Summary Report on Stakeholder Workshop

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Summary Report on Stakeholder Workshop

By

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GE Global Research

Hawaii Roadmap Phase 2

Strategic Energy Roadmap for the Big Island of Hawaii

A Presentation of the Transportation and Electricity Modeling Analysis and Results,
and
A Summary of the inputs and outcomes of the Stakeholder Summit

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Background

Hawaii must make decisions about its energy future. Ideally, energy should be abundant, reliable, affordable, environmentally friendly, emissions-free and petroleum-independent. However, these characteristics really represent trade-offs; for example, a highly reliable system costs more, and a balance must be struck between the costs of increasing the reliability of energy supply versus the costs (economic, social, and public health and safety) of not having energy when it is needed. Deciding on this balance is critical for the State. Such a debate depends upon having accurate assessments of the effects of energy technology, policy, and design choices. New technologies in renewable energy, energy use, energy conversion, transmission, and storage offer opportunities to provide clean, reliable, and secure energy for Hawaii at less cost. ***The purpose of the Hawaii Energy Roadmapping Study is to provide Hawaii with the capability of objectively evaluating its energy options and their true costs and environmental consequences***.

The Hawaii Energy Roadmapping Study is an evaluation of the Big Island's future electricity and transportation energy options with respect to local goals and future world conditions from a technology-neutral perspective. The US Department of Energy (DOE), the Hawaii Natural Energy Institute (HNEI), The General Electric Company (GE), and the Hawaiian Electric company (HECO) and its subsidiary the Hawaii Electric Light Company (HELCO) have collectively provided ~$1.5M over a two-year period to fund the first two phases of this study.

Transportation and Electricity Modeling

In Phase 1, the study developed an evaluation process that can effectively assess energy technologies and serve as guide to the development of energy policies. In Phase 2, the process of evaluating various energy infrastructure evolution scenarios will be used to identify programs that have the potential to address Hawaii's need for an affordable, reliable, environmentally acceptable, petroleum-minimizing energy sector.

The Electric System model consists of a *production cost* and *transient performance* model. The *production cost model* is used to help make decisions about which generators should be used to produce electricity in each hour of the day, based on the HELCO system constraints. This model provides information about the variable cost of production, emissions and other operating characteristics. The *transient performance model* is used to understand the impact of transient operation of different generators on system frequency in a seconds timeframe. Both of these models have been validated against 2006 historical conditions and deemed acceptable as a starting point for infrastructure evolution scenarios.

The Transportation Model has been developed and validated against the data provided in the 2005 Hawaii Databook. The transportation fleet, fuel type and vehicle type breakdown were used in conjunction with fuel demand forecasts, fuel price projections, emissions data, and land use information to evaluate economic, environmental, and sustainability metrics. Presentations of the Transportation and Electricity model results are shown in the Appendix. A flow diagram of each model is shown in Figure 1.

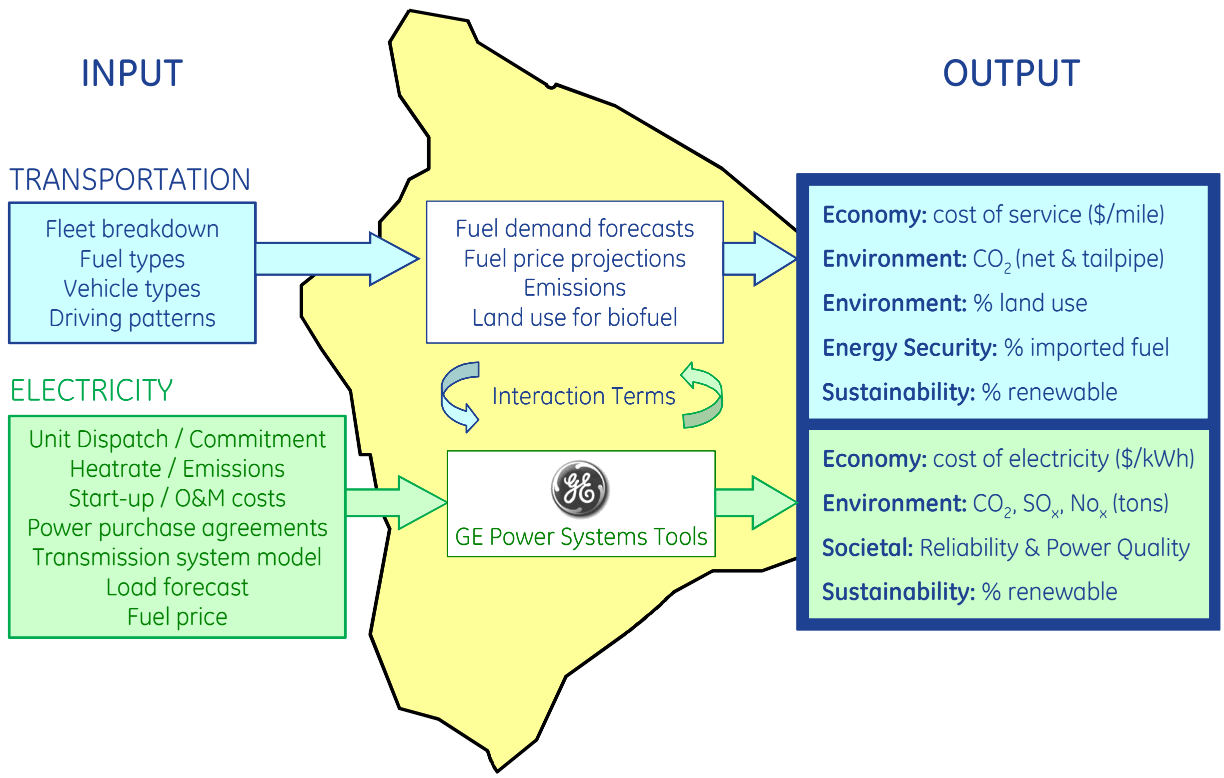


Figure 1: Hawaii Energy Roadmapping Models

It is envisioned that this validated, technology-neutral scenario evaluation tool can be used by policy makers – Local, State and Federal – to give insights and directional estimates of some of the effects of adopting candidate policies or technology strategies. The value of this is to inform discussions on the State's energy roadmap by more accurately determining the effects of energy choices on the supporting infrastructure required and the system performance metrics. Stakeholders identified the relevant metrics during a series of interviews in April and May. A presentation of the results of the stakeholder interviews is provided in the Appendix.

The complexity of energy planning can be demonstrated, as the metrics (cost, environment, reliability, oil independence, public health and safety, economic development, etc.) are often mutually competitive (increasing one metric may require decreasing the others to some extent). While tradeoffs among metrics are to a large extent a policy issue, there are also technical issues. For example, incorporation of as-available energy sources beyond a certain level can be shown to lead to unacceptable levels of system stability and energy availability unless technical mitigating measures are adopted.

Stakeholder Summit

Based on the results of the electric and transportation simulation models and the concerns, preferences and suggestions expressed by the stakeholders during our interviews with them, the project team developed tools to evaluate proposed energy policies and projects in terms meaningful to Hawaii. The Stakeholder Summit was an opportunity to present the results of this initial phase of the project, to explain how we intend to apply what has been learned, and to solicit further input from the diverse interests Hawaii's energy sector must serve. The objectives of the workshop were:

1. To present the capabilities of the energy sector models developed and the metrics to be used to evaluate energy development options.
2. To enable local (county), State and Federal policy makers to explain how they envision using this energy policy/project assessment methodology.
3. To present candidate "scenarios" that we suggest using the models to evaluate in order to exercise the models' capabilities and to provide insight into which strategies would best meet the common objectives of Hawaii's citizens.
4. To try to identify potential technologies or projects that improve Hawaii's energy sector based on a consensus among a diverse group of stakeholders.
5. Finally, to obtain additional broad-based inputs on the above four items and suggestions on how governments, utilities, businesses, consumer and business groups and other organizations could advance our common interests.

An oft-repeated theme during our interviews with Hawaii stakeholders earlier this year was their desire to find ways for utilities, consumers, businesses and environmental groups to cooperate, as partners rather than adversaries, to promote clean and affordable sources of energy in the State. Traditional historical roles, business strategies, and policy positions were not seen as the best ways to address Hawaii's energy issues and, as a result, were seen as also being potentially counter-productive to each stakeholder's achieving its own individual goals. This project hopes to foster constructive dialog and debate on Hawaii's energy choices and, by doing so, to expedite actions, policies or projects that can be chosen by consensus to promote the general good.

Summit Results

The Department of Business, Economic Development & Tourism (DBEDT), Hawaiian Electric Company (HECO), Hawaii Electric Light Company (HELCO), and many other stakeholders assembled on September 27, 2007 at the Marriott Waikoloa, on the Big Island of Hawaii. (A complete list of attendees is provided in the Appendix.) The key stakeholders were given the opportunity to make introductory statements. In the morning session, the transportation and electricity model results were presented, as well as the results of the stakeholder meetings and the scenarios chosen for this second phase of the project. These presentations are provided in the Appendix. In the afternoon session, stakeholders were asked to offer their inputs, advice and suggestions to the project team. Stakeholders offered comments on the overall project strategy and direction for future scenario evaluation. The following paragraphs represent a general summary of the Summit.

HECO/HELCO were generally pleased with the level of detail of the model results and hope the model can be used to inform policymakers of tradeoffs in the electricity sector. The accuracy of the results of the model validation effort exceeded HECO's expectation, and HECO is looking forward to continued cooperation with the project team. HELCO would like to continue cooperating with the project team, especially since using the validated models could predict the efficacy of some of the system design, resource investment, and operating measure changes HELCO is considering in its on-going efforts to improve the electric system on the Big Island. There was general agreement that the high resolution of this tool warrants attention from the federal policymakers.

The State expressed a desire to continue the GE/HNEI/HECO/HELCO partnership and to further develop and apply the tools to help State policymakers identify and quantify tradeoffs. There was general agreement among the stakeholders present that the electric power model can provide answers to some of the questions the State is grappling with concerning various energy technologies, tariff and power purchase regulations, system performance metrics, and other policies. The State recognizes there are legitimate additional costs associated with connecting large amounts of wind generation to the grid (spinning reserve and/or the potential for using other technologies to mitigate intermittency). This model should be used to quantify and communicate that impact to policymakers, understanding the current program is not funded to exhaustively do this. The State is urgently trying to develop solutions to achieve lower energy prices in a world dominated by rising oil prices.

In Phase 2, for each scenario, the analysis will provide quantitative observations about the impacts of specific technology deployments on emissions, variable costs, etc. While the models will not be used for detailed system design and engineering (e.g., each contingency and fault scenario cannot be considered), and the study is not designed to maximize or minimize a specific goal, the models will be used to provide directionally correct information about the impact of technology choices on the economic/environmental metrics. The study cannot be exhaustive and is not intended to replace the HELCO IRP process. The project team must continue to be clear about communicating the capabilities and limitations of the model. (For example, the production cost model is capturing the variable cost of electricity production resulting from different technology deployments. It does not consider the capital costs, lifetime of equipment, rates of return, etc., although those can be separately estimated and incorporated in the assessment.)

