APEC Energy Resiliency Enhancement Project

Project Summary Report

APEC Energy Working Group

September 2024

Asia-Pacific
Economic Cooperation

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1. Introduction

Stable and resilient energy supply is critical for maintaining socio-economic activities. Many APEC economies continue to be challenged by intensifying natural disasters which cause serious damage to energy infrastructure and economy. Energy supply systems also increasingly threatened by man-induced disasters such as cyber-attacks and terrorism. As a result, energy disruption risks have increased dramatically, and energy resiliency has been an emerging priority across APEC economies.

The energy ministers of member economies of the APEC affirmed the importance of energy resiliency to promoting energy security and achieving sustainable development in the 2015 APEC Energy Ministerial Meeting held in Cebu, the Philippines. The meeting resulted in the Cebu Declaration on East Asian Energy Security. Since then, the Energy Working Group (EWG) and the Energy Resiliency Task Force (ERTF) have facilitated discussions on energy resiliency among APEC member economies. As a result, EWG, led by Japan with the support of ERTF and APEC member economies, developed the APEC Energy Resiliency Principle, which was endorsed at the EWG59 meeting held in 2020. Following the Principle, which compiled voluntary norms and measures that stakeholders in each economy should consider and implement for improvements in energy resiliency, the APEC Energy Resiliency Guidelines were published in February 2023.

Energy is the essential for our daily life and economic activities and disruptions in energy supply due to disasters have a great impact on us. However, it is difficult to prepare to the disasters on a regular basis. And especially in emerging economies where economic development is remarkable, social interest in energy resiliency is lower than that in the economy or environment. In addition, when governments and private companies take measures to improve resiliency, it is necessary to evaluate the risk and vulnerability to disasters objectively, but in developing economies, such data is insufficiently collected, and objective evaluation is difficult. As a result, social interest in energy resiliency has not increased and private sectors are not motivated to financing or investing for energy resiliency.

The objective of the APEC Energy Resiliency Enhancement Project (EWG 09 2021A) is based on the follow-up actions stipulated in the APEC Energy Resiliency Principles and the APEC Energy Resiliency Guideline and related workshop. This project aims to enhance the ability to secure stable energy supply by effectively dealing with disasters through the following three activities:

- Conducting research work including identifying, collecting, and assessing indicators to evaluate energy resiliency in APEC economies.
- Developing an APEC Energy Resiliency Sectoral Guideline for Energy Infrastructure Companies.
- Holding a workshop for capacity building on energy resiliency through dissemination of the Principle.

This report provides an overview of the results of these activities above and considers future actions for improvement of energy resiliency of each economy in APEC region based on the results.

2. Research study for indicators to evaluate energy resiliency

2.1 Background of research study

The APEC Energy Resiliency Guidelines describe one of criteria for enhancement of energy resiliency is identifying investment priorities. The Guidelines is written as:

- This process involves reviewing disaster vulnerabilities and potential impact assessment for energy facilities, resources, and other critical infrastructure to identify weaknesses that may compromise a stable energy supply.
- This process will help prioritize the areas where investments are the most necessary, selecting amongst potentially many stakeholders that have insufficient capital for investments in energy resiliency.
- In the case of private sector energy consumers, calculating expected financial losses associated with natural disasters and future climate impacts may help build consensus within each organization to make investments in energy resiliency.
- Governments may develop **toolkits** to help stakeholders identify gaps in energy resiliency and inform financing decisions.

Also, the Guidelines address:

- The need for multi-stakeholder knowledge sharing for energy resiliency enhancement.
- Assessment of resiliency knowledge gaps and capacity building needs may be conducted to facilities knowledge sharing.
- For example, the Philippine Department of Energy (PDOE) is developing an Energy Resilience **Scorecard** to provide an evidence-based guide to financing investments in energy resiliency.

Both “toolkits” and “scorecard” refer to frameworks that include “indicators” that quantify the intensity and impact of disasters. Indicators is generally a number or ratio (a value on a scale of measurement) derived from a series of observed facts, it can reveal relative changes as a function of time. The guidelines define indicators that represent various situations related to disaster impacts and energy resiliency.

Indicators which evaluate of vulnerability of existing energy supply chain against to disasters will be useful for energy infrastructure company's decision making of their investment. On the other hand, there is no clear definition or standard for energy resiliency indicators, and researchers and governments are review and constructing prototype indicators according to their issue recognition and their own objectives, and empirical efforts are being examined.

In this study, it is analyzed trends in energy resiliency related indicator studies being studied and implemented in major economies (Japan; Thailand; the United States), where energy resiliency indicators are being considered, and examined the possibilities and challenges of energy resiliency indicators

2.2 Methodology of research study

This study was conducted mainly based on information collected in the literature and on the Internet. In addition, some of them are conducted through presentations and discussions in the APEC Workshop on Energy Resiliency Enhancement project.

2.3 Review of consideration for building indicators relating energy resiliency enhancement

2.3.1 Overview of energy resiliency indicators consideration

Whilst interest in energy resiliency is increasing, projects related to improving energy resiliency are often seen as costs, so it is important for entities that are actively working to improve resiliency 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 resiliency[1]. 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 resiliency, 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 resiliency measures, and governments and insurance companies have introduced schemes to grant premiums for resiliency-improvement initiatives. In addition, as far as resiliency 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 resiliency, 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[2].

Following sections provides an overview of previous research regarding energy resiliency related indicator, especially in the United States, and existing consideration and development actions are being conducted in Japan and Thailand.

2.3.2 Study of RAND Corporation[3]

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

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

(1) A framework for measuring energy system resiliency.

- The building blocks of resiliency are inputs, which define what is available to support resiliency. 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 resiliency 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 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 resiliency metrics

- The metrics present a complex picture of how resiliency is managed and measured in energy

[1] For example: USAID and NREL (2019), 'Finance for Power Sector Resilience', December; Global Facility for Disaster Reduction and Recovery (GFDRR) (2015), 'Investing in Urban Resilience'

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

[3] Willis, H. H. et al. (2015), *Measuring the Resilience of Energy Distribution Systems*, RAND Corp.

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 domestic 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 domestic levels.

The RAND report illustrates the components that can be used to quantify resiliency 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, resiliency assessment is still at the stage of deepening our understanding of capability and exploring how it can be quantitatively assessed.

2.3.3 Study of Argonne National Laboratory[4]

Enhancing the resiliency 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 resiliency 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. Argonne National Laboratory, in partnership with the Protective Security Coordination Division of the United States Department of Homeland Security (DHS), has developed an index, the Resiliency Measurement Index (RMI), to characterise the resiliency of critical infrastructure.

The RMI was developed as an index to identify the most vulnerable areas of various facilities and to promote facility resiliency measures. In preparing the RMI, the first step was to collect the various actions included in the four phases of resiliency (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 resiliency 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.

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 resiliency) to 100 (high resiliency) for the critical infrastructure analysed.

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[4] Petit, F.D., et al (2013), *Measuring the Resiliency of Energy Distribution Systems*, Argonne National Laboratory, April

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 resiliency 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 resiliency.

The RMI by the Argonne National Laboratory is said to be excellent in that it can evaluate the resiliency 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 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 resiliency assessment, it is not suitable for regional and industry-level resiliency assessment.

