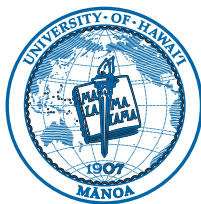**Energy and Greenhouse Gas Solutions**
Targeting Hawai'i Greenhouse Gas Emissions Reductions:
Emission Forecasts for 2020 and Their Implications for Act 234

2009

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Executive Summary

- Act 234 calls for the state of Hawaiʻi to return its greenhouse gas (GHG) emissions to 1990 levels by 2020.
- Under a business as usual environment, we forecast Hawai'i's 2020 emissions to be between 18 and 34 percent above 1990 levels.
- Since transportation and electricity account for about 75 percent of Hawai'i's GHG emissions, most likely a large share of the reductions will need to come from these sectors for Hawai'i' to comply with Act 234.

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Introduction

Act 234 calls for the state of Hawai'i to return its greenhouse gas (GHG) emissions to 1990 levels by 2020. Understanding the implications of this act requires sound estimates of what Hawai'i's 2020 emissions might be in the absence of Act 234. We use the latest emissions data and economic growth projections from University of Hawai'i Economic Research Organization (UHERO) and the U.S. Energy Information Agency (EIA) to develop alternative projections for business as usual (BAU) GHG emissions for 2020. We also quantify the emissions reductions required to meet Act 234 statutory targets.

The projections in this paper build on Hawaii GHG emissions estimates for 2005, as reported in "Hawai'i Greenhouse Gas Emissions Profile 1990 and 2005."[1] The UHERO GHG inventory includes emissions from energy and non-energy sources. Because of the great uncertainty with carbon sequestration (e.g. forestry related sequestration), the inventory omits these numbers. The emissions inventory reported in this paper includes emissions covered by Act 234 as well as emissions from air transport and all marine activities.

Using the economic forecasts from the (UHERO) and the U.S. Energy Information Agency (EIA), we project the 2005 emissions inventory forward to 2020. Our BAU projections assume that no greenhouse gas abatement policy is in place, but we do assume all other energy related laws on the books today remain in place through 2020 (e.g., Hawaii's Renewable Portfolio Standard (RPS) requirements and Federal CAFE standards).[2] The difference between the projected emissions in 2020 and the 1990 inventory yields the emission reductions that will need to take place if the State is to comply with Act 234.

Emissions are sensitive to a number of assumptions:
1. Overall economic growth rate for Hawai'i;
2. Growth rate by sector or how the economy evolves over time whether moving toward or away from energy intensive activities;
3. Autonomous energy efficiency improvement, which represents how energy efficiency improves outside of changes in energy prices or government policies; and
4. Future government or company policies (e.g., Energy Policy Act of 2007 and HECO's IRP-4).

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[1] *"Hawai'i Greenhouse Gas Emissions Profile 1990 and 2005,"* Energy and Greenhouse Gas Solutions, UHERO, Jan. 2009.

[2] Since the plans for the Hawaii Clean Energy Initiative are not concrete and because it is an agreement rather than law, we do not include any of its agreements in our forecast. As these agreements become law or become more concrete, we will update our forecasts to reflect these changes.

Development of Forecasts

We developed two different forecasts – one based on UHERO's economic growth rate for Hawai'i and one based on the Energy Information Agency's economic growth rate for the country as a whole. UHERO forecasts the Hawai'i economy to grow at an average annual rate of 1.6% per year; whereas the EIA forecasts the US economy to grow by 2.5% per year from 2005 to 2020. We first construct a forecast based on UHERO's forecast for all sectors except electricity, and HECO's most recent Integrated Resource Plan for electricity demand forecasts. The EIA-based forecast is then constructed from the UHERO-based forecast by scaling up the UHERO economic forecast by the ratio of the EIA's 2008 Annual Energy Outlook's US GDP forecast to UHERO's forecast of Hawai'i's gross state product (GSP).