The following list represents some of the stakeholder **opinions/comments** from the Summit:

- The model should be used to identify solutions rather than analyze problems.
- The terms of existing power purchase agreements (PPA) have locked the Island into high prices for wind power. Going forward, the terms of new PPAs must change if the island is to achieve a cost-effective renewable energy supply. It is possible that competitive bidding will reduce the prices paid to renewable IPPs in the future.
- Potential wind intermittency mitigation measures, in addition to electric energy storage, include better spillage of wind at the windfarm by the wind developer, or the use of hydro to provide the quick response needed when wind power suddenly declines. Forecasting and improved generator controls may be more cost effective than a strategy incorporating only energy storage.
- If a biofuels industry emerges there can be competition for the commodity between the transportation and electricity sectors on the Big Island.
- The increased energy security (i.e., high use of renewable energy from a very diversified technology base) should incorporate significant amounts of conservation, ocean thermal energy conversion, seawater cooling, and wave power. Such an approach satisfies the energy objectives of the island. Technology immaturity and initial high cost are two reasons high penetrations of ocean-based renewable energy technologies may not be realized by 2018.

The following bullet list represents some of the stakeholder's **suggestions** provided at the Summit. The responses are summarized in italics:

- The project team will need to identify whether the suggested technology deployments in 2018 for each scenario are achievable. *This is a necessary step to ensure the scenarios are grounded in reality.*
- A request was made to include distributed generation in the "enhanced energy management" scenario. *Distributed technologies will represent an important part of this scenario.*
- A request was made to identify and quantify the cost savings of retiring old equipment. *Because this type of analysis must be exhaustive and will require significant input from the utility, the current program is not able to provide this analysis as part of Phase 2. However, this analysis could form the basis of program activities in future portions of the program.*
- A request was made to examine the impact of revising existing/future PPAs. *Due to the parametric nature of the model, sensitivities (such as changes in the PPAs) can be considered for a scenario.*
- It was noted that the model did not consider the impacts of supply interruption on business. *Since the model is technical in nature, the model alone cannot capture these*

impacts, nor can it capture subjective factors, such as aesthetics and cultural impacts of certain technologies.

- HELCO sees great benefit in understanding how much spinning reserve will be needed for additional increments of wind power. *Though this study is not exhaustive, the project team hopes to provide "directionally correct" insight into the effects of spinning reserve on additional increments of wind power.*
- HECO showed an interest in analyzing how demand side management and critical peak pricing can be a surrogate for spinning reserve. *Demand side management will be an important component of the energy management scenario.*
- The State showed an interest in understanding the impact of moderating demand and shifting demand from daytime to nighttime in the energy management scenario. *This type of analysis can be considered in the energy management scenario.*
- Natural gas can be used as a storage option to increase the island's energy security. *The storage of energy commodities, such as natural gas, has not been considered. Additional information about the impact of storage on the price of this and other commodities would be required for this analysis.*
- The stakeholders inquired about the feasibility of adding more wind power to the island. *While this study cannot exhaustively analyze the impact of additional wind power capacity, it can quantify the impact of increasing wind power both with and without mitigating measures.*

Conclusions

The input and time contributed by the various stakeholders was appreciated and adds value to this study. It should be noted that much of the model development was a result of close interaction and time spent with HECO/HELCO staff and management.

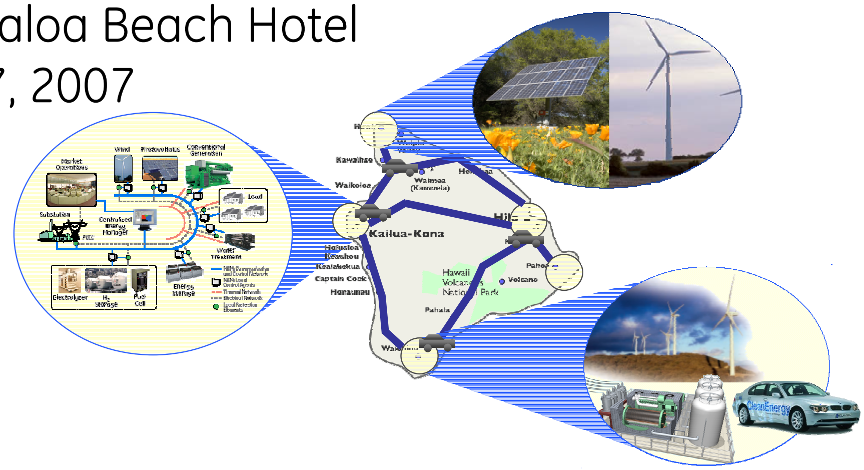
The model results were presented and accepted by the stakeholders in attendance. Based on the consolidation of stakeholder input, scenarios were outlined and presented at the Summit. With general stakeholder acceptance of the scenario themes outlined at the Summit, the project team has commenced more detailed scenario development based on the information and suggestions provided by the stakeholders.

The stakeholders widely accept the objectives of this study and welcome the development of an in-state capability to evaluate policies and to better understand the systems-level impact of various technology decisions. The Strategic Energy Roadmap study intends to create a technically rigorous framework to support this capability.

Appendices

Appendix A – Summit Introduction (Rick Rocheleau)

Big Island Energy Stakeholder Workshop
Marriott Waikaloa Beach Hotel
September 27, 2007

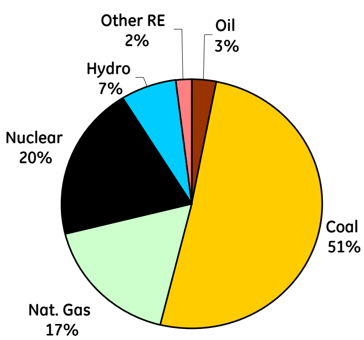


Rick Rocheleau
Director, Hawaii Natural Energy Institute

US DOE | Hawaii Natural Energy Institute | State of Hawaii | GE Global Research GE Energy | Sentech | Hawaii Electric Light Company

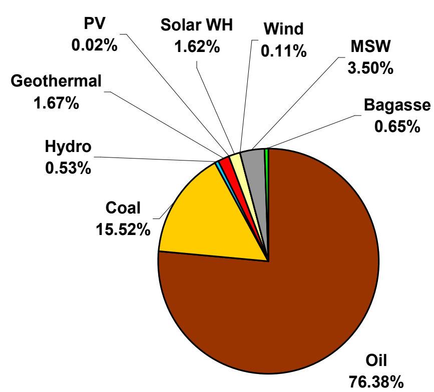
Why are we here?

United States



Source: USEIA

Hawaii



Sources: HECO and KIUC RPS Reports, FERC Form 1 or Annual Reports to PUC, and IPP reports to US EIA

Hawaii needs affordable, reliable, environmentally acceptable energy

Develop roadmap to address Hawaii's future energy needs

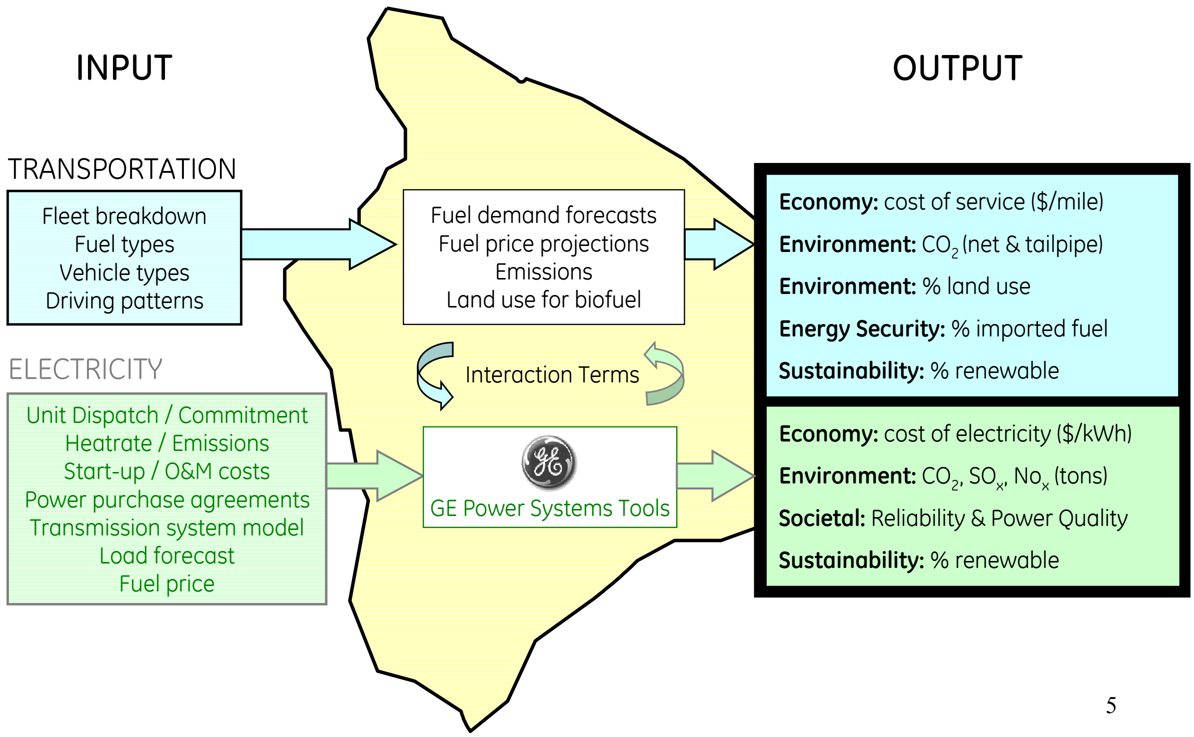
Hawaii Energy Roadmap

- What is it? An technical and economic evaluation of the Big Island's future electricity & transportation energy options with respect to local goals and potential future world conditions
- Objectives:
  - **Phase 1** - Develop an evaluation process and tools that can effectively assess economic and technological implications of various energy scenarios
  - **Phase 2** - Use this process to identify and evaluate programs to transform Big Island energy infrastructure to meet stakeholders target objectives (e.g. affordable, reliable, environmentally acceptable, etc.)
  - Future – Input to decision maker .... implementation

Hawaii Energy Resource Technologies for Energy Security

- Part of a partnership between Hawaii and New Mexico (UH and NMT)
- Objectives include to develop, demonstrate, and deploy technologies to **facilitate greater penetration of Hawaii's renewable resources** into its energy systems;
- Three tasks with Big Island Focus:
  - ***Hawaii Road-mapping – Assessment of Electrical and Transportation Infrastructure and Microgrid Applications***
  - **Research, Development and Testing of Critical DER and Microgrid Technologies at Hawaii Gateway Energy Center.**
  - **Development of Public Policy and Outreach to Accelerate DER/Microgrid Acceptance – support for Hawaii Energy Policy Forum**
- Partners include GE, HELCO, HECO, Sentech, DOE, and DBEDT.