Classification of Components of Resiliency 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

2.3.4 Study of Sandia National Laboratories [5]

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

The report defines resiliency 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 resiliency and evaluates endurance and resiliency to future events, and a method that estimates based on performance, that is,

[5] Vugrin, E., et al. (2017), *Resilience Metrics for the Electric Power System: A Performance-Based Approach*, Sandia National Laboratories, February

actual data at the time of disaster. Performance-based methods are more useful for estimating the cost-effectiveness of capital investment to improve quantitative resiliency, but they are complex and require a lot of data.

The report concludes that it is impossible to create a uniform resiliency measure based on an analysis based on this risk assumption because the events that may occur 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 a reference case for the development of an energy resiliency score system in the future.

Examples of Consequence Categories for Consideration in Grid Resiliency 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)

2.3.5 Study of Japan [6]

In Japan, an expert committee on the quantitative assessment of energy resiliency 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 resiliency.

In parallel, a private sector study group on energy resiliency was established. Experts from multiple energy companies, insurance companies, and research institutes gathered to discuss business applications of

[6] ERIA (2024), *Study on the Possibility of Promoting Quantitative Evaluation Indicators for Strengthening Energy Resilience in the East Asia Region,* ERIA Research Project Report 2024

energy resiliency assessment. In 2022, the Energy Resiliency Council[7] was established under the leadership of the private sector as a successor to the Energy Resiliency Study Group, and a prototype of the quantitative energy resiliency assessment (scoring) has been developed.

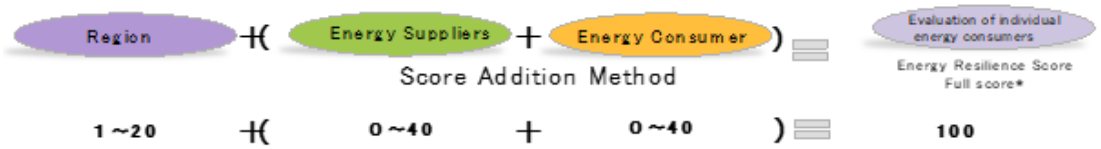
The prototype Energy Resiliency Score (ERS) system is being developed under the following concept:

- 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 resiliency 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.

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.

- **Regional score**: Each economy, 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.
- **Supply score**: The energy resiliency 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.
- **Score for energy consumers**: The evaluation is based on a score addition method, considering the measures taken for each energy type.

Concept of ERS Calculation



Criteria and Evaluation method of Disaster Risk

Weather elements	Risk	Rank	Score	Evaluation details per score
Heavy rain	Landslide Probability Index	360,000 mesh, rated in five ranks per location	1–5 points	Comparison in Japan 1: Relatively dangerous 2: Relatively somewhat dangerous
Strong winds	Storm Entry Rate Index		1–5 points	
Flood	Flood Damage Probability Index		1–5 points	
Earthquake	Index of probability of occurrence of		1–5 points	

[7] 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.

	seismic intensity 5 or higher			3: Relatively medium 4: Relatively somewhat safe 5: Relatively safe
Disaster Risk Assessment			4–20 points	

Evaluation result of Disaster Risk in the Assessed Area

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

A pilot project using the prototype ERS calculation system was conducted in Japan targeting businesses operating heat supply businesses in different regions. In conducting the pilot project, the three heat supply facilities agreed to provide the necessary information in advance.

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

This survey analyzed energy resiliency based on the status of disaster risks, energy supply side risks, and energy consumer side risks in the three regions. The results of the survey, with detailed information provided by the energy supplier, gave comparable regional energy resiliency indicators. In future, it was concluded that 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.

As the result of this pilot survey, the following issues have been identified in the evaluation of energy resiliency using ERS method.

(a) Improvement points in resiliency 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 resiliency 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 resiliency 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

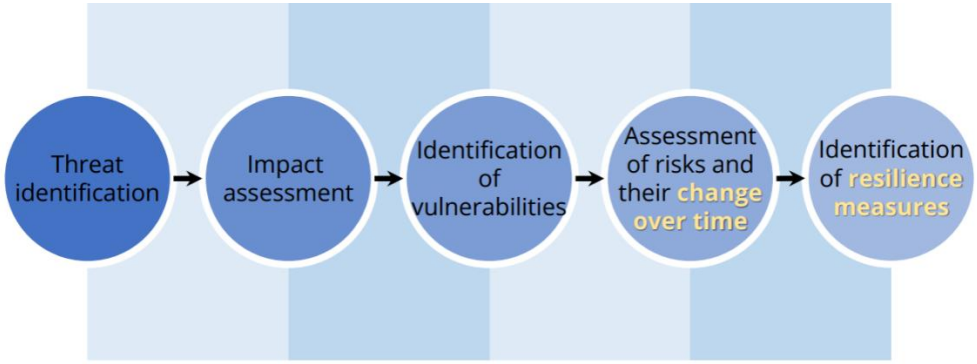
- When evaluating general consumers (applying to various economies and regions) in the future, it may be difficult to collect evaluation information from publicly available data on the supply-side companies (electricity, gas, oil) used by such consumers, and it is necessary to consider how to collect 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.

2.3.6 Study of Thailand

In Thailand, the Energy Resilience Assessment system is in operation, which evaluates the energy resiliency 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[8].

Energy Resiliency Assessment



The Energy Resilience Assessment system can be broadly divided into five review steps[9].

(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.

Threat Likelihood Score

[8] Nuwong Chollacoop, Kampanart Silva, Pidpong Janta, *Situation and Challenges for Energy Infrastructure Resiliency in Thailand,* APEC Workshop on Energy Resiliency Enhancement project (November 2023) presentation

[9] ENTEC (2022), *ASEAN Energy Resilience Assessment Guideline*.

(2) **Impact assessment**: 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) **Identification of vulnerabilities**: 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.

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

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

(5) **Identification of resiliency measures:** Based on the results of the evaluation so far, the measures that should be implemented to build a more resilient energy system are discussed.

Examples of Resiliency Solutions


Battery/Energy Storage System


Diesel Generators

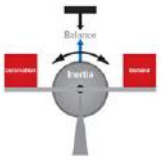

Improved transmission lines


Diversification of grid connection mode


Set standards/requirements


Adapt to the new normal


Increase diversity of the RE sources


Create Electrical load management system

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 resiliency of existing facilities in the future.

2.3.7 Conclusions of research study

- In order to enhance the resiliency of energy systems, the effectiveness of comprehensive indicators based on relevant data is recognized as a concept in order to assess the impact of natural disasters in advance, and various studies and empirical projects are being conducted to build indicators.
- While the effectiveness of the use of indicators is recognized, the availability of data constituting indicators is a major issue. For example, data on natural disasters as a component of indicators has

been prepared by international organizations and insurance companies, and it may be possible to use such data for evaluation by economy, region, and energy supply facility.

Components of Hazards in Existing Indices

Events		UNDRR*1	INFORM*2	AON*3
Natural hazards	Earthquake	✔	✔	✔
	Tsunami	✔	✔	✔
	Volcanic eruption	✔		
	Flood (fluvial/pluvial)	✔	✔	✔
	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.

- The other hand, as pointed out in the efforts of Japan and the United States, the construction of resiliency indicators for existing energy infrastructure facilities requires detailed information at the facility level necessary for calculating indicators, but it is difficult to provide information from energy supply companies, according to the results of research and demonstration projects.
- Therefore, assessing the resiliency of energy infrastructure with indicators requires a feasible approach through numerous dialogues and negotiations, focusing on individual infrastructures and facilities, and checking the availability of data. The initiative in Thailand is considered to be an initiative that evaluates the resiliency of renewable energy power generation facility plans and focuses on feasibility.

