Negative carbon emission by nanomembranes aiming for a carbon recycling society

Shigenori FUJIKAWA
International Institute for Carbon-Neutral Energy Research
Kyushu University, JAPAN
Climate change impact in Japan

Date of cherry-blossom peak-bloom in Kyoto, Japan, 800AD - 2016

Trend
Confidence interval

Data: Yasuyuki Aono, Osaka Prefecture University, Infographics: www.economist.com
CO$_2$ emission in NYC

(http://www.carbonvisuals.com/)
What is the total weight of carbon dioxide in the atmosphere?

大気中の二酸化炭素重量はどのくらいあるでしょうか？
1,000,000,000,000 t
~
2,000,000,000,000 t

Number of automobiles worldwide
ca. 1,400,000,000 cars
“Necessity of negative CO₂ emission”

“To limit global warming to <2 °C, we must reduce the net amount of CO₂ we release into the atmosphere, either by producing less CO₂ (conventional mitigation) or by capturing more CO₂ (negative emissions).”


**Diagram:**
- **(a) CO₂ emissions pathways from the scenario literature**
- **(b) Examples of technologies**

**Legend:**
- **CO₂ emissions in atmosphere:**
  - Mitigated CO₂ emissions
  - Business as Usual
  - Below 2°C
  - Net zero CO₂ emissions
  - Gross negative CO₂ emissions
  - Other NETs
  - Afforestation/Reforestation

- **Technologies:**
  - Conventional abatement technologies
  - Emitting technologies
  - Negative emission technologies

**Note:**
CO₂ in atmosphere should be directly captured. → Direct Air Capture (DAC)
Negative Emissions Technologies and Reliable Sequestration
Huge investments in DAC technologies

Chevron, Occidental buy stake in carbon capturing firm backed by Bill Gates and Murray Edwards

The company describes its pilot in Squamish as a ‘negative emissions facility’ that can subtract CO2 emitted by cars, factories and other industrial sources

Geoffrey Morgan
Jan 09, 2019 • January 9, 2019 • 3 minute read • 🗣 Join the conversation

January, 2021
Contribute $100 million to the "X Prize Contest," for a competition to develop DAC technologies.

Financial Post, Jan 9, 2019
(カナダ)
CLIMEWORKS
(Iceland)
CO\textsubscript{2} Capture Technologies

- Liquid absorption
- Solid adsorption
- Membrane separation
Advantages
• highly feasible
• High volume processing

Required improvements
• Consumes a lot of energy
• Requires a lot of water.
• Limited installation locations
• Large scale is essential
Why not DAC with membranes?
“Capturing CO₂ from the atmosphere: rationale and process design considerations.”
Keith, D., Heidel, K., and Cherry, R.
*Geo-Engineering Climate Change: Environmental Necessity or Pandora’s Box?*

**Membranes**

“Using them (membranes) to separate CO₂ from air where the driving force for CO₂ is at most 40 Pa seems implausible given the relatively low molecular fluxes through membranes.

→ Low gas permeance limits developments of membrane-based DAC
Ultra-fast, CO$_2$ permeation by free-standing nanomembranes

**Thickness : 34 nm**
3000 times thinner than food wrap
(Thinner than COVID-19 virus!)

**CO$_2$ permeance : World high!**
Overwhelmingly higher permeability
(20~30 times higher than previously reported cases)
Membrane separation of CO₂ from low concentration CO₂ gas

**Gas concentration detection**
(gas chromatography)

<table>
<thead>
<tr>
<th>thickness (µm)</th>
<th>permeate (%)</th>
<th>retentate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4</td>
<td>3.6</td>
<td>96.4</td>
</tr>
<tr>
<td>0.15</td>
<td>25.4</td>
<td>74.6</td>
</tr>
</tbody>
</table>

Newly developed separation nanomembrane efficiently separates even low concentration CO₂ gas
What is merits of membranes for DAC?

- Simple and inexpensive process
- No toxic chemicals
- No site limitation for installation
- Size adjustable

CO₂ capture anywhere
<table>
<thead>
<tr>
<th>Centralize or <strong>decentralize</strong>?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electric Power Generation</strong></td>
</tr>
<tr>
<td><strong>centralize</strong></td>
</tr>
<tr>
<td>thermal power plant</td>
</tr>
<tr>
<td><strong>decentralize</strong></td>
</tr>
<tr>
<td>photovoltaic power production</td>
</tr>
</tbody>
</table>
on-road CO₂ emission in US.

