APEC Energy Resiliency Sectoral Guidelines for Energy Infrastructure Companies

APEC Energy Working Group

September 2024

Asia-Pacific Economic Cooperation

Asia-Pacific
Economic Cooperation

APEC Energy Resiliency Sectoral Guidelines for Energy Infrastructure Companies

APEC Energy Working Group

September 2024

APEC Project: EWG 09 2021A

Produced by

The Institute of Energy Economics, Japan
Inui Bldg, Kachidoki, 13-1, Kachidoki 1-chome
Chuo-ku, Tokyo 104-0054, Japan

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

APEC# 224-RE-03.2

Table of Contents

1. Introduction 2
1.1 Background 2
1.2 Purpose of this guideline 2
1.3 Conclusions and recommendations 2
2. Scope 4
3. Terms and Definitions 4
3.1 Energy Resiliency 4
3.2 Energy Resiliency Plans 4
3.3 Human-induced Disasters 4
3.4 Natural Disasters 4
3.5 Build Back Better 4
3.6 Business Continuity Management (BCM) 5
3.7 Augmented reality (AR) 5
4. Role of Energy Infrastructure Companies for Energy Resiliency Enhancement 5
5. Referring useful practices for developing strategy of energy infrastructure companies for their energy resiliency activities 6
6. Conceptual framework for assessment of disaster risk with change over time 7
7. Approaches for energy resiliency enhancement 8
7.1 Identification of events affecting the energy system 8
7.2 Assess risks by event 9
7.3 Considerable design energy supply chains to be resilient 9
7.4 Stability of energy supply 9
7.5 Investment for energy resiliency 10
7.6 Proper asset management 11
7.7 Adaption of emerging technologies 12
7.8 Multi-stakeholder knowledge sharing 12
7.9 Making energy resiliency plan 13
7.10 Build energy resiliency balancing with sustainability 13
8. Criteria for implementing energy infrastructure company's energy resiliency plan 13
8.1 Structured internal/external communication 13
8.2 Governance and resources for energy resiliency enhancement 14
8.3 Emergency response system 14
8.4 Supply-chain management 16
8.5 Engagement for financing for energy resiliency enhancement project 16
8.6 Education and training 17
8.7 Consideration for achievement of build back better 17
9. Cooperative actions for improvement of energy resiliency 17
Bibliography 19

1. Introduction

1.1 Background

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.

1.2 Purpose of this guideline

The purpose of develop guideline is to formulate supply-side 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.

The content of this guideline is constructed by referring and incorporating the following reference information as appropriate (see detail information in Bibliography).

- 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 (ISO 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

1.3 Conclusions and recommendations

This document provides a framework for energy resiliency of energy infrastructure companies to help reduce impacts and ultimately achieve build back better from events, including natural and human- induced

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

2. Scope

The main target of this document 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 sources, technologies, and facilities and secure energy storage and generation facilities sufficiently prepared for natural disasters.

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.

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.

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. Terms and Definitions

3.1 Energy Resiliency

The ability and quality that enables energy systems to withstand extreme natural and human-induced disasters and to recover and return to normal conditions in a timely and efficient manner and to build back better, thereby securing a stable energy supply to society and reducing negative impacts on human lives and economic activities from energy supply disruption.
[Source: APEC Energy Resiliency Principle (2019)]

3.2 Energy Resiliency Plans

An Energy Resiliency Plan is a plan that is developed based on evaluation of the energy-related situation of a stakeholder and provides measures for dealing with disasters. Energy Resiliency Plans may contain guidance on disaster prevention and reduction, restoration, building back better and information sharing.
[Source: APEC Energy Resiliency Guidelines (2022)]

3.3 Human-induced Disasters

Extreme hazardous events that are caused by human beings, ranging from cyber-attacks, to terrorism, to piracy.
[Source: APEC Energy Resiliency Guidelines (2022)]

3.4 Natural Disasters

Catastrophic events with atmospheric, geological, and hydrological origins that can damage energy systems and disrupt the energy supply, including earthquakes, volcanic eruptions, tsunamis, mass movements, hurricanes, tornados, heavy snows, and rain..
[Source: APEC Energy Resiliency Guidelines (2022)]

3.5 Build Back Better

Resiliency of energy supply and systems and the responsible organizations through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies and the environment.

[Source: United nations (2016), Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction]

3.6 Business Continuity Management (BCM)

Process of implementing and maintaining business continuity. **business continuity** defines as capability of an organization to continue the delivery of products and services within acceptable time frames at predefined capacity during a disruption.
[Source: ISO 22313 (2020), Security and resilience — Business continuity management systems — Guidance on the use of ISO 22301]

3.7 Augmented reality (AR)

Virtual objects superimposed upon or composited with the real world.

