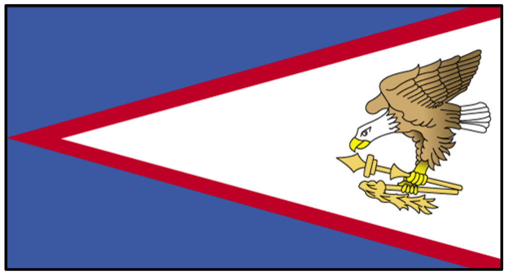

AMERICAN SAMOA

GREENHOUSE GAS INVENTORY

Territorial Energy Office

APRIL 2012

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In particular, we are grateful for the support of the late Falatunatuna Leasiolagi who, as Deputy Director of TEO, saw the value in initiating this work as well as the contribution it could make to establishing an on-going Climate Change program within TEO and the Territory. This report is dedicated in his memory and honor.

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Executive Summary

Westmoreland Associates, under contract to the American Samoa Territorial Energy Office (TEO), has developed this first-ever inventory of greenhouse gas (GHG) emissions attributable to public and private sector activities within the Territory. The inventory uses the year 2010 as its baseline. For comparative purposes, and to the extent data are available, this inventory also presents an estimate of GHG emissions in 2005. This allows an analysis of the GHG emissions trend between 2005 and 2010. The 2010 inventory will continue to be a living document and will need to be updated as new and more accurate data become available in subsequent years.[1]

This inventory identifies the greatest sources of GHG emissions in the Territory, and the data presented represent the best information available through 2011.

In addition to helping characterize the Territory's contribution, albeit small, to total regional and global emissions, the inventory identifies opportunities to reduce energy consumption through efficiency measures and through replacement of fossil fuel supply with renewable energy technologies. It thus provides a basis for developing a climate action plan, with specific targeted emissions reductions over time.

For the year 2010, GHG emissions in American Samoa associated with human activities totaled 329,004 metric tons of carbon dioxide-equivalent (CO2e). This represented a 21% decrease in emissions over the comparison year of 2005 which had 418,697 metric tons CO2e. 2010 emissions totaled nearly 6 metric tons per person on a per capita basis.

Commercial sector emissions in 2010 were by far the largest contributor to the Territory's GHG footprint that year, accounting for 58% of emissions (190,713 metric tons CO2e). Residential sector emissions followed as the second highest source, with 71,250 metric tons CO2e in 2010 (22% 0f the year's total).

Commercial sector emissions dropped from 64% to 58% of the total from 2005 to 2010 due in large measure to the decline in emissions from marine diesel combustion associated with the commercial fishing vessels doing commerce in the Territory. The residential sector's share amounted to 21% of the total, followed by the utility sector at 11%. Industrial and government sectors accounted for 6% and 4% respectively.

All sectors show a decline in GHG emissions from 2005 and 2010, with the commercial sector's decline the largest, down 29% in 2010 from 2005 levels.

Looking at individual sources of GHG emissions, those from the combustion of marine diesel fuel were responsible for 38% of the Territory's emissions in 2010, down from 50% in 2005. GHG emissions from the burning of gasoline were responsible for 17% of total emissions in 2010, up from 13% of the total in 2005 even though absolute emissions in metric tons CO2e were essentially unchanged.

Other fuels making measurable contribution to the Territory's GHG footprint were land diesel and electricity, each at 11%, landfill gas at 10%, and jet fuel at 9%. Other smaller contributors were emissions from wastewater treatment (2%) and butane combustion (1%). Emissions from kerosene combustion and animal management (piggeries) were less than 0.01% of the annual total.

In terms of absolute emissions in 2010, marine diesel emissions dropped 40% while those due to electricity generation declined by a full 13% from 2005 levels. Emissions from kerosene combustion dropped 64% over the period, from 1,254 metric tons to 422 metric tons.

The release of just over 329,000 metric tons of GHGs in American Samoa in 2010 is an extremely small amount compared with total U.S. and global emissions. U.S. emissions in 2010 were 6,821 million metric tons (6.8 billion metric tons), an increase of 10% over 1990 levels. Global GHG emissions (2009) were recorded at 31.3 billion metric tons. All amounts are in equivalent tons of carbon dioxide.

On a per capita basis, the comparisons are more telling. For 2010, the GHG emissions in American Samoa amounted to about 6 tons per person. This is about a third of the 17.2 tons per capita for the U.S. as a whole that same year. However, American Samoa's 6 tons per capita is almost identical to the 6.1 tons per person for China in 2010 and over four times as large as the 1.4 tons per person emissions in India that year.

With per person GHG emissions comparable to China and far above those of India, American Samoans have an incentive for lowering their individual GHG emissions so that they can help set an example for the rest of the world.

GHG emissions from all sources were tabulated and assigned to the five sectors used in this inventory. Results for 2010 (and the comparison year 2005) are provided in Tables 1 and 2 and Figures 1 and 2.

Table 1. GHG Emissions by Sector, % of Annual, Sector Change, 2005 & 2010

Sector	2005	% of annual total	2010	% of annual total	% change 2005-2010
Residential	73,383	18	71,250	21	-3
Commercial	269,671	64	190,713	58	-29
Industrial	22,060	5	19,565	6	-11
Government	13,577	3	12,231	4	-9
Utility	40.006	10	35,245	11	-12
Total	418,697	100	329,004	100	-21

Figure 1. Sector Emissions as % of Territorial Totals, 2010

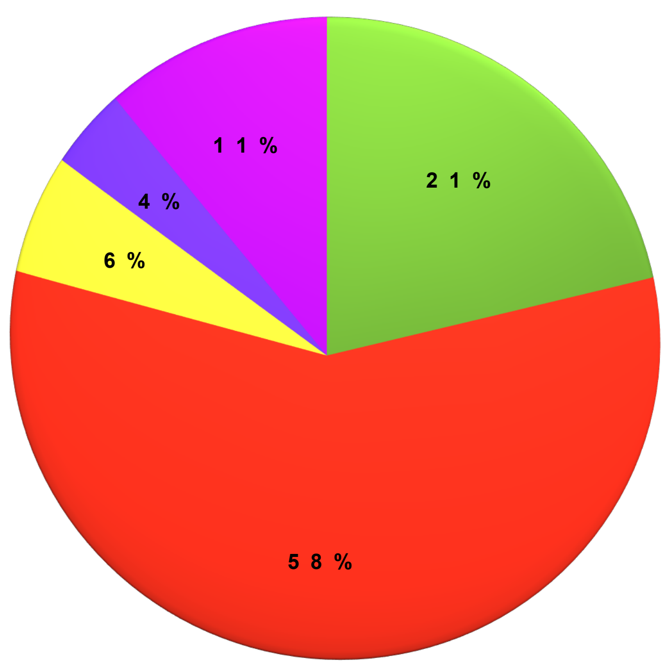
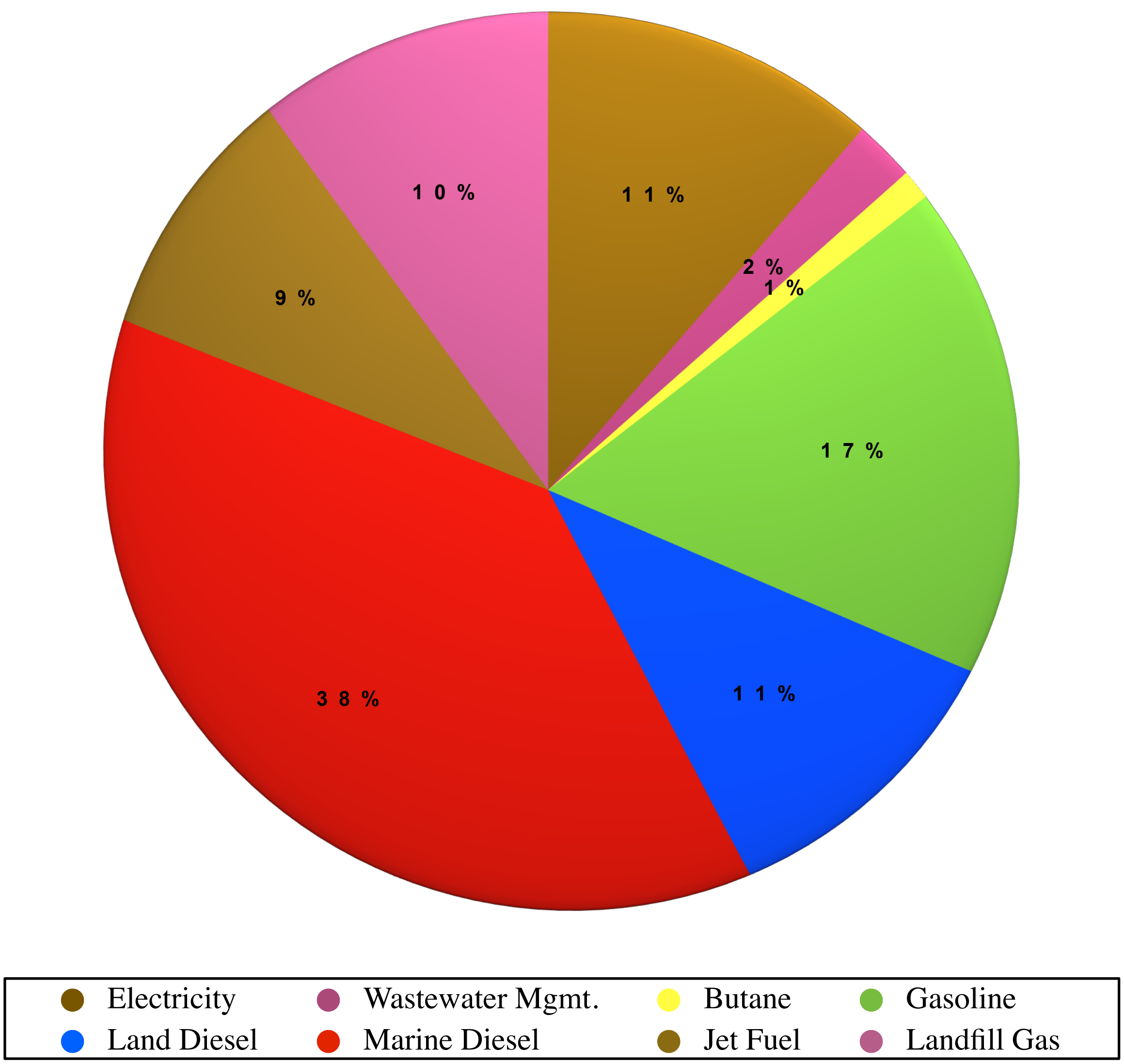


