Decarbonization in Hawai‘i

Update on the Decarbonization Strategy and Succeeding Priority Climate Action Plan

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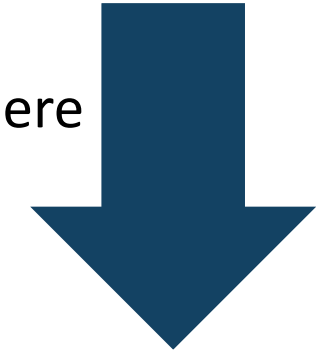
What is Decarbonization?

Reducing greenhouse gases **emitted** into the atmosphere



Increasing the capacity of natural and technological sinks*
(Complementary to reducing emissions – not a substitute).

*Sinks or carbon reservoirs are places or materials where more carbon is stored than released into the atmosphere. Sinks include natural sinks such as soil, rocks, forests, and the ocean, as well as technological sinks. Technological sinks are a newer concept and include engineered materials that store carbon captured from the air, or geological reservoirs where captured carbon dioxide is mineralized into a stored form.

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Hawai‘i Revised Statutes §225P-5, Zero Emissions Clean Economy Target (2018, 2022*)

(a) Considering both atmospheric carbon and greenhouse gas emissions as well as offsets from the local sequestration of atmospheric carbon and greenhouse gases through long-term sinks and reservoirs, a statewide target is hereby established to **sequester more** atmospheric **carbon and greenhouse gases than emitted** within the State **as quickly as practicable, but no later than 2045**[.]; provided that the statewide target includes a greenhouse gas emissions limit, to be achieved **no later than 2030, of at least fifty percent below** the level of the statewide greenhouse gas emissions in **2005**.

*Act 238 (2022) added an interim 2030 greenhouse gas emissions target using a new baseline of 2005 instead of 1990.

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State of Hawai'i Decarbonization - Net Emissions Goal

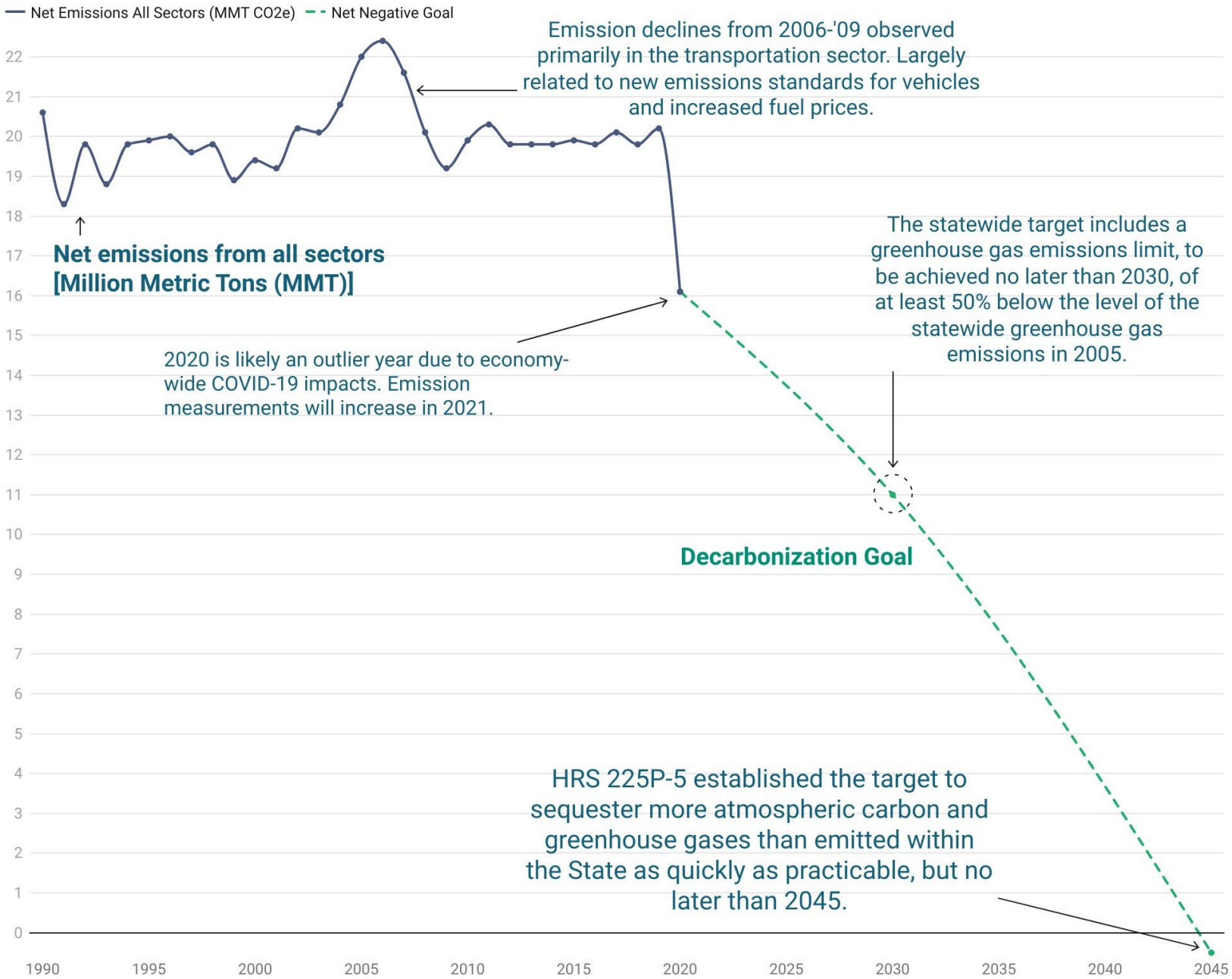

Chart: Hawai'i State Energy Office • Source: United States EPA Greenhouse Gas Inventory Data Explorer • Created with Datawrapper

- Graph shows total estimated emissions expressed in CO2 equivalent since 1990
- While periods of significant dips are tied to times of economic stress, they are also indicators of successful policy (e.g. vehicle emissions standards).
- Emissions have been relatively stagnant since the 1990's – suggesting substantial economic change is needed.

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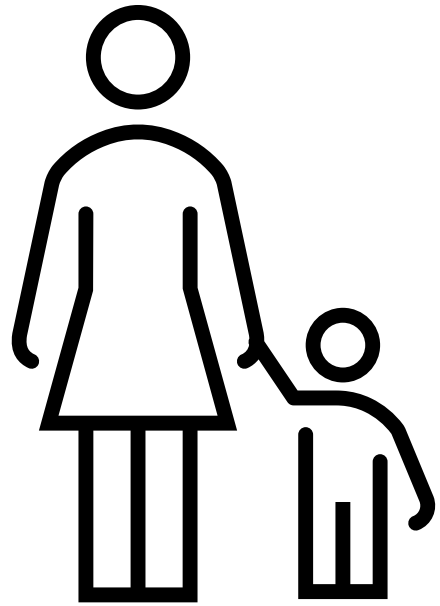
Generational Equity

Each generation has the right to inherit the same diversity and cultural resources enjoyed by previous generations and to have equitable access to the use and benefits of these resources.



Goes beyond climate…

- Energy security
- Quality of life that a secure energy system provides

Generational Equity

Hawai‘i State Constitution, Article XI Section 1

“For the benefit of present and future generations, the State and its political subdivisions shall conserve and protect Hawaii's natural beauty and all natural resources, including land, water, air, minerals and energy sources, and shall promote the development and utilization of these resources in a manner consistent with their conservation and in furtherance of the self-sufficiency of the State. All public natural resources are held in trust by the State for the benefit of the people.”

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Decarbonization Strategy – Act 238

1. **Recommend regulatory or other state action; that will ensure the attainment of the State's decarbonization goals;**
2. Include measures to reduce emissions from electricity, including accelerating the adoption of clean energy and improving energy efficiency for residential, commercial, and government users;
3. Include land use and transportation planning measures aimed at reducing emissions from the transportation sector;
4. Recommend state actions to address emissions associated with air travel and shipping, including how to encourage electrification and adoption of alternative fuels;
5. Recommend best management practices in the agricultural sector;
6. Include long—term carbon sequestration and carbon capture and utilization opportunities;
7. **Make recommendations to aid in the transition of the state workforce to meet the needs of a decarbonized economy;**
8. **Consider impacts to environmental justice, frontline, and low-income communities and make recommendations for how to mitigate any impacts to these communities and to facilitate a just transition to a decarbonized economy;**
9. **Determine the most cost-effective pathway to decarbonization;**
10. Rank recommendations based on level of impact, cost, and ease of implementation;
11. Make recommendations on whether the goals established pursuant to section 225P—5, Hawaii Revised Statutes, should be adjusted, or if additional interim goals between the completion of the analysis and 2045 should be adopted
12. Examine contributions of different carbon sources, how each source can be reduced, what entities are responsible for the reduction of each source, and how each source factors into the determination of statewide greenhouse gas reduction goals; and
13. Include other relevant considerations as deemed appropriate and necessary.

Climate Strategy Coordination

	DUE DATE	JURISDICTION	ELIGIBILITY EPA IMPLEMENTATION FUNDS
Decarbonization Strategy	DECEMBER 2023	STATE	NOT ELIGIBLE
State PCAP	MARCH 1ST 2024	STATE & COUNTIES	ELIGIBLE
C&CH PCAP	MARCH 1ST 2024	C&C HONOLULU	ELIGIBLE

Workplan

PRIORITY CLIMATE ACTION PLAN (PCAP)

A roadmap prioritizing and coordinating projects to be ready to apply for the **$4.6 billion** available nationwide for climate action implementation.

MITIGATION PLANS →

COMPREHENSIVE CLIMATE ACTION PLAN (CCAP)

A community focused detailed action plan identifying steps needed to create a clean, equitable, and resilient climate ready Hawai‘i

Decarbonization Strategy and PCAP Relationship

Decarbonization Strategy

- Required to evaluate different carbon sources, how each source can be reduced, what entities are responsible for the reduction of each source, and how each source factors into the determination of statewide greenhouse gas reduction goals.
- Emission projections based on reduction targets (requirement of CCAP)
- Required to include measures to reduce emissions from all sectors
- The study must consider impacts to EJ, frontline, and low-income communities.

PCAP

- Requires a GHG Inventory
- Requires quantified GHG reduction measures
- Include near-term, implementation ready priority greenhouse gas reduction measures
- Requires a preliminary benefits analysis that identifies low-income and disadvantaged communities that will be affected by the GHG reduction measures in the PCAP

How is progressed tracked?