Note: Virtual and real-world objects co-exist in augmented reality systems.
[Source: ISO/IEC TR 23844 (2023), Information technology for learning, education, and training — Immersive content and technology]

4. Role of Energy Infrastructure Companies for Energy Resiliency Enhancement

A multi-stakeholder approach is essential to improve energy resiliency. The APEC Energy Resiliency Principle identifies four types of key stakeholders that play important roles to enhance of energy resiliency efforts including energy supply industries. Following the Principle, the APEC Energy Resiliency Guidelines describes the role of energy industries as following.

- It is important for energy industries to develop energy resiliency plans, which include measures to effectively prepare, respond to, and recover from natural and human-induced disasters. Energy industries' roles include;
    - Conducting disaster impact analysis and vulnerability risk assessments for energy systems and developing and implementing energy resiliency plans, which includes measures to prevent and mitigate the impact of disasters
    - Periodically reviewing and amending the plans, taking recent technological advancements and lessons learned from operational practices into consideration
    - Establishing an internal and dedicated team or unit responsible for disaster planning, policy development and management and providing periodical training and exercises
    - Introducing asset management programs to balance the cost, risk and performance of resilient energy infrastructure
    - Diversifying energy resources in order to avoid over-dependence on any single energy resource
    - Considering and utilizing cutting-edge energy technologies
    - Training staff on disaster and emergency response and recovery, promoting understanding for energy resiliency and knowledge sharing within organizations
    - Developing performance metrics on energy resiliency to track and evaluate the progress
    - Participating in cross-sectoral efforts to strengthen multi-stakeholder collaboration to improve energy resiliency measures
    - Sharing energy resiliency practices with external stakeholders to contribute to improving energy resiliency efforts within APEC economies and beyond

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.

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.

The example of relevant field of research studies and standards is below (Related research studies, guidelines and ISO/IEC international standards are listed in Bibliography).

- 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

Box 1: Thailand case for development of energy resiliency framework

National Energy Technology Center (ENTEC), Thailand has been promoting the concept of energy resiliency in Thailand and ASEAN since 2019. ENTEC started by **developing a framework for energy resiliency assessment of a renewable power plant by building upon the Self-Guided Reference for Practitioners of National Renewable Energy Laboratory (NREL) with slight modifications to match the local context.**

Energy resiliency assessment extends the effort of energy risk assessment that outputs threats, impacts, vulnerabilities, and risks associated with the power plant in order to prepare for and absorb any consequences from a disruption, by adding the evaluation of change over time of the risks to come up with resiliency solutions that would also enable fast recovery and equip the power plant with adaptive capacity to future disruptions.

ENTEC used this framework to conduct pilot assessments of four different renewable power plants, including a state-owned on-grid solar power plant, a rural solar microgrid, a commercial biomass power plant, and a community biogas plant.

(See Bibliography [5] and [6])

The principles are the foundation for formulating energy resiliency policy and designing and implementing strategy to deliver the policy objectives for energy infrastructure company. They underpin the framework for the process that will deliver the energy infrastructure company's policy objectives.

Considering the role of energy infrastructure company for energy resiliency (see chapter 4), it is recommended to develop their own principle regarding their energy resiliency strategy with consideration the characteristics and risks of its own business.

Box 2: Example of principles for energy resiliency by ISO standard

ISO TC 292 (Security and Resilience) approved the development of ISO 22366, “Security and resilience – Community resilience – Framework and principles for energy resilience” in 2022 which **followed publishment of APEC Energy Resiliency Principle (it will publish in 2025)**. ISO 22366 provides a framework and principles for energy resiliency of organizations (including energy infrastructure company which defined as energy related industries) to help reduce impacts and ultimately achieve build back better from events, including natural and man-made disasters.

ISO CD 22366 provides principles for implementation of energy resiliency by the organization, as follow.

The energy infrastructure companies should consider all of the following principles for societal energy resiliency. These principles are considered to achieve energy resiliency for energy infrastructure companies that depend on stable and reliable energy supply systems during and after significant disruptions and disasters.

