Guam's Priority Climate Action Plan

2024

Prepared by:

UNIVERSITY OF GUAM
CENTER FOR ISLAND SUSTAINABILITY

Sea Grant
UNIVERSITY OF GUAM

Acknowledgements

Guam's Priority Climate Action Plan was funded through the U.S. Environmental Protection Agency's Climate Pollution Reduction Grants Program. This action plan was primarily developed by the Climate Change Resilience Commission and the University of Guam Center for Island Sustainability and Sea Grant in partnership with various local government agencies (listed below). These agencies contributed their data and knowledge needed to develop this action plan. The priority greenhouse gas inventory included in this action plan was made possible by the expertise and assistance of the National Renewable Energy Laboratory. Their efforts to assist in creating the first greenhouse gas inventory of priority sectors for Guam is invaluable information for the island as we work towards combating the effects of climate change. This plan is an important first step towards accelerating emissions reductions and strengthening climate change resilience for Guam.

The various local government agencies who contributed to the development of this plan include:

- Office of the Governor of Guam
- Guam State Clearinghouse
- Guam Department of Administration
- Guam Department of Agriculture Forestry Division
- Guam Power Authority
- Guam Waterworks Authority
- Guam Solid Waste Authority
- Guam Environmental Protection Agency
- Pacific Island Climate Adaptation Science Center
- Guam Green Growth
- UOG Western Pacific Tropical Research Center
- UOG College of Natural and Applied Sciences
- Guam Coral Reef Initiative
- Northern Guam Soil and Water Conservation District
- Guam Bureau of Statistics and Plans
- Guam Department of Public Works
- Guam Regional Transit Authority

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List of Acronyms

BESS	Battery Energy Storage System
BSP	Bureau of Statistics and Plans
CAP	Criteria air pollutant
CCAP	Comprehensive Climate Action Plan
CCRC	Climate Change Resilience Commission
CCU	Consolidated Commission on Utilities
CH_4	Methane
CNMI	Commonwealth of the Northern Mariana Islands
CO_2	Carbon dioxide
CPRG	Climate Pollution Reduction Grant
CSAF	Climate Smart Agriculture and Forestry
DOA GSA	Department of Administration General Services Agency
DoAg	Guam Department of Agriculture
DPW	Department of Public Works
EV	Electric vehicle
FOG	Fats, oils, and grease
G3	Guam Green Growth
GCEF	Guam and Chamorro Educational Facility
GCRI	Guam Coral Reef Initiative
GDOE	Guam Department of Education
GEDA	Guam Economic Development Authority
GEO	Guam Energy Office
GEPA	Guam Environmental Power Authority
GHG	Greenhouse gas
GHGRP	Greenhouse Gas Reporting Program
GPA	Guam Power Authority
GROW	Guam Restoration of Watersheds
GRTA	Guam Regional Transit Authority
GSWA	Guam Solid Waste Authority
GWA	Guam Waterworks Authority
HAP	Hazardous Air Pollutant
LEAC	Levelized Energy Adjustment Clause
LFG	Landfill gas
MOU	Memorandum of understanding
MT CO_2e	Metric Tons of carbon dioxide equivalent
N_2O	Nitrous oxide
NGSWCD	Northern Guam Soil and Water Conservation District
NEI	National Emissions Inventory
NFWF	National Fish and Wildlife
NMC	Northern Marianas College
NOAA	National Oceanic Atmospheric Administration
NREL	National Renewable Energy Laboratory

OAG	Office of the Attorney General
OIA-EIC	Office of Insular Affairs Energizing Insular Communities
PCAP	Priority Climate Action Plan
PI-CASC	Pacific Island Climate Adaptation Science Center
PIRCA	Pacific Islands Regional Climate Assessment
PPA	Power purchase agreement
PUC	Public Utilities Commission
PV	Photovoltaic
QAPP	Quality Assurance Project Plan
SCADA	Supervisory control and data acquisition
SDGs	Sustainable Development Goals
SGSWCD	Southern Guam Soil and Water Conservation District
UOG	University of Guam
UOG CIS & SG	University of Guam Center for Island Sustainability and Sea Grant
UOG CNAS	University of Guam College of Natural and Applied Sciences
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VMT	Vehicle miles traveled
WSU	Washington State University
WWTP	Wastewater treatment plants

Executive Summary

Guam's Priority Climate Action Plan (PCAP) serves to increase the island's resilience to climate change by presenting a baseline greenhouse gas (GHG) inventory of priority sectors and a priority list of GHG reduction measures to be implemented to meet Guam's goals for immediate and necessary climate action. This PCAP also includes a benefits analysis for each reduction measure and a review of the authority or authorities to implement each measure. The main objectives of this PCAP are to:

- Improve an understanding of current and future GHG emissions in Guam;
- Prioritize actions that reduce GHG emissions that affect people's livelihoods;
- Adopt and implement ambitious policies and programs to reduce GHG emissions;
- Encourage climate change resilience and coordination across all sectors;
- Reduce climate pollution while building the clean energy economy in a way that benefits all, provides new workforce training opportunities, and effectively addresses environmental injustices of Guam's most disadvantaged.

Although small islands contribute less than 1% of GHG emissions globally[1], Guam officials recognize that climate change is a defining issue of our time and that its impacts will pose serious challenges to our infrastructure, economy, and unique natural resources. This PCAP will be an important step towards accelerating emissions reductions and strengthening climate change resilience for Guam.

[1] UNDP. (2022). THE STATE OF CLIMATE AMBITION SMALL ISLAND DEVELOPING STATES (SIDS). Retrieved from https://climatepromise.undp.org/sites/default/files/research_report_document/Climate%20Ambition-SIDS%20v2.pdf

1 Overview and Background

1.1 Climate Change

Over centuries, human activities have emitted an increasing amount of GHGs into the atmosphere through the burning of fossil fuels, changes in land use, and global deforestation[2,3]. GHGs, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), naturally trap heat in the Earth's atmosphere. However, increased human activities have driven an increase in global surface temperatures along with other widespread changes in climate. Across the world, communities are experiencing more deadly and extreme weather and climate-related events, as well as changes in average climate conditions.

1.2 The Effects of Climate Change in Guam

Islands across the Pacific are experiencing climate change impacts that affect the sustenance of communities, human health, infrastructure, ecosystems, and cultural and historical resources[4]. Guam, an unincorporated territory of the United States, is the largest and southernmost island of the Mariana Islands Archipelago within Micronesia. Climate change is expected to affect all people of Guam and impair access to healthy food and water, undermine human health, threaten infrastructure and local economies, exacerbate existing inequities, and threaten tropical ecosystems and biodiversity. Climate related impacts in Guam are described in Table 1.

Table 1. **Climate change related impacts in Guam.** These impacts are outlined in the 5th National Climate Assessment Chapter 30 Hawai'i and US-Affiliated Pacific Islands[4].

Resources Impacted	Impacts
Water	The Northern Lens Aquifer, which supplies 80% of the island's drinking water, is at risk from hotter weather, drought, and population increase.
Food security	Fisheries are at risk of a decline which supports the subsistence and dietary needs for many communities.
Human health	Intensity and frequency of extreme events such as flash flooding, drought, and wildfire, could negatively impact human health and safety.

[2] Karl, T. R. (2003). Modern Global Climate Change. Science, 302(5651), 1719–1723. https://doi.org/10.1126/science.1090228

[3] Grecni, Z., Miles, W., King, R., Frazier, A., & Keener, V. (2020). Climate Change in Guam: Indicators and Considerations for Key Sectors. Report for the Pacific Islands Regional Climate Assessment. Honolulu, HI: East-West Center. https://doi.org/10.5281/zenodo.4037481

[4] Frazier, A.G., M.-V.V. Johnson, L. Berio Fortini, C.P. Giardina, Z.N. Grecni, H.H. Kane, V.W. Keener, R. King, R.A. MacKenzie, M. Nobrega-Olivera, K.L.L. Oleson, C.K. Shuler, A.K. Singeo, C.D. Storlazzi, R.J. Wallsgrove, and P.A. Woodworth-Jefcoats, 2023: Ch. 30. Hawai'i and US-Affiliated Pacific Islands. In: Fifth National Climate Assessment. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH30

Built environment	Stronger typhoons and storms will increase the potential for damage to infrastructure.
Ecosystems	Increased frequency of coral bleaching and risk of wildfires will impact Guam's ecosystems.
Cultural and historical resources	Sea level rise will impact many cultural and historical resources located along the coast.

1.3 Addressing the Global Climate Crisis on a Local Scale

Many Pacific Islands have adopted the 17 United Nations Sustainable Development Goals (SDGs) as a path towards climate resilience within the region. These goals are an urgent call for action by all countries that recognizes ending poverty and other deprivations must work in tandem with strategies that improve health and education, reduce inequality, and spur economic growth while addressing climate change and working to preserve our natural resources[5].

In response to this call to action, Governor Lourdes A. Leon Guerrero and Lieutenant Governor Joshua F. Tenorio signed Executive Order No. 2019-23 in 2019, which formed the Guam Green Growth (G3) Working Group. In 2020, the G3 Working Group then created the G3 Action Framework, aligned with the UN's 17 SDGs, that is a compilation of hundreds of goals, objectives, metrics, action items, action leads, and partnerships to achieve a sustainable future for Guam. The G3 Action Framework focuses on five categories of action that include: 1) Healthy and Prosperous Communities, 2) Educated, Capable, and Compassionate Island, 3) Sustainable Homes, Utilities, and Transportation, 4) Thriving Natural Resources, and 5) Sustainable Alliances. G3 is Guam's strategy to take local action to achieve global impact by incorporating cross-cutting elements such as climate action, resilience, public engagement, policy, and the core CHamoru values of respect, cooperation, kindness, generosity, and dignity to all categories.