Table 2. GHG Emissions by Source Type (Metric tons CO2e) 2005 & 2010

Source	2005	%	2010	%
Electricity	41,961	10	36,557	11
Butane	3,902	1	4,878	1
Gasoline	54,857	13	54,469	17
Land Diesel	34,006	8	35,598	11
Marine Diesel	209,888	50	125,945	38
Jet Fuel	28,370	7	31,564	10
Kerosene	1,254	<1*	422	<1*
Landfill Gas	37,471	9	32,584	10
Animal Husbandry	311	<1*	311	<1*
Wastewater Management	6,676	2	6,676	2
Total	416,672	* Total not equal to 100% due to rounding	329,004	* Total not equal to 100% due to rounding

Figure 2. GHG Emissions by Source Type, % of Annual, 2010



Dr. John Holdren, the U.S. National Science Advisor, has noted that greenhouse gas inventories are the first step in developing an effective GHG mitigation response. He adds: “We basically have three choices: mitigation, adaptation and suffering. We’re going to do some of each. The question is what the mix is going to be. The more mitigation we do, the less adaptation will be required and the less suffering there will be.” [2]

On August 21, 2007, the Governor of American Samoa issued Executive Order No. 010A – 2007. It recognized the importance of the American Samoa Government’s commitment to ameliorate global climate change and its negative effects on the Territory and sets forth the government’s short and long-term commitments to this end. The Executive Order established several initial steps to assist the Territory in reducing its own greenhouse gas emissions. These included establishing new fuel economy standards for imported cars, the incremental addition of hybrid-electric vehicles to the Government fleet, appliance and lighting efficiency measures, and other steps addressing air quality and coastal ecosystem health.

The American Samoa Department of Commerce has been engaged in the development of a Territorial Climate Change Framework that is designed to serve as a guide for resource managers in the Territory and to help in directing future climate change-related management strategies. While largely focused on climate change adaptation measures and management strategies, the Framework also anticipates the development of a “carbon footprint” for the Territory which the inventory herein is intended to address.

The Framework is being developed through the efforts of the Territorial Climate Change Advisory Group,[3] established in a follow-up Executive Order, No. 002-2011, issued on June 17, 2011. The Advisory Group will expire in June 2012.

This inventory follows established procedures for assigning emission factors to various activities and allows periodic updates and comparisons to be made as improvements in energy efficiency occur, as alternative energy sources are implemented, as behavioral and technology changes take place, and as better data become available.

It is important to note that this GHG inventory has not been validated by an independent party and is not a tool to develop regulations. Care should also be taken in comparing the results of this inventory to those done in other communities (and other countries) as the sources of emissions analyzed and the greenhouse gases included are likely to be different.

All primary energy consumption in American Samoa is derived from the combustion of petroleum and natural gas liquids, although a growing amount of non-petroleum-derived electricity from solar photovoltaic systems began being connected to the electrical grid in 2010.

The combustion of petroleum and natural gas liquids (LPG, in the form of n-Butane) results in greenhouse gas emissions, the most dominant of which is carbon dioxide (CO2). All petroleum and natural gas liquids consumed in the Territory are imported and most GHG emissions were found to be linked directly to the combustion of fossil fuels.

There are no coal or natural gas or other conventional carbon-based fuels used in American Samoa. Thus, the GHG emissions attributable to American Samoa are limited to the emissions from the combustion of gasoline in motor transit, jet fuel in the aviation sector, kerosene for residential and commercial uses, diesel products for marine, commercial fishing, road and power plant uses, and LPG used in a variety of residential, commercial and industrial end-use applications.

Apart from the small but growing implementation of photovoltaic energy systems in the Territory, most electricity comes from the combustion of #2 diesel in small utility generators.

The inventory also reflects the emissions of methane (CH_4) and nitrous oxide (N_2O), other greenhouse gases which result from the treatment of municipal wastewater in addition to being combustion by-products in energy use. Methane and N_2O emissions are calculated in carbon dioxide equivalents (CO_2e). Two additional anthropogenic sources of methane and nitrous oxide which exist in American Samoa are due to emissions from landfills and emissions from manure management at animal confinement facilities. In American Samoa this is represented by the large number of piggeries which exist in the Territory.

GHG inventories generally include both sources and sinks - activities which act to sequester or bind up one or more GHGs for thousands of years. Examples of GHG sinks in might include land use changes, such as widespread expansion of forest cover. They might also be activities such as human management of captured GHG in practices such as geologic disposal or re-direction of a GHG to consumptive use in an industrial application. However, neither activity (or any other active GHG sequestration) occurs in American Samoa and thus there is no analysis of GHG sinks in this inventory.

Were American Samoa biomass harvests to exceed growth and regeneration, the resultant depletion of national biomass stocks would result in a net greenhouse gas "emission" (flux to the atmosphere). However, the carbon flux from agricultural practices is relatively constant in American Samoa, as the extent of forests, crops, and other biotic land cover is showing neither significant increase nor decrease over time.

From 1990 to 2007 there was only a 3% drop in forest area. With the majority of land surface of Tutuila on slopes of 70% or greater, there is little to no systematic cutting or planting relative to the total extent of the extensive biomass cover across the island. Thus, this GHG inventory excludes the carbon flux occurring as trees, plants and other land cover is gained and lost due to seasonal fluctuations, human intervention, or natural storm damage.

Finally, the inventory does not include emissions attributable to imported goods (materials extraction, manufacture, and transportation). The issue of GHG emissions embedded in imported goods has been recognized for several years and the methodology to track emissions pathways is being refined constantly. A recent study by the U.S. National Academies of Science reports that in 2008 some 26% of global CO2 emissions came from the production of goods for trade.

American Samoa's long-standing dependency on a wide range of imported goods - from food to fuel to automobiles to clothing to manufactured goods - carries with it a greenhouse gas footprint that, while significant, will not be captured in traditional GHG inventory calculations. This additional, consumption-driven emissions footprint will sooner or later be quantifiable.

The Territory must be prepared to have its GHG emissions totals reflect this reality. One feasible approach to reducing the GHG footprint of imported goods is to maximize the recycling of end-of-life-cycle materials so that the emissions from the extractions and processing of virgin materials can be reduced at the point of origin.

PART A

GREENHOUSE GAS INVENTORY FOR AMERICAN SAMOA

Background

American Samoa is an unincorporated Territory of the United States. It is comprised of seven islands with a total land area of 77 square miles and a 2010 population of 55,510. Most of the business, government offices and population of the Territory are situated on the island of Tutuila.

To date there has not been an inventory of GHG emissions specifically attributable to American Samoa. This report addresses that gap and provides a benchmark accounting of GHG emissions which American Samoa can contribute to national, regional and international collaborations essential for addressing climate change mitigation and adaptation.