- The State Department of Health (DOH) is responsible for publishing an annual emissions inventory **(§HRS 342B-71)**.
  - *The director [of health] shall complete a greenhouse gas emissions inventory report each year beginning after 2017 to track emissions and determine the State's progress in the reduction of greenhouse gas emissions.*
- The inventory is inclusive of statewide “tailpipe” or direct emissions only.
- It is **not** inclusive of imported lifecycle emissions.

GHG Emitting Sectors

To analyze emission sources, the UN Intergovernmental Panel on Climate Change (IPCC) provides estimation methods for different economic "Sectors".

Sectors are further divided into individual categories and subcategories.

Estimates are as good as the granularity of input data available. Some data categories are harder to measure than others.

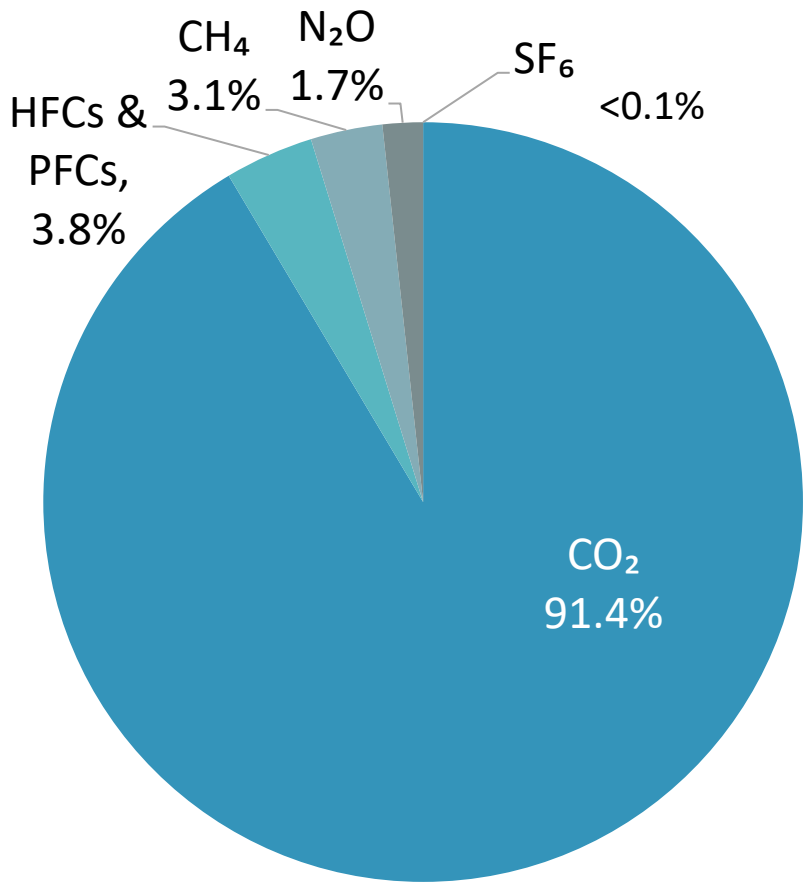
For categories with overlap, IPPC provides standardized guidance to minimize omission or double counting.

Source: 2006 IPCC Inventory Guidance

Sector	Categories (HI examples)	Sub-categories (HI examples)
Energy	1. Electricity Production / Stationary Combustion 2. Transportation 3. Waste Incineration 4. International Bunker Fuels	2a. Ground 2b. Marine 2c. Aviation
Industrial Processes and Product Use (IPPU) Hawai'i categories are few due to the lack of large industry. Categories not applicable to HI include – electronics, metal, chemical, and mineral industries	1. Substitution of Ozone Depleting Substances (ODS) (Fluorinated gases) 2. Mineral Industries 3. Electrical Transmission and Distribution (different from combustion)	1a. Refrigeration 1b. Air Conditioning 1c. Aerosols 2a. Cement Production (mineral industries) (HI production ended 2001)
Agriculture, Forestry, and Other Land Uses (AFOLU)	1. Land-based Agriculture (Soil Carbon) 2. Livestock 3. Forestry 4. Other Land Uses / Land Use Change	1a. Cropland – plant/nutrient managements 1b. Grazing Lands 1c. Synthetic Fertilizer Application 2a. Enteric Fermentation 2b. Manure Management 3a. Deforestation 3b. Forest Management 4a. Fires
Waste	1. Landfills 2. Wastewater treatment 3. Composting	1a. Food Waste 1b. Garden Waste 1c. Paper Waste 1d. Textiles 1e. Plastics

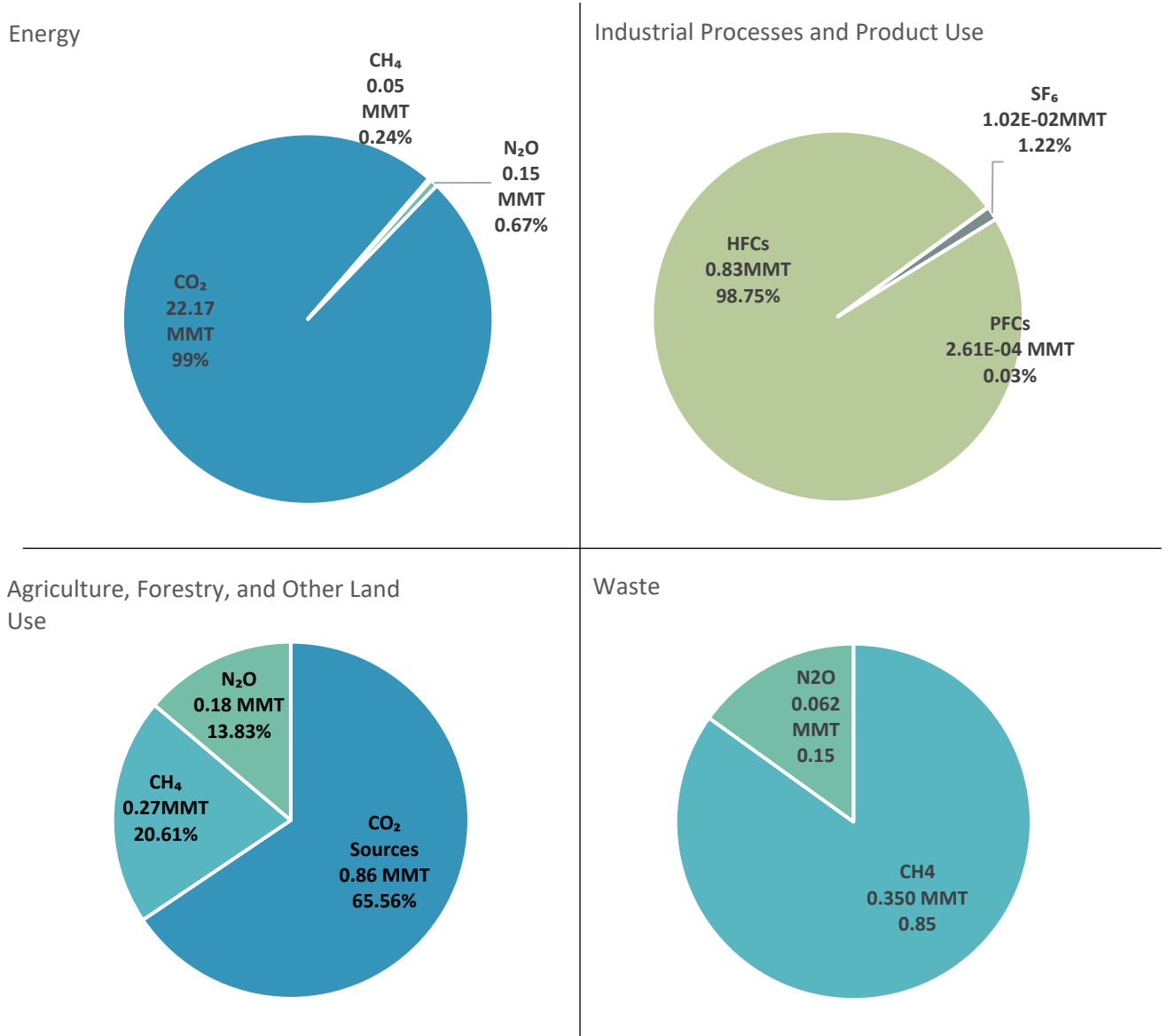
What are greenhouse gases, and what does it have to do with carbon?

- “Carbon” is often used interchangeably with greenhouse gas emissions.
- Carbon dioxide is the dominant source of greenhouse gases (Comprising ~ 91% of emissions in the State),
- Other carbon-based greenhouse gases include methane (CH_4), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).
- Other greenhouse gases emitted in the state are non-carbon based including nitrous oxide (N_2O) and sulfur hexafluoride (SF_6).
- To standardize emission measurements, carbon dioxide equivalent (CO_2e) is used.
- To achieve net-negative emissions, or decarbonization, all greenhouse gas contributions need to be addressed.

