
Heavy Rain	July	Akita, Kanagawa, Shizuoka, Tottori Shimane, Hiroshima Kagoshima
Typhoons	Aug.	Aomori, Chiba
Heavy Rain	Aug.	Gifu, Hiroshima, Fukuoka, Saga
Typhoon No. 14	Sep.	Kochi, Miyazaki

Flood: Saga prefecture

Sediment Disaster		
Event	Month	Affected area
Heavy Rain	July	Shizuoka, Tottri, Hiroshima
Typhoons No. 9 & 10	Aug.	Aomori
Heavy Rain	Aug.	Nagano, Hiroshima, Fukuoka

Debris flow and landslide occurred in Shizuoka



Major disasters in Japan (FY 2021)

Major Eqs. (Intensity per JMA: above 5)		
Event	Month	Affected area
Miyagi-oki	May	Miyagi
Noto	Sep.	Ishikawa
Iwate-oki	Oct.	Aomori
NW of Chiba	Oct.	Saitama, Tokyo
Yamanashi/ Mt. Fuji lakes	Dec.	Yamanashi
Kii-channel	Dec.	Wakayama
Tokara	Dec.	Kagoshima
Chichijima	Jan.	Ogasawara
Huganada	Jan.	Oita
Fukushima-oki	Mar.	Miyagi, Fukushima

Vokanic Eruption		
Event	Month	Affected area
Mt. Sakurajima	April	Miyagi
Suwanosejima	June, Sep., Oct., Nov., Dec.	Kagoshima
Mt. Aso	Oct.	Kumamoto

Eruption at Mt. Aso

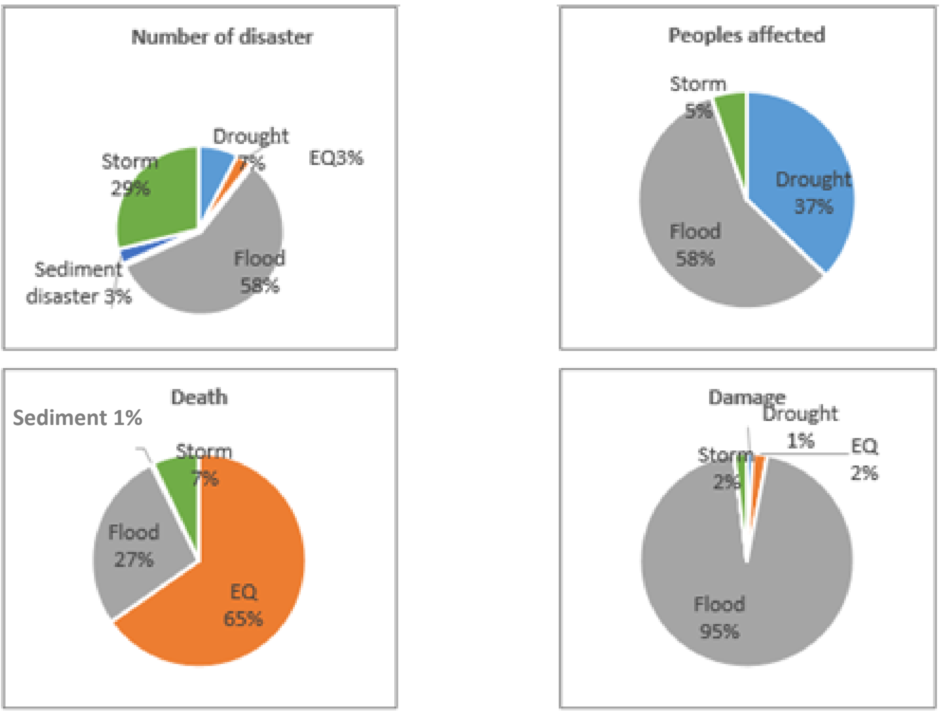
Source: The Institute of Energy Economics, Japan (IEEJ).

2.2. Thailand

Floods and storms are the most common disasters in Thailand, accounting for 87% of the total number of disasters from 1980 to 2011, but their impacts vary. In terms of the total number of people affected, the largest damage is due to flooding, followed by drought. Earthquakes and tsunamis cause the largest number of deaths (65%). Flooding accounts for the largest amount of damage (95%). Most of the deaths from earthquakes and tsunamis were caused by the 2004 Sumatra earthquake, whilst about 90% of the damage from floods was caused by the 2011 floods. For droughts, where the total number of affected people is high, the main feature is that there is no record of the number of deaths.

[27] 2022 White Paper on Disaster Prevention, https://www.bousai.go.jp/kaigirep/hakusho/r4.html

Figure 5.2. Natural Disasters in Thailand, 1981–2011



	Drought	EQ	Flood	Sediment	Sediment (Hydro)	Storm	Volcano	Total
1.Number of disaster	8	3	60	0	3	30	0	104
2. Peoples affected	29,982,602	67,023	46,426,691	0	43,110	4,235,503	0	80,754,929
3. Death	0	8,346	3,493	0	47	895	0	12,781
4.Damage	424,300	1,000,000	44,355,408	0	0	892,039	0	46,671,747

Source: EM-DAT: The OFDA/CRED International Disaster Database.

2.3. Indonesia

Indonesia is a disaster-prone country with frequent natural disasters, such as earthquakes, floods, tsunamis, and landslides, that occur every year. According to EM-DAT[28] data, from 1980 to 2017, there have been approximately 190,000 deaths, 24.45 million people affected, and US$29.4 billion in economic damage. In particular, the Indian Ocean Tsunami of 26 December 2004, one of the worst disasters in human history, left approximately 170,000 people dead or missing in Indonesia. According to the Asian Disaster Reduction Center (ADRC) website, Indonesia's major disasters in the past include the December 2004 Sumatra earthquake and tsunami (165,708 deaths), the March 2005 Sumatra earthquake (905 deaths), and the May 2006 Java earthquake (5,788

[28] EM-DAT Disaster List (http://www.emdat.be/disaster_list/index.html).

deaths) as representative disasters.

Table 5.1. Major Disasters in Indonesia

No.	Year	Month	Death	Cause	Affected area	Source
1	1981	5	500	Flood	Mont Semeru	1)
2	1992	12	2,500	EQ	Sikka, East Flores, Ende	1)
3	2004	12	165,708	EQ/Tsunami		2)
4	2005	3	905	EQ		2)
-	2005	3	915	EQ	Simeule, Nias, Banyak Isl	1)
5	2006	1	154	Flood/Landslide	East Java （Jember, Banjarnegara）	3)
6	2006	5	5,778	EQ		2)
-	2006	5	5,778	EQ	Yogyakarta, Central Java	1)
7	2006	6	219	Flood/Landslide	South Sulawesi	3)
8	2006	7	802	EQ/Tsunami	Tasikmalaya, Ciamis, Suka	1)
9	2006	12	260	Flood/Landslide	Ache, North Smatra, Riau	3)
10	2007	1～2	80以上	Flood/Landslide	80 districts including Jak	3)
11	2007	12～1	83	Flood/Landslide	Central Java, East Java	3)
12	2009	3	101	Flood	SW of Jakarta	3)
13	2009	9	1,195	EQ	Padang, Buki	1)
14	2010	10	11,864	EQ/Tsunami	Kepulauan Mentawi （Sumatra）	1)
15	2014	12	95	Landslide	Central Java	3)
16	2016	6	64	Flood/Landslide	Central Java、North Sulawesi, West Smatra	3)
17	2016	9	53	Flood	Garut, Sumedang districts （Jawa Barat）	1)

Note: 1) EM DAT (supported by USAID); 2) ADRC; 3) International Construction Technology Association.

Source: EM-DAT Disaster List (http://www.emdat.be/disaster_list/index.html).

3. Major Discussions at the Workshop Meetings

3.1. Workshop in Japan

At the first workshop, the participants from Japan explained the concept and role of quantitative evaluation indicators for energy resilience, giving an overview of the prototype model and trial evaluation, and introduced the efforts of businesses related to disaster forecasting. Following the presentation, the following points were discussed.

- What are the challenges of developing similar quantitative evaluation indicators for energy resilience in other Asian countries?
- Which countries can be starting points?

The major discussions at the workshop were as follows.

- A participant from ERIA (hereafter, referred to as ERIA) asked about the flexibility of the Energy Resilience Score and how the risk index could be applied to regions outside of Japan. For example, whilst heavy rains lead to landslides in Japan, they more often lead to floods in ASEAN countries. A recent flood in Kalimantan greatly affected local coal mining, and the resulting delay in coal supply impacted operations, including coal power plants, in Java.
  - A participant from Weathernews Inc. (hereafter, referred to as WNI) replied that the disaster risk assessment for heavy rain uses a computation method developed by the Japan Meteorological Association (JMA, https://www.jma.go.jp/jma/indexe.html) and thus, it cannot be directly applied to other countries, including Indonesia. The development of computation methods tailored to local circumstances in other countries is currently under consideration.
  - Also, WNI explained that to successfully apply the hazard risk index to ASEAN and East Asian counties, the data availability in the targeted countries as well as the quality and resolution of the index will be key. However, compromises may be required to some extent.
- ERIA asked about aggregating different parameters in this methodology and accommodating different geographical characteristics, mentioning that the risk of sea level rise is a critical issue of high concern in many coastal regions of ASEAN countries, whilst mountainous regions are faced with different challenges.
  - WNI pointed out that a few different variables could be considered. Storm surges would be a risk to coastal low-lying areas, whilst wildfires would be a risk in mountainous regions. Selecting the hazards to be included and balancing the different variables could be the key to successfully developing quantitative evaluation indicators. This would be the most important point to be considered in developing and applying customised quantitative evaluation indicators to ASEAN and East Asian countries.
  - A participant from the Institute of Energy Economics, Japan (hereafter, referring to as IEEJ) commented that initial considerations are often made in urban areas

with large populations and can be expanded to other regions, such as mountainous areas.

- ERIA asked whether stockpiling was also considered and whether the period for stockpiling was determined, as this could guarantee minimal operations.
  - A participant from SOMPO Risk Management (hereafter, referred to as SOMPO) replied that stockpiling is included in the BCP for oil and petroleum supply.
  - Participants agreed that stockpiling and energy storage was important on both the supply and demand sides.
- ERIA pointed out that many ASEAN countries suffered from the economic impacts of hazards and that the recovery time was a critical issue.
  - Participants agreed that robustness and promptness are equally important parameters to optimise. Stakeholders need a certain extent of preparedness for disasters.
- Discussion regarding 'which countries can be starting points for developing similar quantitative evaluation indicators for energy resilience in other Asian countries'
  - Participants were asked to comment on which Southeast Asian countries would be appropriate for fine-tuning these components.
  - WNI commented that all countries are important from a climate perspective and that data availability would not vary that much amongst different countries.
  - ERIA pointed out that it would be good to have at least two parameter types represented – geographical characteristics (archipelagos: such as Indonesia and the Philippines / continental: such as Thailand, Viet Nam, Cambodia, the Lao PDR, and Myanmar) and level of development (medium-income countries: Indonesia, Malaysia, and the Philippines / low-income countries: Cambodia, the Lao PDR, and Myanmar) – as the nature of the challenges these countries face are different. By covering these different types of countries, we will also be able to highlight the data gaps, which would be an important point in the evaluation.

<u>Conclusion of the workshop</u>

- Participants agreed three groups of countries can be identified, as seen in these examples:
  - Medium-income insular countries: the Philippines or Indonesia
  - Medium-income continental countries: Thailand or Viet Nam
  - Low-income countries: Lao PDR, Cambodia, or Myanmar

3.2. Workshop in Thailand

In the second workshop, the participants from Thailand had an overview of energy resilience in the Thai context. The Japanese participants explained the concept and role of quantitative evaluation indicators for energy resilience and the results of the trial evaluation using the prototype model and introduced utilising climate and weather data in the quantitative evaluation of energy resilience. Following the presentation, the following point was discussed.

- What are the challenges of developing similar quantitative evaluation indicators for energy resilience in Thailand?

The major discussions at the workshop were as follows.

- A participant from National Energy Technology Center, Thailand (hereafter, referred to as ECTEC) asked about the validity and variability of the distribution of scores for the three components of the resilience score (region, energy supplier, and energy consumer).
  - The IEEJ responded that the draft resilience scoring model was currently being finetuned and may vary across regions with different environments. The IEEJ added that a complex resilience scoring scheme may not be understood in the financial sector, so a simple scoring is necessary. ECTEC commented on the possibility of further simplification of the scoring scheme.
- A participant from the Stock Exchange of Thailand (hereafter, referred to as SET) noted that unlike in Japan, the electricity market is not liberalised in Thailand. He then asked whether the regional score could also reflect country-specific systems and policies.
  - WNI responded that it might be a good idea to reflect energy policies in the score when comparing different countries. In some cases, it may not always be effective to reflect energy policy in the score when comparing local governments and/or local administrative agencies within a country.
  - The IEEJ mentioned that the project team is working with the Asia-Pacific region to expand the energy resilience scoring scheme globally and that it is trying to finetune the regional scores to accommodate regional differences.
  - ECTED commented that in Thailand, some companies have stakeholders in other countries, and thus the policies of various countries may affect their decisions on climate change adaptation. Therefore, incorporating policy factors into the scoring scheme should also be considered.

- ECTED asked whether this evaluation system is flexible enough to adapt to future changes in the definition of resilience, given that the understanding of energy resilience already differs around the world.
  - SOMPO answered that although it is not precisely a quantitative indicator, the project team is trying to convert it into a quantitative indicator by interviewing energy suppliers and energy consumers and by using energy-related public data. He also responded that whilst studies can be conducted to assess the impact of future weather and climate change, this evaluation of energy resilience addresses the current situation, not the future.
  - The IEEJ commented that the project team seeks to deploy AI to evaluate energy resilience scores in the near future. This will require the collection of a variety of data across diverse scales, covering consumers, governments, and/or semi-private entities.
- A participant from Thammasat University, Thailand (hereafter, referred to as Thammasat) mentioned incorporating this energy resilience concept into urban planning. She also asked about indicators and criteria that could be useful to measure living standards, as urban planning and urban development policies focus on urban livelihoods.
  - SOMPO introduced the case of the Philippines, which developed an assessment tool for natural disasters several years ago. On the other hand, he expressed his belief that it is very difficult to evaluate randomly occurring natural disasters and that it is difficult to cover all energy infrastructure because they are not always located in one place. He added that the Philippine hazard system is owned and operated by the Philippine government and government agencies, and that information is consolidated into one system and made available to all citizens and the general public.

<u>Conclusion of the workshop</u>

- Japan is working with the Asia-Pacific region to expand the energy recovery scoring scheme globally and adjust regional scores in detail to address regional differences. In Thailand, some companies have stakeholders in other countries, and the policies of each country may affect decision-making on climate change adaptation. Therefore, it is necessary to consider incorporating policy elements into the scoring system.

3.3. Workshop in Indonesia

In the third workshop, the participants from Japan explained the concept and role of quantitative evaluation indicators for energy resilience and the results of the trial evaluation using the prototype model and introduced utilising climate and weather data in the quantitative evaluation of energy resilience. Following the presentation, the following points was discussed.

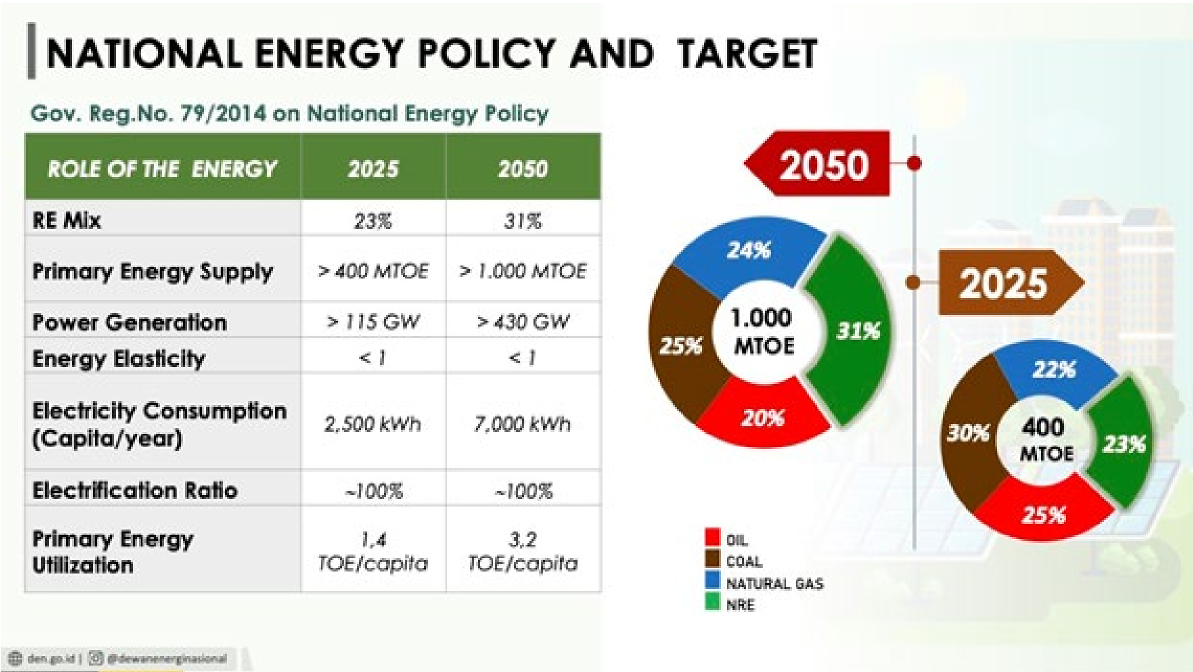
- What are the challenges of developing similar quantitative evaluation indicators for energy resilience in Indonesia?