- The efforts of studies and actions in Japan and the United States show the type of information required to construct indicators and the concept of integrated indicator calculation, these concepts and extensive data lists are invaluable to governments and energy suppliers in APEC economies looking to strengthen their energy resiliency.
- Therefore, given the availability of data, geographical, economic, energy supply and demand structures, and policy differences in APEC economies, it is valuable to develop comprehensive and conceptual guidelines for building energy resiliency indicators.
- One of the considerable ways using such guidelines maybe induce efforts to strengthen the resiliency of the energy system in consideration of existing situation that it is faced. Such guidelines maybe a catalyst for creating opportunities for communication that promote understanding and dissemination of these guidelines, as well as for creating cooperation projects between APEC economies and stakeholders including energy supplier, .energy consumers and financial institutions.

3. Brief introduction of the Sectoral Guideline Development

3.1 Objective of development of the Energy Resiliency Guideline for Energy Infrastructure companies

The purpose of develop the guideline is to formulate supply-side energy resiliency related guidelines for energy infrastructure companies. Some evaluation components will be added or removed in line to meet economy-specific needs. In line with the APEC Energy Resiliency Principle, the guidelines aim to support APEC member economies to build energy systems, which 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.

Components of the strategies and action plans examined for energy resiliency enhancement by energy infrastructure companies are parts of whole components for sustainable business activities of a company. It will expect that through referring to the any type of management related studies, practices and standards, energy infrastructure company formulates feasible strategies and plans for energy resiliency and implement effective responses according to the situation by event of disaster considering to individual circumstances.

Considering this objective, this guideline identified the following relevant field to consider energy resiliency strategy and management by the energy infrastructure companies.

- Energy resiliency management for individual energy sector and region
- Business continuity management systems
- Risk management
- Crysis, emergency management
- Asset management
- Emergency evacuation and disaster response and recovery
- Cybersecurity management systems

The content of this guideline is constructed by referring and incorporating the following reference information as appropriate.

- APEC Energy Resiliency Principle
- APEC Energy Resiliency Guidelines
- Discussions in the APEC Energy Resiliency Enhancement Project Workshop (November 2023)
- Ongoing development of energy resiliency related standards in ISO (such as ISO CD 22366)
- ISO/IEC standards on organizational management system including business continuity management, emergency management, risk assessment, asset management, cyber security management and others
- Regional initiative, research study relating energy resiliency enhancement by government, domestic institute and others

3.2 Scope of the Energy Resiliency Guideline for Energy Infrastructure Companies

The main target of this guideline is energy **i**nfrastructure companies, as they are responsible for taking the initiative to make and implement energy resiliency plans to diversify their supply sources and methods. Furthermore, they should aim to improve their self-sufficiency rate in energy supply sources, technologies, and facilities and secure energy storage and generation facilities sufficiently prepared for natural disasters.

Main scope of this guideline is described as follows:

- This document provides a framework for energy resiliency of energy **i**nfrastructure companies to help reduce impacts and ultimately achieve build back better from events, including natural and human-induced disasters. Generally, energy resiliency is a part of corporate business strategy including risk management, business continuity plan and others. Therefore, the content of this document incorporates the content of international standards related to corporate resiliency strategies to increase the adaptability of different types of companies.

It should be noted in this guideline that the content of the guideline is general and common to all energy **i**nfrastructure companies. The energy supply sector is comprised of various types of industries, including electricity, petroleum products, and gas. In addition, the structure of the domestic energy market, the presence or absence of regulations, and the content of the energy market are not uniform. Therefore, this guideline stipulates the following points to note.

- This document does not provide guidelines on the application for individual energy infrastructure such as power generation company, transmission company, gas company, oil company to address risks and define resiliency measures. Guidelines for individual energy infrastructures may consider separately, if necessary.
- It is recommended that each economy tailor its approach in consideration of economy-specific energy resiliency challenges. This guideline is non-binding in nature, it provides energy resiliency approaches that may be implemented voluntarily by energy infrastructure companies to enhance energy resiliency efforts in their supply-chain.

3.3 Terms and definitions

In general, terms and definitions are the most important component of the guidelines, and consistent and common terminology is needed to promote resiliency in APEC region. Therefore, the following terms and definitions, which are the most important in this standard, are quoted and reproduced from the APEC Resiliency Principle and APEC Energy Resiliency Guidelines.

- Energy Resiliency
- Energy Resiliency Plans
- Human-induced Disasters
- Natural Disasters

The following definitions are defined with reference to internationally widely shared guidelines.

- Build Back Better
- Business Continuity Management (BCM)
- Augmented reality (AR)

3.4 Role of Energy Infrastructure Companies for Energy Resiliency Enhancement

In order to enhance of energy infrastructures in each APEC economy, the APEC Energy Resiliency Principle has identified four relevant stakeholders with their fundamental role, and the APEC Energy Resiliency Guidelines has detailed its roles. Sharing the roles of each stakeholder is essential for energy resiliency enhancement in APEC, and these guidelines restate the role of the or energy resiliency of energy **i**nfrastructure companies in accordance with the description in the APEC Energy Resiliency Guidelines.

3.5 Referring useful practices for developing strategy of energy infrastructure companies for their energy resiliency activities

The energy resiliency strategy developed by energy infrastructure company vary depending on the type of business, the characteristics of the market, the expected impact of disasters, and the geographical

conditions and policy measures differences of each economy. Therefore, when energy infrastructure companies formulate their energy resiliency strategy to develop, maintain and strengthen, it could be developed policies efficiently and appropriately by referring existing relevant studies, practices and guidelines.

And also, the components of the strategies and plans examined for energy resiliency by energy infrastructure companies are parts of whole components for sustainable business activities of a company. It will expect that through referring to the any type of management related studies, practices and standards, energy infrastructure company formulates feasible strategies and plans for energy resiliency and implement effective responses according to the situation by event of disaster considering to individual circumstances.

For the above objectives, from the perspective of considering the overall business plan including energy infrastructure company's own energy resiliency, this guideline introduces reference areas related to strategy consideration, indicating the necessity of comprehensively considering energy infrastructure company's energy resiliency strategy.

The other hand, the principles are the foundation for formulating energy resiliency policy and designing and implementing strategy to deliver the policy objectives for energy infrastructure company. The Energy Resiliency Guidelines does not specify detailed principles for individual stakeholders to formulate their energy resiliency strategy and plan. This is thought to be due to the fact that, for example, energy infrastructure companies include a group of companies with diverse characteristics, such as electric power company, oil company, gas company, and other energy supply companies, and it is difficult to show a shared principle. Therefore, this guideline provides examples that energy infrastructure company can refer to when considering its own resiliency strategy.

3.6 Conceptual framework for assessment of disaster risk with change over time

When the energy infrastructure companies consider its own resiliency strategy, it is important to understand the expected disaster impacts and efforts in a structural and chronological manner.

This guideline provides the concept of the impact on energy infrastructure over time in the event of a disaster, which is shared worldwide, and explains specific changes in the situation with reference to the guidelines issued by ASEAN. It is expected that energy infrastructure companies sharing of time-series changes in the impact of common disasters and necessary efforts will contribute to the development of more executable resiliency strategies, as well as to the provision of useful information and the acquisition of knowledge in the exchange of information among economies.

3.7 Approaches for energy resiliency enhancement

The energy infrastructure companies should investigate and evaluate their energy supply chain related context and should formulate plans to deal with disruptions, emergencies and disasters. The energy infrastructure companies should review and amend the plans continuously taking recent technological advancements into consideration.