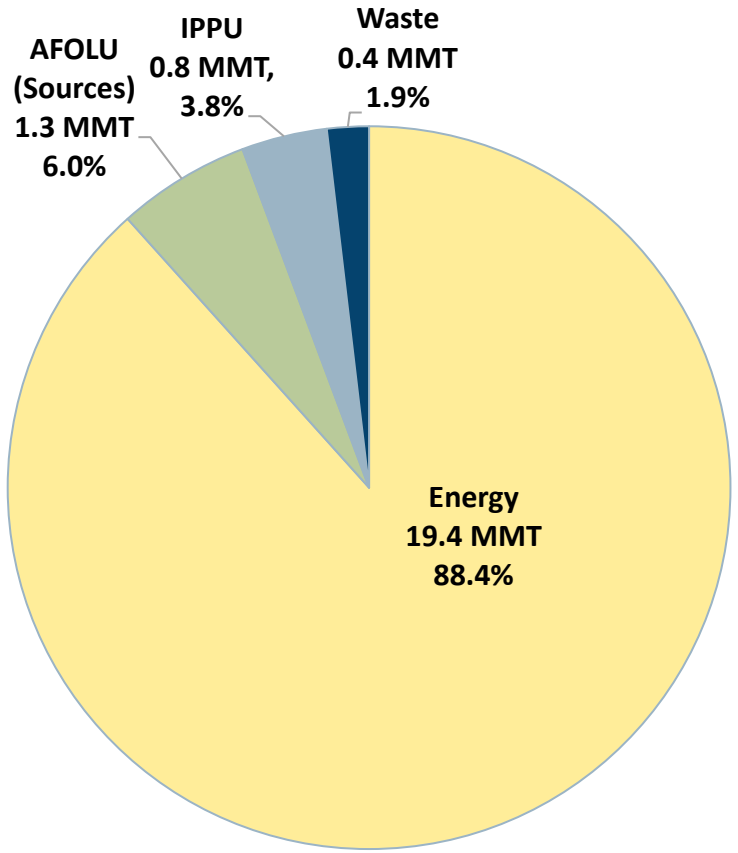


Sources of Emissions by Gas

- Carbon dioxide – Energy sector
- HFCs and PFCs – Replacement of ozone-depleting substances in refrigerants.
- Methane (CH_4) – Landfill waste and enteric fermentation (cows)
- Nitrous Dioxide (N_2O) – primarily agriculture, nitrogen-based fertilizers. Waste treatment.
- SF_6 – Electric Transmission and Distribution



Greenhouse Gas Emitting Sectors in Hawai‘i



Totals may not add due to independent rounding

Source: State of Hawai‘i Department of Health, 2019 GHG Emission Inventory, published 2023

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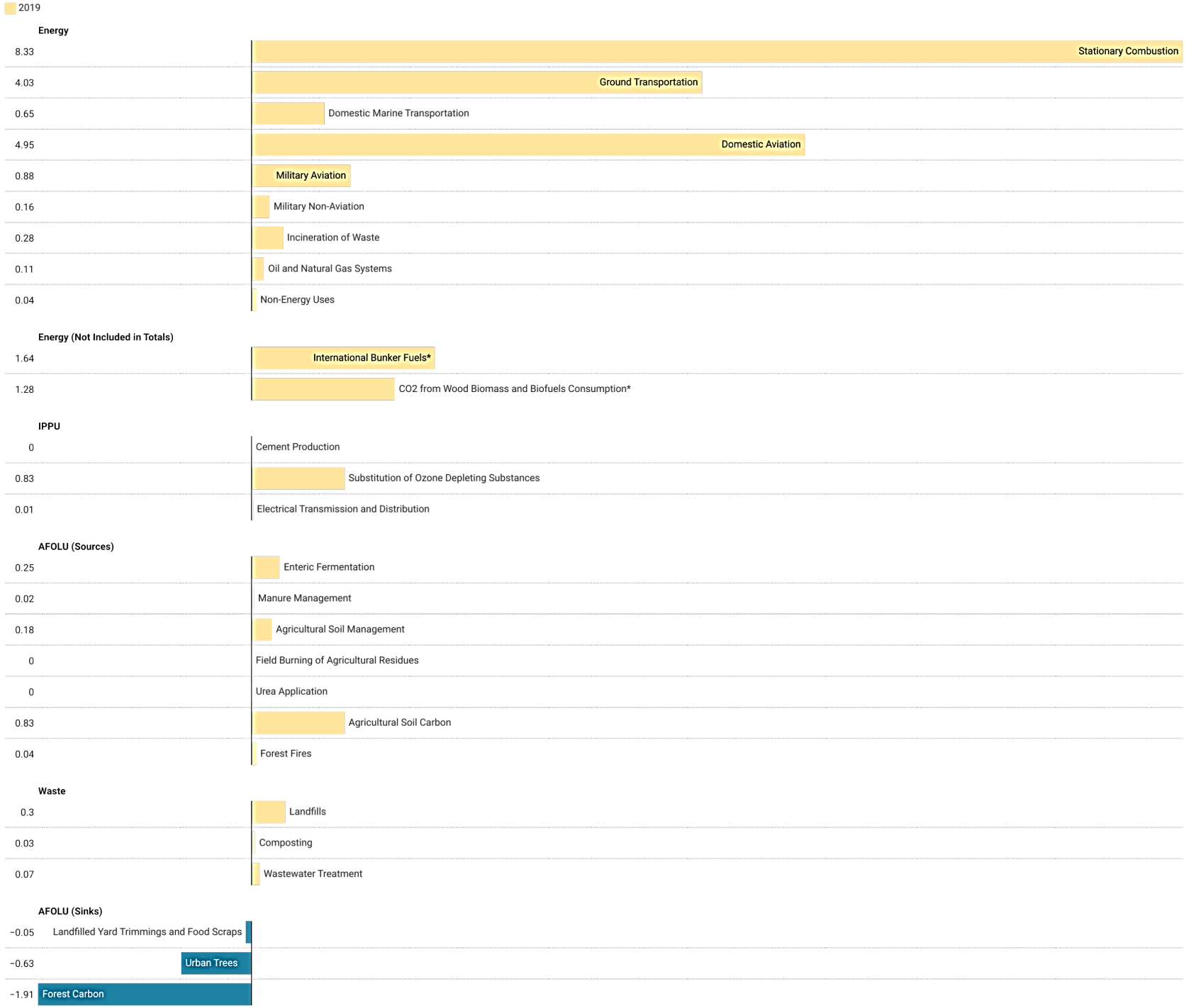
Values standardized to CO2e, based on 100-year Global Warming Potential



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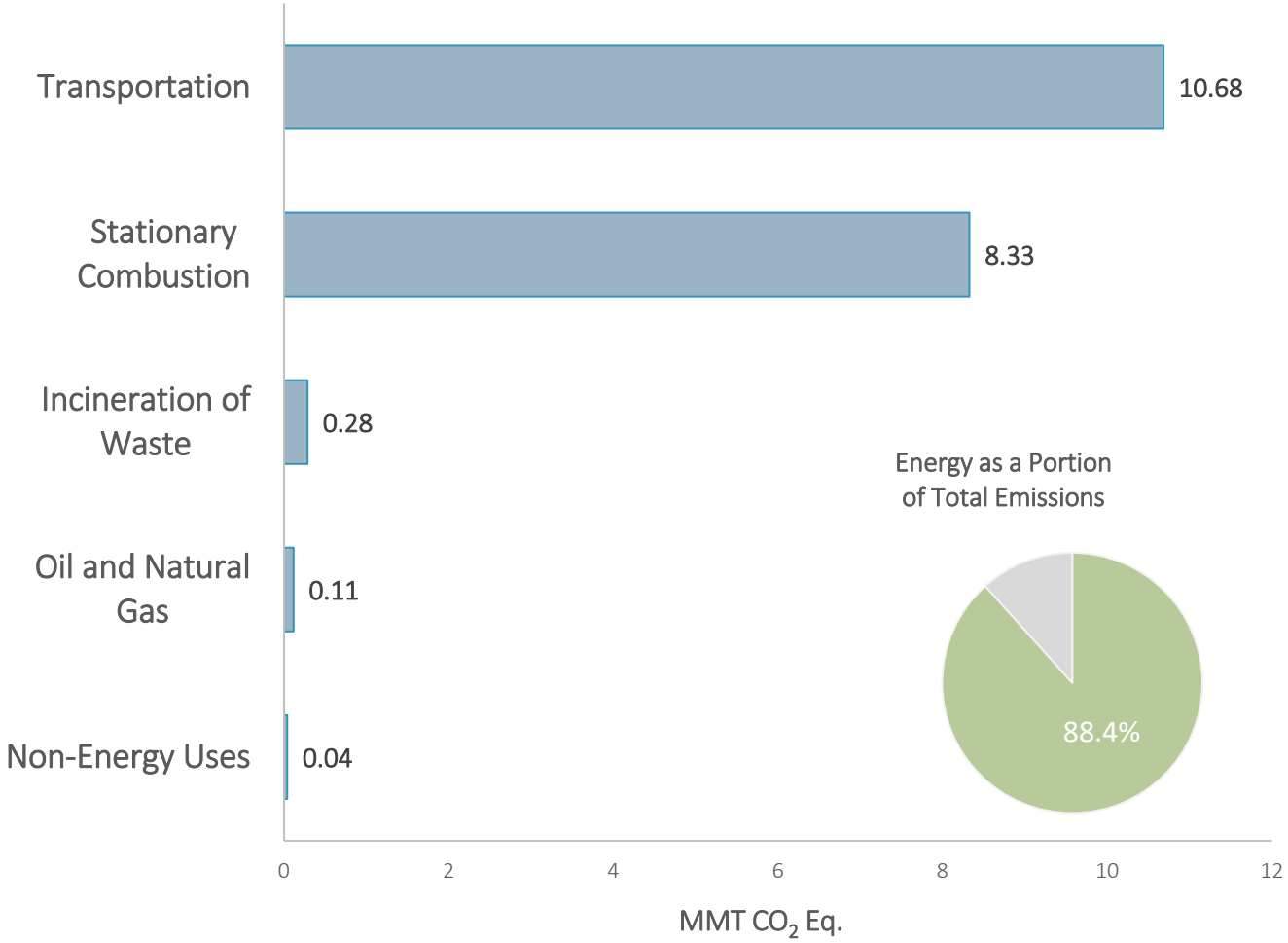
Energy Sector Emissions



Transportation

- *Ground, Marine, Air*

Stationary Combustion or Thermal Power Plants

- Electricity (Hawaiian Electric / KIUC)
- Combustion emissions from refineries

Incineration of Waste

- H-Power

Oil and Natural Gas

- Non-combustion emissions from refinery operations

Non-Energy Uses (of fuel)

- Emissions from fuels such as coal, diesel fuel, and propane not used for energy.