Tons CO₂ per km²

High: 382896
Low: 0

Seattle

L.A.

Houston

Atlanta

Boston

Conor K. Gately et al. PNAS 2015;112:16:4999-5004
CCUS:
Carbon Capture, Utilization, and Storage (Sequestration)
Nanoparticle catalysts for CO$_2$ conversion

- Methane
- Ethylene
- Ethanol
- Carbon monoxide

Electrochemical conversion of CO$_2$ captured from air

Prof. Miho Yamauchi
(Kyushu University)

Prof. Paul Kenis
(Univ. Illinois, Urbana Champaign)

Nanoparticle catalysts for CO$_2$ conversion
Direct Air Capture and Utilization system
Decentralized DAC-U system

Local production and Local consumption
Carbon recycled society
“Moonshot Challenge” in Japan

Promoting high-risk, high-impact R&D aiming to achieve ambitious Moonshot Goals and solve issues facing future society

“Development of Global CO₂ Recycling Technology towards “Beyond-Zero” Emission”
carbon dioxide (CO₂)
“Design” Future

"Designing the Future and Designing for the Future."

Products of Graduate students supervised by Prof. Yoshito Ogata
“Ubiquitous Carbon capture”

Carbon Capture Anywhere!

Thank you for your kind attention
I would argue that accelerated decarbonization requires net-zero by 2035 or sooner in rich countries.
Recent reports present detailed pathways and call for \textbf{greater ambition with decarbonization} in advanced economies.
On 11 March 2022, climate scientists stated that wealthy countries with high greenhouse gas emissions must **phase out all oil and gas production by 2034**. These measures are required to avoid 1.5°C of warming, in line with the Paris Agreement.

Two months later, on 17 May 2022, another group argued that “**staying within a 1.5°C carbon budget ... implies leaving almost 40% of ‘developed reserves’ of fossil fuels unextracted.**”
Funding and implementing new oil and gas developments is referred to as carbon bombing.
Climate scientists are beginning to sound like **Extinction Rebellion**
Extinction Rebellion is an international apolitical network using non-violent direct action to persuade governments to act on the Climate and Ecological Emergency.

We have three demands in the UK:

**01 TELL THE TRUTH**
Government must tell the truth by declaring a climate and ecological emergency, working with other institutions to communicate the urgency for change.

**02 ACT NOW**
Government must act now to halt biodiversity loss and reduce greenhouse gas emissions to net zero by 2025.

**03 BEYOND POLITICS**
Government must create and be led by the decisions of a Citizens’ Assembly on climate and ecological justice.
IPCC 5th Assessment Report states that to stop global warming net anthropogenic additions of CO₂ into the atmosphere have to reach zero.

Paris Agreement requires ‘Parties aim to reach global peaking of greenhouse gas emissions as soon as possible’.

IPCC Special Report concludes that limiting temperature rise to around 1.5°C implies reaching net zero emissions of CO₂ by mid-century.

IPCC 6th Assessment Report presents scenarios that by 2100 would ensure temperature rise between 1.4 to 1.8°C, Recommends net zero 2050 target.

COP26 aimed to secure net zero 2050 and to keep 1.5°C through the Glasgow Climate Pact.

IPCC states that global emissions need to peak before 2025 in order to limit warming to 1.5°C.
Unfortunately, national responses have been mainly linear and delayed (exception UK - but marginal).

We need stronger 2030 targets and more Net Zero 2050 legislation.

Source: 2021 Emissions Gap Report
April 2021, UK government announced \textit{emission reduction target of 78\% by 2035 compared to 1990 levels} (within framework of 2008 Climate Change Act).

Supported by \textit{October 2021 Net-Zero Strategy}. 
Unfortunately, following Covid19 induced decline, **global GHG emissions bounced back in 2021.**
Sub-national governments may have the potential to accelerate decarbonization. In 2020, 823 cities and 101 regions, covering 11 percent of the global population, had net-zero targets.
696 local governments including Tokyo, Kyoto, and Yokohama announced their commitment to net zero carbon emissions by 2050 (as of April 2022). These local governments represent 118 million people (93.1% of Japan’s population).

Ambitious emission reduction targets at the local level are lacking:
“Less than half of large U.S. cities have established GHG reduction targets… [many] tend to fall short of the mitigation pathways that limit warming to 1.5°C as modeled by the IPCC…”

Greenhouse gas accounting at the local level has been problematic:
“… cities faced difficulties when choosing data, system boundaries, and the baseline year for calculations…”

Cities generally adopt territorial- or production-based rather than consumption-based emissions accounting systems.”
Sub-national net-zero targets can be understood as a progressive spectrum from modest to ambitious.

