GUAM ENERGY SECURITY PLAN

Empowering Guam's Future

ABSTRACT

Perhaps the most critical of all critical infrastructure sectors, energy fuels all other sectors, supports Guam's tourism and military industries, and powers the lives of Guamanian citizens. This plan outlines the energy profiles across the island and institutionalizes Guam's strategy to plan for, respond to, and recover from events that may cause energy disruptions.

Author

Guam Power Authority

Version

September 2024

Background on Plan Development

In 2021, Congress passed the Infrastructure Investments and Jobs Act (IIJA), which required Guam to develop an energy security plan that completes the following six tasks:

1. Address all energy sources and regulated and unregulated energy providers;
2. Provide a state energy profile, including an assessment of energy production, transmission, distribution, and end-use.
3. Address potential hazards to each energy sector or system, including:
   a. physical threats and vulnerabilities; and
   b. cybersecurity threats and vulnerabilities;
4. Provide a risk assessment of energy infrastructure and cross-sector interdependencies;
5. Provide a risk mitigation approach to enhance reliability and end-use resilience;
6. Address multi-state and regional coordination, planning, and response, and coordination with Indian Tribes with respect to planning and response; and, to the extent practicable, encourage mutual assistance in cyber and physical response plans.

As the primary agency responsible for managing the implementation of grant activities using federal dollars from the U.S. Department of Energy (U.S. DOE), the Guam Energy Office (GEO) leads the territories' engagements with the U.S. DOE and is responsible for meeting all eligibility requirements for U.S. DOE funding opportunities.

Due to the Guam Power Authority's (GPA's) expertise and knowledge of Guam's energy profile, GEO partnered with GPA to develop and finalize Guam's Energy Security Plan (GESP) through a memorandum of understanding (MOU) and detailed scope of work.

Scope of Work

The MOU between GEO and GPA for the GESP addresses two major scopes of work:

A. Develop, review, revise, and finalize the GESP to ensure it meets the requirements set forth in Section 366(c) of the Energy Conservation and Policy Act (EPCA), as amended by Section 40108 of the Infrastructure Investment and Jobs Act (IIJA); and,

B. Coordinate the GESP development, to the extent practicable, with:
   1. Energy providers from the private and public sectors; and
   2. Other entities responsible for:
      a. Maintaining fuel or electric reliability; and
      b. Securing energy infrastructure.

Authors

Primary Author:

- Guam Power Authority

Supporting Authors:

- Argonne National Laboratory
- National Renewable Energy Laboratory
- Sheffield Scientific

Use of the Assessment of Capabilities in Energy Security Maturity Model

To inform the development of the GESP, GPA hosted discussions with energy security and resilience stakeholders in the Government of Guam (GovGuam) about Guam's energy security capabilities, including strengths and areas for improvement. These discussions were informed by the U.S DOE's Assessment of Capabilities in Energy Security (ACES)[1] maturity model. Authors of this plan referenced notes from these discussions to inform the GESP. GovGuam will continue to utilize the ACES maturity model to assess energy security capabilities and measure progress.

Review / Revision History

The GESP shall be reviewed in accordance with section 10 and shall be revised as necessary. All formal reviews and revisions shall be documented below, and new versions of the plan should be labeled and distributed as appropriate.

Review History			
Version #	**Review Date**	**Reviewer(s)**	**Revisions Needed? (Yes/No)**

Revision History			
Version #	**Revision Date**	**Revisor(s)**	**Revision Description**

[1] Assessment of Capabilities in Energy Security (ACES) Maturity Model: https://aces.anl.gov/

Glossary of Acronyms

Acronym	Description
AAR	After-Action Report
ACES	Assessment of Capabilities in Energy Security
AGMO	Assistant General Manager of Operations
APPA	American Public Power Association
BPA	Bonneville Power Administration
BRIC	Building Resilient Infrastructure and Communities
BSEE	Bureau of Safety and Environmental Enforcement
CBP	U.S. Customs & Border Protection
CCU	Consolidated Commission on Utilities
CEJST	Climate and Economic Justice Screening Tool
CESER	Office of Cybersecurity, Energy Security, and Emergency Response
CFO	Chief Financial Officer
CIP	Critical Information Protection
CISA	Cybersecurity and Infrastructure Agency
CMA	Cyber Mutual Assistance
CNMI	Commonwealth of the Northern Marina Islands
CUC	Commonwealth Utilities Corporation
DAC	Disadvantaged Communities
DHS	U.S. Department of Homeland Security
DLA	U.S. Defense Logistics Agency
DOD	U.S. Department of Defense
DOE	Guam Department of Education
DOI	U.S. Department of the Interior
DOJ	U.S. Department of Justice
DOT	U.S. Department of Transportation
DPW	Department of Public Works
EEAC	Energy Emergency Assurance Coordinators
EEI	Essential Elements of Information
EIA	U.S. Energy Information Administration
EJ	Environmental Justice
EMAC	Emergency Management Assistance Compact
EOC	Emergency Operations Center
EOC ESF	Guam Emergency Operations Center Emergency Support Function
EPA	Environmental Protection Agency
EPCA	Energy Conservation and Policy Act
ESCC	Electricity Subsector Coordinating Council
ESF	Emergency Support Function
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FMCSA	Federal Motor Carrier Safety Administration

Acronym	Description
FSM	Federated States of Micronesia
GEO	Guam Energy Office
GESP	Guam Energy Security Plan
GFD	Guam Fire Department
GHS/OCD	Guam Homeland Security/Office of Civil Defense
GM	General Manager
GovGuam	Government of Guam
GPA	Guam Power Authority
GSA	General Services Administration
Guam CEMP	Guam Comprehensive Emergency Management Plan
GUNG	Guam National Guard
GWA	Guam Waterworks Authority
HAP	Hazardous Air Pollutants
HMGP	Hazard Mitigation Grant Program
HUD	U.S. Housing and Urban Development
ICBM	Intercontinental Ballistic Missiles
ICS	Industrial Control Systems
IIJA	Infrastructure Investments and Jobs Act of 2021
IR	Incident Response
IRS	Internal Revenue Service
IT	Information Technology
IWPS	Island Wide Power System
JIC	Joint Information Center
KUA	Kosrae Utilities Authority
LEAD	Low-income Energy Affordability Data
LMI	Low And Moderate Income
LNG	Liquified Natural Gas
MOU	Memorandum of Understanding
NARUC	National Association of Regulatory Utility Commissioners
NASEO	National Association of State Energy Officials
NEMA	National Emergency Management Association
NERC	North American Electric Reliability Corporation
NGA	National Governors Association
NIMS	National Incident Management System
NIMS	National Incident Management System
NOC	Network Operations Center
NRC	U.S. Nuclear Regulatory Commission
NRCC	National Response Coordination Center
NRF	National Response Framework
NRI	National Risk Index
OE	Office of Electricity
OT	Operational Technology
PA	Public Assistance
PDA	Preliminary Damage Assessment

Acronym	Description
PHMSA	Pipeline and Hazardous Materials Safety Administration
PMA	Power Marketing Administrations
PRTF	Power Restoration Task Force
PUC	Guam Public Utilities Commission
RAC	Response Activities Coordinators
RAPT	Resilience Analysis and Planning Tool
RPS	Renewable Energy Portfolio Standard
RSF	Recovery Support Functions
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SEPA	Southeastern Power Administration
SIEM	Security Information and Event Management
SOC	Security Operations Center
SOP	Standard Operating Procedure
SRMA	Sector Risk Management Agency
SSA	Sector Specific Agency
SWPA	Southwestern Power Administration
THIRA	Threat and Hazards Identification and Risk Assessment
TSA	Transportation Security Administration
U.S. DOE	U.S. Department of Energy
USACE	U.S. Army Corps of Engineers
WAPA	Western Area Power Administration

Table of Contents

1. Introduction / Purpose of Plan

GovGuam defines energy security as the ability to ensure a reliable and resilient supply of energy through efforts to identify, assess, and mitigate risks to energy infrastructure and to prepare for, respond to, and recover from disruptive events with consideration for equity and environmental justice. A disruptive event is defined as any event, incident, or phenomenon that directly impacts or threatens to impact the end-use of electricity, natural gas, or liquid fuels for residential, commercial, or industrial consumers of energy services.

Example disruptive events may include, but are not limited to:

- **Natural hazards**, such as typhoons, tsunamis, earthquakes, wildfires, or other extreme weather conditions.
- **Adversarial attacks**, such as physical or cyber attacks on energy infrastructure by nation-states or other nefarious actors.
- **Climate change-induced hazards**, such as changes in temperature, precipitation, or wind patterns that may impact the functionality of energy infrastructure components.
- **Supply chain issues**, such as transportation delays of necessary fuels or materials needed to supply energy services or the manufacturing of critical energy infrastructure components.
- **Human proceedings,** such as labor disputes or strikes.
- **Market conditions** that make energy services economically unattainable.
- **Technological hazards,** such as aging physical infrastructure or interruption of digital technologies required to deliver energy services.

"Energy Sector" is a broad term inclusive of subsectors, including:

Electricity

Liquid Fuels

Natural Gas

The GESP is a living document outlining Guam's energy profile; a strategy to address energy sector risk, equity, and environmental justice; and a plan to continue developing the next generation of energy and sustainability professionals on the island. Guam faces unique challenges as a U.S. territory remotely located in the western Pacific Ocean. However, GovGuam is filled with ambitious individuals who are motivated to cooperate with each other, as well as with federal and private sector partners, to bolster the resilience of Guam for all of those who reside, visit, and work on the island.

Energy Security is the ability to ensure a reliable and resilient supply of energy through efforts to identify, assess, and mitigate risks to energy infrastructure and to prepare for, respond to, and recover from disruptive events with consideration for equity and environmental justice.

Disruptive Events are defined as any event, incident, or phenomenon that directly impacts or threatens to impact the end-use of electricity, natural gas, or liquid fuels for residential, commercial, or industrial consumers of energy services.

The GESP is structured as follows. Section Two presents Guam's overarching energy profile. The profile includes an overview of geographic, climate, and demographic data; import, production, and consumption data for petroleum; electricity production data; and a synopsis of renewable energy production. Section Three presents an energy sector risk assessment strategy, which contains a methodology for conducting risk assessment and an overview of available tools to assist in the process. Section Four provides a risk assessment on energy infrastructure, including from interdependencies, natural hazards, and adversarial threats. Section Five delineates the energy security and response authorities at the federal and local levels in Guam. Section Six documents planning and preparedness roles and responsibilities and regional, federal, and international coordination. Section Seven documents the energy emergency response cycle. Section Eight identifies risk mitigation approaches that may reduce the vulnerability of Guam's energy assets. Section Nine identifies methods to ensure environmental justice and reduce the energy burden of Guam's citizens.

2. Guam's Energy Profile

This section addresses all energy sources, regulated and unregulated, in the Territory of Guam. In addition, the section provides a territory energy profile which includes an assessment of energy production, transmission, distribution, and end-use. The text is primarily sourced from the U.S. Energy Information Administration's Profile Analysis for Guam and is intended to be updated periodically.

2.1 Overview

Guam, the largest among the thousands of small western Pacific islands that are collectively known as Micronesia, is in the Pacific Ocean about 5,800 miles west of San Francisco and 1,600 miles east of Manila, Philippines.[1,2] The island became a U.S. territory in 1898. Guam lies close to the International Date Line. As a result, it is the first place in the United States to see each new day, which is why Guam is known as the place "Where America's Day Begins."[3] Guam has no fossil energy resources and meets nearly all of its energy needs—including the fuel for generating most of its electricity—with imported petroleum products.[4,5,6,7] However, Guam is increasing its use of wind and solar resources for electricity generation.[8,9,10]

> *Guam imports petroleum products to meet almost all its energy needs.*

Surrounded by coral reefs, Guam sits on the southern edge of the Mariana Trench and is near the Challenger Deep, which lies nearly 7 miles below the surface of the ocean and is the deepest known place on earth. Guam, like the neighboring Mariana Islands, is the top of an undersea mountain, part of a volcanic subsea range stretching northwest toward Japan. At 30 miles long and 4 to 12 miles wide, the territory has about three times the land area of Washington, DC.[11,12,13] Guam has a tropical marine climate that is warm and humid, with little variation in seasonal temperatures that range between 70°F and 90°F throughout the year. The rainy season runs from May to November and can bring devastating typhoons.[14] Guam recorded one of the world's highest measured wind speeds, 230 miles per hour, when Super Typhoon Paka struck the island in 1997.[15]

Guam has a population of about 154,000, plus about 22,000 U.S. military personnel and their families.[16] Tourism and the U.S. military are the two largest contributors to Guam's economy.

Tourism brought in a record 1.6 million visitors in 2019. However, the COVID-19 pandemic has kept many tourists away from Guam since early 2020. Guam had 328,000 visitor arrivals in 2022, which was more than four times greater than in 2021. Most of the island's tourists arrived from South Korea.[17,18,19,20] U.S. military plans to relocate thousands of its personnel from Okinawa, Japan to Guam by the end of 2024 will bring a substantial influx of people to the island.[21,22,23,24] The military currently accounts for about one-fifth of Guam's energy consumption.[25] Total per capita energy consumption on Guam is about half of the per capita consumption in the 50 states.[26]

2.2 Petroleum

Guam has no crude oil reserves, petroleum production, or refineries.[27,28] The island's only port, located at Apra Harbor, receives all imported petroleum products, which primarily come from Asia.[29,30] In 2021, motor gasoline accounted for about 39% of petroleum sales on the island. Sales of diesel fuel—used mostly to generate electricity—closely followed at 38%. Jet fuel accounted for 20% and propane made up most of the rest of the island's petroleum sales.[31,32] In 2012, the Guam government set a goal to reduce petroleum consumption by 20% from 2010 levels by 2020.[33,34] Guam achieved this goal by increasing the efficiency of vehicles on the island, improving traffic flows, reducing vehicle miles traveled, increasing biodiesel use, and generating less electricity from petroleum.[35]

Motor gasoline and jet fuel account for most of Guam's petroleum consumption.

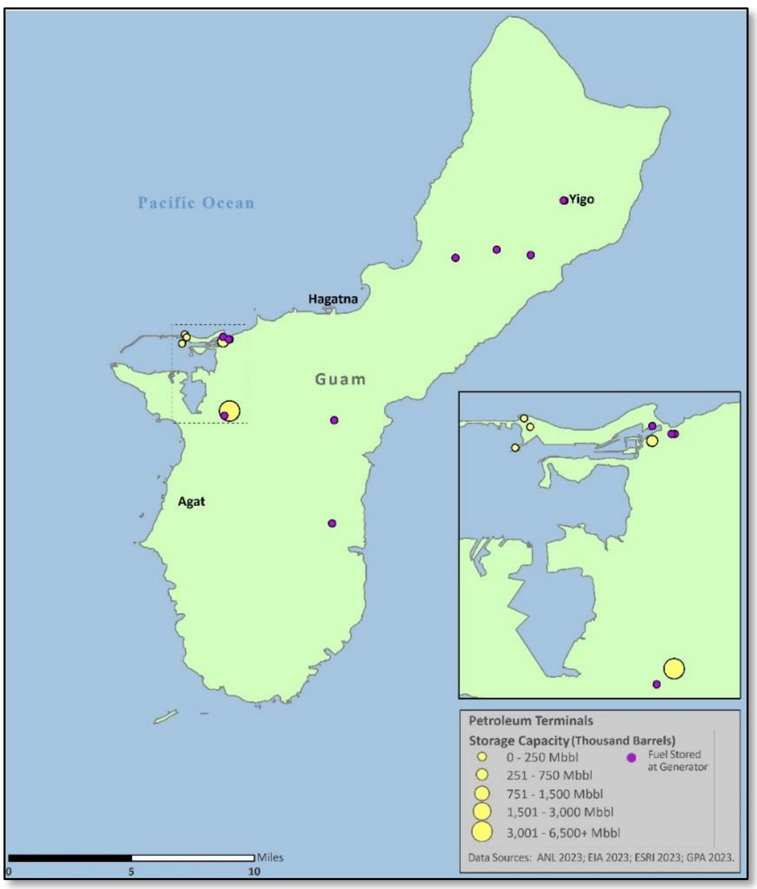


Figure 1: Petroleum Terminals Storage

2.3 Electricity

> *The U.S. Navy is GPA's largest single customer.*

The Guam Power Authority (GPA), a public corporation overseen by the elected Consolidated Commission on Utilities (CCU) and regulated by the Guam Public Utilities Commission (PUC), provides all of Guam's electricity. GPA owns and manages the island's electric grid, which is made up of about 1,800 miles of transmission and distribution lines. Diesel fuel and residual fuel oil account for most of GPA's electricity generation, with renewables accounting for a small share.[36,37]

GPA continues to rebuild and expand its generating assets after an August 2015 explosion and fire at the utility's main Cabras power plant that destroyed two of the station's four generating units.[38] GPA lost about one-seventh of its generating capacity, leaving the island with periodic power rationing and localized power outages. GPA asked large hotels, shopping malls, and military facilities to use their own generators when possible, and the power utility leased high-efficiency diesel generators to stabilize its electricity supply.[39,40,41] In 2021, GPA received approval from regulators for a new power plant to replace all four of the Cabras generating units, which had a combined generating capacity of 212 megawatts. The new Ukudu replacement power plant, which will have a generating capacity of 198 megawatts and can run on either ultra-low sulfur diesel fuel or natural gas, is expected to be operating in 2024.[42,43] Separately, about 120 megawatts of combined new solar power generating capacity in 2022 and 2023 will help offset the loss of the Cabras plant's generating capacity.[44,45]

Guam's residential electricity costs, including fuel surcharges, are almost two times higher than the U.S. average, although Guam's residential electricity rates are typically the lowest among the nearby Pacific islands.[46,47] Because petroleum products generate nearly all of Guam's electricity, GPA imposes a fuel surcharge that can be adjusted every six months to reflect changes in petroleum costs. Guam's electricity rates increased in 2022 after a rise in world petroleum prices. However, the Guam legislature authorized $100 a month in credits on power customers' utility bills to help partially offset the higher rates.[48,49,50]

GPA had slightly more than 52,000 electricity customers in 2021.[51] Residential households accounted for 38% of Guam's electricity use in 2021. The commercial sector—which includes tourist hotels, restaurants, and private office buildings—was the largest consumer of electricity in 2019, but commercial sector energy consumption declined in 2020 after the COVID-19 pandemic curtailed tourism.[52] Commercial sector electricity sales continued to drop in 2021, accounting for 31% of the island's total. Separately, the U.S. military accounted for 20% of electricity use and the Guam government accounted for 11%.[53]

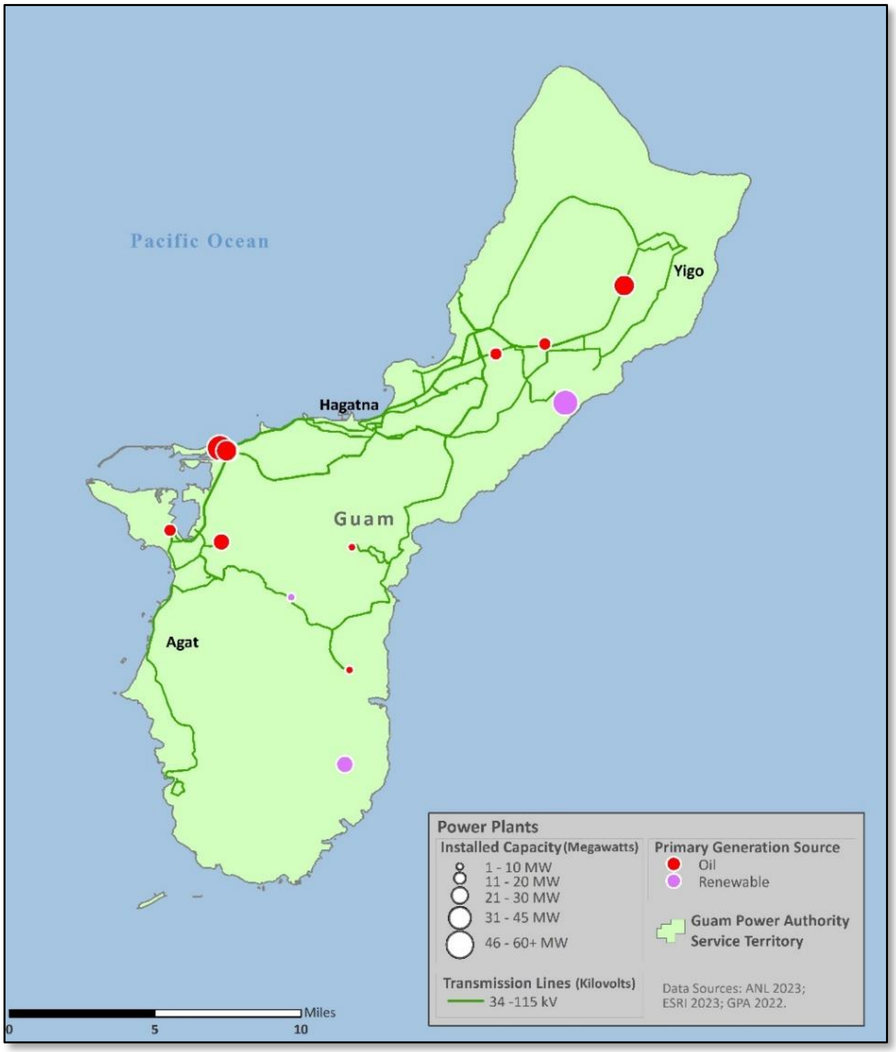


Figure 2: Power Plant Capacity on Guam

2.4 Renewable Energy

In 2008, Guam's legislature enacted a renewable energy portfolio standard (RPS) goal for renewable sources to generate 8% of the island's electricity sales by the end of 2020, 10% by 2025, and 25% by 2035. In 2019, Guam's legislature updated the standard to require that renewables provide 50% of electricity sales by 2035 and 100% by 2045. The RPS recognizes solar, wind, biomass, wave energy, and ocean thermal energy as acceptable renewable sources to meet the standard.[54],[55],[56] In 2021, renewables accounted for about 6% of Guam's electricity generation.[57]

In 2019, Guam updated its Renewable Portfolio Standard to have 50% of its electricity sales generated by renewables by 2035.

Until recently, Guam used little renewable energy for electricity generation on the island beyond a small number of solar PV units (used for cell phone towers and remote weather stations), solar thermal units (used for water heating), and a few small wind generators (less than 5 kilowatts capacity) operated by commercial and residential users.[58,59] In 2015, Guam's first commercial solar PV facility—the 26-megawatt Dandan solar farm with more than 120,000 solar panels—began operating.[60] The facility can generate enough electricity to serve 10,000 homes.[61] The new 60-megawatt Mangilao solar farm came online in 2022. Another solar farm, Malojloj, originally designed with a 60-megawatt capacity, was scheduled to come online by the end of 2023. However, due to increasing transmission line costs, its capacity has been reduced to 41-megawatts and its operationalization has been delayed to the end of 2025.[62,6364] Another 40 megawatts of solar power generating capacity and related storage capacity have also been delayed beyond their intended opening in 2024, following the U.S. Navy's decision to withdraw the property it originally planned to lease for the solar sites.[65,66]

Guam has substantial wind power potential but also has unique wind turbine siting issues. The island is seismically active and is in the Pacific's Typhoon Alley, so wind turbines must be engineered to withstand both earthquakes and typhoon-force winds. Wind turbine siting must also consider impacts on military facilities, endangered species, and other local environmental concerns. Another challenge is maintaining the reliability of the island's small electric grid given the variability of wind power.[67] As a result, Guam generates little wind power. However, in early 2016, GPA inaugurated a wind pilot project—a single 275-kilowatt turbine in the Cotal region of Yona that can generate enough power for 50 homes.[68,69] In late 2022, the U.S. Congress passed legislation opening the offshore waters around Guam to wind power development, along with the other U.S. territories of American Samoa, Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands. The U.S. Department of the Interior will hold wind lease sales in the territories' waters by September 2025, depending on interest from energy companies.[70]

GPA offers net metering, an arrangement that pays customers for surplus power they generate from small-scale solar, wind, and other customer-sited renewable generation installations, up to 25 kW per month for residential systems and 100 kW per month for non-residential systems.[71] The surplus power is distributed on the island's grid.[72] All new net metering systems connected to the grid after June 2020 are required to have energy storage batteries to improve the reliability of electricity supplies.[73] Beginning in 2021, the more than 2,000 customers in GPA's net metering program could no longer roll over their excess net metering credits into the next year or cash out their credits.[74]

2.5 Natural Gas

Guam has no natural gas reserves and does not produce or use natural gas.[75] GPA plans to have a new 198-megawatt power plant in service during the second quarter of 2024 that is capable of burning either ultra-low sulfur diesel fuel or natural gas from imported liquefied natural gas (LNG) that is re-gasified to generate electricity.[76,77] However, while Guam's Public Utilities Commission approved the construction of the plant, its order did not include authorization to use LNG at the plant. The new plant will enable the utility to comply with U.S. federal environmental requirements while using either fuel.[78]

2.6 Coal

Guam has no known coal reserves and does not produce or use coal.[79,80]

3. Energy Sector Risk Assessment Strategy

As a small island located in the Western Pacific, Guam is highly dependent on imported fossil fuels to meet its energy demand. Due to its remote location, energy disruptions can have severe impacts on the island's economy, security, and quality of life. To that end, assessing the risks to energy infrastructure is a complex and continually evolving process, rather than one conducted on a discrete occasion.

Risk is defined as the potential for loss, damage, or destruction of key resources or energy system assets resulting from exposure to a threat. Vulnerabilities are weaknesses within infrastructure, processes, and systems or the degree of susceptibility to threats. Threats and hazards include anything that can expose a vulnerability and damage, destroy, or disrupt energy systems, and can be natural, technological, manmade and physical, and/or cybersecurity. The consequences of losses or degradation of energy infrastructure assets include the loss of energy supply or service, and the associated cascading impacts across a variety of critical sectors including communications, health and medical, transportation, and more. The interdependencies between the energy sector and these other sectors can lead to additional challenges. Among these challenges is the need for energy procurement for natural disaster recovery and significant adverse impacts on communities with energy dependent medical needs (e.g., dialysis machines or respirators).

Risk = the potential for loss, damage, or destruction of key resources or energy system assets resulting from exposure to a threat.

Vulnerabilities = weaknesses within infrastructure, processes, and systems or the degree of susceptibility to threats.

Threats/Hazards = anything that can expose a vulnerability and damage, destroy, or disrupt energy systems; they can be natural, technological, manmade and physical, and/or cybersecurity.

Consequences = loss or degradation of an energy infrastructure asset on energy supply or service, and the associated indirect impacts of those losses on society.