The major discussions at the workshop were as follows.

- A participant from Indonesia's National Energy Council (hereafter, referred to as NEC) described the National Energy Policy in Indonesia and its related activities.
    - As Indonesia faces the global energy market, energy security is a priority. Indonesia uses the energy trilemma principle for implementing energy transition, balancing energy equivalence, energy security, and environmental sustainability. To be in line with its goals under its NDC and Just Energy Transition Partnership (JETP), Indonesia has a target of reaching a 23% share of renewables in the energy mix by 2025, but the current level is around 12.3%. Around 20.9 GW of renewable energy power plants will be developed through 2030 under the green PLN Electricity Supply Business Plan. Indonesia aims to reduce emissions by 358 million tCO_2 by 2030. This will involve phasing out coal power with peak emissions of 290 million tCO_2 in the power sector.
    - In the Indonesia Net Zero Emissions (NZE) roadmap, Indonesia has identified renewable energy development, energy efficiency, and fuel switching as important actions for climate change mitigation.
    - After 2030, no more coal-fired power plants will be developed, and a roadmap covering the early retirement of coal-fired power plants and market mechanisms is currently under development. Conversion from diesel power to gas will be carried out at 47 power plants (3,220 MW) and to renewable energy in 2,130 locations (500 MW). Biomass has been utilised for cofiring in 113 existing coal-fired power plants (19 GW). The government is also providing funds for drilling in 9 geothermal working areas with a total potential of 295 MW. It has also been considering advanced nuclear power technologies, including small modular reactors (SMR).
    - Energy management has been made mandatory in energy-intensive industries and high-performance buildings.

- ➢ Regulations on renewable energy have been established to provide attractive electricity tariffs, and the New and Renewable Energy Bill is expected to be amended in 2023. Indonesia recently launched the first phase of mandatory carbon trading for coal power plants with a capacity of at least 100 MW with an aim to reduce 36 million tCO_2 in 2030.
- ➢ In the oil and gas sector, 16 CCS/CCUS projects are currently being studied. These projects will need further technology and financial collaboration for implementation.
- ➢ In the transportation sector, B35 was implemented for biofuels in February 2023. The implementation of the electric vehicles programme is being accelerated, and incentives for electric motorcycles are being provided.
- ➢ The government also seeks to expand the Minimum Energy Performance Standards (MEPS) and mandatory energy management.
- ➢ Indonesia's National Energy Policy (Government Regulation No. 79/2014) and its targets are focused on reducing the use of fossil fuels, including petroleum, whilst forecasting an increase in energy supply.

Figure 5.3. National Energy Policy and Target



ROLE OF THE ENERGY	2025	2050
RE Mix	23%	31%
Primary Energy Supply	> 400 MTOE	> 1.000 MTOE
Power Generation	> 115 GW	> 430 GW
Energy Elasticity	< 1	< 1
Electricity Consumption (Capita/year)	2,500 kWh	7,000 kWh
Electrification Ratio	~100%	~100%
Primary Energy Utilization	1,4 TOE/capita	3,2 TOE/capita

Source: Ir. Sujatmiko (2023), 'Overview of Energy Resilience In The Indonesian Context', presentation material for the 3rd Workshop Meeting for Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region, 24 May.

- Fossil fuels account for almost 88% of Indonesia's energy mix. Indonesia produces 223,000 barrels of crude oil, which amounts to two-thirds of refinery intake needs. LPG imports amounted to 78.7% of domestic demand in 2022, which was mainly used in the household sector. 3,881 billion British thermal units per day (BBTUD), or 68% of the natural gas produced in Indonesia, is used domestically, mainly in the industrial and fertiliser sectors. Indonesia used 210 million tonnes of coal in 2022, mainly in the power generation sector. This accounted for 31.3% of domestic coal production, with the remainder exported.
- Availability, accessibility, affordability, and acceptability are the four key aspects for measuring energy resilience in Indonesia. Table 5.2 presents the indicators considered under each aspect. Each indicator is scored on a scale of 1 to 10. The overall resilience score has improved every year, reaching 6.61 in 2021.

Table 5.2. Energy Resilience Aspects and Indicators (Indonesia, re-posting)

Aspects	Indicators
C. Availability	A.1 Fossil energy reserves and productivity
	A.2 Energy imports
	A.3 National energy reserves
	A.4 Domestic energy supply
D. Accessibility	B.1 Electricity supply and service
	B.2 Fuel supply and service
	B.3 Supply and service of natural gas and LPG
C. Affordability	C.1 Energy price disparity
	C.2 Ratio of energy expenditures to income
	C.3 Energy subsidy
D. Acceptability	D.1 New and renewable energy percentage in the energy mix
	D.2 Energy intensity
	D.3 Carbon emission of energy sector

Source: Ir. Sujatmiko (2023), 'Overview of Energy Resilience in The Indonesian Context', presentation material for the 3rd Workshop Meeting for Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region, 24 May.

- Indonesia is faced with many challenges pertaining to securing energy resilience. These include insufficient capacity and reliability of refineries to meet domestic fuel and LPG demand, the impact of large disparities in fuel prices on increasing subsidies and the potential disruption of energy supply services, the unavailability of buffer stock, the low share of new and renewable energy (NRE), high reliance on energy imports, and decreasing crude oil production amid increasing fuel consumption trends.
- The Indonesian government issued recommendations for enhancing energy security in 2022. These included increasing new and renewable energy capacity, securing energy buffer stock, reducing LPG imports, and improving refinery capacity. The government seeks to accelerate the construction of new refineries and provide incentives for the expansion of energy infrastructure, including those for geothermal, biomass, solar, and nuclear power. Alternative means to replacing LPG include coal gasification, electric heaters, LNG, and CNG, which has yet to be commercialised. The government also seeks to reduce subsidies for commodities and direct more funds toward human development.

- ENTEC commented that policy changes due to a change of government could be a critical risk factor in Southeast Asia. He complemented the comment by saying that policy instability, including changes in policy, decisively impacts energy resilience. He also stated that policies to be implemented in the future should be considered and that their implementation should be ensured in order to secure energy resilience. He added that not only domestic policy but also policies in other countries could have a large impact as energy is often imported in the ASEAN region, and energy imports are reliant on the economic activities of international companies.
    - SOMPO responded that it is difficult to incorporate all risk in energy resilience scoring and that the current scope of regional scoring, comprising of natural hazards, was developed based on discussions with Japanese energy suppliers, including electric power and gas suppliers.
    - WNI referred to a controversial comment made at the previous workshop, where a participant pointed out that policy implementation systems tend to be rigid and vertical, or based on a silo process, and that they should be changed to be more flexible. He agreed that energy systems are not necessarily confined within a single country, and national policies affect the energy resilience of other nations. Therefore, although the current regional scoring scheme only considers the local climate, it may be necessary to incorporate different climates in different energy systems in other countries depending on the energy system's

degree of reliance on other countries. In the future, we may need to explore how much international consideration is necessary in regional scoring.

  - NEC commented that Indonesia, located in a monsoon climate zone, measures impacts based on the number of infrastructure disruptions. The cost of these disruptions is yet to be assessed, so the next steps could include cost assessment of each climate hazard.
  - IEEJ commented that one of the aims of implementing an energy resilience scoring model is to balance cost and benefit. The Japanese scoring scheme is being developed with a view of using it in the private sector. For example, it can be used to provide guidance to financial institutions when determining lending rates or insurance premiums.

- ERIA asked how different scoring schemes, including the scheme introduced earlier by NEC, would be considered in the proposed scheme and how the optimal resolution would be defined. He stated that a high-resolution assessment would be optimal to define the regional features of different islands. However, he also pointed out how a wider area covering different islands could face the same threat, citing the example of how heavy rainfall affected coal production in Kalimantan, thus disrupting the coal supply from Kalimantan to Java.
  - NEC responded that when climate and energy supply trends are similar across a given area, then low resolution would be sufficient. He also pointed out that the scoring scheme also considered consumer-side aspects. He mentioned that Weathernews' data are based on high resolution.
  - ERIA emphasised that the optimal resolution level was an issue that required further discussion for efficient scoring.
- IEEJ highlighted that a key word in future work would be 'standardisation.' APEC defined the importance of standardisation and international cooperation on indexing based on energy demand and supply infrastructure. Whilst consideration of regional differences is important, it is also important to identify commonalities in order to develop common metrics. Standardisation will involve the consolidation of different concepts and may require a long time.
- NEC pointed out that the proposed scoring scheme only considered given hazards and factors and asked how the regional scoring could be adjusted when the scheme does not include components relevant to a given region.

- SOMPO responded that if there are other hazards or factors that are important to a region, they should be added in order to ensure the comprehensiveness of the scheme.

Conclusion of the workshop

- Availability, accessibility, affordability, and acceptability are the four key aspects for measuring energy resilience in Indonesia. It is possible to consider different types of scoring schemes using the proposed ERS scheme from Japan, but the challenge is how the optimal data resolution will be defined.

Chapter 6

Challenges to be Addressed

1. General

In this project, an empirical evaluation of the ERS was conducted using the prototype ERS model. The concept and results were shared with the participants of the workshops, and discussions were held at the initial stage to consider the specific feasibility of application in each country.

Through the demonstration evaluation using the prototype ERS model and discussions at the workshops, the challenges of the ERS model and the points for improvement for future use were clarified. Key challenges and improvements related to the ERS model include the following issues.

2. Refinement of Scoring

Build a higher level and more homogeneous platform by implementing the current scoring process in various countries, regions, and across numerous infrastructures and companies.

Scoring models need to be developed that fully consider a country or region's energy master plans. For example, the energy type to be supplied should be evaluated in line with the energy master plan.

3. Fine-tuning According to Countries and Regions

3.1. Regional Scores (Climate Scores)

This time, Japan was selected as the target country for demonstration evaluation by the ERS model, the evaluation of regions is focused on 'earthquakes, floods, typhoons, etc.' as weather conditions that have a particularly large impact on energy resilience in Japan. However, since the environment differs from country to country and region to region, it is necessary to determine which hazards, etc. should be selected for each country and region targeted for evaluation. For example, droughts, heavy snowfall, wildfires, landslides, blizzards, and eruptions could be included as candidates for evaluation.

3.2. Regional Scores (Future Perspective)

It is common for the development of energy infrastructure and the scale of energy demand in a region to change over time due to changes in population and economic structure. Therefore, it is important to consider the time horizon when evaluating the ERS. Even if the ERS at the time of evaluation is evaluated as high and it is judged that investment in energy infrastructure is not necessary, it is conceivable that the ERS will decline as energy demand increases after the evaluation, and a shortage of energy infrastructure will become apparent.

Similarly, it is necessary to pay attention to how local energy policies and laws will transform the energy system in the future. For example, the strengthening of climate change policy measures will be a factor in changing the energy supply structure (energy mix), and the ERS may also be affected. On the other hand, even if energy policies are strengthened, the impact on the energy supply/demand structure may be minor because the traditional culture and lifestyle of the region will be maintained in the future.

Considering the future potential of the area to be evaluated, it is necessary to decide whether to implement a score that considers outlooks for changes in the environment of energy supply/demand or conduct a review every few years to reflect the relevant factors at that time.

4. Potential for Utilisation in the Private Sector

Resilience assessments for energy resilience enhancement need to be used by the private sector, particularly in the financial sector, to expand their business. It is expected that the effective use of resilience assessments by the private sector will induce the following activities of private companies and national/local governments.

- Investment and financing based on the evaluation, especially interest rates and terms (financial institutions, etc.).
- Investments to improve valuations (financial institutions and investment companies).
- Investments in local development and large orders (financial institutions, construction companies, and real estate companies).
- Capital investments to improve the rating (financial institutions, equipment manufacturers, energy companies, automobile manufacturers, telecommunications companies, online companies, and consulting firms).
- Legislation and infrastructure to improve energy resilience (national and local governments, construction companies, and public transportation companies, etc.).

Chapter 7

Expected Future Work Regarding the ERS

1. Expectations for the ERS

Investment in enhancing energy resilience is a medium-to-long-term initiative that improves the economic stability of regions and corporations, and it must continue to evolve as changes occur in the natural and living environments.

It is also necessary to visualise the investments required to improve the linkages between main networks and distributed systems under normal conditions and the resilience and speed of energy systems recovery in the event of natural disasters, as well as the effects of such investments.

By visualising these issues, they will be recognised as even more important social issues, and challenges that need to be solved by the entire region, such as infrastructure, will inevitably arise. Moreover, it is necessary to evaluate each entity to resolve how much effort is required, where the limit is, and how much cost should be spent, and to share this evaluation nationally and internationally.

In addition, the scoring should not be abstract. The results of the scoring should be compiled into big data statistics so that we can understand where we stand globally, regionally, and in our industry. By knowing where we stand, we can make more concrete efforts and investments to continue to improve, thereby increasing the sustainability and resilience of our local economies and communities.

Furthermore, the utilisation of digital technology is essential for such initiatives, and AI technology is particularly expected to identify individual weaknesses, compare them with companies with high evaluations, and show specific improvement points, not just evaluations. In addition, advanced digital twin technology can express future occurrences with specific examples, making it possible to understand the effects (costs and benefits) of investment that have been impossible until now.

National and local governments, energy supply and demand companies, companies that provide solutions for both hardware and software, and stakeholders in the financial sector need to act by recognising the system and management for strengthening energy resilience and their own roles. The goal is to build an international platform for sharing initiatives and best practices amongst countries and entities and promote efforts to enhance energy resilience not only in specific countries and regions but also worldwide. The evaluation of energy resilience is expected to lead to a stable energy supply and stable development of the regional economies.

2. Expected Future Work Related to the ERS System

2.1. Improving the Usability of the ERS Evaluation System

The prototype ERS system that was used in this project considers heavy rain, strong wind, earthquakes, and floods, which are key climate hazards in Japan. However, other hazards, such as drought, may be more significant in other regions. To accurately evaluate the resilience of energy infrastructure against hazards, the hazards that these systems will be most likely be exposed to should be considered.

Different hazard components covering a wide range of climate and geophysical hazards as well as man-made hazards have been considered across existing assessments. These may need to be considered when fine-tuning the proposed scoring scheme to meet regional needs. Components may be prioritised based on the magnitude of the damage caused by each hazard, future projections, or the scale of disruptions experienced by energy systems. Table 7.1 offers a list of the different components considered in existing international initiatives and assessments of natural and man-made hazards in both the public and private sectors.

Table 7.1. Components of Hazards in Existing Indices

Events		UNDRR*1	INFORM*2	AON*3
Natural hazards[29]	Earthquake	✓	✓	✓
	Tsunami	✓	✓	✓
	Volcanic eruption	✓		
	Flood (fluvial/pluvial)	✓	✓	✓

[29] The World Meteorological Organization (WMO) defines natural hazards to be severe and extreme weather and climate events and includes drought, tropical cyclones, air pollution, desert locusts, floods and flash floods, landslides and mudslides (mudflow), avalanches, duststorms/sandstorms, thermal extremes, thunderstorms, lighting and tornadoes, forest and wildland fires, heavy rain and snow, and strong winds. Some National Meteorological and Hydrological Services and specialised centres have responsibility for investigating geophysical hazards, including volcanic explosions and tsunamis and hazardous airborne matter and acute urban pollution (https://public.wmo.int/en/our-mandate/focus-areas/natural-hazards-and-disaster-risk-reduction).

Events		UNDRR*1	INFORM*2	AON*3
	Tropical cyclone	✓	✓	✓
	Severe connective storm			✓
	Windstorm			✓
	Hail			✓
	Storm surge			✓
	Freeze			✓
	Drought	✓	✓	
	Bushfire			✓
Man-made hazards	Conflict intensity		✓	
	Projected conflict intensity		✓	
	Terrorism			✓
	Workers' compensation			✓

Notes:

*1 The UN Office for Disaster Reduction (UNDRR)'s Global Assessment Report (GAR) Risk Data Platform (https://risk.preventionweb.net); *2 The Index for Risk Management (INFORM) is a composite indicator developed by the Joint Research Center (JRC) as a tool for understanding the risk of humanitarian crisis and disasters and provides the scientific basis for various EU policy initiatives; *3 AON (2022) highlights the global natural disasters of 2022, which were covered by insurers to help quantify and qualify how topics such as climate change, socioeconomics, and other emerging issues influence catastrophe risk.