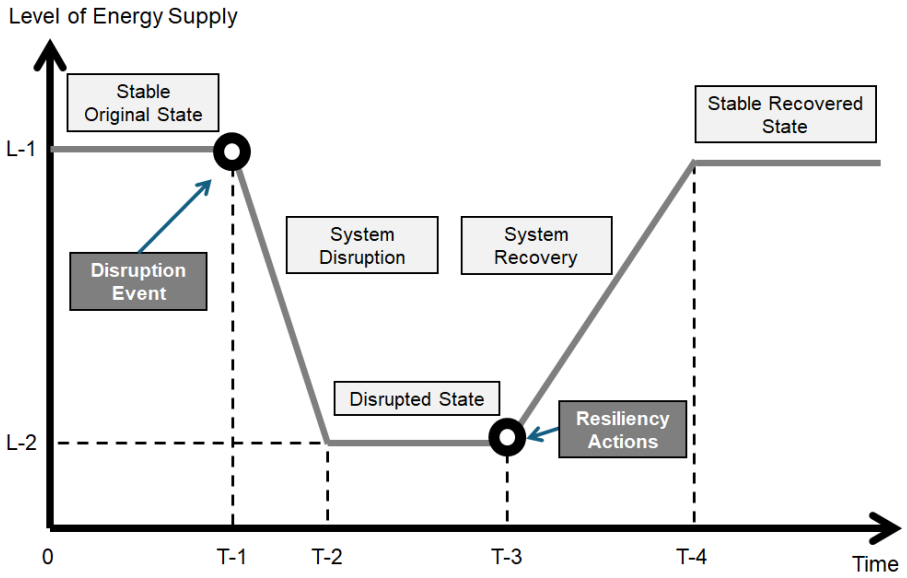
These principles collectively influence the state of resiliency in an energy supply chain that formed by energy infrastructure companies. Implementing any one principle in isolation will likely be insufficient to increase resiliency of energy supply chain.

- Recognize that energy system context matters
- Foster social capital in the energy supply chain
- Maintain diversity
- Manage connectivity
- Encourage collaborative learning by doing
- Understand the risk, and collaboration
- Consider multiple scales and levels and their linkages
- Understand robustness-vulnerability trade-offs
- Pay attention to interdependencies or coupling of multiple infrastructure networks in the energy supply chain
- Emerging Technology Monitoring, Assessment and Risk / Opportunity Consideration
- Build Sustainability into energy resiliency

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. Fig 1 shows conceptual structure of the relationship between necessary efforts and energy supply in chronological order for the process from before the disruption by disaster to recovery.

Fig 1 Conceptual framework for assessment of change over time of risks



Source: Henry, D., & Ramirez-Marquez, J. E. (2012). Generic metrics and quantitative approaches for system resilience as a function of time. Reliability Engineering & System Safety, 99, 114-122, modified contents.

Understanding of change over time is one of the important steps for energy resiliency assessment. It helps to image by the energy infrastructure companies capturing the recoverability and adaptability of their system against to disasters.

When a serious threat combines with a crucial vulnerability, the energy supply chain can be disrupted, changing the system from stable original state to disruptive state, the energy infrastructure companies will need to take resiliency actions to recover the system.

The recovered state may be worse, or the same, or better than the original state, since the main aim of the recovery can be just to make the system operable, or to bring the system back to original conditions, or to make the system more robust to future threats.

To ensure fast recovery, resiliency actions need to be planned beforehand in order to act promptly. To increase adaptive capacity of the system, countermeasures can be taken to enhance some specific features of the system to make the recovered state even better than the original state.

The energy infrastructure companies should start from considering the existing measures for all selected risk to define the business as usual (BAU) scenario for the selected risks and then, can start considering how the identified resiliency solutions could quicken the recovery or increase the adaptability of their system.

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.

7.1 Identification of events affecting the energy system

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.

The energy infrastructure companies seeking to improve energy resiliency should actively prepare for disruptions caused by both natural hazards and human induced actions. These disruptions include:

- Natural hazards: the harm or disruption that can occur to the energy system from natural events such as earthquake, landslide, flood, drought, tornadoes and cyclones, pandemic influenza, insect and animals infestation
- Human induced actions: including deliberate and malicious acts that harm or disrupt the energy system such as terrorism, cyber-attacks and sabotage and unintentional acts that result in accidents that harm or disrupt the system (for example, ISO 27001, Information security management systems describe information security risk assessment)

7.2 Assess risks by event

The energy infrastructure companies should assess the event category and magnitude of the impact on energy supply and demand, and the consequential effects on its own facilities and equipment. Specifically, the following matters are included:

— disruption of the energy supply system (production, distribution and supply to users)

— installation status and capacity of energy backup equipment.

— access to multiple sources of energy

7.3 Considerable design energy supply chains to be resilient

For consider resilient design of energy supply chain, the energy infrastructure companies should identify the risks and implement risk and crisis management processes for all supply chains related to diversified raw materials and parts procurement (including overseas). And also, the energy infrastructure companies should review and verify that production activities can continue when energy supply and demand risks materialize.

7.4 Stability of energy supply

The energy infrastructure companies should cooperate and collaborate with other energy infrastructure companies on risk and resiliency in its relationship with other energy infrastructure companies to collectively take a proactive approach to support prevention and preparation.