Risk assessments should identify the most critical infrastructure assets and provide significant support to other critical infrastructure systems. Understanding the risk to these assets helps to determine overall risk, prioritize mitigation strategies more effectively, and inform prioritization of funding investment decisions.[81]

The purpose of this risk assessment strategy is to identify and prioritize measures that can reduce the potential consequences of energy disruptions on Guam. The strategy will focus on how risk assessments should be conducted, by whom, and how they should inform risk mitigation measures. The following subsections outline a risk assessment methodology and tools to conduct risk assessments.

3.1 Risk Assessment Methodology

Conducting a comprehensive risk assessment that identifies potential risks and vulnerabilities within the island's energy sector is essential to developing meaningful mitigation strategies. A comprehensive risk assessment requires quantitative and qualitative analysis, as available, and input from stakeholders, including energy consumers, infrastructure owners/operators, public sector partners, and community organizations as appropriate. This should be accomplished by using analytical tools to understand both past and future risks to the Territory as well as inventories and assets.

However, abbreviated risk assessments can also be conducted between comprehensive risk assessments for more frequent updates. Frequent updates help ensure stakeholders' understanding of risks evolves alongside the threat/hazard landscape. Abbreviated risk assessments may include meetings with subject matter experts within the Guam energy sector, GPA, Guam Homeland Security/Office of Civil Defense (GHS/OCD), and private sector energy providers, among others. All assessments will include consideration of threats and hazards, vulnerabilities, consequences, criticality of assets, and energy sector interdependencies.

Comprehensive assessments will consider the following steps:

Risk Assessment Process		
Step	**Task**	**Description**
1	Select a specific threat/hazard or combination of threats/hazards to assess.	Determine the threats/hazards that are of most concern. Example disruptive events are listed in Section One.
2	Analyze the risk/probability of the selected threat/hazard occurring.	Select the appropriate analytic approach. Historical natural hazards are well suited for probability-based analysis, while adversarial threats may be well suited for qualitative/scenario-based analysis.
3	Estimate the expected damage of the selected threat/hazard on energy sector infrastructure.	Reference FEMA HAZUS tools or use internal SME knowledge to identify expected damage.
4	Simulate or evaluate the direct and cascading energy sector disruptions based on expected damages.	Disruptions can be simulated using advanced modeling tools or evaluated using SME knowledge or by referencing historical events.
5	Characterize results by consequence metrics.	Examples of consequence metrics include estimates on consumers impacted, load loss, unserved energy, economic damage, lifeline sectors impacted, restoration times, and end-users' ability to cope with disruptions.
6	Identify measures to mitigate the discovered risk in cost effective and equitable manners.	Examples of mitigation measures can be found in Sections Eight and Nine.

Stakeholders specifically interested in cybersecurity or physical security risk assessments should reference the "Cyber/Physical Security Annex," which outlines a detailed risk assessment approach for key security focused energy stakeholders across public and private sectors in Guam.

Effective risk assessments consider the consequence of an asset's loss, the vulnerability of an asset to specific threats/hazards, and the likelihood that an asset will be exposed to a specific threat within the community's broader context. Evaluating historic energy disruptions (where such information is available) is key to establishing previous points of failure and planning for similar potential disruptions. Planning for risks and cascading impacts and interdependencies throughout the risk assessment will allow Guam to develop a more holistic understanding of secondary triggers that may lead to more severe impacts for people and systems.

Risk assessments on energy subsectors are expected to be completed by owners and operators of the energy infrastructure, but encouragement from government agencies, such as GPA and GHS/OCD, to conduct comprehensive and cross cutting risk assessments may be necessary.

Risk Assessment Responsibilities for Owners and Operators

Responsible Party	Risk Assessment Subsector
Guam Power Authority	Electric grid, GPA-owned generation, and key facilities
Independent Power Producers	Independently owned generation plants, solar PV farms, and key assets
Port Authority of Guam	Ability to operate and receive crucial fuels for transportation and electric power generation
Petroleum Industry	Petroleum terminals and fuel delivery networks

GPA, as the lead Emergency Support Function #12 (ESF-12/Energy) agency and **in collaboration with GHS/OCD,** will encourage collaboration between energy infrastructure owners and operators to conduct comprehensive risk assessments and include other stakeholders, such as the tourism industry or the defense industrial base, as necessary. Note that cybersecurity focused risk assessments should follow guidelines outlined in the "Cyber/Physical Security Annex."

3.2 Assessment Tools

Those conducting risk assessments should leverage the variety of tools available to them, including the integration of existing qualitative assessments, risk profiles, quantitative tools, and collaboration with national laboratories. Specific tools used will vary as appropriate to the analysis type and level of assessment being conducted.

Table 1: Risk Assessment Tools

Risk Assessment Tools	
Tool	**Description**
Assessment of Capabilities in Energy Security (ACES)	Intended to be used by GovGuam agencies to self-assess their energy security capabilities, an ACES self-assessment can provide insight into energy security strengths and areas for improvement.
Threat and Hazards Identification and Risk Assessment (THIRA)	A three-step risk assessment process that helps communities understand their risks and what they need to do to address those risks by answering the following questions: 1. What threats and hazards can affect our community? 2. If they occurred, what impacts would those threats and hazards have on our community? 3. Based on those impacts, what capabilities should our community have?
DHS CISA IT/OT Cybersecurity Risk and Vulnerability Assessments	DHS CISA offers several cybersecurity risk and vulnerability assessment tools and hands-on technical assistance to critical infrastructure owners and operators.
Climate Risk and Resilience Portal (ClimRR)	Provides downscaled forward looking climate data on temperature, precipitation, heat index, wind, and other climate variables of interest. Can be leveraged to assess the risk of changing climate conditions on energy infrastructure and operations.
The National Climate Assessment Volume 5	Provides high level climate information for Hawai'i and U.S. Affiliated Pacific Islands. Can be leveraged to assess the risk of changing climate conditions.
Resilience Analysis and Planning Tool (RAPT)	Provides information on Guam infrastructure, hazards, and community indicators.

Whitehouse Climate and Economic Justice Screening Tool (CEJST)	Compiles socioeconomic data to determine census tracts that may be "overburdened or underserved." Can be leveraged to assess which communities be adversely impacted by disruptions in energy services.
FRamework for Overcoming Natural Threats to Islanded Energy Resilience (FRONTIER)	GPA participated in a FRONTIER study managed by Argonne National Laboratory and Lawrence Berkley National Laboratory. GPA can leverage this tool to identify economically viable opportunities to enhance resilience.
Exercises and After-Action Reports	Management of and participation in energy security exercises with key stakeholders supports the validation of energy security plans with an operational focus and may reveal previously unrealized risk. Exercise after-action reports can contribute to formal or informal risk assessments.
Energy Infrastructure Owners' & Operators' Tools or Data Sets	Any additional tools or data points owned by infrastructure owners and operators that can identify risk (e.g., GPA collects electric power disruption data).

4. Energy Sector Threats/Hazards, Vulnerabilities, Risk Assessments

Guam's energy sector is vulnerable to a variety of threats and hazards. These include, but are not limited to, severe weather events, adversarial attacks (nation-state or other nefarious actors), and the effects of a changing climate. These hazards may impact the energy sector directly (e.g., a cyberattack on a power plant) or indirectly, by disrupting the operations of another critical sector upon which the energy sector depends (e.g., a hurricane prevents the timely delivery of fuel).

This section explores the main hazards and threats facing Guam's energy sector, its vulnerabilities to both direct and indirect impacts, and risk assessments for the key hazards/threats. First, Section 4.1 presents an overall threat and vulnerability summary for the electricity and petroleum subsectors, which are the key components of Guam's energy sector. Next, Section 4.2 discusses the relationships between Guam's energy and other critical sectors, or dependencies, that may create vulnerabilities to indirect impacts. Sections 4.3 and 4.4 provide natural hazard and adversarial threat risk assessments, respectively. Information for these sections has been drawn from several sources, including past risk assessments conducted by GPA, Guam's hazard mitigation plans, GPA's integrated resource plans, GPA's emergency plans, after-action reports from previous incidents, and discussions with energy system operators and other stakeholders.

4.1 Overall Threat and Vulnerability Summary

Threats and hazards expose vulnerabilities and damage, destroy, or disrupt energy systems; they can broadly be categorized as climate change, natural hazards, cybersecurity attacks, physical attacks, human proceedings, supply chains, market conditions, and technological. Guam's location in western Pacific the leaves it particularly vulnerable to tropical cyclones and typhoons, as well as geopolitically motivated cyber and physical attacks. Additionally, its distance from the Continental United States creates logistical hurdles.

Tropical cyclones and typhoons frequently present a threat to Guam's energy infrastructure. With near certainty (99.9 percent probability), at least one tropical cyclone with sustained winds of at least 40 mph will come within 86 miles of Guam each year. The annual probability of Guam experiencing a typhoon, in which maximum sustained winds reach at least 74 mph, is similarly high.

Guam's strategic military position makes its energy systems and other critical infrastructure a target for physical or cyber-attacks from adversarial nation states and criminal groups. A successful physical or cyber-attack, which might range from ransomware to an intercontinental ballistic missile (ICBM), could deny access to one or many of the complex systems that comprise Guam's energy sector.

These risks are compounded by Guam's isolated location. Federally deployed resources may take 24 to 72 hours to arrive on the island in the event of a disaster, which may lead to significant delays in repairing damaged infrastructure.

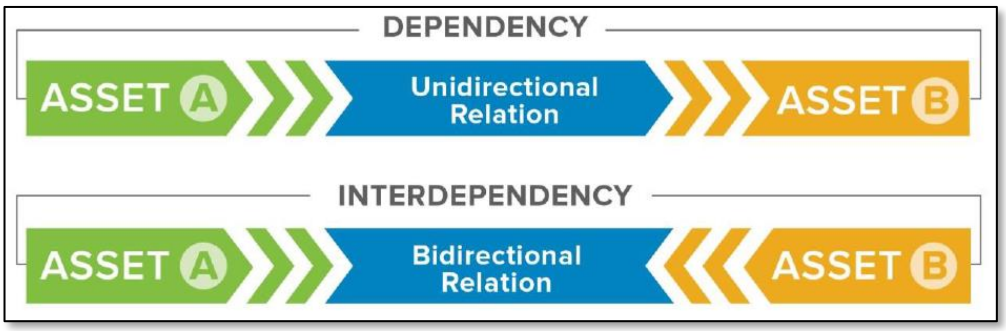
A list of example threat scenarios and their respective threat categories that may expose the vulnerabilities of the energy sector are presented in Table 2. Vulnerabilities are weaknesses within infrastructure, processes, and systems, or the degree of susceptibility to various threats. The impacts of these hazards and threats range from minor disruptions to complete degradation of the energy sector's core processes.

Table 2: Threats and Vulnerabilities for Each Energy Subsector

Threat/Hazard Category	Example Threat/Hazard Scenarios	Vulnerable Subsectors	
		Electricity	Petroleum
Climate Change	• Extreme temperatures • Increased instability and variability in weather patterns • Increased severity and frequency of storms and severe weather	X	X
Natural Hazards	• Typhoons, tropical storms, extreme winds • Flooding • Tsunamis • Earthquakes • Wildland fires • Drought	X	X
Cybersecurity Attacks	• Sophisticated nation-state sponsored attacks intending to disrupt infrastructure and/or conduct cyberterrorism • Threat actors conducting ransomware attacks for cybercriminal or other purposes • Insider threats with non-malicious or malicious intent • Cyber methods to steal private or proprietary information	X	X
Physical Attacks	• Sophisticated nation-state sponsored attacks intending to disrupt infrastructure (e.g., missile, EMP, etc.) • Lone threat actor shooting a substation • Drone swarms ramming critical infrastructure	X	X
Human Proceedings	• Labor disputes or mass retirements • Accidents disrupting energy services • Global pandemics causing labor shortages	X	X
Supply Chain	• Fuel transportation delays • Manufacturing delays in critical energy infrastructure materials • Damage to critical transportation hubs preventing efficient access to island	X	X
Market Conditions	• Energy services become economically difficult to acquire	X	X
Technological	• Aging physical infrastructure • Outdated information technology, operational technology hardware, or software • Global cloud infrastructure disruptions	X	X

4.2 Energy Sector Interdependencies

A dependency is a unidirectional relationship between two assets, where the operations of one asset affect the operations of the other. Upstream dependencies are those assets that directly influence a given asset's operations, while downstream dependencies are those impacted by the given asset's operations. For example, Apra Harbor is an upstream dependency for power plants in Guam, since their operations require timely delivery of fuel, while hospitals are downstream dependencies since they demand a reliable source of electricity to provide healthcare services. Interdependency is a bidirectional relationship between two assets where the operations of both assets affect each other. For example, a water treatment plant requires electricity to operate, and in turn, provides water the power plant uses to cool its equipment. The figure below illustrates the definitions of dependency and interdependency (Petit et al. 2015).



Dependencies and interdependencies between infrastructure components support critical enabling functions, such as electricity distribution and wastewater management. While these connections are vital to day-to-day functions, they also multiply disruption risks to infrastructure systems. The interdependencies between the energy sector and other critical infrastructure sectors, as well as one-way dependencies, leave Guam's energy infrastructure vulnerable to indirect disruptions. Examples of indirect disruptions include supply chain disruptions, adversarial threats, natural hazard events, and other incidents.

Guam faces unique economic and physical vulnerabilities from its reliance on imported fuels through a single harbor. Consequently, incidents that damage energy infrastructure may also present additional access challenges for energy sector mutual aid staff and supplies traveling to the island, and risk assessments must account for this additional complexity. Figure 3 below provides an overview of how interdependencies impact electrical infrastructure.

> NOTE: Guam does not currently utilize natural gas for energy but expects to develop this capability in the coming years.

Damage to energy infrastructure may lead to the loss of services for the public, government agencies, and/or military installations for an indeterminate amount of time. These service losses may create cascading impacts on critical lifelines, including healthcare and communications, and may also compromise supply chain resilience for the territory.

Guam's main economic sectors, tourism, and the defense industrial base, may both be adversely impacted by prolonged interruptions in the energy sector. Recent disruptions from Typhoon Mawar, for example, nearly halved the number of tourists who visited the island in 2023 (510,000 in 2023 versus an annual average of one million).[82] While military installations are less likely to be impacted by a short-term reduction in power services due to their access to generators, long-term disruptions may adversely impact their ability to maintain mission readiness.

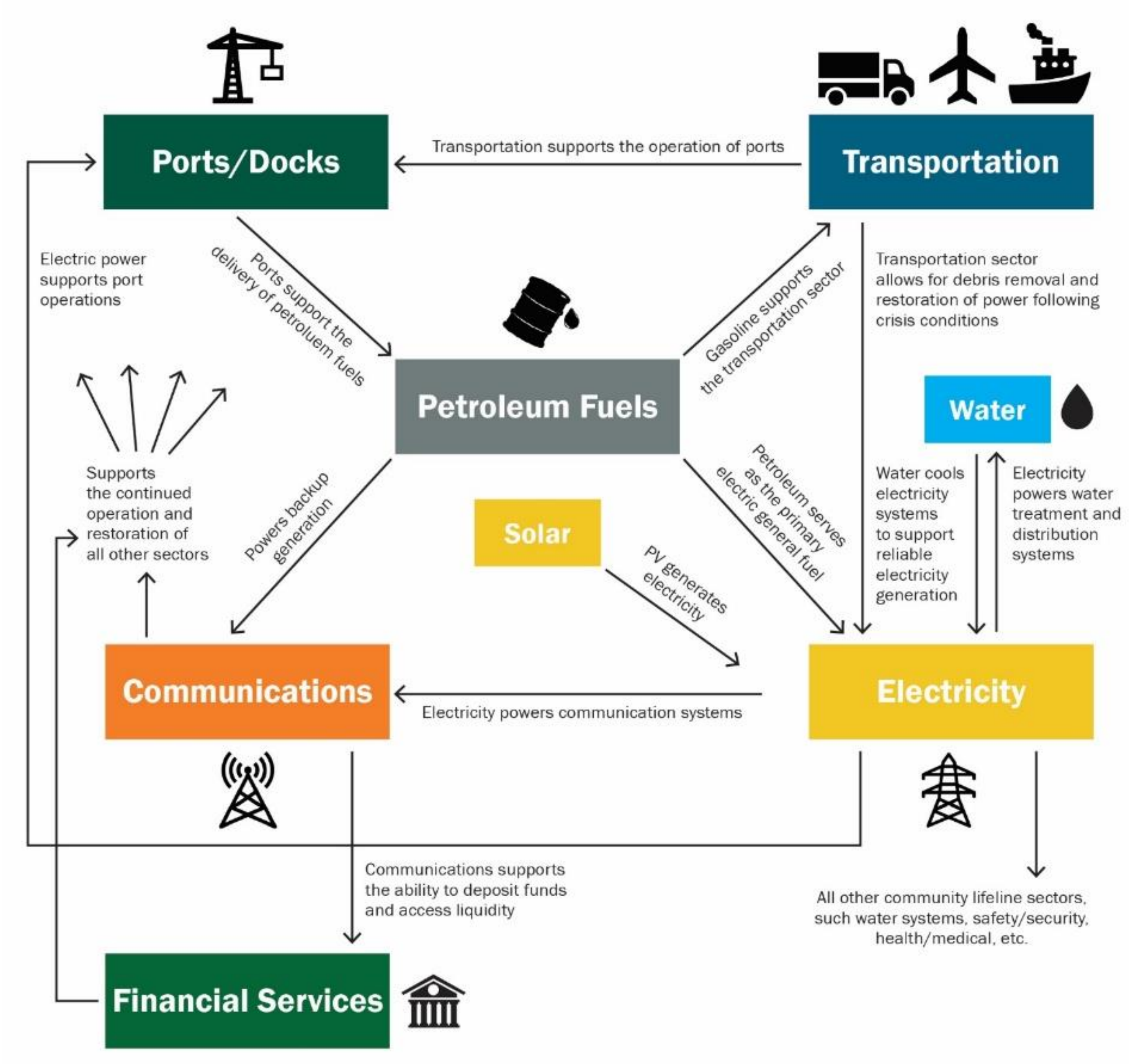


Figure 3: Energy Sector Interdependencies

The energy sector and other critical lifelines (such as transportation; communications; health and medical) are interdependent on one another for successful operations. Many, but not all, interdependencies and upstream dependencies of the electricity and petroleum subsectors are discussed below.

Electricity and Petroleum Interdependencies

Guam's electric grid is nearly entirely dependent on the petroleum subsector, which is in turn dependent on the transportation sector for timely delivery of fuel via tankers in Apra Harbor. Prolonged interruptions to fuel supply, whether from damage to liquid fuel storage or from supply chain disruptions, would significantly hinder GPA's ability to generate electricity for the island.

GPA mitigates the risk from this dependency by maintaining additional fuel storage. GPA stores a three-day supply of diesel fuel onsite at each of its petroleum-fueled generating stations, which it tops off daily, and maintains an additional 60-day fuel supply for power plant operations at the GPA Bulk Storage Facility in Piti. Additionally, GPA has mutual aid agreements with several off-island power companies/agencies including: CNMI, Hawaii Electric Company, Virgin Islands, Palau, and Pohnpei.[83]

To ensure delivery of fuel even during a power outage, the Port of Guam is supported by eight backup generator units. Each generator, which burns 400-800 gallons of diesel fuel per day, is supported by a 500-gallon diesel fuel tank. This fuel burn rate will necessitate a daily refueling schedule if the generators need to be operated 24 hours a day. Refilling of onshore tanks can proceed even during a power outage because tanker ships pump crude oil to shore tanks using shipboard generators. However, if dock operators are concerned over safety, they may suspend ship unloading operations for the duration of an electrical outage.[84]

While these preparations do not eliminate risks to the electricity sector from the liquid fuels subsector, they do mitigate risks related to delays of liquid fuels delivery through Apra Harbor. However, if liquid fuels storage is damaged in an event or rendered inaccessible, the electricity sector could suffer impacts related to loss of power.

Petroleum and Transportation Interdependencies

The petroleum subsector and transportation sector are closely linked. Nearly all transportation on the island relies on gasoline or diesel fuel, and any prolonged interruption to fuel supplies would significantly disrupt the flow of goods, emergency resources, and personnel across the island. The petroleum subsector is also heavily dependent on the transportation sector because all fuel for the island arrives via tanker barges through Apra Port, the only port on the island. In particular, the petroleum subsector is vulnerable to supply chain issues and changes in port operations.

Supply chain issues pose a risk to the petroleum subsector, and consequently the electricity subsector. Nearly 60 percent of Guam's total imports originate in the Continental United States (CONUS). The remainder arrive from Pacific markets: Asia, Australia, New Zealand, and Micronesia. Current sea shipment times are approximately 13 days from the U.S. west coast, 7 days from Hawaii, and 4-6 days from Asian ports after cargo loading. Delays along the supply chain, long-term closures of alternative ports, or severe weather can all impact the timely delivery of fuel.

Additionally, on-island distribution of fuel, commodities, and emergency response resources is dependent upon an operational port and clear roadways. Any impacts on the operations of Apra Harbor may negatively impact fuel supply or the distribution of critical resources. Damage to roadways and bridges or blockages to roads from debris may also impede delivery of fuel shipments via transport trucks across the island.

Electricity and Transportation: Upstream Dependencies

The electricity subsector may be impacted by disruptions to the transportation sector. During a natural disaster, damage to roadways and bridges or road blockages may significantly delay power restoration efforts. These issues may also prevent the delivery of fuel necessary to run electric generators throughout the island.

Transportation and Communications Interdependencies

The transportation sector depends on reliable communication networks to manage coordination of workers and supplies. A disruption to the communications network may impede timely delivery of fuel and other supplies. Ships in port may lose communication with port authorities and pilotage and docking may be hindered. Transport trucks may also be unable to communicate, creating delays in on-island shipping.

In turn, the communication sector is vulnerable to disruptions within the transportation sector. If port operations fail or road access is blocked by damage or debris, repairs to communication infrastructure and the import of necessary equipment may be delayed.

Electricity and Communications Interdependencies

Power outages may disrupt communication systems. If the communication system fails, it may disrupt coordination between emergency management personnel, hindering recovery efforts. It may also impede GPA's ability to oversee and direct power restoration efforts.

To mitigate the impacts of communication outages, Guam operates an 800-MHz trunked public safety communications system called Guam Homeland Security/Office of Civil Defense (GHS/OCD) Public Safety Communications System (GGPSCS). Additionally, the Guam Emergency Operations Center (EOC) has a cellular bidirectional amplifier that enables cellular use in the facility.

Electricity and Healthcare Interdependencies

The electricity subsector depends on a healthy workforce. If staff are injured or ill, they may be unable to perform their work, possibly degrading GPA's operational capacity.

The healthcare sector depends in turn on reliable electricity. To mitigate the risks from power outages, nearly all critical facilities have emergency generators installed according to the 2018 Catastrophic Typhoon Plan. While the generators may provide continued operation, facilities will operate at a lower capacity, and are reliant on continued fuel supplies.

4.3 Natural Hazard Risk Assessment

Guam is vulnerable to multiple natural hazards due to its location in the Pacific Ocean, including severe weather and seismic activity. Guam's 2019 Hazard Mitigation Plan outlines the territory's vulnerability to major natural hazards, and Table 3 below ranks these natural hazards based on the value of general building stock exposed to the natural hazard event. The ranking below omits man-made hazards such as adversarial threats, hazardous materials, or wildland fires (because wildland fires on Guam are primarily caused by human activity).[85]

Table 3: Summary of Natural Hazard Vulnerability Rankings for Guam

Natural Hazard	**Ranking**
Severe Wind	1
Earthquake	2
Tsunami (water level at 16 feet above mean sea level)	3
Flooding (100-year floodplain)	4
Slope Failure	5

Derived from Guam's Hazard Mitigation Plan, 2019.
See the HMP for more information on methodology.
1=most vulnerable, 5 = least vulnerable

In accordance with the strategy outlined in section three, this subsection provides a risk assessment of extreme natural hazards and their consequences on Guam's energy sector. The scenarios explored are based on the top three hazards outlined in Table 3, with the addition of a common wildland fire event. The scenarios presented in this section were crafted as part of GPA's participation in DOE's FRamework for Overcoming Natural Threats to Islanded Energy Resilience (FRONTIER) project, which is managed by Argonne National Laboratory (Argonne) and Lawrence Berkley National Laboratory. Scenarios include an extreme typhoon, an extreme tsunami, an extreme earthquake, and a commonly observed human-caused wildland fire event. Each scenario is based on a historical event that impacted Guam, but the impact assessment considers how current infrastructure would be disrupted if a similar event occurred today.

The risk assessment was crafted by Argonne using transmission power flow data provided by GPA. Argonne simulated realistic impacts on the GPA electric system following plausible natural hazard incidents. To accomplish this, Argonne used unique internal tools to model GPA's transmission system and simulate both the direct impacts on electric infrastructure assets as well as the cascading impacts throughout the entire system. This subsection summarizes overarching simulation results, including load losses and outage durations. However, asset-level information (such as the location of specific vulnerable infrastructure) is omitted because of its sensitivity.

The impact assessment metrics for each scenario include:

- Load Loss (MW) = The aggregate result of the physical inability to serve load and generation supply shortfalls. Load loss is a function of electric power demand that cannot be served by the bulk power system, due to either outages of conducting equipment or insufficient generating resources.
- Outage Duration = The expected amount of time for which load is lost.
- Unserved Energy = The amount of customer demand that cannot be supplied within a region due to a shortage of generation, demand-side participation, or interconnector capacity.

- Customers Affected = Total number of customers who experience any unserved demand, reported by customer segment (e.g. residential, non-residential, public sector, etc.).

Typhoon Scenario Risk Assessment

Analysis of Typhoon Risk: Guam has been affected by approximately 202 tropical cyclones from 1900 to 2013. Approximately 85 of these tropical cyclones, at least 61 of which were typhoons or super typhoons, have made landfall onto Guam and have resulted in severe winds, heavy rainfall, or flooding.

The National Weather Service–Weather Forecast Office (NWS-WFO) Tropical Prediction Center estimated the probability and magnitude of typhoons to occur on Guam based on a relatively comprehensive dataset of 1,469 storms that occurred near Guam during the period 1945 through 1997. Referencing historical events, a major typhoon (≥ 111 mph) is predicted to pass within 60 nautical miles of Guam and is predicted to occur once every five to six years (see Table 4).[86]

> A major typhoon passing within 60 nautical miles of Guam is predicted to occur once every five to six years. .

Table 4: Number of Major Typhoons (≥ 111 mph) within 60, 120, and 180 Nautical Miles of Guam (1945-2018 data)

Distance	Number Major Typhoons	Annual Frequency
Within 180 nautical miles (glancing blow)	51	0.69
Within 120 nautical miles (near miss)	30	0.41
Within 60 nautical miles (direct hit)	13	0.18

Typhoon Scenario: This analysis assumes a storm scenario, called here Paka-Scenario, based on the 1997 Super Typhoon Paka on Guam, in which a super typhoon passes 5 miles north of Guam on a day in December of 2021.