Source: Compiled for various sources as indicated in the table notes.

A similar issue exists in energy supply-side scoring. As the energy transition advances across economies, the diversification of energy sources will not necessarily involve having a fossil fuel-powered system as a backup to electric power. The energy supply-side scoring formula may need to take into consideration a wider range of means of diversifying supply. As indicated at the workshop held in Indonesia, different regions or islands may rely on different energy sources. It is important to consider whether to reflect these regional features in the scoring scheme.

From the above, it is necessary to develop a structure that encompasses a wider and more diverse range of disaster risk indicators for energy supply sectors and the demand sector in the development of ERS assessment systems in the future. As a result, usability can be increased by countries with diverse geographical, climatic, and energy supply/demand structures. In order to achieve this, it will be useful to increase the number of opportunities for evaluation using the ERS evaluation system in the early stages, and to share and promote the ERS system structure and evaluation results with stakeholders in various countries, regions, and industries.

2.2. Promote Collaboration of Data Collection for ERS Evaluation

In Chapter 4, it was pointed out that data collection other than public information to evaluate the ERS is a challenge. When evaluating general consumers (applying to various countries and regions) in the future, it may be difficult to collect evaluation information from publicly available data on the supply-side companies (electricity, gas, and oil) used by such consumers, and it is necessary to consider how to collect data for evaluating the ERS.

To increase the availability of data collection, it is necessary to improve understanding of the content and significance of the ERS, as well as its benefits to consumers. It is necessary to increase the accumulation of empirical results using the ERS evaluation tool in many countries and regions, and to continuously create opportunities for sharing and improving understanding of ERS through discussions amongst stakeholders. These efforts require cooperation not only between individual companies but also between regions and countries.

2.3. Accumulation of scoring data

The scoring data need to be accumulated and analysed by one of the institutions or organisations. If there are a large number of organisations providing indicators, it can be difficult to determine which organisation's indicators should be adopted, making them difficult to use, especially from a business standpoint. Although scoring data may differ by country, region, and subject to be evaluated, it is necessary to collectively manage, analyse, research, and disclose the data for the following reasons.

(1) Data management

When similar scorings occur in many countries around the world, it becomes unclear how reliable they are and which one to select, so it is necessary to collectively manage them. It is also desirable to unify evaluation organisations as much as possible.

(2) Data analysis

Centralisation of scoring data is useful for many analyses and future developments, such as analysis within the same industry and improvement of scoring.

(3) Research

By centralisation of scoring data, for example, the data can be used to conduct significant research on regions, countries, companies, and industries with high resilience, showing why they have high resilience and how to improve resilience. The results can then be used to provide knowledge and services to improve the resilience of countries and regions.

2.4. Standardisation of Reliable and Comparable Data

Fine-tuning the energy resilience scoring scheme to local circumstances will require the consideration of a diversity of indices, as discussed above. Whilst considering regional differences is important, it is also important to identify commonalities in order to develop common metrics to be used across different countries and nations based on a shared understanding of the definition and scope of hazards.

As mentioned, APEC has defined the importance of standardisation and international cooperation on energy resilience indexing based on energy demand and supply infrastructure. As detailed in Chapter 2, initiatives are being taken in the APEC forum to develop general and sectoral guidelines on energy resilience. The standardisation of indices will be the next step, and this will involve the consolidation of different metrics developed in various contexts.

The selection of reliable and comparable data for each hazard type will be a challenge as different public and private entities collect data based on different temporal and special scales. Data collected and assessed by global entities with wide coverage should ideally be chosen when available. However, significant disaster risk information gaps exist even at the national level. Whilst international initiatives have advanced the implementation of early warning systems and preparedness as climate adaptation measures, only half of the countries worldwide report having adequate multi-hazard early warning systems. Less than half of the countries with existing early warning systems have access to appropriate disaster risk information, and even fewer have national legislation and regulatory frameworks for emergency response.[30]

[30] WMO (n.d.), 'Early Warnings for All' (https://public.wmo.int/en/earlywarningsforall).

As a solution to such problems, the use of (international) standards can be considered. It is conceivable that data on natural disasters and energy system vulnerabilities necessary for ERS assessment will be standardised, and reliable and comparable data can be collected by different countries, regions, and companies, etc. The collection of data based on common definitions and measures is expected to promote collaboration and cooperation amongst countries and regions to strengthen energy resilience.

Appendix 1

Contents of the APEC Energy Resiliency Principle and Guidance[31]

A.1. Structure of the Principle

APEC Energy Resiliency Principle

I. Background and Purpose of the principle

Description of the background and purpose of the development

II. Definition of energy resiliency

III. Respect for diversity among economies, holistic approaches and multi-stakeholder processes

Description of the "diversity principle" relating the contents of the Principle

IV. Relevant stakeholders and their roles to enhance energy resiliency

- Governments
- Energy supply industries
- Industrial and general energy consumers
- Financial institutions

Identification relevant stakeholders and description of their roles taking into action for enhancement of energy resiliency

V. Common approaches among different stakeholders towards energy resiliency

- Energy resiliency plans
- Investment and financing to projects towards energy resiliency
- Proper asset management
- Emerging technologies adoption
- Multi-stakeholder knowledge sharing

Description of major common approaches for enhancement of energy resiliency

VI. Follow-up actions based on the principle in EWG/ERTF

[31] This Appendix describes the key content of the APEC Energy Resiliency Principle and is not official guidance from APEC.

A.2. Major Content for Enhancement of Energy Resiliency

(1) Respect for diversity among economies, holistic approaches and multi-stakeholder processes

[Text of the Principle]

- *Member economies and related organizations should respect the diversity of efforts among member economies, holistic approaches from the supply-side to the demand-side, and multi-stakeholder processes with all relevant sectors including energy industries, industrial and general consumers, financial institutions, governments and other related organizations.*
- *The principle covers a whole framework and a comprehensive set of factors and initiatives that contribute to improving energy resiliency to disasters. APEC member economies may select and implement the initiatives relevant to each economy's situation.*

This Principle recognises the diversity of the APEC member economies' energy infrastructure and respects all initiatives in cooperation with relevant stakeholders. For this reason, the APEC economy can select and implement initiatives to strengthen energy resilience according to its own circumstances.

(2) Relevant Stakeholders and Their Roles to Enhance Energy Resiliency

(a) Governments

- *Governments should implement initiatives including enacting, amending and abolishing energy-related regulations to support private actors in enhancing energy resiliency.*
- *Governments should besides establish standards and guidance so that energy supply industries and industrial energy consumers can formulate energy resiliency plans that may contain disaster prevention and reduction, restoration, building back better and information sharing.*

One of the relevant stakeholders for the enhancement of energy resilience is governments (including local governments), which provide specific support measures for private actors to strengthen energy resilience. Governments' key role is to develop standards and guidance for private actors to develop energy resilience plans.

(b) Energy Supply Industries

> - *Energy supply industries should implement initiatives including formulating and implementing energy resiliency plans, diversifying sources of energy supply in terms of fuel types, supplier types, geography and distribution.*
> - *Energy supply industries should besides increase ratio of self-sufficient energy sources, technologies and facilities, introduce grid system integration technologies of variable renewable energy (VRE), secure and store sufficient energy reserves and power generation equipment/facilities in case of disasters.*
> - *Energy supply industries should further increase efficiency of water use in energy supply and utilisation processes, ensure electric redundancy through flexible transmission and distribution systems with wide-area power interchanges, interconnections, loop-systems, multiple connections, double-tracking and power-grid stabilisers, and introduce demand response (DR) system to manage and control energy demand, and thereby well preparing and responding to disasters with all initiatives above.*

Energy supply industries, including petroleum products, electricity and gas, should develop and implement plans to strengthen energy resilience. Amongst them, it is important to secure energy supply in the event of a disaster by improving the energy self-sufficiency rate and strengthening the grid system accompanying the introduction of renewable energy. In addition, energy management systems utilising various technologies should be prepared to respond in the event of a disaster.

(c) Industrial and General Energy Consumers

> - *Industrial and general energy consumers should implement initiatives including formulating and implementing energy resiliency plans, securing and storing additional energy reserves, and deploying distributed energy resource (DER) systems and technologies including in-house power generation, cogeneration, and micro-grid systems.*

This principle identifies energy customers as key stakeholders in strengthening energy resilience and recommends that these energy customers formulate plans to strengthen their own energy resilience and introduce appropriate equipment and technologies in addition to the energy supply sector.

(d) Financial Institutions

> ➢ *Financial institutions should implement initiatives including positively evaluating investing and financing both public and private projects that contribute to enhancement of energy resiliency of member economies.*

The characteristic of this principle is that financial institutions are positioned as important stakeholders in the enhancement of energy resilience in the APEC economies. Assessment of, investment in, and financial support for financial institutions' efforts to strengthen energy resilience are recommended.

(3) Common Approaches Amongst Different Stakeholders Towards Energy Resiliency

(a) Energy Resiliency Plans

> ➢ *Stakeholders should investigate and evaluate their energy-related situation and formulate plans to deal with disasters. Stakeholders should review and amend the plans continuously taking recent technological advancements into consideration.*

(b) Investment and Financing to Projects Towards Energy Resiliency

> ➢ *Stakeholders should actively invest and finance projects that contribute to enhancing energy resiliency in each economy. In addition to post-disaster response and recovery, prior investment to address underlying risk factors is essential in enhancing energy resiliency, as noted in the 'Sendai Framework for Disaster Risk Reduction 2015-2030' adopted at the 3rd United Nations world conference on disaster risk reduction in 2015.*
>
> ➢ *Stakeholders should appropriately evaluate contribution of invested and financed projects to energy resiliency in addition to projects' profitability. From that perspective, indices and matrices to properly measure levels of contribution to energy resiliency should be established as well as building mechanisms for private companies to disclose relevant information to financial institutions.*

In the effort to strengthen energy resilience, it is recommended to actively invest in disaster response and recovery and reduce risks to energy infrastructure. In order to make such investment decisions, it is essential to develop relevant indicators for appropriately evaluating the cost-effectiveness of investments, and it is essential to establish a system for disclosing established indicators and related information from private companies to financial institutions.

(c) Proper Asset Management

> - *Stakeholders should introduce asset management systems to balance cost, risk and performance of energy resilient infrastructure. As the ISO 55000 explains, proper installation, management and renewable cycles of assets are critical in sustaining a stable energy supply and to attract various finance sources, thereby enhancing the energy resiliency of each economy.*

In order to strengthen and maintain each stakeholder's energy resilience, it is recommended to build an appropriate asset management system from the viewpoint of evaluating cost effectiveness. The ISO 55000 series could be referred to for building specific asset management systems. (The ISO 55001 management system provides a framework for establishing asset management policies, objectives, processes and governance, and facilitates an organisation's achievement of its strategic goals. ISO 55001 utilises a structured, effective, and efficient process that drives continual improvement and ongoing value creation by managing asset-related cost, performance and risk.[32])

(d) Emerging technologies adoption

> - *Stakeholders should fully consider and adopt cutting-edge energy technologies including more accurate weather and disaster forecasts and other base technologies including Artificial Intelligence (AI) and Internet of Things (IoT).*
> - *Stakeholders should collaborate to advance new technologies and to secure public and private investment and loans to those technologies towards developing a more resilient energy system.*
> - *Stakeholders should fully consider and take actions to maintain cyber security for energy systems when adopting new information communication technologies.*

In formulating and implementing energy resilience plans, stakeholders are expected to make more accurate predictions about disasters, etc., and to enhance their effectiveness by utilising cutting-edge information-related technologies. In particular, when utilising information technology, stakeholders are required to strive to strengthen and maintain cyber security.

[32] https://committee.iso.org/home/tc251

(f) Multi-stakeholder Knowledge Sharing

> - *Stakeholders should take voluntary measures at all levels. Effective efforts are encouraged to be shared among stakeholders both within economies as well as globally.*

All actions set out in this principle are assumed to be implemented as voluntary measures (rules will not be set in APEC). It is recommended that effective examples of actual efforts contribute to improving energy resilience not only in the APEC area but also internationally. For example, it is possible to implement international standardisation in ISO, etc., by utilising guidelines created based on this Principle and best practices in APEC economies.

(4) Follow-up Actions Based on the Principle in EWG/ERTF

> - *Establish detailed guidelines to support formulation of energy resiliency enhancement plans in APEC member economies. The guidelines would be different depending on stakeholder types, would include a set of indices to evaluate what kind of initiatives could better improve energy resiliency, and would include a set of existing best practices as references for member economies.*
> - *Develop tools to better evaluate risk and vulnerability to disasters. Mutually share experiences related to investment, plans and concrete measures on disaster prevention, response and recovery.*
> - *Offer training programs to support implementation of the principle, the guidelines and tools in member economies.*

Appendix 2

Workshop Agenda

1st Workshop Meeting for

Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region

Thursday, 17 November 2022 | 13:00 - 15:00 ICT (UTC+0700)

CRIEPI, Tokyo, Japan

Hybrid Workshop

Hosted by Economic Research Institute for ASEAN and East Asia (ERIA)

Agenda

13:00 – 13:10 **Opening Address**

by **Mr. KUDO Hiroki**, Board Member, Director, Charge of Electric Power Industry & New and Renewable Energy Unit, IEEJ (in person)

13:10 – 13:15 **Group Photo**

13:15 – 14:15 **Quantitative evaluation indicators for energy resilience: concept, significance and aims**

by **Mr. UMEYAMA Goro**, Social and Public Sector Group Leader, BCM Consulting Department, SOMPO Risk Management Inc. (SOMPO RM) (online)

with

Mr. SUZUKI Takamune, Climatenews project, Project Leader, Weathernews Inc. (WNI) (online) on

Utilizing climate and weather data in the quantitative evaluation of energy resilience

14:15 – 14:45 Discussion

led by Mr. KIMURA Akihiro, Senior Coordinator, Electric Power Industry & New and Renewable Energy Unit, IEEJ (in person

Guiding questions:

1. *What are the challenges of developing similar quantitative evaluation indicators for energy resilience in other Asian countries?*
2. *Which countries can be starting points?*

14:45 – 14:50 Q&A and Wrap-up

led by Mr. KIMURA Akihiro, Senior Coordinator, Electric Power Industry & New and Renewable Energy Unit, IEEJ (in person)

14:50 – 14:55 Closing Remarks

by Dr. Alloysius Joko Purwanto, Energy Economist, Energy Unit, Research Department, ERIA (online)

2nd Workshop Meeting for

Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region

Tuesday, 25 April 2022 | 9:00 - 11:00 ICT (UTC+0700)

Bangkok, Thailand

Hybrid Workshop

Hosted by the Economic Research Institute for ASEAN and East Asia (ERIA)

Agenda

9:00 – 9:20	**Opening Address**
	by **Mr. KUDO Hiroki**, Board Member, Director, Charge of Electric Power Industry & New and Renewable Energy Unit, IEEJ (online)
	and
	by **Dr. Nuwong CHOLLACOOP**, Research Group Director,
	Low Carbon, Energy Research Group, ENTEC
9:20 – 9:25	**Group Photo**
9:25 – 9:40	**Overview of energy resilience and putting it in the Thai context**
	by **Dr. Kampanart SILVA,** Researcher, ENTEC
9:40 – 10:25	**Quantitative evaluation indicators for energy resilience: concept, significance, aims, Pilot Study and Issues**
	by **Mr. UMEYAMA Goro**, Social and Public Sector Group Leader, BCM Consulting Department, SOMPO Risk Management Inc. (SOMPO RM) (online)
	with
	Mr. SUZUKI Takamune, Climate Tech Department, Leader, Weathernews Inc. (WNI) (online) on
	Utilizing climate and weather data in the quantitative evaluation of energy resilience

10:25 – 10:50 **Discussion**

led by **Mr. KIMURA Akihiro**, Senior Researcher, Electric Power Industry & New and Renewable Energy Unit, IEEJ

Guiding question:

What are the challenges of developing similar quantitative evaluation indicators for energy resilience in Thailand?

10:50– 10:55 **Q&A and Wrap-up**

led by **Mr. KIMURA Akihiro**, Senior Coordinator, Electric Power Industry & New and Renewable Energy Unit, IEEJ

10:55 – 11:00 **Closing Remarks**

by **Dr. Alloysius Joko Purwanto**, Energy Economist, Energy Unit, Research Department, ERIA (online)

3rd Workshop for

Study on Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience

in East Asia Region

Wednesday, 24 May 2023 | 13:00 - 15:10 ICT (UTC+0700)

Meeting rooms 3 & 4 at ERIA Office,

Jakarta, Indonesia

Hosted by the Economic Research Institute for ASEAN and East Asia (ERIA)

Agenda

13:00 – 13:10 **Opening Address**

by **Indonesian Government**

by **Mr. KUDO Hiroki**, Board Member, Director in Charge of Electric Power Industry & New and Renewable Energy Unit, IEEJ

13:10 – 13:15 **Group Photo**

13:15 – 13:30 **Overview of energy resilience in the Indonesian context**

13:30 – 14:05 **Quantitative evaluation indicators for energy resilience: concept, significance, aims, Pilot Study and Issues**

by **Mr. UMEYAMA Goro**, Social and Public Sector Group Leader, BCM Consulting Department, SOMPO Risk Management Inc. (SOMPO RM) (online)

with

Mr. SUZUKI Takamune, Leader, Climate Tech Department, Weathernews Inc. (WNI) (online) on

Utilizing climate and weather data in the quantitative evaluation of energy resilience

14:05 – 14:20 **Coffee Break**

14:20 – 15:00 **Discussion**

led by **Mr. KIMURA Akihiro**, Senior Researcher, Electric Power Industry & New and Renewable Energy Unit, IEEJ

Guiding question:

What are the challenges of developing similar quantitative evaluation indicators for energy resilience in Indonesia?