In an effort to proactively address climate change and increase climate action and resilience in Guam, Governor Lourdes A. Leon Guerrero and Lieutenant Governor Joshua F. Tenorio signed Executive Order No. 2019-19 in 2019 which created the Climate Change Resiliency Commission (CCRC). The main objective of the CCRC is to develop an integrated strategy to build resilience against the adverse effects of climate change and to reduce contributing factors, such as targeting the reduction of GHG emissions. The CCRC will focus on measures that include renewable energy, conservation of natural resources of the ocean and land, infrastructure and community resilience, development planning, food security, public health and safety, and reductions in GHGs.

[5] United Nations. (2023). The 17 sustainable development goals. Retrieved from United Nations website: https://sdgs.un.org/goals

2 Climate Pollution Reduction Grants Program

2.1 Overview

Through the Inflation Reduction Act of 2022, the U.S. Environmental Protection Agency (EPA) Climate Pollution Reduction Grants (CPRG) program provides tools to pursue GHG pollution reductions by supporting the development and expansion of territorial climate action plans and the implementation of investment-ready policies, programs, and projects. The main objectives of the CPRG program are to tackle climate pollution while supporting the creation of good jobs and lowering energy costs for families, to accelerate work that addresses environmental injustices, empower community-driven solutions, and to deliver cleaner air by reducing harmful air pollution in places where people live, work, play, and learn.

The PCAP is a narrative report that is meant to highlight a focused list of near-term, high-priority, implementation-ready measures to reduce GHG pollution in Guam. The PCAP also includes an analysis of GHG emissions reductions that will be achieved through implementation focusing on different sectors in Guam. The main sections of this PCAP include:

- A GHG inventory of Guam's priority sectors;
- A list of quantified GHG reduction measures;
- A benefits analysis of GHG reduction measures;
- A review of authority to implement GHG reduction measures.

The expected outcomes of the PCAP are to reduce tons of pollution over the lifetime of the GHG reduction measures identified in the PCAP and to reduce tons of pollution on an annual basis. Other potential outcomes of the PCAP are to improve upon staff capacity to implement policies to address climate change, enhance community engagement, improve ambient air quality, achieve health benefits, increase public awareness of GHG reduction projects and results, and create high-quality jobs with an emphasis on workers from underserved populations.

2.2 Approach and Methods

The development of the PCAP was managed by the CCRC with the support of the Climate Change Resilience Coordinator hired under the University of Guam Center for Island Sustainability and Sea Grant (UOG CIS & SG). Development of the PCAP involved critical research, data collection, community engagement and outreach, and meaningful collaboration with partners and stakeholders.

Research and Data Collection
The Climate Change Resilience Coordinator hired under UOG CIS & SG worked to compile existing climate change related data for Guam. There are many useful texts that address

climate change in Guam, such as the Climate Change in Guam: Indicators and Considerations in Key Sectors report developed by the Pacific Islands Regional Climate Assessment (PIRCA) and Chapter 30 Hawai'i and US-Affiliated Pacific Islands of the Fifth National Climate Assessment Report. As a part of this project and the G3 Action Framework SDGs, work is ongoing to compile and create a living, open access repository of climate change related reports and research for Guam.

The GHG inventory included in the PCAP is the first GHG inventory of priority sectors for Guam. The priority sectors identified for Guam are electricity generation, transportation, solid waste, wastewater treatment, and carbon removal through forest management. Pre-existing GHG emissions data was not readily available across all sectors. Well documented emissions data only existed for the energy and solid waste sectors. Collaboration with various agencies was vital to filling in the data gaps for other priority sectors. The National Renewable Energy Laboratory (NREL) provided their expertise and assisted in the formation of Guam's GHG inventory of priority sectors.

GHG reduction measure data was collected from various implementing agencies through various meetings, correspondence, and collaboration. Implementing agencies were responsible for providing the information needed for each reduction measure which included authority to implement, implementation milestones, geographic location of measure, funding sources, metrics tracking, cost of project, annual estimated GHG and criteria air pollutant (CAP) emissions reductions, implementation authority milestones, and workforce development activities. The workforce development activity data for each reduction measure was compiled for the workforce planning analysis. A benefits analysis and a co-pollutant emissions inventory was conducted by NREL using data collected by the Guam Power Authority (GPA).

Meaningful Collaboration with Partners and Stakeholders

Interagency meetings were held throughout the creation of the PCAP to engage with implementing government agencies. The intent of these meetings were to present information about the CPRG program and the main deliverables of the project to potential partners and collaborators. These meetings were also used as a tool to gather information and feedback from various agencies and organizations regarding the PCAP.

Community Engagement and Outreach

UOG CIS & SG created a website dedicated to the CPRG program for Guam. The website contains information about the CPRG program, the PCAP, the Comprehensive Climate Action Plan (CCAP), and the CPRG planning initiative for Guam. The website also provides contact information for the project team and a list of upcoming events and resources. This website will be used as a tool for the public and various stakeholders to have access to more information regarding this program. The final PCAP will also be published on the website for public access. The website can be found at the UOG CIS & SG website: https://seagrant.uog.edu/cprg/. Outreach to the public about the project was also

conducted at various community events throughout the island. The final PCAP will be presented at the 15th UOG Conference on Island Sustainability under the Science for Climate Action pathway.

2.3 Scope of the PCAP

The scope of this PCAP covers the entire island of Guam which is the largest in size, the most populated, and the southernmost of the 15 Mariana Islands. The island covers an area of 214 square miles with a population of 170,534. Guam is also a part of the vast region of Micronesia made up of more than 2,000 islands.

The funding to develop this project was awarded by the U.S. EPA CPRG Program to the Guam State Clearinghouse in August 2023. UOG CIS & SG is the subgrantee for this project funding. A coordinator was hired at the UOG CIS & SG office in September 2023 to manage the CPRG project for Guam. A Quality Assurance Project Plan (QAPP) was developed for the project and approved by U.S. EPA in December 2023. Data collection and coordination with various project partners were ongoing throughout the development of the PCAP.

Authority for decision-making was held by the main grant recipient, the Guam State Clearinghouse Office, and the subgrantee co-principal investigators of this project. Project management was handled by the Climate Change Resilience Coordinator hired at UOG CIS & SG.

2.4 Guam PCAP Management and Development Team

This section describes the organizations and individuals involved in the creation of the PCAP.

Table 2. Grant Recipient organizational chart. This chart outlines the main grant recipient and subgrant recipient structure for the EPA CPRG Planning Grant for Guam.

Main Grant Recipient	Office of the Governor of Guam - Guam State Clearinghouse
Subgrant Recipient	University of Guam Center for Island Sustainability and Sea Grant

Table 3. Subgrant Recipient organizational chart. This chart outlines the subgrantee organization chart for the EPA CPRG Planning Grant for Guam.

Organizational Title	Name	Agency/Affiliation
Subgrant Co-Principal Investigator	Evangeline Lujan	CCRC
Subgrant Co-Principal Investigator	Fran Castro	UOG CIS & SG
Subgrant Coordinator	Renee Crisostomo	UOG CIS & SG
Subgrant Technical Assistance	Carlotta Leon Guerrero	Office of the Governor

Subgrant Technical Assistance	Romina King, PhD	UOG/PI-CASC
Subgrant Technical Assistance	Clementine Schnabel	Micronesia Challenge
Subgrant Technical Assistance	Rudy Paulino	GEPA

2.5 Special Considerations for Guam Entities

As an island in the middle of the Pacific, Guam faces the issue of geographic isolation which can make development and implementation of GHG reduction measures difficult. These issues include high shipping costs, difficulty procuring technology and equipment, and a reliance on fossil fuels in the travel, mobile and shipping industries. Another issue Guam faces is the lack of available GHG emission data across all sectors. This lack of available data also makes enacting GHG emission-related policies challenging.

3 Priority Greenhouse Gas Inventory

A greenhouse gas (GHG) inventory is a list of emission sources and the associated emissions quantified using standardized methods. GHG inventories are developed for a variety of reasons which include managing GHG risks and identifying reduction opportunities, participating in voluntary or mandatory GHG programs, participating in GHG markets, and/or achieving recognition for early voluntary action.

For Guam's Priority GHG Inventory, priority sectors were identified by local stakeholders that include electricity generation, transportation, solid waste, wastewater treatment, and carbon removal through forest management. These priority sectors align with Guam's priority actions for emissions reductions which are outlined in Section 4 GHG Reduction Measures. Emissions are measured by metric tons of carbon dioxide equivalent, or MT CO_2e. This unit represents an amount of GHG whose atmospheric impact has been standardized to that of one unit mass of carbon dioxide, based on the global warming potential of the gas. The table and chart below outlines the GHG emissions estimated for each priority sector.

Table 4. Estimated GHG Emissions by Sector. Estimated GHG emissions per emissions source category are measured in metric tons of carbon dioxide equivalent (MT CO_2e). Percent totals represent each source category's contribution to the overall gross emissions.