In 1992, the United States signed and ratified the United Nations Framework Convention on Climate Change (UNFCC). By ratifying the UNFCC, parties agree to "develop, periodically update, publish and make available...national inventories of anthropogenic emissions [of greenhouse gases] by sources...."[4] The UNFCC recognizes and requires national GHG inventories reporting on emissions of six substances which are products of human activity: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

The U.S. Environmental Protection Agency reported in 2010 that total U.S. GHG emissions in 2009 were 6,633 Tg or million metric tons CO2-equivalent. No separate break-out of contributions to these totals due to activities in American Samoa was included in this national accounting.

EPA reports that while total U.S. emissions have increased by 7.3% from 1990 to 2009, emissions decreased from 2008 to 2009 by 6.1%. This decrease was primarily due to a decrease in economic output resulting in a decrease in energy consumption across all sectors as well as a decrease in the carbon intensity of fuels used to generate electricity. Similar patterns can be seen in the economic trends underlying American Samoa GHG totals. In addition, regional economic trends involving use and sales of marine and aviation fuels translate into declines in GHG emissions in these sectors as seen in the 2005 and 2010 data.

As discussed in the Methodology section below, only carbon dioxide, methane and nitrous oxide emissions are captured in this inventory. The reasons for this are: 1) they are clearly the dominant three GHGs associated with human activity in American Samoa[5], 2) the difficulty in obtaining statistically significant data on the trace amounts of other GHGs that may be combustion byproducts from activities such as energy production, and 3) American Samoa lacks a manufacturing infrastructure frequently responsible for industrial emissions of HFCs, PFCs and SF6 (i.e. aluminum production, semiconductor manufacturing, magnesium production). Thus, the GHG inventory for the Territory reflects emissions of only CO2, CH4 and N2O.

The U. S. Energy Information Administration does not collect energy consumption data by sector for U.S. territories, only totals. However, fuel consumption data have been obtained from the American Samoa Office of Petroleum Management (OPM) and electricity production data from the American Samoa Power Authority (ASPA). These data sets allow the calculation of emissions from energy consumption in the Territory and the methodologies used are discussed further below.

Project Objectives

The principal objective of this inventory is to provide a first-ever accounting of GHG emissions attributable to public and private sectors in American Samoa. It is intended to serve as a baseline going forward for efforts to reduce and measure those reductions in GHG emissions in the Territory.

The second objective made possible with this inventory is the identification of best, least-cost opportunities for further reductions of GHG emissions in American Samoa. Capturing these opportunities in the years ahead will demonstrate the Territory's commitment to reducing its share of global GHG emissions and its willingness to participate in collaborative regional solutions involving both climate change mitigation and adaptation strategies.

It is important to note that this GHG inventory has not been validated by an independent party and is not a tool to develop regulations. Care should also be taken in comparing the results of this inventory to those done in other communities (and other countries) as the sources of emissions analyzed and the greenhouse gases included are likely to be different.

In particular, other communities will likely feature a more diverse set of conventional energy fuels (such as natural gas and coal) and complicating factors involving electricity purchases, regional transmission and distribution losses, transient emissions from rail, aviation and long-haul trucking, and other factors not present in American Samoa.

To this extent, the calculation of American Samoa's greenhouse gas emissions is a relatively straightforward analytical exercise, dependent largely on the accuracy of petroleum fuel throughput data and electricity production/sales data for a given period.

This inventory does not include emissions attributable to consumer goods imported to American Samoa (emissions from materials extraction, manufacture, and transportation of goods to the Territory). However, the issue of GHG emissions embedded in imported goods has been recognized throughout the world for several years and methodologies to track emissions pathways are being refined constantly.

A recent study released by the U.S. National Academies of Science reports that some 26% of global CO_2 emissions in 2008 came from the production of goods for trade as opposed to domestic consumption.[6] This represents an increase from 20% of global emissions due to goods produced for trade versus domestic consumption in 1990.

Apart from its remaining tuna cannery, the American Samoa economy is without a significant manufacturing base. It is heavily dependent on importation of material goods, from energy to food, furniture, vehicles, textiles -- virtually all consumer goods bought or sold in the territory. As a result, there is a significant though unmeasured GHG emission burden associated with the import-dependent economy above those emissions reflected in this inventory.

A recent study for the State of Oregon Department of Environmental Quality examined GHG emissions linked to consumption of goods other than energy fuels.[7] This analysis provided a consumption-based methodology for all products and services. The methodology used counted the emissions generated to produce all products (including electricity) and services consumed in Oregon, regardless of whether they are produced locally, nationally or internationally.

The principal finding of this study was that the emissions "footprint" of Oregon's consumption is significantly greater than the emissions released within state boundaries. Emissions associated with Oregon's consumption are roughly 47 percent greater than the emissions released within state boundaries.

Owing to the much greater dependence of the American Samoan economy on imported goods, the GHG emissions associated with the production of these goods might well exceed the 47% value determined in the Oregon study. However, until a methodology is developed to specifically address consumption patterns of imported goods in American Samoa it would be premature to include any quantitative consideration of embedded GHG in these imported goods.

Methodology

The methodologies used to calculate GHG emissions in this inventory differ by emission sources: electricity generation, transportation fuel combustion, LPG combustion, waste water disposal, landfilling, and animal waste management.

This report uses the Global Warming Potential (GWP) concept developed by the Intergovernmental Panel on Climate Change (IPCC) to compare the ability of CO_2, CH_4, and other GHGs to trap heat in the atmosphere and reports them in terms of CO_2-equivalent (the ability of a unit or measure of gas such as methane to trap heat in the atmosphere relative to an identical unit or measure of CO_2).[8]

CH_4 and N_2O emissions estimates for American Samoa are expressed in metric tons of CO_2-equivalents (CO_2e). As provided by the IPCC, over a 100-year time horizon, the global warming potential of a molecule of methane is 21 times that of a molecule of carbon dioxide.[9] This inventory reports every ton of methane emissions in American Samoa as having the equivalent of 21 tons of CO_2 warming potential, allowing additivity of all values calculated. For N_2O the GWP value used is 296, meaning one metric ton of N_2O has the GWP of 296 metric tons of CO_2.

Other GHGs recognized and included in the emissions inventories of larger and more complex economies are not measured in this initial accounting for American Samoa. These include gases such as sulfur hexafluoride (SF_6), perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs). It may be possible to estimate these emission types should sources for them be identified and quantified at some future date. At present, they are unconfirmed and beyond the scope of this inventory.

GHG emissions from combustion sources in American Samoa are summarized by emissions source and consuming sectors. The consuming sectors used are: residential, commercial, industrial, government, and utility. The major fuels considered are diesel, motor gasoline, jet fuel, kerosene, and LPG butane. Non-energy sources of GHGs captured in this inventory are wastewater treatment, landfilling, and animal husbandry.

American Samoa energy data were obtained from the following sources: a) petroleum fuel throughput (gallons), 2005 and 2010 - Office of Petroleum Management (OPM), b) n-Butane LPG sales (tons), 2010, Origin Energy, and c) electricity generation by sector (MWH), 2005, 2010 - American Samoa Power Authority (ASPA).

For each fuel type combusted in American Samoa for electricity, transportation or industrial use, a specific fuel emission factor or GHG emissions coefficient, measured in carbon dioxide equivalent per unit of energy, was used. These fuel emission factors were taken from Appendix H of the Instructions to Form EIA-1605, published by the U.S. Energy Information Administration (EIA). These are presented in Table 3 below.

Table 3. GHG Emission Coefficients by Fuel Type

Fuel Type	CO2	N2O	CH4
# 2 Diesel	73.15 kg/MMBtu (22.37 pounds/ gallon)	0.26 grams/gallon	0.74 grams/gallon
Motor Gasoline	19.54 pounds/ gallon	0.0036 g/mile	0.017 g/mile
Jet Fuel	21.09 pounds/ gallon	0.31 g/gallon	0.27 g/gallon
Kerosene	21.09 pounds/ gallon	0.31 g/gallon	0.27 g/gallon
LPG Butane	64.97 kg/MMBtu	N/A	N/A

Emission factors for GHGs released in domestic wastewater treatment operations were taken from Chapter 6 of the 2006 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories. Emissions attributable to municipal solid waste landfills, where available, were taken from the U.S. EPA (2008).[10]

The unit conversion factors used throughout this inventory (energy, weight, volume) follow accepted values found in conversion tables published by the U.S. Energy Information Administration as well as in standard engineering text books.

Electricity-based emissions are calculated for each sector using electricity sales data provided by ASPA. Emissions from electricity generated but not sold (losses due to inefficiencies, line losses) were distributed to each end-use sector according to its share of aggregate electricity sales consumption as provided by ASPA.