- **Copenhagen**
  - **Net zero 2025**
  - 2025 carbon neutrality will require off-setting of residual emissions.

- **Leeds**
  - **Net zero 2030**
  - Currently working on a new roadmap that will consider indirect emissions and aviation.

- **Oslo**
  - **Net zero 2035**
  - Current strategy aims for 95% emission reduction by 2030 (does not include indirect emissions).

- **San Francisco**
  - **Net zero 2040**
  - Updated in 2021 Climate Action Plan from previous net zero 2050.

- **Australian Capital Territory**
  - **Net zero 2045**
  - Target shifted from net zero 2050 to 2045 due meeting 100% renewable energy target.

- **Fukushima Prefecture**
  - **Net zero 2050**
  - Plan in preparation for net zero 2050. Previous target was 45% reduction by 2030.
In part this is explained by **local energy transitions to renewables** (where feasible)

- **Australian Capital Territory**: Reached 100% renewable electricity by **2020**. Secured 640 megawatts of renewable electricity from outside the city.

- **City of Oslo**: 100% renewable electricity by **2030**. Close to 70% renewable electricity in 2018.

- **The City and County of San Francisco**: 100% renewable energy by **2040**. 30% of electricity generated from renewables in 2017.

- **Fukushima Prefecture**: 100% renewable energy by **2040**. Benefits from a national electricity system that is predominately hydropower.

- **Leeds City Council**: Pathway to net zero by **2030**, includes technical measures tied into decarbonization of the national electricity supply.

- **City of Copenhagen**: Fossil fuel use should reach zero by **2030**, but depends on national government action.
From a review of scientific literature, what factors appear most influential?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Robust <strong>emission accounting system</strong></td>
</tr>
<tr>
<td>2</td>
<td><strong>Transparent assumptions</strong> underpinning climate strategy</td>
</tr>
<tr>
<td>3</td>
<td><strong>Recognized methodologies</strong> to determine scope of emissions covered (including consumption emissions)</td>
</tr>
<tr>
<td>4</td>
<td><strong>Climate emergency declaration</strong> (CED) tied into action plan and resources</td>
</tr>
<tr>
<td>5</td>
<td><strong>Policy-governance innovations</strong> (i.e., citizens assembly, citizen juries, participatory budgeting)</td>
</tr>
<tr>
<td>6</td>
<td><strong>Private sector and non-governmental partnerships</strong> (including around financing)</td>
</tr>
<tr>
<td>7</td>
<td><strong>Fiscal and economic measures</strong> including job generation, subsidies and climate budgets</td>
</tr>
</tbody>
</table>
From a review of scientific literature, what factors appear **most influential**?

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8) Ambitious goal to reach <strong>100% renewable electricity</strong> as rapidly as possible</td>
<td></td>
</tr>
<tr>
<td>(9) Mix of <strong>technology-oriented and social interventions</strong> (i.e., not just techno-fix)</td>
<td></td>
</tr>
<tr>
<td>(10) <strong>Energy supply and demand side</strong> policies/measures (i.e., phase out fossil fuels and reduce energy demand)</td>
<td></td>
</tr>
<tr>
<td>(11) Measures to influence <strong>consumer practice and behavior</strong></td>
<td></td>
</tr>
<tr>
<td>(12) <strong>Innovations in whole systems</strong> (e.g., promotion of EVs, charging infrastructure, zero carbon electricity, EV recycling, etc.)</td>
<td></td>
</tr>
<tr>
<td>(13) <strong>Interaction between adjacent systems</strong> (crossing municipal boundaries, cross sectors)</td>
<td></td>
</tr>
<tr>
<td>(14) <strong>Phase out of unsustainable technologies</strong> (ban fossil fuel cars)</td>
<td></td>
</tr>
<tr>
<td>Criteria/City</td>
<td>Copenhagen</td>
</tr>
<tr>
<td>----------------</td>
<td>------------</td>
</tr>
<tr>
<td>Level of Government</td>
<td>Municipal</td>
</tr>
<tr>
<td>Net-Zero Target Year</td>
<td>2025</td>
</tr>
<tr>
<td>(1) Accounting System</td>
<td>✔️</td>
</tr>
<tr>
<td>(2) Transparent Assumptions</td>
<td>✔️</td>
</tr>
<tr>
<td>(3) Methodology</td>
<td>✔️</td>
</tr>
<tr>
<td>(4) Climate Emergency</td>
<td>✔️</td>
</tr>
<tr>
<td>(5) Governance Innovations</td>
<td>✔️</td>
</tr>
<tr>
<td>(6) Partnerships</td>
<td>✔️</td>
</tr>
<tr>
<td>(7) Fiscal/Economic Measures</td>
<td>✔️</td>
</tr>
<tr>
<td>(8) Renewable Electricity Target</td>
<td>✔️</td>
</tr>
<tr>
<td>(9) Techno/Social Measures</td>
<td>✔️</td>
</tr>
<tr>
<td>(10) Energy Supply/Demand</td>
<td>✔️</td>
</tr>
<tr>
<td>(11) Consumers</td>
<td>✔️</td>
</tr>
<tr>
<td>(12) Whole Systems</td>
<td>✔️</td>
</tr>
<tr>
<td>(13) Adjacent Systems</td>
<td>✔️</td>
</tr>
<tr>
<td>(14) Phase out</td>
<td>✔️</td>
</tr>
</tbody>
</table>
How do the case studies compare to the accelerated decarbonization pathway?
Leeds case study - innovative climate policies