Source: State of Hawai'i Department of Health, 2019 GHG Emission Inventory, published 2023

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Transportation

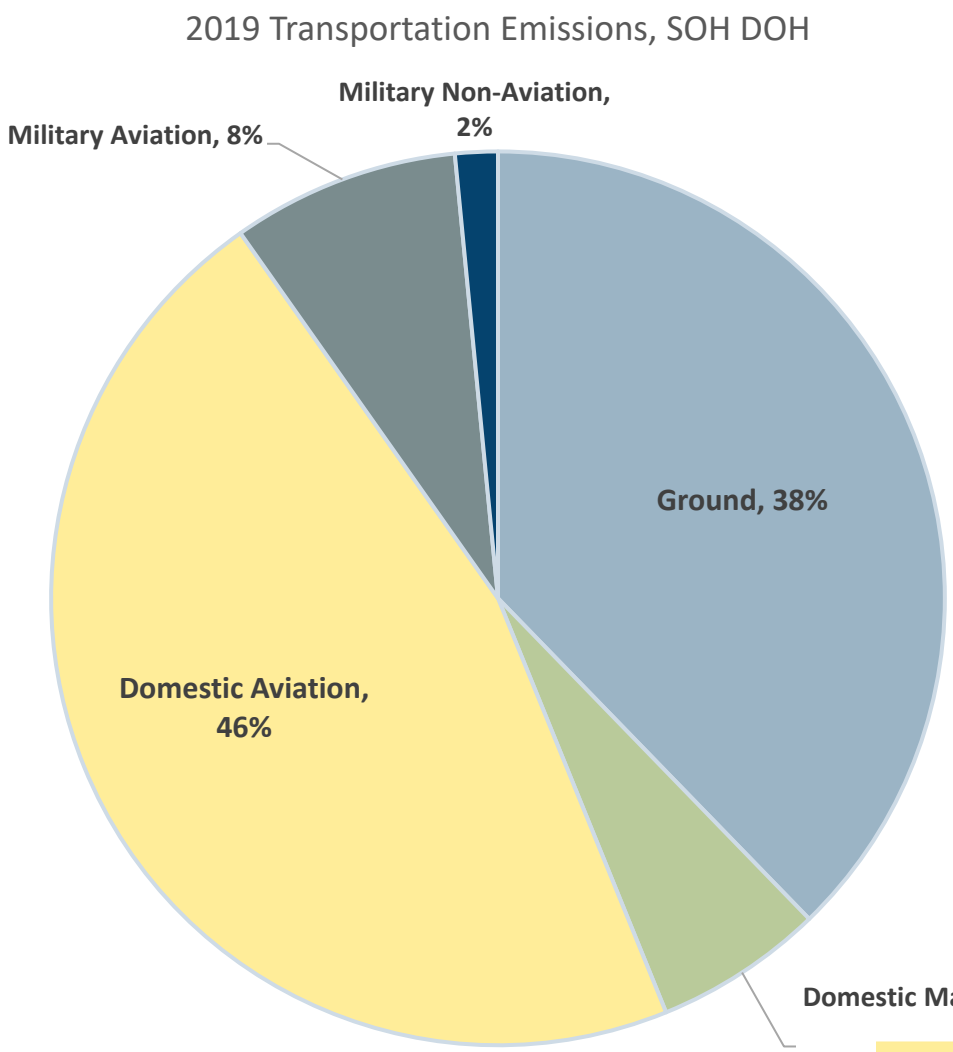
Emissions from the transportation sector primarily come from domestic aviation and ground transportation.

Domestic aviation includes only domestic flights originating in Hawai‘i. In other words, one-way flights to the continental U.S., and interisland travel.

International Bunker Fuels - marine and aviation travel originating in Hawai‘i and ending in a foreign country.

These are NOT included in totals but instead reported separately.

In 2019 emissions from International Bunker Fuels represented: 1.64 MMT CO2Eq



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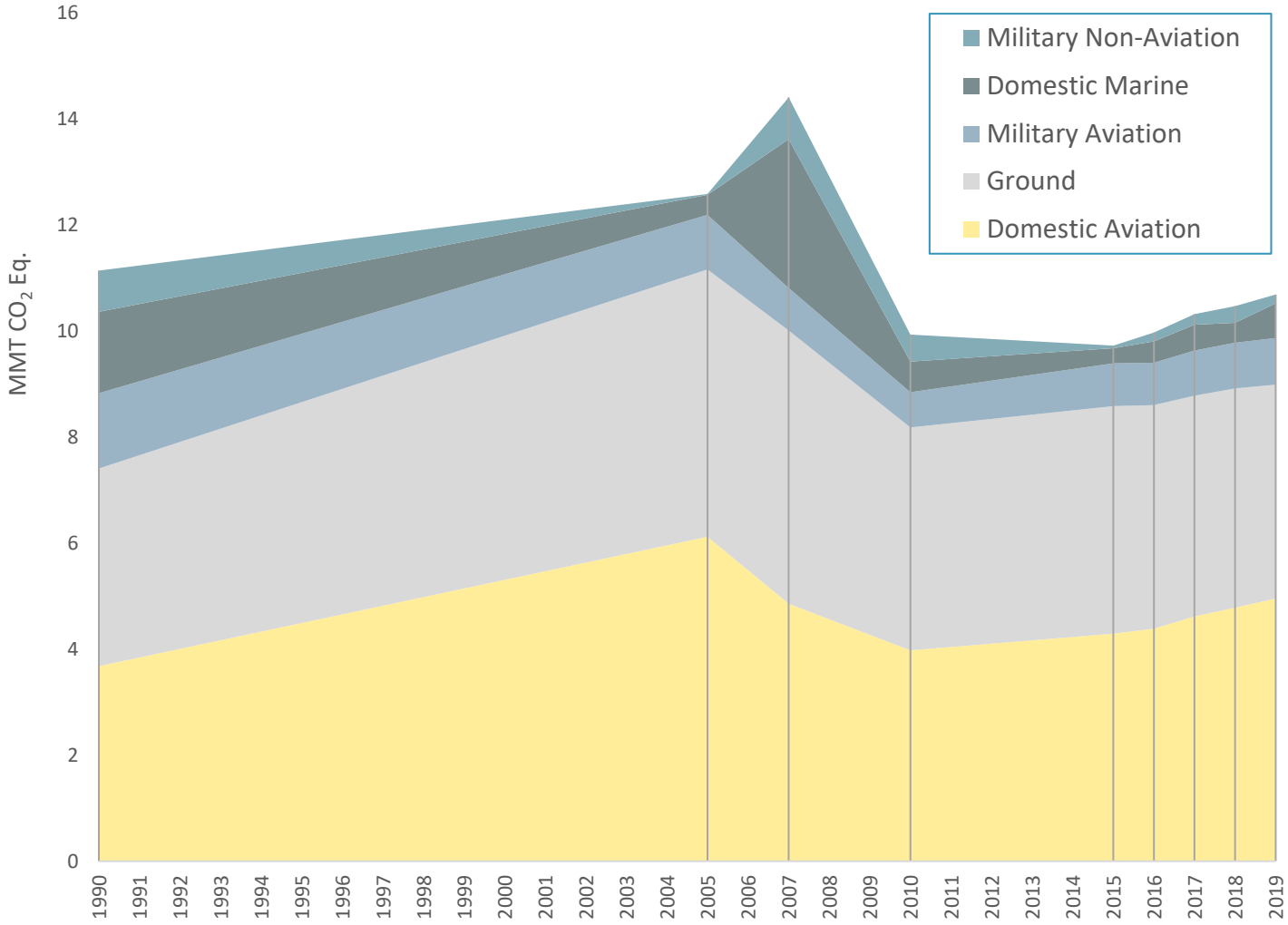
Transportation

- Emissions from the transportation sector have been relatively flat since 2010.
- The “dip” between 2007 and 2010 can be attributed to increased energy and fuel prices coupled with the 2008 economic downturn.
- The decrease was also related to new emissions policies set forth by the Obama administration.
  - Auto emissions / fuel efficiency standards
  - Cash for clunkers



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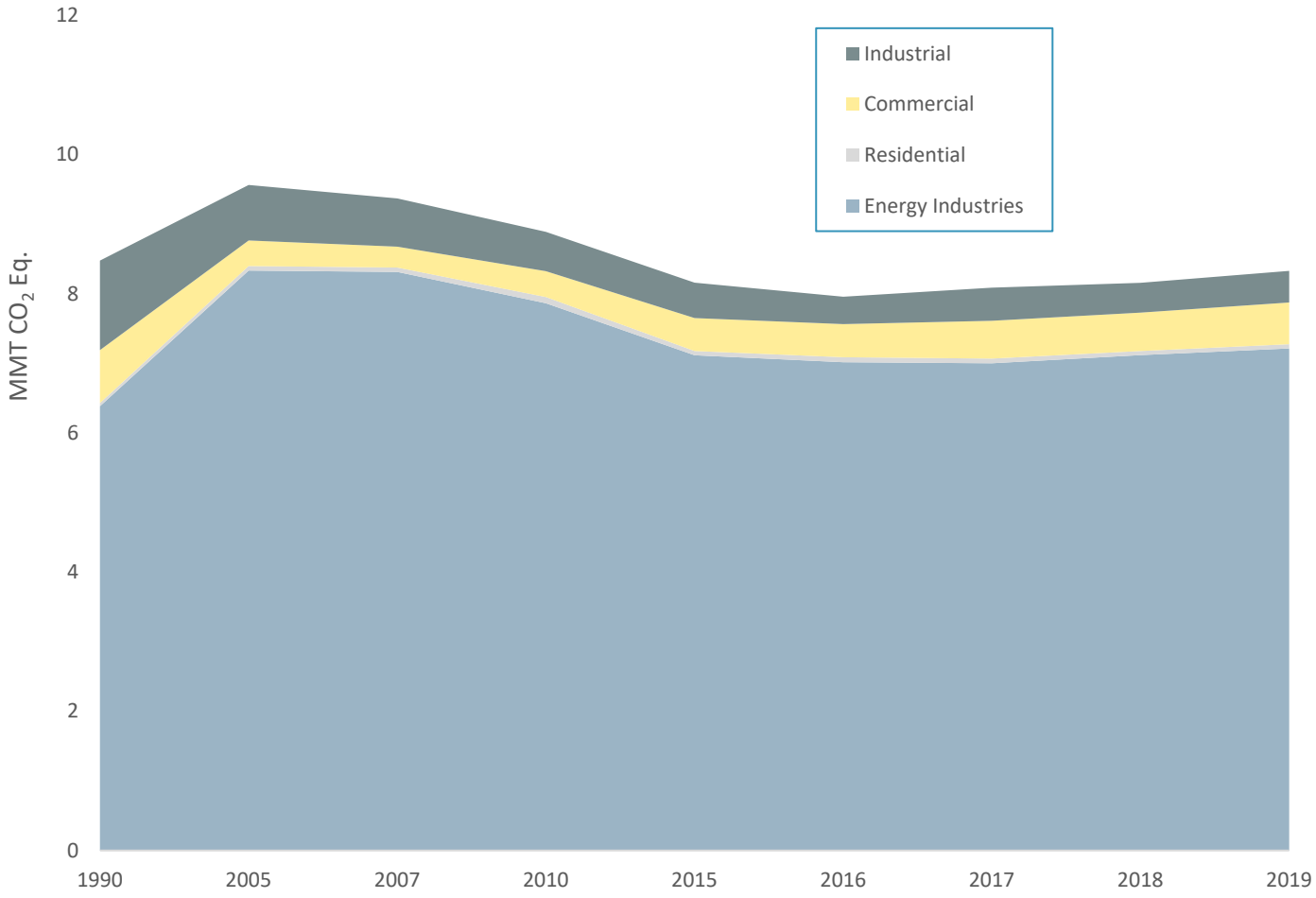
Electricity Sector / Stationary Combustion

- Emissions in the electricity sector have held relatively steady, with a slight observed decrease since 2005.
- Emissions do not closely follow RPS progress, largely because there has not been substantial fossil fuel retirements.
- First major retirement in 2022, with the retirement of the coal plant.
- We expect as plants come offline and begin decommissioning – actual carbon reduction will appear in the data.



