DEFINING CARBON NEUTRAL LANDSCAPES

HAWAII AS A MODEL SYSTEM FOR

UNDERSTANDING CARBON NEUTRALITY

DEFICITS AND ATTAINMENT

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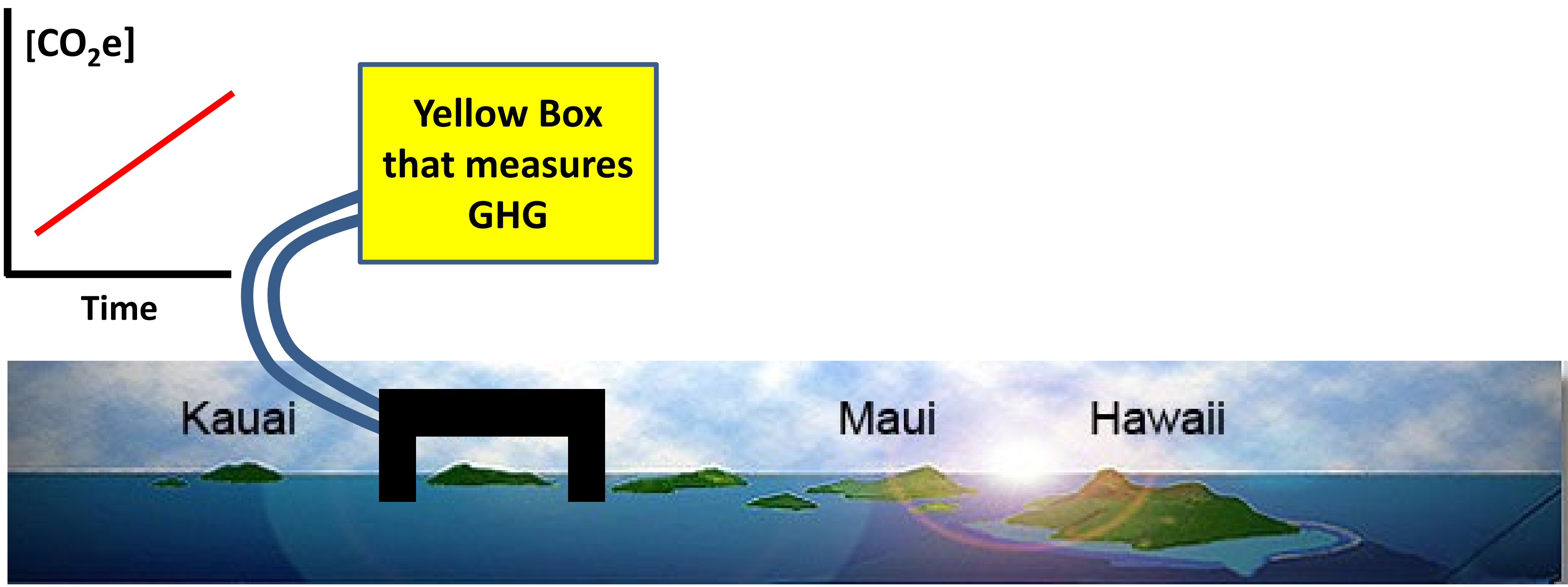
1. Establish a comprehensive greenhouse gas inventory (global warming potential budget) for Hawaii.
2. Develop a plan for how to increase carbon sequestration in natural and working lands to offset our emissions.



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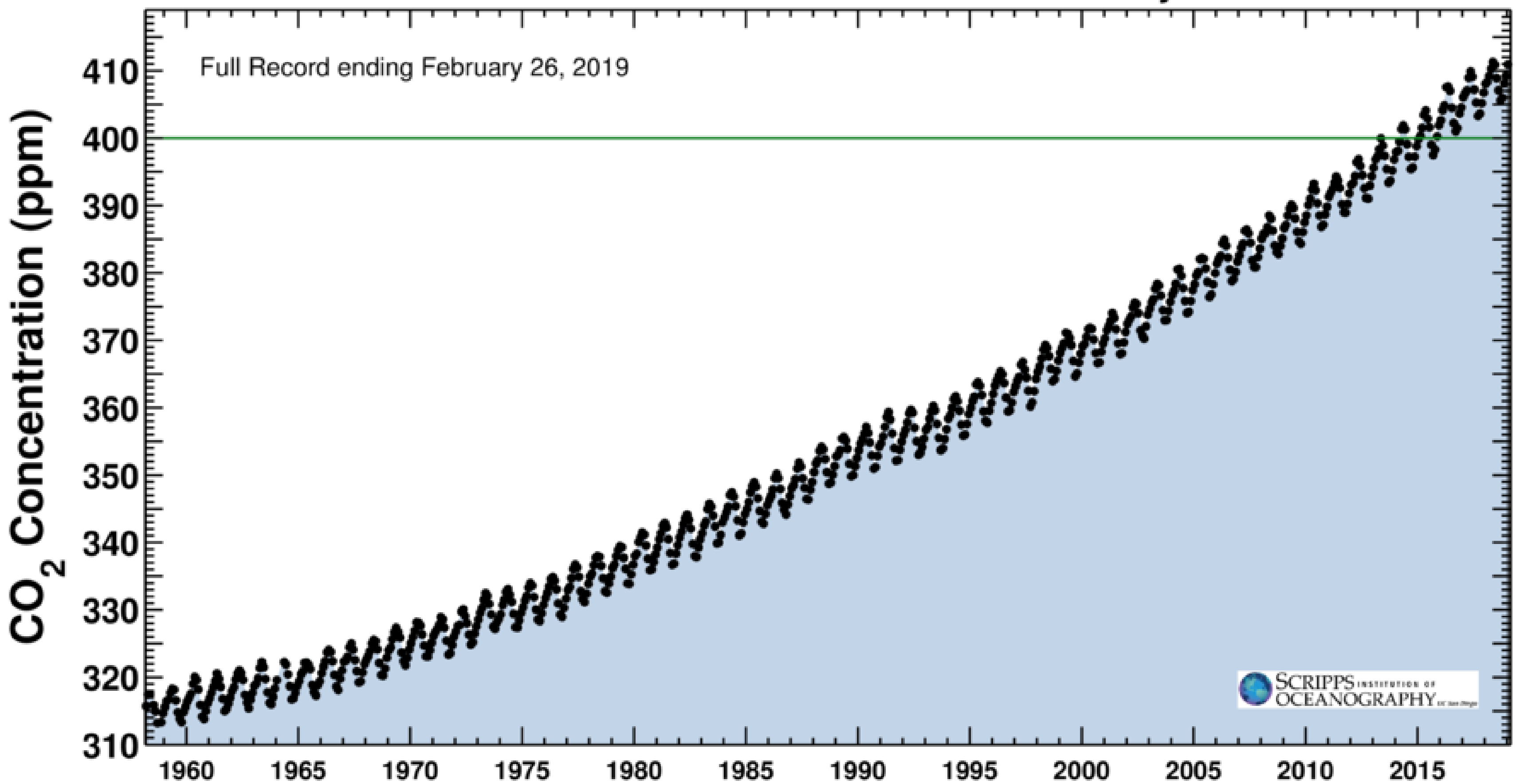
Latest CO_2 reading
February 26, 2019

412.56 ppm

Carbon dioxide concentration at Mauna Loa Observatory



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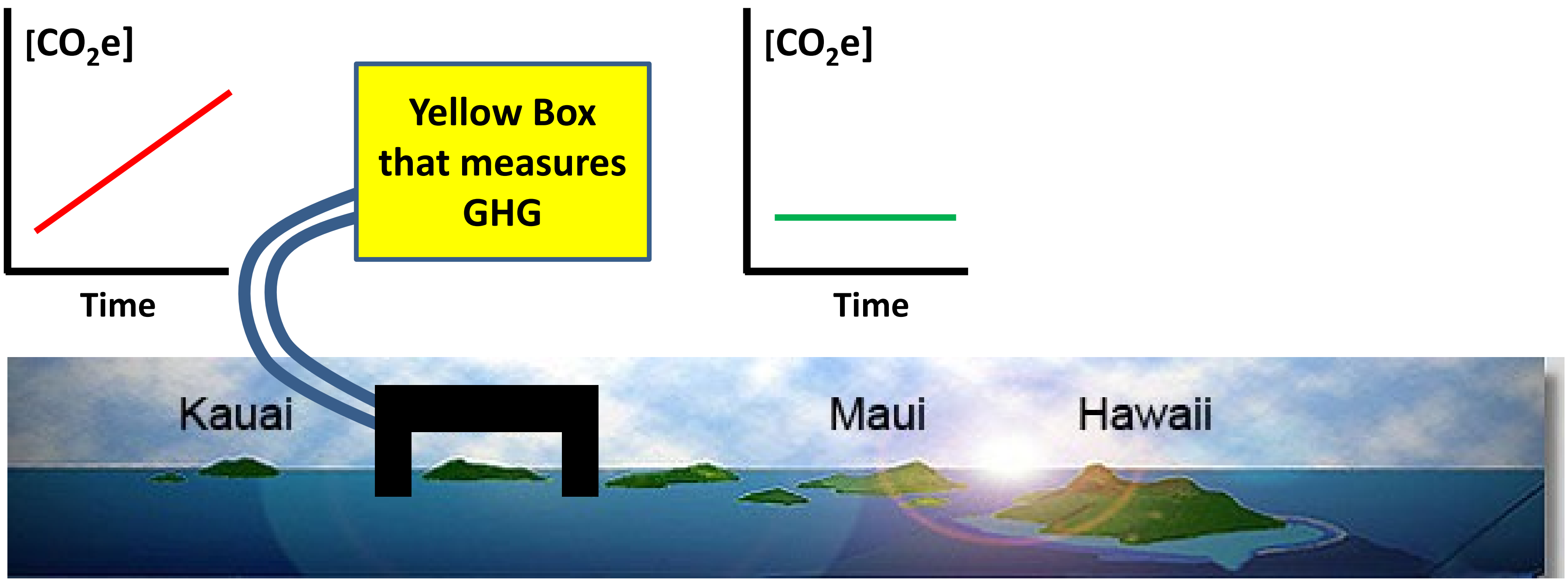