Electricity / Transportation Models



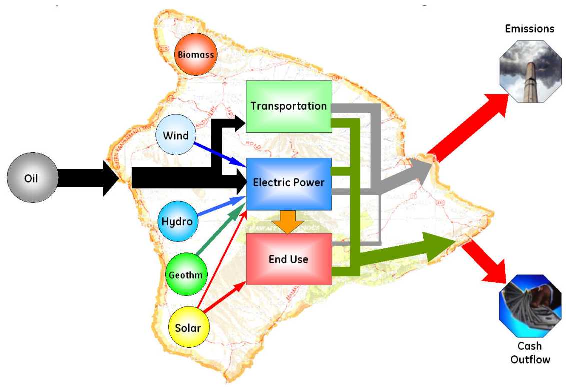
Process

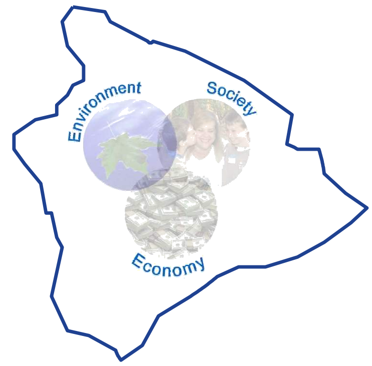
- Develop team and define common goals - HNEI, GEGRC, GE Energy Systems, HELCO, HECO, DOE, DBEDT
- Develop tools (models) that describe current transportation and energy systems of the Big Island. **Validate** models to insure acceptance by all members of the partnership
- Survey stakeholders, define needs and desires of community, and define metrics
- Identify potential future scenarios based on stakeholder input and preliminary model analysis
- *Re-engage stakeholders to insure scenarios address concerns of the stakeholders. Modify as appropriate*
- *Develop selected scenarios to identify potential (technical and economic) to help address Hawaii energy needs considering stakeholder objectives including national needs.*

Appendix B – Scenarios & Stakeholder Interview Summary (Terry Surles, Larry Markel, Devon Manz)

Hawaii Energy Roadmap

Stakeholder Input & Scenario Formulation





Terry Surles Hawaii Natural Energy Institute
Larry Markel Sentech, Inc.
Devon Manz GE Global Research

US DOE | Hawaii Natural Energy Institute | State of Hawaii | GE Global Research GE Energy | Sentech | Hawaii Electric Light Company

Stakeholder Summit

Objectives of today's meeting

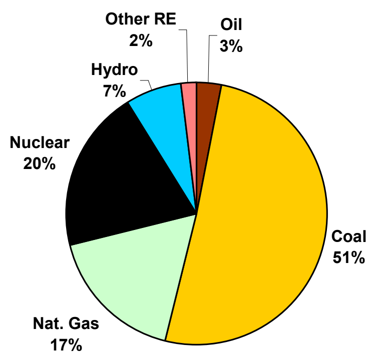
1. To **update** the assembled stakeholders:
    a. Capabilities of the **models** developed and the **metrics** used to evaluate options.
    b. To **present candidate scenarios** – developed from Stakeholder interviews
    c. Discuss how scenario strategies meet common program and stakeholder objectives
2. To enable public and private policy makers to explain how they envision using this assessment methodology
3. To obtain additional **input, advice, and suggestions** from Stakeholders on future paths for energy activities

End Result of Today's Meeting: Obtain **input, advice, and suggestions** on energy activities

1. Comments on overall project strategy and direction
   Are we on the right track, based on our earlier discussions with you?
2. Comments and direction on future scenario evaluation
   What are your thoughts on the most/least appropriate scenarios?
3. Comments and advice on additional areas to be considered
   Are we missing anything that you feel is important for the future?

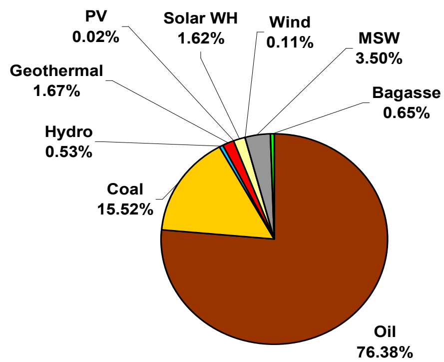
Electricity Generation by Source 2003 – Why we need to reduce petroleum dependency

United States



Source: USEIA

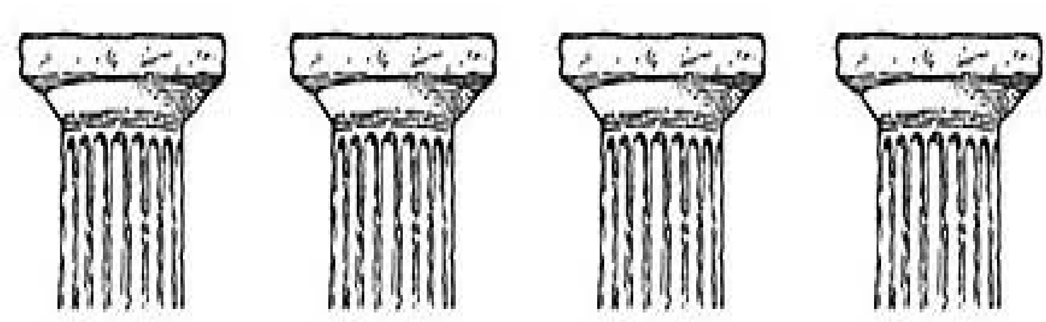
Hawaii



Sources: HECO and KIUC RPS Reports, FERC Form 1 or Annual Reports to PUC, and IPP reports to US EIA

Public-Private Partnerships Are Critical For Addressing Overarching Issues Facing the Nation’s Energy Systems

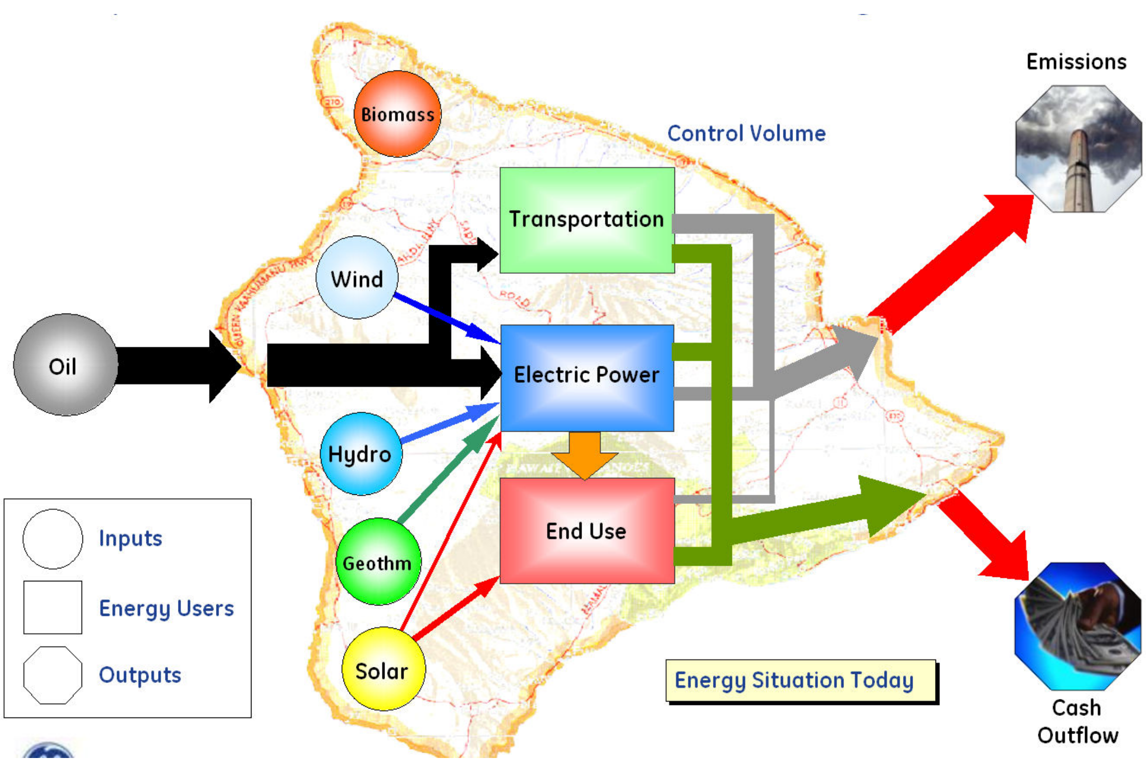
Energy System of the Future



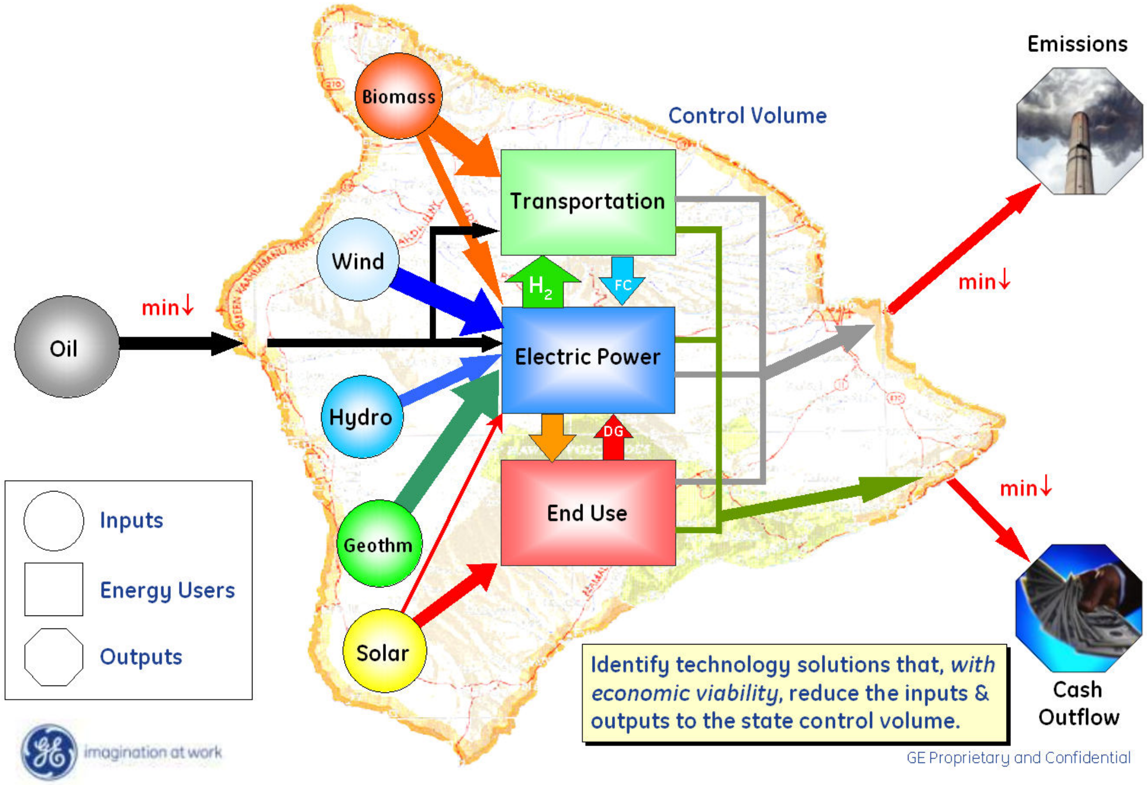
Grid Modernization | Global Climate Change | Energy Security – Transportation/Electricity | Environment Quality