Emissions Source Category	Metric Tons of Carbon Dioxide Equivalent (MT CO_2e)	Percent of Total
Stationary Combustion (from GPA Electricity Generation)	1,184,497	45%
Mobile Combustion (from road vehicles)	1,364,018	52%
Solid Waste	45,404	2%
Wastewater Treatment	18,839	1%
Subtotal Gross Emissions of Priority Sectors for PCAP	**2,612,758**	
Urban Forestry	*-110,192*	*-4%*
Subtotal Net Emissions of Priority Sectors for PCAP	***2,502,566***	

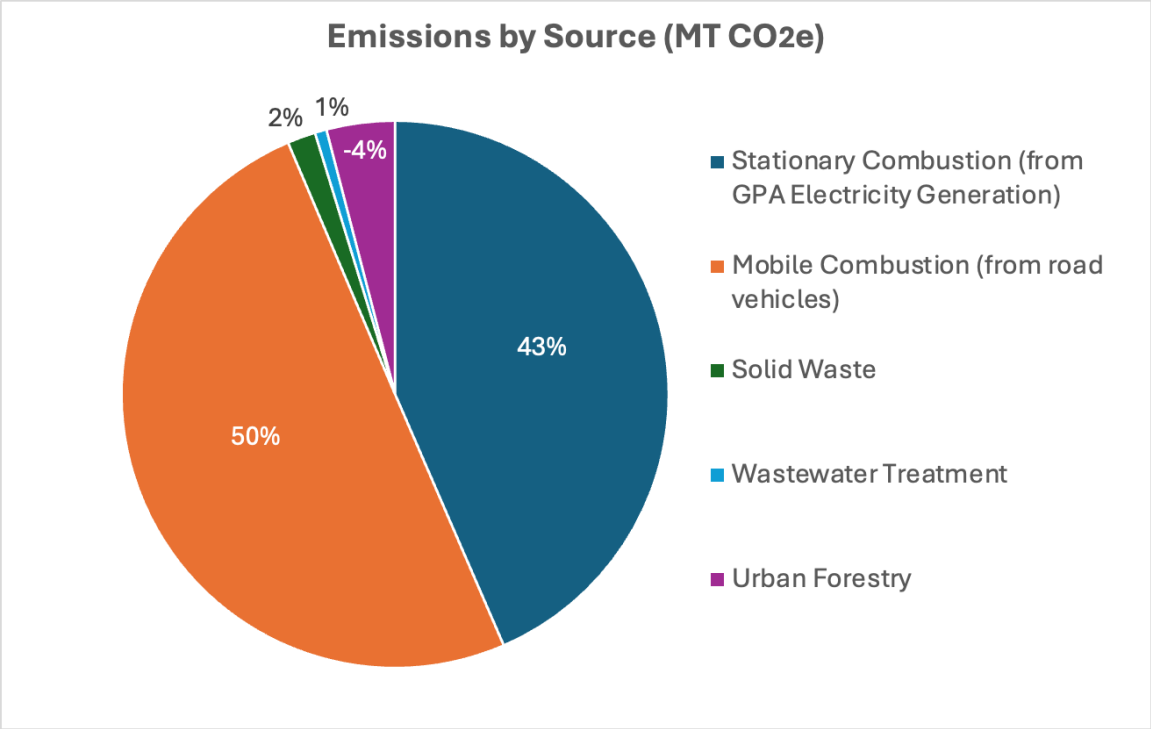

Figure 1. Emissions by Source (MT CO_2e). Each chart section represents a different sector and the percent of total emissions for Guam priority sectors.

3.1 Electricity Generation Sector Emissions

Stationary combustion emissions from Guam Power Authority (GPA) electricity generation can be disaggregated by customer class (i.e. consuming sector) as follows:

Table 5. Emissions for Electricity Generation by Customer Class. Emissions from GPA electricity generation can be disaggregated by customer class (i.e. consuming sector). Percent totals represent GPA-supplied electricity sales by end-use sector in 2021. Estimated emissions are measured in MT CO_2e.

Emissions by Customer Class	Metric Tons of Carbon Dioxide Equivalent (MT CO_2e)	Percent of Total
Residential	450,109	38%
Small Commercial and Government	284,279	24%
Large Commercial and Government	213,209	18%
US Navy	238,899	20%

Combining the emissions estimates above with electricity sales data from GPA, a grid average emissions factor can be derived as follows:

- Guam Annual Average Grid Emissions Factor (2022)
  - 1,184,497 MT CO_2e / 1,535,372 MWh = **0.77 MT CO_2e/MWh *(1,701 lbs. CO_2e/MWh)***

For comparison and benchmarking, the Guam emissions factor is shown below with other comparable data points in Figure 2. Emissions factors are a fundamental tool in developing GHG inventories for air quality management decisions and in developing emissions control strategies. The emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant.

Stationary combustion emissions were determined based on fuel consumed by GPA for power generation and averaged over FY2016-FY2023. This average was calculated to be 14,836,584.90 gallons of Distillate Fuel Oil. This data was extracted from GPA's Annual Fuel Consumption and Fuel Consuming Generating Units database.

GHG emissions calculated from this activity data may not represent all electricity consumption in the territory. Only GPA power generation is represented. Additional sources of emissions from electricity generation may include private/independent generators supplying electricity locally to homes, businesses, hotels/resorts, etc. These other sources of electricity-based emissions data were not collected for the PCAP, but should be quantified for more comprehensive GHG inventories in the future.

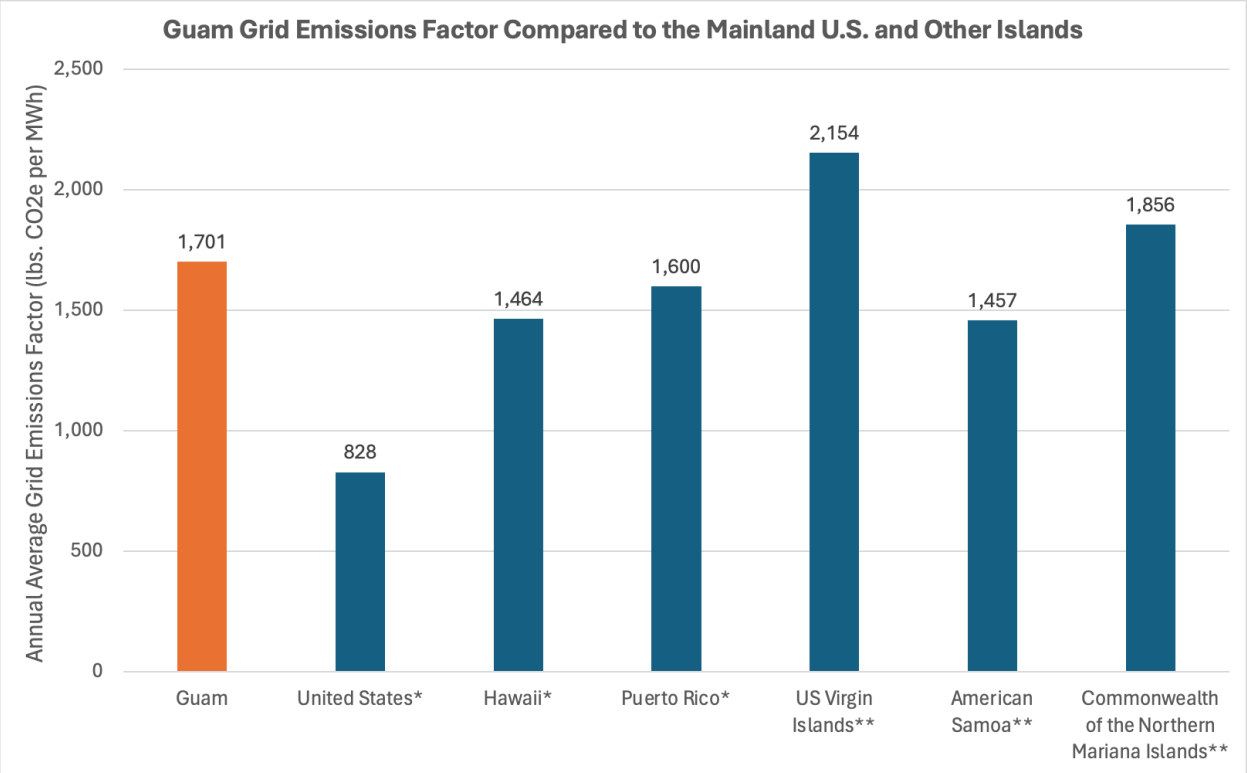

Figure 2. Guam Grid Emissions Factor Compared to the Mainland U.S. and Other Islands. Guam's average grid emissions factor is shown with other comparable data points from the US and other islands. Annual average grid emissions factor is calculated by dividing stationary combustion emissions by the location's population. *Source: EPA eGRID 2022. **Preliminary estimate calculated by NREL for U.S. EPA CPRG PCAPs.

3.2 Transportation Sector Emissions

Quantifying Mobile Combustion emissions from road transportation ideally requires data representing the fuel consumption and vehicle miles traveled (VMT) for each type of vehicle operating on the roads within the geographic area of a community GHG inventory. However, this level of detail is typically difficult to obtain and assumptions are needed to fill in the blanks. In the case of this GHG inventory for Guam, the estimates for road transportation emissions were based on actual fuel sales data and vehicle licensing data[6]. The following assumptions were made to support the quantification of GHG emissions estimates:

- Licensed Motor Vehicle data were reorganized and mapped to the motor vehicle types found in the EPA Local GHG Inventory Tool.

- Gasoline and diesel fuel use values were prorated to each vehicle category. Other manual adjustments were made to fuel use in particular vehicle categories to help

[6] Bureau of Statistics and Plans. (2022). 2021 Guam Statistical Yearbook.

refine the data, such as setting diesel use for motorcycles to zero and reallocating diesel use to other categories.

- VMT values for each vehicle category were estimated by multiplying the assumed fuel use for a particular category by the EPA-default fuel economy (miles per gallon) for that vehicle type.

These assumptions may result in overcounting the VMT, which would cause methane (CH_4) and nitrous oxide (N_2O) emissions estimates to be abnormally high. However, carbon dioxide (CO_2) emissions – the primary greenhouse gas – are influenced only by the volume of fuel combusted. Therefore, the overall GHG emissions for the Mobile Combustion category are most sensitive to the fuel consumption data (i.e., gallons of gasoline, gallons of diesel).

Mobile combustion emissions were determined based on fuel consumed for road transportation for 2022 using a historical average from FY2017-FY2021. This data came from the 2021 Guam Statistical Yearbook produced by the Guam Bureau of Statistics and Plans[7]. VMT was estimated based on Guam vehicle registration data grouped by vehicle type and EPA average fuel efficiencies for different vehicle types.

Guam licensed motor vehicle data from the 2021 Statistical Yearbook indicated an average of 114,782 total registered vehicles from FY2017 – FY2021, which were then grouped according to the vehicle types provided by the EPA Local GrHG Inventory Tool. These vehicle type categories were assigned fuel consumption values for gasoline and diesel, based on prorated portions of the assumed total consumption for each fuel type. Finally, the assumed volumes of gasoline and diesel fuel for each vehicle type were used with U.S. EPA average fuel efficiencies (by vehicle type) to determine an assumed VMT. Transportation emissions by fuel type are outlined in Table 6. Mobile combustion emissions per capita with other comparable data points are outlined in Figure 3.