The Economics of Low CarbonCities
A Mainstream Review for the Leeds City Region

2012 report makes solid economic case for climate action.

Climate Emergency Declaration of March 2019 set the net zero 2030 target

First climate roadmap for the city published in 2019

3 month consultation on climate change - July to September 2019

Citizens jury on climate change. 25 people selected - 12 September to 3 November 2019

Summary report & recommendations published in Nov. 2019
New roadmap published in January 2021
It is critically important that cities apply **consistent methodologies**
From 2017 Oslo has implemented a **climate budget**. However, cities need to align all expenditure with the climate action plan. Spending on projects that undermine climate goals should be **avoided or redirected**.

“All the measures have been assessed from a **Scope 1 perspective**. In other words, they have been assessed for their effect on GHG emissions (CO2, N2O and CH4) within the borders of the City of Oslo, rather than for their effect on consumption.” 2019 Oslo Climate Budget
Accelerated roadmaps, pathways and targets ... align closely with existing modes of governance, policy-making and funding cycles...
... long-term approaches (such as net-zero 2050) encourage contemporary policy-makers to push the burden of implementation onto future leaders, hence slowing the development and diffusion of low-carbon technologies.
Thank you for your attention
Decarbonization Strategies for Hawai‘i

Makena Coffman
Director, Institute for Sustainability and Resilience
Professor, Department of Urban and Regional Planning
Research Fellow, University of Hawai‘i Economic Research Organization

makenaka@hawaii.edu
Hawaii sets ambitious goal: Carbon neutral by 2045

Published: Monday, June 4th 2018, 5:03 pm HST
Updated: Monday, June 4th 2018, 6:13 pm HST
By Samie Gebers, Hawaii News Now Intern

HAWAII (HawaiiNewsNow) - Gov. David Ige signed three bills Monday in an effort to reduce carbon emissions, one of which set a goal of making Hawaii a zero-emissions clean economy by 2045.

House Bill 2182 aims to make Hawaii carbon neutral in just 27 years.

“It really takes the next step,” Ige said. “This measure really ups the ante and commits to a carbon neutral community here on the islands.”

2045 is the same year that Hawaii expects to generate 100 percent of its electricity from clean, renewable sources.

The bill also establishes the greenhouse gas sequestration task force that will look at programs and policies to help further a goal of reducing carbon emissions.

During Monday's signing, Ige added that Hawaii was the first state to adopt a law aligning with the Paris agreement to combat climate change, and HB 2182 is the next step in honoring that.

Another signed bill, HB1986, creates a structure for a carbon offset program, which aims to restore native forests by planting trees and partnering with businesses to further environmental goals.

“We see tremendous potential for restoration, protection and management of forest areas in Hawaii to offer cost-efficient climate change mitigation,” the governor said. “That's why this framework for capturing carbon through reforestation and carbon farming is an important step forward.”

HB2106 will require sea level rise analysis in environmental impact statements before building projects. The governor said requiring the analysis is “just plain common sense,” due to the oceans having impact on beaches, roadways and homes near the shoreline.

“I think, collectively, these three bills I'll be signing today continues and keeps Hawaii at the forefront in the battle in climate change and sea level rise,” Ige said.