None Of These Issues Can Be Resolved Without Partnerships – The Right Kind of Partnership Fosters Innovation for Hawaii

DOE and State Objectives - Sustainability

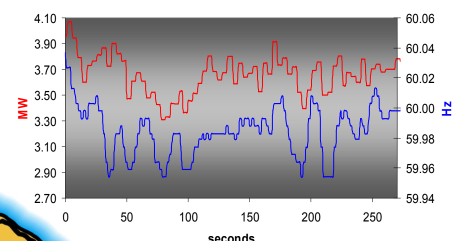


DOE and State Objectives - Sustainability

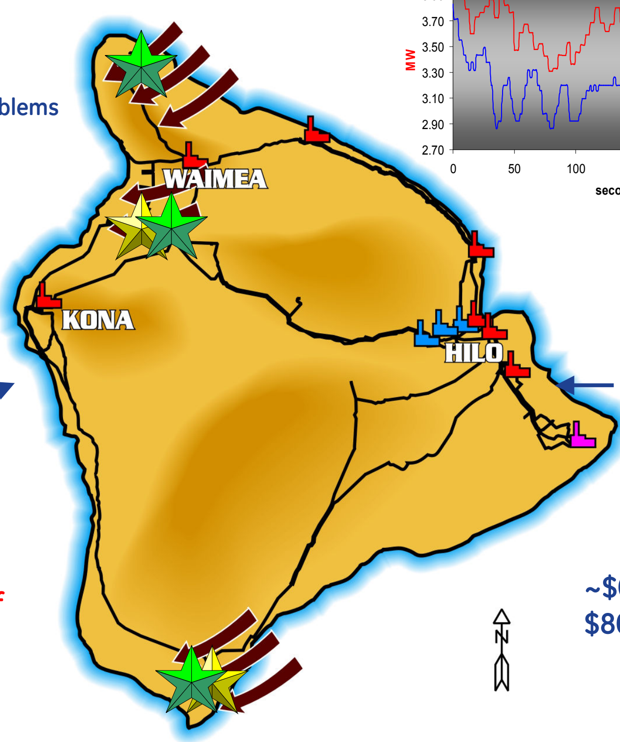


imagination at work

Big Island Challenges



Growing Use of Wind Causes Problems with Grid Frequency



Transmission Congestion

~60% of Island Load

~75% of Island Generation

High Cost/Security of Energy – 90% Dependence on oil

~$0.30/KWh, $80+/bbl oil

Phase 1
Modeling, Validating, Calibrating - Completed

Electricity and transportation sector models describe current Big Island energy system

Models have been calibrated and validated against historical data to the high degree of accuracy required to meet project objectives

Result:

- Analytical tools and baseline for technical and economic assessment of infrastructure futures
- Can be used to establish effective parameters for future growth of the Big Island
- Tools not intended for day-to-day decision making

Development of Better Planning Tools is a Goal Shared by All

Meet DOE mission needs

- Lessons and analytical tools for Mainland grids
- Incorporation of new technologies into grid

Address utility system planning needs

- Understand the implication of more renewable energy
- Mechanism for evaluating new technologies to address system impacts

Address state initiatives for customer benefits, public goods

- understand implications of RPS and other initiatives for reducing petroleum use
- Big Island as a potential showcase for renewable energy and the installation of innovative technologies

Phase 2

Energy Roadmapping – Just starting

Evaluate technical and economic impact of alternative energy infrastructure scenarios for the Big Island, starting from the base case

Scenarios developed based on stakeholder interviews

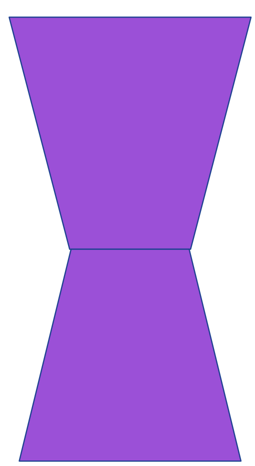
Continue collaboration with HECO/HELCO, state, and county to ensure model evolution is grounded in operational reality

Work with various stakeholders (i.e., government, end-users, IPPs, environmental and economic NGOs) to ensure concerns and opportunities are addressed

A Conceptual View of the Big Island Project

We started with an expansive view of the future

We were
need to get



constrained by the
the models right

Now, we can

think expansively again

What does this study offer?

- A calibrated and validated technical, economic **and** environmental analysis of **both** the electricity and transportation infrastructures on the Big Island.
- A methodology and tool for State policymakers and utility leaders to analyze the impacts and tradeoffs of technologies and policies.
- An in-state capability to perform further energy analyses.

The ability to quantify the environmental, economic and technical tradeoffs of energy technologies and policies in the State.

Stakeholder Engagement

1. Stakeholder Interviews

- What are your key energy-related **metrics**?
- What are your **energy goals** for 2020?
- Is 2020 an appropriate **target** for the study?
- What do you see as **key global influences**?
- What do you see as key **energy technologies**?
- What **policies** should Hawaii implement?
- What other **energy issues** concern you?

Stakeholder Interviews	Consolidation of Stakeholder Input	Identification of Themes	Scenario Development
April	May	July	September

County of Hawaii Energy Office
Bob Arrigoni
Economic Development Alliance of Hawaii
Paula Helfrich
Enterprise Honolulu
Mike Fitzgerald and John Strom
Fairmont Orchid
Ed Andrews
Hamakua Energy Partners
Joe Clarkson
Hawai'i County Council
Pete Hoffmann
Hawai'i Island Economic Development Board
Mark McGuffie
Hawaiian Electric Company, Ltd.
Karl Stahlkopf
Hawai'i Electric Light Company, Inc.
Hal Kamigaki, Chengwu Chen, Art Russell, Lisa Dangelmaier
Hawi Renewable Development
Jim Nestman, Raymond Kanehaikua
Hilton Waikoloa Village
Rudy Habelt (Director of Property Operations)
Kohala Center
Betsy Cleary-Cole (Deputy Director)
Life of the Land
Henry Curtis (Executive Director)
Office of Hawaiian Affairs
Mark Glick Yuko Chiba
Powerlight
Riley Saito
State of Hawaii, Department of Business, Economic Development & Tourism
John Tantlinger, Steve Alber, Priscilla Thompson
State of Hawaii, Public Service Commission, Division of Consumer Advocacy
Catherine Awakuni
Tesoro Hawaii Corporation
Carlos De Almeida
University of Hawaii at Manoa
Makena Coffman

3. Identification of Themes

Stakeholder Interviews	Consolidation of Stakeholder Input	Identification of Themes	Scenario Development

State Policy Goals	Ancillary Power Generation	Utility Partnerships
Energy & Economic Security, Climate Change	Key Energy Metrics	Energy Technologies

Theme 1: State Energy Policy Goals

1. Energy efficiency,
2. Maximizing the use of indigenous resources,
3. Enhancing energy security,
4. Minimizing greenhouse gas emissions, and
5. Reducing the cost of energy.

The majority of stakeholders agree with these overarching goals. However, there is concern that some policy decisions may result in unanticipated adverse effects.

Theme 2: Wind Energy Issues and Opportunities

Wind is good…

But the 21st MW of wind is better than the 71st MW

- *Diminishing returns*

To maintain system stability, we may need to burn more oil

- *Regulating reserves*

At night, we may have to "dump" wind

- *Difficult to finance new wind projects*

There are technologies (and policies) that can help HELCO and Hawaii utilize more wind

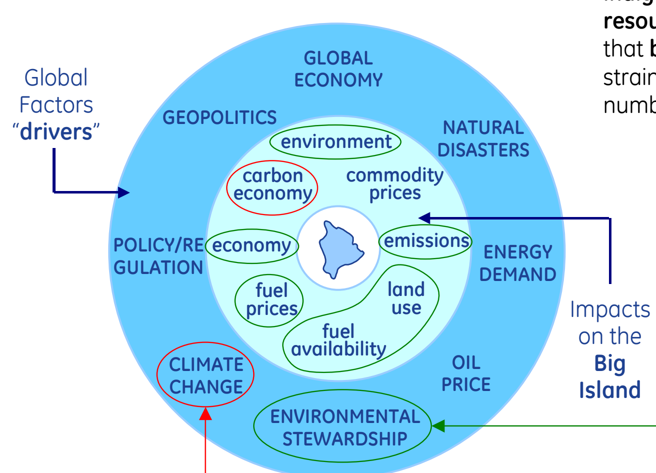
- *Energy storage, AGC tuning, economic incentives*

- Some stakeholders believe Hawaii could reduce the cost of electricity by increasing the penetration of wind power.
- General lack of awareness of the ancillary services needed.
- Understanding the "true cost of wind" can provide the State with data for policies for this and other technologies

Theme 3: Utility Partnerships

- A strong state economy is dependent on competitive and stable prices of energy.
- An economically healthy electricity utility is needed.
- Combined heat and power (CHP), distributed generation (DG), and energy efficiency projects can benefit from collaboration with the utility
  - This will build public equity in energy.
  - Public policy is needed to promote these relationships

Theme 4: Biofuels, Energy & Economic Security, & Climate Change



ENERGY SECURITY is centered around **indigenous production of energy resources**. Stakeholders are concerned that **biofuels may displace food crops**, strain the water supply, and create a number of byproducts with no direct use.

BIOFUELS - If fuel crops on the Big Island are more expensive to produce than importing the same fuels from abroad, **will Hawaii import biofuels** or the commodity to produce biofuels.