This guideline outlines the following key approaches to energy resiliency of energy infrastructure companies while considering the consistency with the APEC Energy Resiliency Guidelines: In particular, 7.1 to 7.8 will be the main elements of their resiliency plan. In addition, as described in 3.5, since the strategy for energy resiliency is part of the corporate management strategy, reference information on ISO standards related to corporate management is provided as appropriate, and the content is used as a reference.

7.1 Identification of events affecting the energy system

7.2 Assess risks by event

7.3 Considerable design energy supply chains to be resilient

7.4 Stability of energy supply

7.5 Investment for energy resiliency

7.6 Proper asset management

7.7 Adaption of emerging technologies

7.8 Multi-stakeholder knowledge sharing

7.9 Making energy resiliency plan

7.10 Build energy resiliency balancing with sustainability

3.8 Criteria for implementing energy infrastructure company's energy resiliency plan

Chapter 8 describes the following seven specific criteria of initiatives to implement the energy resiliency approach of energy infrastructure companies described in Chapter 7.

8.1 Structured internal/external communication

8.2 Governance and resources for energy resiliency enhancement

8.3 Emergency response system

8.4 Supply-chain management

8.5 Engagement for financing for energy resiliency enhancement project

8.6 Education and training

8.7 Consideration for achievement of build back better

3.9 Cooperative actions for improvement of energy resiliency

Chapter 9 outlines how cooperative actions by energy infrastructure companies can contribute to promoting resiliency enhancement of energy infrastructure in society as a whole. Cooperative actions by energy infrastructure companies. Cooperative actions include:

- facilitate stakeholders' understanding of energy resiliency issues
- contribute to knowledge sharing with internal and external stakeholders
- assess energy resiliency knowledge gaps
- determine capacity building needs to facilitate knowledge sharing
- encourage cross-sectoral collaboration

3.10 Bibliography

Bibliography provides references to the content contained in this Guidelines, as well as a list of academics papers, related initiatives, and relevant international standards that can help users understand the content of this guidelines and use for developing their own energy resiliency related strategic content.

4. Summaries of Workshop outcomes

4.1 Background and aims of the workshop

The APEC Energy Working Group (EWG) conducted the Asia-Pacific Economy Cooperation (APEC) Workshop on Energy Resiliency Enhancement project from 9 to 10 November 2023. The workshop was held to disseminate the APEC Energy Resiliency Principle and the APEC Energy Resiliency Guidelines, share knowledge and experiences on energy resiliency among APEC member economies, and solicit input for the development of the APEC Energy Resiliency Sectoral Guidelines for Energy Infrastructure Companies.

Stable and resilient energy supply is critical for maintaining socio-economic activities. Many APEC economies continue to be challenged by intensifying natural disasters which cause serious damage to energy infrastructure and economy. Energy supply systems also increasingly threatened by man-induced disasters such as cyber-attacks and terrorism. As a result, energy disruption risks have increased dramatically, and energy resiliency has been an emerging priority across APEC economies.

The energy ministers of member economies of the APEC affirmed the importance of energy resiliency to promoting energy security and achieving sustainable development in the 2015 APEC Energy Ministerial Meeting held in Cebu, the Philippines. The meeting resulted in the Cebu Declaration on East Asian Energy Security. Since then, the Energy Working Group (EWG) and the Energy Resiliency Task Force (ERTF) have facilitated discussions on energy resiliency among APEC member economies. As a result, EWG, led by Japan with the support of ERTF and APEC member economies, developed the APEC Energy Resiliency Principle, which was endorsed at the EWG59 meeting held in 2020. Following the Principle, which compiled voluntary norms and measures that stakeholders in each economy should consider and implement for improvements in energy resiliency, the APEC Energy Resiliency Guidelines were published in February 2023.

Energy resiliency can be enhanced in various ways, including diversifying energy sources, implementing contingency measures, and building smart systems harnessing cutting-edge technologies such as IT and AI. These solutions will help build a more resilient energy system, and thus more resilient businesses and cities. On the other hand, harnessing emerging technologies will bring new challenges for energy resiliency evaluation, including legal challenges, as well as difficulties in utilizing or processing data for business purposes, depending on the economy. These issues will need to be overcome through international cooperation and will be important issues to be considered in sectoral guidelines.

Against this backdrop, the workshop aims to raise social awareness of energy resiliency in APEC economies and local community with a focus on energy supply infrastructure. Through the discussions at the workshop, it will be sought to gain insight for developing the Energy Resiliency Sectoral Guidelines for Energy Supply Infrastructure to improve resiliency efforts in the sector and enhance participants knowledge and understanding of energy resiliency evaluation.

4.2 Workshop operation

- Title: APEC Workshop on Energy Resiliency Enhancement Project
- Date/Hours: 9 November 2023, 10:00 – 17:30
- Venue: San Francisco, the United States (Hotel Nikko San Francisco)
- The workshops featured presentations and discussions on:
    - Urgent need for evaluating energy resiliency
    - Situation and challenges for energy infrastructure resiliency in member economies
    - Lessons & learns from each economy’s experiences and implications to future APEC activity for energy resiliency enhancement of energy supply sector
        - What are the key challenges to building energy resiliency in your economy/region?

- What would be needed in each APEC economy/region to enhance energy resiliency?
- What could each APEC economy/region contribute to building resiliency in other economies/regions?
- Considering the APEC Energy Resiliency Principles and Guidelines, what additional guideline/guidance or information would be needed to advance energy resiliency in each APEC economy/region?

4.3 Workshop agenda

Agenda items	
10:00-10:20	**Worshop facilitator: Ms Kana Sato**, Senior Researcher, JIME Center, the Institute of Energy Economics, Japan (IEEJ) ***Opening Remarks:*** **Dr Kazutomo IRIE**, President, the Asia Pacific Energy Research Centre (APERC) ***Welcome Remarks:*** **Mr Dan Ton**, Program Manager of Smart Grid R&D, Office of Electricity, the U.S. Department of Energy (DOE)
Part 1: The urgent need for evaluating energy resiliency	
10:20-11:00	***Keynote Speech****:* Introduction of the APEC energy resiliency enhancement project" **Ms Reiko EDA,** Director for Natural Resources and Energy Research International Affairs Division, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), JAPAN **Mr Brian Strong**: Chief Resilience Officer and Director, Office of Resilience and Capital Planning, Office of the City Administrator, City and County of San Francisco
11:20-12:00	***Introduction to APEC Energy Resiliency Principles/Energy Resiliency Guidelines*** **Mr. Hiroki Kudo**, Board Member, Director, in charge of Electric Power Industry Unit, the Institute of Energy Economics, Japan (IEEJ)
Part 2: Situation and challenges for energy infrastructure resiliency in member economies (1)	
13:10-14:40	**Moderator: Ms Tomoko Murakami**, Senior Fellow, Electric Power Industry Unit, the Institute of Energy Economics, Japan (IEEJ) ***Australian Case*** **Dr Kevin J. Foster**, Chairman, Risk Engineering Society (Western Australia) ***Canadian case*** **Dr Guy Félio**, Independent Consultant, Senior Advisor – Infrastructure Resilience ***Japanese case*** **Mr Keisei Nozaki,** Assistant Director, International Affairs Division, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), JAPAN
Part 3: Situation and challenges for energy infrastructure resiliency in member economies (2)	
15:00-16:30	**Moderator: Ms Tomoko Murakami**, Senior Fellow, Electric Power Industry Unit, the Institute of Energy Economics, Japan (IEEJ) ***Chilean case*** **Dr Claudio Huepe Minoletti,** Former Energy Minister of Chile, Universidad Diego Portales ***Indonesian case*** **Dr Ir Djoko Siswanto,** Secretary General, Indonesia National Energy Council, Republic of Indonesia ***Thailand case*** **Dr Nuwong CHOLLACOOP,** Director, Low Carbon Energy Research Group, National Energy Technology Center (ENTEC)