Figure 4 shows the path of the Paka-Scenario for Guam. During Typhoon Paka, sustained winds reached 150 mph, with gusts measured up to 236 mph. The maximum 1-minute sustained wind speeds measured during the actual Typhoon Paka event are depicted in Figure 5.

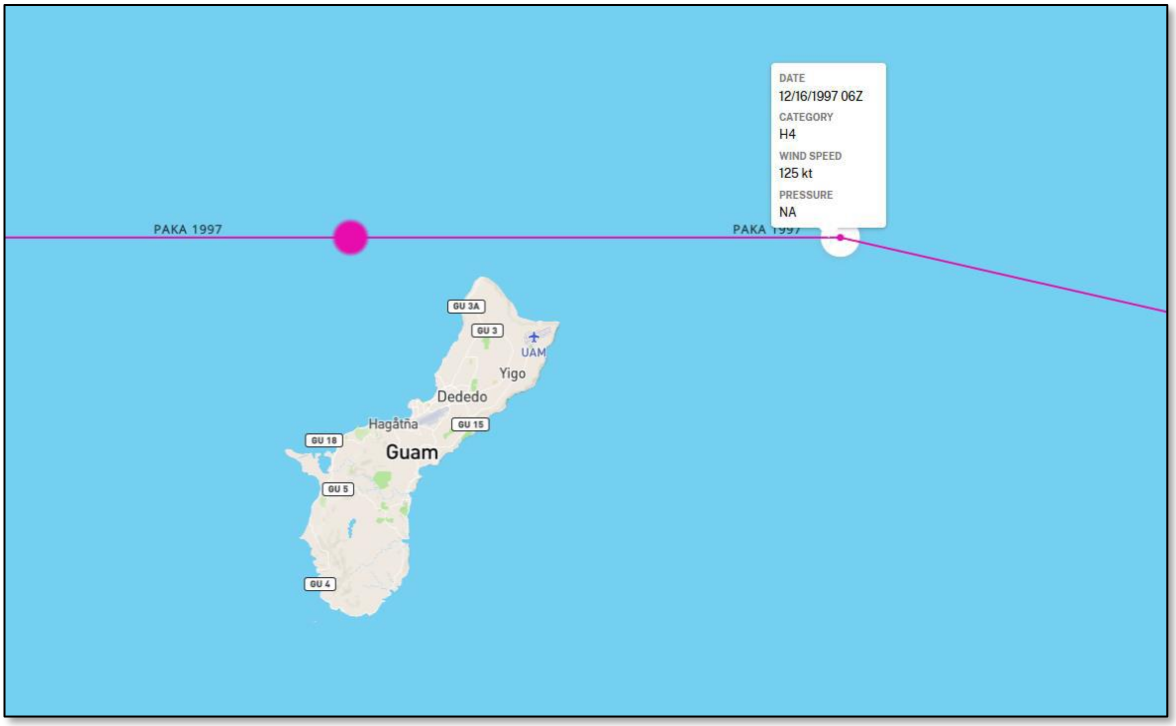


Figure 4: Storm Track of Paka-Scenario from FRONTIER.

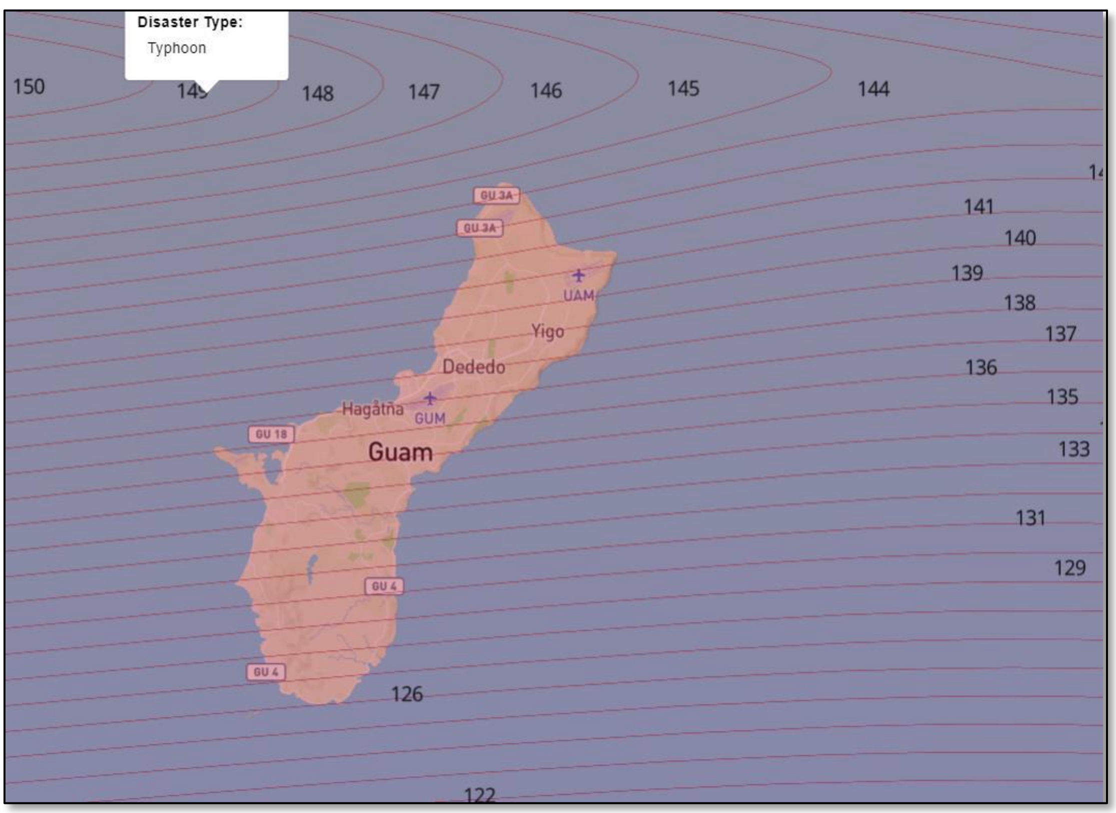


Figure 5: Maximum 1-minute sustained winds (mph) for Typhoon Paka. Data pulled from FRONTIER.

Scenario Impact Assessment: Guam's electrical power system is a combination of aboveground and belowground distribution and transmission lines. Most lines are above ground. Over 90 percent of distribution lines are above ground (582 of 645 total miles of distribution lines), as are 89 percent of transmission lines (154 of 174 total transmission lines). The remaining lines are below ground. Most power poles are made of concrete and can withstand typhoon force winds; however, severe damage to aboveground distribution and transmission lines is likely to occur during a major typhoon.

Consequence Metric	Results
Load Loss	235.1 MW (99%)
Outage Duration	60 days
Unserved Energy	72.8 GWh
Customers Affected	51,740

Because of the vulnerable aboveground distribution lines across Guam, this scenario would result in a near 100% loss of power island-wide due to high winds, flooding, and inundation. The load loss would be 235.1 MW impacting 51,740 customers. The expected restoration time is 60 days, resulting in 72.8 GWh of unserved energy.

Interdependency Impacts: A typhoon which passes near Guam has the potential to severely impact the interdependencies between the energy sector, other critical infrastructure sectors, and community lifelines. Power restoration efforts are dependent on the transportation sector and its ability to support movement of supplies and personnel. This movement could be significantly delayed in areas where access to power lines and other infrastructure has been flooded or damaged. Because electricity is an upstream dependency for other critical infrastructure sectors, impacts to the health and medical sector are expected, with limited routine medical support due to prioritization of generator usage for emergency needs. Water and wastewater treatment infrastructure will also be negatively impacted.

Tsunami Scenario Risk Assessment

Analysis of Tsunami Risk: Historical data regarding tsunami events on Guam is minimal and likely incomplete. A query of NCEI/WDS Global Historical Tsunami Database for Guam, combined with information from the Guam Hazard Mitigation Plan 2019, indicates that 16 historical tsunami events occurred between 1767 to 2012, as shown in Table 5 below.[87] A maximum observed tsunami wave run-up of 6.1 m (20 ft.) occurred in Agat in 1849.

Due to limited historical data, the probability of a tsunami occurring cannot be calculated for Guam. However, the possibility of a large tsunami causing extensive damage is generally low, given available historical information and reported regional considerations that would lower the risk of significant wave run-up (the height of a wave above normal high tide), such as the band of coral reef around the island and the steep bathymetry surrounding the island. Based on historical data, the frequency of tsunamis on Guam is on the order of 0.063 incidents per year (once every 16 years, on average).

Annual risk of a damaging tsunami is 1.2% or once every 86 years.

Historic records indicate that Guam has had only three tsunamis large enough to cause damage—in 1849, 1892 and, most recently, in 1993. Given only three tsunamis were large enough to cause damage on the island in the past 250-plus years, the frequency of damage from Tsunamis is on the order of 0.012 incidents per year (once every 86 years, on average).

Table 5: Historical Tsunami Inundations on Guam, 1767–2019

Date	Earthquake Location	Earthquake Magnitude	Maximum Wave Run-Up (m)
1767	Unknown	N/A	N/A
1809	Mariana Islands	N/A	N/A
4/1825	Mariana Islands	N/A	N/A
1/25/1849	Mariana Islands	7.5	6.1
5/16/1892	Guam, Mariana Islands	7.5	N/A
2/10/1903	Philippines	N/A	0.15
12/9/1909	Guam, Mariana Islands	8	N/A
3/4/1952	Se. Hokkaido Island, Japan	8.1	0.3
10/4/1952	Kamchatka, Russia	8.2	0.3
3/9/1957	Central Aleutian Islands, Alaska	8.3	0.3
5/22/1960	Central Chile	8.6	0.3
10/13/1963	Kuril Islands, Russia	8.1	0.3
3/28/1964	Gulf of Alaska-Alaska Pen.	8.5	0.3
8/8/1993	Guam, Mariana Islands	7.8	2.4
2/27/2010	Maule, Concepcion, Talcahuano, Chile	8.8	1.27
8/13/2010	Mariana Islands	6.9	0.07

Tsunami Scenario: This analysis assumes a tsunami scenario, based on the 1849 tsunami that reached a height of 6.1 meters (20 feet). The tsunami in this scenario is assumed to have been caused by a submarine slide in Apra Harbor, resulting from an offshore earthquake on the Mariana Islands. Expected inundation zones are depicted below.

Figure 6: Expected inundation zones for tsunami scenario from FRONTIER.

Scenario Impact Assessment: The expected inundation zones include several important power plants, substations, and poles/towers, all of which would sustain some level of damage. While this risk assessment only considers damage to electric infrastructure, it is important to note that ports and petroleum terminals are also located within the expected inundation zone. If ports are severely damaged, it could impact the island's ability to receive critical goods and services. If petroleum terminals are severely damaged, it could impact the island's ability to deliver fuel to electric generation plants.

Consequence Metric	Results
Load Loss	31.6 MW (13%)
Outage Duration	87 hours
Unserved Energy	0.6 GWh
Customers Affected	7,000

The disruption of a few important electric subsector assets near Apra Harbor would cause cascading outages, primarily in the central and northern regions of the island. This would cause a systemwide load loss of 31.6 MW and impact 7,000 customers. Referencing past tsunami events on Guam and other regions of the US, the expected time to restore power would be 87 hours, resulting in 0.6 GWh of unserved energy.

Interdependency Impacts: The energy sector is dependent on reliable access to imported petroleum. With the potential for damage to ports and petroleum terminals, the liquid fuels subsector's dependence on ports and docks could lead to shortages within a week of the event. This can lead to shortages of power for retail stations and control systems within the liquid fuels subsector. It can then have cascading consequences on the transportation sector due to limited access to gasoline. Shortages of liquid fuels for public use may lead to diesel generators within the health and medical lifeline running short of diesel and further limiting their operations. It also may limit the transportation lifeline's ability to move around Guam to conduct debris removal and repairs.

Earthquake Scenario Risk Assessment

Analysis of Earthquake Risk: The entire island of Guam is susceptible to the impact of an earthquake, as reflected by its past seismic activity and the presence of various known faults. Fault and seismic data for the region in which Guam is located are generally scarce. The historical seismic catalog for moderate-sized events is most likely incomplete. Additionally, the historical record for large events is likely inadequate, since the recurrence interval (average time between events) for subduction zone earthquakes may be long. Table 6 provides information on major earthquakes affecting Guam, which consists of 10 events recorded since between 1975-2019. Based on these recorded occurrences, an earthquake of significant size (>5.7M) is likely to be felt on Guam every four to five years.

> An earthquake of significance (>5.7M) is likely to be felt every 4-5 years.

Table 6: Recent M 5.7 or Greater Earthquakes Felt on Guam, 1975-2019[88]

Event Date	Description	MM**	Magnitude*
1 Nov 1975	From the same area as the 1936 event. Damage in excess of $1,000,000. No landslides were noted. This quake was 70 miles deep and was preceded by loud subterranean noises. Many businesses lost stock from shelves, and a number of structures were damaged; only one injury was reported. The earthquake was felt strongly in many parts of the island. Epicenter 12.5 miles north of the island.	7.1	VIII
13 Feb 1983	One person slightly injured at Tamuning/Tumon/Tumon. Felt throughout Guam. Epicenter about 25 miles north of the island. Minor damage reported in northern Guam	6.3	V
5 Apr 1990	Felt on Guam. Also felt on Saipan.	7.3	IV
8 Aug 1993	The most severe examples of ground failure were at the filled area of Cabras (Piti power plant and commercial port) and at the Navy wharves across the harbor. Two cases of building failure in the Tumon area were noted. Old residential units in the Apra Heights housing area suffered notable damage and were also razed. No bridge failures occurred, but the Talofofo, Ylig, and Pago bridges required repairs as well as the utilities along the bridges. Forty-eight people injured on Guam. Extensive damage (IX) to hotels in the Tumon Bay area. Damage (VII) occurred at several locations in the northern half of the island. One end of the approach to a bridge at Pago Bay fell more than 18 inches. Many landslides and rockslides were reported, mainly in the southern half of the island. The preliminary estimate of loss from damage to commercial buildings is placed at $112 million, and loss from damage to private residences is estimated at several million dollars.	7.8	IX
23 Apr 1997	Two separate earthquakes occurred from the fault plane of the August 1993 series. Four people injured and some damage to buildings on Guam. Felt (VII) at Inarajan, Merizo, and Yona; (VI) in central Guam; (IV) at Dededo and Yigo. A M 5.7 earthquake was followed 5 seconds later by a M 6.3 earthquake (not an aftershock). Centered about 27 miles west of Rota. Originated at a depth of 65 miles.	5.7; 6.3	VII
12 Oct 2001	Southeast of the initial shock of the August 1993 series. Power was lost. The new school in Piti (on alluvial clay) was most conspicuously affected as well as schools in the Santa Rita area. One person injured, many buildings damaged (VII) and utilities disrupted on Guam.	7.3	VII
26 Apr 2002	Northwest of the August 1993 initial shock. Power was lost through most of Guam. At least 5 people slightly injured and some minor damage (VII) to buildings on Guam. Water and sewer lines broke, and power outages occurred throughout the island.	7.1	VII
9 May 2008	Felt on Guam, also felt on Saipan. No reports of damage or injury.	6.7	IV
11 Sept 2012	155 miles southwest of Hagatna with an epicenter depth of more than 6 miles. Felt on Guam. No reports of damage or injury.	5.8	V
17 Sep 2014	26.7 miles northwest of Piti Village, Guam. No reports of damage or injury	6.7	V

* Magnitude Scales, also known as the Richter scale

** Modified Mercalli (MM) Intensity Scale.

Earthquake Scenario: This scenario is based on the 7.8 M earthquake that occurred in Guam on August 8, 1993.[89] The 1993 earthquake occurred at the same time as a tropical storm was lashing Guam with high winds and heavy rains, but this analysis does not assume that a typhoon is happening simultaneously. The epicenter of this earthquake is assumed to be about 19 miles off the southern coast of Guam, producing a non-destructive tsunami wave of 7 feet.

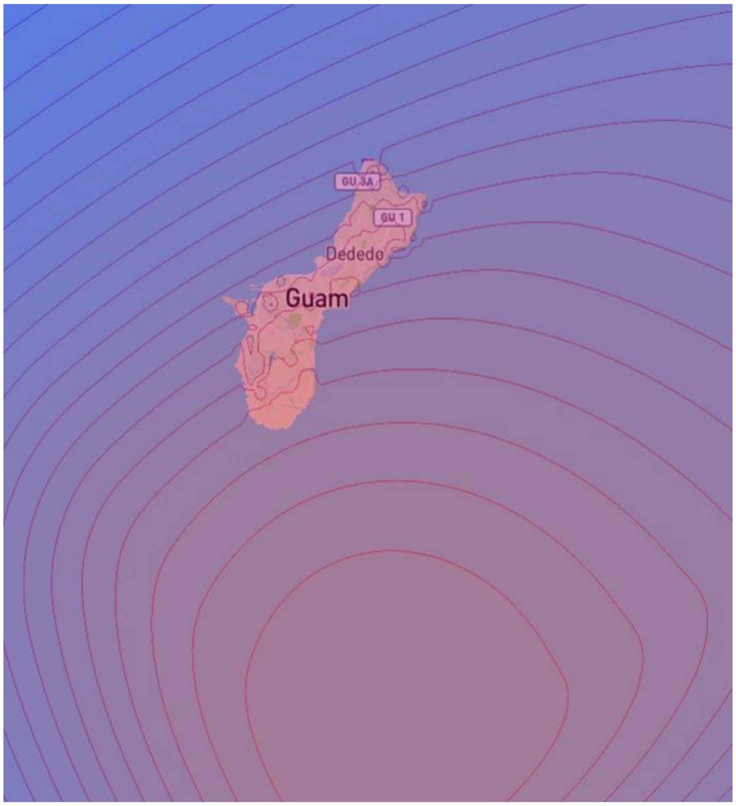


Figure 7: Epicenter of 7.8Mw Earthquake from FRONTIER.

Figure 8: Resulting peak ground acceleration (PGA) from the 7.8Mw earthquake. Image from FRONTIER.

Scenario Impact Assessment: The entire island of Guam is within the direct impact zone of this seismic event, which means most power plants, substations, transmission structures, and power poles across the island would experience some level of damage. The most intense shaking would be experienced in the southernmost portion of the island, but assets in the northern portion would also be impacted. Soil settlement is predicted to affect transmission and distribution power poles across the island, but this settlement is not expected to result in power outages. The electric substations and power plants experiencing greater levels of damage are assumed to cease operations, thus resulting in a load loss of 237.5 MW (100%) impacting 52,264 customers. The expected outage duration is 24 hours, which results in 1.2 GWh of unserved energy.

Consequence Metric	Results
Load Loss	237.5 MW (100%)
Outage Duration	24 hours
Unserved Energy	1.2 GWh
Customers Affected	52,264

Interdependency Impacts: Due to liquefaction the electricity transmission could experience minor damage, with moderate damage to power poles through broken insulators. While this may not lead to power outages, the electricity sector's dependence on the transportation sector's debris removal related to liquefaction in access areas may slow the repair of damage.

Wildland Fire Scenario Risk Assessment

Although Wildland fires are not a part of Guam's natural environment and not considered a "natural hazard" in Table 3 above, the FRONTIER tool includes a wildland fire scenario, and that scenario is depicted here.

Analysis of Wildland Fire Risk: Wildland fires are not part of Guam's natural environment because the island lacks natural ignition sources. Lightning strikes may ignite a wildland fire, but when the island does experience lightning it is usually accompanied by heavy rain. The island's relative humidity is high, usually above 80%, and these moist conditions are not conducive to starting fires from sparks, spontaneous ignition, or cigarettes. However, arson is the primary cause of almost all wildfires on Guam. Local hunters use fire to clear sightlines and draw deer and pigs into the open.[90]

> Approximately two small power outages occur each year due to human caused wildland fire.

GPA keeps track of wildland fire events affecting electric infrastructure. Between 2010 – 2020, GPA experienced 23 line outages due to four grass fires affecting 17 feeder cables. This equates to an average of approximately two electric outages per year caused by wildland fire. These incidents do not typically impact a significant number of customers, nor are those affected without power for very long.

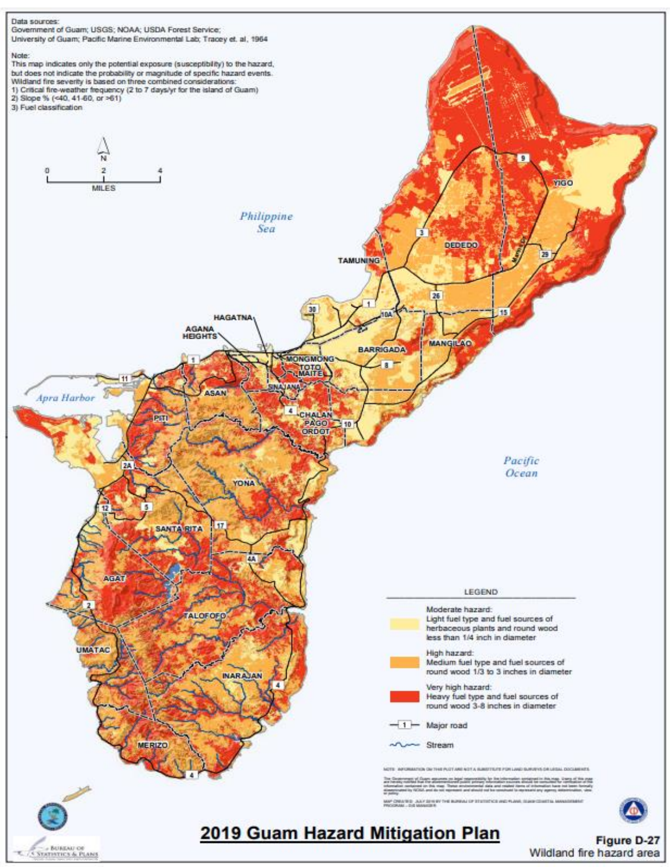


Figure 9: Wildland fire risk based on fuel type and fuel sources. 2019 Guam Hazard Mitigation Plan.

Wildland Fire Scenario: Based on a series of 2017 and 2019 wildland fires in southern Guam, this scenario assumes that a wildland fire occurs near the Umatac substation.

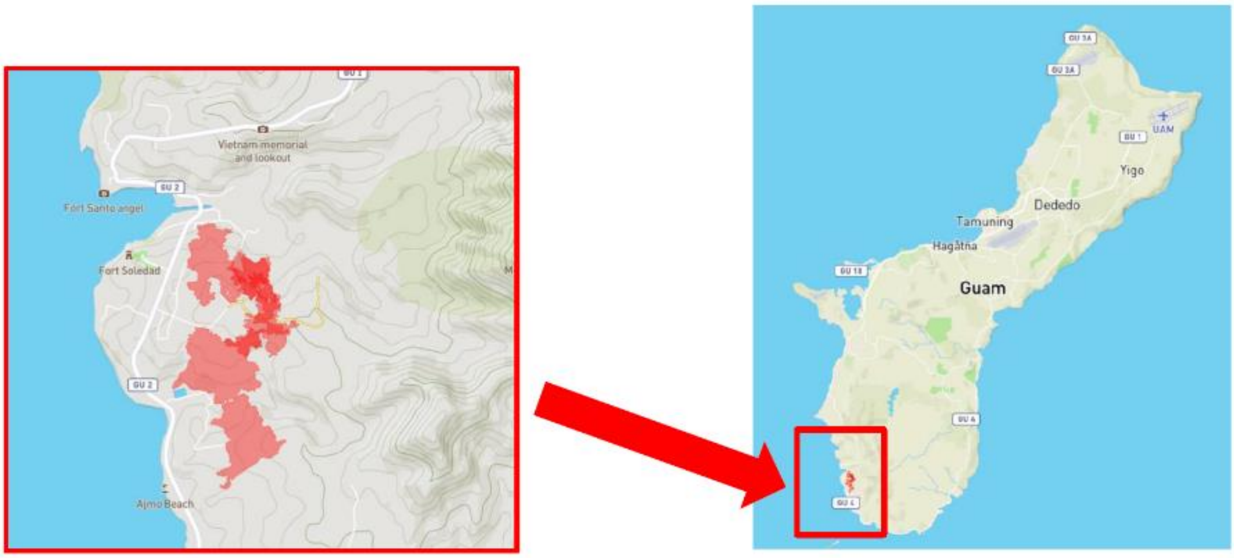


Figure 10: Wildland fire scenario in southern Guam from FRONTIER.

Scenario Impact Assessment: This scenario would result in an isolated outage impacting 950 customers for one hour, with a total load loss of 4.28 MW and 0.9 MWh of unserved energy. This scenario is reflective of most wildland fire incidents impacting electric infrastructure on Guam.

Interdependency Impacts: While current scenarios do not predict significant impacts, climate change may lead to more prolonged droughts, changes in vegetation patterns, and consequently wildfires may burn more acreage in the future. If wildland fires become more prominent of an issue, power systems and another community lifeline sectors could be exposed to enhanced risk.

Consequence Metric	Results
Load Loss	4.28 MW (1.8%)
Outage Duration	1 hour
Unserved Energy	0.9 MWh
Customers Affected	950

4.4 Adversarial Threat Risk Assessment

This subsection provides a high-level risk assessment of adversarial threats, inclusive of physical and cybersecurity attacks. Although this master GESP only provides a high-level overview, a more detailed description of risks related to security architecture resides in the "Cyber/Physical Security Annex", including a roadmap for all energy sector owners and operators to perform a security risk assessment.

Guam's energy sector faces a wide variety of threats from an array of actors. These threats include cybersecurity attacks by adversarial nation states, criminal gangs, or hacktivists; physical attacks by terrorists (domestic or foreign) and vandals on power plants and substations; or an Electronic Magnetic Pulse (EMP) generated from a short-range missile exploded in the atmosphere.

This threat is compounded by the grid's age and limited resources. GPA has been augmenting the grid with automation and some emergency technologies, but it is still mostly dependent on legacy technologies. This dependence leaves Guam's energy infrastructure extremely vulnerable.

Threats – both physical and cyber – against critical electric infrastructure worldwide are forecasted to increase over the coming years. Attacks against U.S. electric infrastructure have already increased since 2021. In 2022, the U.S. Department of Energy's annual summary of electric disturbance events showed an uptick in cyber events and attacks across the United States (see Figure 11).

To mitigate these threats, GPA has established an annual cyber conference to strengthen Guam's preparedness for physical and cyberattacks and to improve its information protection protocols. Further mitigation efforts should include simultaneous monitoring of physical and cyber threats and innovation for maximum electric grid resilience, including incorporating renewable energy sources.