For every aspect and process of energy supply chain, the energy infrastructure companies should make relationship with relevant authority who is responsible for domestic/regional security of energy supply with sharing their action plan and implementation for crisis.

Box 3 Recovery support initiative of power supply

In Japan, based on the impact of past disasters on energy infrastructure, disaster cooperation plans have been prepared by energy suppliers of oil, electricity, and gas. In the event of a large-scale disaster in Japan and a shortage of energy supply to the region, an action plan has been established for major energy suppliers in cooperation with the government to cooperate with each other to supply energy in the event of a disaster.

For example, the oil industry's "Disaster Oil Supply Cooperation Plan" incorporates the following measures.

a) Collecting and sharing information on each company's shipping bases, logistics, affiliated service systems, etc.

b) Responding to urgent requests for the supply of petroleum products received from the government

c) Joint use of shipping bases of other companies in the event that the shipping bases become unavailable due to disasters, etc.

In the power transmission and distribution business operator, the following principles and responses are mainly prescribed in their plan.

Voluntary cooperation Principle:

In the event of an emergency, mutual interchange of materials and equipment and recovery support are provided by power transmission and distribution business operator (disaster-stricken businesses) In accordance with the purpose of mutual support, the judgment of power transmission and distribution companies (excluding disaster-stricken businesses) and voluntarily carry it out.

Principle for scope and work:

The scope of support covers the power transmission and distribution facilities and related facilities of power transmission and distribution business operator that have requested support. Support work are all operations related to the restoration of power transmission and distribution facilities.

Advance preparations from normal time:

In order to implement mutual support appropriately and smoothly in the event of an emergency, it will consider and share the contents of the communication system and support in order to maintain a close cooperation system among power transmission and distribution business operators even in normal times.

Cooperations with related organizations:

In the event of an emergency, not only infrastructure facilities other than electric power, but also buildings, rivers, roads, etc. will be damaged, so it is important to restore them in cooperation with local governments, the Self-Defense Forces, telecommunications carriers, etc.. Power transmission and distribution business operators cooperate with related organizations in the event of an emergency or during normal times.

Response to disasters: In order to implement mutual support appropriately and smoothly in the event of an emergency, and in order to maintain a close cooperation system among power transmission and distribution business operators even in normal times, (1) develop a cooperative system and (2) share items that contribute to support and flexibility.

In the event that the damage to the affected power transmission and distribution business operator is severe, the adjacent business operator will move the power supply vehicle to the vicinity of the affected business operator within its own supply area without waiting for a request from the affected business operator if it is possible to dispatch it in consideration of the damage situation in its own supply area.

Power transmission and distribution business operator will regularly share examples of collaboration and consider strengthening the relationship and cooperation between businesses.

- **Example of recovery support (Noto Peninsula Earthquake in January 2024)**

— Recovery support for power supply in the first month after the earthquake (by 8 companies, total number of people and vehicles)

  - Support personnel (4,754)
  - High-voltage generator trucks (31), Aerial work vehicle (261), Support vehicle (44), Digger derrick truck (95), other vehicle for restoration work (661)
  - Donations

7.5 Investment for energy resiliency

In order to enhance energy resiliency of energy supply chain, investment will be required. Investment decisions should be based on the risk evaluation, prioritization and the cost-effectiveness of considered projects of investments.

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. Indicators should be understanded and supported by not only inside of the energy infrastructure company but the stakeholder that influence their investment, such as financial institutions. Indicators should be enabling the evaluation of the investment and its impact on the resiliency of the energy infrastructure company, targeted energy supply chain and society.

The energy infrastructure companies should consider the following to establish or using indicators.

a) Indicators cannot always be quantitative; when using qualitative indicators, professional or value judgements by subject matter experts are necessary,

b) Indicators should reflect multiple perspectives as appropriate to the context of the energy infrastructure companies.

c) It is important to use the indicators to engage relevant stakeholders.

7.6 Proper asset management

The energy infrastructure companies should implement asset management systems to enhance the resiliency of its energy supply chain and balance costs, risks and performance. This system will enhance energy resiliency through proper installation, management and investment cycles of assets. For example, ISO 55001 describes organization’s asset management actions.

The APEC Energy Resiliency Guideline describes organization’s proper asset management as follows.

Proper asset management can prevent and mitigate the impact of disasters on energy systems, as well as facilitate disaster recovery. Asset management includes proper installation, management and replacement of assets in order to sustain a stable energy supply. It also includes stockpiling assets for disaster recovery. Taking a systematic approach to asset management helps to balance the costs, risks and performance of resilient energy infrastructure and enables stakeholders to tailor their measures to their own resiliency needs and risks.