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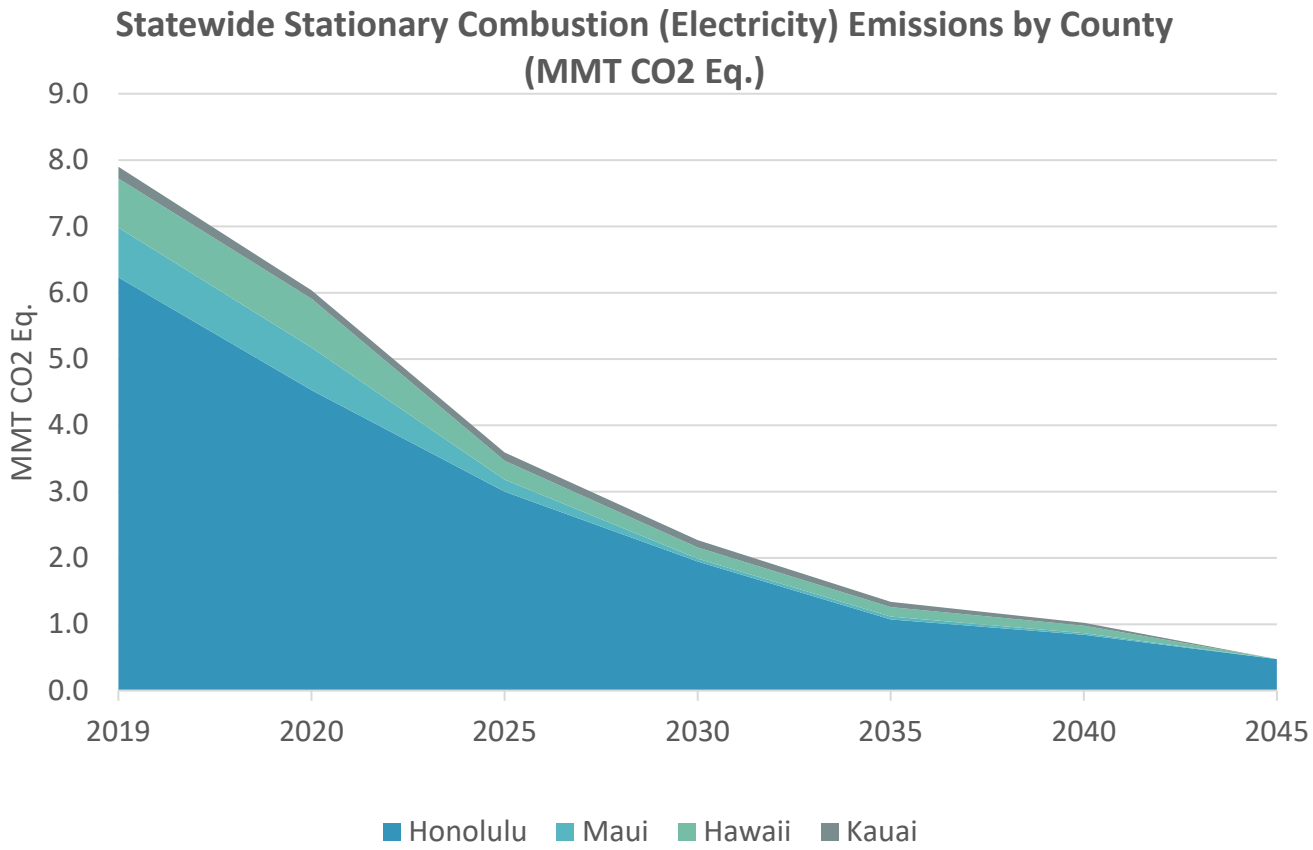
Electricity Sector Projections

The only sector with enforceable policy/ mandates

Renewable Portfolio Standard - RPS, which results in financial losses if not met by the utilities.

RPS Policy results in projected emissions declines.



Source: 2019 GHG Inventory, State Department of Health. April 2023.
*Emissions shown are not inclusive of biogenic emissions.

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What are the options?

- HSEO is evaluating these as a part of the Decarbonization Strategy.
- An analysis of tradeoffs
- Efficiency and electrification matters but it will not be enough to achieve goals
- Must include action in all sectors

Example values that can be explored through scenario design

1. Minimize land impacts of energy infrastructure
   - Maintain natural lands in an undeveloped state
   - Preserve arable land for agriculture
2. Reliance on in-state energy (energy independence)
   - Limit overseas fuel imports
3. Improve air quality
   - Reduce combustion-based electricity generation (including biofuels)
   - Reduce vehicle miles traveled, esp. for diesel vehicles
4. Limit reliance on negative emissions technology and carbon sequestration
   - Aim for the greatest possible direct emissions reductions
5. Minimize total costs of energy transition
   - Focus on the most cost-effective emissions reduction measures
6. Ease of implementation
   - What large-scale changes are needed for each scenario to be plausible?

These values may frequently be at odds

Equity considerations reflected in values 3 and 4, but more discussion will be needed on distributional impacts (not directly modeled)

There may be a conflict here, for example, if fossil combustion + DAC appears to be a relatively low-cost abatement pathway

Act 238 requires identifying the least-cost economy-wide decarbonization pathway

All scenarios will have major implementation challenges

Potential framework for scenario evaluation

Example Scenarios: "Last mile" abatement strategy	Example Values					
	Minimize Land Impacts	**Energy Independence**	**Air Quality**	**Limit Carbon Sequestration**	**Lowest total costs**	**Implementation Feasibility**
High Electrification						
Land Conservation						
Near-Term Transformation (i.e. Transformative Demand Reductions)						
Ranking (illustrative)	**Low**	**Mid**	**High**			

Challenge with assessing ease of implementation last mile: All sample scenarios have considerable reliance on unproven technologies or technology that needs to scale rapidly and dramatically by 2045 to meet the targets.

For discussion:

- Is this a useful framework for scenario design?
- What values should we be considering?
- What are the key policy questions/choices that need to be brought into this framework?
- Should we aim to capture equity and ease of implementation in scenario design, or defer these to output metrics and discussion for final scenarios evaluated?
- Is the "last mile" abatement strategy the right lens for scenario differentiation? Other ideas?

Energy+Environmental Economics

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Mahalo nui loa!

- Your feedback and insight is greatly appreciated!
- If you would like to provide written feedback, please visit our Decarbonization Webpage

  https://energy.hawaii.gov/what-we-do/clean-energy-vision/decarbonization-strategy/
- Strongly encourage reading the material
- Click "*Provide Your Mana'o*" under **Feedback**
- Responses will be saved and HSEO will do our best to incorporate all views and comments.

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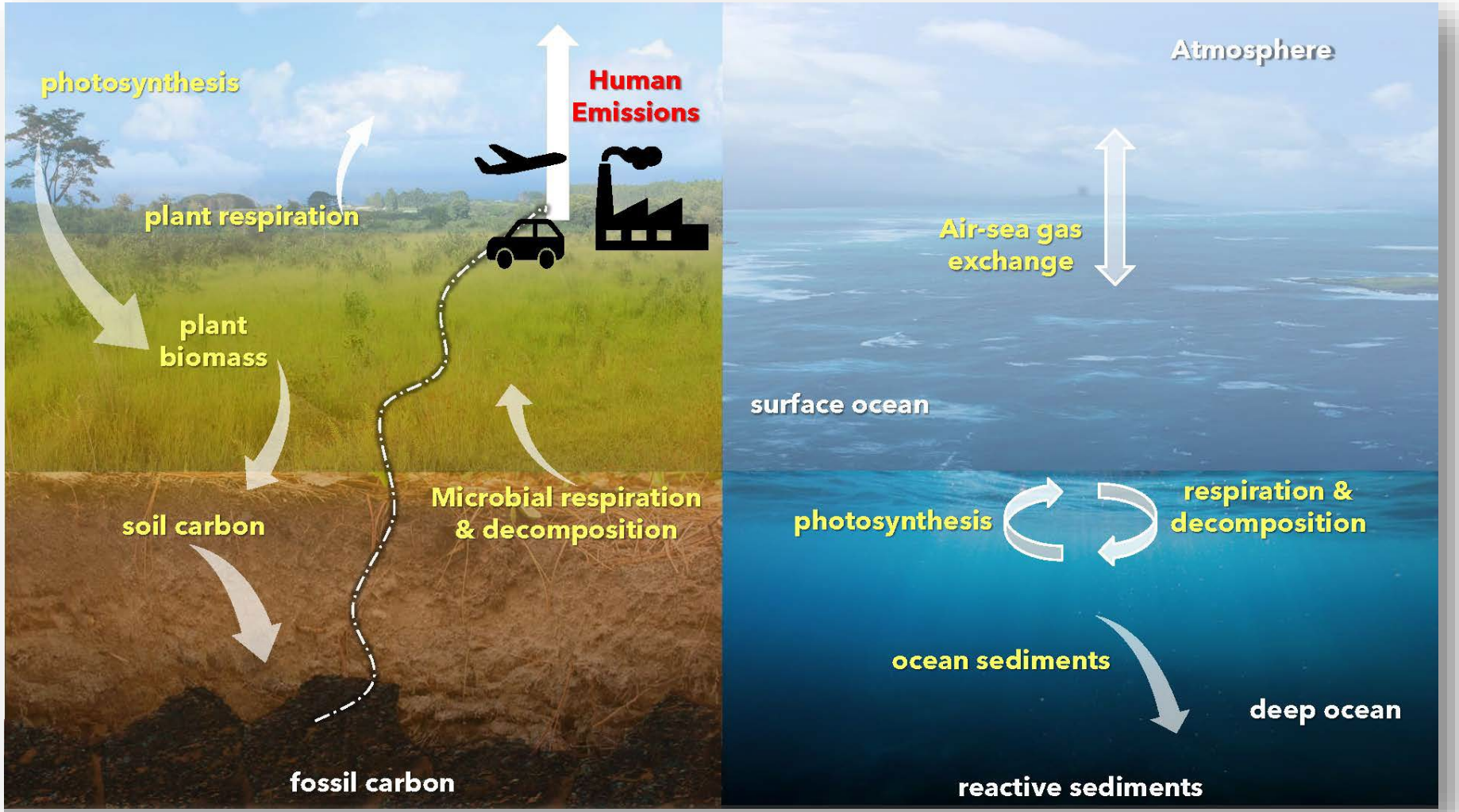
Extra Slides

The Carbon Cycle



Arrows show the movement of carbon between the land, atmosphere, and oceans. The **yellow** text indicates natural fluxes or active carbon, the **white** text indicates stored carbon, and the **red** text indicates human emissions.