Part 4: Lessons & Learns from each economy's experiences and Implications to future APEC activity for energy resiliency enhancement of energy supply sector	
16:30-17:20	**Panel discussion:** ***What are implications to enhance energy resiliency in energy supply sector and role/contents of the standard in APEC.*** **Moderator: Dr Guy Félio (Canada)** Ask to invited speakers questions and discuss
17:20-17:30	***Closing Remarks:*** **Dr Kazutomo IRIE (APERC)**

4.4 Participating economies and organizations

A total of 28 participants (including 6 invited speakers, 12 active participants and 3 speakers through video) were from 11 economies including: Australia; Canada; Chile; Indonesia; Japan; Malaysia; The Philippines; Chinese Taipei; Thailand; The United States; Viet Nam.

List of Speakers and Participants

Economy	Organization	Name	Gender
Australia	Risk Engineering Society (Western Australia Chapter)	Dr Kevin J. Foster	M
Canada	Independent Consultant	Dr Guy Félio	M
Chile	Universidad Diego Portales, Chile (Former Minister of Energy of the Republic of Chile)	Mr Claudio Huepe Minoletti	M
Indonesia	Ministry of Energy & Mineral Resources	Dr/Ir Djoko Siswanto	M
	Ministry of Foreign Affairs	Ms Ruth Yohanna Lumbanraja	F
		Ms T. Elfani Prassanti	F
Japan	Asia Pacific Energy Research Centre	Dr Kazumoto Irie	M
		Mr Yoshiaki Imaizumi	M
		Ms Ikuno Yamaguchi	F
	Ministry of Economy, Trade and Industry	Ms Reiko Eda	F
		Mr Keisei Nozaki	M
	Institute of Energy Economics, Japan	Mr Hiroki Kudo	M
		Ms Tomoko Murakami	F
		Mr Goichi Komori	M
		Ms Kana Sato	F
Malaysia	Ministry of Natural Resources, Environment and Climate Change Malaysia	Mr Wan Aminuddin Wan Hitam	M
		Mr Faiz Farhan Mohd Sharif	M
The Philippines	Department of Energy	Ms Magnolia Baterina Olvido	F
		Mr William G. Quinto	F
Chinese Taipei	Energy Administration, Ministry of Economic Affairs	Ms Shu-Ya, Chiu	F
		Mr I-Wei, Ho	M
Thailand	National Science and Technology Development Agency	Dr Nuwong Chollacoop	M

	Ministry of Energy	Ms Patcharaporn Khajorn-in	F
		Mr Prasert Sinsermsuksakul	M
The United States	City and County of San Francisco	Mr Brian Strong	M
	Program Manager of Smart Grid R&D, Office of Electricity	Mr Dan Ton	M
Viet Nam	Ministry of Industry and Trade	Mr Le Phan Dung	M
		Ms Hoang Thi Ngoc Thanh	F

4.5 Summary of speeches, presentations and discussions, panel discussion

4.5.1 Opening

Following opening remarks from **Dr Kazutomo IRIE, President of the Asia Pacific Energy Research Centre (APERC)** and **Mr Dan Ton, Program Manager of Smart Grid R&D, Office of Electricity, the United States. Department of Energy** as a welcome remark (video message), a total of four sessions were held with discussions between speakers and attendees. The outline of the discussion is as follows.

4.5.2 The first session on "the urgent need for evaluating energy resiliency"

Ms Rieko EDA, Director for Natural Resources and Energy Research International Affairs Division of Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), JAPAN introduced the APEC Energy Resiliency Task Force, Principles, and workshops on the Principles (video message). The expert committee for quantitative assessment of energy resiliency in Japan (contents of the 2020 report), the efforts to formulate ISO on energy resiliency, and the position of this workshop were outlined.

Mr Brian Strong, Chief Resilience Officer and Director, City and County of San Francisco outlined California and San Francisco efforts for energy resiliency. The rapid expansion of solar and wind power across the State to reduce its dependence on fossil fuels, deal with aging power grids (consider energy storage in various places), secure sufficient storage batteries, and save energy (including demand response) are moving forward.

While utilities have been active in improving energy resiliency, more support is needed at the federal level.

During the Q&A session:

Although underground construction is considered because power lines can cause wildfires, it is incredibly costly in cities where a lot underground and above ground infrastructure is in place.

The issue is what kind of performance standards are appropriate for energy resiliency, and he hope that APEC and federal agencies will consider adopting them (City of San Francisco has its own standards for the provision of energy and water in the event of an earthquake).

One of the challenges cited was the reluctance of private companies (e.g., telecommunications companies) to share confidential information about their vulnerabilities.

Mr Hiroki Kudo, Board Member, Director in Charge of Electric Power Industry Unit, The Institute of Energy Economics, Japan (IEEJ) explained the APEC Energy Resiliency Principle, APEC Energy Resiliency Guideline, and APEC Energy Resiliency Enhancement Project.

He also informed the outline and benefits of ISO 22366 (Security and resilience - Community resilience - Framework and principles for energy resilience) as a related activity and pointed out that how to harmonize

between the APEC guidelines and international standards related energy resiliency enhancement is an important point, and that it includes supply chain networks as a benefit for users.

4.5.3 The second session "Situation and challenges for energy infrastructure resiliency in member economies (1)"

Experts from three APEC member economies (Australia; Canada; Japan) gave their presentation and discussed the status of resiliency in energy infrastructure in each economy.

Dr Kevin J. Foster, Chairman, Risk Engineering Society (Western Australia), introduced the status of Australia's energy resiliency related efforts. Australia's Inter-State electricity grid is limited to the eastern States. South-Western Australia has a completely separate electricity grid and there are various other smaller isolated grids in remote regions of the economy. Renewable energy production is growing rapidly, especially solar and wind power. Electricity authorities are gradually developing a capability to electrically isolate roof top solar panels by remote control, especially when it is necessary to maintain stability of the grid. In addition to natural disasters such as wildfires, cyclones, floods and droughts, other risks can come from supply chain failures, such as a coal mine or thermal power plant closing earlier than planned. Delays in large-scale clean energy could result in reliability gaps from 2025).

He pointed out a chronic shortage of skilled technical tradespeople and engineers needed to design, build, operate and maintain energy infrastructure. Australia's governance framework, critical infrastructure resiliency strategy, legislation and resiliency principles were outlined. Incentives are necessary for private companies to invest in energy resiliency. Energy resiliency principles need to be globally standardised and harmonized and should be based on socio-technical systems thinking: for both societal and engineering resiliency, not just one or the other.

During the Q&A session:

He pointed out that the economics incentives of connecting electricity and gas grids between Western and Eastern Australia and with other economies in the region are likely very weak.

Australia is a major exporter of energy, and other economies depend on Australia for their supply chains. Therefore, he also pointed out that due to these trade obligations. It is not necessarily a simple matter to close coal mines or natural gas production facilities in the near future.