Considerations for Ballistic Missile Threats

The Government of Guam has published a Terrorism/Weapons of Mass Destruction Annex to the Comprehensive Emergency Management Plan that outlines the authorities and response modes for addressing physical attacks, such as ballistic missiles, or weapons of mass destruction. Response to this type of threat will heavily involve military forces, therefore guidance on ESF 16 (military support to civil authorities) should also be referenced.

Tier 1 response measures, outlined in section 7, would likely also be relevant in this type of event.

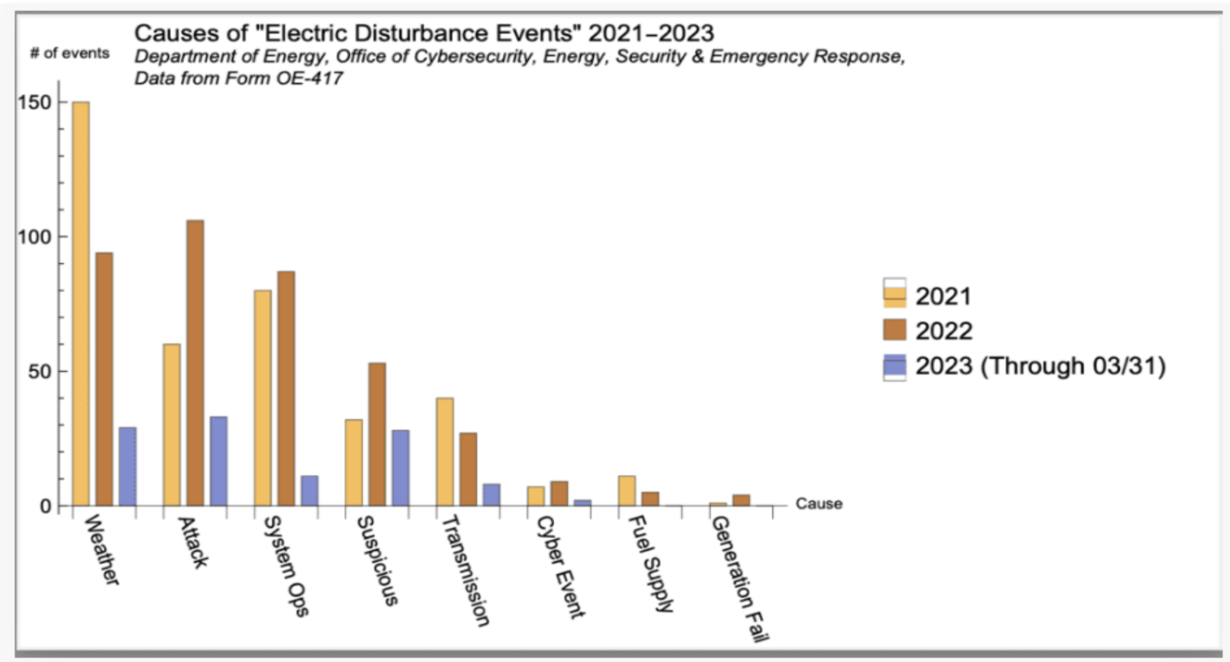


Figure 11: Causes of "Electric Disturbance Events" 2021-2023, OE-417

Guam's energy sector should be aware of the different types of adversarial threat actors and their motivations. A threat actor is any individual or group that poses a cyber or physical threat. Threat actors are the perpetrators of attacks with malicious intent and are often categorized by a variety of factors, including motive, type of attack, and targeted sector. See the table below that captures common threat actors and their motivations.

Common Threat Actors & Motivations	
Threat Actors	Motivation
Cybercriminals	Profit
Nation-State	Geopolitical
Terrorist Groups	*Ideological Violence*
Thrill-seeker	*Satisfaction*
Insider Threats	*Discontent*
Hackers	*Variable*

Electricity Subsector

Most cyberattacks against the electric grid primarily exploit human error, outdated software, or poorly secured networks. The most common cyber attack vectors against Guam's electric grid are listed in Table 7.1, and common physical security attack vectors are listed in Table 7.2. An attack vector is a method used to gain privileged access to networks, systems, Internet of Things (IoT), Information Technology (IT) and Operational Technology (OT) infrastructure. In other words, they enable hackers to exploit vulnerabilities and can lead to security incidents. An attack vector provides an avenue for a cybercriminal to infiltrate a system, steal information, or disrupt service.

The cyber threat landscape has expanded as systems have grown more connected through the integration of IT and OT into industrial control systems (ICS).

Table 8 describes the nine asset types most likely to be exploited by threat vectors. These assets should be considered in any cyber risk assessment conducted by GPA and their trading partners, and internal controls should be developed for each.

Attack vector is a specific method or pathway through which an attacker gains unauthorized access to a system or network and exploits vulnerabilities. To address common attack vectors, security controls must spread across the majority of the attack surface. The process begins by identifying all possible entry points into your private network and ingress and egress points into the physical environment.

Table 7.1: Guam Power Authority's most common cyber security attack vectors

Cyber Security Attack Vector	**Description**
Social engineering	This refers to the use of deception (usually exploitation of their target's goodwill) to manipulate someone into divulging sensitive information which can then be used for fraudulent purposes. Examples of social engineering attacks include baiting, scareware, pretexting, tailgating, and phishing.
Illicit access to physical machines	One of the most common physical security threats is illicit access to a machine. Whether it is a traditional computer or a server, someone can gain unauthorized access to the device.
Malicious physical access controls	Malicious physical access controls are attacks where an individual gains access to a system by bypassing physical controls meant to protect it.
Malicious damage or loss of sensitive items	This type of physical security threat occurs when a person gets access to a sensitive item and then makes a copy of it. They can then spread this copy widely or destroy the original. Either way, it severely compromises an organization's security posture by exposing sensitive data to an unauthorized party.
Email scams and attachments	An email scam is when a cybercriminal sends an email that appears to be from a legitimate source in the hopes of stealing sensitive data or money, infecting a computer with malware, or getting someone to click on an attachment that leads to a fraudulent site.
Compromised or weak credentials	A weak password is an open door to cybercriminals or attackers that can be used to gain access to private information, steal data, and commit identity theft. With reused passwords, if a hacker compromises one set of credentials, they can do the same to other accounts.
Unsecured Wi-Fi networks	Data transmission across unsecured public Wi-Fi networks is easily monitored.
Outdated software and operating systems	Software, operating systems, hardware, and networks are susceptible to security vulnerabilities. Users can fall victim to security incidents because they use unpatched software and/or operating systems, hardware and/or devices and networks.

Cyber Security Attack Vector	Description
Ransomware	Ransomware is a form of extortion in which data is either encrypted or permanently deleted unless a ransom is paid.
Third-party breaches	Third-party vendors are businesses that provide services or materials to Guam and its trading partners. These vendors can be internal (such as human resources, information technology and operational technology) or external (such as suppliers or distributors). Breaches of third-party networks can expose data that was confidentially shared between the original user and the third party.
Change management and configuration weaknesses	Change management of assets along with misconfiguration-induced vulnerability is the root cause of many issues. For example, configuration weaknesses can lead to simple mistakes that allow attackers to access your IT/OT infrastructure without knowledge.
Zero-day vulnerabilities	Zero-day vulnerabilities are flaws in a software program that are publicly disclosed by their 'discoverer' before the developer of the program has had time to address them.
Distributed Denial of Service (DDoS)	DDoS cyber-attack is a hacking technique used to bring down data centers, like websites and servers, or prevent users from accessing them in the first place.
SQL injections	Injection attacks are common, and SQL injection is the top application layer web attack. It allows hackers to gain database information such as usernames and passwords and potentially compromise websites and web applications that rely on the database.
Cross-Site Scripting (XSS)	XSS attacks are another type of injection attack, in which malicious scripts are injected into otherwise benign and trusted websites. XSS attacks occur when an attacker uses a web application to send malicious code, generally in the form of a browser side script, to a different end-user.

A physical attack vector refers to the method or combination of methods that cybercriminals use to breach or infiltrate an organization's physical infrastructure.

Each facility shall implement the appropriate physical security measures to ensure an effective protection strategy for critical assets, personnel, property and information. Physical security measures aim to protect people, property, information, and assets from compromise or harm. Understanding these vectors helps organizations better defend against targeted attacks and safeguard their assets.

Table 7.2: Guam Power Authority's most common physical security attack vectors

Physical Security Attack Vector	Description
Workplace Violence	Workplace violence ranges from threats and verbal abuse to physical assaults and even homicide.
Crime/Theft	Risk of burglary, robbery, vandalism, theft, and fraud requires utilizing technology that would allow the location/high-value items to be locked down quickly, record the crimes in progress
Combined Natural Disaster and Physical Attack	Natural disasters have increased by a factor of five over the past 50 years, primarily fueled by climate change. Business continuity and recovery plans for hazardous weather are essential for companies. Some systems can utilize early warnings to detect these events, alert companies, and properly communicate with employees to put their disaster evacuation plans in place. Some nefarious actors may use natural disasters as an opportunity to strategically cause additional damage through a kinetic attack.
Trespassing	Trespassing refers to knowingly entering another person's property without their permission. It can be both a criminal offense and a civil violation. • Criminal Trespassing - Intentionally entering or remaining on someone else's property without authorization. • Civil Trespass - Unlawfully entering someone's property without permission.
Unauthorized protesting	Unauthorized protesting refers to demonstrations or gatherings that occur without proper permits or authorization from local authorities.
Malicious intent to cause significant negative impact to the environment	Intent to compromise systems which, if successful, would result in significant negative impact to the environment
Malicious intent to cause serious bodily harm and/or death.	Active Assailant – Active Shooter, active aggressor, etc. Intent to compromise systems which, if successful, could cause serious bodily harm and/or death if not prevented.
Obvious signs of compromise and/or personnel	Large breach point, fire/smoke, active adversarial activity, e.g. personnel actively attempting to gain entry, personnel actively engaged in other criminal activity, to include trespassing, etc.

The integration of IT and OT in ICS expands the cyber threat landscape by introducing threat vectors as direct consequences of the greater connectivity of systems. The following 9 asset types with the top 3 being the most likely to exploit to execute physical and cyber-attacks on the Guam power system and its participant. The following 9 Asset Types must be part of the risk assessment of the Guam Power Authority and its trading partners. Internal controls must be mapped to each of these 9 asset types for each control selected along with risk scenarios as part of its physical, logical and information Risk-Based Program.

Table 8: Most Likely Asset Types to be Exploited by Threat Actors

Asset Type		**Description**	**Inherit Protection From**
1	**Device /HW**	Automated processing systems and the underlying operating systems	Network, Hardware, Location, Personnel, Organization
2	**Application/SW**	Compiled computer code	Hardware, Organization
3	**Network**	Physically and logically connected devices, usually communicating via the TCP/IP protocol suite	Organization, Location, Personnel
4	**Information**	General classes of information that require protection based on sensitivity.	Software, Hardware, Network, Location, Personnel, Organization
5	**Location**	Facilities, rooms, racks, containing resources requiring protection	Organization
6	**Source Code**	Human modifiable (un-compiled or interpreted) source code	Organization
7	**Media**	Information storage	Software, Hardware, Network, Location, Personnel, Organization
8	**Organization**	Collections of resources (people, equipment, facilities, etc.) with a common mission, business objective, or purpose	None
9	**Personnel**	People within scope of the compliance program	Organization

Petroleum Subsector

One of the major critical infrastructure sectors for Guam is the Jose D. Leon Guerrero Commercial Port (Port of Guam), Guam's only deep-water port which receives about 90% of the island's imports. The Port of Guam faces growing pressure to fortify its cybersecurity defenses. Collaboration among port authorities, government agencies, shipping companies, and cybersecurity experts is essential to develop comprehensive strategies for threat prevention, incident response, and system resilience. Proactive measures, continuous monitoring, and investments in cybersecurity technologies are crucial to counter this evolving threat landscape, to bring about the smooth functioning of port operations and global commerce.

All petroleum products are periodically shipped to Guam via fuel tankers and unloaded at both F1 and Golf piers. The use of two piers for fuel delivery helps to ensure redundancy and continuity in fuel distribution and achieve port resiliency in times of emergencies impacting either wharf. Any impact to the operations of either pier will have ripple effects throughout the island economy.

Maritime facilities are critical for the shipment and reception of raw and finished goods for trade within Guam. Petroleum enters or leaves Guam by ship. To operate efficiently, maritime facilities use information technology (IT) and operational technology (OT) systems for various functions, including communication, equipment operation, cargo tracking, and business operations. Compromise of these systems could lead to disruptions of port operations and related supply chains, resulting in financial losses and detrimental impacts to electricity production across the island.

Table 9: Port Facility Cybersecurity Risks

Port Facility Cybersecurity Risks	
Facility Access	The degradation or disruption of systems used to identify and direct cargo, truck drivers, and facility personnel can cause significant congestion or the closure of the terminal until systems restoration is complete.
Terminal Headquarters – Data	Malicious actors may access information systems within the terminal to access sensitive energy client and partner information and data. Malicious actors may also attempt to exploit or sell up-to-date and historic operational gas transmission data and trends as well as supply chain information.
Terminal Headquarters – Ransomware	The manipulation or destruction of data, most commonly seen in ransomware attacks, can disrupt operations within a facility until systems and data can be restored from reliable, isolated backups. Ransomware attacks have resulted in facilities being partially or completely offline for days, causing significant business losses and disruptions.
Information Technology (IT) and Operational Technology (OT) Systems	IT and OT Systems – systems, devices, and communications links used to control physical processes at ports, including cargo handling equipment and pumps – are being increasingly incorporated into Guam maritime facilities. The compromise of IT and OT systems could cause changes to cargo movements, interrupt port operations, and cause physical damage to equipment and safety risks for personnel.

Port Facility Cybersecurity Risks	
Positioning, Navigation, and Timing (PNT)	Position, Navigation, and Timing plays an essential role in Guam's maritime functions such as vessel navigation, port logistics, and island logistics. Loss of PNT services would disrupt vessel movements in the port and complex logistics systems at the port facilities. Loss of PNT could also lead to collisions and allisions, resulting in potential damage to fixed infrastructure, pollution, release of hazardous material, fires, loss of life, vessel sinking, and/or blocking of a navigable channel.
Vessel	Compromised systems aboard a vessel or inside a port facility could lead to the compromise of additional waterside or landside systems. Interconnectivity between berthed vessels and maritime facilities through the sharing of Wi-Fi, network connections, USB storage devices, etc. can lead to system compromises that otherwise may not have occurred.

Potential Consequences

Energy infrastructure forms the backbone of modern societies, and any disruption could have far-reaching consequences. Physical and cyber security is integral to protecting flow energy services. Potential consequences of a successful physical or cyber security attack include reputational damage, legal and regulatory consequences, and financial losses. Table 10 provides a non-comprehensive list of the potential consequences of physical and cyberattacks.

Table 10: Potential Consequences of Adversarial Attacks on Critical Infrastructure

Physical Attack	Cyber Attack
• Property damage • Injury or loss of life • Disruption of operations • Reputational damage • Recovery costs • Legal and regulatory Consequences • Financial losses • Reduced market competitiveness • Reduced employee morale • Increased insurance premiums • National security concerns	• Financial losses • Loss of confidential information • Disruption of operations • Reputational damage • Intellectual property theft • Legal and regulatory Consequences • Credit rating reduction • Reduced market competitiveness • Increased cyber insurance Premiums • National security concerns

5. Energy Security and Emergency Response Authorities

This section identifies relevant GovGuam and federal authorities for energy security and emergency response activities within Guam. The energy security-specific roles and responsibilities for each organization are described, along with specific guiding statutes that assign them.

5.1 GovGuam Authorities

This section presents the energy security-specific roles and responsibilities for GovGuam and Guam localities. These roles and responsibilities were originally established in the Guam Comprehensive Emergency Management Plan (Guam CEMP), which is the overarching territory-wide plan that describes the "basic strategies, assumptions, operational objectives, and mechanisms through which the Guam Emergency Operations Center Emergency Support Function (EOC ESF) Team will mobilize resources and conduct activities to guide and support local emergency management efforts through preparedness, response, recovery, and mitigation."

As defined in the National Response Framework, Emergency Support Functions (ESFs) are the primary emergency response coordinating structure. A department or agency is designated as the coordinator for each ESF, along with several primary and support agencies. ESFs provide the structure for coordinating interagency response during an incident and group together the functions most frequently used to prepare for, respond to, and recover from disruptive events.

Table 11 provides a quick reference chart for the roles and responsibilities for Guam's agencies and departments and the relevant energy sectors. Further details for these roles are provided in Table 12.

Table 11: GovGuam Energy Security Roles and Responsibilities

Department or Agency	Sector	Preparedness & Response	Situational Awareness	Standards & Regulations
Governor		✓	✓	✓
Legislature of Guam				✓
Guam Energy Office (GEO)		✓		
Public Utility Commission (PUC)				✓
Consolidated Commission on Utilities (CCU)				✓
Guam Power Authority (GPA)				
Guam Homeland Security – Office of Civil Defense (GHS/OCD)		✓	✓	✓
Mariana Regional Fusion Center			✓	
Village Mayors and Vice Mayors			✓	
Department of Public Works (DPW)		✓	✓	
Guam Public Health & Social Services (DPHSS)		✓	✓	
Guam Memorial Hospital Authority (GMHA)		✓	✓	
Guam Environmental Protection Agency (EPA)		✓		✓
Guam Fire Department (GFD)		✓	✓	

Guam Police Department (GPD)		✓	✓	
Guam Telephone Authority (GTA)			✓	
Department of Education (DOE)		✓	✓	
Mayors' Council of Guam (MCOG)		✓	✓	
Guam Department of Administration/General Services Administration (GSA)			✓	
Guam Department of Agriculture (DOA)			✓	
Guam Housing and Urban Renewal Authority (GHURA)			✓	
Guam Economic Development Authority (GEDA)			✓	
Guam National Guard (GUNG)		✓	✓	

Electricity **Liquid Fuels** **Cyber & Physical Security** **Emergency Response**

Table 12: Descriptions of GovGuam Energy Security Roles and Responsibilities

Guam Department or Agency	Energy Security Roles and Responsibilities
Office of the Governor of Guam	Through executive orders, policy directives, or other authorities, the Governor determines priorities related to energy security initiatives on behalf of GovGuam and executes territory level strategies to bolster the energy security posture of Guam in coordination with public and private sector partners. In the event of a disaster, including an energy disruption of significance, the Governor is responsible for: • Declaring a disaster if the emergency exceeds local capabilities in accordance with G.C.A. section 65107. • Amending or suspending certain orders as appropriate to enable efficient response actions. • Communicating with the public in an accessible manner to help people, businesses, and organizations cope with consequences of the incident. • Requesting and coordinating federal assistance through the EOC ESF.
Legislature of Guam	The legislature provides legislative oversight over energy security roles and responsibilities across GovGuam, ensuring that stakeholders have appropriate authorities and resources to identify, assess, and mitigate risks to energy infrastructure and to prepare for, respond to, and recover from disruptive events.
Guam Energy Office (GEO)	GEO applies for and administers funding opportunities sponsored by the U.S. Department of Energy, or other agencies, that support the energy security initiatives of GovGuam.
Public Utility Commission (PUC)	The PUC provides regulatory oversight over GPA, ensuring that GPA has financial resources and authorities to identify, assess, and mitigate risks to energy infrastructure and to prepare for, respond to, and recover from disruptive events.
Consolidated Commission on Utilities (CCU)	The CCU provides operational oversight over GPA, ensuring that GPA leadership is focused on initiatives to strengthen the energy security posture of the utility.

Guam Department or Agency	Energy Security Roles and Responsibilities
Guam Power Authority (GPA)	GPA is the primary agency for emergency support function (ESF) 12, which encompasses energy services. GPA is responsible for monitoring energy markets, mutual assistance work, holding/ participating in staff training & exercises, engaging with stakeholders, updating the energy security plan, completing after-action reports, and undergoing continuous improvement efforts. In the event of a disruption leading to the activation of the EOC ESF Team, GPA coordinates response and recovery actions to restore energy services.
Guam Homeland Security – Office of Civil Defense (GHS/OCD)	As the primary agency for ESF-5 (emergency management) and ESF-2 (communications), GHS/OCD is responsible for coordinating and facilitating all government of Guam, military, and federal liaison response agencies and their resources in mitigating, preparing, responding, and recovering from all types of emergencies, including energy disruptions (inclusive of fuel shortages) in order to protect the lives, environment, and property of the island of Guam. As the primary agency for ESF-15 (External Affairs), GHS/OCD is responsible for assisting and/or coordinating public messaging efforts with GPA if the event includes impacts to the energy sector.
Mariana Regional Fusion Center (MRFC)	The MRFC coordinates the exchange of criminal intelligence, threats, and hazards, including energy specific information, through public safety partnerships to enhance regional communications among law enforcement, first responders, GovGuam, private sector and community partners.
Village Mayors and Vice Mayors	During times of crisis, including energy disruptions, Village Mayors and Vice Mayors serve as "Civil Defense Wardens," and their offices serve as command posts for their respective villages. They primarily become responsible for liaising between the EOC and their village on village needs, village resources, and the dissemination of public information.

Guam Department or Agency	Energy Security Roles and Responsibilities
Department of Public Works (DPW)	As the primary agency for ESF-1 (Transportation), DPW is responsible for coordinating the clearing or fixing of roads to support energy restoration efforts in the event of a disruption. As the primary agency for ESF-3 (Public Works and Engineering), DPW is responsible for coordinating resources to support emergency public works and engineering.
Guam Public Health & Social Services (DPHSS)	As one of the primary support organizations for ESF-8 (Public Health and Medical Services), DPHSS is responsible for coordinating with GMHA to identify medical care facilities and residences' vulnerability to power outages.
Guam Memorial Hospital Authority (GMHA)	As one of the primary support organizations for ESF-8 (Public Health and Medical Services), GMHA is responsible for coordinating with DPHSS to identify medical care facilities.
Guam Environmental Protection Agency (EPA)	As one of the primary agencies responsible for ESF-10 (Oil and Hazardous Material Response) Guam EPA is responsible for responding to incidents involving oil or other hazardous material (e.g., spills, fires, etc.) and coordinating its response with the Guam Fire Department (GFD).
Guam Fire Department (GFD)	As one of the primary agencies responsible for ESF-10 (Oil and Hazardous Material Response) GFD is responsible for responding to incidents involving oil or other hazardous material (e.g., spills, fires, etc.) and coordinating its response with Guam EPA. GFD is the primary agency responsible for ESF-4 (Firefighting) and ESF-9 (Search and Rescue) and is responsible for providing coordinated support to detect and suppress urban, rural and wildfires. GFD is also responsible for managing the deployment of resources in urban, non-urban, and water search and rescue in response to emergencies or disaster events.
Guam Police Department (GPD)	As the primary agency responsible for ESF-13 (Public Safety and Security), GPD is responsible for enforcing laws and responding to and investigating any incidents of vandalism, theft, or terrorism on energy infrastructure.

Guam Department or Agency	Energy Security Roles and Responsibilities
Incumbent Local Exchange Carrier / Guam Telephone Authority (GTA)	Along with GHS/OCD, the GTA is the primary agency for ESF-2 (Communications). The GTA is responsible for coordinating the execution of communications-related missions and operational activities.
Department of Education (DOE)	As one of the primary agencies for ESF-6 (Mass Care) DOE is responsible for coordinating with the Mayors' Council of Guam (MCOG) to protect evacuees and other disaster victims from the effects of the disaster.
Mayor's Council of Guam (MCOG)	As one of the primary agencies for ESF-6 (Mass Care) MCOG is responsible for coordinating with the DOE to protect evacuees and other disaster victims from the effects of the disaster.
Guam Department of Administration/General Services Administration (GSA)	As primary agency for ESF-7 (Resource Support) GSA is responsible for finding, obtaining, allocating, and distributing resources to satisfy needs that are generated during an emergency.
Guam Department of Agriculture (DOAg)	As primary agency for ESF-11 (Agriculture and Natural Resources) the DOAg is responsible for nutrition assistance, including the food stamp program.
Guam Housing and Urban Renewal Authority (GHURA)	As one of the primary agencies for ESF-14 (Long Term Community Recovery) GHURA is responsible for assisting the Government of Guam in transitioning from short-term and immediate recovery operations to long term recovery activities.
Guam Economic Development Authority(GEDA)	As one of the primary agencies for ESF-14 (Long Term Community Recovery) GEDA is responsible for assisting the Government of Guam in transitioning from short-term and immediate recovery operations to long term recovery activities.
Guam National Guard (GUNG)	As primary agency for ESF-16 (Military Support to Civil Authorities) GUNG is responsible for supporting the Government of Guam in response to natural or man-made disasters, chemical, biological, radiological, nuclear, and explosive threats, and terrorist threats or incidents in order to protect life and property, and shall assist the Government of Guam in restoration of essential government operations.

5.2 Federal Authorities

On behalf of the federal government, the U.S. DOE is the lead agency for ESF-12 (Energy), as well as the Sector Risk Management Agency (SRMA) and the Sector Specific Agency (SSA) for the energy sector. The Office of Cybersecurity, Energy Security, and Emergency Response (CESER) manages DOE's SRMA and ESF-12 responsibilities. During events requiring a federal response, CESER activates its Energy Response Organization to manage response activities, including deploying ESF-12 responders, sharing situational awareness products, and coordinating with and providing technical assistance to federal partners; state, local, tribal, and territorial (SLTT) authorities; and industry partners.

The following tables provide an overview of the many federal departments and agencies that play a role in energy security. Many of these agencies have roles and responsibilities that extend beyond the energy sector. Each agency's energy-related activities have been categorized as applying to electricity, liquid fuels, or natural gas. Agencies that safeguard the cyber- and physical security of energy infrastructure are also indicated.

Agencies' energy security activities may involve:

- **Energy emergency preparedness and response**, including hosting and participating in preparedness planning and exercises and deploying responders or resources during an emergency event.
- **Information sharing and situational awareness,** including publishing data and threat information and issuing situation reports during emergency events.
- **Development and enforcement of standards and regulations** for energy industry safety and security. During emergency events some of these standards and regulations may be waived to facilitate faster response and restoration.