Until late 2011, APSA used the same #2 diesel fuel in both Tafuna and Satala generators, including the temporary Aggreko units that were in use from post-tsunami 2009 until summer 2011. Thus, the GHG emissions attributable to ASPA power generation in 2010 (and the 2005 emissions provided for comparison purposes) are derived from those resulting from the combustion of #2 diesel fuel exclusively. [11]

Data on transportation fuels use in the Territory (motor gasoline, diesel, jet fuel) have been supplied by the Office of Petroleum Management (OPM) which manages and measures the throughput of liquid fuels at the American Samoa tank farm. Fuel Emission Factors provided by the U.S. Energy Information Administration (USEIA) have been used to calculate emissions from transportation sector fuels consumed in American Samoa.[12]

The attribution of these transportation related emissions to various sectors was estimated based on the fuel type consumed by the type and class of registered vehicles in the Territory for 2008, the most recent year data were available.[13] For example, gasoline emissions were spread among commercial, residential and government sectors as a percent of the total registered vehicles using gasoline as a fuel. Data do not exist to measure the fuel efficiency or fuel consumption of individual vehicles by sector.

Vehicle breakout by type and classification is displayed in Table 4.[14] Privately-owned vehicles (POV) are assigned to the residential sector; rental cars, taxis, and cargo vehicles - largely trucks - are considered commercial; and government vehicles are assigned to the government sector. The small size of the American Samoa industrial sector makes its vehicle fuel use negligible in comparison to the other three sectors. No breakout of utility sector vehicles was available and they are therefore likely spread among the other sectors.

Table 4. Vehicle Registration by Type, 2008

Vehicle Type	Fuel	Number	Classification
Personal Automobiles	Gasoline	7,781	Residential
Rental Cars	Gasoline	130	Commercial
Taxis	Gasoline	85	Commercial
Buses	Diesel	135	Commercial
Cargo Trucks	Diesel	431	Commercial
Trailers	Diesel	121	Commercial
Government Vehicles	Gasoline	440	Government

Emission factors, in pounds of GHG (CO_2, CH_4, N_2)) per unit volume (gallons), were factored against the total amount of each transportation fuel consumed in the Territory in the two years studied.

Emissions of GHGs from fuels used in aviation and marine vessels are attributed to American Samoa based only on fuel sold in American Samoa. Emissions from fuels already on-board airplanes and marine vessels when entering the Territory are not counted. This method simply attributes the emissions to American Samoa for those fuels added prior to departure, as measured by gallons of throughput per year.

Data are not readily available nor are methodologies agreed upon to assign aviation emissions to the Territory based on some partial attribution of total gallons of fuel consumed when traveling to and from the Territory. Emissions attributable to fuel use by marine vessels is even more difficult to calculate as fuels are often added at sea or in other ports. For this initial GHG inventory for the Territory, it seemed reasonable to assign aviation and marine transport emissions to American Samoa based strictly on the gallons of fuel sold in the Territory.

Other GHG emissions were derived from CH_4 and N_2O sources in the Territory, though these are relatively negligible compared to CO_2 emissions from the energy sector, even in terms of CO_2-e. Sources on the types and extent of wastewater treatment on Tutuila as well as information on animal sources of methane (piggery wastes) were supplied by the American Samoa Environmental Protection Agency (ASEPA). Emission coefficients for all GHGs associated with these practices were obtained from the USEPA and factored against known wastewater and animal waste generation and management activities in the Territory.

Finally, as noted above, most of the business activity and population of the Territory are on the island of Tutuila. While the GHG emissions of the Territory are predominantly attributable to activities taking place on Tutuila, a small amount of GHG emissions arise from human activity on other islands of the Territory. However, the data sets used to conduct this emissions inventory consolidate energy use across the Territory by sector rather than by island and thus there is no island-specific breakout of emissions.

Sector Analyses and Findings

Greenhouse gas emissions totals were derived based on emission source (type of fuel combusted, or other GHG-producing activity such as municipal solid waste landfills and animal feeding operations, primarily piggeries) and GHG-producing sector. Emission sources considered are 1) transportation fuels - motor gasoline, diesel, jet fuel, and kerosene, 2) electricity - derived from combustion of diesel, 3) n-Butane, largely for stationary combustion applications such as appliances, and 4) methane derived from animal feeding operations and municipal solid waste landfilling. Emission sectors have been categorized as: 1) residential, 2) commercial, 3) industrial, 4) government, and 5) utility.

TOTAL GHG EMISSIONS BY EMISSION SOURCE

1. Electricity

In 2010, electricity generation in American Samoa resulted in the emission of 36,557 metric tons of CO2. This represented a 13% decrease in emissions over the comparison year of 2005, owing largely to a drop in industrial electricity consumption. Electricity use by sector and associated CO2 emissions are highlighted in Tables 5 and 6.

Table 5. Electricity Generation Sales by Sector (MWh) [15]

Sector	2005	2010
Residential	53,184	49,932
Commercial	49,018	45,428
Industrial	40,416	23,044
Government	30,115	30,485
Utility	9,499	10,004
Total	182,380	158,893

Using these electricity consumption data, and the GHG emissions coefficients for diesel generated electricity, the following GHG emissions were calculated and attributed by sector for the years 2010 and the comparison year 2005.

Table 6. GHG Emissions - by Electricity Generation Sector (metric tons CO2e) [16]

Sector	2005	%	2010	%
Residential	12,236	29	11,489	31
Commercial	11,278	27	10,452	29
Industrial	9,345	22	5,302	15
Government	6,928	17	7,013	19
ASPA	2,174	5	2,301	6
TOTAL	41,961	100	36,557	100

2. n-Butane (LPG)

Origin Energy imports and sells LPG in American Samoa in the form of n-Butane. Origin 's predecessor companies began LPG service in the Territory in 1983.

Origin Energy reports a throughput (sales) of 1,600 tons of LPG Butane per year in 2010 to a mix of end-use sectors. End-uses range from powering equipment (fork lifts at the Star Kist cannery) to residential and commercial cooking and water heating. Relative consumption by sector in 2010 was 30% domestic, 35% commercial, and 30% industrial (cannery).

Sales data were not available for 2005 but are estimated to have been 80% of 2010 levels. GHG emissions are presented for 2005 as 80% of 2010 totals. Sector shares of LPG use are held the same for both years absent any data to allocate them otherwise.

Using industrial emissions coefficients, there are approximately 47 million Btu per ton of n-Butane. There are 143 pounds of CO2 released per million Btu of Butane combusted. Factoring 47 million Btu/ton of n-Butane times the 1,600 tons of Butane sold annually in American Samoa times 143 pounds of CO2 per ton of Butane and divided by 2204.6 pounds per metric ton yields 4,878 metric tons of CO2 emissions attributable to Butane combustion based on 2010 sales. With 2005 sales of Butane estimated at 80% of 2010 levels, the associated CO2 emissions for that year came to 3,902 metric tons. Sector sub-totals are given in Table 7.

Table 7. CO2 Emissions by Sector From n-Butane Combustion in 2010 and 2005 (metric tons CO2e)*

Sector	2005	2010
Residential	1,366	1,707
Commercial	1,366	1,707
Industrial	1,170	1,464
TOTAL	3,902	4,878

* Emission coefficients for N2O and CH4 attributable to Butane combustion were deemed negligible for this analysis due to the extremely complete combustion of LPG

3. Gasoline

Total gasoline sales in 2010 were 6,145,499 gallons. From Table 1, the CO2 emission coefficient for gasoline is 19.54 pounds per gallon. Thus, CO2 emissions as a result of gasoline combustion in the Territory (all transportation) amount to 54,469 metric tons. Two additional GHGs are emitted in gasoline combustion - N2O and CH4 - but in amounts too small to be consequential to this inventory (together they amounted to less than one metric ton in 2005 and again in 2010). Thus, the only GHG of importance to the analysis of gasoline emissions is CO2.

By sector, residential uses constituted 92% of the total gasoline consumed and thus 92% of the gasoline-derived CO2 emissions, or 50,112 metric tons of CO2. Government vehicles represent 5% of the gasoline-fueled vehicles, 5% of the gasoline-derived CO2 emissions or 2,723 metric tons of CO2. The commercial sector is responsible for the remaining 3% of gasoline-derived CO2 emissions, or 1,634 metric tons of CO2. Industrial sector emissions attributable to motor vehicle gasoline combustion are considered negligible due to the small number of vehicles in this category relative to Territory-wide totals.

For 2005, the gasoline sales and associated CO2 emissions were 6,189,216 gallons and 54, 857 metric tons CO2, essentially the same as in 2010. Table 8 presents GHG emissions by year and by sector.

Table 8. GHG Emissions From Gasoline Combustion by Sector (Metric tons CO2e)

Sector	2005	2010
Residential	50,468	50,112
Commercial	1,646	1,634
Government	2,743	2,723
Total	54,857	54,469

4. Land and Marine Diesel

Marine diesel use has historically been dominated by the commercial fishing vessels doing commerce with American Samoan canneries. When one of the two canneries recently closed and as industry refueling practices changed, the amount of marine diesel fuel being sold in American Samoa dropped considerably. This change is most reflected in the numbers of marine vessels refueling in American Samoa in recent years.