15:00– 15:05 **Q&A and Wrap-up**

led by **Mr. KIMURA Akihiro**, Senior Researcher, Electric Power Industry & New and Renewable Energy Unit, IEEJ

15:05 – 15:10 **Closing Remarks**

by **Dr. Alloysius Joko Purwanto**, Energy Economist, Energy Unit, Research Department, ERIA

Appendix 3

Workshop Participants List

1st Workshop

Participants List

Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region

CRIEPI, Tokyo, Japan / Hybrid Meeting

November 17, 2022

No	Country/ Organization	Participation	Status	Name	Position	Department	Organization
1	ERIA	Online	Organizer	Alloysius Joko Purwanto	Energy Economist	Energy Unit, Research Department	Economic Research Institute for ASEAN and East Asia (ERIA)
2	ERIA	Online	Organizer	Citra Endah Nur Setyawati	Research Associate	Energy Unit, Research Department	Economic Research Institute for ASEAN and East Asia (ERIA)
3	IEEJ	In-person	Project Leader	KUDO Hiroki	Board Member, Director in charge of	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
4	IEEJ	In-person	Project Member	KIMURA Akihiro	Senior Coordinator	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
5	IEEJ	In-person	Project Member	YOSHIDA Masato	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
6	IEEJ	In-person	Project Member	NAKAMURA Hiroko	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
7	CRIEPI	In-person	Secretariat of Energy Resilience Score Committee	BANDO Shigeru	R&D Manager	Kanagawa Prefecture	Central Research Institute of Electric Power Industry (CRIEPI)
8	CRIEPI	In-person	Secretariat of Energy Resilience Score Committee	TAKAHASHI Masahito	Senior research scientist	Grid innovation research lab and Socio economic research center	Central Research Institute of Electric Power Industry (CRIEPI)
9	SOMPO RM	Online	Secretariat of Energy Resilience Score Committee	UMEYAMA Goro	Chief Consultant	BCM Consulting Department	SOMPO Risk Management Inc. (SOMPO RM)
10	CRIEPI	In-person	Secretariat of Energy Resilience Score Committee	MITSUI Hirotaka	general manager	interdivision project office	Central Research Institute of Electric Power Industry (CRIEPI)
11	WNI	Online	Secretariat of Energy Resilience Score Committee	SUGIYAMA Noriyuki	Data Scientist	Climate Tech.	Weathernews Inc. (WNI)
12	WNI	Online	Member of Energy Resilience Score Committee	SUZUKI Takamune	Manager	Climate Tech Division	Weathernews Inc. (WNI)
13	IEEJ	In-person	Coordinator	MAEKAWA Kiminori	Senior Research Fellow, Manager	International Cooperation Group, Fossil Energies & International Cooperation Unit	The Institute of Energy Economics, Japan (IEEJ)
14	IEEJ	In-person	Assistant Coordinator	IWABUCHI Yu	Clark	International Cooperation Group, Fossil Energies & International Cooperation Unit	The Institute of Energy Economics, Japan (IEEJ)
15	IEEJ	In-person	Assistant Coordinator	USUI Emi	Clark	International Cooperation Group, Fossil Energies & International Cooperation Unit	The Institute of Energy Economics, Japan (IEEJ)
16	IEEJ	Online	Assistant Coordinator	YOSHIDA Mari	Senior Clark	International Cooperation Group, Fossil Energies & International Cooperation Unit	The Institute of Energy Economics, Japan (IEEJ)


Noriyuki Sugiyama
Joko Purwanto
IEEJ AKIHIRO KIMURA
Masato Yoshida_IEEJ
Masahito Takahashi
IEEJ_Hiroki Kudo
Shigeru Bando_CRIEPI
Goro Umeyama
weathernews_Suzuki
Hiro Mitsui
IEEJ Hiroko Nakamura

2nd Workshop

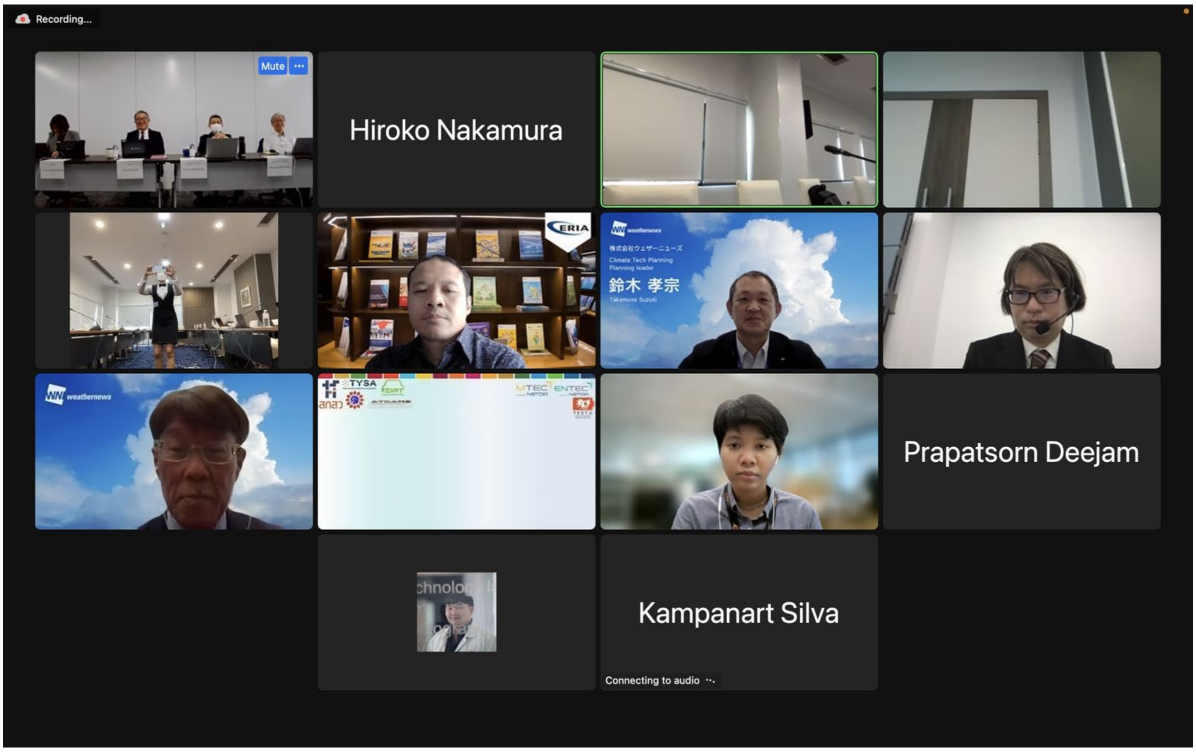
Participants List

Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region

Arnoma Grand, Bangkok, Thailand / Hybrid Meeting

April 25, 2023

No	Country/ Organization	Participation	Status	Title	Name	Position	Department	Organization
1	ERIA	Online	Organizer	Dr.	Alloysius Joko Purwanto	Energy Economist	Energy Unit, Research Department	Economic Research Institute for ASEAN and East Asia (ERIA)
2	IEEJ	In-person	Project Member	Mr.	Akihiro KIMURA	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
3	IEEJ	In-person	Project Member	Mr.	Kentaro HAYASHI	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
4	IEEJ	Online	Project Leader	Mr.	Hiroki KUDO	Board Member, Director	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
5	IEEJ	Online	Project Member	Ms.	Hiroko NAKAMURA	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
6	SOMPO RM	Online	Secretariat of Energy Resilience Score Committee	Mr.	Goro UMEYAMA	Chief Consultant	BCM Consulting Department	SOMPO Risk Management Inc. (SOMPO RM)
7	SOMPO RM	Online	Secretariat of Energy Resilience Score Committee	Mr.	Takeshi KUWABARA	Senior Consultant		SOMPO Risk Management Inc. (SOMPO RM)
8	WNI	Online	Secretariat of Energy Resilience Score Committee	Mr.	Noriyuki SUGIYAMA	Data Scientist	Climate Tech.	Weathernews Inc. (WNI)
9	WNI	Online	Member of Energy Resilience Score Committee	Mr.	Takamune SUZUKI	Manager	Climate Tech Division	Weathernews Inc. (WNI)
10	Thailand	In-person		Assoc Prof Dr.	Wijitbusaba Marome	Lecturer/director	Urban policy and planning	Thammasat University
11	Thailand	In-person			Pakpoom Buabthong	Lecturer		Nakhon Ratchasima Rajabhat University
12	Thailand	In-person			Apimuk Maharungruangrat	Technical Assistant	Low Carbon Policy and Technical Support Office	Thailand Greenhouse Gas Management Organization
13	Thailand	In-person			Thiti Ratchadatikun	Plan and Policy Analyst	Strategy and Planning Division	Department of Alternative Energy Development and Efficiency
14	Thailand	In-person			surin maneevitjit	VP issuer & listing 4		The Stock Exchange of Thailand
15	Thailand	In-person			Chanwit Kongklew	Project Coordinator	Policy and Strategy Section	Natural Resources and Environmental Policy and Planning
16	Thailand	In-person			Nuwong Chollacoop	Director	Low Carbon Energy Research Group	National Energy Technology Center
17	Thailand	In-person		Dr.	Kampanart Silva	researcher	Renewable Energy and Energy Efficiency Research Team	National Energy Technology Center
18	Thailand	In-person		Mr.	Khemrath Vithean	Research Assistant	Renewable Energy and Energy Efficiency Research Team	National Energy Technology Center
19	Thailand	In-person		Dr.	Pidpong Janta	Research Assistant	Renewable Energy and Energy Efficiency Research Team	National Energy Technology Center
20	Thailand	In-person			Theerapat Khamnuanthip	Environmentalist, Professional Level	Climate Measure and Mechanism Development Section	Natural Resources and Environmental Policy and Planning
21	Thailand	In-person			Chatchai Karuna	Engineer	Energy research	Department of Alternative Energy Development and Efficiency (DEDE)
22	Thailand	In-person			Ms. napason pattanatongkul	Research Assistant	Renewable Energy and Energy Efficiency Research Team	National Energy Technology Center
23	Thailand	In-person			Nopparada Sutthichackr	electrical engineer	Structural Engineering and System Bureau	Department of Public Works and Town & Country Planning (DPT)
24	Thailand	In-person			Ananya Nampan	electrical engineer	structural engineering and system bureau	Department of Public Works and Town & Country Planning
25	Thailand	Online		Ms.	Tippawan Photiwat	Environmentalist, Professional Level	Climate Change Management and Coordination	ONEP
26	Thailand	Online		Ms.	Prapatsorn Deejam	Environmentalist, Practitioner Level	Climate Change Management and Coordination	ONEP
27	IEEJ	Online	Project Assistant Staff	Ms.	Miho NOGAI	Cief Clerk	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)


Recording...
Hiroko Nakamura
Prapatsorn Deejam
Kampanart Silva
Connecting to audio

3rd Workshop

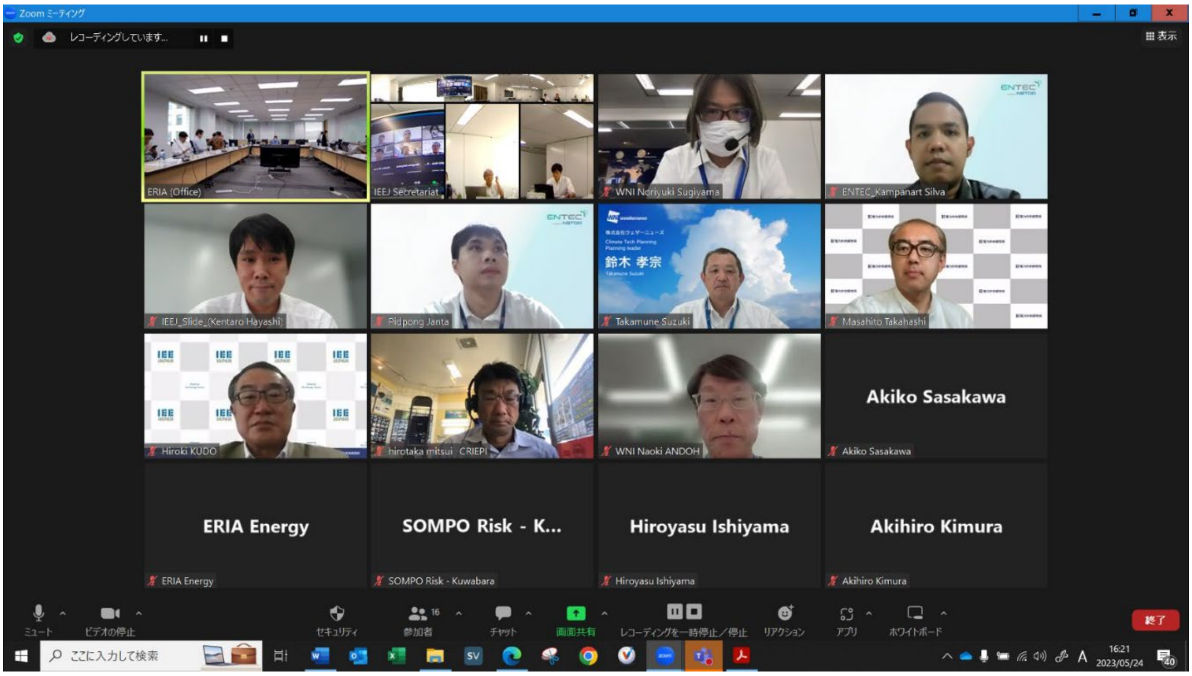
Participants List

Study for Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in East Asia Region

ERIA Meeting Room / Hybrid Meeting

May 24, 2023

No	Country/ Organization	Participation	Status	Title	Name	Position	Department	Organization
1	ERIA	In-person	Organizer	Dr.	Alloysius Joko Purwanto	Energy Economist	Energy Unit, Research Department	Economic Research Institute for ASEAN and East Asia (ERIA)
2	ERIA	In-person	Organizer	Mr.	Ryan Wiratama Bhaskara	Research Associate	Energy Unit, Research Department	Economic Research Institute for ASEAN and East Asia (ERIA)
3	ERIA	In-person	Organizer	Mrs.	Citra Endah Nur Setyawati	Research Associate	Energy Unit, Research Department	Economic Research Institute for ASEAN and East Asia (ERIA)
4	ERIA	In-person	Organizer	Mrs.	Nadiya Pranindita	Research Associate	Energy Unit, Research Department	Economic Research Institute for ASEAN and East Asia (ERIA)
5	IEEJ	In-person	Project Member	Mr.	Akihiro KIMURA	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
6	IEEJ	In-person	Project Member	Mr.	Hiroko NAKAMURA	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
7	IEEJ	Online	Project Leader	Mr.	Hiroki KUDO	Board Member, Director	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
8	IEEJ	Online	Project Member	Mr.	Kentaro HAYASHI	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
9	IEEJ	Online	Project Member	Ms.	Akiko SASAKAWA	Senior Researcher	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)
10	SOMPO RM	Online	Secretariat of Energy Resilience Score Committee	Mr.	Goro UMEYAMA	Chief Consultant	BCM Consulting Department	SOMPO Risk Management Inc. (SOMPO RM)
11	SOMPO RM	Online	Secretariat of Energy Resilience Score Committee	Mr.	Takeshi KUWABARA	Senior Consultant		SOMPO Risk Management Inc. (SOMPO RM)
12	WNI	Online	Secretariat of Energy Resilience Score Committee	Mr.	Noriyuki SUGIYAMA	Data Scientist	Climate Tech.	Weathernews Inc. (WNI)
13	WNI	Online	Member of Energy Resilience Score Committee	Mr.	Takamune SUZUKI	Manager	Climate Tech Group	Weathernews Inc. (WNI)
14	WNI	Online	Member of Energy Resilience Score Committee	Mr.	Naoki ANDOH		Climate Tech Group	Weathernews Inc. (WNI)
15	CRIEPI	Online	Member of Energy Resilience Score Committee	Mr.	Hirotaka MITSUI	Guest Researcher	Grid Innovation Research Division	Central Research Institute of Electric Power Industry (CRIEPI)
16	CRIEPI	Online	Secretariat of Energy Resilience Score Committee	Mr.	Masahito TAKAHASHI	Senior Research Scientist	Strategy and Planning Division and ENIC Division, Gred Innovation Research Laboratory Socio-economic Research Center	Central Research Institute of Electric Power Industry (CRIEPI)
17	Indonesia	In-person		Mr.	Sujatmiko	Head of Bureau		Indonesia National Energy Council
18	Indonesia	In-person		Mr.	Prima Agung	Staff		Indonesia National Energy Council
19	Indonesia	In-person		Mr.	Adil Fajar	Staff		Indonesia National Energy Council
20	Japan	In-person		Mr.	Takashi Shimada	President Director		PT. Kansai Electric Power Indonesia
21	Japan	In-person		Mr.	Takashi Shukuya	President Director		PT. Tokyo Gas Indonesia
22	Japan	In-person		Mr.	Norio Shigetomi	Director	Indonesia Representative Office	KYUDENKO Corporation
23	Japan	In-person		Mr.	Tomoichi Yamaguchi	President Director		Santomo Resources Corporation
24	Japan	In-person		Ms.	Rumi Hoshino		Corporate Planning Department	Santomo Resources Corporation
25	Japan	In-person		Mr.	Naoki Inoue, CPCU	Director		PT Sompo Insurance Indonesia
26	Japan	In-person		Mr.	Masahiko Itoi	Advisor	Japanese Business Group	PricewaterhouseCoopers Indonesia
27	Thailand	Online	Observer	Dr.	Kampanart Silva	researcher	Renewable Energy and Energy Efficiency Research Team	National Energy Technology Center
28	Thailand	Online	Observer	Dr.	Pidpong Janta	Research Assistant	Renewable Energy and Energy Efficiency Research Team	National Energy Technology Center
29	Japan	Online	Project Assistant Staff	Ms.	Miho NOGAI	Chief Clerk	Electric Power Industry & New and Renewable Energy Unit	The Institute of Energy Economics, Japan (IEEJ)