CLIMATE CHANGE MITIGATION is a central policy goal for the State. **Nearly unanimous agreement** was received from the stakeholders

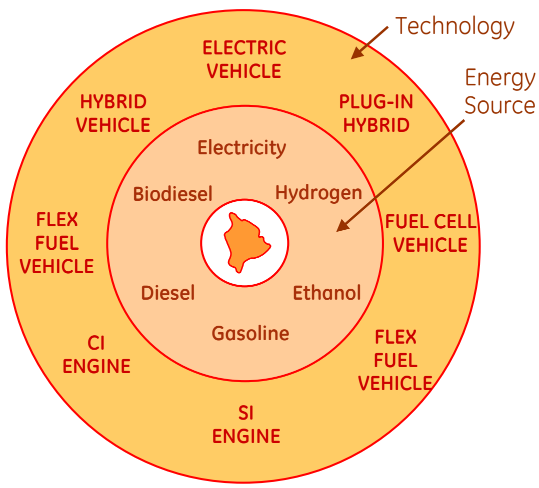
Theme 5: Key Energy Metrics

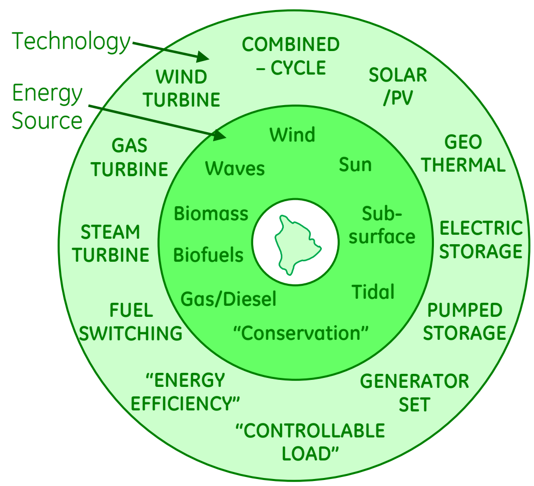
CLASSIFICATION		METRIC
Economic	*Cost*	$/kWh (Electricity), $/gal (Transportation)
Sustainability	*Penetration of Renewables*	% renewable
Energy Security	*Petroleum Use*	% petroleum
Social	*Many Factors*	Land, water, cultural values, aesthetics
Environmental	*Emissions*	tons/year (CO_2, NOx, SOx)

Theme 6: Energy Technologies

Most commonly mentioned energy technologies:

1. Wind Power & Energy Storage Technologies
2. Biofuels (palm oil, micro-algae, eucalyptus) for Transportation
3. Plug-in Hybrid Electric Vehicles,
4. Distributed Solar Power
5. Gasification (coal, waste, biomass) for Power Generation
6. Enhanced Grid Communications/Controls/Monitoring





4. Scenario Development

Stakeholder Interviews → Consolidation of Stakeholder Input → Identification of Themes → **Scenario Development**

1. Scenarios were chosen based on the six themes discussed by the stakeholders.
   - Two technology-focused scenarios and two goal-oriented scenarios.

2. A baseline model will be developed for 2018 with the proposed technology deployments for each scenario taking place in that year.

INCREASING ENERGY SECURITY

Based on a specific technology deployment that is focused on using indigenous resources, especially renewable resources (wind, solar, geothermal, biofuel).

Key Metric
% reduction in petroleum use

HIGHER WIND PENETRATION

Given the trends in Hawaii for increased wind farm development, a renewable energy strategy consisting primarily of increased wind utilization will be considered.

Key Metric
% increase in wind power

REDUCING ELECTRICITY COSTS

Based on a change in customer energy use habits and/or a specific technology deployment that is focused on achieving the lowest energy cost, given assumptions about the future policy landscape and price of fuel.

Key Metric
Cost of electricity (cents per kWh)

ENHANCED ENERGY MANAGEMENT

Using new and/or innovative approaches, such as demand-side management, customer-sited energy storage, energy efficient technologies and plug-in hybrid electric vehicles to contribute to regulating reserve requirements.

Key Metric
Cost of electricity (cents per kWh)

Scenario Checklist

SCENARIO	FOCUS	KEY METRIC	THEMES					
			1	2	3	4	5	6
Increasing Energy Security	Goal-oriented	% imported	X			X	X	X
Reducing Cost of Electricity	Goal-oriented	$/kWh	X			X	X	X
Higher Wind Penetration	Technology	% renewable		X		X	X	X
Enhanced Energy Management	Technology	$/kWh			X	X	X	X

For each Scenario we must consider future variables...

Scenario Elements	Impact
Energy Storage Technologies	Maintains power system stability by providing support for intermittent renewables, while minimizing the curtailment of renewables.
Oil Price	Fluctuations in the oil price will impact the cost of electricity, transportation, citizen behavior
Carbon Policy	The economics of lower carbon-emitting technologies will be enhanced relative to fossil-fuel counterparts.
Renewable Portfolio Standards	Alternative target dates and percentages could affect the cost of energy in a non-linear fashion.
Power Purchase Agreements	Changes to this policy will affect the price HELCO and ratepayers pay future independent power producers.
Energy Cost Adjustment Charge	Changes to this policy will affect customer and utility finances and promote technologies that hedge against rising oil prices.

Summary of Past Events and Next Steps

1. The opinions of stakeholders were solicited in April and May 2007.
2. Consolidation of stakeholder input revealed six common themes.
3. These themes were used to construct technology and goal-oriented scenarios for the year 2018.
4. Details of these general scenarios will be constructed by observing the impact on cost, emissions, etc. of incremental changes to a base case.
5. Each scenario will be constructed using technology deployments and making assumptions about future policy landscapes and global conditions.

Stakeholder Summit

Stakeholder Summit
Objectives of today's meeting

1. To **update** the assembled stakeholders:
   a. Capabilities of the **models** developed and the **metrics** used to evaluate options.
   b. To **present candidate scenarios** – developed from Stakeholder interviews
   c. Discuss how scenario strategies meet common program and stakeholder objectives
2. To enable public and private policy makers to explain how they envision using this assessment methodology
3. To obtain additional **input, advice, and suggestions** from Stakeholders on future paths for energy activities

Accomplishments to Date

- A validated set of models that account for the complexities of Hawaii's energy sector
- A method to evaluate key technical issues and policy questions
- An evaluation of metrics (sometime competing) important to the values of Hawaii's citizens
- A local capability to do these analyses and assessments in the State

What we're hoping will result

1. Establish the analytical capability in Hawaii to support more informed planning and policy processes
2. Focus the dialog in Hawaii on tradeoffs among feasible choices, not abstract technology advocacy
3. Quantify the value of alternate technologies, and determine where they can best be utilized
4. Support, with accurate and technology-neutral analysis, on-going Hawaii planning and policy activities
5. Identify some individual energy technology choices or projects that should be expedited
6. Facilitate development of partnerships and new business relationships among stakeholders to achieve common objectives

What We Hope to Obtain from the Stakeholder Audience Today

1. Comments on overall project strategy and direction
   Are we on the right track, based on our earlier discussions with you?
2. Comments and direction on future scenario evaluation
   What are your thoughts on the most/least appropriate scenarios?
3. Comments and advice on additional areas to be considered
   Are we missing anything that you feel is important for the future?

Appendix C – Results of the Transportation Model (Steve Sanborn)

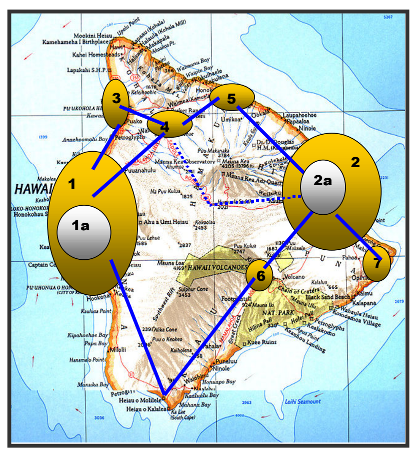
Hawaii Strategic Energy Roadmap

Transportation System

Stephen Sanborn — GE Global Research
Devon Manz — GE Global Research
Ralph McGill — Sentech, Inc.

US DOE | Hawaii Natural Energy Institute | State of Hawaii | GE Global Research GE Energy | Sentech

Approach



Assessment Envelope

- Big Island of Hawaii

Infrastructure Segments

- Sources (importation & on-island sources, production/conversion into transportation energy carriers, bulk storage)
- Distribution (receiving terminal(s), pipelines, tanker truck fleet(s) trucking, intermediate storage)
- Dispensing Capacity (by geographic region)

Consumption Segments

- Granular Vehicle Classes
  (e.g., passenger cars, light duty trucks, heavy duty trucks, tractor trailers, buses, etc.)
- Subdivide into existing major fleets as relevant
  (e.g., # vehicles by vehicle-class & fuel type for Personal, Retail & Delivery, Entertainment-Tourism, Public Transportation, Airport Ground Support, Off-Road & Construction, Marine, Military, etc.)
- Functionalize for scenario analysis
  - % growth of current petroleum-fueled fleets
  - Addition of selected alternative fuel fleets (I.e., add usage of ethanol, biodiesel, H2 & electricity)

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Scope

Capability to Quantify Transportation Energy & Fuels Scenarios

- Transportation Fuel Consumption
  - Bottoms-up estimate rooted in baseline 2004 vehicle fleet data for Big Island
  - Segmentation & Granularity by:
    - Fuel type (gasoline, diesel, propane, electricity, ethanol, biodiesel, hydrogen)
    - Energy Flow (actual & capacity), by energy carrier type, for each geographic region
    - Vehicle Fleets with a reasonable degree of vehicle class & fuel type & miles traveled.
      (NOTE: aircraft and large commercial vessels not included in Phase 1)
- Interactions with Electric Power Model:
  - Electricity demand *(future use of electricity as "fuel" or for H2 production)*
  - Biofuel consumption *(future use of biofuels by both Transportation & Electricity)*
- Broad-based growth (& growth constraints) anticipated by stakeholders
- Global Fuel Market future price projections as an upper bound
- Quantified measures that roll-up into Metrics

Validation: "Current Situation Scenario should replicate the current situation in Hawaii.

Assessment: "Current Snapshot " - Best Estimate of year 2005 transportation consumption & quantitative values for metrics

"Future Snapshot" - Single point projection to the year 2020.

- Sensitivity Analysis

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Metrics

Energy Security – The diversity of Fuel Types & sources used to meet demand. (e.g., % petroleum, % renewable, % biofuel, % imported, % produced either on-island or at least within Hawaiian Islands)

Economics – Cost-Of-Service (COS) – Based on market price estimates for fuel types used in scenario, and then applied to the elements of the vehicle fleets (e.g., $/gal, $/vehicle/mile, $/vehicle/year)

Environmental Impacts – Tailpipe emissions with vehicle fleet & fuel type granularity, agricultural land requirements by crop/fuel type.

Societal Impacts - ·These are user interpretations of underlying scenario results with focus on: land use and the above metrics. Considerations relate to: Land use & impact on local customs; Acceptance by on-island residents &, tourists; Citizen Health & Safety.