Incorporate Systematic Approaches for Asset Management

Effective asset management should incorporate systematic approaches to build resilient energy infrastructure. The process includes:

- Identify risk and conduct vulnerability assessment
- Review existing asset management practices to evaluate the current level of preparedness, gaps, and opportunities for enhancing energy resiliency
- Develop policy and strategy to enhance asset management. This includes formalizing the organization’s commitment to integrating energy resiliency issues in asset management policy and identifying approaches to enhance energy resiliency measures based on the impact assessment and cost relative to risk reduction benefits. A long-term financial plan should be considered to support energy resiliency measures.
- Implement asset management practices by integrating energy resiliency measures
- Monitor and evaluate the progress

Tailor Asset Management Measures to Resiliency Needs and Risks

Asset management measures should be adopted based on each organization’s needs and energy resiliency risk. Examples of such measures include:

- Diversify resources of energy supply
- Increase ratio of self-sufficient energy sources, technologies and facilities
- Modernize the existing infrastructure
- Implement solutions to manage energy supply and demand

- Secure sufficient energy reserves and energy production facilities
- Address redundancy in energy systems
- Stockpiling assets for disaster recovery

Based on the resiliency risks identified in their organizations, energy infrastructure companies may implement various schemes to ensure stable and reliable system operations. Energy infrastructure companies may use cutting-edge energy management systems that help forecast energy demand and control energy equipment for proper asset management and high efficiency operation.

7.7 Adaption of emerging technologies

Energy infrastructure companies may introduce and adopt advanced energy systems in order to enhance performance of energy infrastructure as well as its resiliency against disruptions. Investing in advanced energy technologies is key to realizing a more robust energy system.

The emergence of new technologies comes with advanced benefits and performance opportunities. The energy infrastructure companies should retain the ability to control the system at any point if it is seen to deliver unexpected or undesirable outcomes.

The energy infrastructure companies should

- fully consider and adopt appropriate cutting-edge energy technologies including more accurate weather and disaster forecasts and other base technologies including artificial intelligence (AI) and internet of things (IoT).
- regularly assess the risks associated with the use of AI in energy systems and develop strategies to mitigate these risks.
- consider the ethical and social implications of AI in energy systems and engage with stakeholders to address these concerns.
- improve operation and maintenance of energy infrastructure and support training of emergency responders through augmented reality (AR) technology applications such as smart glasses.
- collaborate to advance new technologies and secure public and private investment and loans for technologies that develop a more resilient energy system.
- maintain cyber security for energy systems when adopting new information communication technologies.
- identify and carefully assess risk to reflect the potential of adopting new technologies to positively enhance resiliency.
- develop well aligned management controls, timely decision making, and active learning systems that contribute to greater effectiveness.

Energy infrastructure companies with significant dependency on ICT systems should develop an iterative, continuous monitoring program.

7.8 Multi-stakeholder knowledge sharing

The energy infrastructure companies should undertake knowledge sharing at all levels, and also share lessons learned with other energy infrastructure companies domestically and globally.

Knowledge sharing is key to enable all stakeholders to share a common understanding and knowledge to effectively cooperate with each other to implement necessary actions to enhance energy resiliency. The energy infrastructure companies should join several types of the knowledge sharing programs which all or part of stakeholder attend to, as applicable.

The APEC Energy Resiliency Guidelines identify the type of multi-stakeholder knowledge sharing program as follow

- Assessment of resiliency knowledge gaps and capacity building needs
- Cross-sectoral collaboration

— International collaboration for capacity building

— Use of online platforms and tools for knowledge sharing

7.9 Making energy resiliency plan

The energy infrastructure companies should:

— develop and implement their energy resiliency plan based on reviews from 7.1 to 7.8, and considering resiliency varies with each situation.

— engage all related stakeholders in energy resiliency planning, as applicable. In the early stages of the planning phase to seek areas for collaboration and identify potential barriers to implementation.

— conduct interim review to verify the performance and to identify additional actions required.

— coordinate the plans of other energy infrastructure companies horizontally (including cross-border interoperability as appropriate) and vertically, and such coordination should follow legal framework established by relevant authorities according to the legal framework established by the state authorities, where appropriate.

7.10 Build energy resiliency balancing with sustainability

Building sustainability into energy resiliency ensures energy systems are planned, designed, operated and maintained to support sustainability objectives. By incorporating sustainability into energy resiliency, strategies, energy infrastructure companies create energy systems that are both resilient and sustainable, ensuring a reliable supply of energy for current and future society.