Table 13: Federal Roles and Responsibilities

Department or Agency		Sector	Preparedness & Response	Situational Awareness	Standards & Regulations
White House		Electricity, Liquid Fuel, Natural Gas, Cyber and physical security	✓	✓	
DHS	FEMA	Electricity, Liquid Fuel, Natural Gas	✓	✓	
	CISA	Cyber and physical security	✓	✓	
	Coast Guard	Liquid Fuel, Natural Gas	✓		✓
	TSA	Liquid Fuel, Natural Gas, Cyber and physical security	✓		✓
	CBP	Electricity, Liquid Fuel, Natural Gas			✓
DOE	CESER	Electricity, Liquid Fuel, Natural Gas, Cyber and physical security	✓	✓	
	OE	Electricity		✓	✓
	EIA	Electricity, Liquid Fuel, Natural Gas		✓	
	FERC	Electricity, Liquid Fuel, Natural Gas			✓
DOT	FMCSA	Electricity, Liquid Fuel			✓
	PHMSA	Liquid Fuel, Natural Gas	✓		✓
EPA		Electricity, Liquid Fuel, Natural Gas			✓
IRS		Liquid Fuel			✓
DOD	USACE	Electricity, Liquid Fuel, Natural Gas	✓		✓
NRC		Electricity	✓	✓	✓
DOJ	FBI	Cyber and physical security	✓		
DOI	DOI BSEE	Liquid Fuel, Natural Gas		✓	✓

Electricity | Liquid Fuel | Natural Gas | Cyber and physical security

Table 14: Descriptions of Federal Roles and Responsibilities

Federal Department or Agency		Energy Security/Emergency Response Role
White House		The White House—particularly the National Security Council—participates in public briefings and interagency situational awareness activities. The President also has the authority to declare a national state of emergency.
Department of Homeland Security (DHS)	Federal Emergency Management Agency (FEMA)	FEMA coordinates federal incident response and recovery activities. FEMA's duties during an event include assisting the President in carrying out the Stafford Act, operating the National Response Coordination Center (NRCC), supporting all Emergency Support Functions (ESFs) and Recovery Support Functions (RSFs). The FEMA mission assigns the Defense Logistics Agency (DLA) to provide fuel support to federal responders and, if requested, SLTT responders and critical infrastructure. FEMA funds Public Assistance (PA) disaster funds, hazard mitigation projects through the Building Resilient Infrastructure and Communities (BRIC) Program, Hazard Mitigation Grant Program (HMGP), and others.
	Cybersecurity and Infrastructure Agency (CISA)	CISA leads the national effort to understand, manage, and reduce risk to cyber and physical infrastructure. CISA manages the Pipeline Cybersecurity Initiative, leveraging expertise from government and private partners to identify and address cybersecurity risks to pipeline infrastructure. CISA publishes best practices for cybersecurity protection. During a cyber incident, CISA assists impacted infrastructure, helps investigate the responsible actors, and coordinates the national response to significant cyber events.
	U.S. Coast Guard	The U.S. Coast Guard is the principal federal agency responsible for maritime safety, security, and environmental stewardship in U.S. ports and inland waterways used for the movement of energy products, including petroleum, natural gas, and coal. The Coast Guard reviews and approves security assessments and security plans developed by vessel owners and terminal operators, and inspects terminals for compliance with security requirements. The Coast Guard's role is particularly important during hurricanes and other severe weather that can disrupt energy supplies (primarily liquid fuels) into and out of U.S. ports.

Federal Department or Agency		Energy Security/Emergency Response Role
	Transportation Security Administration (TSA)	TSA oversees the physical security and cybersecurity of all U.S. pipelines. TSA issues directives for owners and operators of pipelines to better secure pipelines against cyberattacks. TSA also oversees security at marine ports, where oil and gas marine terminals, petroleum refineries, and other energy infrastructure may be located. TSA conducts background checks and issues federal identification cards (called TWIC® cards) to workers accessing secure areas within port boundaries, including fuel truck drivers, refinery workers, and other energy industry workers. TSA may waive TWIC requirements during energy emergencies to facilitate energy restoration and response activities.
	U.S. Customs & Border Protection (CBP)	CBP is the primary federal agency tasked with ensuring the security of the nation's borders. CBP is responsible for enforcing and administering laws and regulations to control and oversee vessel movements in to, out of, and between U.S. ports. CBP enforces the Merchant Marine Act of 1920, also called the Jones Act, which generally prohibits the transportation of merchandise between two U.S. ports in any vessel not built in, documented under the laws of, and owned by citizens of the United States. Applications may be made to CBP for the Secretary of Homeland Security to grant a Jones Act waiver, which can help facilitate the delivery of fuel and equipment during energy shortages.
U.S. Department of Energy	Office of Cybersecurity, Energy Security, and Emergency Response (CESER)	CESER's mission is to enhance the security of U.S. critical energy infrastructure to all hazards, mitigate the impacts of disruptive events and risk to the sector overall through preparedness and innovation, and respond to and facilitate recovery from energy disruptions in collaboration with other federal agencies, the private sector, and State, local, tribal, and territory governments. CESER's preparedness and response activities include SLTT capacity building, energy security and resilience planning, hosting energy emergency exercises and deploying ESF-12 responders to impacted regions during emergencies. CESER facilitates interagency coordination, shares situational awareness products, and provides emergency response support to SLTT governments. CESER also advances research, development, and deployment of technologies, tools, and techniques to reduce risks to the Nation's critical energy infrastructure posed by cyber and other emerging threats.

Federal Department or Agency		Energy Security/Emergency Response Role
		CESER administers programs that can be used to mitigate impacts to energy infrastructure and energy supply, and to provide resources during energy emergencies: • The Federal Power Act Section 202(c) grants DOE the power to temporarily order connections of facilities, and generation, delivery, interchange, or transmission of electricity during grid emergencies. • The Strategic Petroleum Reserve is a federally owned emergency supply of crude oil. Volumes can be released to mitigate the impact of crude supply disruptions. • The Northeast Home Heating Oil Reserve and Northeast Gasoline Supply Reserve provide emergency supplies of heating oil and gasoline, respectively.
	Office of Electricity (OE)	OE provides national leadership to ensure that the Nation's energy delivery system is secure, resilient and reliable. Through research and development, OE develops new technologies to improve electric infrastructure. OE also oversees the Federal and state electricity policies and programs that shape electricity system planning and market operations.
	Office of Enterprise Assessments	The Office of Enterprise Assessments oversees four federal Power Marketing Administrations (PMAs) - Bonneville Power Administration (BPA), Southeastern Power Administration (SEPA), Southwestern Power Administration (SWPA) and Western Area Power Administration (WAPA) – that operate electric systems and sell the electrical output of federally owned and operated hydroelectric dams in 34 states.
	U.S. Energy Information Administration (EIA)	EIA collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment. EIA's data can be used in energy security planning and energy emergency response activities. EIA publishes state energy profiles, data products related to energy supply, demand, infrastructure, and prices, as well as GIS maps.
	Federal Energy Regulatory Commission (FERC)	FERC is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC's role includes oversight of the transmission and wholesale sale of electricity in interstate commerce, transportation of oil by pipeline in interstate commerce, and proposals to build liquefied natural gas (LNG) terminals and interstate natural gas pipelines as well as licensing hydropower projects. During energy emergencies, FERC also has emergency authority under the Interstate Commerce Act to direct companies to provide

Federal Department or Agency		Energy Security/Emergency Response Role
		preference or priority in transportation, embargoes, or movement of traffic. This authority can be used to direct interstate pipeline operators to prioritize shipments of specific fuels to address shortages.
U.S. Department of Transportation	Federal Motor Carrier Safety Administration (FMCSA)	FMCSA sets safety requirements for interstate commercial drivers, such as hours of service requirements limiting how long drivers can be on the road before a mandatory break. During energy shortages, FMCSA can waive these requirements to facilitate the delivery of specific energy products, most often liquid fuels, or to facilitate the movement of utility crews, trucks, and other resources involved in the restoration of electric power.
	Pipeline and Hazardous Materials Safety Administration (PHMSA)	PHMSA regulates pipelines and rail tank cars to advance the safe transportation of petroleum, natural gas, and other hazardous materials. The agency establishes national policy, sets and enforces standards, educates, and conducts research to prevent incidents. The agency also prepares the public and first responders to reduce consequences if an incident does occur. During pipeline incidents (explosions or spills), PHMSA investigates and issues corrective action orders to pipeline operators before pipeline service can resume. During energy shortages, PHMSA can issue emergency special permits and waivers of certain regulations to facilitate the pipeline supply of fuel to the affected region. PHMSA also regulates rail tank cars that carry petroleum, biofuels, or liquefied natural gas.
U.S. Environmental Protection Agency (USEPA)		USEPA sets standards for certain fuels, including regulating the vapor pressure of gasoline, requiring reformulated gasoline in certain markets, and specifying the sulfur content in diesel fuel. These fuel specifications can be waived during emergencies to facilitate the supply of fuel into the affected region, or to provide fungibility of available supply within the affected region. USEPA also regulates air emissions from energy infrastructure, including power generating facilities and fuel storage terminals. During disaster events, USEPA may choose not to enforce these regulations to facilitate power supply and fuel supply in the affected region.
Internal Revenue Service (IRS)		IRS collects federal motor taxes on diesel fuel used for on-highway transportation. Diesel used for off-highway purposes (heavy machinery, generators, farm equipment, etc.) is not subject to tax and is dyed red. In coordination with USEPA, the IRS can choose to not collect the penalty typically imposed on using non-highway diesel in on-road vehicles (although the IRS still collects tax on this fuel).

Federal Department or Agency		Energy Security/Emergency Response Role
Department of Defense (DOD)	U.S. Army Corps of Engineers (USACE)	USACE assists FEMA during disaster response, including installing generators and delivering generator fuels in communities through its Temporary Emergency Power Mission and sending responders to assist in disasters and provide situational awareness.
U.S. Nuclear Regulatory Commission (NRC)		The NRC is involved in emergency preparedness and response involving nuclear facilities or materials. The NRC also publishes a daily status report on all nuclear power reactors.
U.S. Department of Justice (DOJ)	Federal Bureau of Investigation (FBI)	The FBI leads investigations into cyber attacks and intrusions. The FBI collects and shares intelligence and engages with victims while working to unmask those committing malicious cyber activities.
U.S. Department of the Interior (DOI)	Bureau of Safety and Environmental Enforcement (BSEE)	BSEE has responsibility for the safety of the environment and conservation of offshore resources. BSEE administers the Oil Spill Preparedness Program and provides support for oil spill response efforts. During hurricanes and other inclement weather in the Gulf of Mexico, BSEE publishes data on the offshore oil and gas rigs that have been evacuated, as well as the amount of production that has been temporarily shut in. BSEE also leads the development of workplace safety and environmental compliance strategies for offshore renewable energy projects on the Federal Outer Continental Shelf.

Other Federal Information Resources:

Resource: CESER Energy Waivers Library

CESER's Energy Waivers Library provides additional detail on regulatory relief granted by federal agencies during energy disruptions. The library also lists contact information for each agency and provides examples of past uses of each waiver.

Resource: CESER Roles and Authorities

CESER's Roles and Authorities webpage outlines the various executive branch and DOE authorities that establish CESER's role in securing the Nations' energy infrastructure, maintaining situational awareness, discovering and mitigating cyber threats, and orchestrating response and recovery operations.

Resource: Power Outage Incident Annex (2017)

For more detailed descriptions of federal agency roles during a long-term power outage, refer to **Table 10: Roles and Responsibilities in a Long-Term Power Outage Incident** in FEMA's Power Outage Incident Annex (2017).

Resource: National Incident Management System (2017)
FEMA's National Incident Management System (NIMS) provides a consistent nationwide template that guides all levels of government, nongovernmental organizations and the private sector through the command and coordination of incidents, resource management, and information management. This framework is applicable to emergency responders and other emergency management personnel, NGOs, the private sector, and elected and appointed officials responsible for making decisions regarding incidents.

6. Energy Security Planning and Preparedness[91]

This section documents planning and preparedness roles and responsibilities and describes regional coordination efforts with other territories, foreign nations that freely associate with the U.S., and broader U.S. networks based on CONUS.

6.1 ESF-12 Planning and Preparedness Responsibilities

As the lead Guam ESF-12 agency, GPA leads energy security planning and preparedness efforts on behalf of GovGuam by regularly coordinating with GEO and GHS/OCD. Planning and preparedness efforts include monitoring energy markets, mutual assistance work, staff training & exercises, engaging with stakeholders, updating the GESP as necessary, completing after-action reports following disruptions, and undergoing continuous improvement.

6.2 Emergency Management Assistance Compact (EMAC)

EMAC has been ratified by U.S. Congress (PL 104-321) and is law in all 50 states, the District of Columbia, Puerto Rico, Guam, the U.S. Virgin Islands, and the Northern Mariana Islands. EMAC is administered by the National Association of Emergency Managers (NEMA), and serves as a platform for mutual assistance between states and territories during any emergency or disaster when the territory has depleted its resources, supplies, or equipment. Members can share resources from all disciplines, protect personnel who deploy, and be reimbursed for mission-related costs.[92]

In the event a request for disaster assistance comes from another state, the Governor of Guam may order the mobilization of Government of Guam resources under EMAC to be deployed to the impacted jurisdiction. Similarly, Guam can request and receive assistance from other states through EMAC. The management and coordination of these resources will be administered through the Operations Section of the EOC ESF Team under the direction of the Operations Section Chief.[93]

6.3 State Energy Emergency Assurance Coordinators (EEAC) Program

The Energy Emergency Assurance Coordinators (EEAC) Program is a cooperative effort between the U.S. DOE CESER, the National Association of State Energy Officials (NASEO), the National Association of Regulatory Utility Commissioners (NARUC), the National Governors Association (NGA), and NEMA.

The EEAC Program provides U.S. states and territories with a means of sharing and receiving credible, accurate, and timely information with other states/territories and DOE leading up to and during energy emergencies. Structured communications are essential for understanding the severity, magnitude, and consequences of energy disruptions regardless of the causes.

EEACs serve as points of contact for U.S. DOE in the event of an emergency. Membership is made up of representatives from state energy offices, public utility commissions, state ESF-12 responders, emergency management agencies, homeland security agencies, local governments, and governors' offices. Additional guidance can be found here.

GovGuam has designated a primary and secondary EEAC contact, who have planning and/or response roles during energy emergencies. These individuals are registered on ISERNet, which is an online web-based platform hosted by U.S. DOE CESER.

ISERNet EEAC Designation	Contact	Role
Primary	John Cruz, Guam Power Authority m. 671.483.9557 email: jcruz@gpagwa.com	Assistant General Manager for Engineering and Technical Services / ESF-12 for GovGuam
Secondary		

U.S. DOE leverages the EEAC network to communicate important notices, such as situation reports and outage estimate reports. DOE distributes TLP:AMBER information (situational awareness/analysis, alerts, etc.) to EEAC email listservs leading up to and during energy emergencies. For example, during the COVID-19 pandemic, CESER disseminated weekly COVID-19 situation reports to all states in addition to situation reports for emergency events like Hurricane Laura. States/territories can also share information with other states or directly with DOE.

6.4 Mutual Assistance Agreements – Physical

Because Guam is an island located in the western Pacific Ocean nearly 6,000 miles from the continental US, mutual assistance opportunities to restore energy services following a disruptive event are more limited compared to utilities operating within the continental US. Despite limitations, GPA has established and maintains six memorandums of understanding (MOUs) with utilities on nearby islands and the American Public Power Association (APPA) to physically restore power following natural catastrophes or other occurrences. Because GPA is accustomed to severe weather events (particularly high winds) causing outages and mutual aid becoming necessary, GPA maintains a fleet of extra utility repair trucks for mutual aid crews to utilize on island. In rare circumstances, utility repair trucks and equipment can be transported to Guam to support restoration activities.

MOUs exist between the following islands and utilities:

- Commonwealth of the Northern Marina Islands (CNMI)
  - Commonwealth Utilities Corporation (CUC)
- Federated States of Micronesia (FSM)
  - Chuuk Public Utility Corporation
  - Kosrae Utilities Authority (KUA)
  - Pohnpei Utilities Corporation
  - Yap State Public Service Corporation
- Palau
  - Palau Public Utilities Corporation
- American Public Power Association

Common practice used throughout these MOUs include a purpose for the agreements, procedures for requesting assistance, and terms for payment of services rendered. Agreements are administered in good faith and each participating utility agrees to not hold the other liable for any potential harm caused during the execution of the assistance agreement, except in cases of negligence or misconduct.

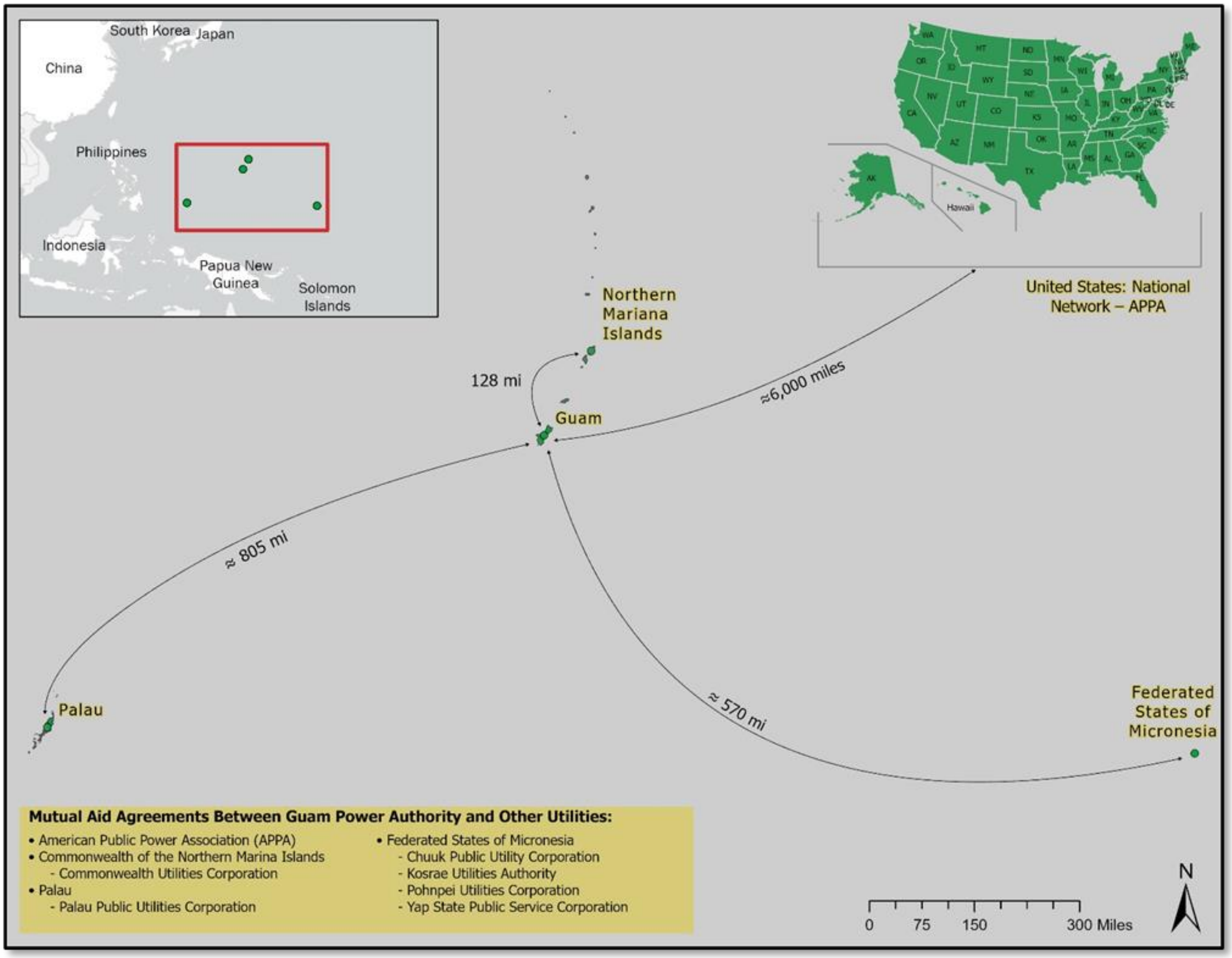


Figure 12: Mutual Aid Agreements between GPA and Other Utilities

Mutual Aid Example

Following Typhoon Mawar in May/June 2023, GPA executed many mutual aid agreements and hosted utility crew members from various neighboring islands and even the Public Utility District from Snohomish County, Washington. Crews from nearby islands flew into Guam and utilized extra GPA equipment to support restoration efforts, and the crew from Snohomish County, Washington transported their own trucks and equipment across the Pacific to support restoration efforts using the world's largest cargo plane (APPA Story).

6.5 Mutual Assistance Agreements – Cyber

To effectively capitalize on the pool of cybersecurity professionals within Guam, the Guam Power Authority (GPA) and Guam Waterworks Authority (GWA) share information technology and cybersecurity personnel to manage daily operations of networks and control centers of critical energy services. In case a cybersecurity incident occurs that requires skill sets or manpower beyond GPA and GWA's capabilities to address it, GPA can call upon industry experts to assist through the Electric Subsector Coordinating Council's (ESCC) Cyber Mutual Assistance (CMA) Program for assistance. "The CMA Program is an industry framework developed at the direction of the ESCC to provide emergency cyber assistance within the electric power and natural gas industries. The CMA Program is composed of industry cyber experts who can provide voluntary assistance to other participating entities in advance of, or in the event of, a disruption of electric or natural gas service, computer systems, and/or IT infrastructure due to a cyber emergency."[94]

Beyond the electricity subsector, GovGuam will encourage other critical infrastructure sectors to participate in cyber mutual assistance programs as appropriate, including the Port Authority of Guam and liquid fuel distribution companies.

7. Energy Emergency Response

7.1 Response Cycle Overview

Emergency management is a continuous cycle of Preparedness → Response → Recovery → Mitigation. This section focuses on the Response part of the cycle. Responding to energy emergencies involves an iterative process of gathering information, assessing the actual or potential consequences of the incident, and taking action to share critical information, facilitate system restoration, and mitigate impacts to dependent lifeline sectors and consumers. This process is repeated over the course of an emergency with response actions adapting to changing conditions as the situation evolves.[95]

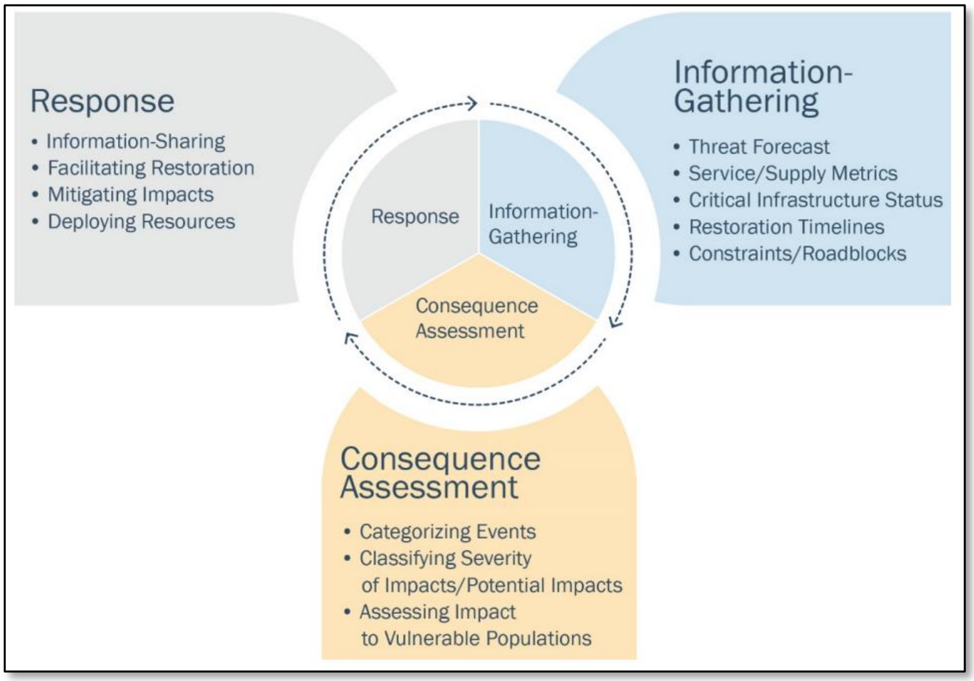


Figure 13: Response Cycle

The primary agency responsible for energy emergency response in Guam is GPA. In accordance with the Guam Comprehensive Emergency Management Plan,[96] GPA is the lead agency implementing actions under ESF-12. Support agencies include GHS/OCD; Department of Administration, General Services Administration (GSA); Guam National Guard (GUNG); Department of Public Works (DPW); and Guam Waterworks Authority (GWA).

For the liquid fuel industry in Guam, the industry works with Territorial and Federal government agencies to assess and respond to emergencies as appropriate. According to the Oil and Natural Gas Industry Preparedness Handbook, there is extensive communication between government and industry representatives throughout an emergency.[97] Through the mechanisms of ESF-12, and specifically through coordination with GHS/OCD, Guam agencies and the oil industry work together to address emergency situations.

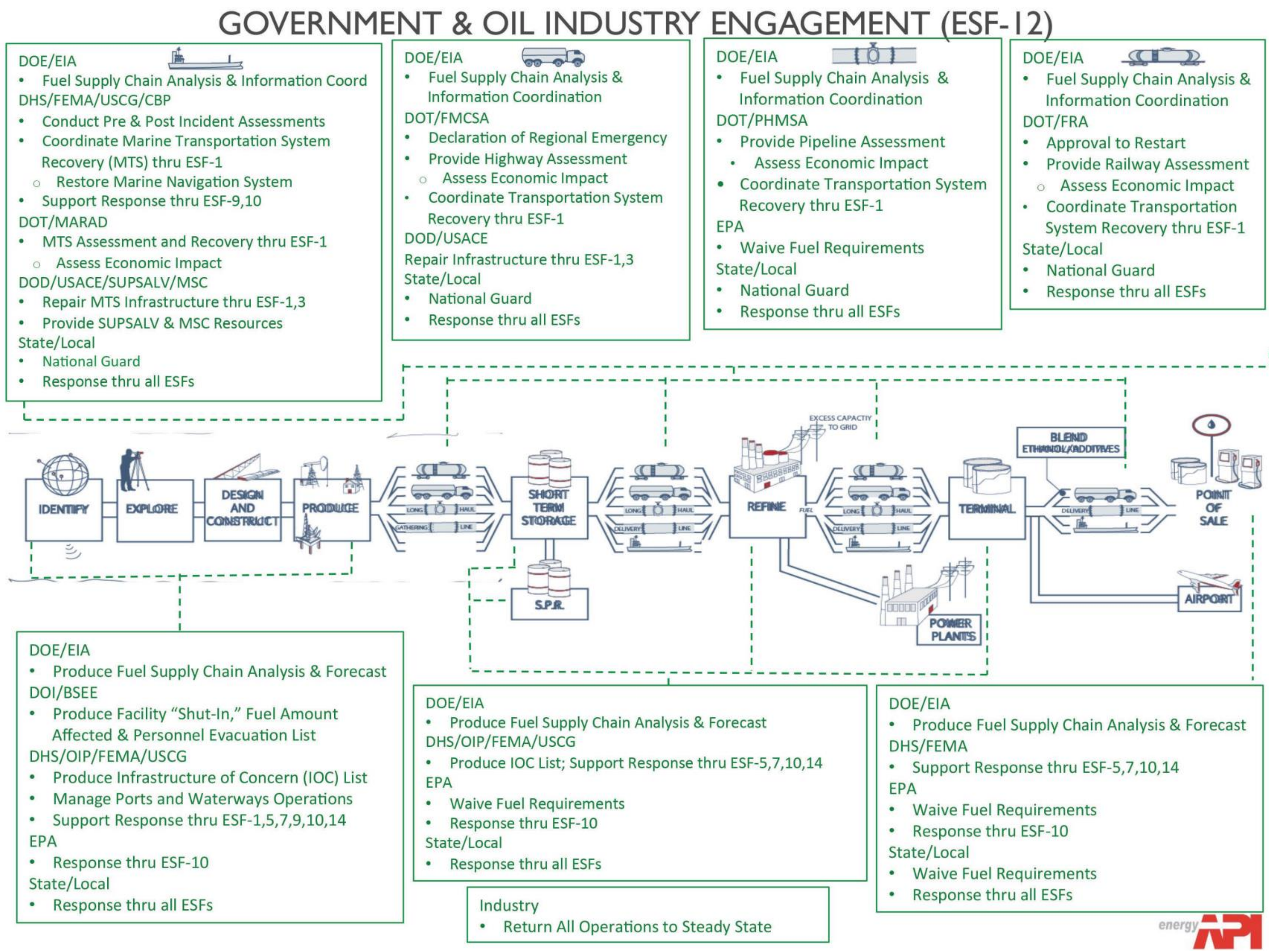


Figure 14: Government and Oil Industry Engagement

7.2 Information Gathering/Situational Awareness

The initial step in responding to emergencies is to collect timely, precise, and useful data regarding potential threats and their effects on energy systems and services. This data is essential for gaining a clear understanding of the situation, which, in turn, informs the next phases of the response process, including assessing consequences and deciding on response actions. The table below outlines the available resources for situational awareness categorized by energy type and the corresponding information they provide.