Table 6. Transportation Emissions by Fuel Type for Guam. Calculated emissions by fuel type are estimated by each GHG and calculated into MT CO_2e for overall emissions totals.

Guam Transportation Emissions by Fuel Type				
Fuel	**MT CO_2**	**MT CH_4**	**MT N_2O**	**MT CO_2e**
Gasoline	458,220	4,981	10,394	473,594
Diesel	460,514	60	632	461,205
Jet Fuel	429,218	-	3,566	432,784
Totals	***1,347,952***	***5,040***	***14,591***	***1,367,583***

[7] Bureau of Statistics and Plans. (2022). 2021 Guam Statistical Yearbook.

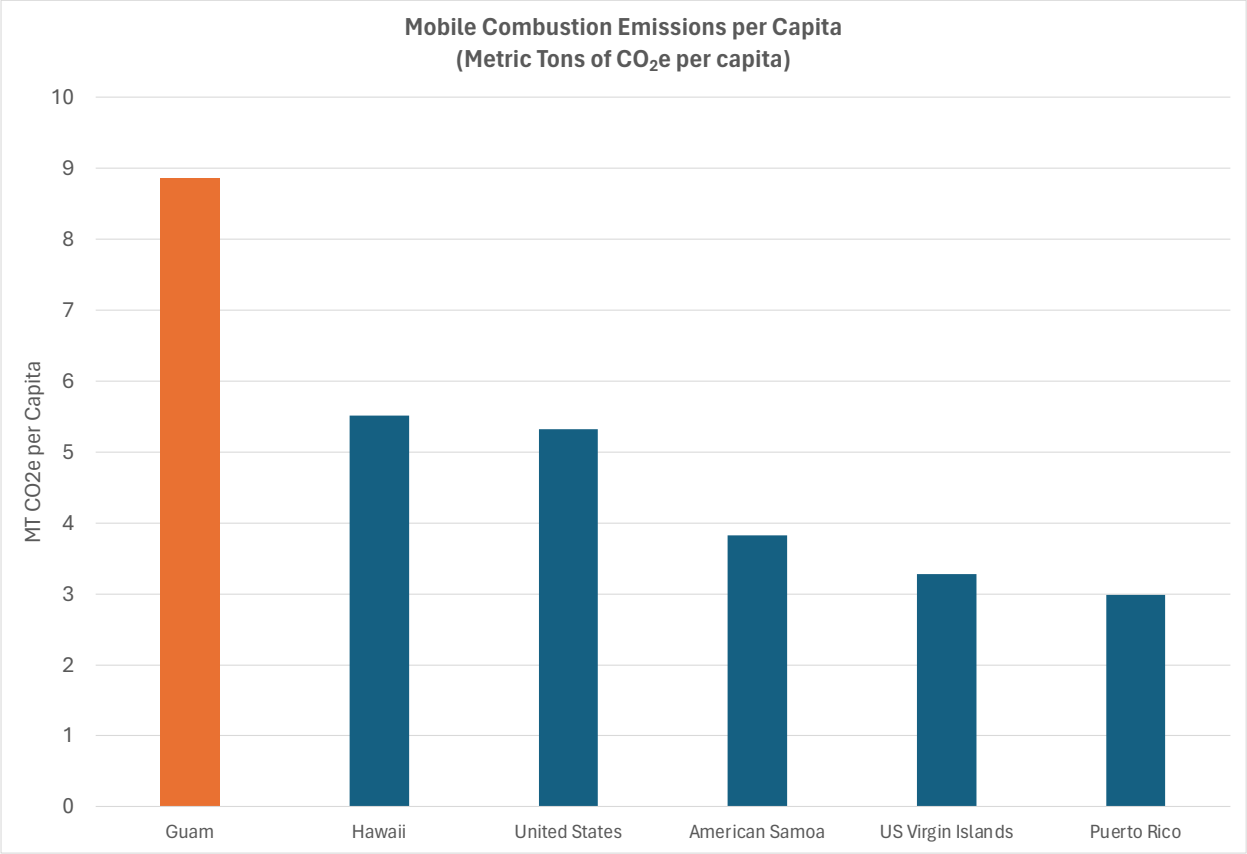

Figure 3. Mobile Combustion Emissions per Capita. Guam's mobile combustion emissions per capita compared to the mainland U.S. and other islands. MT CO_2e per capita is calculated by dividing mobile combustion emissions by the location's population.

3.3 Solid Waste Sector Emissions

Solid waste emissions have been determined on landfill characteristics, such as the presence or lack of landfill gas (LFG) collection systems. Layon Landfill, a landfill with no LFG collection system, was evaluated using the California Air Resources Board's Landfill Emissions Tool using data on annual waste deposited in the landfill. Ordot Dump, a landfill with a comprehensive LFG collection system, was evaluated using data on volume of LFG collected, fraction of CH_4 in LFG, and the CH_4 collection efficiency. Landfill emissions by landfill system are outlined in Table 7.

Table 7. Landfill Emissions in Guam. Emissions estimates for the Layon Landfill and Ordot Dump in Guam. Layon Landfill has no LFG collection. Ordot Dump has a comprehensive LFG collection in place. Emissions are measured in MT CO_2e.

Landfill System	MT CO_2e
Layon Landfill (No LFG collection)	44,589
Ordot Dump (Comprehensive LFG Collection)	815
Total Emissions from Landfills	**45,404**

3.4 Wastewater Treatment Sector Emissions

Wastewater treatment emissions have been determined based on wastewater treatment plant (WWTP) characteristics, such as type of treatment applied (aerobic or anaerobic), availability of data on digester gas production, and population size served by septic systems. WWTP data was provided by GWA:

- Population served by facilities with nitrification/denitrification = 45,989
- Population served by facilities without nitrification/denitrification = 44,566
- Population served by aerobic treatment facilities = 90,555
- Population served by septic systems = 63,281
- Average total nitrogen discharged (kg N/day) = 24.01175

Table 8. Wastewater treatment Emissions in Guam. CH_4 and N_2O emissions of wastewater are measured in MT CO_2e.

Emissions Type	MT CO_2e
CH_4	17,473
N_2O	1,364
Total Emissions from Wastewater Treatment	**18,837**

3.5 Carbon Removal through Forest Management Sector

Carbon removal through Forest Management was estimated by calculating the percent of urban area with tree cover using data from the Guam Forest Action Plan 2020-2030[8]. Urban forestry sequestration has been estimated based on the following data:

- Total Urban Area = ~358 km^2
- % of Urban Area with Tree Cover = ~41%

3.6 Other Sectors to Consider

Seagrass meadows and mangrove forest ecosystems in Guam are relatively small and understudied and will need to be properly quantified and monitored in order to estimate their blue carbon. Presently, initial steps for blue carbon efforts in Guam can include (1) formally acknowledging the value of blue carbon, and (2) maintaining the current existing blue carbon ecosystems in marine preserves and other areas. With additional funding, research capacity, and policy discussion, a better understanding of blue carbon stocks can

[8] Guam Department of Agriculture Forestry & Soil Resources Division. (2021). Guam Forest Action Plan 2020-2030.

be obtained and guide future efforts. Moving forward, Guam may seek to join blue carbon programs that are a part of broader United States or Pacific carbon sequestration programs or goals, and utilize resources from federal agencies like the United States Geological Survey (USGS) and National Oceanic Atmospheric Administration (NOAA). Guam can also learn from other pacific islands, such as Palau, which has monitoring plans for mangrove ecosystems and existing blue carbon estimation efforts.

Other sectors that Guam may consider in the comprehensive GHG inventory include waste generation and agriculture and land management which will be covered by the CCAP.

4 GHG Reduction Measures

This section provides a list of near-term, high-priority, implementation-ready GHG reduction measures that target various sectors in Guam that seek to achieve the most significant GHG reductions possible. Each measure provides a cost estimate of the measure, a list of key implementing agencies, the target priority sector, an estimate of quantifiable GHG emissions reductions, an implementation schedule and milestones, metrics for tracking progress, the expected geographic location of the measure, and an identification of funding source(s).

4.1 Electricity Generation Sector

Electricity Generation Measure #1: Guam Green Growth (G3) Renewable Energy Project

Project Description
This project will install a 100kWh solar generating renewable energy system that will increase Guam's contribution toward renewable energy and reduce the island's reliance and expenditures on imported fuel. The solar generating system will include a total of 255 solar frames to be installed at the CHamoru Village, located in the capital village of Hagåtña. A portion of this project includes the installation of electric vehicle (EV) chargers. This portion of the project can be found under Section 4.2 Transportation Sector under Transportation Measure #1.

Cost Estimate and Funding Sources
This project is budgeted to cost $1,539,436.00. Funds were awarded to implement this project through the U.S. Office of Insular Affairs - Energizing Insular Communities program.

Implementing Agencies and Partners
UOG CIS & SG will be in charge of implementing this project with support from Guam Green Growth (G3), Department of CHamoru Affairs, Guam Energy Office (GEO), Guam Power Authority (GPA), and the Office of the Governor and Lieutenant Governor.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 94.7 metric tons CO_2e annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:
- Hire project coordinator to oversee the project
- Secure vendor under UOG's formal procurement process
- Project coordinator and vendor will work with partner agencies to secure all required permits, review design plans, and satisfy all utility criteria
- Vendor orders solar panels and inverters
- Vendor erects carport structures and installs solar energy system

Metrics for Tracking Progress of Measure
Metrics will include monthly reporting by the project coordinator and semi-annual programmatic reporting and financial reporting (or as required) to the Office of Insular Affairs Energizing Insular Communities (OIA-EIC) Program.

Location of Measure
CHamoru Village (Hagåtña, Guam)

Electricity Generation Measure #2: Installation of Solar Panels at Layon Landfill

Project Description
Guam Solid Waste Authority (GSWA) will install solar panels at the Layon Landfill spanning the 300 acre property. The solar farm will entail a "leapfrogging" system that will be implemented wherein when an active disposal area is filled and reaches closure, a new disposal area will be used and the solar panels will be relocated to the filled and closed disposal cell. This system will assure constant energy production.