The UHERO model was used to obtain an overall economic growth rate for the economy and growth rates by sectors. The UHERO forecast is derived from an econometric model that estimates key sources of growth for Hawai'i's economy. Visitor arrivals and expenditures are estimated on the basis of variables such as the GDP of the origin country, the relative cost of a Hawai'i vacation, exchange rates, and supply constraint factors such as the occupancy rate. The length of stay was then determined based on autoregressive integrate moving average (ARIMA) models that assumed that deviations from recent average length of stay are transitory. Visitor spending was based on the application of daily average person levels of spending, broken into two categories – lodging and all other expenditures. UHERO population projections utilize the cohort component method. This method is used by the US Social Security Administration and the US Census Bureau. The population projections from the UHERO demographic model have been integrated into the UHERO long-range forecasting model. UHERO also forecasts of growth in federal government expenditures, both military and civilian, construction, and other key drivers of Hawai'i's economy.

The sectoral growth rates explain how the output of each sector grows in terms of the value of output; however, these rates do not indicate how energy usage grows in each sector. Historically, economy-wide energy usage has grown at a slower rate than the overall economic growth rate because with technological advances, efficiency improves and less energy is required to produce a dollar of output. For most of the economy, we used the EIA's estimates for how energy usage would grow relative to economic output to convert the growth rate in Hawai'i's economic output to a growth rate in energy usage by these sectors. The Annual Energy Outlook (AEO 08) forecasts an autonomous energy efficiency improvement (AEEI) of 1.8% per year for the US from 2008 to 2030.[3]

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[3] This is a bit lower than the historical average from 2002 to 2007 of 2.15% per year as energy prices were rising. Going back further, one finds the AEEI from 1960-1999 averaged about 1.1%, and the average during the high oil prices of 1974-1985 averaged about 3%.

For three sectors, we deviate from this economy-wide AEEI to apply some outside knowledge. For light-duty vehicles, we assume that the implementation of the Energy Policy Act will improve light-duty vehicles fuel economy. The Energy Policy Act of 2007 raises the CAFE standard from today's level of 27.5 mpg to 35 mpg by 2020. Because of the uncertainty in vehicle fleet turnover and amount of vehicle efficiency improvement that will occur over time, we considered two cases. The more optimistic case assumed that the entire vehicle fleet in 2020 would emit 23% (1-27.5 mpg/35 mpg) less than Hawai`i's current fleet. The other case assumes that an efficiency improvement of only half as much namely 11.5%. This optimistic assumption is used for the forecast derived using UHERO growth rate assumption, and the lower efficiency improvement case is employed in the forecast derived using EIA's growth assumption.

For air transport, we assume some level of continued turnover of inefficient fleet based on historical numbers. Specifically, the efficiency improvement in air transport is assumed to be half as great as the efficiency improvement from 1990 to 2005. This leads to an energy intensity improvement of about 15% from 2005 to 2020.

Multiplying these efficiency improvements by the growth rates yields the growth in energy usage, and, hence, carbon emissions. Table 1 shows the two different carbon emission forecasts for Hawai`i in 2020: UHERO, which is based on UHERO's economic forecast; and EIA, which scales up the UHERO forecast in all sectors so that the overall economic growth equals that of the AEO 08 for the US.

For the electricity sector, emissions are computed by first taking the demand estimates from the four major utilities (HECO, MECO, HELCO, and KIUC). Then, it is assumed that together they exactly meet the 20% RPS mandate. Of the 80% of generation that is not from renewables, most comes from oil-fired units and the remainder from the burning of coal at the AES facility on Oahu and the HC&S sugar refinery on Maui. We assume coal-fired generation stays at the same level as today since expansion would likely be difficult given the concern about carbon emissions. Therefore, oil-fired generation fills in the remainder of the total generation after subtracting out the coal-fired and renewable generation. Emissions from the coal-fired generation are known from historical data. The emissions from the oil-fired units are computed by multiplying the generation from oil-fired units by an average heat rate to arrive at oil consumption. Then we multiply the average emissions factor for petroleum products by oil consumption to compute emissions from this generation.