Zoom ミーティング
レコーディングしています...
ERIA (Office)
IEEJ Secretariat
WNI Noriyuki Sugiyama
ENTEC_Kampanart Silva
IEEJ_Slide_(Kentaro Hayashi)
Takamune Suzuki
Masahito Takahashi
Hiroki KUDO
WNI Naoki ANDOH
Akiko Sasakawa
ERIA Energy
SOMPO Risk - K...
SOMPO Risk - Kuwabara
Hiroyasu Ishiyama
Akihiro Kimura
ミュート
ビデオの停止
セキュリティ
参加者
チャット
画面共有
レコーディングを一時停止／停止
リアクション
アプリ
ホワイトボード
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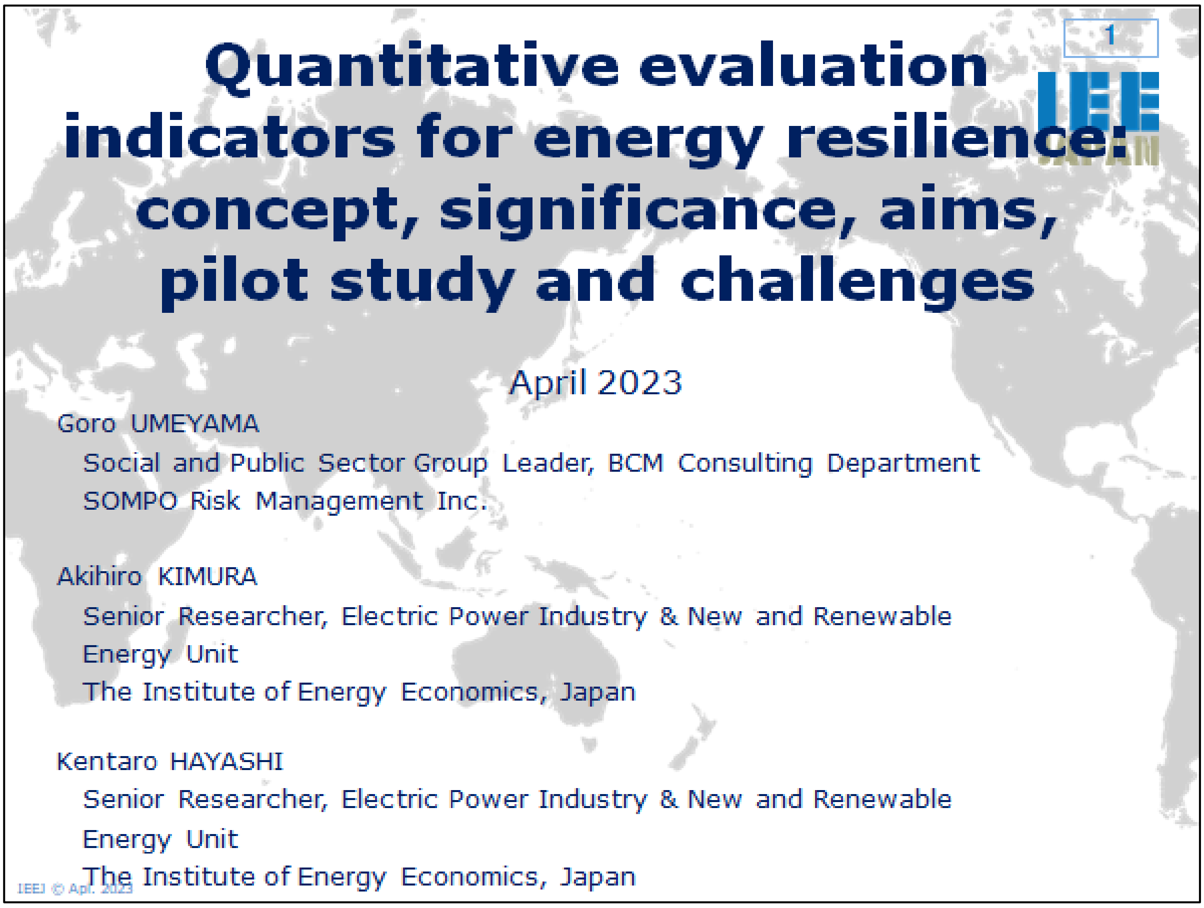
2023/05/24

Appendix 4

Presentation Material at the Workshops

Presentation by Japanese participants (Contains all the slides explained in the 3 workshops)



Energy Resilience Score - Concept -

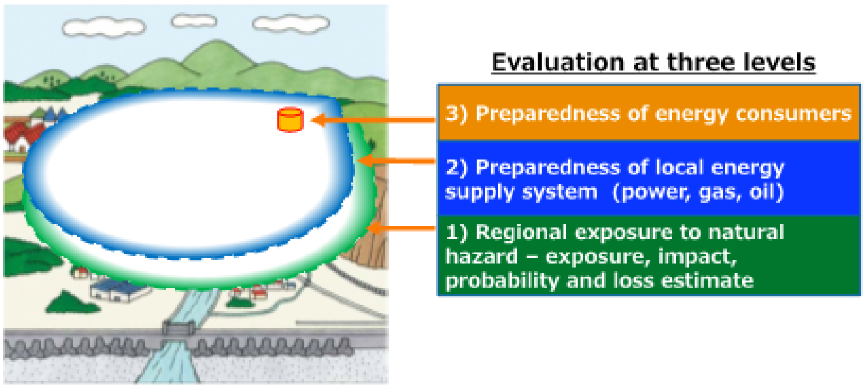
The Energy Resilience Score (ERS) system is being developed under the following concept:

- The quantitative evaluation indicators to be adopted in the ERS system should be "easy to understand" and ”indexable with published data.”
- An ERS should be capable of expressing the degree of resilience improvement.
- An overall ERC is calculated by quantifying local hazards and the efforts of suppliers and energy consumers that affect stable energy supply and rapid post-disaster recovery.

Proposed Energy Resilience Score System

Overview of proposed Energy Resilience Score

- The proposed Energy Resilience Score system is intended to evaluate energy consumers in terms of their facilities’ capability of maintaining stable supply and operations under normal conditions and their preparedness in avoiding severe energy supply disruptions in the face of disaster.



Evaluation steps for the Energy Resilience Score

4

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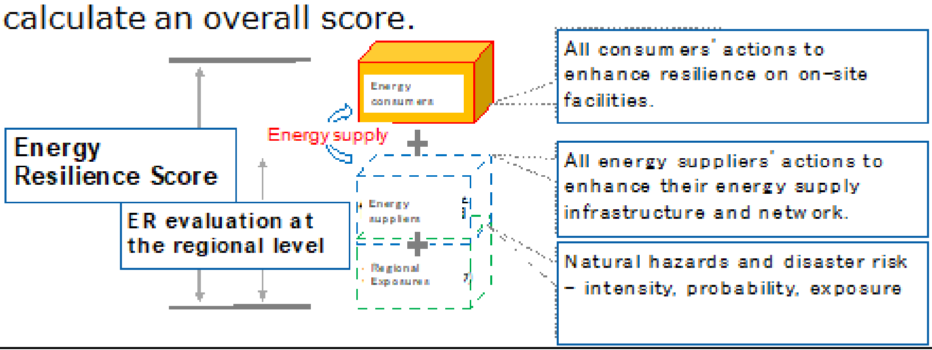
- 1. Assess the disaster risk of the region where the energy consumers (business occupancy) are located (Make assessments based on the impact and likelihood of disasters).
- 2. Check whether the region's energy supply (electricity, gas, oil, water, etc.) has been designed to increase resilience in response to local disaster risks, and whether stable supply is maintained under normal conditions.
- 3. Evaluate energy consumers' energy resilience efforts to calculate an overall score.



Approach to Calculating Energy Resilience Score

5

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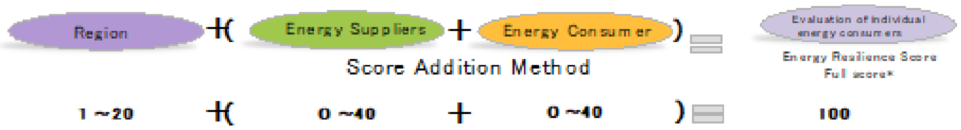
- **Regional Score**: Each country or city or region differs in terms of its risk level; and therefore, efforts to address that risk level must be appropriately evaluated. For this purpose, the risk level of the region is organized as a basic score.
- **Supply Score**: The energy resilience of each energy type is different in each region; and therefore, the system will be designed to allow evaluation of different energy types depending on the energy consumer.
- **Score for energy consumers**: The evaluation is based on a score addition method, considering the measures taken for each energy type.

Energy Resilience Score - Concept



*Full score represents the situation with very low possibility of supply interruptions during normal and emergency situations.

Evaluation Methodology of Regional Score

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- Regional hazard risk indicators cover natural hazards, such as earthquakes, typhoons, and landslides. This evaluation of hazard risk is based on historical weather data from the past few decades.
- Based on the hazard risk indicator values, the amount of damage (on buildings and roads in the region) is evaluated and evaluation results are used for energy suppliers and consumers.

Evaluation Methodology for Regional Score

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Hazard	Risk Index	Data Used	Period	Spatial Resolution	Method
Heavy rain	Landslide Probability Index	Japan Meteorological Agency (JMA) 's Precipitation Reanalysis Data	1988-2020	1km	In line with JMA's Landslide Warning methodology
Strong wind	Probability of 25m/s-or-more Wind Index	JMA's Best Typhoon Track Data of maximum wind speed, radius of 25-m/s wind, central pressure, date and time of landfall, of the typhoons landed in Japan.	1977-2020	1km	WNI's original method
Earth-quakes	Probability of Seismic Intensity 5-minus-or-more Index	The original data for the Probabilistic Seismic Activity Forecast Map by the Headquarters for Earthquake Research Promotion (HERP)	30 years	1km	The probabilistic seismic activity forecasting method by the seismic intensity scales of HERP
Floods	Flood depth	Flood hazard map made by government (MLIT)	1000 return period	1km	WNI's original method

Energy supply side score

8
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Evaluation Methodology of Energy Suppliers Score

- Adopt published data, including data submitted to national and local government agencies as required by relevant laws and rules.
- Based on interviews and discussions with suppliers, evaluation indicators were subdivided to enable evaluation of industry-specific initiatives in the categories of "alternative energy procurement," "innovation and capital investment," "distribution network resilience," and "emergency preparedness.

Quantification indicators (energy supply side score)

9
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Category 1	Category 2	Evaluation points
Electric power	Alternative energy procurement	• Power portfolio with multiple energy sources • Regionally distributed energy sources • Preparedness for peak energy demand and control measures of supply and demand. • Cooperation with other electric power suppliers, etc.
	Innovation and Capital Investment	• Capital investment for stable energy supply, constant system renewal (expansion of power distribution automation equipment, digital substations, etc.) • Training to operate the facility in the event of a disaster • Training program • Frequency of training
	Strengthening of the distribution network	• SAIDI (System Average Interruption Duration Index): Average outage duration per consumer • SAIFI (System Average Interruption Frequency Index): Average number of outages per consumer • Availability of disaster countermeasures (earthquake-proofing, flood countermeasures, etc.)
	Emergency Preparedness	• Existence of BCP and disaster countermeasures manual • Training to enhance the effectiveness of BCPs and disaster management manuals • Frequency of training, scope of training and participating entities. • Third-party evaluation of the BCP has been conducted.

Quantification indicators (energy supply side score)

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Category 1	Category 2	Evaluation points
Gas	Alternative energy procurement	Natural gas, LP Gas • Multiple procurement sources (LNG) and flexible procurement system
	Innovation and capital investment	Natural gas: Smart energy networks - Installation of advanced facilities that can cope with power outages (EneFarm, cogeneration) and distributed energy facilities (power generation close to the customer).
	Strengthening of the distribution network	Natural gas • Durability of gas pipelines and disaster countermeasures at LNG terminals (earthquake-proofing, typhoon and tsunami countermeasures), looping of supply line network LP Gas • Redundancy in production and storage facilities. • Example: Redundancy in manufacturing facilities such as spare units and the ability to provide temporary supply. • Measures against earthquakes and floods at gas storage facilities.
	Emergency preparedness	• BCP and disaster countermeasure manuals in place • Measures in line with the Guidelines for Coordination and Cooperation to Ensure Safety among Gas Utilities. • Training to enhance the effectiveness of BCP and disaster preparedness manuals. • Third-party evaluation of BCP.

Quantification indicators (energy supply side score)

11 IEE JAPAN

Category 1	Category 2	Evaluation points
Petroleum/oil	Alternative energy procurement	• Ratio of domestic production to domestic consumption (*The value exclude naphtha, which is mainly imported even in normal times) • Number of stockpiling days relative to domestic consumption
	Innovation and Capital Investment	• AI featuring equipment, energy cost reduction efforts, less labor intensive facilities. Examples: refinery operations, maintenance program, transformation of the entire supply chain, mechanization to reduce the number of people coming to work in the refinery in light of corona infection control, etc.
	Strengthening of the distribution network	• Percentage of refineries and depots equipped with emergency power sources • Percentage of SS equipped with emergency power supply • Adopted earthquake scenario (magnitude of seismic motion) for seismic design and liquefaction resistance measures of the refineries.
	Emergency Preparedness	• Supply chain BCP and disaster countermeasures manuals. • Implementation of trainings to enhance effectiveness of BCP and disaster preparedness manuals. • Third-party evaluation of BCP • Supply chain coordination plan in the disaster • Types of scenario earthquakes and other disasters (flood, wind, snow, etc.) to be anticipated • Time required to restore oil supply (time required to restore to 1/2 of normal incoming/outgoing shipment volume)

Quantification indicators (energy supply side score)

12 IEE JAPAN

Category 1	Category 2	Evaluation points
Administrative facilities (water supply, roads, etc.), sewerage	Emergency preparedness (administrative facilities (water supply, roads, etc.))	• BCP of municipalities, disaster countermeasures manual, countermeasures for waterlines and roads. • Training to enhance the effectiveness of BCP and disaster countermeasure manuals.
	Emergency preparedness (Wastewater)	• BCP of wastewater facilities and lines by municipalities. • Disaster preparedness manuals • Training to enhance the effectiveness of BCP and disaster countermeasure manuals.

Energy consumer side score

13 IEE JAPAN

Evaluation Methodology of Energy Consumers Score

- In addition to indexing energy consumers with published data, it was decided to use an index that surveys and evaluates the presence or absence of initiatives among energy consumers in the areas to be evaluated.
- The score for the consumer side would be based on whether the company is making efforts to maximize the use of multiple energy sources (including renewable energy) in the event of disaster, in cooperation with energy suppliers in the region where the energy consumer is located.
- In addition, the evaluation will also recognize efforts on the part of energy consumers to ensure that business facilities can continue to operate or to reduce the amount of time that the facility operations are suspended, even if energy supply is disrupted due to a disaster.
- In particular, a company's consideration of securing multiple energy sources, preparedness at its own facilities, BCP, training for contingency plans, and other measures are important factors in preparing for energy disruptions, and therefore, these points are focused on in the evaluation.