Cost Estimate and Funding Sources
This project is budgeted to cost $3,700,000.00. GSWA has identified $500,000 to fund the Layon Landfill Infrastructure Plan with the intent to apply for the U.S. EPA CPRG Program Implementation Grant for implementation.

Implementing Agencies and Partners
GSWA will be in charge of implementing this project with oversight from the GSWA Board and support from GPA.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 107,090 metric tons CO_2e annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:
- Development of Layon infrastructure Request for Proposal
- Development engineering study
- Construction of transmission line
- Grading of site for panel placement
- Upgrading stormwater management system
- Procurement of solar energy system
- Solar energy system placement and construction

Metrics for Tracking Progress of Measure
Metrics will include a published project overview, monthly status updates, and final reports on construction and operation.

Location of Measure
Layon Landfill (Inalåhan, Guam)

Electricity Generation Measure #3: Solar for All Guam

Project Description
This project will work to make solar energy accessible to low-income households through the creation of a loan program with advantageous rates to install solar PV systems.

Cost Estimate and Funding Sources
This project is budgeted to cost $100,000,000.00. Funding was applied for through the U.S. Environmental Protection Agency – Solar for All program. Award of funding status is pending.

Implementing Agencies and Partners
GEO will be the lead applicant of this grant to ensure households meet income criteria and will guide and direct interested families toward the loan program. GPA will provide their technical expertise and conduct energy audits and rooftop assessments of eligible households. Guam Economic Development Authority (GEDA) will oversee the creation and management of the loan program and administer loan funds to eligible families. UOG CIS & SG will oversee outreach and workforce development.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 113,987.22 metric tons CO_2e over the course of the 5-year project.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Program planning for project
- Hire staff to implement and manage project
- Procurement of solar energy systems and other equipment
- Education and outreach material development
- Outreach and marketing
- Loan deployment process
- Issuance of solar systems for 4 years (1,170 total throughout program)
- Recruitment and implementation of workforce development program for 4 years (4 cohorts total)

Metrics for Tracking Progress of Measure
Metrics will include annual reporting and a collection of annual reporting from various partnering agencies and the final reporting required at the end of the grant period.

Location of Measure
Guam

Electricity Generation Measure #4: Standalone BESS Grid Services

Project Description
GPA requires 180 MW/720MWh of standalone BESS (Battery Energy Storage Systems) to provide grid services to the island. The BESS will be built across five (5) different sites. This project will also include the development of an autonomous grid controller that will receive system data including real-time synchrophasor data over GPA's secure fiber optic network. The grid controller will identify grid stability issues and take actions to remediate them before they jeopardize the grid.

Cost Estimate and Funding Sources
This project was budgeted to cost $374,000,000.00. Identified funding for this project will include a combination of Levelized Energy Adjustment Clause (LEAC) and Capital Funding.

Implementing Agencies and Partners
GPA will be the sole implementing agency on this project.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 462,436.20 metric tons CO_2e, 468.94 metric tons CH_4, and 1,117.95 metric tons N_2O annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Select sites for BESS installation
- Develop bid documents for BESS procurement including the autonomous grid controller
- Conduct procurement process
- Select contractors and award bids
- Obtain Consolidated Commission on Utilities (CCU) and Public Utilities Commission (PUC) approvals of contracts
- Conduct system impact studies
- Execute projects including integrating systems with GPA system protection and grid controls through supervisory control and data acquisition (SCADA)
- Test systems
- Operate and maintain systems

Metrics for Tracking Progress of Measure
GPA will use its standard metrics for construction management. In addition, GPA will provide a dashboard with the following performance measurements:

- System time deviation
- Solar photovoltaic (PV) production dropout stabilization events
- Synchronous generation trip events stabilization
- Number of stability events identified and ameliorated

- Phase IV projects already track GHG emissions reductions

Location of Measure
Five (5) of GPA's substations in Guam

Electricity Generation Measure #5: Solar Virtual Power Plant Program – GDOE School Focus

Project Description
Guam Power Authority (GPA) will implement a Solar PV Virtual Power Plant that will target Guam Department of Education (GDOE) Schools for installation of solar PV systems and standalone plug and play microgrid controllers under a hierarchical control scheme. GDOE will be paid a fixed negotiated rate for use of their rooftops and ground level properties and will be charged the lesser of the solar PV power purchase agreement (PPA) rate and the LEAC rate in lieu of the LEAC tariff (fuel charge) for energy consumed by the school.

Cost Estimate and Funding Sources
This project was budgeted to cost $56,500,000.00. LEAC Funding has been identified to fund implementation of this project.

Implementing Agencies and Partners
GPA will be the sole implementing agency on this project.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 23,480.34 metric tons CO_2e, 23.81 metric tons CH_4, and 56.76 metric tons N_2O annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Assess school rooftops for suitability
- Select schools for solar PV installation
- For each school, develop bid documents for Solar PV System procurement
- For each school, develop bid documents for modular microgrid controller
- Conduct procurement process
- Select contractors and award bids
- Obtain CCU and PUC approvals of contracts
- Execute projects
- Negotiate GDOE "rental" payment
- Operate and maintain systems

Metrics for Tracking Progress of Measure
GPA will use its standard metrics for Construction Management. In addition, GPA will

provide a dashboard for all schools for all schools on a publicly accessible website showing each schools dashboard and a summary total of all schools' metrics. This dashboard is the Solar PV Virtual Power Plant Program Performance Dashboard.

Location of Measure
Various GDOE schools in Guam

Electricity Generation Measure #5: Solar Virtual Power Plant Program – GDOE School Focus

Project Description
Guam Power Authority (GPA) will implement a Solar PV Virtual Power Plant that will target Guam Department of Education (GDOE) Schools for installation of solar PV systems and standalone plug and play microgrid controllers under a hierarchical control scheme. GDOE will be paid a fixed negotiated rate for use of their rooftops and ground level properties and will be charged the lesser of the solar PV power purchase agreement (PPA) rate and the LEAC rate in lieu of the LEAC tariff (fuel charge) for energy consumed by the school.

Cost Estimate and Funding Sources
This project was budgeted to cost $56,500,000.00. LEAC Funding has been identified to fund implementation of this project.

Implementing Agencies and Partners
GPA will be the sole implementing agency on this project.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 23,480.34 metric tons CO_2e, 23.81 metric tons CH_4, and 56.76 metric tons N_2O annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Assess school rooftops for suitability
- Select schools for solar PV installation
- For each school, develop bid documents for Solar PV System procurement
- For each school, develop bid documents for modular microgrid controller
- Conduct procurement process
- Select contractors and award bids
- Obtain CCU and PUC approvals of contracts
- Execute projects
- Negotiate GDOE "rental" payment
- Operate and maintain systems

Metrics for Tracking Progress of Measure
GPA will use its standard metrics for Construction Management. In addition, GPA will provide a dashboard for all schools for all schools on a publicly accessible website showing each schools dashboard and a summary total of all schools' metrics. This dashboard is the Solar PV Virtual Power Plant Program Performance Dashboard.

Location of Measure
Various GDOE schools in Guam

Electricity Generation Measure #6: Greening Cultural Facilities

Project Description
The Guam and Chamorro Educational Facility (GCEF), also known as the Guam Museum, a division Department of Chamorro Affairs shall reduce the negative effects of fuel generation with environmentally friendly alternatives as a part of its existing policy on green and clean energy sources. The project allows the implementation of natural resources for clean generation using solar and wind energy thus warranting the installation of a 100kWh solar and wind energy system. The Skinner Plaza on which the GCEF sits, is solar installation ready with Skinner Plaza on a daisy chain solar lighting system. Moreover, the GCEF is a part of the overall Guam and Chamorro cultural assets that includes historic parks and sites.

The project goal is to increase Guam's contribution toward renewable energy and reduce the island's reliance and expenditures on imported fuel. This shall be achieved with solar frames, inverters, and batteries as well as the installation of wind turbine, and EV chargers. This portion of the project can be found under Section 4.2 Transportation Sector under Transportation Measure #1.

Cost Estimate and Funding Sources
This project is budgeted to cost $3,250,00.00. Funds were awarded to implement this project through the U.S. Office of Insular Affairs - Energizing Insular Communities program.

Implementing Agencies and Partners
The Guam and Chamorro Educational Facility also known as the Guam Museum, a division of Department of Chamorro Affairs will oversee implementing this project with support from G3, Department of Chamorro Affairs, GEO, GPA, and the Office of the Governor and Lieutenant Governor.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 94.7 metric tons CO_2e annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Hire project coordinator to oversee the project
- Secure vendor under formal procurement process
- Project coordinator and vendor will work with partner agencies to secure all required permits, review design plans, and satisfy all utility criteria
- Vendor orders solar panels and inverters
- Vendor erects carport structures and installs solar energy system

4.2 Transportation Sector

Transportation Measure #1: Guam Green Growth (G3) Renewable Energy Project

Project Description
This project will install a total of ten (10) Level 2 EV chargers. Five (5) will be installed at the CHamoru Village in the village of Hagåtña and five (5) at the UOG campus in the village of Mangilao. A portion of this project includes the installation of a solar energy system which can be found under Section 4.1 Energy Sector under Energy Measure #1.

Cost Estimate and Funding Sources
This project is budgeted to cost $1,539,436.00. Funds were awarded to implement this project through the U.S. Office of Insular Affairs - Energizing Insular Communities program.

Implementing Agencies and Partners
UOG CIS & SG will be in charge of implementing this project with support from G3, Department of CHamoru Affairs, GEO, GPA, and the Office of the Governor and Lieutenant Governor.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 3.8 metric tons CO_2e annually per electric vehicle charged.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Hire project coordinator to oversee the project
- Secure vendor under UOG's formal procurement process
- Project coordinator and hired contractor will work with partner agencies to secure all required permits, review design plans, and satisfy all utility criteria
- Vendor orders EV charging systems
- Vendor installs EV charging stations
- Purchase electric vehicles to be used for program activities

Metrics for Tracking Progress of Measure
Metrics will include monthly reporting by the project coordinator and semi-annual programmatic reporting and financial reporting (or as required) to the OIA-EIC Program.