Table 1 Emissions forecast under different economic growth rate assumptions

	(Million Metric Tons CO2e)				Reduction to Return to 1990	
By Fuels	**1990**	**2005**	**2020**		**(%)**	**(%)**
			UHERO	**EIA**	**UHERO**	**EIA**
Coal	0.1	1.5	1.5	1.5	95%	95%
Petroleum Products	13.5	14.9	14.4	16.5	6%	18%
LPG	0.4	0.4	0.4	0.4	7%	14%
Total	**14.0**	**16.7**	**16.3**	**18.4**	**14%**	**24%**
By Sectors	**1990**	**2005**	**2020**	**2020**		
Com. + Ind. + Res.	3.4	2.5	2.3	2.5	-47%	-34%
Transportation	13.1	13.3	15.0	17.8	13%	27%
Air	7.5	6.0	7.5	8.6	0%	12%
Ground-LDV	3.1	4.6	4.8	6.2	35%	50%
Ground-Other	0.6	1.0	1.0	1.1	43%	48%
Marine In State	0.1	0.3	0.3	0.3	46%	51%
Marine Out of State	1.8	1.5	1.5	1.6	-18%	-8%
Electric Power	6.8	8.4	8.0	8.3	15%	18%
Non-Energy	1.5	2.3	2.1	2.4	30%	37%
Total w/o Air	**15.5**	**19.0**	**18.4**	**20.8**	**16%**	**26%**
Total	**24.7**	**26.4**	**27.4**	**31.0**	**10%**	**20%**

Table 1 displays historic emissions for 1990 and 2005 as well as the two forecasts and the required percentage reduction from these forecasts to attain 1990 emission levels. 1990 historical emissions are displayed because Act 234 calls for a return to these emission levels. The 2005 emission levels are displayed because this is the final year in the UHERO emission inventory. In addition, proposed Federal policies have used 2005 as the basis for emission targets. For example, the recently released Boucher-Dingell Draft Bill calls for the US to reduce emissions to 6% below 2005 levels by 2020.

The table divides emissions by fuel type and by sector. In terms of fuel type, emissions predominantly come from petroleum products. The remaining roughly 10% of energy-related carbon emissions come predominantly from coal-fired generation (around 75%) with the remaining amount from LPG.

When looking at emissions by sector, the combination of residential, industrial, and commercial accounts for about 9% and 13% of all 2005 GHG emissions and Act 234 covered 2005 emissions, respectively. These emissions cover direct non-transportation combustion of fossil fuels. For example in the residential sector, these emissions come primarily from the burning of synthetic gas for heating water and direct combustion for cooking.

When combined, transportation and electricity sectors are responsible for about 82% and 75% of all 2005 GHG emissions and Act 234 emissions, respectively. But other sectors are directly or indirectly responsible for these emissions through their demand for these services. The table breaks transportation into ground, and marine. Ground transportation is further divided into transportation from light duty vehicles and all other vehicles. Emissions from electricity generation come from either coal or oil-fired generation. In fact almost all emissions due to coal come from electricity generation.

Emissions from non-energy related activities (e.g. agriculture, waste and wastewaster treatment) make up the remaining emissions in Table 1. These emissions account for about 8.5% and 12% of all 2005 GHG emissions and Act 234 emissions, respectively.

Total emissions are expressed with and without emissions from air transport because Act 234 exempts emissions from this source. However to understand Hawai'i's total emissions profile and to better understand the consequences of national legislation, which may include emissions from air transport, total emissions including those from air transport are computed and displayed.

Implications For Meeting Act 234

The issue at hand is what these forecasts imply for Hawai'i's ability to comply with Act 234. The two columns that report the percentage reduction to return to 1990 levels provide some insight into this issue. If the economy grows at an average rate of 1.6% per year and energy efficiency improvements can be made as forecast, then Hawai'i would only need to find an additional 16% of reductions to return to its emissions to 1990 levels. If, however, Hawai'i's economy grows at a rate closer to the US average predicted by the EIA, then Hawai'i would need to reduce its emissions by 26% from the forecast to comply with Act 234.[4]

With transportation and electricity being responsible for the largest shares of GHG emissions, Hawaii could effectively comply with Act 234 by reducing fossil fuel use in these sectors.   Reductions will need to come from other sectors, but a large share of the reduction is likely to come from these two sectors. Reductions in these sectors could come about in many ways: conservation, increased energy efficiency, or changes in technology choices. In terms of vehicle transportation, this could mean using mass transit or walking instead of driving, driving more fuel efficient vehicles, or using alternative fueled vehicles (e.g., hybrid or plug-in hybrid electric vehicles). For the

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[4] If Hawai'i abandoned Act 234 and Boucher-Dingell became law assuming air transport emissions are not covered, then under UHERO's forecast, Hawai'i would be in compliance without any further reductions, and under the EIA forecast, Hawai'i would need to reduce emissions by 10%. If air transport emissions were covered, then Boucher-Dingell would require reductions of 7% and 20% under the UHERO and EIA forecasts, respectively. In either case, Boucher-Dingell would be less stringent for Hawai'i than Act 234.

electricity sector, the same categories for reductions are available: conservation (e.g., households running A/C less or at higher temperatures), increased energy efficiency through improving the heat rate at certain generating units and improving the efficiency of things that use electricity, and replacing fossil-fired generation with renewable fuel-powered generation.