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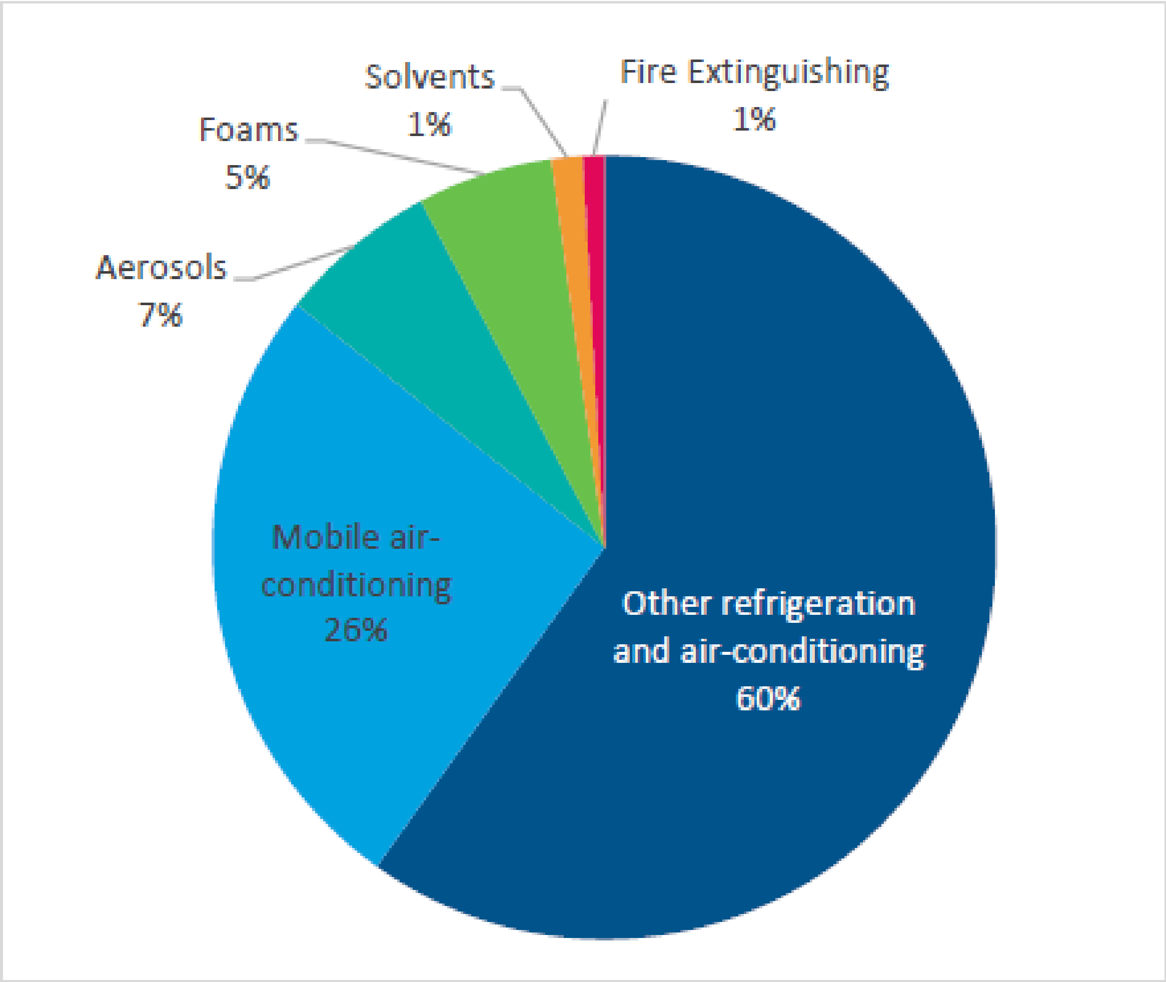
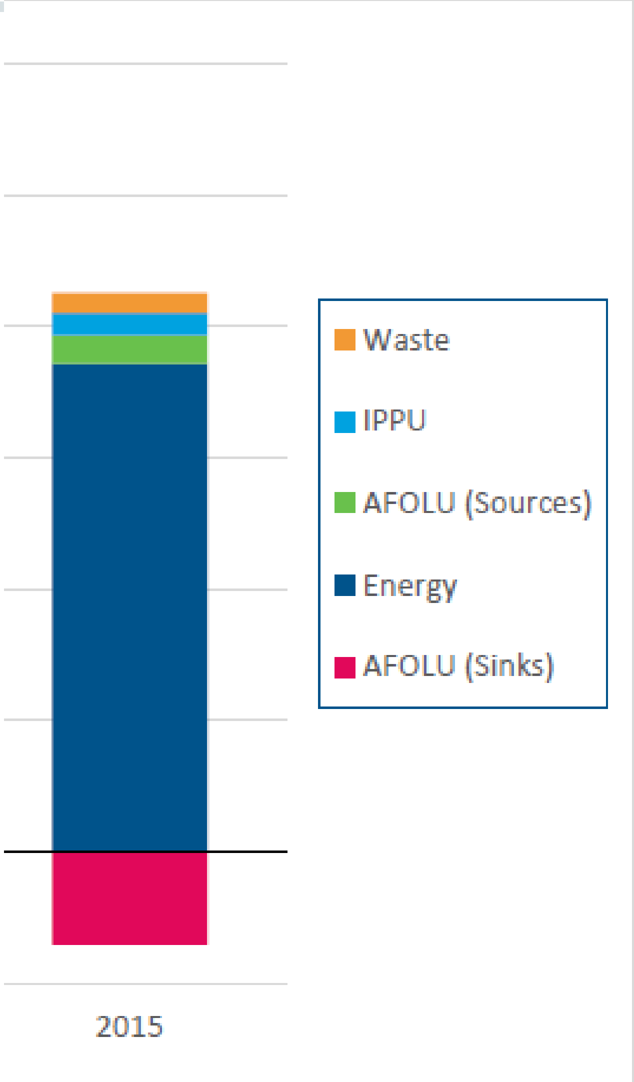
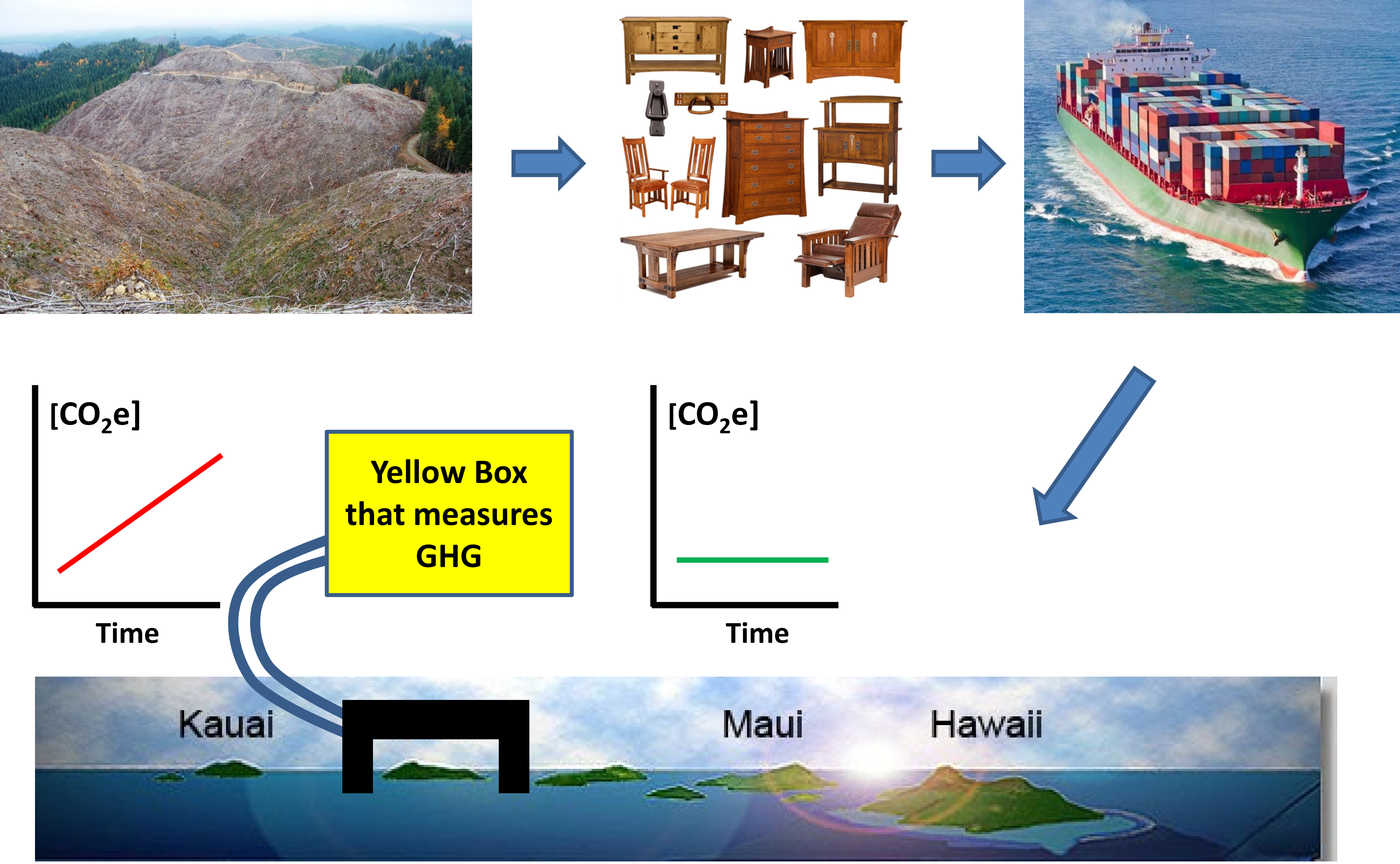
Figure 4-4: 2015 Emissions from ODS Substitutes by Sub-Category