Table 15: Situational Awareness Tools

Key: Data type

Geospatial	Inventory	Production/ Generation	Transport/ Transmission/ Distribution	Consumer Outages	Pricing

Tool	Power	Liquid Fuels	Natural Gas
	U.S. Department of Energy (DOE) Tools		
DOE Emergency Situation Reports	Customer outages and summaries of electric system damage and estimate restoration timelines. Level of resources committed for restoration	Refinery status, capacity, and output, petroleum terminal status, regional product inventories, offshore crude oil production impacts	Natural gas pipeline status, gas utility customer outages, onshore and offshore natural gas production impacts
DOE Estimated Customer Power Outages	Predicted customer outages based on strength and track of hurricane or major storms	Identification of critical petroleum infrastructure that may be impacted by storms or power outages	Predicted degree to which electrically powered compressors, if used, may be affected by storms or power outages

Tool	Power	Liquid Fuels	Natural Gas
U.S. Energy Information Administration (EIA) Tools			
EIA Energy Atlas	Electricity infrastructure: power plants, substations, transmission lines, electric retail service territories	Liquid fuels infrastructure: oil wells, platforms, pipelines, biofuel plants, terminals, refineries (locations and capacities)	Natural gas infrastructure: gas wells and platforms, pipelines, natural gas processing plants, underground storage
EIA Hourly Grid Monitor	Hourly electricity generation by fuel type, interchange, and day-ahead demand forecasts	Hourly oil-fired generation	Hourly natural gas-fired generation
EIA Weekly Petroleum Status Report	-	Weekly supply, demand, inventory, and import data	-
EIA Winter Heating Fuels	Electric generation and prices	Propane and heating oil inventories and prices	Natural gas inventories and gas prices
EIA SHOPP	-	State weekly residential heating oil and propane prices	-
EIA Natural Gas Storage Dashboard	-	-	Evaluate natural gas storage activity, consumption by sector, exports, and prices
EIA Daily Prices	Daily electricity prices	Daily crude, gasoline, diesel, and propane prices	Daily natural gas spot prices
Other Government Agency Tools			
U.S. Coast Guard Homeport	-	Operational status of ports that import/export oil	Operational status of ports that import/export liquified natural gas (LNG)
NPMS PIMMA	-	Crude oil and petroleum product pipeline locations	Natural gas pipeline and LNG plant locations
BSEE Activity Statistics Update	-	Oil production shut-in and rig activity	Natural gas production shut-in and rig activity
HHS emPOWER Map	Locations of electricity-dependent individuals with medical needs	-	-

Tool	Power	Liquid Fuels	Natural Gas
	Industry/Public Tools		
Company Websites/ Social Media	Estimated restoration timelines	Updates on infrastructure status, usually via press releases	Critical notices on natural gas company websites, daily gas flows to delivery points
Trade Press	Customer outages for small utilities and estimated restoration times	Refinery, pipeline, and terminals status updates	Natural gas pipeline and LNG terminal status updates

Apart from the aforementioned tools, GPA and GEO should also gather information from all possible sources before and during energy emergencies. Potential information sources include industry associates, industry trade associations, fellow state agencies, the federal government, and energy offices in different states. The Energy Emergency Assurance Coordinators Program (referenced in Section 6.3) serves as a key resource for state contacts and is accessible through ISERnet. It is advisable to establish and nurture these contacts well in advance of any emergency situations. Through such outreach efforts, GPA and GEO can gain insights into energy infrastructure and market consequences that may not be accessible through monitoring tools.

GPA's situational awareness procedures are outlined in Standard Operating Procedure (SOP) 049, Storm Preparedness, Operational Response, and Power Restoration.[98] The GPA's Communications Office is the liaison to the Joint Information Center (JIC) for information regarding Authority pre- and post-storm activities until deactivated by the Office of Homeland Security/Civil Defense. The Communications Office will ensure information to be released is approved by the General Manager and issued to Response Activities Coordinators (RACs) and all GPA representatives manning various call centers prior to the general media release.

Each Division Manager will report on availability of critical essential personnel, radios, vehicles, tools, and critical equipment necessary for pre-storm preparation and post-storm restoration operations. The General Manager may request from any Division Manager any of these items he deems necessary to accomplish restoration efforts. The Assistant General Manager of Operations (AGMO) will update the General Manager daily on the status/progress of pre-storm preparation and post-storm restoration activities.

7.3 Event Consequence Assessment

Throughout an energy emergency, Territorial officials responsible for energy and emergency response should continuously assess the consequences to determine the scale, duration, and geographical scope of the necessary response measures. This assessment involves the examination of both quantitative and qualitative data collected during the information-gathering and situational awareness phase.

The evaluation of consequences during the response phase builds upon activities conducted before the event, often referred to as "blue sky" day baselining activities. These baseline activities encompass the development of state energy profiles, which identify crucial energy infrastructure, standard energy supply and demand levels, and a comprehensive understanding of typical market dynamics, energy pricing, and other metrics used as reference points during emergency incidents.

Key factors to consider during the consequence assessment include, but are not limited to:

- Evaluating threat information, including an analysis of how various types of threats affect energy systems.
- Assessing the effects on energy consumers, such as power outages for customers and disruptions in retail gas stations. This assessment should include estimates of these impacts' magnitude and predictions of the disruption durations, i.e., the restoration timelines.
- Examining the consequences for lifeline sectors, such as safety and security, health and medical services, and transportation. These sectors are essential community services that enable the functioning of society, often having interdependencies between them. Restoring energy to lifeline

sectors is typically prioritized during the response phase to facilitate broader energy restoration and stabilize community services.

- Considering the impacts on vulnerable populations who are disproportionately affected by energy disruptions. Vulnerable communities may require additional support in navigating energy emergencies, including extra resources like backup generators and heating/cooling centers, along with targeted outreach efforts.
- Assessing the consequences on critical energy delivery systems, such as critical power plants, pipelines, and refineries. This assessment should also consider the impacts on supply chains and the availability of alternative supply options.
- Analyzing the impacts on energy markets, which include aspects like bulk fuel stocks and electric balancing authority reserve margins. This assessment should also encompass the effects on energy prices.

For power outage consequence assessment specifically, as noted in GPA's SOP 049,[99] the Engineering Division will be responsible for conducting a post-typhoon island-wide assessment of all damages and an assessment of GPA facilities except for Generation facilities.

The Generation Division will be responsible for the damage assessments and cost estimates for all generation facilities. This includes an assessment of all power plant structures, fuel oil pipelines, storage tanks, and the bulk storage fuel farm facility. The Engineering Division will be the central compiler of all damage assessment cost data, including damage estimates provided by the Generation Division of all generation facilities. The Engineering Division will submit the damage assessment report and estimate to the General Manager (GM), AGMO, and Chief Financial Officer (CFO).

Shortages of liquid fuels, including gasoline, distillate fuel oil, jet fuel, and propane, can arise from sudden increases in fuel demand or significant disruptions in the fuel supply chain. Demand-induced shortages can occur, for example, when demand for gasoline surges during pre-hurricane evacuations or for heating fuels like distillate fuel oil and propane during extended cold weather periods. On the other hand, supply-related shortages can result from disruptions in crude oil production, oil refining, or the transportation and distribution of refined fuels. In many cases, severe shortages are a combination of both demand and supply factors. Fuel shortages and accessibility problems may also emerge during prolonged power outages when fuel infrastructure that relies on electricity, such as terminals, pumps, and refineries, becomes inoperative. Simultaneously, there may be a sudden spike in fuel demand for backup generators and emergency response vehicles. Since liquid fuel is stored at various points in the supply chain, from bulk terminals to individual vehicle tanks, it typically takes several days for disruptions in the supply chain to lead to widespread shortages among end users. However, panic buying can accelerate the impact of these disruptions.

7.4 Response Actions

For power emergencies, according to the Guam Comprehensive Emergency Management Plan Emergency Support Function Annex,[100] GPA has outlined a comprehensive set of actions to be taken in response to emergencies. These actions encompass various aspects of emergency management and coordination:

1. GPA will activate notifications promptly to ensure effective communication during emergency situations.

2. Adequate personnel will be assigned and scheduled to cover the Emergency Operations Center (EOC) for an extended period, ensuring continuous support.
3. The agency will regularly review the emergency contact listings of support agencies, whether automated or manual, as necessary.
4. GPA will establish and maintain contact with federal ESF-12 following established procedures.
5. Comprehensive records of work schedules and costs incurred by ESF-12 agencies and organizations during the event will be maintained.
6. Probability and timeframes for the recovery phase of the event will be evaluated, and pre-planning for recovery actions will commence if deemed probable.
7. Response information will be generated in a timely manner, including essential elements of information (EEI) such as the status of operations, obstacles, unmet needs, and internal damage assessments conducted by ESF-12 agencies. Additionally, GPA will track power outages, restoration status, and the use of emergency generators at key facilities.
8. GPA will coordinate various activities with Guam Homeland Security/Office of Civil Defense (GHS/OCD), FEMA Logistics, and other ESFs, including assessing the status of emergency generators, determining power generation needs, and coordinating the availability and transportation of generators.
9. Participation in the Power Restoration Task Force (PRTF) activities will be based on the situation's demands, including assessing off-island power restoration capabilities, sourcing transportation assets, mobilizing generator assets, and coordinating damage assessments.
10. GPA will assist and monitor the deployment of utility repair personnel and equipment to restore the power transmission system for the Island Wide Power System (IWPS), prioritizing restoration efforts based on protocols.
11. The agency will provide assistance and coordination to sustain federal and off-island personnel and equipment supporting ESF-12's mission throughout their deployment.
12. GPA will support refueling operations during the response and recovery phases for all power, water, and debris clearance emergency generators and vehicles.
13. Post-event, in collaboration with federal ESF-7 and the EOC ESF Team, ESF-12 will adjust the Fuel Prioritization Plan, determine viable commercial fuel stations, and execute necessary agreements to procure fuel.
14. As requested by the EOC, GPA will participate in Preliminary Damage Assessment (PDA) teams to survey incident or disaster impacts and report findings for further action.
15. Coordination with the Tourist Planning Task Force (TPTF) will ensure refueling support for generators at hotels and resorts during sheltering or evacuation operations.

These actions demonstrate the comprehensive and coordinated approach of the Guam Power Authority in responding to emergencies and ensuring the continuity of critical services.

7.5 Response Action Matrices

According to the U.S. DOE's Response Playbook for States and Territories,[101] various energy sector stakeholders must take action throughout the course of an energy emergency to 1) facilitate the restoration of energy systems and 2) to mitigate the impact of energy disruptions to critical infrastructure, essential services, and vulnerable populations. As part of this response, representatives from GPA, GEO, GHS/OCD, and others may be activated to staff the Guam EOC during Tier 2 and Tier 3 events. This section outlines possible energy emergency response actions of various territory and private sector actors. These actions are categorized by:

- Event Type: Power outages and liquid fuel shortages.
- Actors Include: GPA, GEO, GHS/OCD, industry partners, and other territorial agencies
- Event Consequence:
  - Tier 3 | Minor/Moderate Event = Routine or moderately disruptive event impacting energy services for hours to days.
  - Tier 2 | Significant Event = Highly disruptive event impacting energy services for days to weeks.
  - Tier 1 | Major Event = Catastrophically disruptive event impacting energy services for weeks to months.
- Time-Phase of the Event
  - Pre-Event: The hours or days immediately preceding an anticipated event, such as a hurricane, when stakeholders may have the ability to mobilize and prepare for eventual response action. Some "no-notice" events, such as a sudden infrastructure failure or adversarial attacks, will not have a pre-event component.
  - Response/Restoration: This period begins when impacts from the event (e.g., outage, shortage) are first felt until the time all impacts have been resolved.

The matrices on the following pages provide possible response options —categorized by time-phase and consequence tier—for each event type and actor. Note: the activities in each tier build on each other, so the response actions during a Tier 3 event would also be taken during Tier 2 and Tier 1 events.

Tier 3 | Minor to Moderate Event

- Routine or moderately disruptive event impacting energy services for hours to days.

Tier 2 | Significant Event

- Highly disruptive event impacting energy services for days to weeks.

Tier 1 | Major Event

- Catastrophically disruptive event impacting energy services for weeks to months.

Power Outages

Leading Agency: Guam Power Authority

Tier	Pre-Event	Response
Tier 3 Minor / Moderate Event	• Situational Awareness and Information-Sharing: Monitor threat forecasts and predictive outage modeling. • Public Messaging: Begin public messaging about the anticipated event and the possibility of outages. • Resource Management: Conduct inventory of resources available for response.	• Situational Awareness and Information-Sharing: Leverage monitoring tools and stakeholder contacts to gather information on outage impacts and duration. • Public Messaging: Develop, publish, and update outage maps and estimated times of restoration. • Resource Management: Assess staffing capabilities and resource adequacy of state to respond to the event. • Restoration: Restore customers according to set prioritization method
Tier 2 Significant Event	Same as Tier 3, plus • Situational Awareness and Information-Sharing: Participate in internal and external situational awareness activities (e.g., regional calls, federal calls, briefing state leadership, etc.). Communicate with Guam ESF-12 partners. • Public Messaging: Begin public messaging about safety protocols to prepare the public. • Resource Management: Stage equipment near predicted outage areas. Begin coordinating with mutual aid partners. Prepare for Guam EOC activation.	Same as Tier 3, plus • Situational Awareness and Information-Sharing: Develop situation reports and share with stakeholders, including information on the extent and duration of power outages. • Public Messaging: During an electricity shortage, utilities may request voluntary electricity conservation from customers. Hold a press conference with GovGuam officials. • Regulatory Relief: Governor may consider declaring a state of emergency. • Resource Management: Activate the Guam EOC. Activate mutual aid if necessary. Coordinate with industry and territorial partners to address access issues, including prioritizing road clearing for power restoration, emergency shelters, etc.
Tier 1 Major Event	Same as Tier 2 & 3, plus • Resource Management: Proactively communicate anticipated needs for federal support (e.g., personnel, resources, etc.) to federal ESF-12 • Resource Management: Leverage Emergency Management Assistance Company (EMAC) agreements to arrange for support from other regions	Same as Tier 2 & 3, plus • Situational Awareness and Information-Sharing: Survey potential resource needs for industry and local emergency managers • Regulatory Relief: Coordinate with utility regulators about any needed regulatory or prioritization exceptions. • Resource Management: Engage federal partners for federal resource requests, regional situational awareness, etc.

Liquid Fuel Shortage

Leading Agency: Petroleum Industry, in collaboration with GHS/OCD

Tier	Pre-Event	Response
Tier 3 Minor / Moderate Event	• Situational Awareness and Information-Sharing: Monitor threat forecast to understand potential concerns for the region's fuel supply and distribution infrastructure. • Situational Awareness and Information-Sharing: Identify risk factors that could exacerbate or prolong energy impacts or cause impacts to cascade into other sectors. • Resource Management: Communicate with industry groups and fuel industry contacts on precautionary actions taken (if any) in advance of the event	• Situational Awareness and Information-Sharing: Monitor impacts to the region's fuel supply and distribution infrastructure; Identify any current or potential cascading impacts or interdependencies, including impacts to power generation. • Situational Awareness and Information-Sharing: Monitor in-territory fuel availability for first responders and other government users by leveraging information from territory agencies, local emergency management agencies, industry partners, and public data. • Resource Management: Assess staffing capabilities and resource adequacy of territory to respond to the event • Restoration: Restore service according to prioritization protocols.
Tier 2 Significant Event	Same as Tier 3, plus • Situational Awareness and Information-Sharing: For pre-event evacuations, monitor fuel availability and pricing at retail stations and airport. • GovGuam: Prepare for Guam EOC Activation. • Situational Awareness: Establish communication with federal partners • Regulatory Relief: Prepare waiver forms as necessary in case regulatory relief is necessary. • Resource Management: Communicate with fuel industry groups and contacts to assess current and anticipated needs; Relay this information to territory and federal government partners as needed. • Resource Management: Coordinate with emergency managers to assess the availability of territory resources (e.g., fuel reserves, territory fuel for first responders, and other critical fuel users).	Same as Tier 3, plus • Situational Awareness and Information Sharing: Provide fuel sector situational reports to GovGuam agencies as needed. • Situational Awareness and Information-Sharing: Participate in internal and external situational awareness briefings (e.g., regional calls, federal calls, briefing governor) to provide territory-specific fuel outlook and address potential regional fuel concerns. • GovGuam: Activate Guam EOC / Consider declaring a state of emergency. • Resource Management: Coordinate resource needs (e.g., fuel shipments) at the territorial level, connecting industry and territory agencies, as needed. • Resource Management: Relay and coordinate resource needs with federal partners • Resource Management: Coordinate with industry and territory partners to address access issues, including prioritizing road clearing and port access; addressing infrastructure damage; and supplying fuel to critical users. • Regulatory Relief: Assist with directing industry waiver requests to the appropriate regulators, as needed.

<u>Tier 1</u> Major Event	Same as Tier 2 & 3, plus • Resource Management: Work with GovGuam to leverage EMAC agreements and arrange for support from other areas. • Resource Management: Pre-deploy resources, consider the need for activating a federal-territory Fuel Task Force to coordinate fuel sector resource needs.	Same as Tier 2 & 3, plus • Public Messaging: Call for fuel conservation in public messaging, in coordination with GovGuam officials. • Situational Awareness and Information-Sharing: Coordinate response actions and implementation with other areas in the impacted region as conditions warrant. • Resource Management/Impact Mitigation: Support federal agencies and ESF 12 to administer fuel allocation, establish temporary fueling locations for emergency responders, and other state programs to mitigate fuel shortage.

8. Energy Resiliency and Hazard Mitigation

8.1 Guam's Risk Mitigation Approach

Guam's Energy Security Plan outlines strategies to reduce the potential consequences of energy disruptions, secure critical energy infrastructure, and enhance energy sector reliability and end-use resilience for the territory. Efforts to identify, assess, and mitigate risks to energy infrastructure is a shared responsibility between stakeholders. Using this cross-functional approach allows for an island-wide perspective to prepare for, respond to, and recover from energy supply disruption-related events.

To minimize potential harm to Guam and its energy partners, risk mitigation strategies will be analyzed, developed, and implemented. This plan involves developing strategies to eliminate risk when feasible, decrease risk when it is not feasible, and manage the consequences that arise from risk exposure. Identifying connections and interdependencies between infrastructure elements and sectors allows for more efficient risk management strategies to increase security and resilience.

Security may be defined as reducing the risk to critical infrastructure from intrusions, attacks, or the effects of natural or man-made disasters, through the application of physical means or defensive cyber measures.

Resilience may be defined as the ability to prepare for and adapt to changing conditions. This means being able to withstand and recover rapidly from disruptions, deliberate attacks, accidents, or naturally occurring threats or incidents. Resilient infrastructure must also be robust, agile, and adaptable. A strong critical infrastructure security and resilience program is based on collaboration and information sharing.

8.1.1 Securing Critical Energy Infrastructure

Securing the energy supply chain is a significant priority for GovGuam. The implementation of the strategy will require collaboration and partnership among multiple stakeholders, including government agencies, private-sector energy providers, and community organizations. The approach must leverage risk assessments to identify and address potential risks and vulnerabilities in the supply chain and prioritize funding to mitigate those gaps to ensure a resilient and reliable energy supply chain.

The following measures can be taken to secure critical energy infrastructure:

- Conduct regular risk assessments of the energy supply chain to identify potential vulnerabilities and threats.
- Strengthen partnerships and communication between government agencies and private sector energy providers to improve coordination during emergencies.
- Enhance physical security at critical energy infrastructure sites, such as power plants, fuel terminals, and pipelines.
- Invest in advanced cybersecurity technologies and protocols to protect energy infrastructure from cyber attacks.
- Establish backup supply chains and diversified fuel sources to reduce the impact of supply disruptions.

8.1.2 Strengthening Energy Sector Reliability

To enhance energy sector reliability, Guam must invest in modernizing and upgrading its energy infrastructure. This includes improving generation, transmission, and distribution systems, upgrading aging power plants, and investing in renewable energy sources. The following measures can be taken to ensure energy sector reliability:[102]

- Increase investment in renewable energy sources such as solar, wind, biomass, wave, energy, and ocean thermal energy.
- Upgrade and modernize transmission and distribution systems to reduce the frequency and duration of power outages.
- Enhance emergency response plans and procedures to include energy partners and strengthen redundancy operations in the event of an outage.
- Promote energy efficiency programs to reduce energy consumption and demand.
- Invest in advanced metering infrastructure and grid modernization technologies to improve system reliability and efficiency.

8.1.3 Enhancing Energy Supply Resilience for End-Users

To enhance energy supply resilience for end-users, Guam's government must invest in measures that enable energy consumers to cope with potential energy disruptions. These measures include:

- Promoting the use of energy-efficient appliances and equipment to reduce energy consumption and demand during peak periods.
- Providing opportunities for energy consumers to gain access to backup power generation and storage facilities, such as batteries, generators, and fuel cells.
- Establishing partnerships with community organizations, businesses, to establish micro-grids and distributed energy generation systems.
- Improving building codes and standards to ensure that new construction is designed to be energy efficient and resilient to natural disasters.
- Investing in energy storage technologies to reduce the reliance on imported fossil fuels and improve grid stability.
- Providing training and education regarding energy efficiency and conservation.

8.2 All-Hazards Risk Mitigation Measures

All-hazard risk mitigation measures include developing energy systems that are robust, redundant, and resilient to several risks. While it is impossible to fully eliminate risk, impact-focused measures to promote robust systems can limit disruptions due to external factors. Focusing on developing redundancies, rapid detection programs, and recovery plans will all help Guam mitigate risks to its energy infrastructure.[103] Recommended all-hazard risk mitigation measures and their respective energy subsector are listed in Table 16. Energy sector stakeholders across Guam should communicate frequently about mitigation measures and prioritization to reduce duplication of efforts.

Table 16: All-Hazards Risk Mitigation Measures

Robustness

Measure	Description	Sector
Demand response programs	Demand response programs relieve pressure on electric delivery systems by reducing or time-shifting customer energy usage. Demand reduction during peak periods reduces the chance of system overload and service failure. In addition to enhancing reliability, demand response can also help reduce generator or supplier market power and lessen price volatility.	
System segmentation	Energy systems (power grids, liquid fuels pipeline networks) can be sub-divided to more efficiently isolate damaged areas, allowing undamaged segments to continue serving customers. By segmenting networks, service isolations can be more targeted and affect fewer customers.	
Undergrounding power lines	Placing transmission lines underground protects them against external threats, including high winds and falling branches, wildfires, extreme heat or cold, icing, dirt/dust/salt accumulation, and animals. Buried lines may be more vulnerable to flooding if located in low-lying areas and may be more difficult and expensive to maintain and repair.	

Redundancy

Measure	Description	Sector
Backup generators	Fixed or portable backup generators can provide backup power to critical facilities when grid-supplied power is interrupted. Backup generators may be designed to power emergency functions, such as emergency lighting, fire suppression, or stormwater removal, or may be designed to power some or all of a facility's operational functions. Mobile generators can power utility or emergency responder base camps (sites where response personnel and equipment are staged). Backup generators require adequate fuel supply to operate.	
Battery storage	Battery energy storage can be used to provide backup power during electric grid outages. Batteries can be deployed at utility-scale as front-of-the-meter systems, providing services like utility load peak shaving or behind-the-meter by customers. Batteries are often paired with solar photovoltaic systems and included in microgrid designs.	
Microgrids	A microgrid is a group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid. It can connect and disconnect from the grid to operate in grid-connected or island mode. Microgrids can improve customer reliability and resilience to grid disturbances.	

Rapid Detection/Recovery

Measure	Description	Sector	
Advanced distribution management systems	Advanced distribution management systems integrate numerous utility systems and provide automated outage restoration and optimization of distribution grid performance. These functions improve the resilience of the distribution system and decrease the length of customer outages.		
Artificial intelligence analysis	Artificial intelligence analysis can augment the abilities of subject matter experts to prioritize transmission line operations, identify defects, and update asset management systems.		
Distribution automation	Distribution automation uses digital sensors and switches with advanced control and communication technologies to automate feeder switching; voltage and equipment health monitoring; and outage, voltage, and reactive power management.		
Drones for asset inspection	The use of drones to inspect power lines or other energy assets allows for safer and more frequent inspections, enhanced asset information, reduced operational costs and failure rates, and extended asset lifetimes.		
LiDAR for vegetation management	Vegetation is the primary cause of overhead power line outages. "Light Detection and Ranging" (LiDAR), is remote-sensing technology that can measure how close vegetation is to power lines. LiDAR units can be deployed on the ground, drones or aircraft, to enable more effective vegetation management reducing the impact of storms on electric infrastructure.		
Remote-operated valves	Remote-operated valves more efficiently isolate systems during disruptions or peak event load management (e.g., temporarily disconnecting customers).		
Advanced Metering Infrastructure	Advanced metering infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables bi-directional communication between utilities and customers. Smart meters can provide near-real-time visibility into customer outages and help utilities allocate resources and restoration activities more efficiently.		
Supply chain resilience planning	Assessing current supply chains and working with relevant stakeholders to strategically plan for the continuity and rapid restoration of those supply chains after major disruptions improves supply chain resilience.		