Dr Guy Félio, Independent Consultant, Senior Advisor, Infrastructure Resilience introduced the status of Canada's energy resiliency related initiatives. Due to geographical circumstances and population distribution, trade and interconnectivity with the United States have a significant impact on Canada. Climate-related disasters have increased in recent years, with insured losses alone surpassing CAD billions annually in recent years (e.g., the May 2022 derecho cost more than CAD1.1 billion in insured losses). Non-insured losses are typically twice those amounts.

It is not always possible to solve all problems by making the equipment infrastructure itself more robust (e.g., damage caused by debris blown from a nearby construction site by a tornado). In light of the United States - Canada blackout in August 2003, interdependence between utilities is also a risk, and O&M risks should also be considered in the context of resiliency. It is possible to deal with physical infrastructure risks, but building bigger and stronger requires enormous costs, and the solution should be a combination of infrastructure and non-infrastructure solutions, not just technology.

In addition, it is necessary to consider the perspective of smart cities and domestic security as cyber risks. Canada has developed codes, standards, and laws related to resiliency, and there are many strategies and plans by energy companies. Revisions to codes and standards take time, so other methods and tools that can provide faster results should be considered. It is also important to ensure adequate capacity of experts in climate risk assessment and resiliency.

During the Q&A session:

He pointed out the reduction of insurance premiums as an incentive for private companies and property owners to take resiliency measures.

In addition, he said that opportunity losses are not included in the calculation of losses due to natural disasters, and that insured losses are only 30-50% of the total losses.

Mr Keisei Nozaki, Assistant Director, International Affairs Division, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), JAPAN introduced the status of Japan's energy resiliency related initiatives (video message). There is an urgent need to develop and strengthen disaster-resilient power system infrastructure due to the two major issues of threatening the power supply, the occurrence of intensifying natural disasters and the use of renewable energy as the main power source. As a countermeasure, the Energy Supply Resilience Act was enacted.

4.5.4 The third session "Situation and challenges for energy infrastructure resiliency in member economies (2)"

Experts from three APEC member economies (Chile; Indonesia; Thailand) gave their presentation and discussed the status of resiliency in energy infrastructure in each economy.

Dr Claudio Huepe Minoletti, Former Energy Minister of Chile, Universidad Diego Portales introduced the status of Chile's energy resiliency related initiatives. More than 50% of the renewable energy generation capacity is located in the north of the economy. The risk from natural disasters is under the jurisdiction of the MEN, CNE, and SEC and SENAPRED, while the risk of man-made attacks is under the jurisdiction of the Ministry of the Interior.

In the wake of the 2010 earthquake, energy resiliency efforts have changed significantly, with policy focusing not only on infrastructure security, but also on supply and operational security. Efforts have been made to integrate information into a single platform, and a lot of information has been collected, but how to handle various forms of information is an issue.

Legislative action has been taken to require all sectors to plan for disaster response, to map key infrastructure for monitoring, and develop plans for risk management. However, there is no systematic approach to resiliency and a comprehensive legal framework and regulation.

There is also a problem in Chile as private companies are the actors of the market and the government doesn't have all information.

Dr Ir Djoko Siswanto, Secretary General, Indonesia National Energy Council, Indonesia introduced the status of Indonesia's energy resiliency related initiatives. The IEA has conducted an emergency response review in Indonesia and has formulated energy rules and policies such as the Energy Law, National Energy Policy, National Energy Master Plan, Regional Energy Master Plan, and Energy Crisis and Energy Emergency Assessment and Response Procedures (Decree of NEC)).

The Decree of NEC clearly stipulates the measures taken by the central government. Future measures to strengthen resiliency include expanding renewable energy, phasing out energy subsidies, expanding stockpiles, conducting drills to mitigate supply disruptions in cooperation with ASEAN economies as an emergency response, and improving oil refining capacity.

During the Q&A session:

He cited cooperation and knowledge sharing between Indonesia and the Philippines and other economies in the region in response to a question about what the appropriate strategy for the private sector is to strengthen infrastructure for economies with market-driven energy sectors.

Dr Nuwong Chollacoop, Director, Low Carbon Energy Research Group, National Energy Technology Center (ENTEC) Introduced the status of Thailand's energy resiliency related initiatives. In regard to energy resiliency is in the context of adaptation, energy resiliency assessments are conducted based on risk assessment methods. Although it is difficult to obtain the commitment of the private sector in resiliency measures, his team aims to strengthen information sharing and cooperation to increase engagement.

Resiliency assessments are applied to a variety of different renewable energy technologies. Introduced the ASEAN COSTI Priority for 2021, three workshops on energy resiliency, and the ASEAN Energy Resilience Assessment Guideline. The SOP (Standard Operating Procedure) presented in the guidance shows the procedure step by step to make private companies aware of the time and cost required (the guidance itself still needs revision).

Resiliency assessment in Malaysia and cooperation with Japan (Ministry of Economy, Trade and Industry (METI), The Institute of Energy Economics, Japan (IEEJ) and Japan International Cooperation Agency (JICA) were introduced.

During the Q&A session:

Thailand raised the National Determined Contributions (NDC) target towards carbon neutrality but pointed out that energy resiliency is not explicitly included in NDCs, NDCs are mitigation, and resiliency is in the context of adaptation.

4.5.5 Panel session "Panel discussion: What are implications to enhance energy resiliency in energy supply sector and role/contents of the standard in APEC"

All of the face-to-face speakers (six in total) participated in the panel discussion. The moderator was Dr Félio (Canada). The moderator asked three questions, and each speaker answered them. The main contents were as follows.

Question 1: What are the main challenges of building energy resiliency in your economy or region?

Australia: Information-sharing networks are functioning well, but they were originally developed for security and have restricted distribution and access. Reliability considerations are also an issue, and more rational decision-making is needed to avoid future problems.

Chile: As an organizational issue, it seems to be clearly stated in the law, but it is unclear who will be responsible for implementation in actual operation. Preparing people and organizations to plan and execute resiliency behaviors. Financing to implement resiliency measures.

City of San Francisco: Strengthening appropriate cooperation (collaboration across sectors and institutions). Securing resources to leverage data. Cities face many different challenges, and climate change is important, but only one of them.

Indonesia: Lack of regulations and resources to implement them. Review of policies (towards 2060 carbon neutrality). Development of infrastructure and power grids. Fundraising assistance. Cooperation with other economies.

Thailand: Stakeholder involvement (private companies, NGOs, etc.). Develop policies and implementation guidelines. Development of simple adaptations.

Question 2: What do you need in your economy and region to strengthen energy resiliency?

Australia: Investment in innovation and technology (potentially hydrogen) and better management of transition periods are needed. Better information sharing arrangements for exchanging experiential knowledge

Chile: Resiliency debate needs to be broadened to a broader audience. Sharing experiences and good practices of learning by doing as a way to contribute.

City of San Francisco: We need “pressure and advocacy” on energy resiliency – use. APEC’s signals of the importance of energy resiliency. Linking energy resiliency to economic resiliency. Where we can contribute: the United States resources and, local voices on resiliency (city initiatives).

Indonesia: Funding is needed to plan and implement energy resiliency measures. Technology transfer and sharing are also necessary. Where you can contribute is by sharing your experience.

Thailand: Energy resiliency solutions need to be implemented. Where I can contribute is in resiliency training.

Question 3: Consider the APEC Energy Resiliency Principles and the APEC Energy Resiliency Guidelines, and what additional guidance and information is needed in your economy or region?