The energy infrastructure companies should:

— consider feasible and optimizing business strategy for achieving the sustainability objectives in planning, designing, operation and maintenance of energy systems with keeping energy resiliency.

— appropriate distribution of resources and services to meet sustainable resiliency objectives.

This needs a holistic approach that considers the entire energy supply chain, from production to consumption of energy and considers the balanced interdependence of energy systems with other sectors of the economy and society.

By incorporating sustainability into energy resiliency, energy infrastructure companies could be creating energy systems that are both resilient and sustainable, ensuring a reliable supply of energy.

8. Criteria for implementing energy infrastructure company’s energy resiliency plan

8.1 Structured internal/external communication

The energy infrastructure company’s energy resiliency is enhanced by a clearly articulated and understood purpose, vision and values to provide clarity to decision making at all levels of the energy infrastructure company.

The energy infrastructure company should prioritize the following activities to demonstrate support for their energy resiliency internally and/or externally.

— articulate its energy resiliency vision and purpose to all stakeholders to provide strategic direction, coherence and clarity in all decision-making.

— ensure individual energy resiliency goals and objectives are aligned with and committed to the energy infrastructure company’s purpose and vision that are integrated with their quality management system. One of the references as example about it is ISO 9001 which provides guideline for quality management system.

— monitor and review regularly the suitability of the energy infrastructure company's energy resiliency strategies and alignment with their purpose, vision and objectives.

— reflect on and revise as required the energy infrastructure company's energy resiliency purpose and vision in response to external and internal changes.

8.2 Governance and resources for energy resiliency enhancement

A governance structure and resources that are supportive of energy infrastructure company's energy resiliency demonstrate a commitment to, and existence of shared beliefs and values, positive attitudes and behavior.

Furthermore, energy infrastructure company's energy resiliency is enhanced by leadership that develops and encourages others to lead under a range of conditions and circumstances, including during periods of uncertainty and disruptions. One of the examples references about it is ISO 22316-2017 which provides guideline for effective and empowered leadership.

The energy infrastructure company should prioritize and resource the following activities:

— determine the beliefs, values and behaviors related to energy resiliency within the company.

— identify core values and behavior that enhance energy infrastructure company's energy resiliency and establish criteria that can be applied to assess individuals' performance.

— engage people at all levels to promote the energy infrastructure company's energy resiliency values, strategy and vision.

— foster creativity and innovation that enhances the energy infrastructure company's energy resiliency.

— empower people to identify and communicate threats and opportunities and to take action that will benefit the company.

— build and sustain a positive threat/opportunity reporting cultural environment that supports and encourages the empowerment of people to act as critical friends in support of the energy infrastructure company's aims and objectives.

— encourage recognition of potential issues as a duty of care to identify and communicate threats and opportunities and take action that will benefit the company.

— monitor and review company's governance to detect any changes that may influence their energy resiliency.

8.3 Emergency response system

The energy infrastructure company should build emergency response systems for disruptions in the energy supply system (production and distribution) and equipment outages caused by natural and human-induced disasters, taking into consideration their business continuity management (BCM). ISO 22301 is one of the examples which provides guidelines for BCM.

The energy infrastructure company should build the following emergency response systems for disruptions.

— procurement of multiple sources of energy

— identification of energy supply disruption risk and the impact on energy infrastructure company's activities

— specific identification of backup equipment necessary to respond to energy supply interruptions within the energy infrastructure company's boundaries

— provide manuals for responding to energy supply interruptions including methods for collecting information on disasters and energy supply/outage circumstances

— planning and implementation of education and regular training within the organization in response to energy supply interruptions

— considering when planning that regular energy sources may not be available to organizations for implementation in the case of breakdown.