There were 1,000 marine vessels in total taking on diesel fuel in 2003, however that number dropped to 639 in 2008. Fishing vessels alone dropped in number from 590 in 2003 to just 137 in 2008, the last year for which data were available. Marine diesel sales dropped from 20.5 million gallons in 2005 to 12.3 million gallons in 2010.

Emission factors for marine diesel used are: a) N_2O - 0.26g/gallon; b) CH_4 - 0.74 grams/gallon, and c) CO_2 - 22.37 pounds/gallon. GHG emissions for marine diesel reflect these three GHGs and are displayed in Table 9.

Table 9. GHG Emissions From Marine Diesel Combustion (Metric tons CO2e)

GHG	2005	2010
CO2	208,012	124,808
N2O	1,157	946
CH4	319	191
Total	209,888	125,945

Land diesel consumed in 2010 for non-utility uses amounted to 3,489,498 gallons. Uses for this fuel ranged from light and heavy duty trucks, motor vehicles, commercial electrical generators, inventories held in reserve for back-up generators, construction equipment, commercial and industrial equipment, and other uses. No data could be found that provide an allocation of land diesel among these various end-use categories or end-use sectors. As a result, estimates needed to be made as to how the nearly 3.5 million gallons of land diesel were used and thus how the GHG emissions from its use could be allocated among end-use sectors.

In the absence of data that breaks out sales of non-utility land diesel, we estimated that 40% of sales (1,395,799 gallons) went to stationary uses (i.e. portable generators) and 60% (2,093,699 gallons) for land transportation (trucks and other diesel-powered vehicles). We held these percentages constant for the analysis of 2005 diesel consumption and emissions analysis.

For 2010, sectoral breakdowns of stationary uses of diesel were estimated to be 60% commercial, 30% industrial, and 10% government. Similarly, land transportation diesel uses by consuming sector were estimated at 5% residential, 5% government, 40% industrial, and 50% commercial.

For 2005, slightly different sector percentages were used to reflect conditions and trends in the American Samoa energy economy that year. Differences include: 1) a higher percentage of industrial and government sector use of stationary diesel compared to 2010 and 2) an opposing higher use in the commercial sector in 2010 for stationary diesel as businesses began generating more of their own electricity due to more frequent utility grid outages since 2005.

In addition, we use a lower commercial sector percentage of transportation diesel in 2005 compared to 2010. By 2010, an increase in commercial and industrial activity (and use of fuels such as transportation diesel fuel) occurred linked to funding flowing to the Territory under the American Recovery and Reinvestment Act of 2009. Totals in gallons consumed by sector are presented in Table 10.

Finally, GHG emissions coefficients for land and marine diesel combustion were taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.[17]

Table 10. Land Diesel Consumption by Sector (Gallons)

Stationary Diesel	Sector	Gallons 2010	%	Gallons 2005	%
	Residential	*	-	*	-
	Commercial	837,479	60	635,245	50
	Industrial	418,740	30	444,671	35
	Government	139,580	10	190,573	15
Total		1,395,799	100	1,270,489	100
Land Transportation Diesel	**Sector**	**Gallons 2010**	**%**	**Gallons 2005**	**%**
	Residential	104,684	5	190,573	10
	Commercial	1,046,851	50	857,580	45
	Industrial	837,480	40	670,007	35
	Government	104,684	5	190,573	10
Total		2,093,699	100	1,905,733	100

* In the absence of sales data or other evidence, residential use of diesel for stationary applications is estimated to be too small to be statistically significant for this analysis.

Total land diesel GHG emissions came to 35,598 metric tons of CO2e in 2010 and 34,006 metric tons CO2e in 2005. Tables 11 and 12 break out these emissions by sector - stationary and transportation - as assigned above.

Table 11. 2010 Land Diesel GHG Emissions by Sector (Metric tons CO2e)

Sector	Stationary	Transportation	Total
Residential	*	1,062	1,062
Commercial	8,620	10,622	19,242
Industrial	4,301	8,498	12,799
Government	1,433	1,062	2,495
Total	14,354	21,244	35,598

Table 12. 2005 Land Diesel GHG Emissions by Sector (Metric Tons CO2e)

Sector	Stationary	Transportation	Total
Residential	*	1,934	1,934
Commercial	7,920	8,701	16,621
Industrial	4,544	7,001	11,545
Government	1,972	1,934	3,906
Total	14,436	19,570	34,006

5. Jet Fuel

Reported data from other GHG inventories indicate that for aircraft fuels, CO2 emissions account for about 98% of all CO2-equivalent emissions. Based on the effort required to identify and account for the various gases comprising the remaining 2%, this inventory limits itself to CO2 emissions attributable to the gallons of jet fuel consumed in the aviation sector.

The most direct methodology available is based on an aggregate figure of fuel consumption (gallons) for aviation (provided by OPM) multiplied by an average emission factor per gallon of jet fuel. The default emission factor for CO2 used in this report (21.09 pounds of CO2 per gallon of jet fuel combusted) represents an average based over all flying phases.

More sophisticated methodologies are being developed which take into account age of aircraft, flight duration, fuel use per flight phase (idle/taxi/take off/climb/cruise/descent/landing) and other factors, however use of such a methodology is beyond the scope of this analysis, at least at this initial stage.

Sales of jet fuel in American Samoa in 2010 totaled 3,299,532 gallons and in 2005 totaled 2,965,592 gallons. Using the CO2 coefficient above, jet fuel GHG emissions totaled 28,370 tons in 2005 and 31, 564 metric tons in 2010, a 10% increase. These totals are listed in Table 13.

Table 13. Jet Fuel Emissions (Metric tons CO2e)

	2005	2010
Metric Tons CO2e	28,370	31,564

6. Kerosene

Kerosene, sold at retail gasoline stations, is used in a variety of residential and commercial appliances and other stationary end-uses. Kerosene sales in 2010 amounted to 42,922 gallons, a significant decrease from the 126,258 gallons sold in 2005. Sales data by sector are not maintained, however we estimated a mix of 60% residential and 40% commercial for both 2005 and 2010.

The CO2 attributed to kerosene combustion in 2010 amounted to 418 metric tons, down from 1,232 metric tons in 2005, a decline of 66%. Smaller contributions from N2O and CH4 raised the two years' totals to 422 metric tons CO2e (2010) and 1,254 metric tons CO2e (2005). Volume numbers for each of the two years, by sector, are presented in Table 14.

Table 14. Kerosene Emissions by Sector (Metric tons CO2e)

Sector	2010	2005
Residential	253	752
Commercial	169	502
Total	422	1,254

7. Landfill Gas

Municipal solid waste (MSW) landfill gas, which by volume is roughly a 50/50 mixture of methane and carbon dioxide with trace amounts of many other compounds, has the potential to cause or contribute to a number of aesthetic, health and environmental problems if not captured and treated.[18] These include odors, potential explosion hazards, ground-level ozone formation and global warming.

In American Samoa, approximately 80 - 150 tons of solid waste are landfilled six days a week for an annual total of 25,000 - 46,800 tons. We use the mid-point of this range, and estimate that municipal solid waste landfilled in American Samoa amounts to 36,000 tons/year. A recent study of the American Samoa solid waste stream showed that roughly half of this tonnage is organic material (paper, organics) and the remainder is inorganic (construction debris, glass, metals).[19] Thus, we conclude that municipal solid waste capable of releasing GHGs after being landfilled amounts to about 18,000 tons per year.

Studies indicate that 0.05- 0.1 ton CH_4 is emitted per ton of landfilled MSW depending on the dry biomass content.[20] For a 50% biomass content as in the American Samoa landfill, a ton of landfilled waste was found to emit 0.08 tons of CH_4. Looking at the 18,000 tons per year of dry biomass being landfilled we calculated the release of 1,440 tons of CH_4. Importantly, this equates to 30,240 tons of CO_2 when applying the GWP of methane.

Further, GHG emissions of N_2O from municipal solid waste have been estimated to be 0.44 kg/metric ton of waste. Again using the 18,000 tons per year number of tons of solid waste landfilled, the N_2O linked annually to American Samoa's landfill operations is an additional 2,344 metric tons CO_2e.

The GHG emissions attributable to municipal solid waste disposal practices in American Samoa amount to 32,584 tons (2010). Without 2005 data as to tons of municipal waste landfilled, we believe that a stronger American Samoa economy in 2005 may well have resulted in increased landfill tonnages of municipal solid waste by as much as 15%. We therefore estimate GHG emissions of CH_4 and N_2O to have been 15% higher per ton in

2005 than in 2010. For CH4, this amounts to 34,776 metric tons CO2e and for N2O the amount is 2,696 metric tons CO2e for a total of 37,472 metric tons CO2e. These emissions are attributed to the utility sector as the American Samoa Power Authority (ASPA) manages the solid waste collection and disposal system in the Territory.