Adapted from NASA Earth Observatory

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Intro Decarbonization handout from HEC. Working on information like this to set the stage for the Decarb conversation. Need to create materials that are broadly accessible for community/legislature, and the more detailed technical information for industry and further stages of community outreach.

What is Decarbonization?

Decarbonization is the process by which economies reduce the total greenhouse gases (GHG) emitted into the atmosphere, while also increasing the capacity of natural and technological carbon sinks.

The Hawai'i Revised Statutes §225P-5 establishes a Zero Emissions Clean Economy Target, which means that as a state we are aiming to **sequester more atmospheric carbon and GHGs than we emit** as quickly as practicable, but **no later than 2045**.
An interim target has also been set for 2030 to reduce state GHG emissions to at least fifty percent below our 2005 levels.

Decarbonization is an **interconnected economy-wide effort** and will require everyone's participation in some capacity. Understanding decarbonization starts with building foundational knowledge by learning more about the major sectors involved.

Electricity
Reduce dependence on fossil and high-carbon alternative fuels for electricity generation by increasing energy efficiency and renewable electricity.

Transportation
Reduce dependence on fossil fuels for ground, air, and marine transportation through electrification, alternative fuels, or reducing vehicle miles traveled (VMT).

Waste
GHG emissions in this category are from landfills and from wastewater treatment plants. Incorporate waste reduction practices and reuse policies that use waste as a resource. Capture and use methane emissions for energy generation.

Agriculture, Forestry, and Land Use
Maintain and increase natural carbon sinks through climate-smart agricultural practices that maintain soil health, conserving forests, and supporting afforestation and urban forestry. Reduce emissions from fertilizer application and enteric fermentation.

Industrial Processes and Product Use (IPPU)
A hard-to-abate sector. Emissions from IPPU in Hawai'i come from the substitution of ozone polluting substances with alternative refrigerants and electrical transmission and distribution.

Negative Emissions Technologies
Capture and store GHGs from the atmosphere. Incorporate these technologies only when life-cycle analyses indicates incorporation will result in net negative emissions and will not compete with reductions.

The Hawai'i State Energy Office is developing a Decarbonization Strategy to identify potential pathways for reaching our statewide goals. We will be sharing more information soon to help connect the dots and build out a wholistic decarbonization conversation. Scan the QR code or visit **energy.hawaii.gov** to stay updated and learn more.

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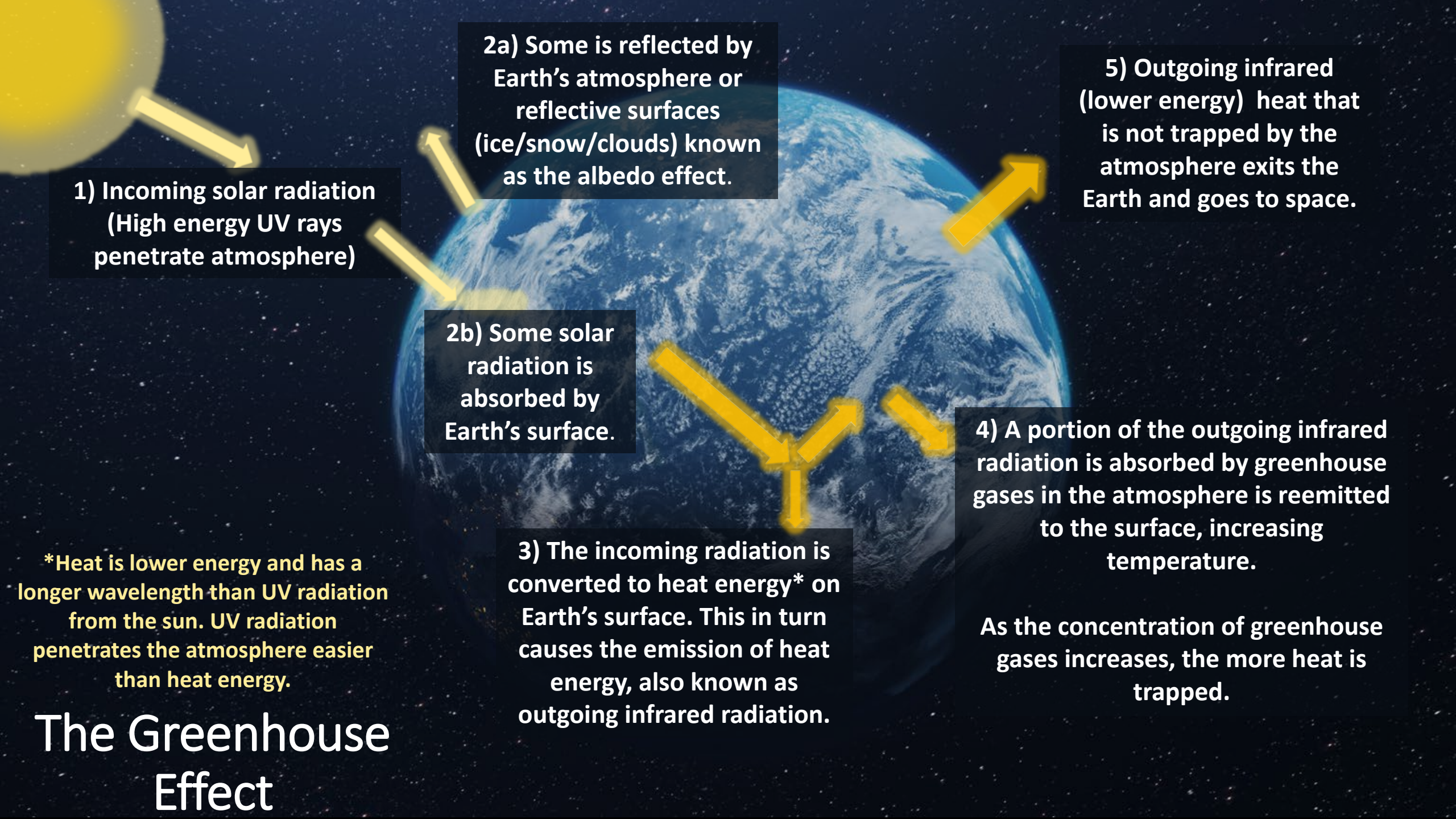

1) Incoming solar radiation (High energy UV rays penetrate atmosphere)
2a) Some is reflected by Earth's atmosphere or reflective surfaces (ice/snow/clouds) known as the albedo effect.
2b) Some solar radiation is absorbed by Earth's surface.
3) The incoming radiation is converted to heat energy* on Earth's surface. This in turn causes the emission of heat energy, also known as outgoing infrared radiation.
4) A portion of the outgoing infrared radiation is absorbed by greenhouse gases in the atmosphere is reemitted to the surface, increasing temperature.
As the concentration of greenhouse gases increases, the more heat is trapped.
5) Outgoing infrared (lower energy) heat that is not trapped by the atmosphere exits the Earth and goes to space.
*Heat is lower energy and has a longer wavelength than UV radiation from the sun. UV radiation penetrates the atmosphere easier than heat energy.
The Greenhouse Effect

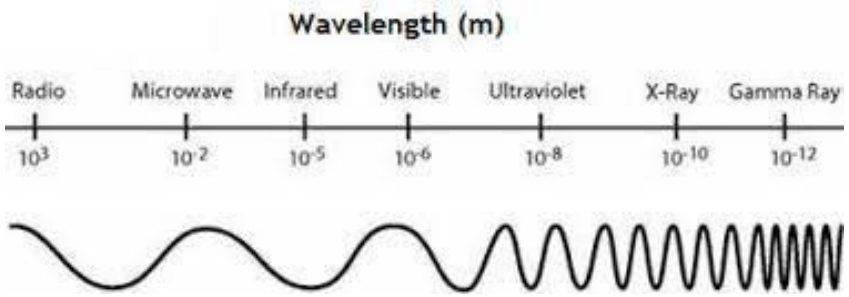
The Greenhouse Effect

Comparable to parking a car in the sun and how a “greenhouse” works.

High energy ultraviolet and visible light energy penetrates the glass.

Once inside the UV and visible light is absorbed and re-emitted as lower-energy infrared heat.

The lower energy heat cannot escape the glass, allowing the greenhouse to stay warm despite lower temperatures outside.