Australia: Practical guidance is needed, including case studies. Addressing skills shortages and promoting education and development. Explanation of the difference between risk management and resiliency management.

Chile: Simplified language to disseminate the guidelines. How will resiliency be monitored and evaluated, including how investment priorities will be chosen? The impact of decisions and policies on resiliency.

City of San Francisco: Guidance on justifying investment needs. Quantification of benefits for cost-benefit analysis. Showing what is valuable. Resiliency presents, such as a resiliency scorecard.

Indonesia: Lessons and examples from other economies and regions that have adopted and implemented the Energy Resiliency Guidelines. Relationship with net zero (how to link it). Calculating the cost of implementing resiliency measures and how to implement them (lessons learned from successful cases).

Thailand: Sector-specific guidance (e.g., public and private sectors). Since it targets various economies, specific content is included in addition to general content. Include case studies. Include easy-to-understand explanations like infographics.

4.5.6 Summary of moderator’s observations from panel discussions

The implementation of energy resiliency regulations, policies and programs appears challenging due to a number of factors, more pronounced in some economies than others; they include:

- Institutional challenges
  - Lack of instruments (regulations, policies, codes, standards) for energy resiliency
  - Difficulty to implement energy resiliency measures, due to lack or gaps in:
    - Collaboration and engagement: within and between sectors (public and private)
    - Awareness of needs and benefits of energy resiliency, including impacts on other sectors of the economy and well-being of citizens
- Financing energy resiliency measures and initiatives
- Examples (case studies, lessons learned) of successful energy resiliency initiatives

The economies represented on the panel indicated particular needs to meet the above challenges, such as:

- Investments in innovation and technology
- Broadening the energy resiliency conversation and debate beyond central governments by engaging relevant stakeholders including the private sector (often responsible for the energy infrastructure) and civil society.
- Using APEC credibility and energy resiliency related work to support advocacy for energy resiliency

- Developing strong business cases for energy resiliency that include evaluating (monetized) economic and societal benefits.
- Examples or case studies of successful energy resiliency solutions, particularly related to implementation

The above economies can also contribute to the advancement of energy resiliency in other regions or economies. Example of the contributions include sharing:

- Experiences on energy resiliency initiatives including but not limited to the development and implementation of policies and regulations.
- Technologies to enhance energy resiliency
- Training and capacity development

Overall, the panelists indicated that the APEC Energy Resiliency Guidelines could be further developed and enhanced by:

- Providing practical guidance on implementation, including lessons learned and case studies (a standard template for case studies could be developed to collect data and information and publish as a compendium supplement to the current guidelines)
- Develop capacity building to train and raise awareness related to energy resiliency
- Tools to quantify the benefits of energy resiliency and build strong business cases that include the contributions of resilient energy systems to society and the economy.
- Communication material (tools) related to energy resiliency targeted at various stakeholders in simple language, including for example infographics
- Implementation guidance by sectors: public (policies, programs) and private (investment, infrastructure)

Finally, several representatives of the economies participating in the workshop indicated the importance of the Energy Resilience standard (ISO 22366) currently under development. Although projected to be released in October 2025, this standard is expected to be an important complement to the APEC guidelines.

4.6 Conclusion of the workshop and Next Steps

4.6.1 Key Findings

In the workshop, six experts from APEC economies and one city presented the current status of energy infrastructure and countermeasures against risks caused by disasters. In the panel discussion, they discussed future initiatives and challenges, and expressed expectations for related APEC activities in the future. Specifically, the following suggestions were presented.

- Risks from natural disasters to the energy infrastructure of each economy have become apparent, and the need to strengthen energy resiliency has been recognized. However, at present, these efforts are not sufficient, and it is necessary to continue to consider efforts to strengthen energy resiliency.
- In order to strengthen energy resiliency, it is necessary to develop relevant guidelines. In particular, best practices in other economies are likely to be used if they can be referenced.
- Sharing best practices for each economy is also a beneficial action for economies that are considering countermeasures in the future. The guidelines are considered to be the starting point for the consideration and implementation of such initiatives.
- In order to strengthen energy resiliency, it is also effective to use tools (indicators) that can assess risks to energy infrastructure.
- It is also expected that international standards such as ISO and APEC guidelines will be linked to promote activities aimed at strengthening energy infrastructure, including from an international perspective, in cooperation with each economy.

4.6.2 Next Actions to Consider suggested through the workshop discussion

Strengthening energy resiliency to disasters is recognized as an important issue for APEC economies. On the other hand, the workshop participants indicated that the response differs among each economy, such as the energy supply structure, the status of energy supply infrastructure, and the interrelationship with climate change countermeasures.

Against this backdrop, there was a strong expectation for action to share experiences, knowledge and best practices on energy resiliency-related initiatives in each economy. Therefore, it would be beneficial to continue to provide opportunities for sharing them through workshop. The following themes and discussions suggested through the workshop are considered to be as follows.

Focus on actual and best practices for energy resiliency enhancement efforts by energy infrastructure sector

- Discussion of implications for each economy through sharing of initiatives, experiences, and best practices for energy resiliency enhancement in individual energy infrastructure sectors (power supply, petroleum product and gas supply chains, etc.).
- Considering the establishment of guidelines and guidance for each individual energy infrastructure field through information and discussions gathered at the workshop and other sources.

Examination of the feasibility of formulating guidelines in other sectors identified by the APEC Energy Resiliency Principle (energy consumers, finance sectors)

- Sharing initiatives, experiences and best practices for energy resiliency enhancement among energy consumers and the financial sector.
- Discussion for the direction of future actions will be considered regarding the significance and expected effects of the establishment of guidelines in both sectors.

Sharing of the relationship between energy resiliency enhancement and other policies

In the workshop, the scope of energy policy is complex, including not only energy resiliency enhancement but also climate change countermeasures (mitigation, adaptation) and other policy issues, and it was shown that the actual situation and challenges vary depending on each economy.

- Discussing of what the implications are for each economy's situation: through discussion of the current status and challenges of energy resiliency efforts faced by each economy, what goals are set, how they relate to other policy issues (how to prioritize policies), and the challenges and best practices they face.
- Potential discussion issues: how resources are allocated, such as financial and human resources, allocation of funds to required investments, approaches that are expected to have synergies between different policy issues, and capacity enhancement through international cooperation.

Promoting Multi-Stakeholder Knowledge Sharing

The APEC Energy Resiliency Principle identify multi-stakeholder knowledge sharing as follows:

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

- Consideration of the possibility of actions that can contribute not only to APEC economies but also to global efforts to strengthen APECs energy resiliency: Identification of disaster risks and management in the event of a disaster (Business Continuity Planning (BCP), Business Continuity Management (BCM)), consistency with climate change measures, etc.

- Candidates for participation in the discussion include such as policymakers, experts, and researchers who are involved in the related fields, for example, initiatives related to energy resiliency such as ASEAN, initiatives related to climate change measures such as AZEC (Asia Zero Emission Community), ISO/TC 292 (Security and Resilience) and ISO/TC 262 (risk management) and other standards related to the sustainable corporate activities.