Location of Measure
CHamoru Village (Hagåtña, Guam) and UOG (Mangilao, Guam)

Transportation Measure #2: Replacing GWA's Fleet with EVs

Project Description
Guam Waterworks Authority (GWA) will reduce transportation emissions by replacing twenty (20) vehicles of their vehicle fleet with EVs. This project will also work to install EV charging stations for agency use.

Cost Estimate and Funding Sources
This project is budgeted to cost $2,000,000.00. GWA is intending to apply for U.S. EPA CPRG Program Implementation Grant funding.

Implementing Agencies and Partners
GWA will be the sole implementing agency on this project.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 283 metric tons CO_2e annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Publish scope of work and necessary procurement documentation
- Approval of the contract CCU
- Finalize purchase agreements
- Delivery of EV schedule
- Installation of EV charging stations

Metrics for Tracking Progress of Measure
Metrics will include tracking the number of EVs to be purchased, tracking vehicle usage and hours used, and tracking usage of EV chargers. These metrics will be included in a final report.

Location of Measure

GWA Main Facility, Mangilao, Guam

Transportation Measure #3: Replace the Guam Regional Transit Authority's (GRTA) Fleet with EVs

Project Description
The Guam Regional Transit Authority (GRTA) will reduce their transportation emissions by replacing ten (10) ADA compliant transit vehicles of their vehicle fleet with EVs through the Government of Guam competitive procurement process. This project will also include the installation of electric vehicle charging stations, batteries, and contractual for installation, maintenance, training, A&E design for charging stations for agency use.

Cost Estimate and Funding Sources
This project is budgeted to cost $4,695,000.00. The GRTA is intending to apply for U.S. EPA CPRG Program Implementation Grant funding.

Implementing Agencies and Partners
The GRTA will be in charge of implementing this project in collaboration with GPA, Bureau of Statistics and Plans (BSP), Office of the Attorney General (OAG) and Department of Administration General Services Agency (DOA GSA).

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 624 metric tons CO_2e annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Establish grant award
- Execute MOU with work request to subaward funds to GPA for the procurement of the A&E design, build, installation, maintenance, and training for the EV charging stations to include securing all required permits
- Prepare and execute Invitation for Bid (IFB) for the procurement of ten (10) ADA compliant EVs for transit to include electric vehicle operation, training, and maintenance of electric vehicle use
- Execution of GRTA subaward agreement to GPA for procurement of A&E design, build, installation, maintenance, and training of electric vehicle charging station
- Execution of electric vehicle for transit IFB contract
- Delivery of ten (10) ADA compliant electric vehicles for transit
- Implementation of electric vehicles
- Implementation of electric vehicle charging stations
- Training of maintenance of electric vehicle transit vehicles and charging stations
- Required reporting of programmatic and financial reporting, and metrics to grantor until grant close out

Metrics for Tracking Progress of Measure
Metrics include tracking the number of vehicles replaced with EVs, EV utilization (mileage) and hours used, number of EV charging stations installed, EV charging station utilization, the number of employees trained to operate and maintain EVs, and tracking the usage of EV chargers.

Location of Measure
GRTA Facility, Tamuning, Guam

Transportation Measure #4: Replace the Department of Public Works (DPW) Fleet with EVs

Project Description
The Department of Public Works (DPW) will reduce their transportation emissions by replacing ten (10) service vehicles of their vehicle fleet with EVs through the Government of Guam competitive procurement process. This project will also include the installation of EV charging stations, batteries, and contractual service for installation, maintenance, and training for agency use.

Cost Estimate and Funding Sources
This project is budgeted to cost $1,975,000.00. The DPW is intending to apply for U.S. EPA CPRG Program Implementation Grant funding.

Implementing Agencies and Partners
The DPW will be in charge of implementing this project in collaboration with the GPA, BSP, OAG, and DOA GSA.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 4.07 metric tons CO_2e annually per electric vehicle.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Establish grant award
- Execute MOU with work request to subaward funds to GPA for the procurement of the A&E design, build, installation, maintenance, and training for the EV charging stations to include securing all required permits
- Prepare and execute Invitation for Bid (IFB) for the procurement of ten (10) ADA compliant EVs for transit to include electric vehicle operation, training, and maintenance of electric vehicle use
- Execution of GRTA subaward agreement to GPA for procurement of A&E design, build, installation, maintenance, and training of electric vehicle charging station
- Execution of electric vehicle for transit IFB contract

- Delivery of ten (10) ADA compliant electric vehicles for transit
- Implementation of electric vehicles
- Implementation of electric vehicle charging stations
- Training of maintenance of electric vehicle transit vehicles and charging stations
- Required reporting of programmatic and financial reporting, and metrics to grantor until grant close out

Metrics for Tracking Progress of Measure
Metrics include tracking the number of vehicles replaced with EVs, EV utilization (mileage) and hours used, number of EV charging stations installed, EV charging station utilization, the number of employees trained to operate and maintain EVs, and tracking the usage of EV chargers.

Location of Measure
DPW Facility, Tamuning, Guam

4.3 Solid Waste Sector

Solid Waste Measure #1: Converting Waste Cooking Oil into Biodiesel

Project Description
GSWA will convert waste cooking oil into biodiesel fuel to be used for the agency's diesel fleet.

Cost Estimate and Funding Sources
This project is budgeted to cost $400,000.00. GSWA is intending to apply for U.S. EPA CPRG Program Implementation Grant funding.

Implementing Agencies and Partners
GSWA will be the lead implementing agency on this project with oversight from the GSWA Board.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 259 metric tons CO_2e and 4.17 kgs NO_2 annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Delivery contract for waste cooking oil
- Funding established
- Request for Proposal for conversion equipment

- Award and installation
- Training of existing personnel to use conversion equipment
- Commission project

Metrics for Tracking Progress of Measure
Metrics will include a published project overview, monthly status updates, and the final operation report.

Location of Measure
Layon Landfill (Inalåhan, Guam)

Solid Waste Measure #2: From Waste to Resource – Repurposing Guam's Plastic Waste into Sustainable Building Material Alternatives

Project Description
This project will focus on repurposing plastic waste using the ByFusion method to develop an alternative and sustainable building material for Guam.

Cost Estimate and Funding Sources
This project is budgeted to cost $4,999,999.00. Implementing agencies are intending to apply for U.S. EPA CPRG Program Implementation Grant funding.

Implementing Agencies and Partners
UOG CIS and SG will be the lead implementing agency of this project with support from the CCRC, Guam Building Code Council, G3, DPW and GSWA.

Estimate of GHG and Criteria Pollutant Emissions Reductions
Produced blocks are estimated to produce 41% fewer emissions than concrete blocks commonly used in Guam.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Plastic waste diversion from landfill
- Workforce development and training
- Outreach and education
- Structural feasibility demonstrations of building material

Metrics for Tracking Progress of Measure
Metrics include quarterly reporting, fiscal reporting, reporting to project leads, GHG emissions reductions, circular economy impact, and final reporting.

Location of Measure
Guam

4.4 Wastewater Treatment Sector

Wastewater Treatment Measure #1: Anaerobic Digester Feasibility Study and Construction of Anaerobic Digester

Project Description
GWA will address wastewater biosolid waste diversion through anaerobic technology. Implementation of this project will include drafting a feasibility study and the construction of an anaerobic digester.

Cost Estimate and Funding Sources
This project is budgeted to cost $24,500,000.00. GWA is intending to apply for U.S. EPA CPRG Program Implementation Grant funding.

Implementing Agencies and Partners
GWA will be the lead implementing agency with support from GSWA.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to reduce 30-40% of biogas emissions (CH_4 and CO_2) from food waste and fats, oils, and grease (FOG) being disposed of in Guam's landfill and wastewater system.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

Phase 1: Feasibility study
- Scope of work developed for feasibility study of appropriate anaerobic digestor for Guam
- Procurement and selection of contractor
- Approval of contractor selection from the CCU
- Contract approval
- Collection of critical data
- Draft study review
- Final report of feasibility study

Phase 2: Construction
- Scope of work for construction based on feasibility study
- Selection of contractor
- Approval of contractor selection from the CCU

- Contract approval
- Permits approval
- Construction starts
- Construction ends
- Food waste agreements approved between parties

Metrics for Tracking Progress of Measure
Metrics include a published feasibility study, the selection of a site for the an anaerobic digester, agreements with food waste contributors, tracking construction progress, monitoring of food waste, monitoring of power generated from CH_4, yearly progress reports to the CCU and GSWA Board.

Location of Measure
GWA Upper Tumon Office - GWA Wastewater Facility

4.5 Forestry Sector

Forestry Measure 1: Commodities and Practices to Reduce GHG Emissions in Pacific Island Forestry and Agriculture Systems (CaPPacForAg)

Project Description
This innovative project addresses GHG emission reductions in Pacific Island Agriculture and Forestry Systems and seeks to improve affordable food and nutrition security of disadvantaged, at-risk, island communities through an inter-disciplinary, culturally sensitive approach by working with local farmers and forestry managers.

Cost Estimate and Funding Sources
This project is budgeted to cost $4,999,999.00. Funding was awarded to implement this project through the U.S. Department of Agriculture – Natural Resources Conservation Service.

Implementing Agencies and Partners
UOG Western Pacific Tropical Research Center and UOG College of Natural and Applied Sciences (CNAS) will be the lead implementing agencies on this project. Washington State University (WSU) will be responsible for creating and maintaining a database of GHG emissions field data for Guam and Saipan. Three (3) pilot farms from Saipan, Rota, and Tinian will partner with Northern Marianas College (NMC) to participate in the first round of the incentive program. Guam Department of Agriculture (DoAg) will implement Climate-Smart Agriculture and Forestry (CSAF) practices in which GHG emissions will be assessed on Cotal Conservation Area that encompasses 502 acres in the village of Santa Rita.