8. Animal Husbandry

There are an estimated 800 piggeries on the island of Tutuila, with 8-10 animal units per piggery, each responsible for a small amount of GHG emissions. These piggeries are almost always family-owned operations and thus considered in the residential sector for this overall inventory.

There are two sources of GHG from piggeries, the release of methane from enteric fermentation in each animal, and the release of methane from the management of manure from each piggery. While piggery GHG emissions are small compared with emissions from other sources, the Global Warming Potential (GWP) of methane (21 times that of CO2) requires a calculation be made to determine the GHG contribution of piggery management in American Samoa.

The U. S. EPA has an accepted methodology used to estimate emissions from livestock enteric fermentation, with emission factors specific to each animal type.[21] These factors are based on research data and expert opinion. Average emission factor estimates are from Crutzen, et al. (1986), who developed emission factors for developed and developing countries.

Typical animal size, feed intakes, and feed characteristics are considered in these estimates. Emission factors have not been developed specifically for the U.S. because emissions from non-cattle livestock are small relative to emissions from cattle.

For American Samoa, we use the value of 1.5 kg of methane per “animal head” or “animal unit” per year. For 2010, we use an estimate of 9,000 pigs being managed in the Territory. The resulting methane emissions total 13,500 kg CH4. With methane’s GWP of 21, this equates to 283 metric tons of CO2e attributable to enteric fermentation from the 9,000 pigs under management in the Territory.

To this must be added the methane emissions attributable to management of the manure from the 800 piggeries in the Territory in which the 9,000 animals are kept. Globally, data on emissions from piggeries manure management are derived from facilities which are orders of magnitude larger in size than those in American Samoa. Treatment methods used in these larger facilities can often produce additionally significant amounts of methane beyond those due to enteric fermentation.

However, because of the small average size of American Samoa piggeries, these lagoon treatment approaches are not used and liquid manure is not stored in a way to allow methane to be more rapidly created. Thus, for this analysis, we assume that the methane releases from manure management of the 800 piggeries in the Territory total no more than 10% of the emissions owing to enteric fermentation. Thus, an additional 28 metric tons of CO2e are attributable annually to manure management for a total emissions of GHG due to piggeries of 311 metric tons CO2e.

Data were not available for the year 2005, however we estimated that the number of piggeries and animal units were essentially unchanged from 2010. Emissions for each year are reflected in Table 15.

Table 15. Emissions From Animal Husbandry (Piggeries), Metric tons CO2e

	2005	2010
Enteric Fermentation	283	283
Manure Management	28	28
Total	311	311

9. Wastewater Management

There were some 9,000 residences on Tutuila according to the 2000 Census. Of these, about 40% were connected to the wastewater treatment system. Homes from Aoa-eastward are not connected nor are homes west of Leone. Of those residences not connected to the system, 10% have septic systems and the remaining 90% use “cesspools” for waste disposal. GHG emissions in the form of methane occur to differing degrees based on the type of wastewater treatment and waste disposal practices in use.

According to a recent report by the Water Environment Research Foundation, the U.S. EPA has determined that more than 80% of the methane emissions associated with wastewater originate from on-site septic systems.[22] The report also finds that methane and CO2 are the primary GHGs found in emissions from septic tanks, while CO2 and N2O are the primary GHGs from the soil dispersal system. Septic system emissions on an average, per capita-year basis, measured in metric tons of CO2e are: methane - 0.10, CO2 - 0.12; and NO2 - 0.022, for a total of 0.24 metric tons per capita-year.

A U.S. EPA evaluation of the Tutuila wastewater treatment infrastructure presents the following description of how wastewater is currently managed at the two treatment facilities on the island.

> "The Tafuna sewage treatment plant provides primary treatment and undisinfected discharge through an ocean outfall. The processes consist of long-channel grit removal, manual bar screens, a deep-well influent pump station, three clarigesters, and an ocean outfall. Clarigesters are primary sedimentation basins with a clear well section above an anaerobic digester section. ASPA operates the Tafuna sewage treatment plant under the assumption that each clarigester has a rated capacity of 1.0 mgd, for a total of 3.0 mgd. However, the as-built drawings list a smaller design criterion of 2.6 mgd. The average daily flows of 1.92 mgd over the 12 months from July 2006 through June 2007 are nearing the as-built design criterion but not the assumed rated capacity."[23]

The Tafuna plant has a service population of 14,424. The three anaerobic digesters each have a volume of 142,743 gallons/day. Production of solids is on the order of 540 lbs/day with a 20-day residence time in the digesters.

The Utelei sewage treatment plant discharges to the Pago Pago harbor. It employs four clarigesters but has no no grit removal or sludge drying. Two digesters have a volume of 86,342 gallons and the other two digesters have a volume of 112,776 gallons. There is no room for expansion. Digested sewage from Utelei is trucked to the sludge drying beds at the Tafuna plant. The Utulei plant has a dry weather capacity of 2.21 mgd with average daily flows of 1.69 mgd July 2006-June 2007. Its service population is reported at 14,734.

GHG emissions can be attributed to the three principal forms of waste treatment in the Territory: the two centralized plants in Tafuna and Utulei; septic systems; and the more prevalent and less-managed "cesspools" identified by American Samoa EPA.

Centralized Treatment

The USEPA's Draft Inventory of Greenhouse Gas Emissions and Sinks includes a detailed methodology for characterizing the GHG emissions of all forms of domestic wastewater treatment. For centralized systems common to the United States, most with secondary and many with tertiary treatment, the methodology includes features such as the percentage of Biological Oxygen Demand (BOD) treated after primary treatment, the maximum CH4-producing capacity of domestic wastewater, and other characteristics of large, centrally-located treatment plants.

In American Samoa, such a detailed methodology is not appropriate due to the very basic level of treatment of wastewater that occurs in advance of ocean disposal. There is such a short holding time for the wastewater that little bacterial breakdown has a chance to occur. As a consequence, the production of CH4 in the American Samoa wastewater plants is small, though not zero.

To account for this in reasonable fashion, we factored the population served by the Utulei and Tafuna plants (29,158) as a per cent of the U.S. State and Territorial population served by centralized systems as used in the U.S. Inventory (250 million) to arrive at a percent of the 2.7 Tg of methane (CO2e) attributable to this emissions source.

Based on 2010 census data, the American Samoa population's "share" of this number is 0.0001% or 270 metric tons. At the scale of the U.S. Inventory analysis, there is no statistically important difference in emissions from centralized treatment in American Samoa from 2005 through 2010. Thus the same 270 metric tons of CO2e value for CH4 was used for the 2005 findings as well. Both are attributable to the utility sector which manages the treatment facilities.

N2O emissions from domestic wastewater treatment in the U.S. is approximately one-third that of methane emissions as measured in CO2e. Thus, an additional 90 tons of GHG attributable to N2O is added to the 2005 and 2010 emissions figures, for a total of 360 metric tons per year of CO2e.

Septic Systems

Based on ASEPA estimates, some 10% of those residences not connected to centralized wastewater treatment employ septic tanks.[24] With no additional data to rely upon, we assume that 10% of the population not connected to centralized treatment used septic systems in 2010 (or a total of about 2,600 people). Using per capita emission factors provided above, 2,600 people were responsible for 624 metric tons of CO2e.

Cesspools

There were no data or literature found for this inventory that examined GHG emissions from uncontrolled wastewater disposal practices. We estimate that GHG emissions generated from cesspools are comparable in amount to those from septic systems, perhaps much more so. In the absence of data, however, we use the same GHG emission factors for them as for septic systems. Thus, the 23, 717 individuals using the cesspool method of wastewater disposal would have generated a total of 5,692 metric tons of CO2e in 2010.

In the absence of meaningful data for the earlier 2005 period, we held the GHG volumes constant for both septic and cesspool methods of disposal and attributed these again to the residential sector in the overall sector comparisons. Totals for the various types of GHG source, by sector are presented in Table 16.

Table 16. GHG Emissions by Wastewater Management Type, 2005 and 2010 (Metric tons CO2e)

Management Type	2005	2010
Centralized Treatment	360	360
Septic Systems	624	624
Cesspools	5,692	5,692
Total	6,676	6,676

TOTAL GHG EMISSIONS BY END-USE SECTOR

GHG emissions from all sources were tabulated and assigned to the 5 sectors used in this inventory. Results for 2010 (and the comparison year 2005) are provided in Table 17. Commercial sector emissions are by far the largest contributor to the Territory's GHG footprint, accounting for 58% of emissions in 2010 (191,203 metric tons CO2e) and 65% in 2005 (269,929 metric tons CO2e). Residential sector emissions followed as the second highest source, with 71,250 metric tons CO2e in 2010 (22% 0f the year's total) and 73,027 metric tons in 2005 (18% of that years much higher overall emissions number).