Quantification indicators (energy consumer side score)

14

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Category	Evaluation points
Consideration of securing multiple energy option	• Risk assessment for energy security is implemented (multiple energy (electricity, gas, oil, hydrogen, etc.) options are considered in consultation with energy suppliers)
Electric power	• Seismic retrofitting of substations, local distributed power sources (renewable energy, storage batteries, electric vehicles, etc.), equipment capable for power outages (EneFarm, cogeneration), etc., Measures against anticipated disaster risk are considered for onsite power receiving facilities in consultation with supply side. • Number of days that operations can be maintained using alternative energy sources during energy supply disruption. • Cooperative system with the supply side in the event of a disaster. (e.g. emergency action agreement in a disaster)
Gas	• Medium-pressure natural gas pipelines • Earthquake-resilient gas pipes on the consumer's premises and measures taken to prevent LP gas containers from tipping over, etc. (Measures for gas receiving facilities of the company are introduced in consultation with the gas supplier.) • Number of days that operations can be maintained using alternative energy sources in the event of gas supply outage (e.g. effective use of LP gas as an energy source in the event of natural gas supply outage.) • Cooperative scheme with supply side in the event of disaster. (e.g. emergency action agreement in a disaster)
Petroleum/Oil	• Earthquake-resistance / seismic retrofit, etc. of storage facilities (Measures for oil storage facilities on site are provided in consultation with the supply side?) • Rules to fill up the gas tank of car when the fuel meter is about half full. • Oil stock maintained for a certain number of days of use based on risk assessment. • Cooperative scheme with supply side in the event of disaster. (e.g. emergency action agreement in a disaster)

Quantification indicators (energy consumer side score)

15

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Category	Evaluation points
Water supply	• Seismic retrofit of water supply lines in the site. • Availability of an onsite emergency water tank.
Facilities, BCP, training, etc.	• Risk assessment of facilities and equipment (vulnerability assessment in preparation against earthquakes, floods, etc.) • Countermeasures for facilities and equipment (upgrading facilities to cope with exposure to earthquakes, floods, etc.) • BCP and disaster countermeasure manual • Availability of training to enhance the effectiveness of BCPs and disaster management manuals. • Financial capacity and preparedness such as coverage by insurance. • Third-party evaluation of BCP

Pilot study at the three energy supply facilities in Japan

16

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- A pilot study covering 3 regional sites in Japan are currently underway. The facilities are operated by Tokyo Urban Service Corporation.

①	②	③
Start of supply: February 1991 Supply floor area: 139,000m² Supply to: Government buildings and halls, commercial buildings	Start of supply: February 2020 Supply floor area: 185,000m² Supply to: Public facilities and commercial buildings	Start of supply: January 1999 Supply floor area: 318,000m² Supply to: Commercial buildings, residential buildings, public facilities

Pilot Study at Three Energy Supply Facilities in Japan:

17

IEE JAPAN

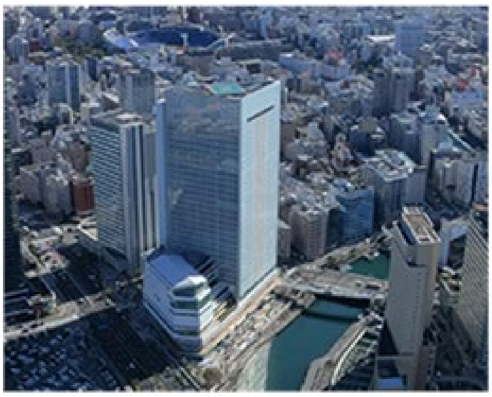
- Facility ①

Pilot Study at Three Energy Supply Facilities in Japan:

18

IEE JAPAN

- Facility②



Pilot Study at Three Energy Supply Facilities in Japan:

19

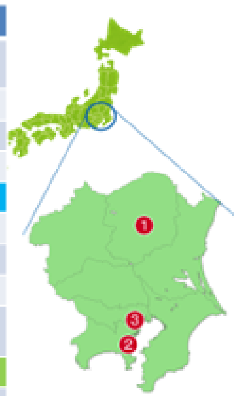
IEE JAPAN

- Facility③

Pilot Study at Three Energy Supply Facilities in Japan:

20

		①	②	③
Region	sediment-related disaster	3 /5	5 /5	4 /5
	floods	5 /5	5 /5	5 /5
	Typhoon	4 /5	4 /5	4 /5
	earthquake	1 /5	1 /5	1 /5
	Subtotal	13 /20	15 /20	14 /20
Energy Supplier	electricity	3.6 /10	4.2 /10	3.6 /10
	Gas	- /10	3.3 /10	- /10
	Coal	- /10	- /10	- /10
	administrative facility	1.1 /10	1.1 /10	1.1 /10
	Subtotal	4.7 /40	8.6 /40	4.7 /40
Energy consumers	Multiple energy security	8.0 /8	8.0 /8	8.0 /8
	electricity	1.7 /10	5.0 /10	1.7 /10
	Gas	- /5	0.7 /5	- /5
	Coal	- /5	- /5	- /5
	Water	0.0 /4	0.0 /4	0.0 /4
	Equipment/BCP/ Training	4.4 /8	3.6 /8	4.4 /8
	Subtotal	14.1 /40	17.3 /40	14.1 /40
Total		31.8 /100	40.9 /100	32.8 /100




ENTEC a member of NSTDA
Overview of Energy Resilience and Putting it in the Thai Context
Kampanart SILVA, Researcher
Pidpong JANTA, Assistant Researcher
Renewable Energy and Energy Efficiency Team (RENT)
Low Carbon Energy Research Group (LCRG)
National Energy Technology Center (ENTEC)
National Science and Technology Development Agency (NSTDA)
kampanart.sil@entec.or.th, pidpong.jan@entec.or.th


ENTEC a member of NSTDA
ENTEC | National Energy Technology Center
National Energy Technology Center (ENTEC) was formally established on June 9, 2020
when it was approved by the Thai Cabinet.
It becomes the fifth national center under the National Science and Technology Development Agency (NSTDA).
สวทช NSTDA
BIOTEC a member of NSTDA
NECTEC a member of NSTDA
MTEC a member of NSTDA
NANOTEC a member of NSTDA
ENTEC a member of NSTDA
Vision: A leading organization and a focal point for Thailand's energy technology development
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2


ENTEC
NSTDA
ENTEC | Research and Development
Solar (PV, Thermal), Bioenergy, Wind, Artificial photosynthesis, perovskite solar cell, Hybrid tandem PV, Digital PV
High energy density & low cost battery (Li-ion and beyond) Supercap. H2 storage/fuel cell
Oil, Natural Gas, Coal
RE integrationDistributed energy system, Flexible grid, Smart/Microgrid Blockchain, IoT
Thermal, Electrical Zero energy bldg./ factory [Transport | Power | Industry | Household | Agriculture]
Renewable Energy
Energy Storage
Conventional Energy
System Integration & Energy Management
Energy Efficiency
Energy Policy/Resilience
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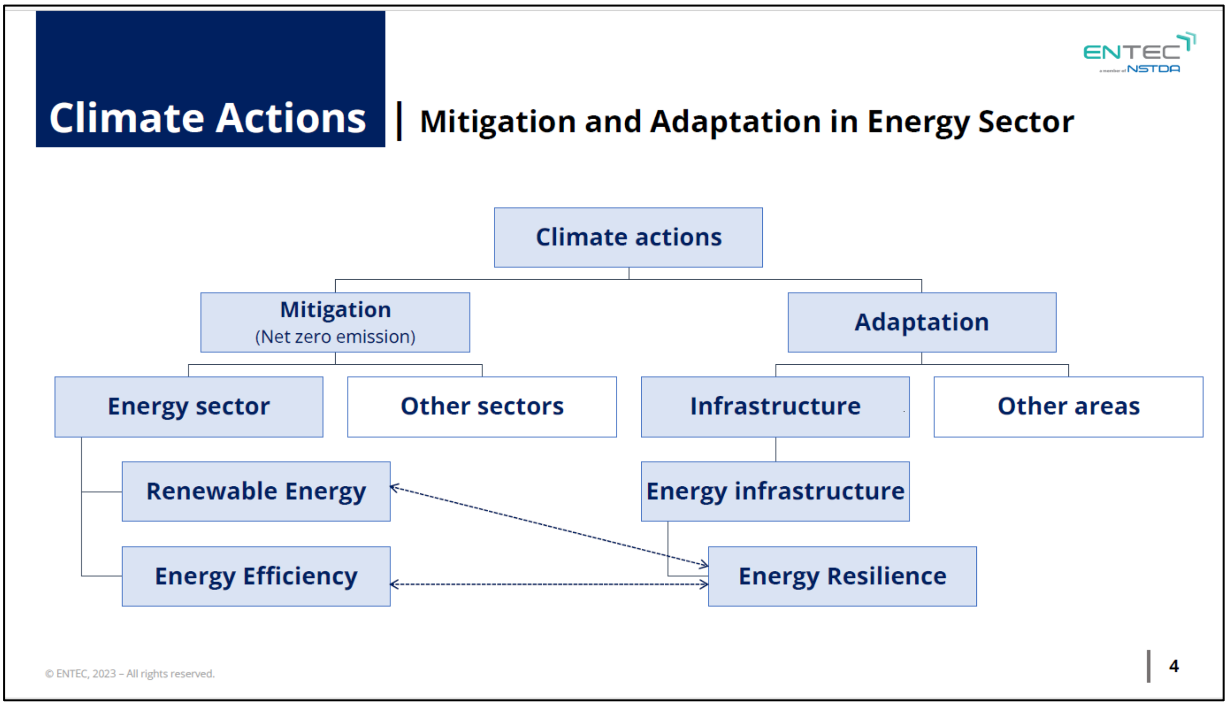
https://www.entec.or.th/rd/
3


ENTEC
NSTDA
Climate Actions | Mitigation and Adaptation in Energy Sector
Climate actions
Mitigation
(Net zero emission)
Adaptation
Energy sector
Other sectors
Infrastructure
Other areas
Renewable Energy
Energy infrastructure
Energy Efficiency
Energy Resilience
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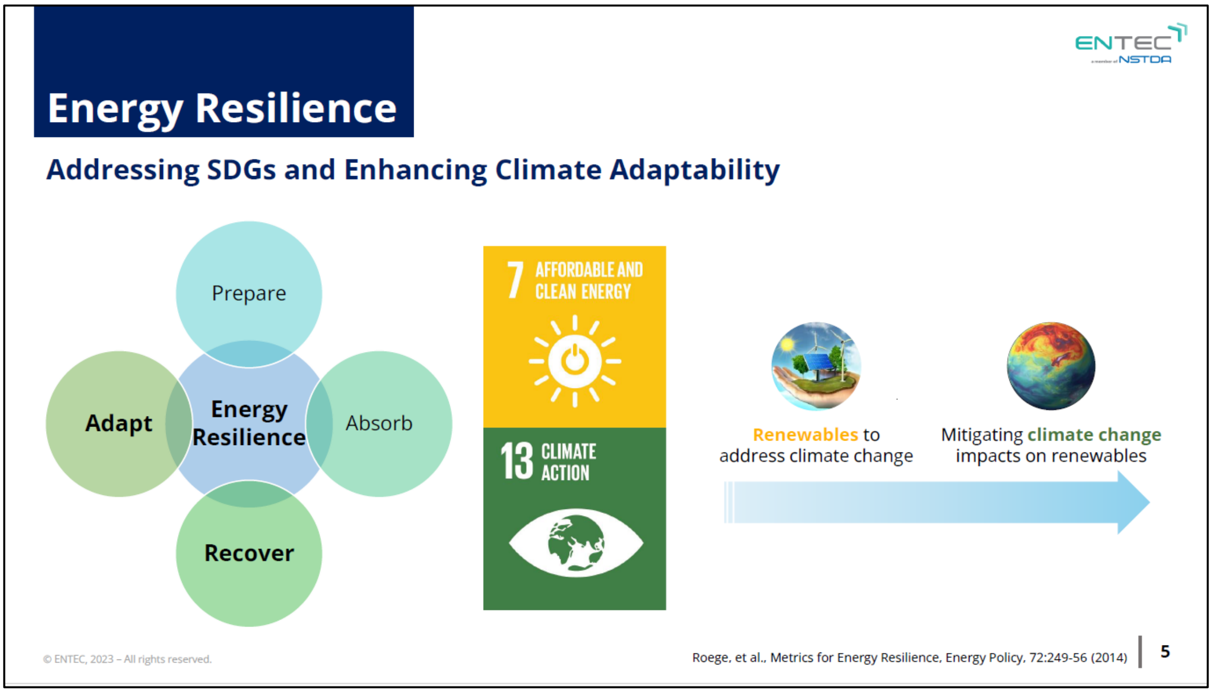
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Energy Resilience
Addressing SDGs and Enhancing Climate Adaptability
Prepare
Adapt
Energy Resilience
Absorb
Recover
7 AFFORDABLE AND CLEAN ENERGY
13 CLIMATE ACTION
Renewables to address climate change
Mitigating climate change impacts on renewables
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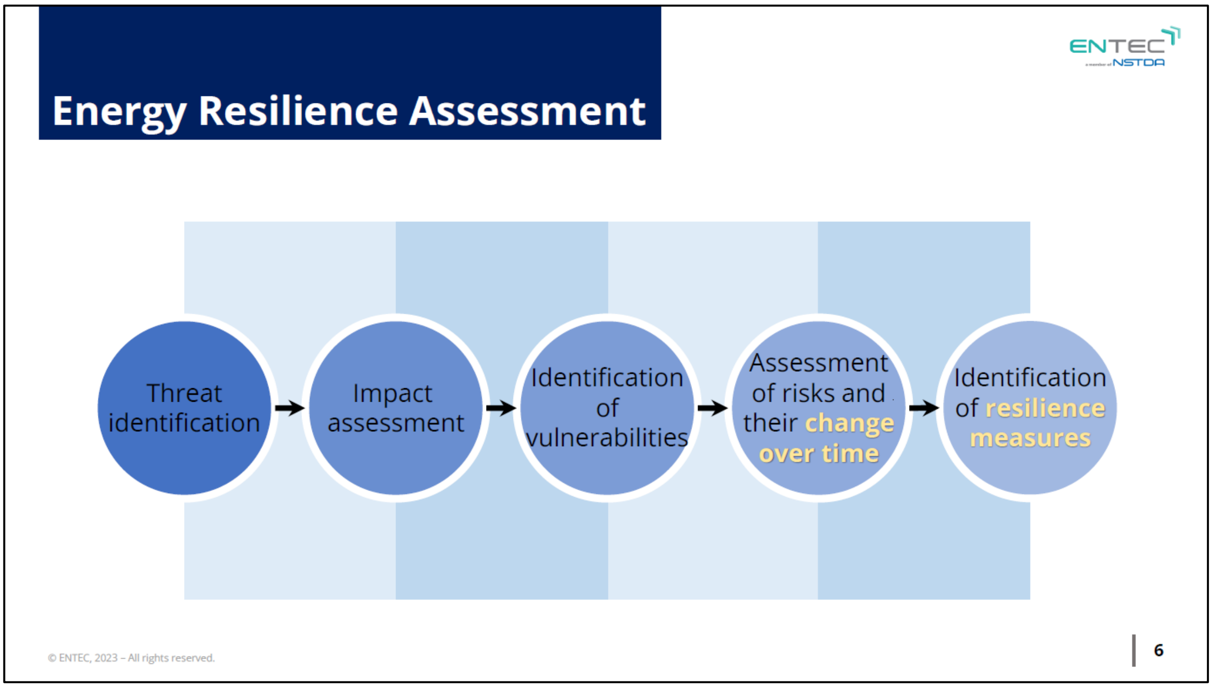
Roege, et al., Metrics for Energy Resilience, Energy Policy, 72:249-56 (2014)
5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Energy Resilience Assessment
Threat identification
Impact assessment
Identification of vulnerabilities
Assessment of risks and their change over time
Identification of resilience measures
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6

Energy Resilience Assessment | Thai Context

ENTEC NSTDA

700 kW Solar Power Plant
@CMRU, Chiang Mai

100 kW Microgrid
@Ban Pha Dan, Lamphun

Local state-owned power plant	Commercial Power plant
Rural microgrid	Community plant

4.9 MW Biomass Power Plant
@Ban Khao Noi, Phitsanulok

Biogas Plant + 60 kVA Generator
@Ban Kham Khaen, Khon Kaen

Promoting Energy Resilience in ASEAN

ENTEC NSTDA

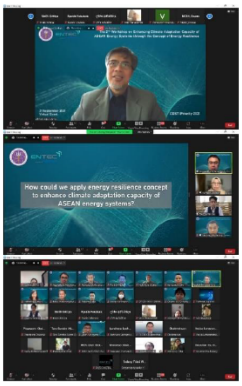
Energy Resilience as ASEAN COSTI Priority for 2021

AGENDA ITEM 6. COSTI DIRECTION 2021-2025
6.1 COSTI 2021 ANNUAL PRIORITIES

6.1.4 To implement at least 2 projects addressing the Sustainable Development Goals
(1) EU-ASEAN Dialogue on Green Technology & Innovation Mapping (Philippines) [10 min]
(2) Energy Resilience (Thailand) [10 min]
(3) ASEAN Water Quality Index (Indonesia, Malaysia, Philippines) (tbc) [10 min]