Estimate of GHG and Criteria Pollutant Emissions Reductions

This project is projected to reduce 1,814.4 metric tons CO_2e sequestered annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Eligibility determination, application submission, and approval of farmer workplan
- Farmers receive 25% of full incentive
- Hire staff to work on project (program coordinator, administrative assistant, communications coordinator, research assistants, and post-doctoral researchers)
- Establish vendors and procure equipment
- Create baseline of current practices and GHG emissions to be reviewed and verified by an independent third-party
- Conduct outreach, training, and other technical assistance annually
- Assess and evaluate post-project potential

Metrics for Tracking Progress of Measure
Metrics include quarterly data collection, quarterly reporting, annual reporting, project staff evaluations, and final reporting.

Location of Measure
Guam and Commonwealth of the Northern Mariana Islands (CNMI)

Forestry Measure #2: Guam Restoration of Watersheds (GROW)

Project Description
This project aims to reduce the flow of land-based pollutants through restoration of significant soil erosion currently impacting water quality and the marine coastal environment by involving the local community in restoration and management of Ugum Watershed and increasing awareness of poor land use practices. The restoration of watersheds through tree planting activities works to offset the communities carbon footprint. This project will also work to increase the capacity to measure and reduce carbon emissions for the project through the hiring of a consultant for a carbon credit offset certification. This project has the potential to expand restoration to other adjacent watersheds in southern Guam which include expanding work in the Manell/Geus Watershed, in the As Gado area, in the Pago Bay Watershed, maintaining the Cotal areas, and starting restoration in the Ylig, Talofofo, Dandan, and Inarajan Watersheds. Expansion of this project should also consider training for forest maintenance, tree care, tree climbing, tree ridging, and creating a community volunteer wild fire team to prevent and respond to forest fires.

Cost Estimate and Funding Sources
This project currently costs $557,000.00. Funding for this project comes from Sea Grant, National Fish and Wildlife Foundation (NFWF), and U.S. Forest Service. This project may also seek funding through other means to expand work.

Implementing Agencies and Partners
UOG CIS & SG is the lead implementing agency on this project with support from Guam DoAg - Forestry Division, Southern Guam Soil and Water Conservation District (SGSWCD). U.S. Forest Service, and Ocean Foundation.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to sequester 120,900 kg CO_2e annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Schedule planting events
- Host watershed tours at the project site as requested
- Conduct outreach at community and school events
- Test and develop watershed restoration tools
- Provide training and mentorship for student research assistants and interns
- Share findings in extension publications, conference presentations, and community meetings
- Hire consultant to develop carbon offset program

Metrics for Tracking Progress of Measure
Metrics include reporting of research, data, and outcomes to the National Sea Grant Office during reporting periods. The carbon consultant will deliver a workplan, a carbon credit certification application, a carbon credit certification approval, and a carbon registry to UOG CIS & SG.

Location of Measure
Ugum Watershed, Guam

Forestry Measure #3: Urban Community Green Space

Project Description
This project aims to create urban carbon sinks through developing a community greenspace. By restoring pockets of native habitats in urban areas, we connect wildlife, people, and the planet.

Cost Estimate and Funding Sources
This project is budgeted to cost $1,500,000.00. Northern Guam Soil and Water Conservation District (NGSWCD) is intending to apply for U.S. EPA CPRG Program Implementation Grant funding.

Implementing Agencies and Partners
NGSWCD will be the lead implementing agency with support and collaboration of the Guam Department of Parks and Recreation and Guam DoAg's Urban Community and Forestry Division.

Estimate of GHG and Criteria Pollutant Emissions Reductions
This project is projected to sequester 5670 kg – 18,900 kg CO_2e annually.

Implementation Schedule and Milestones
Implementation schedule and milestones of this measure are as follows:

- Conduct stakeholders meeting with implementing partners to initialize a memorandum of understanding (MOU)
- Finalize plan of action with map of area in sections
- Hire staff for project
- Establish vendors and purchase necessary equipment
- Conduct survey of area for pre-assessment – test soil health, type of forest (limestone or mixed), and other factors
- Create educational materials and other resources for distribution
- Establish walkways and recreational areas for community use as well as other areas that will promote sustainability and community responsibility
- Conduct outreach about the greenspace
- Host and schedule planting events with volunteers
- Host workshops, events and programs about conservation and stewardship practices implemented, native species, farming, and healthy living
- Conduct on-going surveys throughout life of project
- Share findings with community, reports, and conferences

Metrics for Tracking Progress of Measure
Metrics include quarterly data collection, quarterly reporting, annual reporting, staff evaluations, and a final reporting of the project that includes results of conducted surveys, monitoring participation in outreach, monitoring soil health, monitoring wildlife, and community and environmental impact.

Location of Measure
Northern Guam

5 Benefits Analysis

In addition to reducing GHG emissions, reduction measures also work to reduce co-pollutants of criteria air pollutants (CAPs) and toxic or hazardous air pollutants (HAPs). CAPs include particle pollution ($PM_{2.5}$, PM_{10}), ground-level ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead. HAPs include gases such as hydrogen chloride, benzene, toluene, and perchloroethylene.

A co-pollutant emissions analysis was performed on the stationary combustion sector, focusing mainly on GPA-operated generators that supply power to the island.

Table 9. GPA Generator Fuel Type and Fuel Use. Fuel type and fuel use data by generator was collected from GPA to produce co-pollutant emissions found in Table 9.

GPA Generator	MW	Fuel Type	Fuel Use (gallons)		
			Turbine (ULSD)	Turbine (Fuel Oil)	Engine generator (ULSD)
Cabras 1	66	diesel/fuel oil	1,671	545,881	-
Cabras 2	66	diesel/fuel oil	1,739	267,048	-
MEC 8 (IPP)	44.2	diesel	0	-	437,455
MEC 9 (IPP)	44.2	diesel	0	-	443,402
MDI Dsl	10.6	diesel	-	-	10,569
Dededo CT #1	23	diesel	153,818	-	-
Dededo CT #2	22	diesel	152,640	-	-
Macheche CT	22	diesel	105,298	-	-
Yigo CT	22	diesel	87,926	-	-
Talofofo	8.8	diesel	-	-	10,473
Yigo Diesels	40	diesel	-	-	110,480
Tenjo	26.4	diesel	-	-	28,185
TEMES (IPP) (Piti 7)	40	diesel	341,850	-	-
Other	-	-	0.37	-	5,582

Table 10. Co-Pollutant Emissions Inventory of GPA Power Generation. Co-pollutant emissions are measured in a unit of tons/year pollutant emissions. *PM=PM10=PM2.5 for several sets of emissions factors.

GPA Generator	NOx	CO	SO2	PM*	PM10	PM2.5	VOC/TOC
Cabras 1	33.73	0.13	0.06	0.46	0.46	0.46	0.02
Cabras 2	16.56	0.06	0.03	0.23	0.23	0.23	0.01
MEC 8 (IPP)	97.99	26.03	0.05	1.90	1.52	1.47	2.51
MEC 9 (IPP)	99.32	26.38	0.05	1.92	1.54	1.49	2.54
MDI Dsl	2.37	0.63	0.00	0.05	0.04	0.04	0.06
Dededo CT #1	9.48	0.04	0.02	0.13	0.13	0.13	0.00
Dededo CT #2	9.40	0.04	0.02	0.13	0.13	0.13	0.00
Macheche CT	6.49	0.02	0.01	0.09	0.09	0.09	0.00
Yigo CT	5.42	0.02	0.01	0.07	0.07	0.07	0.00
Talofofo	2.35	0.62	0.00	0.05	0.04	0.04	0.06
Yigo Diesels	24.75	6.57	0.01	0.48	0.38	0.37	0.63
Tenjo	6.31	1.68	0.00	0.12	0.10	0.09	0.16
TEMES (IPP) (Piti 7)	21.06	0.08	0.04	0.29	0.29	0.29	0.01
Other	1.25	0.33	0.00	0.02	0.02	0.02	0.03
Total	336.46	62.63	0.29	5.93	5.02	4.90	6.05

A co-pollutant emissions analysis for other priority sectors are not available at this time.

6 Broader Assessment of Benefits and Workforce Planning Analysis

The anticipated benefits outlined in this section are a broader assessment of benefits associated with each GHG reduction measures. This broader assessment of benefits can include but are not limited to air quality improvements, improved public health outcomes, economic benefits, increased climate resilience, or other environmental benefits.

Workforce related challenges and opportunities can be a critical element of assessing the feasibility of GHG reduction measures. These may include skilled labor shortages, impacts on existing jobs and industries, opportunities for the creation of high-quality jobs, and expanding economic opportunity to underserved workers through reduction measure implementation. This section describes how activities or policies will lead to the creation of high-quality jobs and capacity building in Guam.

6.1 Energy Sector

Energy Measure 1: Guam Green Growth (G3) Renewable Energy Project

The project will support the emerging green economy by reducing carbon emissions of the G3 Circular Economy Makerspace and Innovation Hub at CHamoru Village. The hub provides local entrepreneurs with access to equipment to stimulate new green industries on the island. This project is well-positioned as it will serve as a pilot circular economy project at the heart of cultural exchange in the island's capital. Funding from this project will allow hiring of a project coordinator to oversee the project and work directly with vendors and work closely with the Department of CHamoru Affairs, GPA, and GEO on this project. This project will also support the local economy by hiring a vendor to order solar panels and inverters, as well as a vendor to erect two parking flat roofed carports and install the solar energy system and the at the CHamoru Village. Non-energy benefits includes the addition of weather protection, avoidance of brownouts that lead to the deterioration of electronics, and the support of the emerging green market industry and creation of cottage industries.

Energy Measure 2: Installation of Solar Panels at Layon Landfill

The project implemented by the GSWA will hire local contractors for the expertise needed for the installation and maintenance of a solar energy system. This will be the island's first active landfill and solar farm on the same property.