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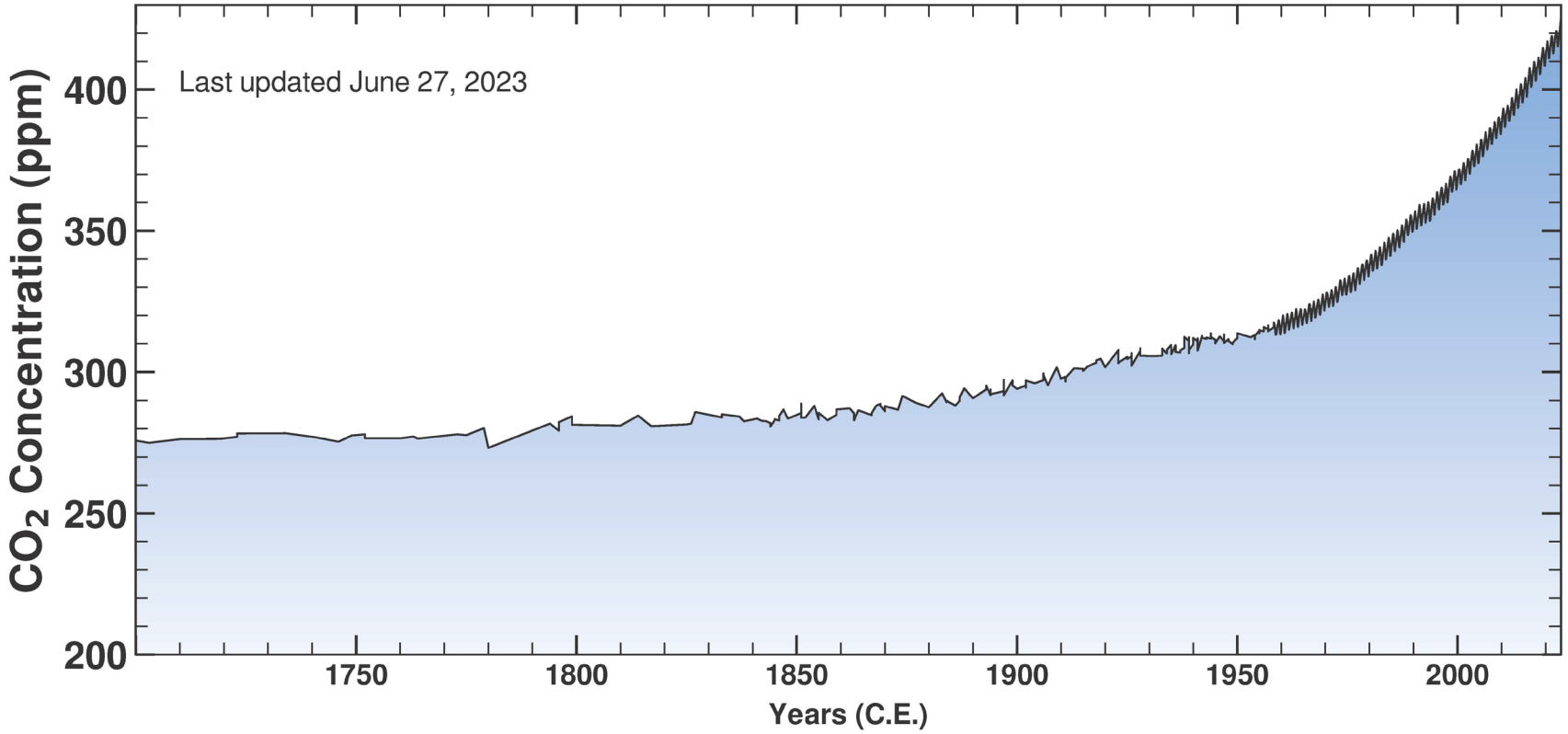
The Keeling Curve

The Keeling Curve is the exemplary graph demonstrating how the levels of atmospheric CO_2 have been building up in the atmosphere, driving an increase in global temperatures.



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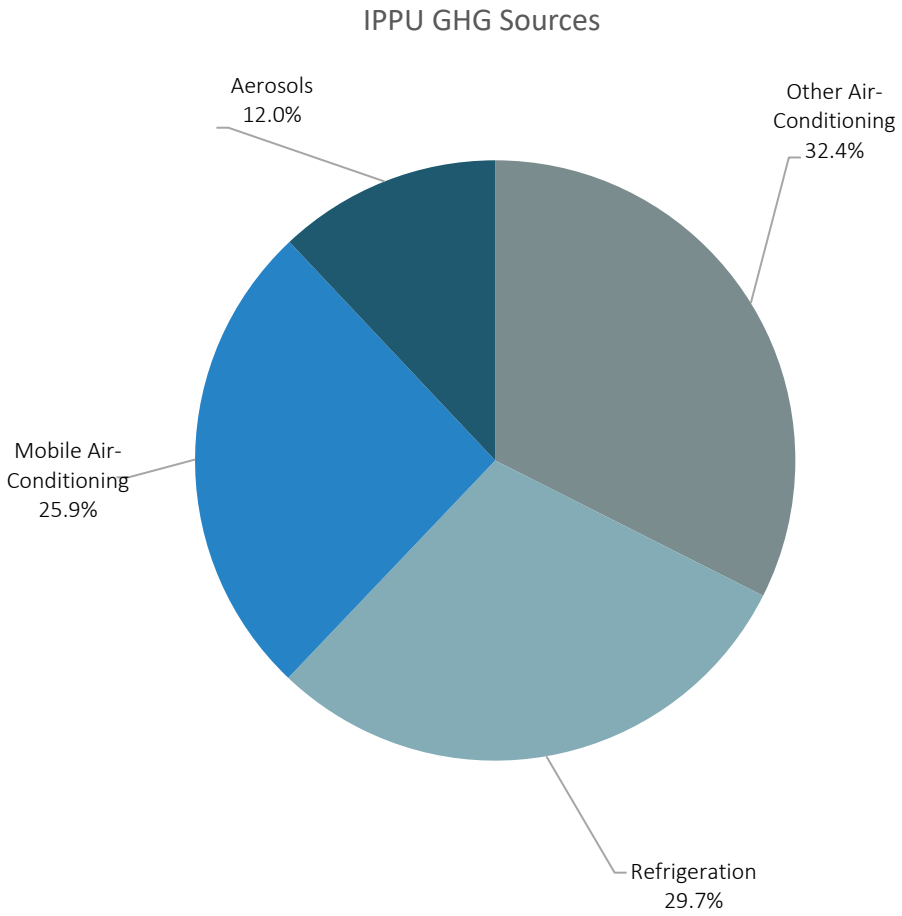
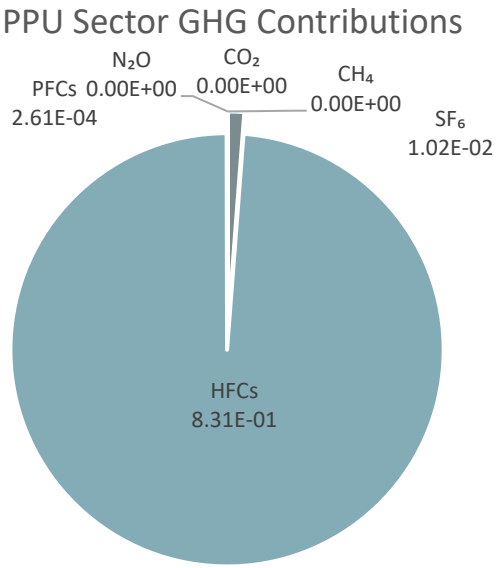
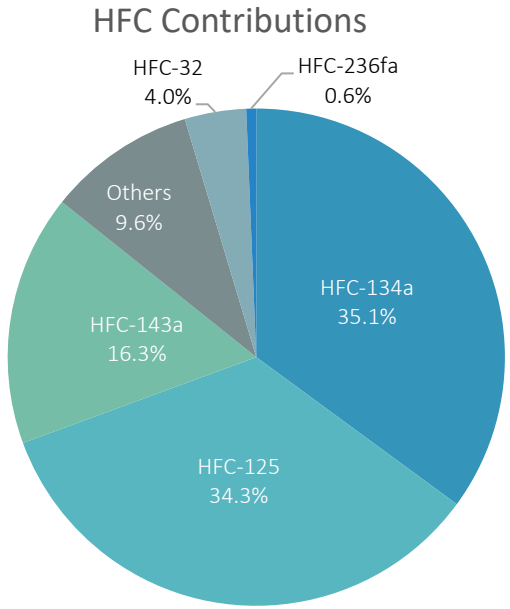
Industrial Processes and Product Use IPPU