Transportation Specific Sensitivities

δ COS_{ervice} / δ %ethanol (or other biofuels)

δ Tailpipe Emissions/ δ %ethanol use (or other biofuels)

δ Land Required/ δ %ethanol (or other biofuels)

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Model

INPUT

Parametric Data:
- Vehicle Fleets with class, fuel type & miles/year
- Alternative Fuel production parameters
- Fuel Spot Price benchmark parameters

Pro-Forma User Input:
- *WHAT-IF scenario changes*
  - *% change in # of vehicles by type*
  - *% change in miles per year by type*
  - *Scenario Year for price projection*
  - *% change in MPG by type*
- *Alternative Fuel Fleet(s)*
  - *Define Fleet size and fuel*
  - *Define miles/year/vehicle & MPG*
  - *Select alternative fuel feedstock(s) for CAPEX & biomass agriculture land use*

Processing

Estimate fuel demand:
- whole island
- each conventional fleet
- each alternative fleet

Estimate fuel prices:
- Estimate Hawaii retail price of:
  - gasoline & diesel based on spot and market prices.
  - biofuels based on projections.

Estimate emissions:
- Tailpipe CO2 & criterion emissions
- Well-To-Tank CO2 emissions

Estimate Land-use:
- Estimate feedstock specific biomass acreage needed

Output

Energy Security
- % of fuel is petroleum
- % of fuel is biofuels
- % of fuel is green fuels
- % of fuel is electricity or elec-based

Economic
- $$/gallon for fuel types
- $$/mile for vehicle type
- $/year for vehicle type
- CAPEX estimates:
  - Alternative Fuel production

Environmental/Societal
- Well-to Wheel and Tailpipe Emissions
  (CO2, CO, NOx, SOx, VOC, PM10)
- % Agricultural Land area required for local biomass production

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Validation

	Hawaii Databook 2004	Infractructure Model (A)	Infractructure Model (B)	Hawaii Databook 2005	Infractructure Model (C)	Infractructure Model (D)
Gas Demand (Mgal)	*not reported*	62.17	63.9	74.148	68.1	69.93
Diesel On-Road Demand (Mgal) *	*not reported*	10.34	15.76	11.535	13.76	16.52
Diesel Off-Road Demand (Mgal)	*not reported*	9.25	9.25	9.54	9.54	9.25
Total Fuel (Mgal) *	85.40	81.76	88.91	89.00	91.40	95.7
		-4.3%	4.1%		2.7%	7.5%
Miles/year/vehicle	9,729	9,730	10k - 15	10,043	10,032	10k - 15k
Total Vehicle Miles (Mmiles) *	1,516.6	1,613.3	1,701.4	1,651.2	1,784.8	1835.9
Total Vehicles *	168,229	168,231	168,231	178,524	180,338	180,338

*excludes tractor trailers

Within 10%

Model (A): Vehicle Data set for 2004 Databook

Model (B): Vehicle Data set for 2004 with adjusted miles/vehicle/year

Model (C): Vehicle Data set for 2005 Databook

Model (D): Vehicle Data set for 2005 with adjusted miles/vehicle/year

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Forward-Looking Snapshots

Scenario "Tuning Knobs"

- # of vehicles in each sub-fleet
- Miles/year/vehicle for each sub-fleet
- MPG improvement for vehicles in each sub-fleet
- Addition/substitution of alternative fuel sub-fleets
- Ethanol blending ratio & feedstock(s)
- Biodiesel blending ratio & feedstock
- Calendar Year for fuel pricing

Vehicle Fleet Growth & Changes

- Pop. and GCP growth as surrogate indicators
  - 37% pop. growth by 2020 → personal vehicle fleet
  - 44% increase in Hawaii GCP by 2020 → commercial fleet
- Penetration of E-FFVs and B-FFVs
  - **Target:** 20% renewable fuels by 2020
  - **Estimate:** 14% FFVs by 2020 (Biofuels Summit)

Hawai'i County

	2005	2020	%
Population	163K	203K	25%
Population (+tourists)	**166K**	**227K**	**37%**
Gross County Product (B$, 2000)	**4.3**	**6.2**	**44%**
Personal Income ($/yr/per)	23K	30K	30%

Source: Population and Economic Projections for the State of Hawaii to 2030, DBEDT

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Sensitivities in 2020

In 2020, the situation might look like this:

- *+37% On-Island population growth*
- *+44% County Gross Annual Product growth*
- *E-FFVs and B-FFVs readily available*

SCENARIOS	Spark Ignition	Compression Ignition	2005	2020
Baseline	Gas	Diesel	X	X
100% E10	E10	Diesel	X	X
100% B5	Gas	B5	X	X
100% Blended fuels	E10	B5	X	X
20% E85	Gas/E85	Diesel		X
20% B80	Gas	Diesel/B80		X
20% E85 & 100% B5	Gas/E85	B5		X
20% B80 & 100% E10	E10	Diesel/B80		X

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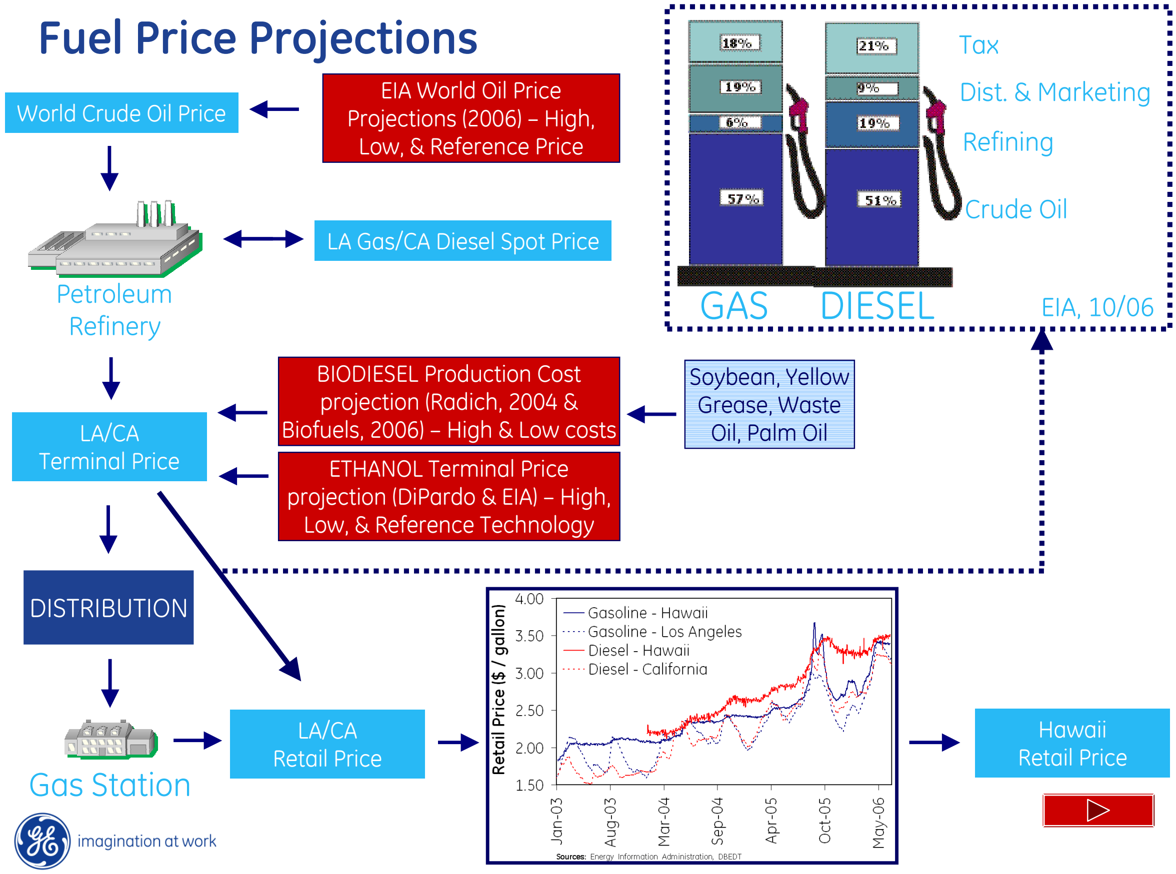
Fuel Price Projections



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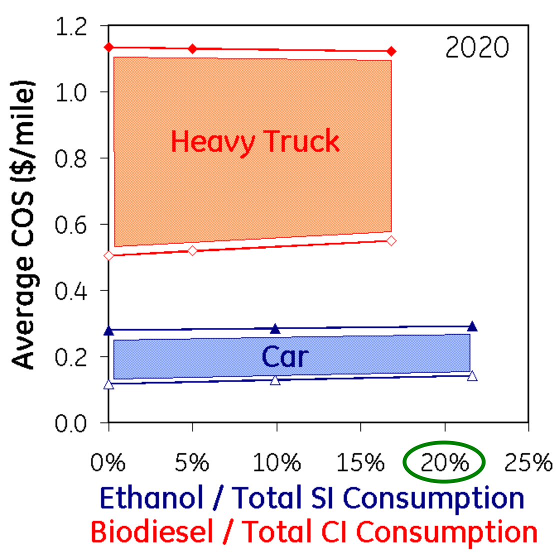
Results - Monetary Cost of Energy Security



Penetration of Biofuels

- The average cost-of-service was determined for two vehicle fleets for the year 2020 scenarios.
- The high and low COS are calculated from the high and low fuel price projections.
- The method in which the 20% Alternative fuels standard is achieved has an effect (i.e. E85 vs E10).
- The monetary cost of increasing energy security through the use of biofuels will largely not be borne by the consumer.

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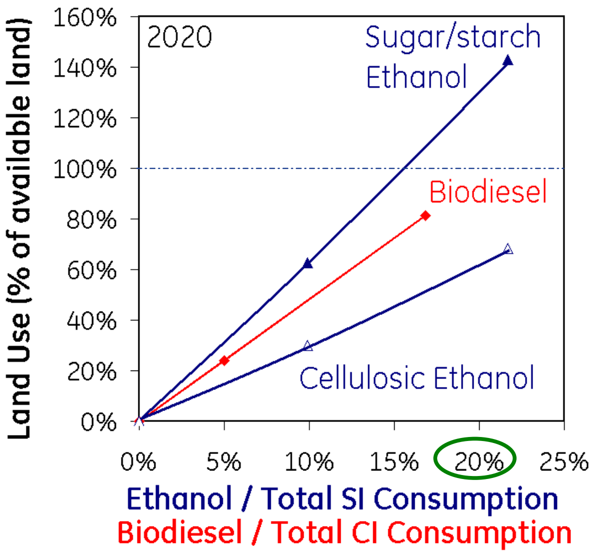
Results – Environment/Societal Cost of Energy Security



Penetration of Biofuels

- The acres of available land were obtained form the RMI Biofuels Summit.
  - 23,200 acres was used here
  - 27,000 per Stillwater, or ultimate land estimates such as 1,200,000 acres could be used as appropriate
- The 20% Alternative fuels standard can be achieved in various ways.
- It will be challenging to reach the 20% standard with on-island produced biofuels alone.