Understanding Guam's current energy resilience baseline and associated vulnerabilities is essential to identifying tools for growth. Promoting a robust and redundant energy system that is prepared for rapid detection and recovery from a threat requires assessing abilities across a variety of critical capabilities, including information sharing, stakeholder engagement, workforce development, cybersecurity threats, and energy policies. Each of these capabilities complement one another and conducting regular self-assessments will allow for a more effective prioritization of funding and investment strategies beyond scheduled equipment upgrades. Integrating the ACES tool as part of a holistic approach to risk mitigation will enhance all-hazards resilience and provide an opportunity for Guam to assess improvements over time and develop strategies for long-term resilience investments based on the outcomes of these and other risk assessments.[104]

Figure 15: Energy Security Strategy Development Process

8.3 Hazard-Specific Mitigation Measures

There is no one-size-fits-all approach to mitigating risk. Infrastructure hardening efforts must consider the threat or hazard in question to identify the appropriate risk mitigation action. For example, encrypting emails won't mitigate the risk of severe winds damaging infrastructure, and undergrounding power lines won't mitigate the risk of insider security threats. Even within the same threat categories, undergrounding power lines may protect them from severe winds, but it may make them more vulnerable to flooding. This subsection outlines hazard-specific risk mitigation measures for the benefit of Guam's energy sector, and are generally relevant to all energy subsectors, including electricity and liquid fuels.

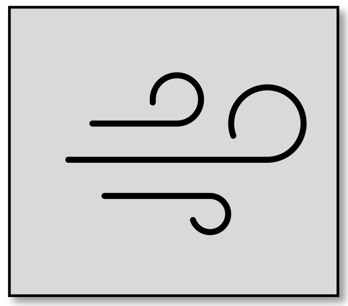
8.3.1 Natural Hazard Risk Mitigation Measures

In accordance with Natural Hazard Risk Assessment section (4.3), these hazard mitigation measures align with the four natural hazard scenarios previously presented, including typhoons, tsunamis, earthquakes, and wildland fires.

Typhoon

Many of the hardening measures which apply to tsunami impacts also may improve the typhoon resistance of individual assets or groups of assets. The following includes these and other measures:

- Elevating equipment located in low-lying areas can protect it from flooding that would otherwise damage or destroy it. This applies especially to buildings, structures, and equipment in substations and power plants.
- Preserving certain kinds of natural habitats (e.g., coastal wetlands) provides a natural barrier to lessen the impact of storm surge.



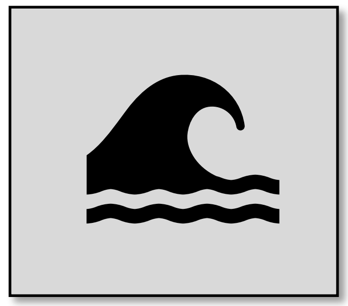
- Installing flood walls, gates, and/or barriers can protect essential equipment in flood-prone areas from water intrusion and avoid restoration delays after major storms and floods.
- Relocating energy assets away from flood-prone areas can reduce or eliminate their exposure to flooding and inundation threats.
- Installing stormwater pumps to remove floodwater and prevent equipment from being submerged. Regular maintenance and keeping an inventory of spares ensures availability of working pumps during flooding events.
- Designing equipment located in flood-prone areas, such as underground transmission and distribution components in low-lying areas to continue functioning when subjected to flooding and the introduction of contaminants such as salt, fertilizer, motor oil, and cleaning solvents.
- Evaluating at-risk transmission and distribution towers and poles and improving the foundations can help mitigate sagging or collapse due to soil erosion.
- Converting overhead transmission and distribution lines to underground cables can mitigate susceptibility of towers and lines to wind, vegetation, and debris.
- Improving vegetation management practices around transmission and distribution lines can help prevent faults and downed lines.
- Replacing wooden poles and towers with concrete, steel, or composite poles and towers can improve their ability to withstand sustained extreme winds.
- Installing breakaway connectors, designed to disconnect when a distribution line is pulled by a falling limb or other debris, can mitigate the shock hazard of downed lines and prevent poles from falling as a result of the downed line.

- Appropriate use of dead-end towers (also called anchor towers or anchor pylons), self-supporting structures made with heavier material than suspension towers, can reduce the likelihood of tower collapse.

Tsunami

Many of the hardening measures which apply to non-wind related typhoon impacts also apply to tsunami impacts. Hardening measures which may improve the resistance of individual assets or groups of assets to impact forces and inundation resulting from a tsunami include the following:

- Relocating energy assets and portions of at-risk facilities away from the tsunami zone, which can eliminate their exposure to inundation threats.



- Elevating equipment located in low-lying areas to protect it from flooding that would otherwise damage or destroy it. This applies especially to buildings, structures, and equipment in substations and power plants.
- Constructing barriers (reinforced walls and columns) to protect against impact forces and scour.
- Installing stormwater pumps to remove flood water and help prevent equipment from being submerged. Regular maintenance and keeping an inventory of spares ensures availability of working pumps during flooding events.
- Installing breakaway connectors designed to disconnect when a distribution line is pulled by a falling limb or other debris, which can mitigate the shock hazard of downed lines and prevent poles from falling because of the downed line.
- Appropriate use of dead-end towers (also called anchor towers or anchor pylons), self-supporting structures made with heavier material than suspension towers, which reduce the likelihood of tower collapse.
- Evaluating at-risk transmission and distribution towers and poles and improving the foundations to mitigate sagging or collapse due to soil erosion.

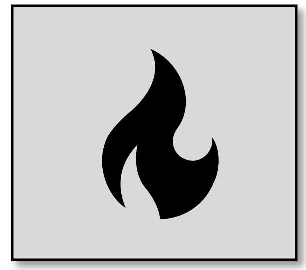
Equipment located in flood-prone areas, such as underground transmission and distribution components in low-lying areas, should be designed to continue functioning when subjected to flooding from water containing typical levels of contaminants such as salt, fertilizer, motor oil, and cleaning solvents.

Earthquake

Specific hardening actions for earthquake resilience may be identified by evaluating vulnerable assets under seismic engineering principles. This may include installing base isolation platforms—designed to absorb ground motion—beneath substation transformers and buildings, improving the structures and foundations of transmission towers and distribution poles, and examining connections for their ability to withstand shaking and lateral displacement. Underground cables are less susceptible to tower damage and to falling structures, vegetation, and other debris, but they are vulnerable to ground displacement. Significant damage to underground cables has been observed, particularly due to liquefaction.[105] Repairs of underground cables can be more challenging than those of overhead lines, potentially resulting in longer restoration times.

Wildland Fires

Although wildland fires in Guam are predominantly caused by human proceedings, fires are fueled by natural vegetation. Wildfire hazards are unique in that they may be caused by a power system under certain weather conditions. Dry foliage may contact power lines under high-wind conditions and lead to ignition. Hardening efforts therefore involve both mitigation of ignition related to the power system and of damage caused by a fire of any origin.

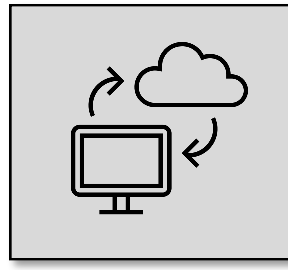


Hardening measures which may be employed to reduce wildfire risk include the following:

- Replacing bare wire overhead conductors on high-voltage transmission lines with covered conductors, which have a nonconductive covering, greatly reducing the number of faults and the risk of ignition.
- Reconductoring, or installing new conductor wires on existing towers, to increase transmission capacity and reduce line sag, which can reduce vegetation contact, faults, and the risk of ignition, while also improving the system's transmission capacity. Reconductoring typically involves replacing traditional steel-reinforced lines with composite core lines.
- Converting overhead transmission and distribution lines to underground cables, which can mitigate faults, ignition, and damage from fires.
- Installing breakaway connectors designed to disconnect when a distribution line is pulled by a falling limb or other debris, which can mitigate the shock hazard and potential ignition resulting from a downed line.
- Replacing wooden poles with ones made from fireproof materials, or wrapped in fireproof sheaths (e.g., wool-ceramic fiber), which can mitigate distribution or transmission circuit failure from fire.
- Pre-treating infrastructure (e.g., by applying flame retardant coatings or wrapping assets such as utility poles in flame retardant sheaths) to decrease wildfire damage and expedite restoration of service.
- Evaluating the operation of fault protection devices in wildfire-prone areas and considering disabling automatic reclosing on some of these devices may lead to reduced ignition risk from fault clearing attempts.

8.3.2 Cyber Risk Mitigation Measures

By investing in comprehensive risk-based cyber security programs, Guam's energy sector can enhance its cyber resilience and safeguard its critical infrastructure, ensuring the continued safety and integrity of energy services. Recommendations include:



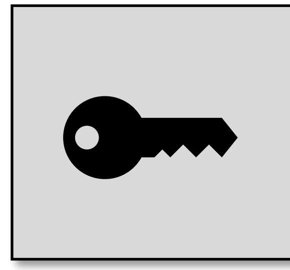
- **Tamper-resistant controls on field devices:** Field devices must implement hardware security controls to prevent physical tampering.
- **Trusted procurement procedures:** Users of commercial off-the-shelf hardware and software IT/OT products that are ready-made and available for purchase by the general public must follow strict procurement procedures that only allow installing certified devices that follow strict security standards.
- **Patching and updating:** Support staff must install critical updates as soon as they are available after appropriate testing, both for operating systems and ICS software. They should also install and regularly update anti-virus and anti-malware software on all hosts. They should disable unused remote access/RDP ports and monitor remote access/RDP logs as well.
- **Encryption:** Devices must implement end-to-end encryption and include embedded security in their processes. In some cases, certificate pinning (SSL pinning) must be required to avoid spoofed devices, and this includes protection from side channel attacks that can compromise encryption keys.
- **Authentication and access control procedures:** Facilities should implement strict authentication and authorization procedures for their employees and for all software entities. They should also develop access control measures to prevent unauthorized access to critical cyber systems.
- **Penetration testing and internal audit:** All facilities must implement rigorous vulnerability assessment and penetration testing audits on a regular basis to ensure continuous analysis of operational systems.
- **Employee training and awareness:** All employees working on critical systems must have proper training or certifications to support the elevated threat level of their positions. Human error and phishing attacks are most effectively avoided through proper employee awareness rather than technical means.
- **Network segmentation:** All facilities must deploy proper network segmentation, with DMZ configured and network isolation to protect critical systems. Whenever possible, ICS should not share the same network with internet-accessible devices.
- **Use of different technologies:** Implemented ICS should use devices and systems from different vendors to reduce the number of compromised assets per vulnerability. Although this measure introduces management complexity, it is a vital control for increasing resilience of critical systems.

- **Segregation of duties and minimum privileges:** Staff must have discrete credentials and relevant privileges based on their job description and needs. The Principle of Least Privilege must be implemented on all accounts and require administrator credentials to install software.
- **Catalog and reduce system dependencies:** Critical systems must identify and minimize dependencies on other systems and services, such as third-party processes.
- **Minimize unified closed loop:** Although closed-loop systems facilitate monitoring and control and manual control exacerbates workload, operators should minimize the use of automatic controls over critical machinery or at least implement heavy monitoring and break closed-loop systems down to individual procedures.
- **Create backups:** Staff should regularly back up data, air gap, and password-protect backup copies offline. Copies of critical data should not be accessible for modification or deletion from the system where the data resides.
- **Recovery plan:** Facilities should implement a recovery plan to maintain and retain multiple copies of sensitive or proprietary data and servers in a physically separate, segmented, and secure location (i.e., hard drive, storage device, the cloud). They should also establish, test, and update incident response (IR) plans and continuity of operations plans (COOPs).
- **Ensure password security:** Staff should use multi-factor authentication (MFA) where possible. They should use strong passwords, avoid reusing passwords for multiple accounts, and regularly change passwords for network systems and accounts, implementing the shortest acceptable time frame for password changes.
- **Use secure networks only:** Support staff should only use secure networks and avoid public Wi-Fi networks. Installing and using a VPN adds another layer of network security.
- **Email security:** Email security can be increased by adding an email banner to messages originating outside the organization and disabling hyperlinks in received emails.
- **Threat Intelligence:** Facilities should leverage threat intelligence platforms to filter and prioritize alerts, focused on hazards most likely to have a major impact. Staff should stay informed about evolving risks and adapt security measures accordingly.

8.3.3 Physical Security Risk Mitigation Measures

Physical security is a multifaceted discipline that relies on a wide array of tools and technologies, each tailored to address specific security challenges. These tools work in harmony to create comprehensive protection for various environments. The following controls are opportunities to mitigate physical security risks across all energy subsectors on Guam.

- **Access Control Systems:** Access control systems form the backbone of physical security, dictating who can enter specific areas. These systems utilize various methods such as key cards, key fobs, PIN codes, and biometric scanners like fingerprint and retina readers. By authenticating the identity of individuals, access control systems ensure that only authorized personnel can enter secure spaces, enhancing overall safety.



- **Surveillance Cameras:** Surveillance cameras, equipped with cutting-edge features, provide real-time monitoring and act as powerful deterrents. Modern cameras come with motion detection, night vision, and even facial recognition capabilities. These technologies enable security personnel to identify suspicious activities promptly. Additionally, recorded footage serves as valuable evidence during investigations, enhancing overall security measures. Advanced surveillance systems can enhance monitoring capabilities and help detect and prevent security breaches.
- **Detection Systems:** Detection systems are designed to alert security personnel the moment an unauthorized access attempt is detected. Intrusion detection systems act as a proactive measure, preventing potential security breaches before they escalate. These systems employ sensors placed strategically around sensitive areas. If an intrusion is detected, alarms are triggered, allowing security personnel to respond swiftly. A variety of detection systems may be used. Access Control involves limiting access to authorized individuals and includes measures like locks, gates, and electronic access cards. Properly assigning access levels ensures restricted areas remain secure. Video surveillance cameras play a crucial role. They monitor and record activities, helping identify potential threats. Intrusion Detection Sensors detect disturbances. Examples include door contacts, window break sensors, and motion detectors. When triggered, alarms activate to alert security personnel.
- **Environmental Monitoring:** Systems can monitor environmental factors like temperature, humidity, and smoke. For instance, fire alarms and sprinkler systems protect against fire-related threats.
- **Perimeter Security:** Perimeter security focuses on controlling access points to a property. By controlling access, perimeter security enhances overall surveillance efforts and prevents unauthorized individuals from breaching secure areas. Perimeter and designed and used to control access to sensitive or critical information and information processing facilities. A physical security perimeter may consist of physical barriers and controls such as fences, walls, gates, locks, alarms, and manned reception areas. It also protects against environmental hazards such as fire, smoke, water, and dust.
    - **Security Personnel:** Trained security personnel are a crucial component of physical security. Their expertise allows them to assess situations, respond to incidents effectively, and interact with individuals to maintain a secure environment. Whether stationed at entry points, patrolling premises, or monitoring surveillance feeds, security personnel provide a human touch to physical security, enhancing overall vigilance. Physical security

personnel are crucial for safeguarding an organization's assets, facilities, and personnel in the protection of assets and facilities:

- **Incident Response Plans:** Develop a comprehensive incident response plans. These plans outline procedures to follow during emergencies or security incidents. Regularly review and update these plans to ensure they align with current threats and organizational needs.
- **Risk Assessment and Mitigation:** Conduct regular risk assessments to identify vulnerabilities and prioritize mitigation efforts. Understand the different types of risks, including strategic, external, and internal risks. Develop a plan to eliminate or reduce risks and manage their impact.
- **Layered Approach:** Construct a layered approach to security. Combine multiple measures and strategies to holistically protect the organization. No single solution can address all risks; a combination of security measures is more effective.
- **Threat Intelligence:** Leverage threat intelligence platforms to filter and prioritize alerts. Focus on hazards most likely to have a major impact on your organization. Stay informed about evolving risks and adapt your security measures accordingly.

9. Addressing Environmental Justice, Equity, and Workforce Development

Environmental justice (EJ) is a term that describes the equitable treatment, meaningful involvement, and fair distribution of impacts with regard to the development, implementation, and enforcement of environmental laws, regulations, and policies.[106] The federal application of the term began in 1994 with President Clinton's Executive Order 12898, mandating agencies incorporate EJ into their mission by identifying and addressing any disproportionately high and adverse human or environmental effects of their programs, policies, and activities on minority populations and low-income populations. The U.S. Department of Energy offers the following definitions of Environmental Justice and Energy Equity:

- Energy equity recognizes that disadvantaged communities have been historically marginalized and overburdened by pollution, underinvestment in clean energy infrastructure, and lack of access to energy efficient housing and transportation.[107]
- Environmental justice is the recognition and remediation of the disproportionally high and adverse human health or environmental effects on underserved communities.[108]

President Biden's 2021 Executive Order 14008, commonly referred to as the "Justice40 Initiative," builds upon EJ principles by committing 40 percent of the administration's climate change and energy investments to "disadvantaged" communities.[109] Eight priorities were identified through stakeholder engagement, by the White House Environmental Justice Advisory Council, and additional research.[110]

- Decrease energy burden in disadvantaged communities (DACs). Energy burden is the percentage of gross household income spent on energy costs.[111]
- Decrease environmental exposure and burdens for DACs
- Increase parity in clean energy technology (e.g., solar, storage) access and adoption in DACs.

- Increase access to low-cost capital in DACs.
- Increase clean energy enterprise creation and contracting (MBE/DBE) in DACs.
- Increase clean energy jobs, job pipeline, and job training for individuals from DACs.
- Increase energy resiliency in DACs.
- Increase energy democracy in DACs

9.1 Assessment Tools

Several tools exist to assess whether communities qualify as disadvantaged or disproportionately impacted. The Environmental Protection Agency's (EPA) Environmental Justice Screening and Mapping Tool maps census tracts exposure to various public health hazards such as criteria air pollutants, legacy soil and water pollution, and flooding. The Department of Energy's Low-income Energy Affordability Data (LEAD) tool provides energy burden data for household electricity and fuel use. However, neither tool provide data for Guam.

The Whitehouse Climate and Economic Justice Screening Tool (CEJST) compiles socioeconomic data to determine census tracts that may be "overburdened or underserved." A census tract qualifies for this designation if it meets or exceeds the threshold for one or more burden categories (climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, or workforce development), *and* meets or exceeds the threshold for an associated socioeconomic burden (usually 65th percentile for low income/household income at or below 200% of the federal poverty level).

According to the CEJST, 9 of 57 census tracts within Guam are classified as disadvantaged in the workforce development category. However, the tool *only* has access to Guam employment, income, and education data. Thus, no data on portions of the population exposed to hazards are readily available.

Guam's energy burden, a metric of energy affordability, is 8%. The commonly accepted threshold of a high energy burden is 6% and above.[112] The average Guam household consumes around 13.5 MWh of electricity per year. At a cost of $0.3491 per kWh, the average Guam household spends about $4,713 per year on electricity. With a median household income of $58,289, Guam households spend around 8% of their annual income on home electricity.

Table 17. Comparative Home Energy Burden of U.S. Territories (2019)

Geography	**Median Household Income** (USD) (2019) [1]	**Residential Electricity Rate** (cents per kWh) (2023) [2]	**Average Annual Residential Energy Consumption** (MWh) (2021) [3]	**Average Annual Residential Energy Spending**	**Average Home Energy Burden**
U.S. Average	$69,560	$0.1614	10.6	$1,711	2%
Guam	$58,289	$0.3491	13.5	$4,713	8%
Virgin Islands	$40,408	$0.4200	5.4	$2,268	5.6%
Northern Mariana Islands	$31,362	$0.3789	7.9	$2,993	10%
American Samoa	$28,352	$0.3707	5.1	$1,890	6.6%

*Note: not including fuels or transportation. residential electricity rates are base rates plus fuel charges from spring 2023, not including monthly customer charges. Average annual residential energy consumption calculated from Annual Electric

Power Industry Report tables (residential sales of electricity to ultimate customers in MWH in 2021 divided by the number of ultimate residential customers in 2021.)
Data sources: [1] Income[113,114] [2] energy rates[115],[116],[117],[118] [3] energy consumption[119],[120],[121]

9.2 Guam Environmental Justice Policy

Guam law does not directly address environmental justice. However, as a territory of the U.S. government, federal policies apply to investments made on the island using federal funding. The 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act present opportunities for Guam energy entities to leverage federal funding to address energy affordability through appliance rebates and home repairs, increase clean energy jobs, implement projects to increase resilience to climate change impacts, and support pollution reducing transportation and energy projects.[122]

Guam Power Authority is responding to the U.S. Department of Energy's Justice40 Policy Priorities as they apply for federal grants. Table 18 lists GPA's targets to support affordable clean energy and transportation infrastructure development; energy efficiency programs, clean energy training and workforce development; and remediation and reduction of legacy pollution. However, these are not officially adopted policies of the territory.

Table 18. GPA Response to the U.S. Department of Energy's Justice40 Policy[123]

Justice40 Priority	GPA Indicator	GPA Target
Decrease energy burden in disadvantaged communities (DACs)	Electric energy cost reduction	Achieve a 50% reduction in LEAC (electricity fuel charge) by replacing energy production from high and volatile priced fuel oil sources with price stable lower cost renewable energy sources.
Decrease environmental exposure and burdens for DACs	Reduce hazardous air pollutants (HAP) and GHG emissions	Achieve an additional 37% reduction in HAP and GHG emissions by replacing fossil fuel based electric energy production with zero- emission renewable energy by 2030
Increase parity in clean energy technology access and adoption in DACs	Clean renewable energy is shared by everyone. Access to clean energy technology is made more affordable.	Grow the GPA Energy Sense Rebate Program from cumulative to date about $9M rebates by at least another $15M by 2030
Increase access to low-cost capital in DACs	Reduce the cost for investments in energy efficient appliances to improve their affordability.	Grow the GPA Energy Sense Rebate Program from cumulative to date about $9M rebates by at least another $15M by 2030
Increase clean energy enterprise creation and contracting in DACs	Incentivize the market for energy efficient equipment, renewable energy, and energy reduction services.	Grow the GPA Energy Sense Rebate Program from cumulative to date about $9M rebates by at least another $15M by 2030
Increase clean energy jobs, job pipeline, and job training for individuals from DACs	Increase clean energy jobs	Facilitate STEM Education including renewable energy technology, energy efficiency technology, and energy engineering.

Justice40 Priority	GPA Indicator	GPA Target
Increase energy resiliency in DACs	Improve energy reliability, resiliency, affordability, and power quality for GPA customers.	Execute GPA's Clean Energy Master Plan. Continue to pursue new technologies to improve GPA grid operations and energy affordability.
Increase energy democracy in DACs	Clean renewable energy is shared by everyone.	Achieve goal of 50% of energy production from renewable energy sources by 2030.

Guam Energy Office and Guam Power Authority could build upon these strategies and targets to develop concrete, actionable, and measurable goals that ensure 40% of investment benefits flow to disadvantaged communities. An advisory committee on equity, built of trusted local community leaders and compensated for their time, could support the identification of disadvantaged and disproportionately impacted communities, help develop an equity framework, help execute a community engagement process, and support GEO and GPA in the development of programs. Tools such as the Census Bureau's statistics on income, education, employment, labor force, and race could be overlayed with FEMA and local data on natural hazards to identify populations disproportionately exposed to climate change impacts such as flooding and heavy wind that can disrupt power supply.

9.3 Opportunities for Increasing Energy Equity and Environmental Justice on Guam

1. Identify disproportionate impacts and burdens. All U.S. Territories and federally recognized Tribes automatically qualify for "disadvantaged" status. However, further investigation would be required to identify specific populations disproportionately exposed to hazards and disproportionately impacted by energy burden. Guam's energy strategies and goals could be strengthened by first assessing the disproportionately distributed hazards, pollution, and burdens of the island. The GovGuam or Guam Energy Office could lead a series of assessments to identify populations living near hazardous or polluted areas, or that spend more than 6% of annual income on home energy.

Natural hazards and areas projected to be impacted by climate change can be mapped with Guam's FEMA Hazard Mitigation Plan and EPA's list of superfund sites. These natural hazard and polluted areas can be overlayed with indicators of social vulnerability or limited access to evacuation resources during an emergency. For example, the U.S. Center for Disease Control's Social Vulnerability Index or U.S. Census data identifies census block groups with lower income, lower educational attainment, limited access to vehicles, and limited English.

Guam Energy Office could work with Guam Power Authority to quantify the number and location of customers that spend more than 6% of annual income on home energy. Guam Power Authority customers could be mapped by their annual energy consumption in MWh and median household income (using U.S. Census data). This metric could form the basis and target of future programs such as weatherization, rebates, tariffs, and hardening projects. Alternatively, the "Federal Poverty Level" or "Low and Moderate Income" indicators can be used as thresholds for program eligibility.[124]

2. Increase meaningful involvement. All Justice40 covered programs and all DOE funding opportunity applications are required to engage in stakeholder consultation in determining program benefits. Community Benefits Plans are a requirement of all DOE Bipartisan Infrastructure Law and Inflation Reduction Act funding opportunities.[125]

Guam energy entities could increase the meaningful involvement of communities in defining challenges, developing visions, and prioritizing solutions. An Equity Advisory Group could be established or drawn upon to help develop an overall equity strategy that addresses the eight Justice40 priorities. Such a group could be formed by local leaders to formulate a framework for engaging with community members and lead the organization and execution of the engagement process. Through the public engagement process, the Equity Advisory Group could assess needs and prioritize solutions. In collaboration with theGovGuam, equity goals and strategies could be strengthened to include metrics, identify lead agencies, be timebound, commit financial resources, and establish mechanisms for reporting progress.

3. Reduce energy burden in disadvantaged communities. Possible avenues to reduce Guam citizens' energy burdens include:

Weatherization assistance program. The Guam Energy Office manages the Weatherization Assistance Program that improves residential energy efficiency and affordability for eligible low-income households primarily through energy saving appliance replacement. GEO could expand program eligibility to all households that have an energy burden of over 6%. GEO could develop a multifamily housing and affordable housing retrofit program to further the benefit of this program to disproportionately burdened communities.