For 2010, the remaining contributions came from the utility sector (11% and 35,118 metric tons CO2e), the industrial sector (6% and 19,565 metric tons CO2e) and lastly, the government sector (3% and 9,736 metric tons CO2e).

Table 17. American Samoa GHG Emissions, by Sector, 2005 and 2010 (Metric tons CO2e)

Sector	2005	%	2010	%
Residential	73,724	18	70,909	21
Commercial	270,012	64	190,372	58
Industrial	22,354	5	19,271	6
Government	13,577	3	12.231	4
Utility	40,006	10	35,245	11
Total	419,673	100	328,028	100

Summaries for each sector and year are presented below.

1. Residential

Residential GHG emissions are the sum of emissions from residential electricity use, private automobile use, domestic uses of n-Butane and kerosene, animal husbandry and untreated wastewater systems. These emissions are displayed in Table 18 below.

There was a total of 71,250 metric tons of CO2e attributable to the Residential Sector in 2010. This represents a 3% decline in sector emissions over 2005. In each of the two years the combination of gasoline and electricity-derived emissions account for over 85% of the sector's totals. The 3% decline in 'GHG emissions from 2005 to 2010 is due to lower sector consumption of kerosene and land diesel.

Table 18. Residential Sector GHG Emissions, 2005, 2010 (metric tons CO2e)

GHG Emission Source	2005	%	2010	%
Electricity	12,236	17	11,489	16
Gasoline	50,112	69	50,112	70
Diesel	1,934	3	1,062	1
n-Butane LPG	1,366	2	1,707	2
Kerosene	752	1	253	<1
Animal Husbandry	311	<1	311	<1
Untreated Wastewater Systems	6,316	8	6, 316	9
TOTAL	73,027	*	71,250	*

* **Total does not equal 100% due to rounding**

2. Commercial

Commercial sector GHG emissions (CO2e) are attributable to electricity, motor gasoline, land diesel, marine diesel, kerosene, aviation fuel, and n-Butane LPG uses. These emissions from all gases are displayed in Table 19 below.

There was a total of 191,203 metric tons of CO2e attributable to the Commercial Sector in 2010. This represents a 29% decline in sector emissions over 2005. In 2010, the combination of marine diesel (66%) and jet fuel (17%) were the two largest contributing sources of GHG emissions. The large decline in overall GHG emissions from 2005 to 2010 is due to lower sector consumption of marine diesel attributable to structural changes in the fishing and fish cannery industries.

Table 19. Commercial Sector GHG Emissions, 2005, 2010 (metric tons CO2e)

GHG Emission Source	2005	%	2010	%
Electricity	11,278	4	10,452	5
Gasoline	1,634	<1	1,634	1
Land Diesel	16,662	6	19,242	10
Marine Diesel	209,888	78	125,945	66
n-Butane LPG	1,366	<1	1,707	1
Jet Fuel	28,599	11	32,054	17
Kerosene	502	<.01	169	<.01
TOTAL	269,929	*	191,203	*

*** Total does not equal 100% due to rounding**

3. Industrial

There was a total of 19,565 metric tons of CO2e attributable to the Industrial Sector in 2010. This represents a 11% decline in sector emissions over 2005. In 2010, the combination of land diesel (65%) and electricity (27%) were the two largest contributing sources of GHG emissions. The decline in GHG emissions from 2005 to 2010 is due to lower sector consumption of electricity due to the economic downturn and the shuttering of a large cannery. Totals and sector breakouts are provided in Table 20.

Table 20. Industrial Sector GHG Emissions, 2005, 2010 (metric tons CO2e)

GHG Emission Source	2005	%	2010	%
Electricity	9,345	42	5,302	27
Gasoline	*	*	*	*
Land Diesel	11,545	52	12,799	65
n-Butane LPG	1,170	5	1,464	8
TOTAL	22,060	**	19,565	100

*** Negligible as a % of overall vehicle use compared to other end-use sectors**

**** Total does not equal 100% due to rounding**

D. Government

There was a total of 9,736 metric tons of CO2e attributable to the Government Sector in 2010, essentially unchanged from 2005. The combination of electricity and gasoline combustion were the two largest contributing sources of GHG emissions in the sector. Though data for streetlight electricity consumption are kept separately by ASPA, they are included in the Government Sector analyses throughout this inventory. Totals and sector breakouts are provided in Table 21.

Table 21. Government Sector GHG Emissions, 2005, 2010 (metric tons CO2e)

GHG Emission Source	2005	%	2010	%
Electricity	6,928	72	7,013	72
Gasoline	2,723	28	2,723	28
TOTAL	9,651	100	9,736	100

E. Utility

There was a total of 35,118 metric tons of CO2e attributable to the Utility Sector in 2010. This represents a 6% decline in sector emissions over 2005. Methane releases from the American Samoa landfill represent 93% of the sector's GHG emissions. Another 6% is due to electricity consumption with about 1% due to emissions from the utility's centralized wastewater treatment activities. Results are summarized in Table 22.

Table 22. Utility Sector GHG Emissions, 2005, 2010 (metric tons CO2e)

GHG Emission Source	2005	%	2010	%
Wastewater Treatment	360	<1	360	1
Landfill	37,477	94	32,584	93
Electricity	2,174	5	2,174	6
TOTAL	40,011	*	35,118	100

*** Totals do not equal 100% due to rounding**

PART B

GREENHOUSE GAS MITIGATION: LEAST-COST OPPORTUNITIES FOR AMERICAN SAMOA

With this initial inventory of GHG emissions completed, an opportunity exists to begin identifying measures that can most immediately and cost-effectively lower those emissions. The focus of this effort needs to be on those sources of GHG that offer the largest potential for overall reduction, primarily electricity generation and transportation fuels use.

Using information gathered in the collection of data for this inventory, as well as energy management practices identified in the draft Energy Assurance Plan (EAP)[25] for American Samoa (final EAP expected July 2012), several easy. low-cost, opportunities exist to reduce GHG emissions in American Samoa. These include:

1. Reduction in electrical generation/distribution sector inefficiencies
2. Increased use of pre-paid electricity meters
3. Continuation of appliance efficiency incentive programs
4. Reduction in the volume of non-revenue water loss
5. Continued implementation of renewable energy systems
6. Improved transportation fuel efficiency
7. Diversion of organic materials from landfills
8. Increased use of LED streetlights

1. Reduction in electrical generation/distribution sector inefficiencies

In 2008, line losses accounted for 8.4 % of the electricity generated by ASPA's two generating stations. The GHG associated with the lost 15,000,000 kWh would be easy savings to capture with an increase in distribution system efficiency. If half of the efficiency losses were recaptured, there would be a savings of 1,725 metric tones /CO2 per year with no reduction in electricity end-use services delivered to the American Samoan economy.

2. Increased use of pre-paid electricity meters

Prepaid electrical meters have been used in American Samoa since 2000. Initially, they were introduced by ASPA to address late payment issues with customers. Use of the meters requires customers to prepay a fixed amount to ensure upfront revenue to the utility.

ASPA's experience with prepaid meters has been that these customers monitor their electrical usage more than those who are billed at the end of a billing period. These customers then use electricity more efficiently than post-pay customers. ASPA estimates that customers with prepaid meters who control their daily energy use will reduce demand anywhere from 5-15%. Thus, GHG savings in this same amount are being achieved through use of the prepaid meters. With about 20% of ASPA's residential customer customers using prepaid meters, the opportunity exists for the other 80% to reduce electricity consumption, monthly bills, and GHG emissions by anywhere from 5-15%.

A 50% increase in the use of pre-paid meters in the residential sector alone could potentially save 19,973 MWH/year and 4,596 metric tons of GHG/year.

Prepaid meters cost approximately $320 uninstalled and have a lifetime of about 10 years. They thus represent an easy low-cost approach to achieve significant energy, cost and GHG emissions reduction. If prepaid meters could be made widespread through the commercial, industrial and governmental sectors, savings in all of the categories would be even more consequential.

3. Continuation of successful appliance efficiency incentive programs

Using funds from federal energy grant programs, the Territorial Energy Office (TEO) has successfully replaced or incentivized the replacement of energy-inefficient appliances, air conditioners and light fixtures throughout the Territory. In coming years, TEO should expect some level of continued U.S. Department of Energy funding to continue these efforts and these funds should be aggressively directed to the many remaining appliance replacement opportunities which have not yet been addressed with earlier funding.

Programs such as this offer the quickest energy and cost savings as well as GHG emissions reduction per dollar of investment and should be continued. For each MMBTU of energy saved by these efficiency projects, there is a GHG reduction of 0.07 metric tons. While small on a single-appliance level, totals will increase rapidly as efficiency programs reach scale.