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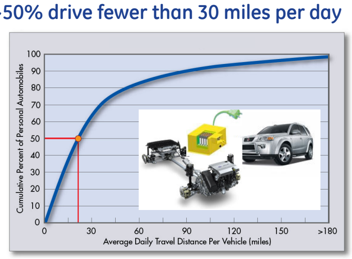
Phase 2 Scenario Analysis

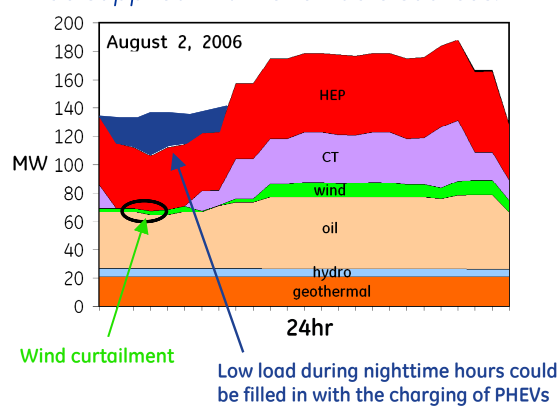
There is potential for some transportation energy to be shifted to the power system.

~50% drive fewer than 30 miles per day



http://www.calcars.org/epri-driving- solution-1012885_PHEV.pdf

At night EV/PHEV charging could be supplied with renewable sources.



Future Work

The potential role of PHEVs in providing generation reserve for the power system, thereby reducing the cost of electricity and potential overall emissions, will be evaluated.

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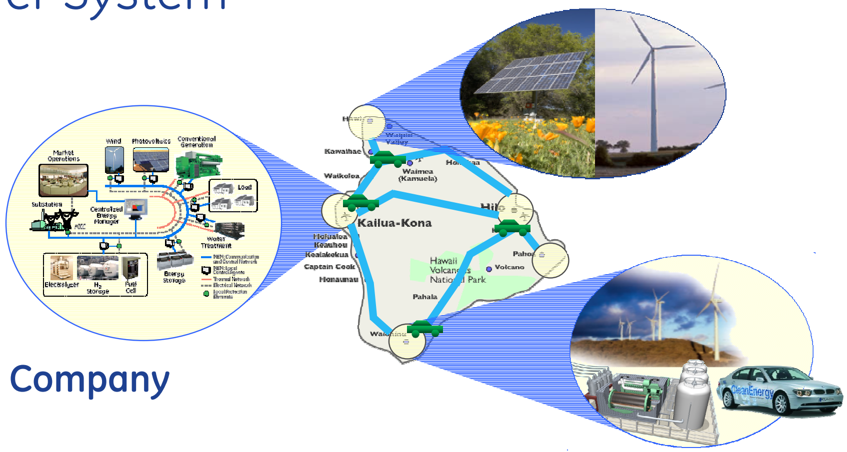
Appendix D – Results of the Electricity Model (Nick Miller)

Hawaii Strategic Energy Roadmap
Electric Power System



General Electric Company

Nick Miller

Gene Hinkle

Sebastian Achilles

Juan de Bedout

Devon Manz

US DOE | Hawaii Natural Energy Institute | State of Hawaii | GE Global Research GE Energy | Sentech | Hawaii Electric Light Company

Project Approach – 50,000ft view

In Phase 1…

- The project team developed and validated a model of the HELCO system.
- The model was used to determine how incremental changes (in wind, solar, geothermal, etc) impact the cost of electricity, emissions, imported petroleum, etc.

In Phase 2…

- Four scenarios, comprised of various technology deployments, will be evaluated by the project team.
    - The stakeholders have and will provide substantial input into the scenario formulation process.
- The model will be used to evaluate the key metrics (i.e., cost of electricity, % renewable, % imported) for each scenario

What does this study offer?

- A calibrated and validated technical, economic **and** environmental analysis of the electricity infrastructure on the Big Island.
- A methodology and tool for State policymakers to help analyze the impacts and tradeoffs of technologies and policies.
- An in-state capability to perform further energy analyses.

The ability to quantify the environmental, economic and technical tradeoffs of energy technologies and policies in the State.

What are the limitations of this study?

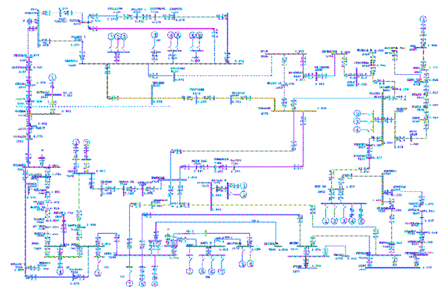
- The production cost modeling tool considers only the variable cost (fuel, O&M and start-up of each unit). In order to fully analyze the tradeoffs, additional information is needed, such as the capital cost of a technology deployment.
- The electricity model is not an exhaustive study, nor is it a substitute for utility planning (HELCO IRP).
- The model is a quantitative tool and does not output qualitative issues, such as siting, aesthetics, cultural values, etc.

Electrical System Modeling

The model is comprised of two specific simulation packages:

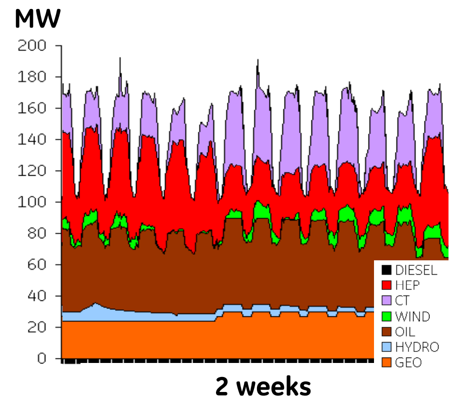
1. Dynamic Simulation (GE PSLF™)

- Transient Stability Simulation
- Long-Term Dynamic Simulation
  - Second-by-second load, wind variability driving full dynamic simulation of the HELCO grid for several thousand seconds (~1 hour)



2. Production Simulation (GE MAPS™)

- Hour-by-hour simulation of grid operations



Constructing Phase 2 Scenarios

Impact of adding:

X MW of wind/solar/geothermal, or
X MW of spinning reserve, or
X MW of storage, or
X MW of load....

These incremental changes to the baseline model will be used to identify the impact of various technologies on achieving specific goals (i.e., How does the addition of 1MW of geothermal energy change cost of electricity?)

ON

Economy: Cost of electricity ($/kWh)

Environment: CO_2, SO_x, NO_x, (tons)

Energy Security: % imported petroleum

Sustainability: % renewable

WILL BE USED TO CONSTUCT FOUR SCENARIOS

Production Cost Modeling
GE MAPS^{TM}

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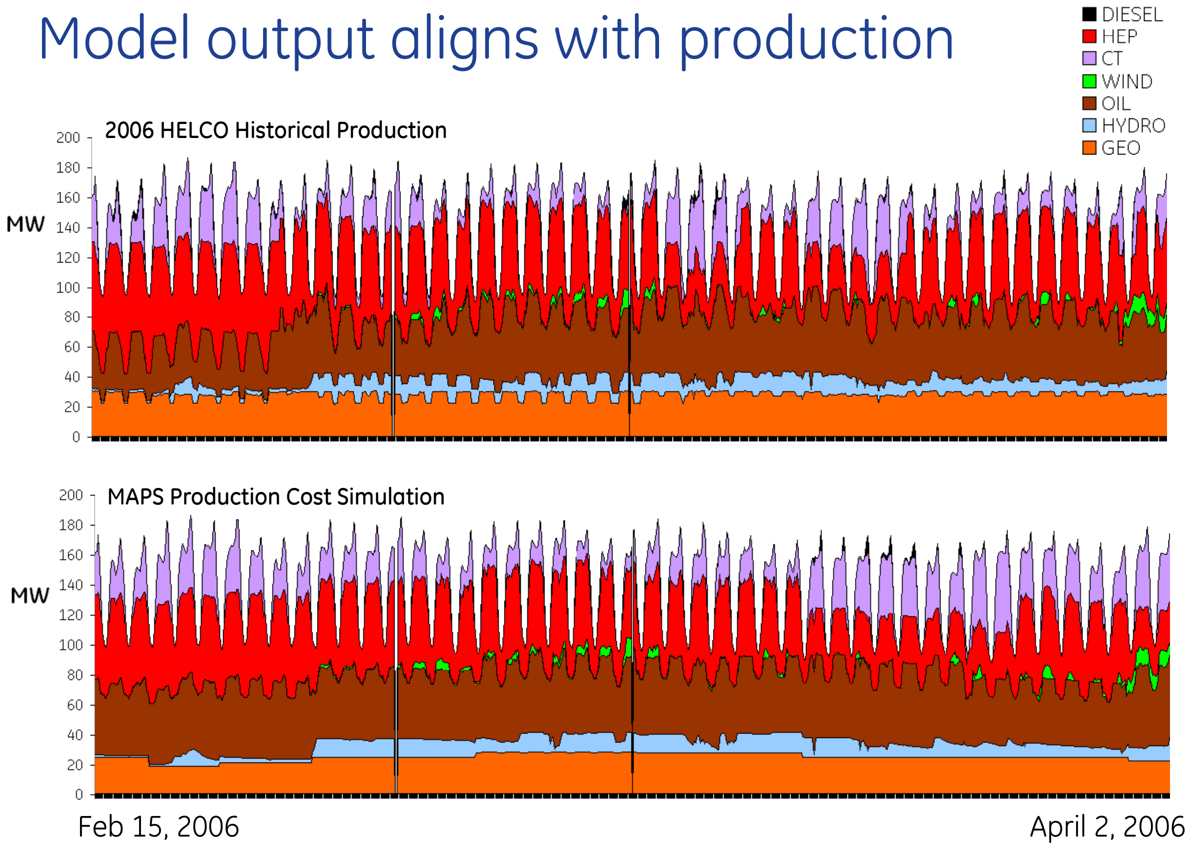
What is production cost modeling?