Hawaii Greenhouse Gas Emissions Report for 2015



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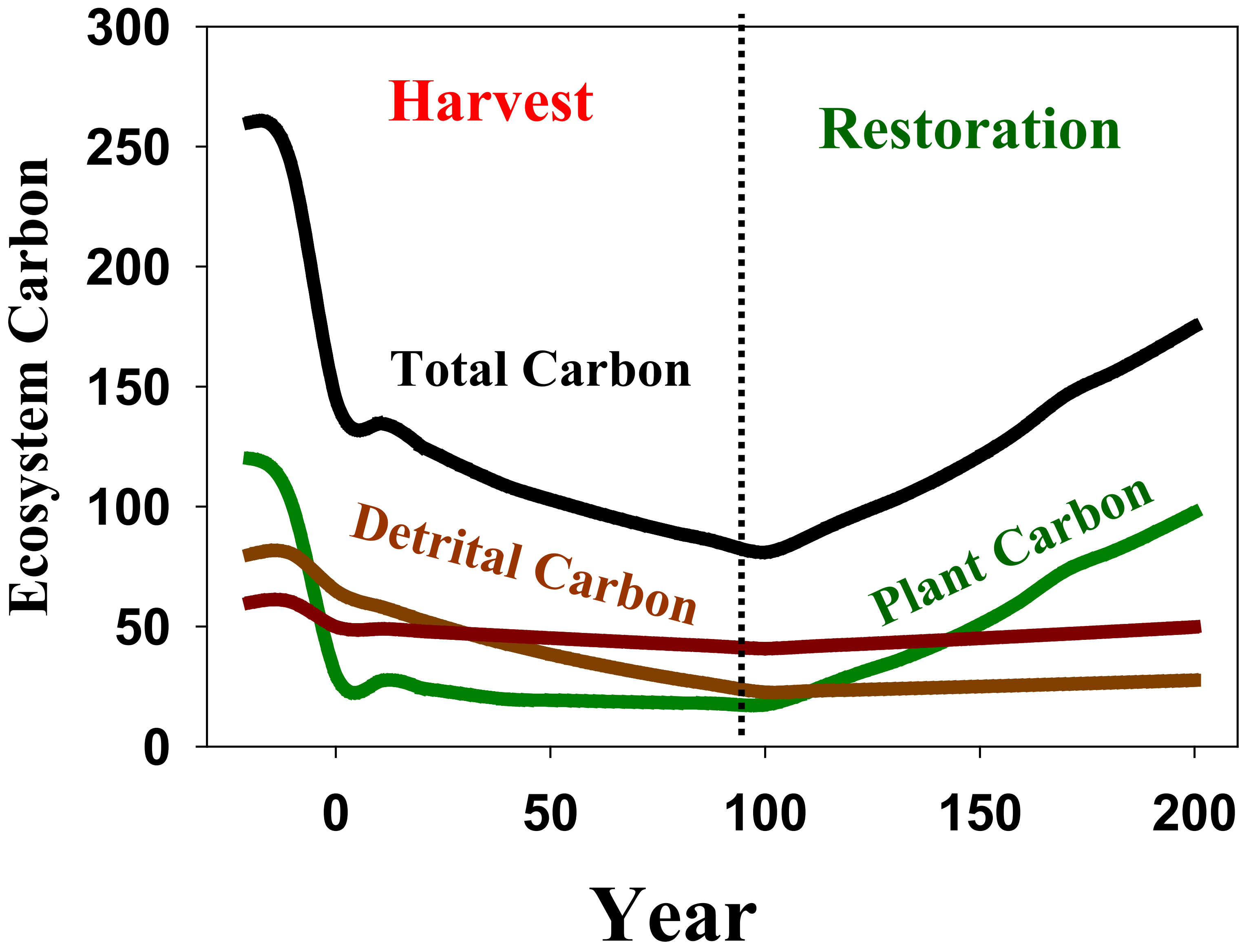
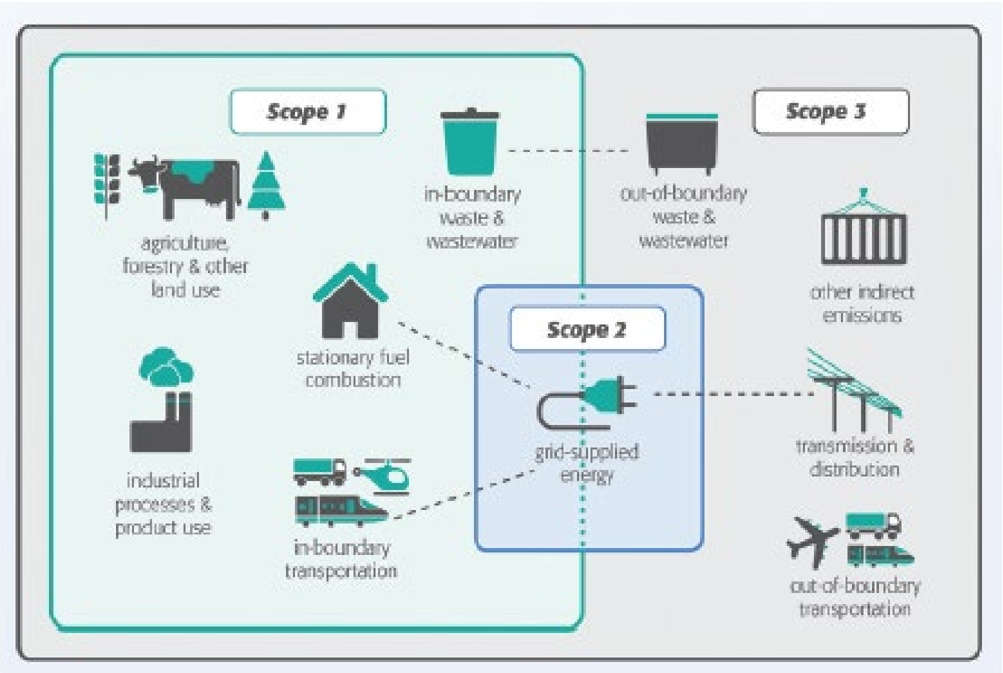
Carbon stocks (MtC/ha) in plants, soils & dead wood



CO_2e

CO_2e

CO_2e



Source: ICLEI, WRI and C40, "Global Protocol for Community Scale Greenhouse Gas Inventories", p. 11.

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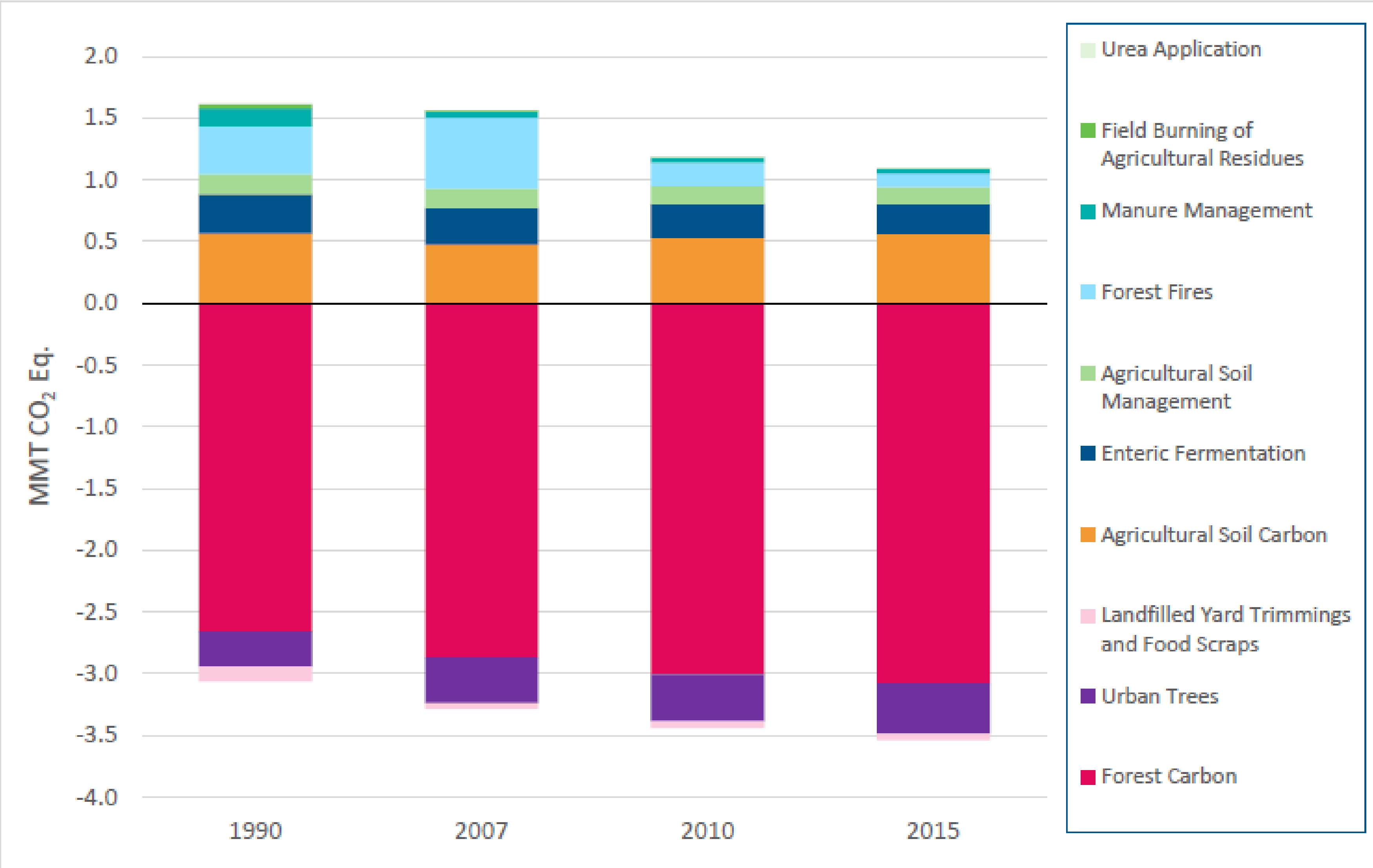
HB2182