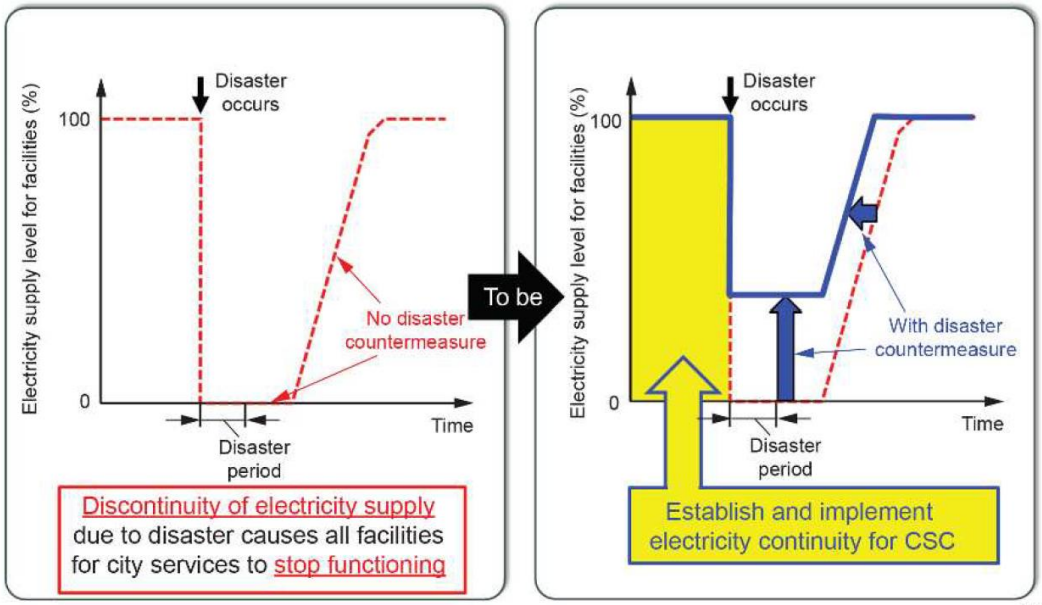
— other considerable activities.

— **Box 4 Contributing to energy resiliency enhancement through proactive response**

Organizations that receive grid electricity supply need to secure back-up power sources in order to be able to continue providing their services when the grid electricity supply is discontinued due to disasters, up until the time when the electricity supply is back to normal. Therefore, the loss of the grid electricity supply due to disasters results in the potential impact of a massive loss of such services.

For the city services to recover quickly so that the major loss of services can be minimized when a disaster strikes, organizations should prepare in advance to ensure that they can secure a minimum level of services until electricity supply returns to normal, planning to facilitate full recovery of services at the earliest possible stage. The energy infrastructure company could be preparing should establish a business continuity plan (BCP) in order to address this need.

In preparation for a shortage of power supply in the event of a disaster, The energy infrastructure company can enhance the resiliency of the area where power services are supplied by incorporating the development of a backup system using a distributed power supply system into its resiliency plan and implementing it in advance.



[Source: IEC 63152, Smart cities –City service continuity against disasters – The role of the electrical supply, modified text]

Box 5 Prepare countermeasures in advance based on disaster predictions

If there is a concern about the risk of disasters due to weather forecasts, it is possible to quickly restore energy infrastructure by estimating the impact of disasters on energy supply before damage to energy infrastructure occurs and preparing in advance to respond to dissemination. Japan's power companies have a voluntary initiative to support recovery through mutual cooperation in the event of a disaster and are working to assess the risk of a disaster based on weather forecasts in advance and prepare for recovery support before a disruption caused by disaster.

- In Japan, Typhoon No. 10, which was formed near Ogasawara on 1 September 2020, moved from the Daito Island region of Okinawa Prefecture to the Amami region from 6 to 7 September, and approached the Kyushu region with very strong intensity.
- Due to the record high sea surface temperature near Japan, it was expected to become a special warning level 2-3 days before the approach by Weather Forecast.
- In response to the forecast of a special warning level in advance, 362 recovery personnel and 53 high-voltage power supply vehicles were dispatched from 6 companies east of the Kansai region 1-2 days before the approach.
- (Finally, due to the rapid decline of its intensity before the approach of Kyushu, it did not intensify to the level previously expected).

Typhoon No. 10's Path

8.4 Supply-chain management

When managing energy supply chain risks, energy infrastructure company should identify and understand their exposure around third party services, systems and products. This should recognize that the supply chain will include elements that are integrated into the detailed processes and systems that are essential to the exposure's activities.

In addition, the whole supply chain should need to be continually assessed to verify the integrity and capabilities of providers to meet the availability and capacity needs of the energy infrastructure company. The energy infrastructure company should assess the needs to diversify or decentralize activities and resources to improve energy resiliency.

The energy infrastructure company should:

- identify risks associated with disruption of energy supply due to disasters, etc. in their supply-chains taking into consideration their supply chain continuity management (SCCM). ISO 22318 is one of the examples which provides guidelines for SCCM.
- consider how to respond to identified energy supply risks in the supply-chain.
- share necessary information on energy supply risks in their supply-chain with companies that have been identified as potentially impacted and encourage them to respond.

8.5 Engagement for financing for energy resiliency enhancement project

In order to smoothly invest in the projects related to energy resiliency enhancement, energy infrastructure company may engage the stakeholder that influence their investment such as financial institutions. The energy infrastructure company may disclose the following information for engagement to stakeholders.

- Detail information about the energy resiliency enhancement-related activities and projects
- Investment plan based on the risk evaluation, prioritization and the cost-effectiveness of considered projects.

— Appropriate indicator (see 7.5) regarding disaster vulnerabilities and impact assessments on their energy facilities, resources, and other critical infrastructure.