Copyright 2018 Hawaii News Now. All rights reserved.

U.S. Climate Alliance

Source: https://www.usclimatealliance.org/about-us/
Hawai‘i GHG Emissions Trends

Figure 1-1: Hawaii Net GHG Emissions by Year (Including Sinks)

Figure 2-1: GHG Emissions and Projections from the Energy Sector under the Baseline Scenario

Renewable & Clean Energy Standards

30 States + DC have a Renewable Portfolio Standard, 5 states have a Clean Energy Standard (8 states have renewable portfolio goals, 5 states have clean energy goals)

- WA: 15% x 2020* (100% x 2045)
- OR: 50% x 2040* (large utilities)
- CA: 60% x 2030 (100% x 2045)
- NV: 50% x 2030 (100% x 2050)
- AZ: 15% x 2025*
- NM: 80% x 2040 (IOUs) (100% by 2045 (IOUs))
- CO: 30% by 2020 (IOUs) **†
- ND: 10% x 2015
- MN: 26.5% x 2025 (IOUs) 31.5% x 2020 (Xcel)
- WI: 10% 2015 (100% x 2050)
- MI: 15% x 2021**
- IA: 105 MW
- IL: 25% x 2026
- MO: 15% x 2021
- OK: 15% x 2015
- TX: 5,880 MW x 2015*
- UT: 20% x 2025†
- SD: 10% x 2015
- KC: 20% x 2020
- KS: 20% x 2020
- KY: 15% x 2021
- LA: 10% x 2015
- AL: 10% x 2015
- SC: 2% 2021
- MS: 10% x 2021 (IOUs)
- GA: 15% x 2015
- FL: 25% x 2021*
- NC: 12.5% x 2021 (IOUs)
- VA: 100% x 2015
- WV: 10% x 2021 (IOUs)
- OH: 8.5% x 2026
- NY: 70% x 2030 (100% x 2040)
- MA: 35% x 2030 + 1% each year thereafter (new resources) 6.7% x 2020 (existing resources) (80% x 2050)
- RI: 38.5% x 2035; 100% x 2030 Goal
- CT: 40% x 2030; (100% x 2040)
- NJ: 50% x 2030; (100% x 2050)
- PA: 18% x 2021†
- DE: 25% x 2026†
- MD: 50% x 2030
- DC: 100% x 2032

* Extra credit for solar or customer-sited renewables
† Includes non-renewable alternative resources
RPS Success, To Date

Source: Renewable Portfolio Standards Status Reports, 2010-2019, PUC
Additional Policy Tools: A Carbon Tax

1. State of Hawai‘i introduces a carbon tax charging fossil fuel imports for each ton of carbon they pollute.

2. Industries increase the price of polluting goods to compensate for the increased cost.

3. Low-GHG products become relatively cheaper as they are not subject to the tax.

4. Consumers prefer to buy low-GHG products, reducing household GHG emissions.

5. Industries and utilities have financial incentive to reduce GHG emissions.

6. GHG emissions fall in both homes and industry.

Source: Carbon Pricing Assessment for Hawai‘i. https://energy.hawaii.gov/carbon-pricing-study
## Two Carbon Tax Levels ($2012/MT CO₂ Eq.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Low Tax</th>
<th>High Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>2025</td>
<td>$50</td>
<td>$240</td>
</tr>
<tr>
<td>2030</td>
<td>$54</td>
<td>$430</td>
</tr>
<tr>
<td>2035</td>
<td>$60</td>
<td>$620</td>
</tr>
<tr>
<td>2040</td>
<td>$65</td>
<td>$810</td>
</tr>
<tr>
<td>2045</td>
<td>$70</td>
<td>$1,000</td>
</tr>
</tbody>
</table>

$70/MT CO₂ Eq. ~ $0.65/gallon of gasoline  
$1000/MT CO₂ Eq. ~ $9.00/gallon of gasoline

Source: Carbon Pricing Assessment for Hawai‘i. https://energy.hawaii.gov/carbon-pricing-study
Total GHG

Source: Carbon Pricing Assessment for Hawai‘i. https://energy.hawaii.gov/carbon-pricing-study

Total Output
A Way to Support an Equitable Green Transition

Charge a fee on fossil fuels.

Options for Revenue Use

Allocate the revenue to the State's general budget.

Return the revenue to households as direct transfers.