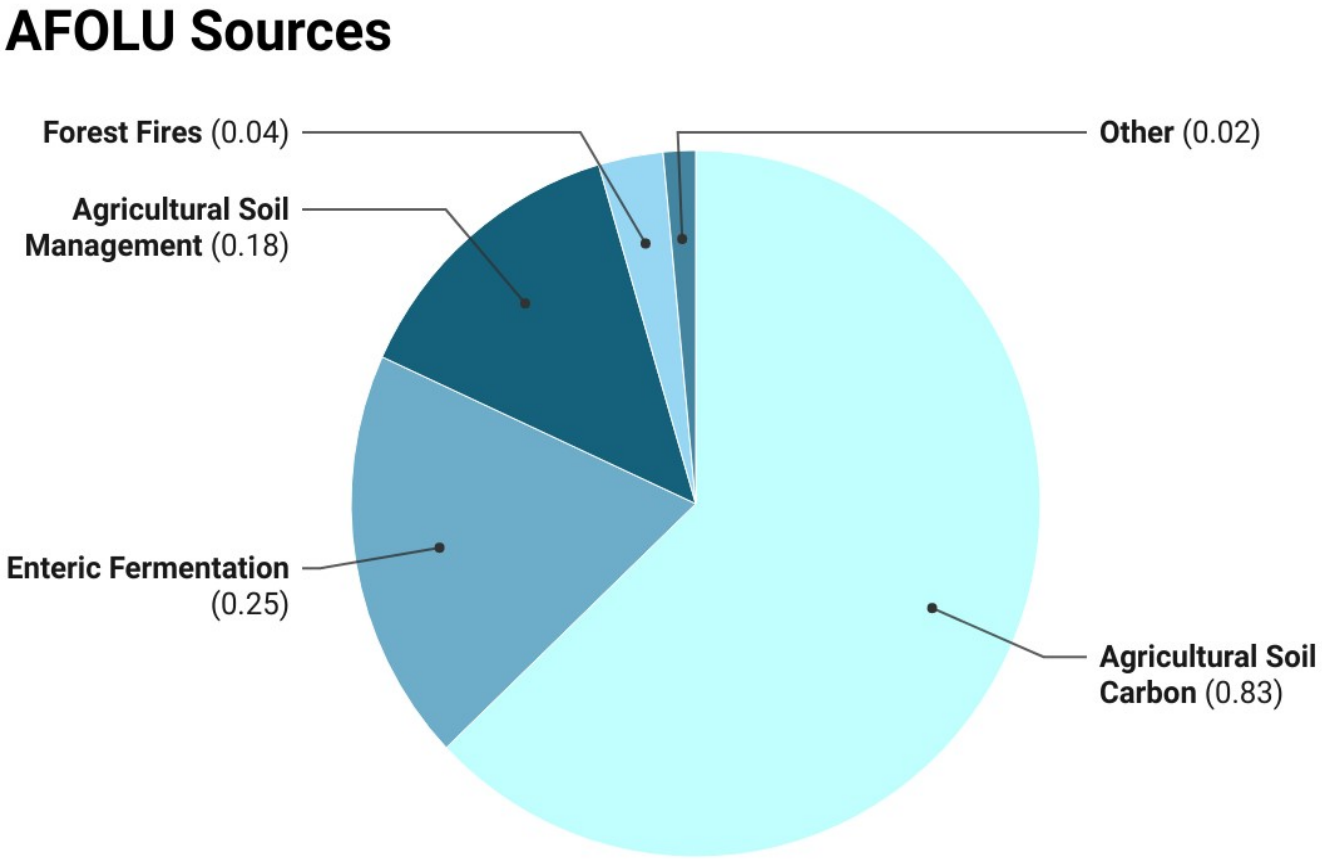


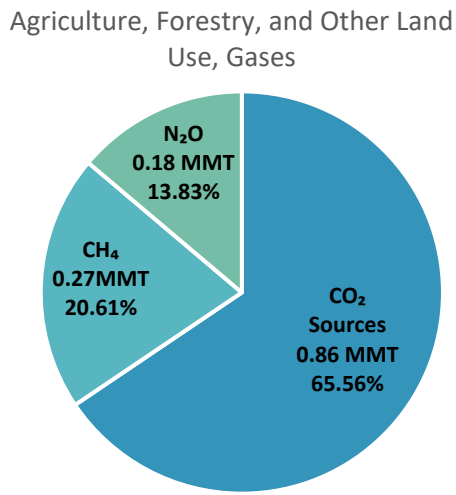
International Bunker Fuels

- **Domestic vs. International Aviation and Marine Bunker Fuels**
- Consistent with IPCC (2006), the following approach is used to determine emissions from the transportation sector:
- **Included in Hawai‘i Inventory Totals:** All transportation activities that occur within Hawai‘i (e.g., flights from O‘ahu to Maui) and domestic interstate activities originating in Hawai‘i (e.g., flights from Honolulu to Los Angeles).
- **Estimated but Excluded from Hawai‘i Inventory Totals:** Any fuel combustion used for international flights and marine voyages that originate in Hawai‘i (e.g., flights from Honolulu to Hong Kong).
- **Not Estimated:** All transportation activities that originate outside Hawai‘i (e.g., travel from Los Angeles to Honolulu, travel from Tokyo to Honolulu).

Agriculture, Forestry, and Other Land Use

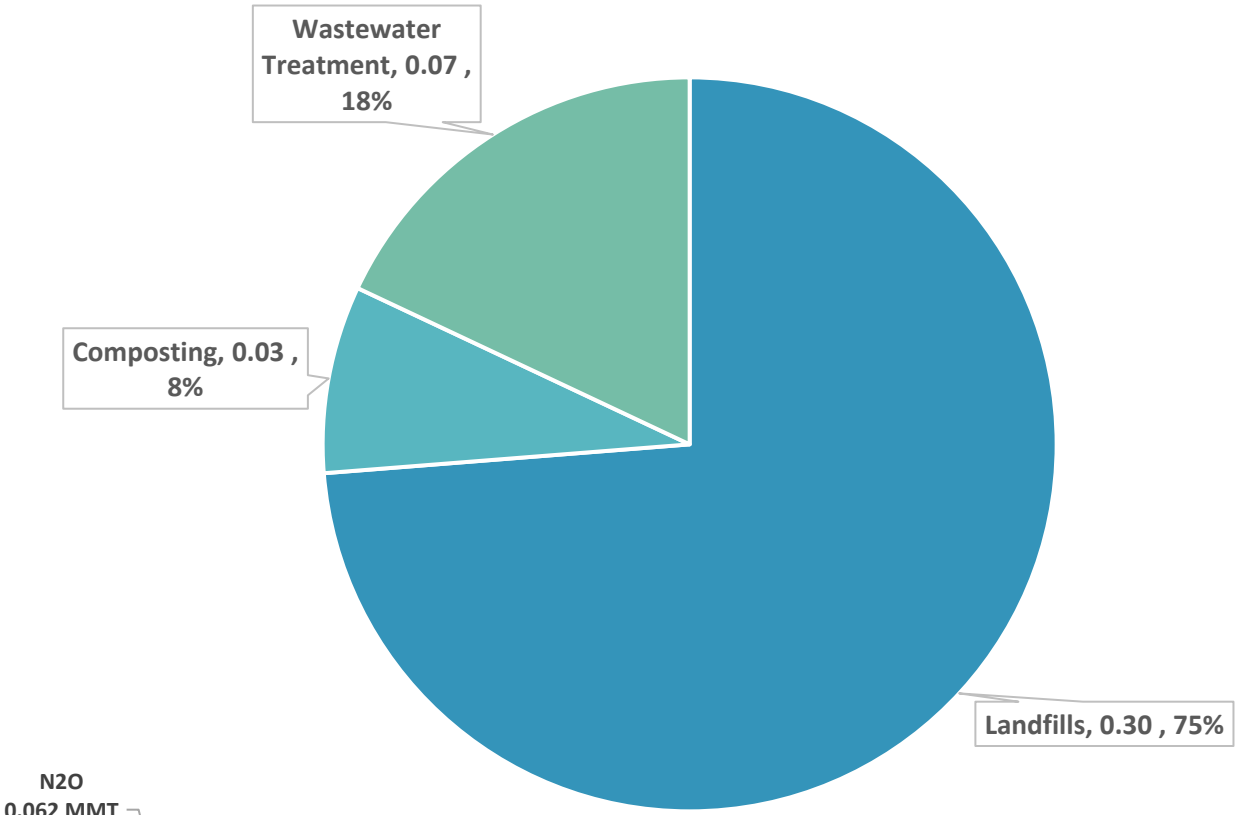
- From the 2019 inventory, per this inventory, emissions estimates demonstrate that “soil carbon” is the largest emitter in the state, followed by enteric fermentation.

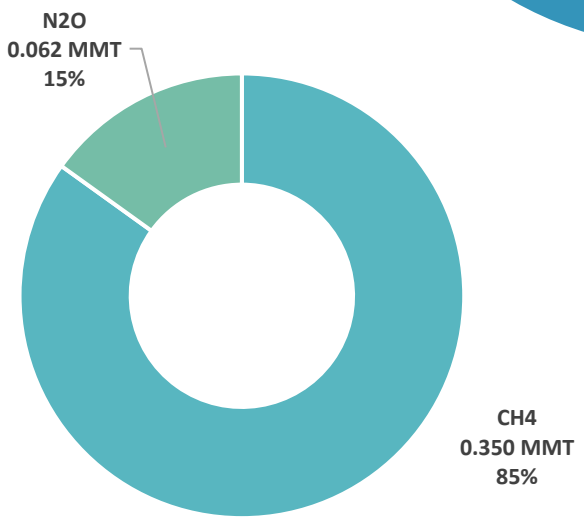




Waste Sector Emissions

- 75% from Landfills
  - All Methane (CH4)
- 17.5% Wastewater Treatment
  - 0.03 CH_4 and 0.05 N_2O
- 7.5% Composting
  - 58% CH_4 and 42% N_2O





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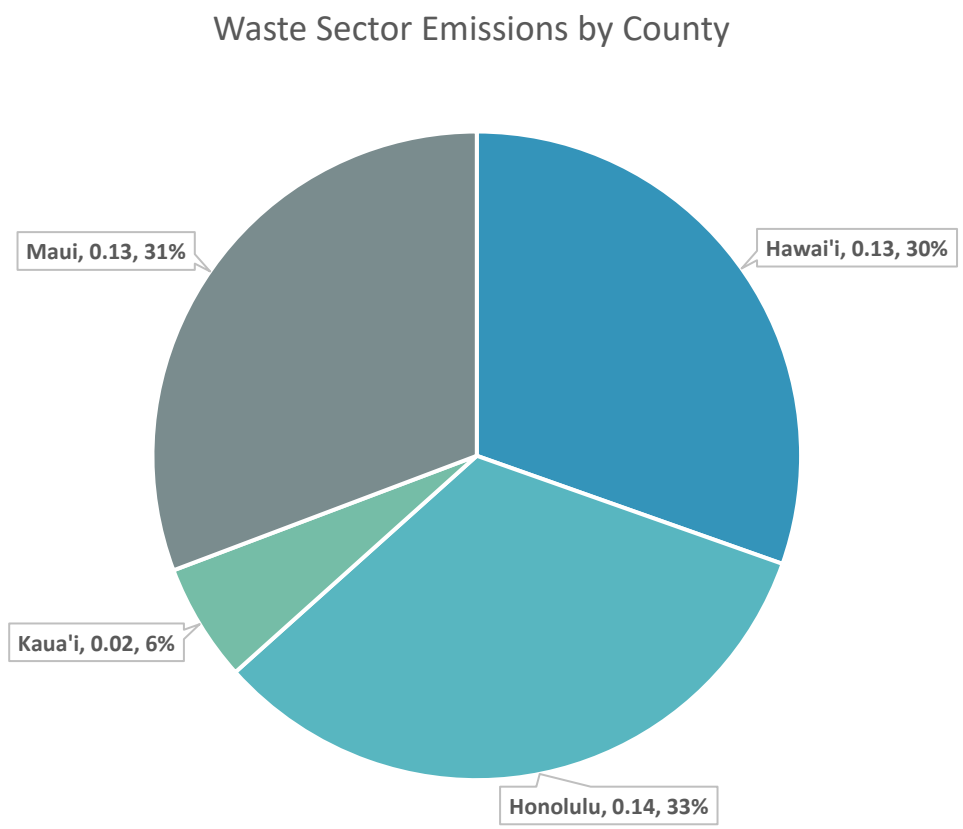
Waste Sector Emissions by County

- Emissions by County between Honolulu, Hawai‘i, and Maui each represent about 1/3 of waste emissions.
- Kaua‘i makes up a small portion.
- Large portion of Honolulu’s goes to H-Power (not accounted for in this part of the inventory)



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Carbon Dioxide Equivalents

- GHG Emissions are aggregated, summarized, or presented in terms of *Carbon Dioxide Equivalents, or CO_2e.*
- Metric standardizes emissions – makes comparison “apples to apples”.
- Global Warming Potentials (GWP) are used to standardize non-CO_2 emissions,
- GWPs are determined using two metrics: 1) radiative efficiency and 2) lifetime
  1) Radiative efficiency - the ability of the GHG molecule to absorb heat energy
  2) Lifetime – an estimate of how long the molecule resides in the atmosphere
- CO_2 has a GWP of 1 because it is the reference gas.
- Methane is said to be more “potent”; the estimated GWP of methane used by EPA/IPCC is 25 for over 100 years.
- If evaluated on a shorter time frame methane is more potent. When considering the impact over 20 years GWP increases to 84-87.
- 100-year GWPs are standard for inventories per IPCC guidelines.

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