§225P-B Zero emissions clean economy target. (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.

Figure 5-4: AFOLU Emissions and Removals by Source and Sink Category and Year



Hawaii Greenhouse Gas Emissions Report for 2015

Uncertainties and Areas for Improvement

The Tier 1 Gain Loss Method as outlined by the *2006 IPCC Guidelines* (IPCC 2006) was used to calculate carbon flux in managed Hawaii forests. Unmanaged forests are not included in this analysis per IPCC

Uncertainties associated with forest fire estimates include the following:

- Wildfire acres burned data and the area of wildland under protection were not available for all inventory years. As a result, estimates for these data were proxied based on the available data. There is significant annual variability in wildfire acres burned data, so 1994 data may not accurately represent wildfire acres burned in 1990. Further investigation into alternative sources for historical wildfire acres burned may be considered in future analyses.
- The ratio of forest and shrubland area is also a source of uncertainty for all inventory years because the ratios are estimated based on land cover data for years 2000 and 2014. Additional land cover data should be incorporated into future analyses if it becomes available.
- The estimate of carbon density in forests and shrubland and their assumed combustion efficiencies are not specific to Hawaii. Further research into the carbon density and combustion efficiencies in Hawaii may be considered in future analyses to further tailor these emission factors for the state of Hawaii.

The estimated sequestration rates in urban trees are based only on trees in Honolulu. Honolulu County accounted for 56 percent of Hawaii's urban area in 2010 (U.S. Census 2012). While Honolulu County has the largest share of urban area, its sequestration rates may not align with urban trees in other counties. Further research into urban tree sequestration rates by county or island may be considered in future analyses.

The CarbonNeutral Protocol

The global standard for carbon neutral programmes

Step 1: Define the Subject

Give a clear description of the subject

Step 2: Measure the Subject's Emissions

Provide a complete and accurate account of the GHG emissions of the subject

Step 3: Set Target

Set a target to achieve net zero emissions

Step 4: Reduce Emissions

Achieve the target through a combination of internal reductions and environmental instruments

Step 5: Communicate

Provide accurate and transparent information on how CarbonNeutral® certification is achieved

Step	Entities	Products[1]	Activities
1. Select GHG accounting protocol	The GHG Protocol Corporate Standard, or ISO 14064-1, or the Climate Registry's General Reporting Protocol or similar consistent protocols must be used.	The GHG Protocol Product Standard, PAS 2050, ISO/TS 14067 or methods set out in steps 2-7 below must be applied unless the CarbonNeutral certifier identifies valid reasons for using other methods.	The GHG Protocol Product Standard, PAS 2050 or methods set out in steps 2-7 must be applied unless the CarbonNeutral certifier identifies valid reasons for using other methods.
2. Define boundary	The boundary must include all sites, plants and vehicles owned by or under the direct management control of the subject.	The boundary must be consistent with the definition of the subject. For cradle-to-customer subjects, the boundary must extend to the point of customer delivery. For cradle-to-grave subjects, the boundary must extend to end-of-life disposal.	The boundary must be consistent with the definition of the subject and must include the sites and/or vehicles involved in the delivery of the activity.
3. Identify emissions sources	Assessments must include emissions sources as specified in **Annex B** – CarbonNeutral® certifications and their specific required assessment emissions sources.		
4. Identify GHGs to be measured	All Kyoto Protocol GHGs, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, sulphur-hexafluoride (SF_6) and nitrogen trifluoride (NF_3) must be measured in the assessment, insofar as they apply to the subject.		
5. Establish time period	Assessments must at a minimum be conducted annually and should relate to a 12 month data period. The final date of an assessment data period must not be earlier than nine months prior to start of CarbonNeutral® certification period (i.e. data more than 21 months old is not permitted).	For standard consumer products, assessments must at a minimum be every three years, unless a significant change to the product supply chain has occurred in which case another assessment must be undertaken. For one-off or custom produced products the timescale must relate to the production and delivery period.	For standard consumer activities, assessments must at a minimum be annual. For one-off or custom activities the timescale must relate to the production and delivery period.
6. Determine data validity	Primary data must be used in preference to secondary data, where it is readily available, up to date and geographically relevant. Estimates, extrapolations, models and industry averages may be used where primary data is unavailable. When this is done, these assumptions must be recorded by the party carrying out the assessment. A qualitative and/or quantitative description of the uncertainty associated with the client-supplied data should be made. In cases where the quality of client supplied data is not known (e.g. in online calculators), the dependency of results on the quality of input data should be made clear.		
7. Measure GHG emissions	The subject's GHG emissions must either be directly measured or quantified using national, regional, international, or other relevant emission factors, with preference given to emission factors most closely associated with the emissions source (e.g. DEFRA emission factors for UK-based assessments). The assessment must be reported in units of CO_2e according to the 100 year potential of each gas. Preference should be given to the GWP factors included within the latest assessment report of the Intergovernmental Panel on Climate Change (IPCC) (currently 5th). In instances where most relevant emission factors available use previous GWP factors, it is still acceptable to use these emission factors. GWP factors applied must be clearly stated in the assessment. Emission sources that are required to be assessed (see **Annex B**) but are estimated to represent less than 2% of the subject's total GHG emissions, but collectively no more than 5% of the subject's GHG emissions, may be calculated and reported using simplified estimation methods.		
8. Quality assurance	All GHG assessments must either be conducted or checked, and in the case of GHG tools and calculators, be approved, by an independent, expert third party approved by Natural Capital Partners to ensure they have met the above requirements in this table. **Annex F** details requirements and recommendations for the presentation of GHG assessments; and, **Appendix 2.8** provides further guidance on quality assurance and verification.		

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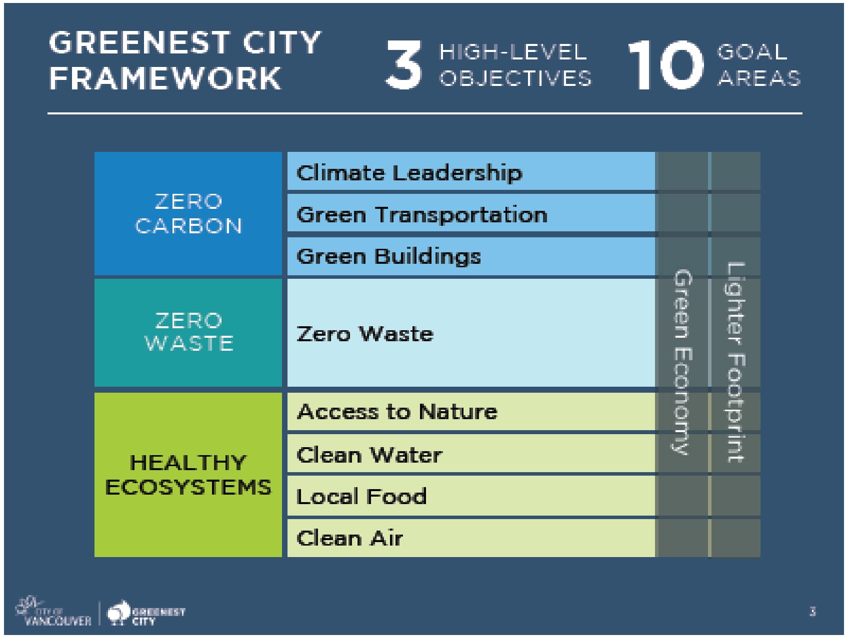
The GHG Protocol for Project Accounting