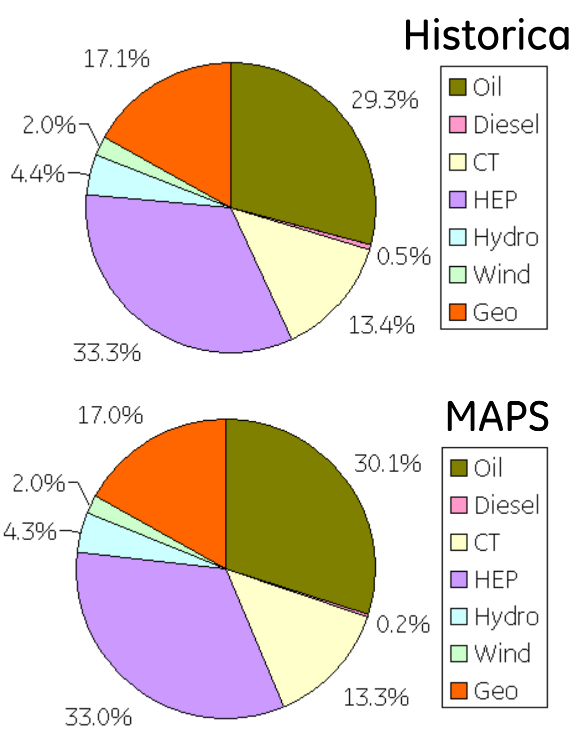
- Throughout the year HELCO has to make decisions about which generators should be used to produce electricity in each hour of the day.
- This decision depends on **many** constraints, including the cost of each generator, the capabilities of the transmission system, and rules about when each generator can be operated.
- **GE MAPS^{TM},** the production cost tool used in this study, was used to simulate the HELCO production for 2006.
- Production cost modeling allows HELCO to determine the cost of electricity production, emissions, etc ne

Model output aligns with production



The model validates annual production

Annual Production (GWh by Fuel Type)



	GWh (2006)	
	Historical	MAPS
Oil	364	376
Diesel	6	3
CT	166	167
HEP	414	412
Hydro	54	54
Wind	25	25
Geo	212	212
Total	1241	1250

Less than 1% difference between actual annual GWh (by type) in 2006 and the results of the MAPS model.

Dynamic Simulation
GE PSLF™

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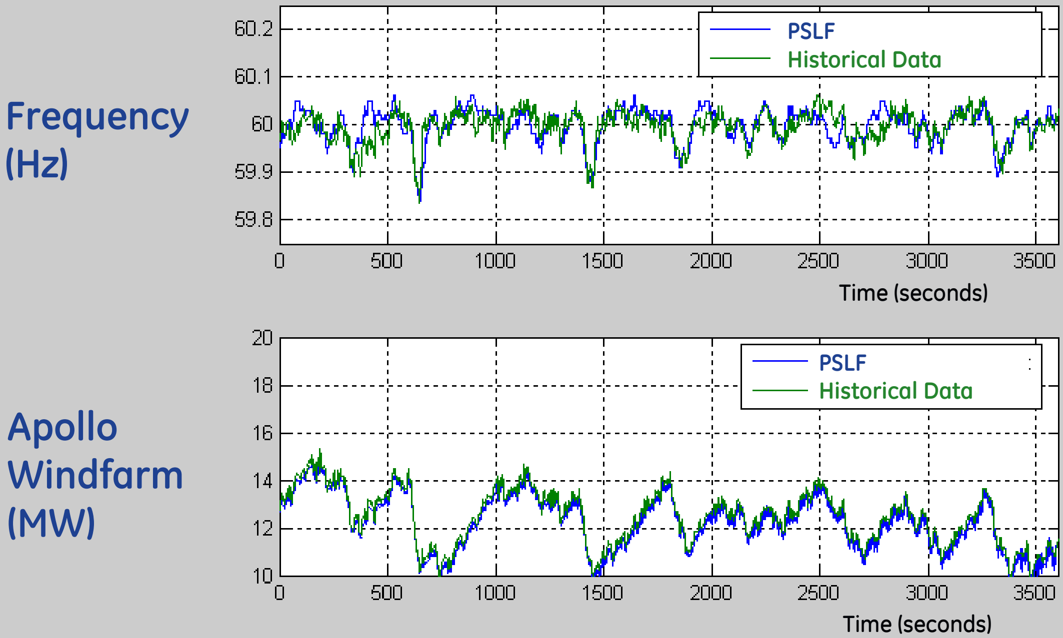
What is dynamic modeling?

- Dynamic (or transient stability) modeling is used to simulate the system behavior (such as frequency) during transient operation.
- Dynamic modeling can be used to understand the impact of transient operation of different generators on system frequency in a seconds timeframe.
- Dynamic modeling is needed to ensure that system frequency remains relatively stable during critical operating practices
    - eg. A gust of wind during the night causes a large windfarm to quickly produce additional electricity. If another generator is unable to reduce its electricity production as quickly as the windfarm picked up, the system frequency will deviate from 60Hz.
- **GE PSLF™** was used to simulate HELCO operation

Model results align with historical data

Example: Significant Wind Fluctuation (04/03/07)



What are the types of analyses we can perform with this tool?

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What if 1MW of wind power is added to Apollo wind farm?

		Fuel Use	Emissions (tons)		
	GWh	MMBtu	NOx	SOx	CO_2
Combined Cycle	-2.1	-15545	0	-2	-1352
Combustion Turbine	-1.3	-13905	-1	-2	-1245
Diesel	0.0	-341	0	0	-29
Puna Geothermal	0.0	0	0	0	0
Small Hydro	0.0	0	0	0	0
Steam Oil	-0.6	-7582	-1	-1	-726
Wind	4.1	0	0	0	0
Solar	0.0	0	0	0	0
Grand Total	0.1	-37374	-2	-6	-3352

- With no other changes to the system, an increase in wind power offsets fossil fuel generation and reduces emissions
- But, HELCO must maintain their system frequency at 60Hz.
- Sudden changes in wind power output will affect the frequency, therefore increasing wind power requires some additional considerations.

Is there more to this story?

Cost Adders

Wind power reduces the island's carbon footprint, and reduces the amount of imported petroleum, but…

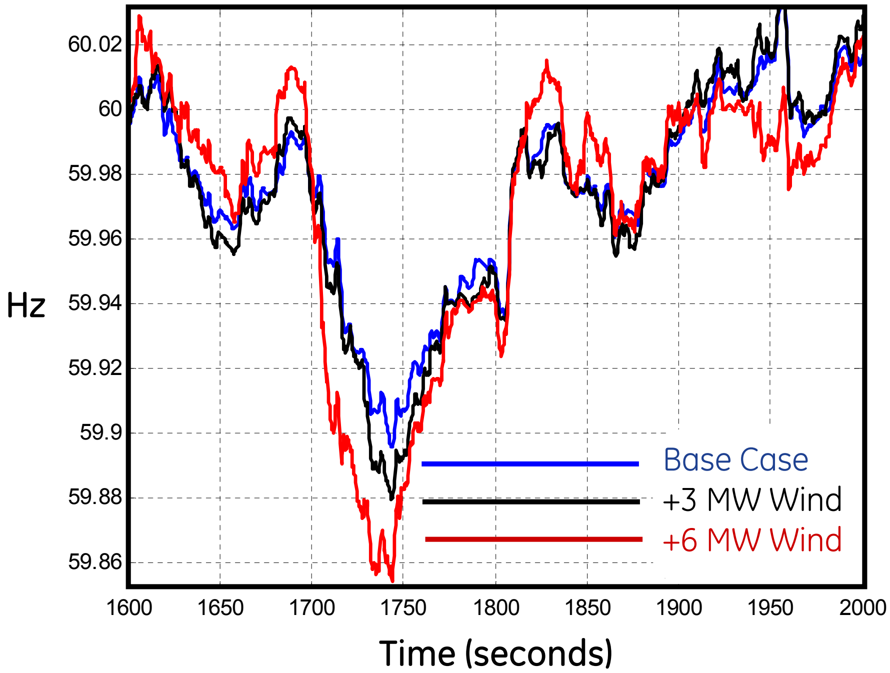
↑ 1) **More spinning reserve will be needed** - More oil must be burned so some generation is ready to quickly meet changes in the system load or wind farm output, and/or

↑ 2) **New technologies** can be used to mitigate the intermittency of wind power.

? 3) **Price paid to wind producers** matters. If HELCO pays a wind producer more than it costs them to produce electricity from fossil fuel generation, more wind power will cost the island more.

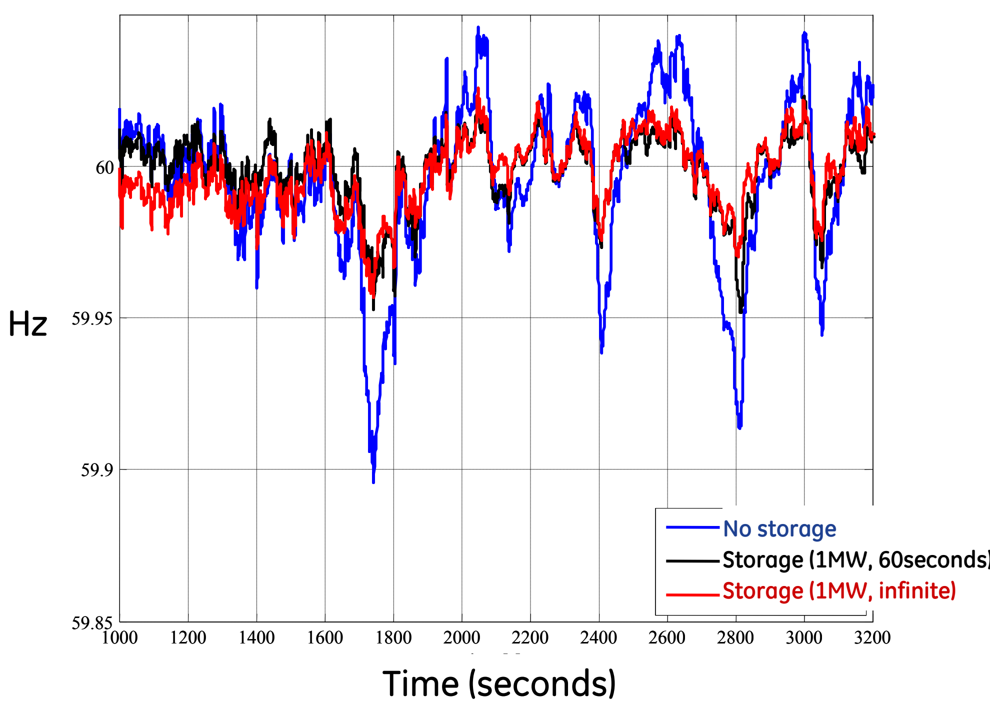
Example: What if HELCO had More Wind?

Significant Wind Fluctuation on May 23rd 2007



Example: Does Energy Storage Help?

Significant Wind Fluctuation on May 23rd 2007



Conclusions

1. GE has developed an electricity model that has validated an entire year of production based on historical data from 2006.
2. The model is capable of quantifying the environmental, economic and technical tradeoffs of incremental changes in power generation and other technologies, however this study **is not** exhaustive and **is not** a substitute for IRP.
3. The discussion of incremental changes of various technology deployments from the baseline provides direction for scenario development.
4. We will be opening the floor to the stakeholders, for discussion, this afternoon.

Appendix E – Summit Participants List

Stakeholder Summit
Waikoloa Bach Marriott, September 27, 2007

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(Revised 10/12/07)

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