Examples of appliance replacements include refrigerators, air conditioning units, freezers, energy efficient lightbulbs, low flow shower heads and faucet aerators, water heater timers, power strips, and solar hot water heaters. TEO's appliance replacement accomplishments using ARRA and Weatherization Assistance Program (WAP) funds through March 2011 are presented in Table 23.

Table 23. TEO Appliance Replacements and Savings Through March 2011

Appliance (#s)	Energy Savings (MMBtu/year)	GHG Reductions for Total Program Accomplishments (metric tons CO2e/year)
Refrigerators (280)	488	8.4
Small Air Conditioners (50)	915	3.0
Small Air Conditioners (60)	915	3.6
Large Air Conditioners (80)	1,130	6.4
Compact Fluorescent Lights (420)	644	16.8
TOTAL	4,092	38.2

Other efficiency benefits will accrue from appliance replacements that should be part of any extended energy efficiency and GHG reduction initiatives. These values, again small on an individual unit level, can accrue on scale and on a year-to-year basis. They include: low-flow shower heads and faucet aerators - 1570 MMBtu/year savings/aerator; water heater timers -1464 MMBtu/year savings/timer; domestic solar water heaters - 159 MMBtu/year savings/system; and power strips - 21 MMBtu/year savings/power strip.

4. Significant reduction in the volume of non-revenue water loss

The American Samoa Power Authority provides drinking water to the island of Tutuila from a network of wells, pumping stations, storage tanks and distribution lines. The pumping, movement, treatment, and distribution of potable water requires energy at every step of the way. Data collected through early 2011 by ASEPA staff suggest that the difference between the amount of water pumped in ASPA's system and the amount sold (known as "non-revenue water") is above 60%. Thus, due to leaks and other system inefficiencies 416 MWh of electricity is lost monthly, on average. There is a significant GHG emissions footprint associated with this single energy efficiency opportunity alone.

Water losses include those from tank overflows during filling as well as leaks in distribution system pipes. After backing out known losses, ASPA staff note that the system's unknown/un-located leaks still amount to about 18% of the water originally pumped. In addition, most existing water storage tanks were built in the early 1970s and are deteriorating with time.

There are several cost and operational reasons to reduce the amount of water and energy lost due to water system inefficiencies and each would bring with it a reduction in the GHGs linked to the electricity ASPA generates to move water. An effort to reduce water losses is something that should be undertaken even if GHGs emissions were not a factor in a decision to do so. It represents another easy opportunity to reduce GHG emissions at a positive economic return to the utility and its customers.

5. Continued implementation of renewable energy systems

Under the leadership of the Territorial Energy Office, American Samoa and its electric utility are quickly gaining access to a supply of photovoltaic (PV) energy coming on-line in projects developed using a mix of State Energy Program and ARRA funds. With these funds, 2.4 MW of PV has been installed and linked to the ASPA distribution system and help offset diesel fuel and lower GHG emissions whenever the incident solar energy allows. American Samoa was recently awarded a #1 ranking of all States and Territories for TEO's aggressive program of PV build-out. For every kWh of electricity provided to the ASPA grid by the TEO PV projects, GHG emissions are prevented.

As funding from the U.S. Department of Energy, and possibly other agencies of the U.S. government, allow, additional renewable energy systems should be brought on-line. Importantly, the Territory should invest the effort required for the maintenance and upkeep of all renewable energy systems installed so that their full compliment of benefits can be achieved over their 20+ year lifespans.

6. Improved transportation fuel efficiency through driver education, fleet replacement, and social/cultural marketing steps

A strong fuel and GHG-saving tool already in place in American Samoa is the widespread use of driver courtesy in the absence of traffic signals wherein drivers routinely allow cross-traffic to move without significant delays. This avoids the need for traffic signals which have proven to be both costly (operational energy use, purchase and maintenance of lamps, productivity and fuel lost to idling at lights, etc.) as well as largely unnecessary on an island with fewer than 10,000 vehicles. A high value should be placed on the continued use of traffic circles, stop signs, and "Samoan courtesy" in lieu of adding even one traffic light in the Territory.

An additional, low-cost opportunity to reduce energy costs and GHG emissions involves replacement of low-efficiency vehicles with new generation, high-efficiency internal combustion and hybrid engine technologies. With average fleet fuel efficiency in American Samoa of 13-15 mpg, easy opportunities exist to transition the American Samoa vehicle fleet to more energy and GHG-efficient vehicles with fuel economies of 30 to 40 mpg. As fuel prices exceed $4.50 a gallon, the economic incentive to make this transition continues to grow.

Other transportation opportunities consist of changed driving behaviors that reduce idling and moderating the use of air conditioning, both of which consume expensive fuel and add GHG emissions to the atmosphere while not moving people or cargoes. Looking ahead, these may be luxuries that an era of expensive gasoline no longer allow.

7. Diversion of organic materials from landfills

Organic materials account for about 55% of waste currently reaching landfills, primarily consisting of food scraps, yard trimmings, wood, and paper/paperboard (EPA, 2010e). Due to their role as the source of CH4 in landfills, the diversion of these materials prior to landfilling may be used as a GHG reduction strategy. Diversion methods include composting, recycling, and anaerobic digestion.

Organic waste diversion from landfills prevents CH4 generation proportionally to the amount of organic waste diverted. For example, CH4 generation at landfills is halved with a 50% organic waste diversion rate. Combining organic waste diversion with a gas collection and control system can further reduce GHG emissions.

8. Increased Use of LED Streetlights

In both 2010 and 2005, about 1.9 MWH of electricity was used to power streetlights in American Samoa. The lamps in these streetlights are traditional fixtures which could easily be replaced with new, energy efficient light-emitting diode (LED) lamps. A major manufacturer of these LED lights has recently announced that it has halved the cost of its own products in the hope that local governments will begin adopting the new technology more rapidly.[26] It achieved the cost reduction through design changes in the lamps that now use fewer semiconductor chips.

This action would require a simple, one-time cost and be a prime candidate for investment of capital improvement funds coming annually to the Territory. A reasonable supply of replacement lamps should be held on hand in the event of lamp breakage due to storms, vandalism, etc.

Cost-savings that can be realized by the American Samoa Government (the sector under which streetlight energy use was included) are a combination of reduced electricity costs and lower and less frequent maintenance costs. Each results in reduced GHG emissions as a major co-benefit to the cost-savings features of the technology.

In addition to these early opportunities to reduce GHG emissions in the Territory, American Samoa has other GHG reduction options which can be undertaken when and as funding is available for more capital intensive projects. These would include wastewater treatment line extension to areas now using GHG-intensive septic and cesspool systems and a transition away from diesel combustion for primary electricity generation.

Each of these measures has multiple co-benefits to the American Samoa economy and society in addition to the reduction of GHGs. These co-benefits (improved public health and sanitation, individual and business energy savings, stimulation of the local economy, etc.) should be considered as part of any cost-benefit analysis in support of sewer line extension and conversion to alternative, renewable base-load energy technologies.

In summary, there are multiple, low-cost opportunities for American Samoa to take advantage of on its path toward a low-GHG emission future. Each has additional benefits to the economy and people of the Territory and should be considered even if reducing GHGs was not a primary objective.

Moving to reduce GHG emissions signals to the region and to the world the commitment the Territory is wiling to make on behalf of a more climate-stable planet. American Samoa's GHG emissions are small in comparison to global totals, however actions to reduce those emissions send a message to the world that it is indeed possible to make progress against the threat of climate disruption, particularly to small, island communities.

ENDNOTES AND REFERENCES

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[3] “Gov. establishes climate change advisory group.” Samoa News, June 22, 2011.

[4] United Nations Framework Convention on Climate Change, Article 4(1)(a). 1992.

[5] Nationally, the largest source of GHG emissions is CO2 from fossil fuel combustion, accounting for 79% of total U.S. GHG emissions in 2009 according to the USEPA.

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[9] Intergovernmental Panel on Climate Change, IPCC. 1966**.**

[10] Inventory of U.S. Greenhouse Gas Sources and Sinks: 1990-2006. US.Environmental Protection Agency (EPA-430-R-08-005). Section 3-3. April 15, 2008.

[11] Note: GHG inventory analyses for years beyond 2011 will need to account for CO2 emissions from ultra-low sulfur diesel fuel now being burned at the Satala plant to the extent that its CO2 emission coefficient is distinguishable from that of the higher sulfur #2 diesel consumed at the generating station prior to 2011.

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[13] American Samoa Statistical Yearbook. 2008.

[14] ibid.

[15] "ASPA Sales Data by Customer." ASPA. Data adjusted up by a factor of 12% to account for energy consumed in power generation plus system line losses.

[16] The CO2 emissions coefficient for #2 diesel is 161 pounds per MMBtu; 3.1413 Btu/MWH; and 2204.6 pounds/metric ton.

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