Energy Measure 3: Solar for All Guam

The project plans to encourage programs that focus on supporting communities and other solar market stakeholders through investing in workforce development opportunities for community members and providing project deployment technical assistance. To build capacity and ensure there is a skilled workforce to deploy solar, this project will create an Energy Corps focused on preparing the community for the emerging energy transition of Guam. Energy Corps members will receive comprehensive and hands-on training and education on the processes and procedures of rooftop solar installation and maintenance. This project will also train and educate GEDA employees on low-income loan processes and opportunities. GEO will also provide training to local contractors, provide testing and certifications on energy efficiency and electrification technologies, and develop a state-sponsored workforce program. Equity and community benefits include household energy cost savings and an increase in climate resiliency.

Energy Measure 4: Standalone BESS Grid Services

GPA estimates that contractors will install approximately 170 MW of BESS. This will provide an excellent opportunity for Guam to develop the workforce capacity needed to construct these facilities. The operations and maintenance of these facilities will require individuals

with strong technical skills. Without these standalone BESS, GPA would have a high risk of blacking out on a regular basis. Phase IV of the renewable energy plan reduced CO_2 by about 462,436.20 metric tons under the first year of operation. This reduction will decrease by about 1% per year proportional to the annual decrease in solar PV system production capability. This system will also provide grid services including energy shifting, fast frequency regulation, rapid reserve response to solar PV production dropouts, rapid reverse for synchronous generation trips, and reactive power management.

Energy Measure 5: Solar Virtual Power Plant Program – GDOE School Focus

GPA estimates that contractors will install 1,320,000 solar PV panels as a part of Phase IV of the renewable energy plan. This will provide an excellent opportunity for Guam to develop the workforce capacity needed to install these systems. The operations and maintenance of these systems will require individuals with strong technical skills. For example, a local solar project hired former GPA personnel to operate their control system and manage their operations and maintenance. This project will also reduce GDOE's total power costs. If the solar PV portion of these projects are funded by grants in part or whole, the solar PV energy produced and consumed at the schools would be discounted to account for the funding. The project will mitigate the impact of large solar PV systems on GPA's distribution system as well as enable the forming of microgrids to resolve various system issues.

Energy Measure 5: Greening Cultural Facilities

The project supports the internal and external environments of the cultural facilities and works to maintain the mission of providing safe, adequate, and appropriate space to store and care for artifacts. These spaces will allow for the viewing of cultural artifacts, making it more accessible to the community. This project will also deliver tangible and intangible cultural resources to the community.

6.2 Transportation Sector

Transportation Measure 1: Guam Green Growth (G3) Renewable Energy Project

The project will support the emerging green economy by reducing carbon emissions of the G3 Circular Economy Makerspace and Innovation Hub at CHamoru Village. The hub provides local entrepreneurs with access to equipment to stimulate new green industries on the island. This project is well-positioned as it will serve as a pilot circular economy project at the heart of cultural exchange in the island's capital. Funding from this project will allow hiring of a project coordinator to oversee the project and work directly with vendors and work closely with the Department of CHamoru Affairs, GPA, and GEO on this project. This project will also support the local economy by hiring a vendor to order the EV charging

systems and a contractor to install the ten (10) EV charging stations at the CHamoru Village and UOG. Non-energy benefits includes the support of the emerging green market industry and creation of cottage industries and an increased consumer buy-in and cost savings of EVs.

Transportation Measure 2: Replacing GWA's Fleet with EVs

This project will convert GWA's fleet from traditional passenger vehicles to EVs. By replacing GWA's vehicle fleet, there will be a need to improve the technical skills and knowledge at the agency to include specialized expertise in the operation and maintenance of EV technology. The project may lead to hiring new employees with these specialized skills. The increase in EVs on island will increase the demand for a highly skilled local workforce who are able to maintain EVs, repair EVs, and install and maintain charging systems. GWA intends to conduct training programs on the use and maintenance of EVs and their charging systems as well. The benefits of this project include the reduction of GHG emissions that come directly from GWA's vehicle fleet, the reduction of fuel costs, and a reduction in maintenance costs. GWA's fleet will be used by operators who are required to visit the agency's critical facilities multiple times per day. The presence of GWA's EV fleet will be an opportunity to increase the confidence in the use of EVs in the community.

Transportation Measure #3: Replace the Guam Regional Transit Authority's (GRTA) Fleet with EVs

This project will convert GRTA's transit vehicle fleet from traditional transit vehicles to EVs. By replacing GRTA's transit fleet, there will be a need to improve the technical skills and knowledge at the agency to include specialized expertise in the operation and maintenance of EV technology. The increase in EVs on island will increase the demand for a highly skilled local workforce who are able to maintain EVs, repair EVs, and install and maintain charging systems. The presence of GRTA's EV transit fleet will be an opportunity to increase the confidence in the use of EVs in the community.

Transportation Measure #4: Replace the Department of Public Works (DPW) Fleet with EVs

This project will convert DPW's vehicle fleet from traditional service vehicles to EVs. By replacing DPW's fleet, there will be a need to improve the technical skills and knowledge at the agency to include specialized expertise in the operation and maintenance of EV technology. The increase in EVs on island will increase the demand for a highly skilled local workforce who are able to maintain EVs, repair EVs, and install and maintain charging systems. The presence of DPW's EV fleet will be an opportunity to increase the confidence in the use of EVs in the community.

6.3 Solid Waste Sector

Solid Waste Measure 1: Converting Waste Cooking Oil into Biodiesel

The project implemented by the GSWA will hire local contractors for the expertise needed for the equipment needed to convert waste cooking oil into biodiesel to run the Guam Solid Waste Authority diesel fleet. The use of biodiesel for GSWA's diesel fleet will allow the island to reduce its dependence on fossil fuels and work to reduce cooking oil waste.

Solid Waste Measure 2: From Waste to Resource – Repurposing Guam's Plastic Waste into Sustainable Building Material Alternatives

This project will bring a new economic industry for Guam by converting plastic waste into a sustainable building material alternative. This industry or practice does not currently exist on the island so this project will fund the training of personnel to be able to maintain and operate the equipment needed to implement this technology. The project will also hold demonstrations for interested stakeholders to be able to learn and understand the feasibility of this sustainable alternative.

6.4 Wastewater Sector

Wastewater Treatment Measure 1: Anaerobic digester feasibility study and construction of anaerobic digester

A contractor will be hired to complete a feasibility to determine the most appropriate anaerobic digester system for Guam. GWA will then hire a contractor to design and build the anaerobic digester system from the results and recommendations of the feasibility study. This project will increase the workforce capacity needed to construct and operate this type of facility and will require current GWA workers to increase their skills in operating an anaerobic digester with the intent to use the methane gas produced to power the facility. This project will also require additional workforce capacity to collect food and FOG waste from local schools, farmers, and grocers, etc. This will be an opportunity for new businesses to emerge to meet the demand for the collection and management of food and organic waste for anaerobic digestion. It is expected that the local food waste stream will be reduced by 30-40% with the implementation of this technology. Benefits of this project also include recycling methane for power generation, reducing the amount of sludge, bio-water, and food waste disposed at the Layon Landfill, extending the life of the Layon Landfill, improving waste practices by treating organic waste in a sustainable manner, reducing cost incurred from disposal of sludge material, reducing the amounts of FOG within GWA's wastewater system. FOG is the main cause of sanitary sewer overflow spills in Guam. Reducing these

spills will reduce pollutants entering coastal and marine waters, protect public health, and will reduce damage to private properties.

6.5 Forestry Sector

Forestry Measure 1: Commodities and Practices to Reduce GHG Emissions in Pacific Island Forestry and Agriculture Systems (CaPPacForAg)

This project intends to grow the workforce indirectly by assisting farmers with adopting climate-smart practices and marketing their produce to a wider audience. Farmers will be given stipends that will be used at their discretion, with the potential of using the stipend for labor costs. Faculty at UOG will be working together to produce a marketing survey to evaluate the current market and identify potential market opportunities for climate-smart commodities. Additionally, there will be a Willingness-to-Pay market survey which will reveal the market demand for these crops. These marketing efforts will encourage farmers to continue in their efforts to use climate-smart practices. A post-doc employee will also be recruited for adapting the marketing plan, conducting the surveys, and modeling the cost-benefits of carbon-neutral practices. This project will also call for the combined efforts of the co-principal investigators, the post-doc, and the communications associate to facilitate the selling of these commodities through various channels.

Forestry Measure 2: Guam Restoration of Watersheds (GROW)

This project will support six (6) graduate students over a 4-year period to participate in place-based research experiences in the GROW Initiative. The students will focus on learning outcomes of an agroforest, soil and emissions testing, measuring erosion control rates, and monitoring activities through the use of unmanned aerial vehicles. Each student will work with UOG faculty on this project. As a part of this research experience in Ugum, students will be provided with mentoring, training, and resources necessary to succeed. The GROW project also contributes to the workforce development goals for UOG CIS & SG's region and contributes to the goals of the Sea Grant Diversity and Inclusion Community of Practice and visioning efforts. The carbon credit offset certification portion of this project will hire a consultant to develop a carbon certification program for the GROW project and other future restoration projects of UOG CIS & SG.

Forestry Measure #3: Urban Community Green Space

This project promotes the use of native trees and plants, reduces the use of pesticides and chemicals in our soil, and builds healthier communities through providing recreational space and educational sources inspired by CHamoru culture. This, in turn, enhances efforts around climate resiliency, community resiliency, urban forestry, water conservation, and beautification.

7 Conclusion and Next Steps

Under U.S. EPA's CPRG program, Guam's PCAP works to tackle damaging climate pollution, accelerate work to address environmental injustice, empower community-driven solutions, and to deliver cleaner air by reducing harmful pollution. The PCAP is an important step towards building resiliency against the adverse effects of climate change by reducing GHG emissions on the island.

The PCAP is a pre-requisite for competing in the second phase of the CPRG program in the future, which will competitively award $4.6 billion for implementation. Any future application for an implementation award under the CPRG for Guam will need to include this PCAP that describes the programs, policies, measures, and projects the entity will carry out with the implementation grant funding.

The second deliverable of this program will be the CCAP that will be due at the end of the grant period in 2027. The CCAP will provide an overview of Guam's significant GHG sources and sink sectors, establish near-term and long-term GHG emissions reduction goals, and provide strategies and identify measures addressing the highest priority sectors to help Guam achieve those goals.