4.7 Workshop Evaluation Survey

15 respondents from 18 attendees	Strongly Agree	Agree	Disagree	No response	Total
＊The objectives of the workshop were clearly defined.	12	3	0	0	15
＊The workshop achieved its intended objectives.	11	4	0	0	15
＊The agenda items and topics covered were relevant.	11	4	0	0	15
＊The content was well organized and easy to follow.	11	4	0	0	15
＊Will you apply the project's content and knowledge gained at your workplace?	9	6	0	0	15
＊The time allotted for the workshop was sufficient.	7	7	1	0	15
＊The workshop included diverse viewpoints across economies and professions (government, private sector, academia).	9	6	0	0	15
＊The workshop was effective in sharing successful expertise, best practices, and knowledge.	9	6	0	0	15
＊The workshop was a good foundation for future international cooperation and discussion among APEC economies regarding energy resilience.	11	4	0	0	15
＊The workshop was a good opportunity to provide you with new insights and awareness about energy resilience-related activities.	11	4	0	0	15
＊The workshop improved your understanding of energy resilience.	10	5	0	0	15

4.8 Site visit

The Workshop participants (four Speakers, 12 Active Participants, three APERC staff and three IEEJ staff) visited Stanford University Central Energy Facility (CEF) as a self-guided tour on 10 November 2023.

The CEF is one of the integral parts of the "Stanford Energy System Innovations Project". The CEF has an equipment which transforms vapor into hot water and recovers heat, In addition to a substation in order to provide a whole area of Stanford University's campus with high-efficient heat energy. The CEF reduces 80% of greenhouse gas emissions and 20% of water consumption.

The high voltage substation has a capacity of 100mVA, which is equivalent to two-folds of electricity demand in the university campus. The high voltage substation reduces 60kV power supplied by Pacific Gas and Electric Company (PG&E) through grid transmission network into 12kV power, and supplies to the university campus. More than 100 emergency power generations supply power for lighting, elevators, safety devices, and so forth.

Hot water and cold-water distribution equipment supplies hot water and cold water depending on season and temperature 20-mile-long pipeline. The CEF recycles water and reuses waste heat. The CEF supplies 90% of heat demand of the university campus.

5. Conclusion and Recommendations

5.1 Key findings

[Research study]

- In order to enhance the resiliency of energy systems, the effectiveness of comprehensive indicators based on relevant data is recognized as a concept in order to assess the impact of natural disasters in advance, and various studies and empirical projects are being conducted to build indicators.
- The availability of data constituting indicators is a major issue. For example, data on natural disasters as a component of indicators has been prepared by international organizations and insurance companies, and it may be possible to use such data for evaluation by economy, region, and energy supply facility.
- The other hand, the construction of resiliency indicators for existing energy infrastructure facilities requires detailed information at the facility level necessary for calculating indicators, but it is difficult to provide information from energy supply companies, according to the results of research and demonstration projects.
- Assessing the resiliency of energy infrastructure with indicators requires a feasible approach through numerous dialogues and negotiations, focusing on individual infrastructures and facilities, and checking the availability of data. The initiative in Thailand is considered to be an initiative that evaluates the resiliency of renewable energy power generation facility plans and focuses on feasibility.

[Sectoral guidelines development]

- The energy resiliency strategy developed by energy infrastructure company vary depending on the type of business, the characteristics of the market, the expected impact of disasters, and the geographical conditions and policy measures differences of each economy.
- And the components of the strategies and plans examined for energy resiliency by energy infrastructure companies are parts of whole components for sustainable business activities of a company. It will expect that through referring to the any type of management related studies, practices and standards, energy infrastructure company formulates feasible strategies and plans for energy resiliency and implement effective responses according to the situation by event of disaster considering to individual circumstances.
- Therefore, when energy infrastructure companies formulate their energy resiliency strategy to develop, maintain and strengthen, it could be developed policies efficiently and appropriately by referring existing relevant studies, practices and guidelines.

[Workshop]

- Risks to natural disasters in the energy infrastructure of each economy have become apparent, and the need to strengthen energy resiliency has been recognized. However, at present, these efforts are not sufficient, and it is necessary to continue to consider efforts to strengthen energy resiliency.
- In order to strengthen energy resiliency, it is necessary to develop relevant guidelines. In particular, best practices in other economies are likely to be used if they can be referenced.
- Sharing best practices for each economy is also a beneficial action for economies that are considering countermeasures in the future. The guidelines are considered to be the starting point for the consideration and implementation of such initiatives.
- In order to strengthen energy resiliency, it is also effective to use tools (indicators) that can assess risks to energy infrastructure.
- It is also expected that international standards such as ISO and APEC guidelines will be linked to promote activities aimed at strengthening energy infrastructure, including from an international perspective, in cooperation with each economy.

5.2 Recommendations

[Research study]

- The efforts of studies and actions in Japan and the United States show the type of information required to construct indicators and the concept of integrated indicator calculation, these concepts and extensive data lists are invaluable to governments and energy suppliers in APEC economies looking to strengthen their energy resiliency.
- Therefore, given the availability of data, geographical, economic, energy supply and demand structures, and policy differences in APEC economies, it is valuable to develop comprehensive and conceptual guidelines for building energy resiliency indicators.
- One of the considerable ways using such guidelines maybe induce efforts to strengthen the resiliency of the energy system in consideration of existing situation that it is faced. Such guidelines maybe a catalyst for creating opportunities for communication that promote understanding and dissemination of these guidelines, as well as for creating cooperation projects between APEC economies and stakeholders including energy supplier, energy consumers and financial institutions.

[Sectoral guidelines development]

- It is recommended that each economy tailor its approach in consideration of economy-specific energy resiliency challenges.
- Guidelines for individual energy infrastructure companies should be considered separately such as power generation company, transmission company, gas company, oil company and other energy related supplier, if necessary..

[Workshop]

- Focus on actual and best practices for energy resiliency enhancement efforts by energy infrastructure sector
  - Discussion of implications for each economy through sharing of initiatives, experiences, and best practices for energy resiliency enhancement in individual energy infrastructure sectors (power supply, petroleum product and gas supply chains, etc.).
    - Considering the establishment of guidelines and guidance for each individual energy infrastructure field through information and discussions gathered at the workshop and other sources.
- Examination of the feasibility of formulating guidelines in other sectors identified by the APEC Energy Resiliency Principle (energy consumers, finance sectors)
  - Sharing initiatives, experiences and best practices for energy resiliency enhancement among energy consumers and the financial sector.
  - Discussion for the direction of future actions will be considered regarding the significance and expected effects of the establishment of guidelines in both sectors.
- Sharing of the relationship between energy resiliency enhancement and other policies
  - Discussing of what the implications are for each economy's situation. Through discussion of the current status and challenges of energy resiliency efforts faced by each economy, what goals are set, how they relate to other policy issues (how to prioritize policies), and the challenges and best practices they face.
  - Potential discussion issues: how resources are allocated, such as financial and human resources, allocation of funds to required investments, approaches that are expected to have synergies between different policy issues, and capacity enhancement through international cooperation.
- Promoting Multi-Stakeholder Knowledge Sharing
  - Consideration of the possibility of actions that can contribute not only to APEC economies but also to global efforts to strengthen APECs energy resiliency: Identification of disaster risks and

management in the event of a disaster (Business Continuity Planning (BCP), Business Continuity Management (BCM)), consistency with climate change measures, etc.

- Candidates for participation in the discussion include such as policymakers, experts, and researchers who are involved in the related fields, for example, initiatives related to energy resiliency such as ASEAN, initiatives related to climate change measures such as AZEC (Asia Zero Emission Community), ISO/TC 292 (Security and Resilience) and ISO/TC 262 (risk management) and other standards related to the sustainable corporate activities.