PART II GHG REDUCTION ACCOUNTING AND REPORTING

CARBON NEUTRAL CITIES ALLIANCE

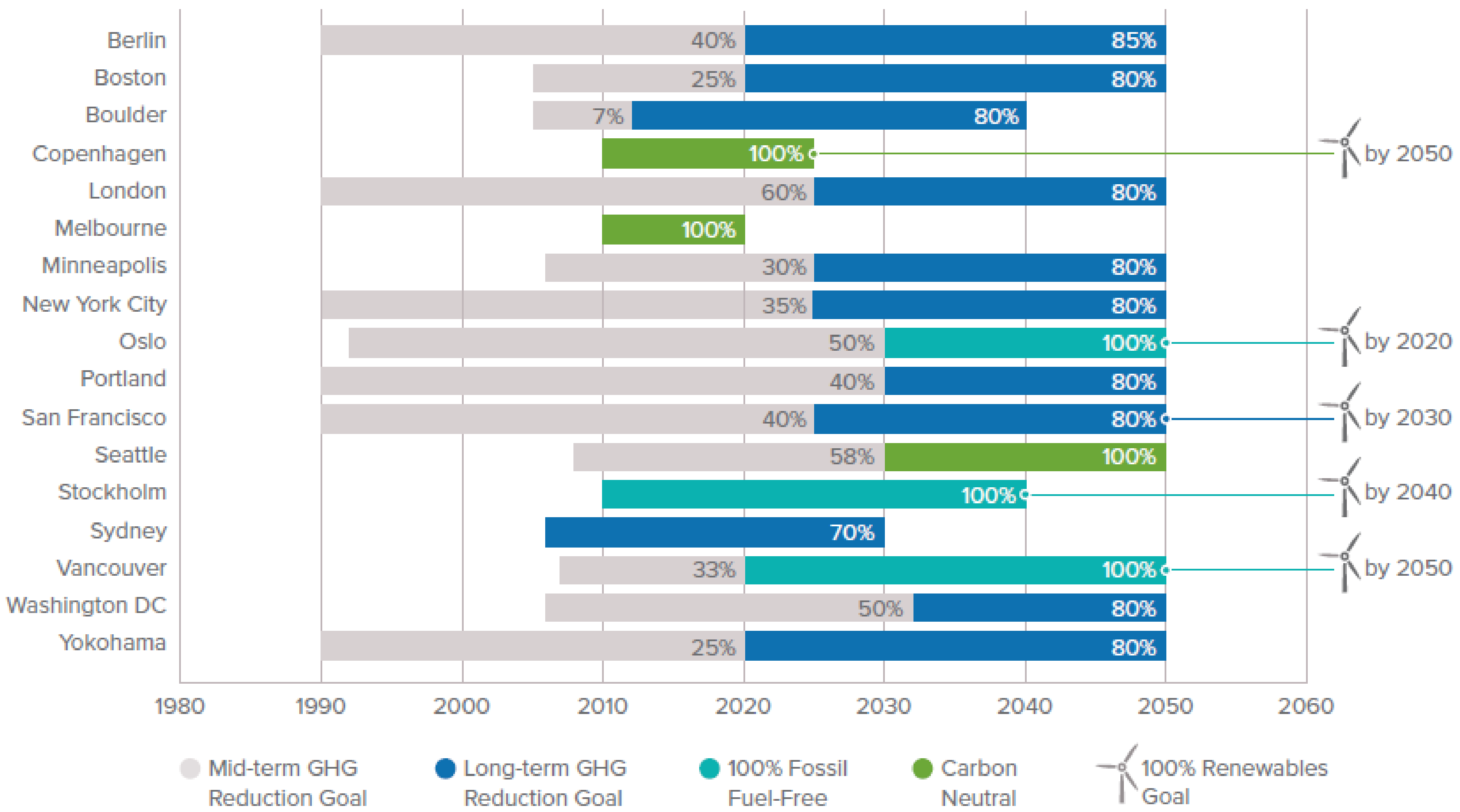
Framework for Long-Term Deep Carbon Reduction Planning



Source: City of Vancouver, "Greenest City 2020 Action Plan Update."

- *Developing Carbon Neutrality Planning Standards*—Developing approaches, analysis, and tools to support carbon neutrality; standardizing measurement and verification methodologies for tracking progress.
- *Advancing "Transformative Change" in Key Urban Sectors*—Sharing and implementing best practices for achieving "transformative" deep carbon reduction strategies in urban transportation, energy use, and waste systems.
- *Advocating for Policy Change*—Identifying and advocating for policies at the state, regional, and federal levels to reduce emission sources not controlled directly by cities and engaging with other external stakeholders who are critical to cities' success.
- *Speaking with a Common Voice*—Helping CNCA cities demonstrate their leadership and communicate with a common voice.
- *Creating a CNCA "Innovation Fund"*—Investing in high-potential, city-led projects that develop, test, implement, and amplify deep decarbonization strategies and practices.
- *Increasing Alliance Impact*—Sharing Alliance learnings with a broader audience to benefit the "next wave" of cities striving for carbon neutrality.

CNCA Cities' Long-Term and Interim GHG Reduction Targets



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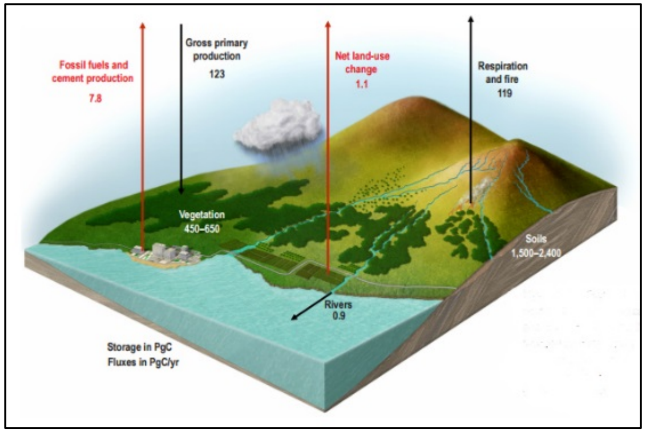
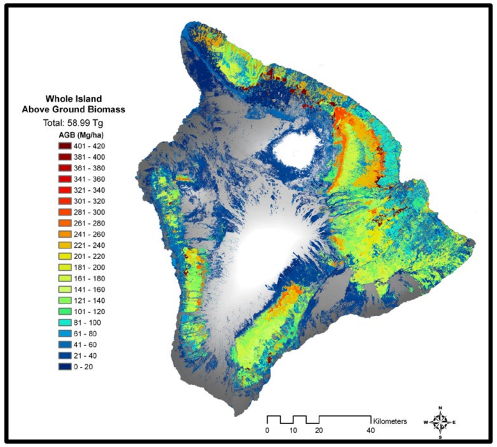
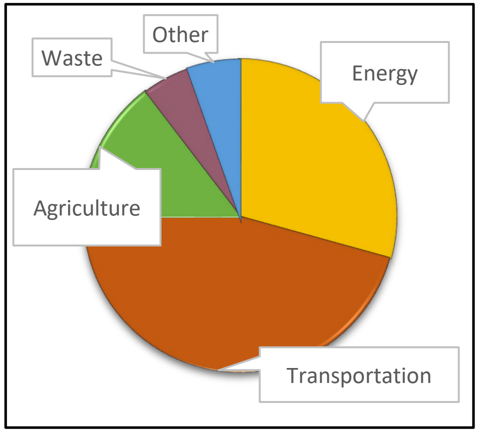
Available Datasets…