8.6 Education and training

The energy infrastructure company should allocate appropriate competent people to address vulnerabilities providing education and training to enable early recovery from critical impacts on energy supply and demand by disasters.

The energy infrastructure company should prioritize and provides resources to:

— make appropriate decisions on respond to impact of disasters.

— maintain core services at an acceptable, pre-determined level.

— select and develop employees with a diverse set of skills, knowledge and behavior to contribute to the organization's ability to respond and adapt to early recovery from the critical impact on energy supply and demand by disasters.

— develop an ability to identify and respond to disasters in a flexible manner, including modifying and redeploying capabilities, arrangements, structures, activities and behavior to adjust to considerable risks by disasters on energy supply and demand.

— routinely review the suitability, availability and allocation of resources.

— provide regular training on early recovery activities from the impact of disasters on energy supply and demand.

8.7 Consideration for achievement of build back better

Pre-consideration of preparing action for the recovery, rehabilitation and reconstruction phase of the disaster is an important opportunity to build back better. By integrating disaster risk reduction into development measures, energy infrastructures will be more resilient to disasters.

Considering this objective, the energy infrastructure company should:

— prepare or review and periodically update risk registers and resiliency plans with, as appropriate, the involvement of the relevant stakeholders, to serve as the basis for planning new or retrofit energy infrastructure.

— consider the impact of disaster risks in planning, design and operations of energy infrastructure (for example, developing hazard map for the purpose of sharing and understanding of the risks by disasters).

— include adaptative capacity in the energy supply system to account for unforeseen risks.

— facilitate, as appropriate, the participation of relevant sectors and stakeholders.

9. Cooperative actions for improvement of energy resiliency

The energy infrastructure company should engage with stakeholders to identify the areas for cooperation to deliver enhanced energy resiliency of energy supply chain.

Considering this objective, the energy infrastructure company should:

— facilitate stakeholders' understanding of energy resiliency issues and contribute to knowledge sharing with internal and external stakeholders.

— assess energy resiliency knowledge gaps and determine capacity building needs to facilitate knowledge sharing.

— encourage cross-sectoral collaboration to facilitate peer-to-peer learning, networking and capacity building. Possibility opportunities are including:

a. a shared platform or coalition created to increase engagement of governments, all energy related supply industries, energy users, financial institutions, and other knowledge partners

b. capacity building support provided through cross-economy learning, transdisciplinary working groups, and exchanges through conferences and seminars

c. online repositories of best practices knowledge established to make resiliency knowledge accessible to wider stakeholders.

Bibliography

[1] United nations-2015, *Sendai Framework for Disaster Risk Reduction 2015-2030*

[2] Asia-Pacific Economic Cooperation (APEC)-2020, *APEC Energy Resiliency Principle*

[3] Asia-Pacific Economic Cooperation (APEC)-2023, *APEC Energy Resiliency Guidelines*

[4] Henry, D., & Ramirez-Marquez, J. E. (2012). *Generic metrics and quantitative approaches for system resilience as a function of time*. Reliability Engineering & System Safety, 99, 114-122.

[5] U.S. Department of Energy's National Renewable Energy Laboratory (2019), *POWER SECTOR RESILIENCE PLANNING GUIDEBOOK - A Self-Guided Reference for Practitioners* -.

[6] National Energy Technology Center (ENTEC)-2022, Thailand, *ASEAN Energy Resilience Assessment Guideline*

[7] United States Department of Commers's National Institute of Standards and Technology (2024), *The NIST Cybersecurity Framework (CSF) 2.0*

[8] ISO 22313, *Security and resilience — Business continuity management systems — Guidance on the use of ISO 22301*

[9] ISO 22316, *Security and resilience — Organizational resilience — Principles and attributes*

[10] ISO/TS 22318, *Security and resilience — Business continuity management systems — Guidelines for supply chain continuity management*

[11] ISO 22320, *Security and resilience — Emergency management — Guidelines for incident management*

[12] ISO 22322, *Security and resilience — Emergency management — Guidelines for public warning*

[13] ISO 22361, *Security and resilience — Crisis management — Guidelines*

[14] ISO/CD 22366, *Security and resilience – Community resilience – Framework and principles for energy resilience*

[15] ISO 31000, *Risk management — Guidelines*

[16] IEC 31010, *Risk management — Risk assessment techniques*

[17] ISO 55001, *Asset management — Management systems — Requirements*

[18] IEC 63152, *Smart cities –City service continuity against disasters – The role of the electrical supply*

[19] ISO/IEC 27001, *Information security, cybersecurity and privacy protection — Information security management systems — Requirements*