GEO's existing weatherization program could also be expanded to include building envelope upgrades to improve whole building efficiency. Inefficient buildings gain heat (or lose heat) through windows, air vents, and walls. Building envelope upgrades include window replacement, ventilation retrofit, wall insulation, and automatic thermostats can improve energy efficiency by up to 50%.[126] This would make buildings more comfortable as well as reduce energy bills. More efficient homes increase resilience by increasing the amount of time residents can survive a power outage without air-conditioning. Weatherization programs can also prepare rooftops for distributed solar generation by offering structural retrofits and repairs. Weatherization programs also create good jobs with limited need for technical training.

Fuel diversification for lowered and stabilized energy costs. GPA's current target is to reduce the LEAC by 50% by increasing locally generated renewable energy. GPA could expand the impact of this goal by offering virtual net metering and/or virtual community solar with a special rate structure for LMI households. Offering community solar or virtual net metering subscriptions would also increase energy democracy and energy technology access by allowing customers who cannot afford to install and maintain rooftop solar (or who's rooftops cannot support it) to opt-in to purchasing clean energy.

Rebates. GPA's current target would grow the GPA Energy Sense Rebate Program from about $9M rebates by at least another $15M by 2030. To meet the Justice40 priorities, GPA could dedicate 40% of the Program budget for LMI households and multifamily buildings. It could also expand the type and amount of funding available to LMI households.

4. Decrease environmental exposure and burdens for DACs. The Guam Power Authority's current target is to reduce hazardous air pollution by 37% by replacing fossil fuel generation with renewable energy. This goal could be improved by addressing the impacts of legacy pollution on disadvantaged LMI populations. A legacy fund could be established through GPA or other GEO programs to ensure funding is available to address legacy energy pollution impacts and unintended consequences from the transition to renewable energy on Guam. The GovGuam could also initiate a program to support assisted migration away from hazardous areas in coordination with FEMA and the Housing and Urban Development (HUD) agencies.

5. Increase parity in clean energy technology access and adoption in DACs. The Guam Power Authority could develop a DER energy service contract program. Many LMI customers cannot afford to purchase or maintain their own solar PV array. A service contract enables customers to benefit from solar PV without having to pay the upfront cost of materials and installation, or the maintenance cost over the lifetime of the system. Customers are charged a monthly bill for the utility-owned solar installed on their property.

6. Increase access to low-cost capital in DACs. Guam Energy Office could create a solar rebate program to offset the cost of solar ownership. In many cases, the upfront cost of solar PV is a barrier to home and commercial building owners. Access to low interest financing could reduce this barrier. In tandem with its weatherization program, GEO could help homes and businesses prepare rooftops for solar PV racking. Forty percent of program funding could be reserved for LMI residents and business owners or all residents whose energy burden is greater than 6%. This would help Guam Power Authority meet its decarbonization targets while increasing access to clean energy technology.

7. Increase clean energy enterprise creation and contracting in DACs. Guam Power Authority and GEO could leverage fees and taxes to stand up a clean energy entrepreneur financing program, and reserve 40% of these funds for disadvantaged contractors, vendors, developers, and industry innovators. For example, Guam Power Authority may prefer to leave solar energy service contracts up to the private sector. Guam Energy Office could provide incubation funding to small minority business owners to start up such a service.

8. Increase clean energy jobs, job pipeline, and job training for individuals from DACs. Possible approaches include:

> **Expanding employment opportunities** for residents of Guam through the energy transition. Guam Power Authority's current targets include facilitating Science, Technology, Engineering and Mathematics (STEM) Education including renewable energy technology, energy efficiency technology, and energy engineering. This target could be strengthened by identifying partner organizations and funding sources to support such a training program and reserving 40% of this funding for residents from disadvantaged or burdened communities. Guam Energy Office could engage high schools, trade schools, community colleges, and the University of Guam to identify existing technical and STEM education gaps and programs to build upon.
>
> **Hiring Commitments**. Guam Power Authority could commit to hiring local residents who meet certain demographic characteristics (such as LMI, low educational attainment, or individuals transitioning away from fossil fuel jobs). Guam Power Authority could also provide job training for these individuals and existing staff to ensure access to good paying jobs and advancement.
>
> Guam Power Authority and other private energy developers and utility providers could voluntarily enter into **community benefits agreements**. Community benefits plans and agreements are contractual obligations negotiated between community members and a developer that make certain commitments to the community where a development or its impacts will be located in exchange for support of the project. These could include local hiring commitments, job training commitments, pollution remediation, local asset and infrastructure improvements,

economic development funds, or funds to mitigate future unintended consequences of development projects. Mandates for community benefits agreements could be adopted into government development regulations.

The GovGuam could support programs to create new energy efficiency and renewable energy jobs including weatherization, construction, operations and maintenance technicians, business owners, EV mechanics, manufacturing, battery and materials recycling, and building permitting and inspections.

9. Increase energy resiliency in DACs. Through meaning engagement with community members and advisory groups in planning processes, GEO and GPA can increase energy resilience for disadvantaged communities identified through detailed assessments. Advisory groups and community representatives can help identify existing community assets and social networks that provide critical services in times of crisis. These key stakeholders can also help prioritize locations for resilience hubs that could receive funding for nearby grid hardening, battery storage, and microgrid projects.

Guam Energy Office and GPA could also stand up or incentivize an energy storage service contract and cooling services contracts. These programs could reserve 40% of funding for LMI customers and business owners.

The GovGuam could seek to establish mutual aid agreements with the U.S. Navy to support community critical facilities with power from microgrids in times of disaster. The Navy could also expand services to community members in times of crisis, including medical services, water purification services, access to power supply for charging devices, access to EV charging, access to laundry services, access to cooling for medications and products, access to showers, toilets, and auxiliary housing.

10. Increase energy democracy in DACs. By virtue of increasing meaningful participation of community in energy planning processes, GPA and GEO can increase energy democracy. Energy democracy means empowering customers to choose where their energy comes from and who owns it. In addition to an LMI virtual solar subscription program, Guam Power Authority could offer a green tariff for residents that choose to opt-in to 100% renewable energy.

9.4 Other EJ and Equity Resources

See a list of federal programs and funding opportunities.
https://www.energy.gov/indianenergy/current-funding-opportunities

See list of other low-income community energy solutions. https://www.energy.gov/scep/slsc/low-income-community-energy-solutions

See more resources on community benefits plans. https://www.energy.gov/infrastructure/about-community-benefits-plans

10. GESP Execution and Plan Maintenance

The GESP should be routinely referred to by energy security professionals and updated regularly so it continuously reflects the current energy profile and energy security operations of GovGuam. This brief section outlines which agencies are responsible for maintaining the plan through regular updates and executing tasks intended to promote visibility and usefulness of the plan.

Plan Maintenance		
Task	**Timeline**	**Responsible**
Update the Energy Profile (Section 2) and Energy Security Authorities (Section 5) as appropriate.	Every two years	GPA
Update Energy Sector Threats, Vulnerabilities, and Risk Assessments (Section 4) as appropriate.	Every four years, or ongoing basis with dedicated personnel	GPA, GEO, GHS/OCD, In collaboration with industry partners
Wholesale Plan Review and Update	Every six years	GPA, GEO, GHS/OCD, In collaboration with industry partners

Plan Execution		
Task	**Timeline**	**Responsible**
Apply risk assessment strategy (section 3) to update or develop new risk assessments	Ongoing	GPA, GPA trading partners, and other owners/operators of energy infrastructure
Conduct or organize trainings on the GESP with GovGuam and industry stakeholders, including planning and response activities for energy disruptions	Ongoing	GPA, in collaboration with energy security stakeholders
Conduct energy sector exercises and craft after action reports to continuously improve	Ongoing	GPA, in collaboration with energy security stakeholders
Organize and maintain information sheets on situational awareness tools, energy response playbooks, etc.	Ongoing	GPA, in collaboration with energy security stakeholders

11. End Notes

[1] Foster, Sophie, and Dirk Anthony Ballendorf, Guam, Encyclopedia Britannica, updated January 4, 2023.

[2] U.S. Central Intelligence Agency, The World Factbook, Guam, Geography, updated January 11, 2023.

[3] Guam Economic Development Authority, About Guam, accessed January 10, 2023.

[4] U.S. Energy Information Administration (EIA), International Energy Statistics, Guam, 2021 primary energy data in quadrillion Btu, Coal, Dry natural gas, Petroleum & other liquids.

[5] U.S. Central Intelligence Agency, The World Factbook, Guam, Energy, Electricity generation sources, Refined petroleum products-imports, updated January 10, 2023.

[6] U.S. EIA, International Energy Statistics, Guam, Electricity, Generation (billion kWh), 2017¬-21.

[7] U.S. Central Intelligence Agency, The World Factbook, Guam, Economy, Imports-Commodities, 2019.

[8] Guam Power Authority, 2022 Integrated Resource Plan, accessed January 10, 2023.

[9] U.S. Central Intelligence Agency, The World Factbook, Guam, Energy, Electricity-generation sources, 2020.

[10] DeRivi, Tanya, "Guam Power Authority bolsters resilience and charts path to 50% renewables," American Public Power Association (May 3, 2021).

[11] Foster, Sophie, and Dirk Anthony Ballendorf, Guam, Encyclopedia Britannica, updated January 4, 2023.

[12] Guampedia, Geography of Guam, accessed January 10, 2023.

[13] U.S. Central Intelligence Agency, The World Factbook, Guam, Geography, updated January 11, 2023.

[14] Foster, Sophie, and Dirk Anthony Ballendorf, Guam, Land, Encyclopedia Britannica, updated January 4, 2023.

[15] "Tropical cyclone projections: changing climate threats for Pacific island defense installations," Weather, Climate, and Society (Volume 11, Issue 1, January 2019), Climate variability, p. 6.

[16] Military Installations, Joint Region Marianas - Naval Base Guam In-depth Overview, Population, accessed January 10, 2023.

[17] Guam Economic Development Authority, Economic Resources, Visitor Industry, Military, accessed January 10, 2023.

[18] Cho, Kelly Kasulis, "In This Remote American Outpost, Pandemic Recovery Is a Faraway Dream," The New York Times (August 25, 2021).

[19] Guam Visitors Bureau, December 2022 Monthly Arrivals Summary, p. 1, 5.

[20] Guam Visitors Bureau, "Over 216K recorded in visitor arrivals for FY2022," Press release (October 13, 2022).

[21] Limtiaco, Steve, "Guam, Okinawa governors discuss U.S. Marines relocation," Pacific Daily News (August 30, 2019).

[22] Staff Reports, "Marine Corps activates Camp Blaz in Dededo, first new Marine Corps base since 1952," Pacific Daily News (October 1, 2020).

[23] "Military: Development of Marine Corps base on Guam on track," The Guam Daily Post (March 30, 2021).

[24] Kaur, Anumita, "Guam split on Marine Corps relocation," Pacific Daily News (April 9, 2021).

[25] Baring-Gould, Ian, et al., Guam Initial Technical Assessment Report, National Renewable Energy Laboratory, NREL/TP-7A40-50580 (April 2011), p. 2.

[26] U.S. EIA, International Energy Statistics, Guam, Energy intensity, Energy consumption per capita, 2017-21.

[27] U.S. EIA, Guam Profile Data, Reserves, Supply, accessed January 11, 2023.

[28] U.S. EIA, Number and Capacity of Petroleum Refineries, Guam, as of January 1, 2022.

[29] Port Authority of Guam, About PAG, accessed January 11, 2023.

[30] U.S. Central Intelligence Agency, The World Factbook, Guam, Economy, Imports-Commodities, Imports-Partners, 2019.

[31] Guam Energy Office, Fuel and Power Data Compilation, 2021 Fuel Sales by Petroleum Companies.

[32] U.S. Central Intelligence Agency, The World Factbook, Guam, Energy, Electricity generation sources, 2020.

[33] Conrad, Misty Dawn, and Sean Esterly, Guam Strategic Energy Plan (July 2013), p. i.

[34] U.S. EIA, International Energy Statistics, Guam, Petroleum and other liquids consumption (Mb/d), 2010, 2020.

[35] U.S. EIA, International Energy Statistics, Guam, Petroleum and other liquids consumption (Mb/d), 2010, 2020.

[36] Guam Power Authority, 2021 Annual Report, GPA Overview, p. 6.

[37] Guam Power Authority, About, Fact Sheet, accessed January 12, 2023.

[38] Borja, John, "Guam Power Authority on Long Road to Renewables," Pacific Daily News (May 14, 2017).

[39] Daleno, Gaynor Dumat-ol, "Power Supply Vulnerable; More Outages Possible," Pacific Daily News (April 14, 2016).

[40] Daleno, Gaynor Dumat-ol, "PUC to GPA: Cut Cost," Pacific Daily News (October 30, 2015).

[41] Daleno, Gaynor Dumat-ol, "Rented Power Plant to Go on Line Soon," Pacific Daily News (December 20, 2015).

[42] Guam Power Authority, 2021 Annual Report, Attachment: Guam Power Authority, Financial Statements, Additional Information, and Independent Auditor's Report, Years Ended September 30, 2021 and 2020, United States Environmental Protection Agency, p. 2.

[43] Guam Power Authority, "Kepco Breaks Ground, Cuts Ribbon on Power Projects," Press release (July 20, 2022).

[44] Guam Power Authority, 2021 Annual Report, High System Reliability, p. 10.

[45] Guam Power Authority, 2021 Annual Report, Attachment: Guam Power Authority, Financial Statements, Additional Information, and Independent Auditor's Report, Years Ended September 30, 2021 and 2020, New Generation, p. 2, Future Borrowing, p. 9.

[46] Guam Power Authority, 2021 Annual Report, Regional Rate Comparison-As of September 30, 2021, p. 8.

[47] U.S. EIA, Electric Power Annual 2021 (November 7, 2022), Table 12.6, Guam, Average Price of Electricity to Ultimate Customers (cents per kilowatthour), and Table 2.4, Average Price of Electricity to Ultimate Customers.

[48] O'Connor, John, "Power rates going up again," The Guam Daily Post (October 28, 2022).

[49] Guam Power Authority, Rates, Rate Schedules, Levelized Energy Adjustment Clause as of July 1, 2022, GPA-Docket 22-15, June 16, 2022.

[50] Daily Post Staff, "Another $500 credit coming for GPA bills," The Guam Daily Post (December 19, 2022).

[51] U.S. EIA, Electric Power Annual 2021 (November 7, 2022), Table 12.6, Guam, Number of Ultimate Customers.

[52] Cho, Kelly Kasulis, "In This Remote American Outpost, Pandemic Recovery Is a Faraway Dream," The New York Times (August 25, 2021).

[53] Guam Power Authority, 2021 Annual Report, Attachment: Guam Power Authority, Financial Statements, Additional Information and Independent Auditors' Report, Years Ended September 30, 2021 and 2020, Annual Electric Sales in kWh, p. 62.

[54] DSIRE, NC Clean Energy Technology Center, Guam-Renewable Energy Portfolio Goal (updated May 6, 2015).

[55] National Conference of State Legislatures, State Renewable Portfolio Standards and Goals, Guam, Enabling Statute or Order: Guam Public Law §29-62, updated August 13, 2021.

[56] Cruz, Philip, "A vision of Guam future: Embarking on 100% green energy path by 2045," Pacific Island Times (January 12, 2020).

[57] U.S. EIA, International Energy Statistics, Electricity, Guam, Generation, 2017-21.

[58] U.S. EIA, International Energy Statistics, Electricity, Guam, Generation, 2017-21.

[59] Baring-Gould, Ian, et al., Guam Initial Technical Assessment Report, National Renewable Energy Laboratory, NREL/TP-7A40-50580 (April 2011), p. 18.

[60] "NRG Renew Completes Guam's First On-Island Solar Facility," The Weekly Junction (October 12, 2015).

[61] Guam Power Authority, 2015 Annual Report, p. 20.

[62] Guam Power Authority, 2021 Annual Report, High System Reliability, p. 10.

[63] O'Connor, John, "Solar plant that can power 14K homes to rev up in June," The Guam Daily Post (May 28, 2022).

[64] Taitano, Joe II, "GPA will work to salvage unfinished solar farm project," Pacific Daily News (January 28, 2024).

[65] O'Connor, John, "Phase III solar project pending as Navy withdraws use of property," The Guam Daily Post (August 18, 2022).

[66] O'Connor, John, "Utilities commission authorizes renewable energy procurement," The Guam Daily Post (October 30, 2022).

[67] Baring-Gould, Ian, et al., Guam Initial Technical Assessment Report, National Renewable Energy Laboratory, NREL/TP-7A40-50580 (April 2011), p. 30, 31.

[68] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, WINDExchange, Wind Energy in Guam, accessed January 13, 2023.

[69] Losinio, Louella, "Cotal wind turbine back in operation," The Guam Daily Post (January 17, 2019).

[70] Webster, Joseph, and Elina Carpen, "Does the IRA make US offshore wind the "next big thing?" Atlantic Council (October 25, 2022).

[71] DSIRE, NC Clean Energy Technology Center, Guam-Net Metering (updated March January 4, 2024).

[72] DSIRE, NC Clean Energy Technology Center, Guam-Net Metering (updated March 19, 2021).

[73] O'Connor, John, "CCU approves battery requirement for solar-powered homes," The Guam Daily Post (February 27, 2020).

[74] O'Connor, John, "Rollover policy ending for net-metering credits," The Guam Daily Post (June 1, 2020).

[75] U.S. EIA, International Energy Statistics, Guam, Natural gas reserves (tcf), 2021, Dry natural gas production (bcf), 2021, Dry natural gas consumption (bcf), 2021.

[76] Guam Power Authority, 2021 Annual Report, High System Reliability, p. 10, Attachment: Guam Power Authority, Financial Statements, Additional Information and Independent Auditors' Report, Years Ended September 30, 2021 and 2020, Future Borrowing, p. 9, Integrated Resource Plan, Continued, p. 52.

[77] O'Connor, John, "Cabras 2 offline for overhaul," The Guam Daily Post (January 12, 2023).

[78] Daily Post Staff, "Justice Department files GPA settlement; agency must pay $400K," The Guam Daily Post (February 10, 2020).

[79] U.S. EIA, International Energy Statistics, Guam, Coal and coke, Production, Consumption, 2021.

[80] U.S. EIA, International Energy Statistics, Guam, Coal and coke, Coal reserves, 2021.

[81] U.S. Department of Energy, Office of Electricity and Energy Reliability, Creating a Risk Assessment Culture for State Energy Infrastructure Decision-Making. Accessed August 14, 2023.

[82] Guam Visitors Bureau, Mawar impacts May arrivals, Industry remains resilient, June 16, 2023.
[83] https://ghs.guam.gov/sites/default/files/2018_guam_catplan_final_20180213.pdf
[84] 2018 Guam Catastrophic Typhoon Plan, D-8:
https://www.ghs.guam.gov/sites/default/files/2018_guam_catplan_final_20180213.pdf

[85] Guam Hazard Mitigation Plan, 2019 Update: https://ghs.guam.gov/sites/default/files/final_2019_guam_hmp_20190726.pdf
[86] 2019 Guam Hazard Mitigation Plan, https://ghs.guam.gov/sites/default/files/final_2019_guam_hmp_20190726.pdf
[87] NOAA 2022. "NCEI/WDS Global Historical Tsunami Database," https://www.ngdc.noaa.gov/hazel/view/hazards/tsunami/event-data?locInclude=guam

[88] Guam Hazard Mitigation Plan of 2019, Page 5-21: https://www.ghs.guam.gov/sites/default/files/final_2019_guam_hmp_20190726.pdf
[89] The shake map of this earthquake can be downloaded from the USGS website, which also provides various technical details of the earthquake event and its impact. https://earthquake.usgs.gov/earthquakes/eventpage/usp0005y3k/executive

[90] Guam Hazard Mitigation Plan. Page 5-63. https://ghs.guam.gov/sites/default/files/final_2019_guam_hmp_20190726.pdf
[91] Note that there are no federally or territorially recognized Indian Tribes in Guam so this plan does not outline "coordination with Indian Tribes with respect to planning and response."

[92] Emergency Management Assistance Compact, NEMA: https://www.emacweb.org/

[93] The Territory of Guam Comprehensive Emergency Management Plan, 2016, Page 49

[94] The ESCC's Cyber Mutual Assistance Program: https://www.electricitysubsector.org/-/media/Files/ESCC/Documents/CMA/Cyber-Mutual-Assistance-Program-One-Pager.pdf?la=en&hash=827569B6061E85794AC581BF383C89E5D9DCD419

[95] U.S. Department of Energy, "Energy Emergency Response Playbook for States and Territories". 2022. https://www.energy.gov/sites/default/files/2022-05/DOE_CESER_Energy%20Emergency%20Response%20Playbook%20for%20State%20and%20Territories%20FINAL_508_0.pdf
[96] The Territory of Guam Comprehensive Emergency Management Plan, 2016, Emergency Support Function Annex. Guam CEMP - GHS OCD | Government of Guam

[97] Oil and Natural Gas Industry Preparedness Handbook. 2022 https://www.api.org/-/media/Files/Policy/Safety/ONG-Industry-Preparedness-Handbook.pdf

[98]Guam Power Authority. Standard Operating Procedure 049: Storm Preparation, Operational Response, and Power Restoration Procedures. 2019. https://admin.guampowerauthority.com/uploads/SOP_049_Storm_Prep_Operational_Response_and_Power_Restoration_eff_2_15_19_3fd173541b.pdf

[99]Guam Power Authority. Standard Operating Procedure 049: Storm Preparation, Operational Response, and Power Restoration Procedures. 2019. https://admin.guampowerauthority.com/uploads/SOP_049_Storm_Prep_Operational_Response_and_Power_Restoration_eff_2_15_19_3fd173541b.pdf

[100] The Territory of Guam Comprehensive Emergency Management Plan, 2016, Emergency Support Function Annex. Guam CEMP - GHS OCD | Government of Guam

[101] U.S. Department of Energy, "Energy Emergency Response Playbook for States and Territories". 2022. https://www.energy.gov/sites/default/files/2022-05/DOE_CESER_Energy%20Emergency%20Response%20Playbook%20for%20State%20and%20Territories%20FINAL_508_0.pdf

[102] U.S. Climate Resilience Toolkit, Building Resilience in the Energy Sector, accessed August 18, 2023. https://toolkit.climate.gov/topics/energy-supply-and-use/building-resilience-energy-supply-and-use

[103] U.S. Department of Energy, Office of Cybersecurity, Energy Security, and Emergency Response, State Energy Security Plan Optional Drop-In: Energy Sector Risk Mitigation Measures, May 2022, accessed September 15, 2023.

[104] U.S. Department of Energy, Office of Cybersecurity, Energy Security, and Emergency Response, Assessment of Capabilities in Energy Security (ACES). Accessed September 15, 2023.

[105] Kongar, I., Giovinazzi, S. & Rossetto, T. "Seismic performance of buried electrical cables: evidence-based repair rates and fragility functions." *Bull Earthquake Eng* **15**, 3151–3181 (2017). https://doi.org/10.1007/s10518-016-0077-3

[106] U.S. Department of Energy. (2012). Executive Order 12898, Federal Actions to Address Environmental Justice in Minority and Low-Income Populations. https://www.energy.gov/sites/prod/files/2016/05/f31/Env%20Justice-Minority-Lowincome-Pop-508.pdf

[107] U.S. Department of Energy. (n.d.-a). *Energy Equity and Environmental Justice*. Energy.Gov. Retrieved September 19, 2023, from https://www.energy.gov/eere/energy-equity-and-environmental-justice

[108] U.S. Department of Energy. (n.d.-a). *Energy Equity and Environmental Justice*. Energy.Gov. Retrieved September 19, 2023, from https://www.energy.gov/eere/energy-equity-and-environmental-justice

[109] House, T. W. (2021, January 27). Executive Order on Tackling the Climate Crisis at Home and Abroad. The White House. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/

[110] U.S. Department of Energy. (n.d.-b). Justice40 Initiative. Justice40 Initiative. Retrieved September 19, 2023, from https://www.energy.gov/diversity/justice40-initiative

[111] U.S. Department of Energy. (n.d.-c). Low-Income Community Energy Solutions. Energy.Gov. Retrieved September 19, 2023, from https://www.energy.gov/scep/slsc/low-income-community-energy-solutions

[112] American Council for an Energy-Efficient Economy. (n.d.). Understanding Energy Affordability. Retrieved September 6, 2023, from https://www.aceee.org/sites/default/files/energy-affordability.pdf

[113] Census Table PBG43 Median Household Income 2019, including military - https://data.census.gov/table?t=Income+(Households,+Families,+Individuals)&tid=DECENNIALDHCVI2020.PBG43

[114] US Median Household Income - https://www.census.gov/library/publications/2021/demo/p60-273.html#:~:text=Median%20household%20income%20was%20%2467%2C521,median%20household%20income%20since%202011.

[115] U.S. Energy Information Administration. (2023, February 16). Territory Profile and Energy Estimates—Guam—Profile Analysis. https://www.eia.gov/state/analysis.php?sid=GQ

[116] Benavente,2023

[117] Commonwealth Utilities Corporation. (2023). *Rates and Tariffs—Commonwealth Utilities Corporation*. https://www.cucgov.org/rates-and-tariffs/

[118] American Samoa Power Authority. (2023, March). American Samoa Power Authority—Billing Rates as of March 2023. https://www.aspower.com/ASPAWEB/rates/202303_FS.pdf

[119] EIA Annual Electric Power Reports for US and Territories

[120] Annual Electric Power Industry Report—Table 2.2 Sales and Direct Use of Electricity to Ultimate Customers by sector, by provider, 2011 through 2021. (n.d.). Retrieved August 29, 2023, from https://www.eia.gov/electricity/annual/html/epa_02_02.html.

[121] U.S. Energy Information Administration. (2022). Electric Sales, Revenue, and Average Price: Table 1—2021 Total Electric Industry—Customers. https://www.eia.gov/electricity/sales_revenue_price/pdf/table1.pdf

[122] U.S. White House. (2022). The Inflation Reduction Act Delivers for Guam. https://www.whitehouse.gov/wp-content/uploads/2022/09/The-Inflation-Reduction-Act-Delivers-for-Guam.pdf

[123] Guam Power Authority. (n.d.). GPA Clean Energy Master Plan, UN SDGs, and Justice 40. Retrieved August 30, 2023, from https://guampowerauthority.com/gpa-initiatives/clean-energy-master-plan

[124] U.S. Department of Energy. (n.d.-c). Low-Income Community Energy Solutions. Energy.Gov. Retrieved September 19, 2023, from https://www.energy.gov/scep/slsc/low-income-community-energy-solutions

[125] U.S. Department of Energy. (n.d.-d). Why Energy Efficiency Upgrades. Energy.Gov. Retrieved September 20, 2023, from https://www.energy.gov/eere/why-energy-efficiency-upgrades

[126] U.S. Department of Energy. (n.d.-d). Why Energy Efficiency Upgrades. Energy.Gov. Retrieved September 20, 2023, from https://www.energy.gov/eere/why-energy-efficiency-upgrades