Hawaii Carbon Assessment

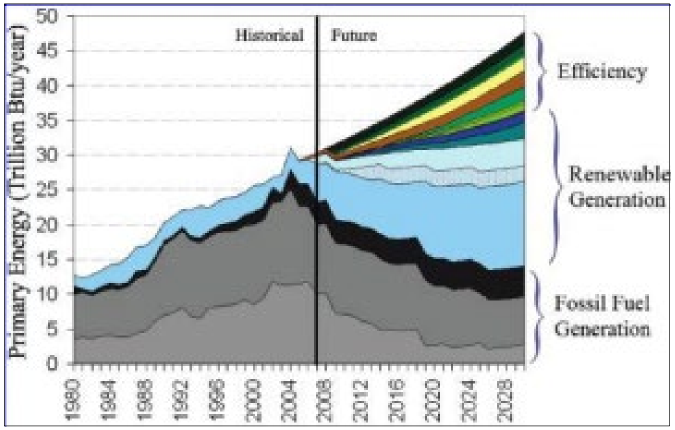
Doi.org/10.3133/pp1834





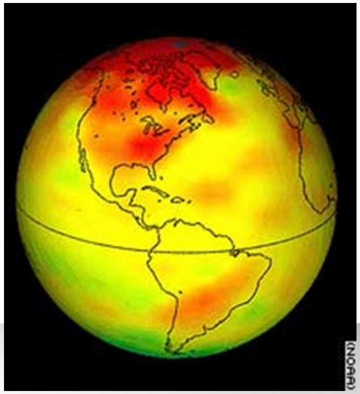
Hawaii Greenhouse Gas Inventory

http://health.hawaii.gov/cab/hawaii-greenhouse-gas-program/

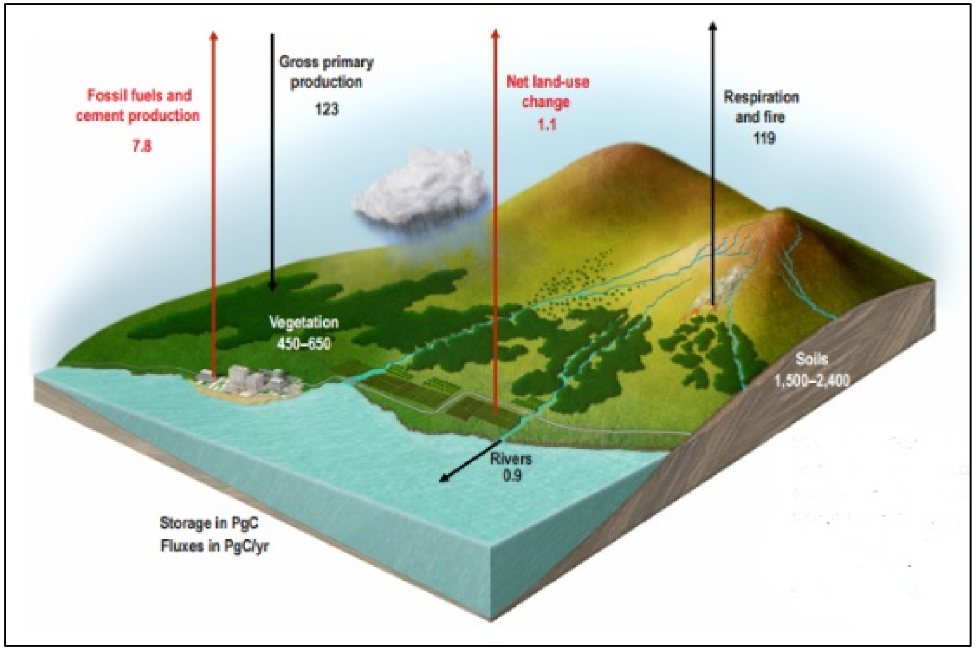


Hawaii Material Energy Flow Budgets

www.environment.yale.edu/profile/chertow



Available Datasets…



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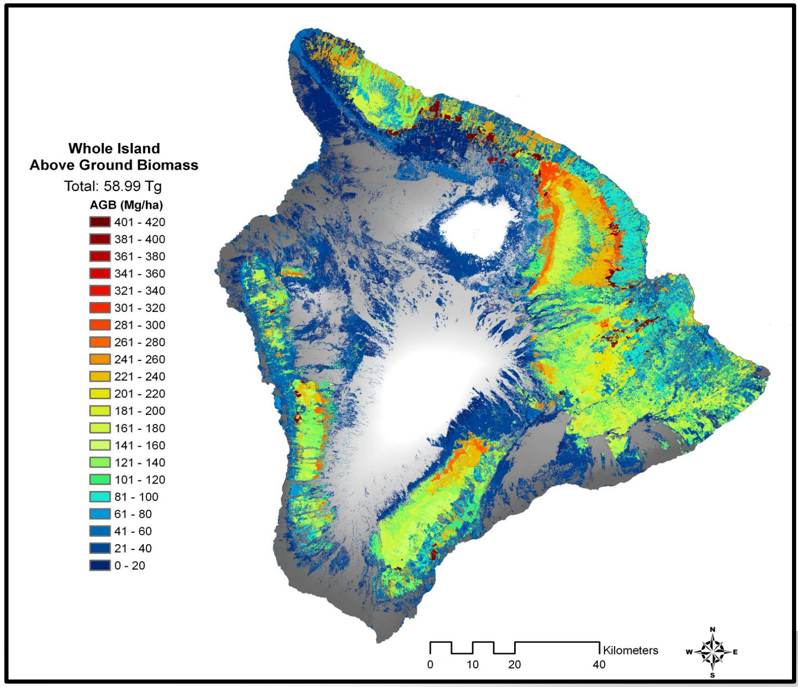


Available Datasets…

Hawaii GHG Emissions and Sinks by Sector/Category for 1990, 2007, 2010, 2015, 2020, and 2025 (MMT CO_2e); Reproduced from Tables ES-1 and ES-2 (Projections) * of the Report.						
Sector/Category	1990	2007	2010	2015	2020	2025
Energy	19.61	21.84	20.46	18.57	18	15.51
IPPU	0.17	0.54	0.67	0.83	0.89	0.95
AFOLU (Sources)	1.61	1.56	1.18	1.1	1.18	1.11
AFOLU (Sinks)	-3.06	-3.28	-3.44	-3.54	-3.57	-3.6
Waste	0.75	1.05	0.89	0.78	0.84	0.9
Total Emissions (Excluding Sinks)	**22.15**	**25.00**	**23.21**	**21.28**	**20.9**	**18.46**
Net Emissions (Including Sinks)	**19.08**	**21.71**	**19.77**	**17.75**	**17.34**	**14.86**
Domestic Aviation	4.66	4.42	2.87	3.23	3.46	3.67
Net Emissions (State Goal) **	**14.43**	**17.29**	**16.9**	**14.52**	**13.88**	**11.19**

2015 Hawaii Greenhouse Gas Inventory
http://health.hawaii.gov/cab/hawaii-greenhouse-gas-program/

Available Datasets…

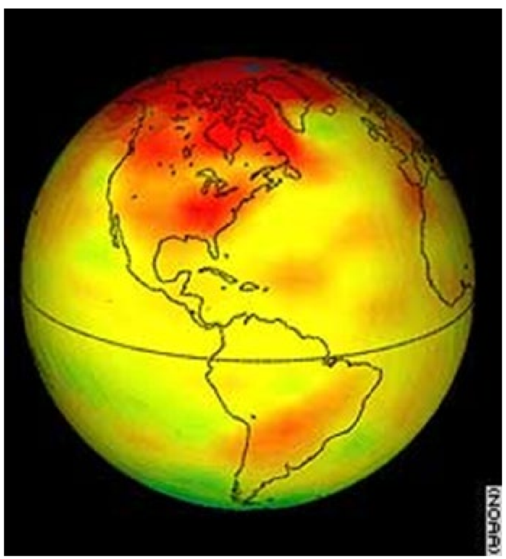
Table 1 Island-wide material flows for Oahu, Hawaii, 2005 (in 1,000 tons, excluding water)

Mass balances	*1* +	*2* −	*3* =	*4*	*5* =	*6* +	*7* +	*8*
Products (waste materials)	*Imports*	*Domestic production*	*Exports*	*Apparent consum.*[a]	*Waste generation*[a]	*On-island recycling*	*Disposal*	*Waste exports*
Lumber (C&D, wood)	350	9	270	89	58	8	50	0
Paper (paper)	110	0	40	70	360[b]	0	290	70
Minerals (C&D, glass)	540	3,400	215	3,725	460	210	250	0
Metals (scrap)	2,450	0	1,600	850	176[b]	0	21	155
Chemicals (hazardous)	145	0	69	76	30[b]	15	2	13
Food and agriculture (scraps, sludge)	857	104	239	722	203	43	160	0
Biomass/green waste	0	200	0	200	160	80	80	0
Fossil fuels/ash	9,500	0	2,700	6,800	70	70	0	0
Final products/ discarded products	2,659	5	1,534	1,130	274	15	255	4
Total	16,611	3,718	6,667	13,662	1,791	441	1,108	242

Note: 1,000 tons (short tons) = 2,000,000 pounds (lb) ≈ 907,000 kilograms (kg, SI) = 907 metric tons. Consum. = consumption. C&D = construction and demolition.

[a]Calculated by mass balance

[b]Incorporates waste from final products



Hawaii Material Energy Flow Budgets

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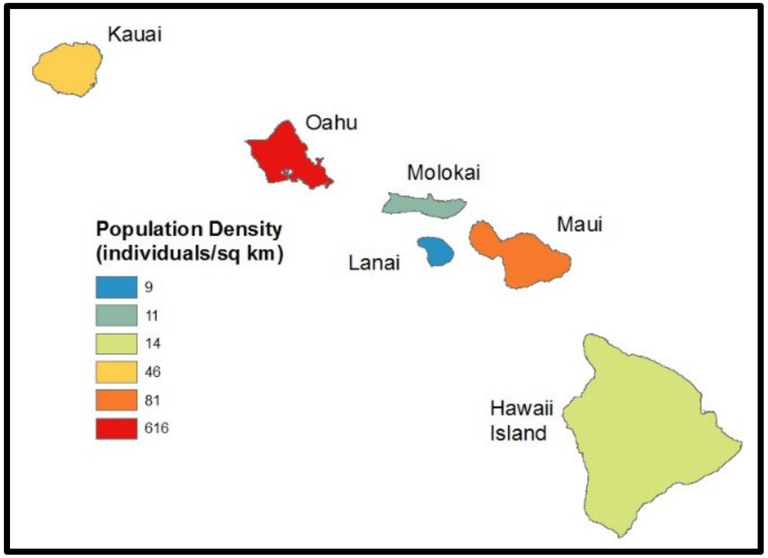
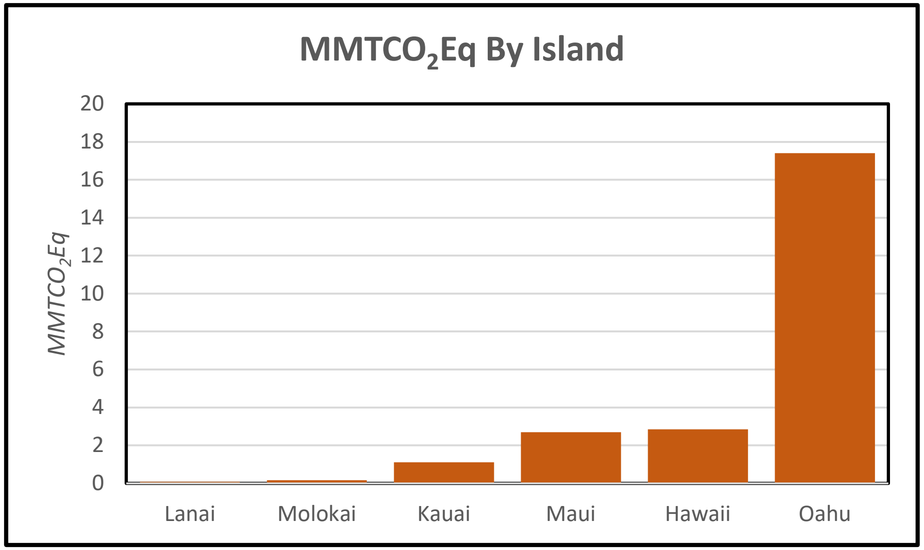
Hawaii as a model system:



Population Density by Island



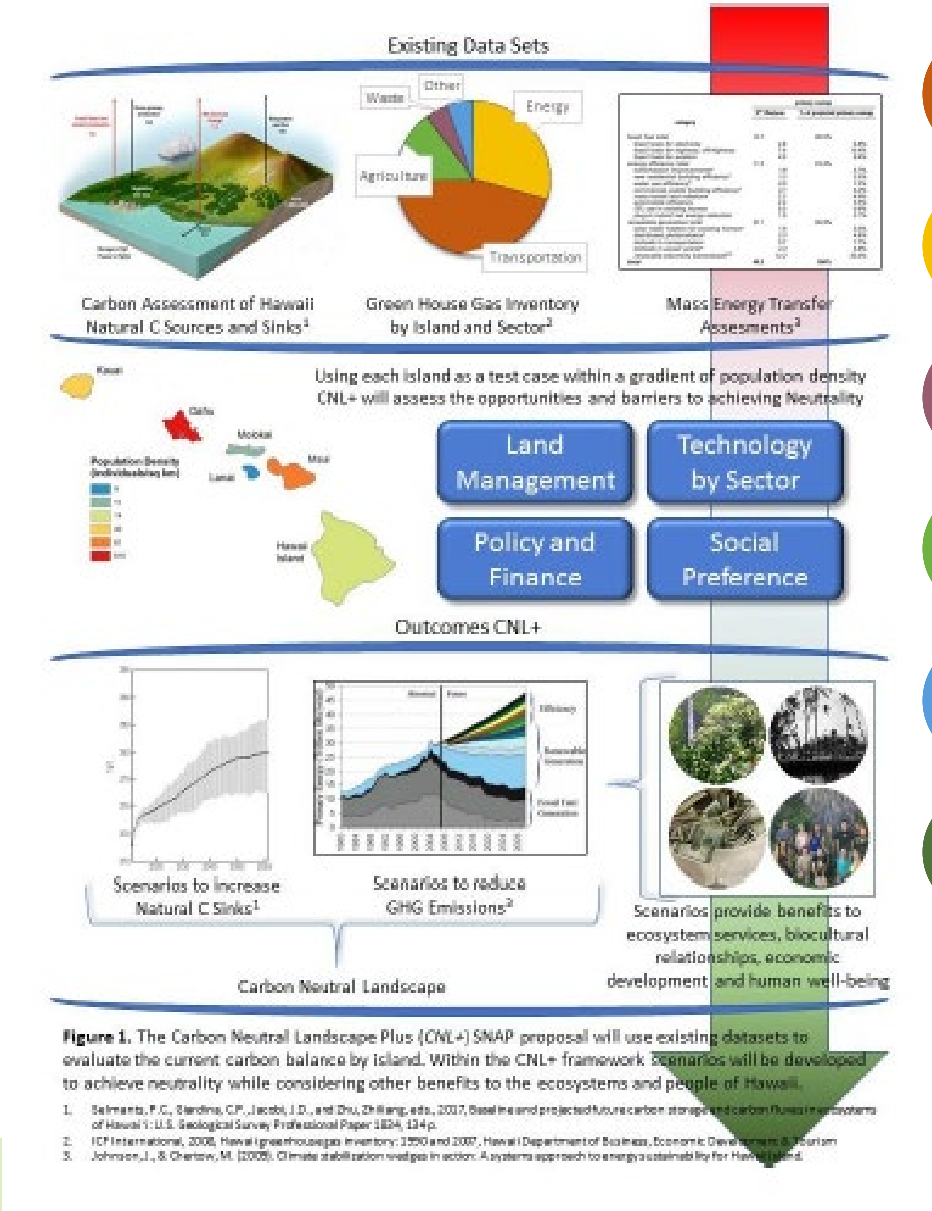
CO_2 Emissions by Island

Technology by Sector

Land Management

Policy and Finance

Social Preferences



Transportation

Energy

Waste

Agriculture

Sequestration

Importation

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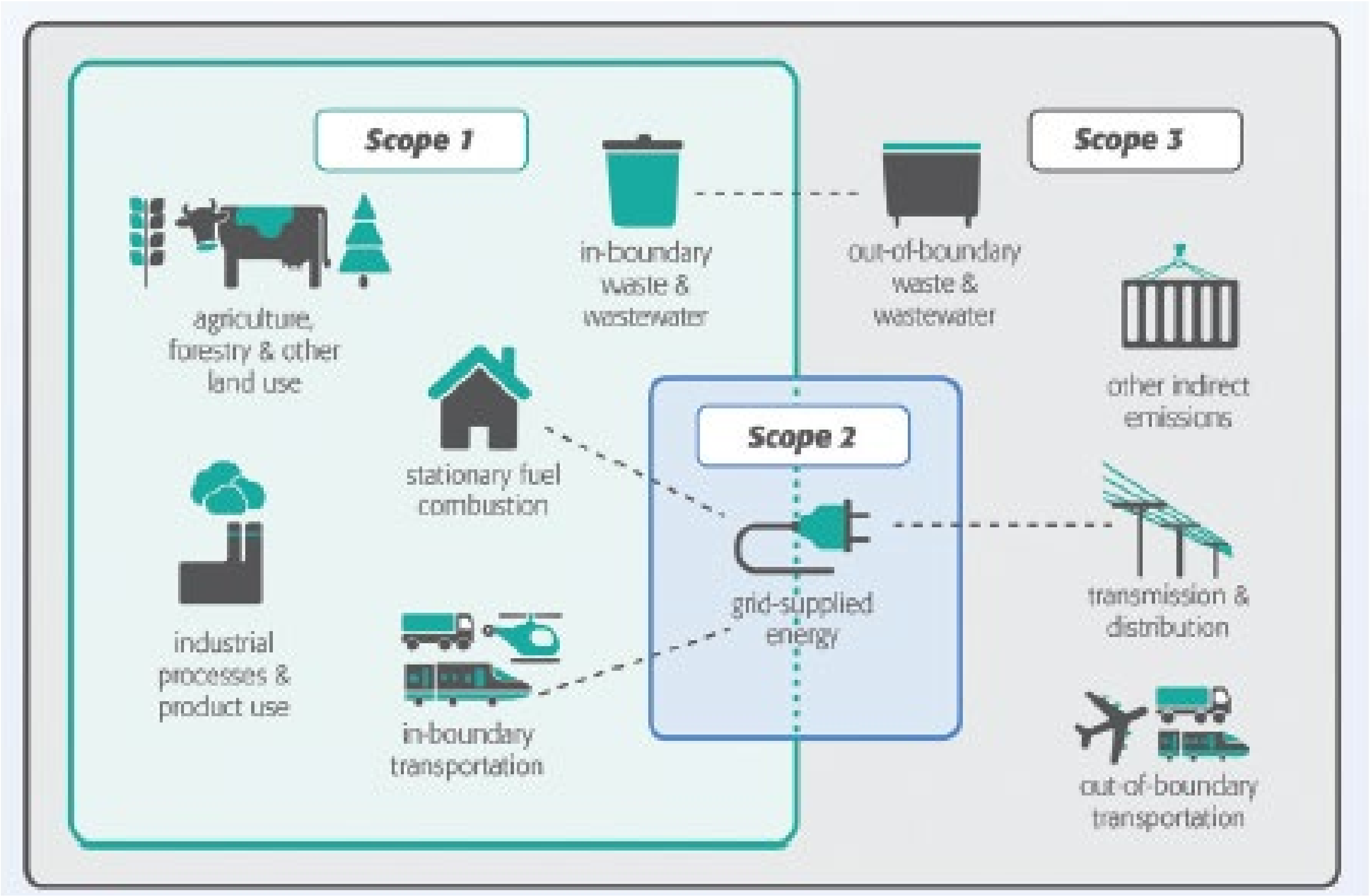
Clearly define neutrality and so the task at hand



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Adopt a framework and build a plan

CARBON NEUTRAL CITIES ALLIANCE

Framework for Long-Term Deep Carbon Reduction Planning

Most Recent Climate Action Plans of Alliance Cities

Berlin	"Climate-Neutrality Berlin 2050: Results of a Feasibility Study"
Boston	"2014 Climate Action Plan Update"
Boulder	"Boulder's Climate Commitment 2015 [Draft]"
Copenhagen	"Copenhagen Energy Vision 2050;" "CPH 2025 Climate Plan (2(
London	"2020 Vision: The Greatest City on Earth"
Melbourne	"Net Zero Emissions By 2020: Update 2014"
Minneapolis	"Climate Action Plan (June 2013)"
New York City	"New York City's Pathways to Deep Carbon Reductions (Decemb
Oslo	"Environment and Climate Report 2013"
Portland	"Climate Action Plan 2015"
San Francisco	"Climate Action Strategy 2013 Update;" "San Francisco Climate /
Seattle	"Getting to Zero: A Pathway to a Carbon Neutral Seattle (2011);" (June 2013)"
Stockholm	"Roadmap for a Fossil Fuel-Free Stockholm 2050"
Sydney	"Sustainable Sydney 2030: Community Strategic Plan (2014)"
Vancouver	"Greenest City: 2020 Action Plan;" "Renewable City Strategy 20
Washington DC	"Sustainable D.C."
Yokohama	"FutureCity Initiative (2012);" "Yokohama Action Plan 2013-2017"