Emission Reduction Scenarios

What level of reductions are needed from these two sectors? We consider a scenario with three changes from the original assumptions behind the emissions forecast of Table 1:

1. There is a 20% reduction in emissions from light-duty vehicles. The reductions in LDVs could come from reduced driving, driving more fuel efficient vehicles, or driving alternative fueled vehicles (e.g., PHEVs) or all of these.
2. Emissions from oil-fired generation are cut by one-third. This reduction could occur through a significant conversion of oil-fired generating units to biofuel-fired units. Some of this reduction could occur through increases in generation efficiency, increase in renewable generation such as wind, or conservation (e.g., increased DSM programs).
3. Assume continued reductions in emissions from air transport consistent with the improvements made from 1990 to 2005 is also included in this scenario.

Table 2 reports the results of this emissions forecast under the UHERO assumed growth rate and the EIA growth rate.

Table 2 Reference and alternative forecasts for Hawai'i's 2020 CO2 emissions covered under Act 234 (Millions of metric tons of CO2)

		(Million Metric Tons CO2e)			
	History	Reference Forecast		Improved Ele Red VMT	
		UHERO	EIA	UHERO	EIA
By Fuels	**1990**	**2020**	**2020**	**2020**	**2020**
Coal	0.1	1.5	1.5	1.5	1.5
Petroleum Products	13.5	14.4	16.5	11.3	13.4
Natural Gas	0.4	0.4	0.4	0.4	0.4
Total	**14.0**	**16.3**	**18.4**	**13.2**	**15.4**
By Sectors	**1990**	**2020**	**2020**	**2020**	**2020**
Com. + Ind. + Res.	3.4	2.3	2.5	2.3	2.5
Transportation	3.8	6.0	7.6	5.1	6.4
Ground-LDV	3.1	4.8	6.2	3.8	5.0
Ground-Other	0.6	1.0	1.1	1.0	1.1
Marine In State	0.1	0.3	0.3	0.3	0.3
Electric Power	6.8	8.0	8.3	5.8	6.5
Non-Energy	1.5	2.1	2.4	2.1	2.4
Total w/o Air	**15.5**	**18.4**	**20.8**	**15.4**	**17.7**

Under the UHERO assumption of economic growth, this idealistic policy would induce enough reductions for the state to comply with Act 234; but under EIA's assumed economic growth rate, an additional 2.2 million metric tons of GHG emissions would need to be cut. This simple example illustrates the great uncertainty involved in policy design and compliance. In addition, this scenario analysis says nothing about the costs to achieve these reductions, and therefore, the scenario is silent on how these reductions will be achieved in each sector and what share of the reductions will occur in each sector. Furthermore, this simple analysis provides limited insight into the origin of additional emission reductions if these policies fail to bring about the needed reductions.

Further analysis using sophisticated economic models must be undertaken to estimate the costs and emission reductions for various policies. Costs would certainly accompany any significant reduction in emissions as people and companies must be motivated to change their current behaviors and industries must be motivated to produce more efficient technologies. Economic analysis can be used to help determine the best set of policies to induce the needed emissions reductions so that Hawai'i will comply with Act 234. This type of analysis would help identify from which sector emissions can most cost-effectively be reduced. At the heart of such analysis would be a comparison of the cost-effectiveness of market-based policies against command-and-control type policies and the distributional impacts of these policies among types of industries and households. Furthermore, the analysis would suggest how the emission reductions might come about – conservation, increased efficiency, or new technologies – which provide further insights on policy design.

UHERO EGGS Executive Sponsors

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Energy and Greenhouse Gas Solutions (EGGS) seeks to provide economic solutions to climate change in Hawai'i. We combine a careful understanding of local conditions with frontier economic modeling and analysis to offer solutions that work for Hawai'i's people and environment. EGGS is an initiative of the University of Hawai'i Economic Research Organization (UHERO).

For more information, please visit **http://www.uhero.hawaii.edu/eggs**

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