Energy Resilience Workshops

1st Workshop



2nd Workshop

3rd Workshop

1st Workshop (June 17, 2021)

- 23 participants from 5 countries
- Enhance **understanding** linkage between energy resilience and sustainability/climate change
- Discuss the ways to use energy resilience to **build capacity** of energy systems toward climate change adaptation

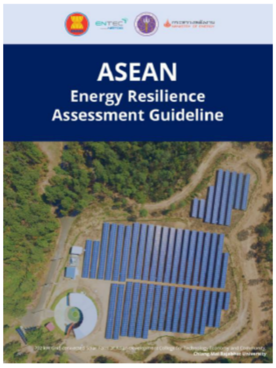
2nd Workshop (September 21, 2021)

- 35 participants from 6 countries
- Increasing awareness and engage **national and regional stakeholders**
- Promoting **application** of energy resilience in ASEAN energy systems

3rd Workshop (May 9, 2022)

- 84 participants from 11 countries
- Leverage **efforts of ASEAN and APEC** in promoting energy resilience
- Promote **grassroots activities** in order to apply energy resilience in actual energy systems

ASEAN Energy Resilience Assessment Guideline



ASEAN Energy Resilience Assessment Guideline

- **Endorsed by SCSER and approved by COSTI** at COSTI-82 on October 19, 2022.
- Consists of **SOP for energy resilience assessment** and materials needed for the assessment.
- Can help induce **investment in resilience enhancement of clean energy infrastructure**

Assessment Guideline Components

ENTEC a member of NSTDA

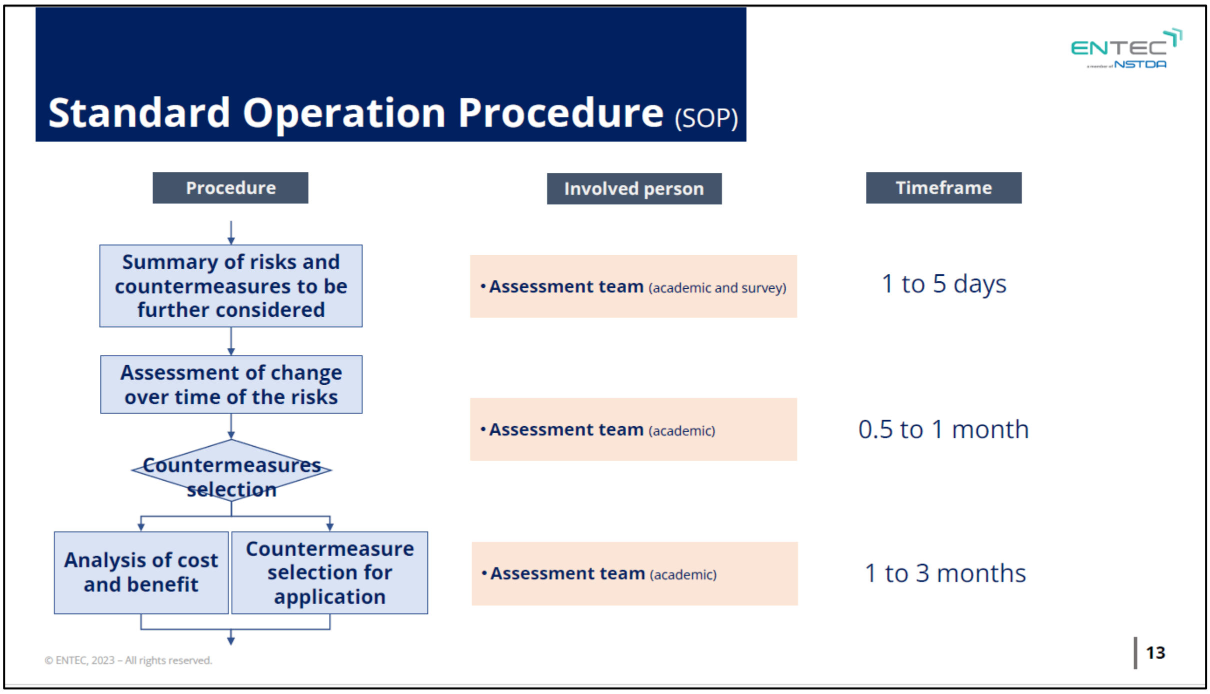
Standard Operation Procedure (SOP)

Samples of worksheets

Standard Operation Procedure (SOP)

ENTEC a member of NSTDA

Procedure	Involved person	Timeframe
Determination of assessment direction and scope	• **Assessment team** (academic) • **Representative of power plant**	0.5 to 1 day
Data collection and preparation for discussion with stakeholder	• **Assessment team** (academic) • **Representative of power plant**	0.5 to 3 months (based on assessment intensity)
Assessment exercise with secondary data	• **Assessment team** (academic and survey) • **Representative of power plant**	0.5 to 1 day
Energy resilience assessment	• **Assessment team** (academic and survey) • **Representative of power plant** • **Stakeholders**	1 day


ENTEC
NSTDA
Standard Operation Procedure (SOP)
Procedure
Involved person
Timeframe
Summary of risks and countermeasures to be further considered
Assessment team (academic and survey)
1 to 5 days
Assessment of change over time of the risks
Countermeasures selection
Assessment team (academic)
0.5 to 1 month
Analysis of cost and benefit
Countermeasure selection for application
Assessment team (academic)
1 to 3 months
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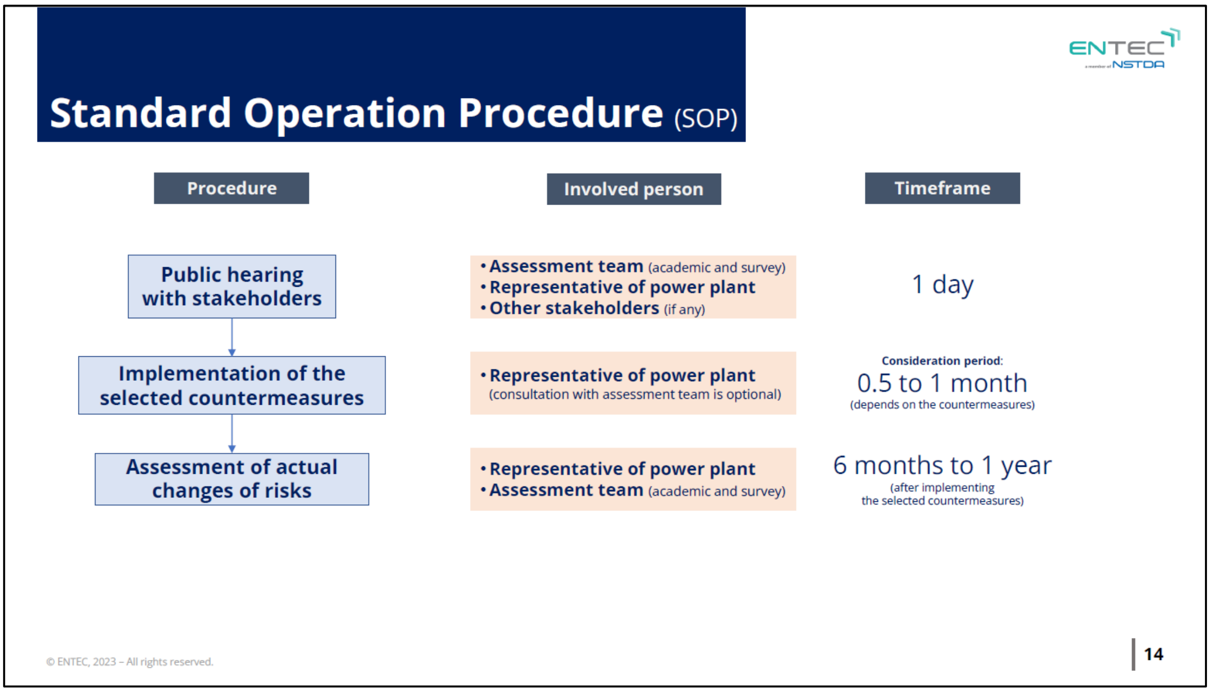
ENTEC
NSTDA
Standard Operation Procedure (SOP)
Procedure
Involved person
Timeframe
Public hearing with stakeholders
Assessment team (academic and survey)
Representative of power plant
Other stakeholders (if any)
1 day
Implementation of the selected countermeasures
Representative of power plant
(consultation with assessment team is optional)
Consideration period:
0.5 to 1 month
(depends on the countermeasures)
Assessment of actual changes of risks
Representative of power plant
Assessment team (academic and survey)
6 months to 1 year
(after implementing the selected countermeasures)
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Energy Resilience Assessments in ASEAN

Universiti Teknologi MARA (UiTM)
$50MW_{AC}$ large-scale solar photovoltaic power plant in Gambang, Malaysia

$2.8MW_{AC}$ solar rooftop and solar integrated carpark in UiTM Penang, Malaysia

Important Findings | Energy Resilience Assessments in Malaysia

Solar Power Plant in Gambang

Personnel at **supervising** and **operating levels** and **a representative from UiTM Holdings** participated the full-scale energy resilience assessment.

- **A dedicated operation team** was proposed as a measure to address the threat from **future East Coast Rail Line construction** and the vulnerability due to **lack of planning and standard procedure**.
- **Database for damage records** and **agrivoltaic** were proposed as measures to address the threat from **animal invasion** and the vulnerability due to **lack of physical protection**.

Solar Rooftop and Solar Integrated Carpark in Penang

Personnel at **supervising** and **operating levels** and **representatives from private enterprise** and UiTM participated the full-scale energy resilience assessment.

- **Maintenance contract** and **monitoring of spare parts** were proposed as measures to address the threat from **extreme weather** and **power loss** and the vulnerability due to **lack of spare parts/backup system**.
- Revisiting emergency response plan was proposed as a measure to address the threat from **extreme weather** and the vulnerability due to **lack of preparedness, awareness, and clear procedure**.

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Highlights of Energy Resilience Assessment

ENTEC a member of NSTDA

- Maintaining Strength of **Conventional Risk Assessment** (evaluation of ability to prepare and absorb)
- Based on **experience of stakeholders**, complimented by expertise of assessors
- Future-focused nature → **enhanced adaptive capacity**
- Change of risks over time → **fast recovery**
- Reduced opportunity loss → **better profitability**

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SECRETARIAT GENERAL OF NATIONAL ENERGY COUNCIL

Overview Of Energy Resilience In The Indonesian Context

Ir. Sujatmiko
Head of Energy Crisis and Supervision Facilitation Bureau
Secretariat General of National Energy Council,
The Republic of Indonesia

Jakarta, May 24th, 2023

PURPOSE OF NATIONAL ENERGY MANAGEMENT

The establishment of a just, sustainable, and environmentally friendly energy management in order to create national energy independence and national energy security based on energy sovereignty and equitable economic values.

- **National Energy Security is a condition that guarantees the availability of Energy by utilizing and having public access to Energy at an affordable price in the long term while still paying attention to the protection of the Environment.**
- **National Energy Independence is the guarantee of Energy availability by making the most of domestic potential sources.**
- **Energy sovereignty is the right of the state and nation to independently determine energy management policies to achieve energy security and independence.**
- **Equitable economic value is a value / cost that reflects the cost of energy production, including environmental costs and conservation costs as well as benefits that are assessed based on community capacity and determined by the Government.**

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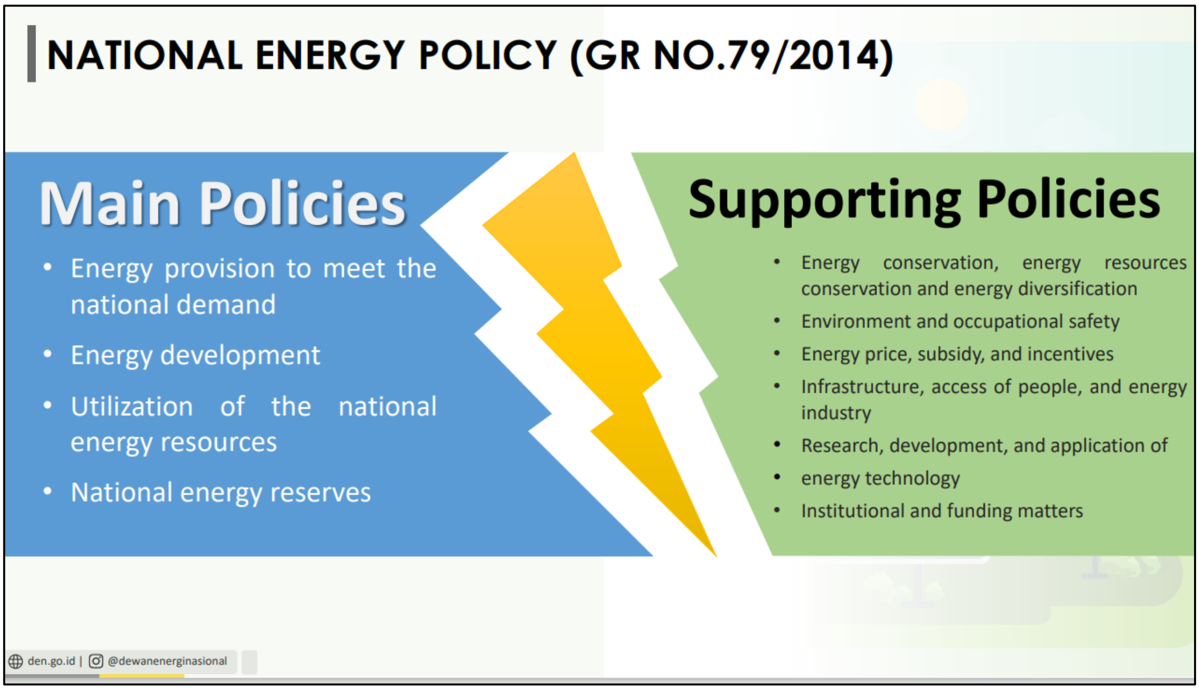
NATIONAL ENERGY POLICY (GR NO.79/2014)
Main Policies
Energy provision to meet the national demand
Energy development
Utilization of the national energy resources
National energy reserves
Supporting Policies
Energy conservation, energy resources conservation and energy diversification
Environment and occupational safety
Energy price, subsidy, and incentives
Infrastructure, access of people, and energy industry
Research, development, and application of
energy technology
Institutional and funding matters
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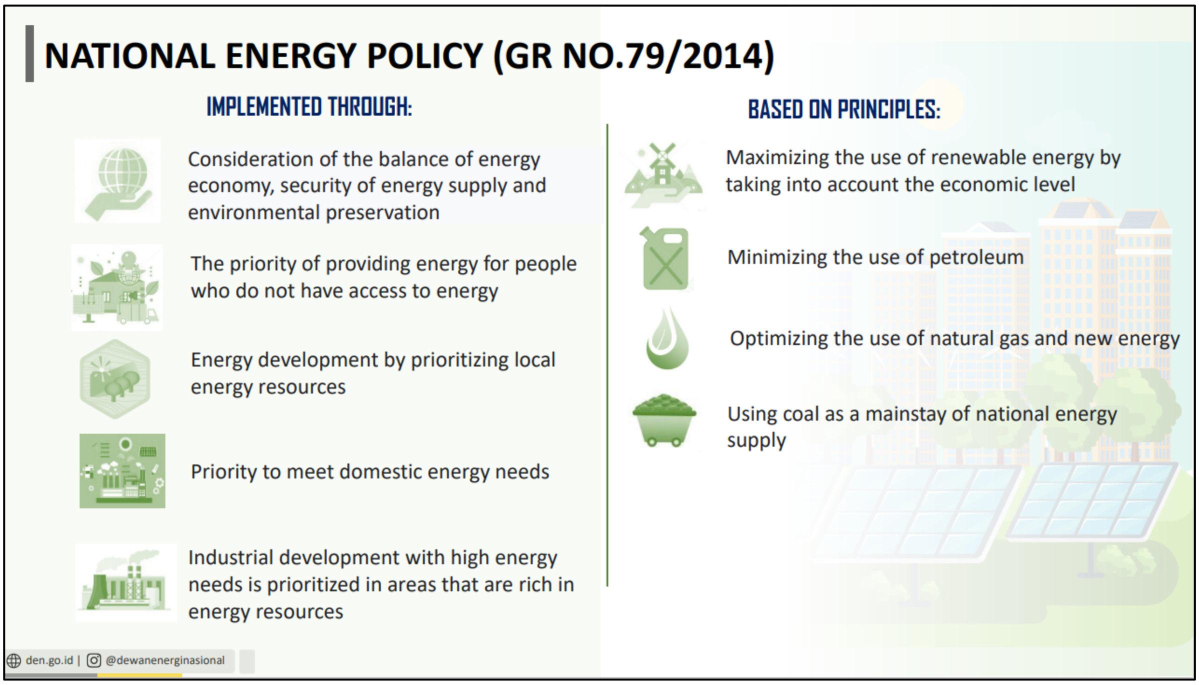
NATIONAL ENERGY POLICY (GR NO.79/2014)
IMPLEMENTED THROUGH:
Consideration of the balance of energy economy, security of energy supply and environmental preservation
The priority of providing energy for people who do not have access to energy
Energy development by prioritizing local energy resources
Priority to meet domestic energy needs
Industrial development with high energy needs is prioritized in areas that are rich in energy resources
BASED ON PRINCIPLES:
Maximizing the use of renewable energy by taking into account the economic level
Minimizing the use of petroleum
Optimizing the use of natural gas and new energy
Using coal as a mainstay of national energy supply
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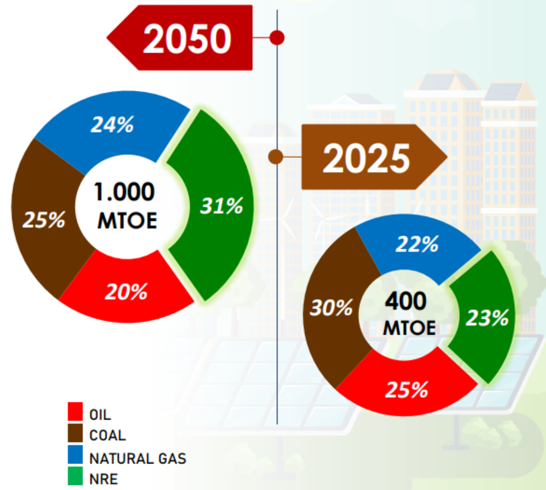
NATIONAL ENERGY POLICY AND TARGET