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OTHER RESOURCES

Carbon Neutral Cities Alliance	The Urban Sustainability Directors Network	Cities striving for carbon neutrality recognize that averting the worst impacts of climate change will require cutting GHG emissions by at least 80% by 2050.
Scan of Leading Edge Thinking and Practice on Carbon-Neutral Communities	Innovation Network for Communities	The project identifies and details 9 core strategies that need to be implemented at scale in a developmental way over the next four decades for cities to achieve 80x50 goals. The project report also identifies opportunities for collaboration and networking among cities to accelerate their progress towards these goals.
Measuring Up 2015: How US Cities Are Accelerating Progress Toward National Climate Goals	World Wildlife Fund & ICLEI	A scan of what leading-edge cities in the U.S. are doing to reduce carbon emissions, with a focus on Atlanta, Minneapolis and Portland.
"Climate Action in Megacities: C40 Cities Baseline and Opportunities"	Arup	A comprehensive analysis of what the mayors of the C40 megacities are doing to tackle climate change
"Pathways to Deep Carbonization," September 2014	Institute for Sustainable Development and International Relations and Sustainable Development Solutions Network	This 2014 report by the Deep Decarbonization Pathway Project (DDPP) summarizes preliminary findings of the technical pathways developed by the DDPP Country Research Partners with the objective of achieving emission reductions. The DDPP is a knowledge network comprising 15 Country Research Partners, and several Partner Organizations who develop and share methods, assumptions, and findings related to deep decarbonization.
Transform Communities' Energy Systems	Rocky Mountain Institute	By 2050, we need all U.S. communities to have transformed how they use energy in transportation, industry, buildings, and electricity. To achieve this, we need to work with individual communities to create beacons of success and share the models that will enable other communities to follow a similar path.
Sustainable Transportation Energy Pathways: A Research Summary for Decision Makers	UC Davis, Institute of Transportation Studies	This chapter explores how such deep reduction targets (50 to 80 percent) could be met in the transportation sector by 2050, with a focus on California and the United States as a whole. It presents a framework for understanding emission reductions in the transportation sector, lays out the major mitigation options for reducing emissions, and presents scenarios to explore how deep reductions could be achieved.

Table I-1: Total Capacity Buildouts for the Years 2017-2025 by PSIP Scenario (MW)

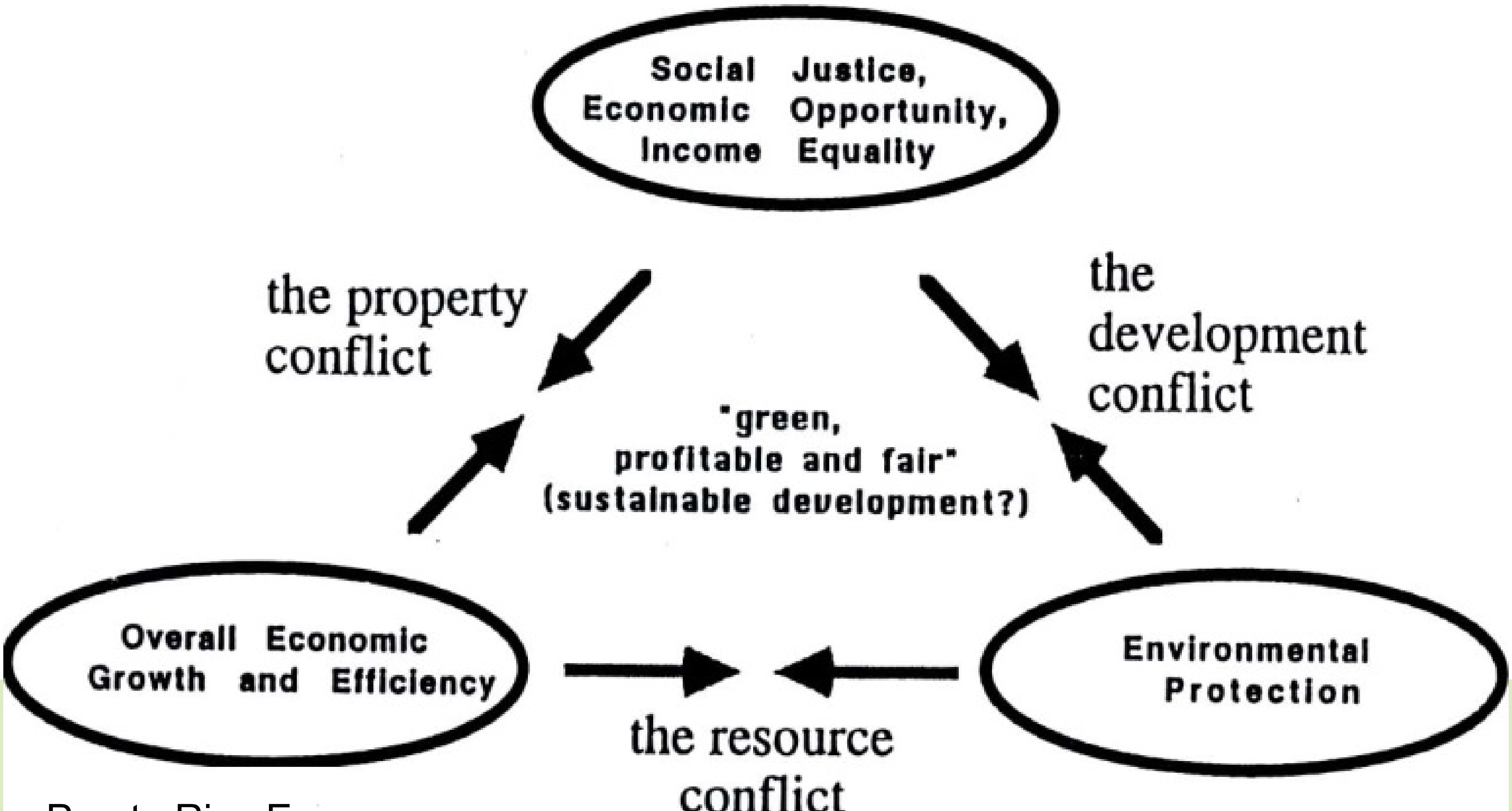
Energy Source	E3	E3 with LNG
Wind	368	113
Utility-Scale Photovoltaic	572	329
Biofuels	40	20
Geothermal	0	0
Hydro	4	1
Battery storage	568	496
Liquefied natural gas	0	106
Flexible dispatchable generation	54	54
Combined cycle turbine	0	3
Synchronized condenser	61	55
Internal combustion engine	18	0
Unspecified	150	50

Hawaii Greenhouse Gas Emissions Report for 2015

Hu Honua is a 30 MW facility

Project name	Island	Developer	Size	Storage	Cost per KWh
Waikoloa Solar	Hawaii	AES	30 MW	120 MWh	$0.08
Hale Kuawehi	Hawaii	Innergex	30 MW	120 MWh	$0.09
Kuihelani Solar	Maui	AES	60 MW	240 MWh	$0.08
Paeahu Solar	Maui	Innergex	15 MW	60 MWh	$0.12
Hoohana	Oahu	174 Power Global	52 MW	208 MWh	$0.10
Mililani I Solar	Oahu	Clearway	39 MW	156 MWh	$0.09
Waiawa Solar	Oahu	Clearway	36 MW	144 MWh	$0.10

Social Acceptance and Adoption of Carbon Neutral Lifestyles:



Puerto Rico Epscor

Establish principles for the operating environment

- **Use the best available science**
- **Lead by example**
- **Make carbon management everyone's responsibility**
- **Don't reinvent the wheel$_{\text{ZEV}}$**
- **Base decisions on data**
- **Seek strategies that produce co-benefits**
- **Don't hesitate / don't delay**
- **Integrate targets into other planning processes**
- **All hands on deck**
- **Embrace social equity in climate action**

Mahalo!

Berlin	Since 1990, GHG emissions have dropped 29%, while GDP has grown 19% and population has increased 1%.
Copenhagen	Since 2005, GHG emissions have decreased 31%, while population increased 15% and the local economy grew by 18%.
London	Since 1990, GHG emissions have decreased 11%, 14% since 2008. Population increased by 600,000 since 2008—the fastest rate in the city's history. As a result, per-person carbon emissions reduced 30% from 1990 level and 19% since 2008.
Minneapolis	Between 2006-2013, GHG emissions have decreased 9.4%, while population increased 6.5% and the regional GDP increased 22%.
Oslo	Since 2013, GHG emissions have decreased 22%.
Portland	Since 1990, GHG emissions have decreased 14%, while population increased 31% and jobs increased 20%.
San Francisco	Since 1990, GHG emissions have decreased 23%, while population has increased 15% and there has been a 49% increase in the local economy.
Seattle	Since 1990, through 2012, GHG emissions have decreased 4% (after accounting for offsets), while population has grown 23% and the number of jobs increased 14%. On a per-person basis, GHG emissions have declined 22% since 1990 and 6% since 2008.
Stockholm	Between 2011-2013, GHG emissions have decreased by approximately 9%, while population grew by approximately 4% and the local economy grew by approximately 3%.
Sydney	From 2006 to 2012, GHG emissions have decreased 12%, while population increased 16% and GDP grew 23%.
Vancouver	From 1990, to 2014, GHG emissions have decreased 7%, while population has grown 34% and the number of jobs increased 30%. On a per-person basis, GHG emissions have declined 30% since 1990 and 13% since 2007.
Washington D.C.	Between 2006-2013, GHG emissions have decreased 16%, and per capita emissions 24%, while population increased 11%, employment grew 8%, and GDP grew 9%.