Percentage Change from Baseline

- $70/MT CO2 Eq.
- $1000/MT CO2 Eq.
- $70/MT CO2 Eq. - dividend
- $1000/MT CO2 Eq. - dividend

Average Household Income in Each Quintile
Climate Action At-A-Glance

This Climate Action Plan (CAP) presents 9 climate strategies and 46 actions for the City to pursue in the next 5 years to substantially reduce GHG emissions from ground transportation, electricity and waste sectors — a reduction of 44% by 2025 relative to 2015, an additional 16% relative to an estimated baseline. This CAP focuses on City actions over the next five years at a magnitude in line with reductions needed to reach the ultimate goal of carbon neutrality by 2045.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Encourage Density and Mixed Land Use In Strategic Areas</td>
</tr>
<tr>
<td>2</td>
<td>Enable and Provide Multiple Modes of Green Transportation</td>
</tr>
<tr>
<td>3</td>
<td>Encourage Mode Shift through Parking Efficiency</td>
</tr>
<tr>
<td>4</td>
<td>Electrify the City Fleet and Support High Efficiency Vehicles</td>
</tr>
<tr>
<td>5</td>
<td>Reduce Energy Demand by Increasing Energy Efficiency</td>
</tr>
<tr>
<td>6</td>
<td>Maximize Energy Efficiency and Renewable Energy throughout City Operations and Assets</td>
</tr>
<tr>
<td>7</td>
<td>Expand Renewable Energy Planning and Expedite Permitting</td>
</tr>
<tr>
<td>8</td>
<td>Promote Waste Prevention</td>
</tr>
<tr>
<td>9</td>
<td>Maximize Waste Resource Efficiency</td>
</tr>
</tbody>
</table>

Source: O‘ahu Climate Action Plan. resilienttoahu.org
Hawai‘i’s mayors commit to shared goal of 100 percent renewable ground transportation by 2045

Honolulu Mayor Kirk Caldwell was joined by Maui Mayor Alan Arakawa, Kaua‘i County Mayor Bernard Carvalho, Hawai‘i County Managing Director Wili Okabe, Honolulu City Councilmember Joey Manahan, Master Navigator Nainoa Thompson, and students of Kamale‘o Academy aboard the Hōkūle‘a in Pōka‘i‘i Bay Tuesday. Each of the county representatives signed respective proclamations committing to transform Hawai‘i’s public and private ground transportation to 100 percent renewable fuel sources by 2045.

Figure 7: Illustrative GHG Emissions Pathways for Passenger Cars and Trucks

Figure 8: GHG Emissions Pathways for Heavy Duty Vehicles

Source: O‘ahu Climate Action Plan. resilienttoahu.org
Figure 5: O‘ahu Island-wide GHG Emissions Projections to 2045

Source: O‘ahu Climate Action Plan. resilientoahu.org
Key Takeaways

• Hawai‘i’s GHG emissions are primarily from the energy sector.
• Electricity sector emissions are declining, and continued progress depends on realization of both decentralized and large-scale renewable energy projects.
  – Land and community-impacts of large-scale projects must be addressed and mitigated proactively.
  – The RPS can be a strong policy tool to reduce GHGs, but lacks the ability to be economy-wide.
• The most efficient economy-wide GHG reduction tool is to directly price carbon.
  – Giving monies back to people can make this a more equitable approach.
• There are complementary roles for multiple levels of government – Federal, State and Municipal.
Figure 3: Comparison of 2016 Per Capita GHG Emissions

O‘ahu’s per capita GHG emissions are more than twice the global average.

Source: O‘ahu Climate Action Plan. resilienttoahu.org
“Adaptation is fundamentally about our ... Security, Well-being, Identity, Self-determination, Human rights ... Survival.”

- Former Chief Secretary of RMI, Ben Graham (2019), National Climate Change Dialogue in Ebeye
Figure 4: CAP GHG Emissions Baseline and CAP-Pathway Projections

Source: DRAFT O‘ahu Climate Action Plan. resilientoahu.org
Figure 10: GHG Emissions Pathways for the Electric Sector

Source: DRAFT O‘ahu Climate Action Plan. resilientoahu.org
U.S. Conference of Mayors Climate Protection Agreement

Source: http://www.mayors.org/climateprotection/map.asp
no wind turbines no regrets

ILWU 142 supports renewable energy
Wind Power to keep Lanai green
U.S. Formally Begins To Leave The Paris Climate Agreement

November 4, 2019 · 3:46 PM ET
Heard on All Things Considered

Source:

Source: http://time.com/5171805/paris-agreement-united-states-david-banks/