Gov. Reg.No. 79/2014 on National Energy Policy

ROLE OF THE ENERGY	2025	2050
RE Mix	23%	31%
Primary Energy Supply	> 400 MTOE	> 1.000 MTOE
Power Generation	> 115 GW	> 430 GW
Energy Elasticity	< 1	< 1
Electricity Consumption (Capita/year)	2,500 kWh	7,000 kWh
Electrification Ratio	~100%	~100%
Primary Energy Utilization	1,4 TOE/capita	3,2 TOE/capita



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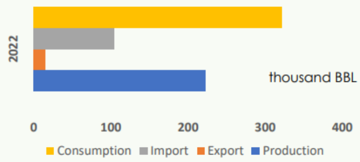
ENERGY CURRENT CONDITIONS (2022)

CRUDE OIL

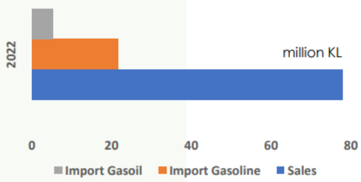
National oil production in 2022 is **223 thousand BBL**, unable to meet **oil refinery input** is **322 BBL** .

Around **32%** of crude is still **imported** in 2022 to meet refinery intake needs



FUEL OIL

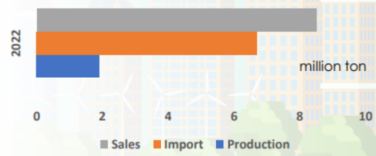
Fuel imports amounted to 27.8 million KL (**35.7%**), mainly gasoline (21.6 million KL) & gasoil (5.2 million KL)



LPG

LPG imports amounted to **78.7%** (6.74 million ton) of the domestic demand of 8.56 million ton.

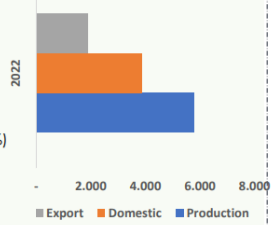
Utilization of **LPG 91.2%** (7.81 million ton) for **3 kg LPG** used for the household sector.



NATURAL GAS

Utilization of domestic natural gas reached **68%** (3,881 BBTUD) and the remaining 1,912 BBTUD was exported.

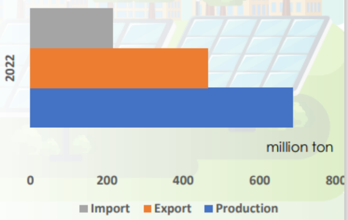
The larger users of natural gas are the **industrial** sector (42%) and **fertilizer** (18%)



COAL

Domestic coal utilization of 31.3% (215 million ton) where the majority for the electricity sector

Coal exports are still dominant, reaching **67,7%** (**465 million ton**) of total production



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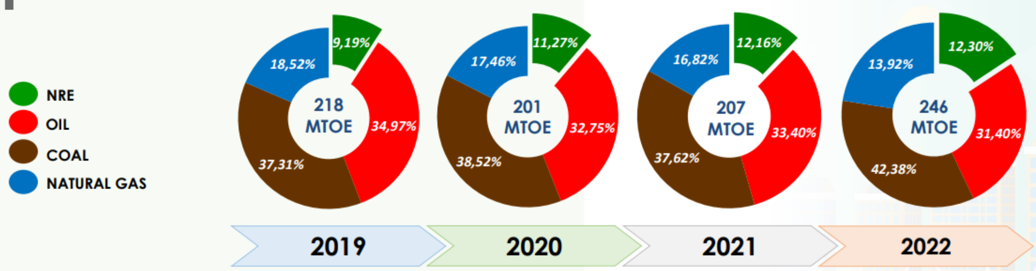
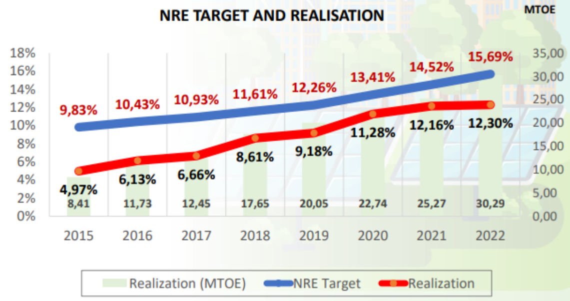
PRIMARY ENERGY MIX



PRIMARY ENERGY	2019		2020		2021		2022	
	Target	*Realization*	*Target*	*Realization*	*Target*	*Realization*	*Target*	*Realization*
NRE	32,75	20,05	38,56	22,69	44,65	25,27	51,32	30,29
	12,20%	9,19%	13,42%	11,27%	14,52%	12,16%	15,69%	12,30%
OIL	81,46	76,29	82,88	65,94	86,46	69,45	89,22	77,35
	30,35%	34,97%	28,84%	32,75%	28,12%	33,40%	27,27%	31,40%
COAL	97,64	81,39	104,89	77,55	109,02	78,23	112,88	104,40
	36,38%	37,31%	36,49%	38,52%	35,46%	37,62%	34,50%	42,38%
NATURAL GAS	56,54	40,40	61,08	35,16	67,32	34,97	73,72	34,30
	21,06%	18,52%	21,25%	17,46%	21,90%	16,82%	22,53%	13,92%
TOTAL (MTOE)	**268,39**	**218,12**	**287,40**	**201,34**	**307,45**	**207,92**	327,14	246,34

Source: RUEN, HEESI 2021

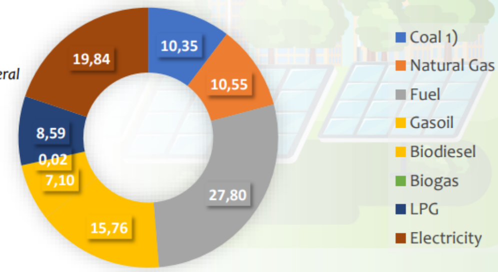


FINAL ENERGY CONSUMPTION 2015 – 2021 (%)

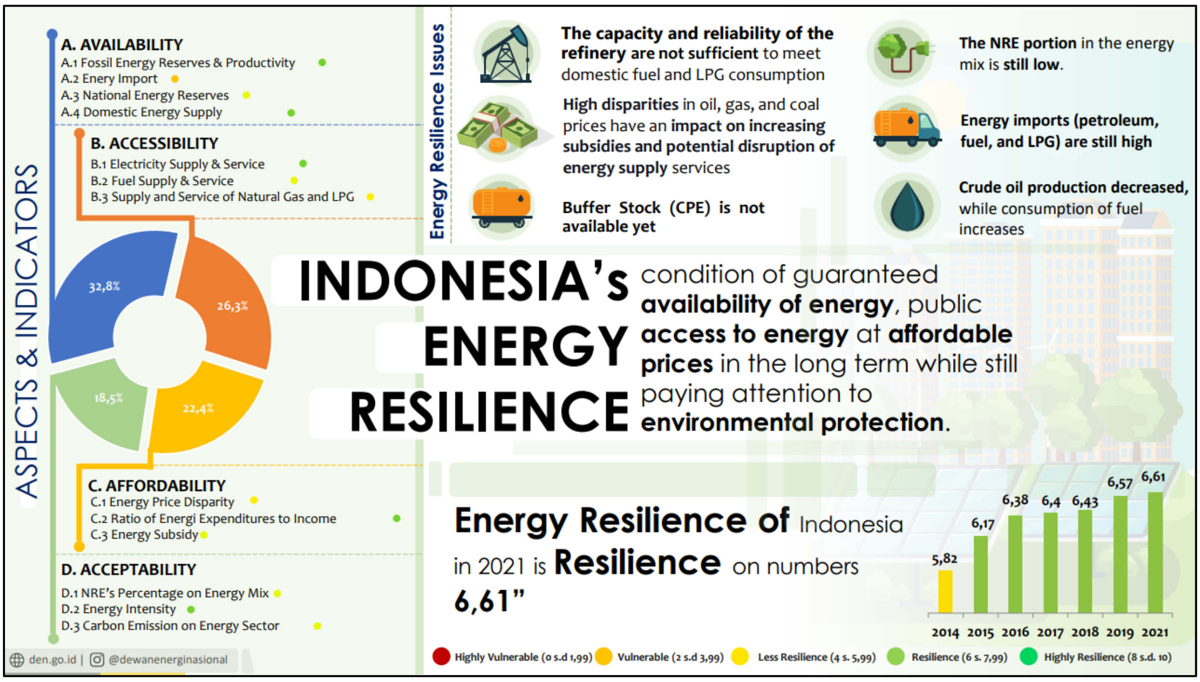
Year	Coal [1]	Natural Gas	Fuel	Bio Gasoil [2]			Biogas	LPG	Electricity
				Gasoil	Biodiesel	Blending Product			
2015	9,25	12,55	42,56	11,31	0,78	12,09	0,02	7,16	16,37
2016	8,62	10,49	44,59	8,03	2,64	10,67	0,02	7,67	17,94
2017	7,64	11,54	42,96	10,01	2,16	12,17	0,02	7,95	17,73
2018	11,61	11,04	37,04	12,24	2,81	15,05	0,02	7,45	17,79
2019	17,76	10,04	27,78	15,95	4,40	20,35	0,02	7,02	17,03
2020	13,52	11,60	26,46	14,85	6,48	21,34	0,02	8,14	18,93
2021	10,35	10,55	27,80	15,76	7,10	22,86	0,02	8,59	19,84

Note : Commercial Energy (excluded biomass)
1) Coal is including briquette
2) Biogasoil is a blending product between gasoil and biodiesel. Gasoil consumption is derived from data processing; while biodiesel consumption data is obtained from the Directorate General of New and New Renewable Energy and Energy Conservation

Source: Handbook of Energy & Economic Statistics of Indonesia 2021



Source: RUEN, HEESI 2021


ASPECTS & INDICATORS
A. AVAILABILITY
A.1 Fossil Energy Reserves & Productivity
A.2 Enery Import
A.3 National Energy Reserves
A.4 Domestic Energy Supply
B. ACCESSIBILITY
B.1 Electricity Supply & Service
B.2 Fuel Supply & Service
B.3 Supply and Service of Natural Gas and LPG
32,8%
26,3%
18,5%
22,4%
C. AFFORDABILITY
C.1 Energy Price Disparity
C.2 Ratio of Energi Expenditures to Income
C.3 Energy Subsidy
D. ACCEPTABILITY
D.1 NRE's Percentage on Energy Mix
D.2 Energy Intensity
D.3 Carbon Emission on Energy Sector
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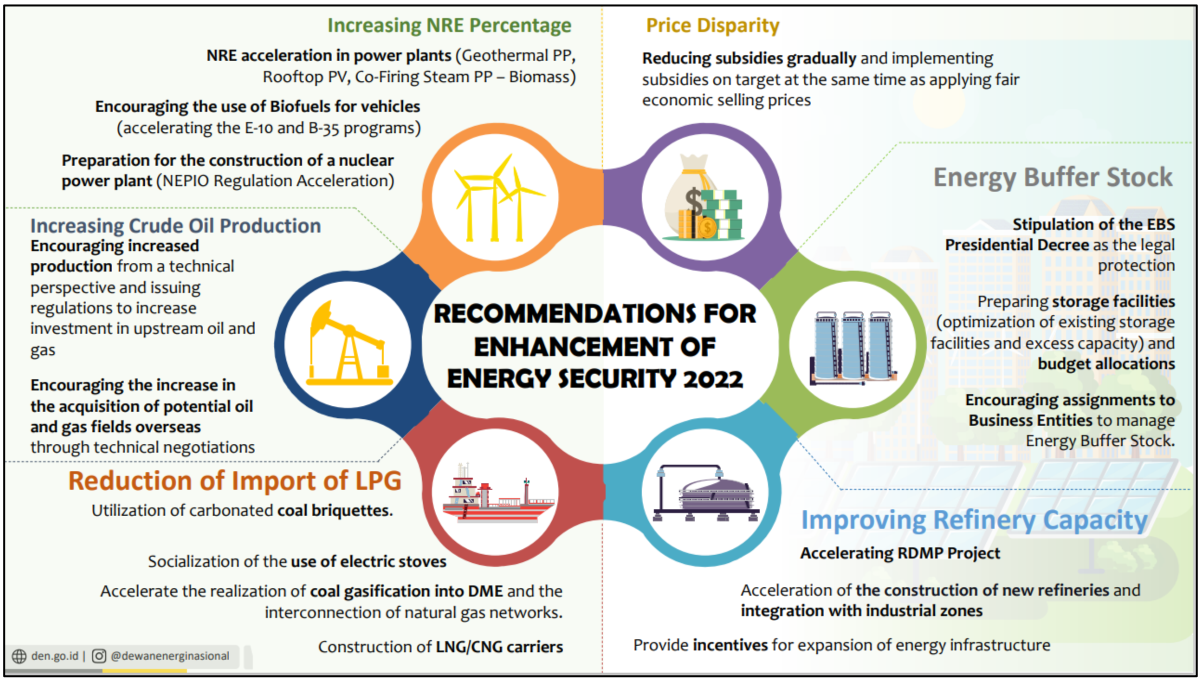
Energy Resilience Issues
The capacity and reliability of the refinery are not sufficient to meet domestic fuel and LPG consumption
High disparities in oil, gas, and coal prices have an impact on increasing subsidies and potential disruption of energy supply services
Buffer Stock (CPE) is not available yet
The NRE portion in the energy mix is still low.
Energy imports (petroleum, fuel, and LPG) are still high
Crude oil production decreased, while consumption of fuel increases
INDONESIA's ENERGY RESILIENCE
condition of guaranteed availability of energy, public access to energy at affordable prices in the long term while still paying attention to environmental protection.
Energy Resilience of Indonesia in 2021 is Resilience on numbers 6,61"
5,82
6,17
6,38
6,4
6,43
6,57
6,61
2014 2015 2016 2017 2018 2019 2021
Highly Vulnerable (0 s.d 1,99)
Vulnerable (2 s.d 3,99)
Less Resilience (4 s. 5,99)
Resilience (6 s. 7,99)
Highly Resilience (8 s.d. 10)


Increasing NRE Percentage
NRE acceleration in power plants (Geothermal PP, Rooftop PV, Co-Firing Steam PP – Biomass)
Encouraging the use of Biofuels for vehicles (accelerating the E-10 and B-35 programs)
Preparation for the construction of a nuclear power plant (NEPIO Regulation Acceleration)
Price Disparity
Reducing subsidies gradually and implementing subsidies on target at the same time as applying fair economic selling prices
Increasing Crude Oil Production
Encouraging increased production from a technical perspective and issuing regulations to increase investment in upstream oil and gas
Encouraging the increase in the acquisition of potential oil and gas fields overseas through technical negotiations
RECOMMENDATIONS FOR ENHANCEMENT OF ENERGY SECURITY 2022
Energy Buffer Stock
Stipulation of the EBS Presidential Decree as the legal protection
Preparing storage facilities (optimization of existing storage facilities and excess capacity) and budget allocations
Encouraging assignments to Business Entities to manage Energy Buffer Stock.
Reduction of Import of LPG
Utilization of carbonated coal briquettes.
Socialization of the use of electric stoves
Accelerate the realization of coal gasification into DME and the interconnection of natural gas networks.
Construction of LNG/CNG carriers
Improving Refinery Capacity
Accelerating RDMP Project
Acceleration of the construction of new refineries and integration with industrial zones
Provide incentives for expansion of energy infrastructure
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