TESTIMONY OF

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Subject: Renewable Distributed Generation, Differences Between Commercial Wind Farms and Small Distributed Generation Wind Turbine Applications, Discussion on Renewable Technology Feasibility and Viability, and Policies and Incentives for Renewable Energy Development

Introduction

Q. Please state your name, position and business address.

A. My name is Arthur Seki, Director of Technology at Hawaiian Electric Company, Inc. ("HECO"). My business address is 820 Ward Avenue, Honolulu, Hawaii 96814. My educational background and experience are listed in HECO-200.

Q. Could you briefly summarize your work experience?

A. After graduation, I worked in the field as a research associate conducting well tests of the state's first geothermal well (Hawaii Geothermal Project—Well A) in Puna, Hawaii. I later joined the Hawaii Natural Energy Institute at the University of Hawaii as a research associate. I spent 14 years in this position conducting research, studies and demonstration projects related to geothermal, photovoltaic, solar thermal electric, ocean thermal energy conversion, biomass, hydrogen and other resources. In 1990, I joined HECO as their energy specialist. My duties at this position include monitoring and evaluating and conducting research, studies and demonstration projects related to renewable energy and emerging technologies (i.e., photovoltaic, biomass, wind, ocean energy, pumped storage hydroelectric, coal gasification, hydrogen, fuel cells and other technologies). In 2002, I became the Director of Technology at HECO. My duties at this position include the activities of the energy specialist and also managing our Electric Power Research Institute membership and technology transfer.

Q. What will your direct testimony cover?

A. My direct testimony will cover renewable energy distributed generation ("DG"):

1) Photovoltaic;
2) Photovoltaic with energy storage;
3) Fuel cells;

4) Small wind turbines;

5) Differences between commercial wind farms and small distributed generation wind turbines applications;

6) Discussion on renewable technology feasibility and viability; and

7) Policies and incentives for renewable energy development.

Photovoltaic

Q. What are photovoltaic ("PV") systems?

A. PV systems convert sunlight directly into electricity.

Q. How do PV systems work?

A. A PV cell utilizes the photovoltaic effect, whereby photons in sunlight are absorbed by the PV cell and transfer energy to electrons in the atoms of the PV cell. The electrons then escape from the atoms to become direct current ("DC") electric current. The PV cells are grouped to make a PV module or panel. Several PV modules or panels are grouped to make a sub-array or array.

Q. Is there other equipment in the PV system?

A. Yes. Besides the PV panels, other balance-of-system equipment will include an inverter to convert DC electricity to alternating current ("AC") electricity, electrical breakers, transformers and other electrical equipment that will allow the interconnection of the PV system with the utility electric grid.

Q. Does HECO have experience with PV in Hawaii?

A. Yes. HECO, Hawaii Electric Light Company, Inc, ("HELCO") and Maui Electric Company, Ltd ("MECO") have collaborated on various PV projects and installed numerous PV systems, including Sun Power for Schools ("SPS") installations, throughout Hawaii. These include grid-connected PV systems at:

- Hickam Air Force Base (25 kW);
- Kihei PVUSA (18 kW);
- Kona Gymnasium (15 kW);
- HELCO Kona Base Yard (5.4 kW);
- Hawaiian Islands Humpback Whale N.M.S. (4.2 kW);
- Ford Island - Pearl Harbor (2 kW);
- Bishop Museum (1.5 kW);
- County of Maui Lahaina Civic Center (1.2 kW);
- Kaimuki High School (2 kW);
- McKinley High School (2 kW);
- Waianae High School (2 kW);
- Waialua High School (2 kW);
- Waipahu High School (2 kW);
- Campbell High School (2 kW);
- Mililani High School (2 kW);
- Castle High School (2 kW);
- Kahuku High School (2 kW);
- Baldwin High School (1 kW);
- Molokai High School (1 kW);
- Hilo High School (1 kW);
- Kealakehe High School (1 kW); and
- Kalanianaole Intermediate School (1 kW).

Q. Did HECO, HELCO and MECO install PV systems as part of the SPS program?

A. Yes. The SPS program is in its eighth year of existence. Since 1996, 20 PV systems (grid-connected and off-grid) have been installed on 20 high and middle school rooftops and campus grounds using monies from federal programs (i.e., grants), customer voluntary contributions and utility funds.

Q. Are there other PV installations within the state?

A. Yes. Private hotels and businesses have installed larger PV systems. In general, these installations had the benefit of federal and state government tax credits to reduce the cost of these PV systems. One hotel even had U. S. Department of Energy monies to assist in buying down the project cost.

Q. What are the advantages of PV systems?

A. The advantage of PV systems are as follows: use no fuel other than sunlight; are commercially available with multiple manufacturers; modular; no moving parts (solid state technology); quiet; and emit no pollution.

Q. What are the disadvantages of PV systems?

A. The disadvantages of PV systems are: expensive; provide power only when adequate sunlight is available; require land; and require replacement of solid-state components.

Q. How much do PV systems cost?

A. PV systems are capital intensive and cost more than many other electric generation technologies. Total capital costs for PV systems in Hawaii, including interconnection and indirect costs (e.g., permitting, engineering and overhead), are estimated to range from $9,000 per kW to $13,000 per kW. Factors such as system size, bulk order pricing, and site and installation specifics can affect PV system costs.

Q. Can PV be counted upon to provide power on demand?

A. Not without an energy storage system. The amount of electricity generated by the PV system is dependent on the amount of sunlight that strikes the panels of the PV system. The amount of sunlight (intensity and duration) that strikes the PV panel is highly variable and cannot be predicted.

Q. Can PV systems provide electricity at night?

A. No. PV systems cannot generate power at night.

Q. Can PV systems operate in an efficient manner in the shade or cloudy periods?

A. No. PV systems cannot operate in an efficient manner in the shade or cloudy periods. The PV system output is reduced drastically if it is in the shade due to clouds, trees or buildings.

Q. What are the land requirements for large (> 100 kW) PV systems?

A. Large PV systems would require about 5 to 10 acres per MW of relatively flat land in a sunny area.

Q. Can PV systems be located on rooftops?

A. Yes. PV systems can be located on rooftops. The PV system should be located in a south face orientation, free from shade caused by trees or buildings.

Q. Would PV systems compete for rooftop space for a solar water heating system?

A. Yes. PV systems and solar water heating systems require the same south face orientation, which should be free from shade.

Q. What solid-state components have to be replaced?

A. The inverter is a solid-state device that may have to be replaced every 5 to 7 years.

Q. What is the status of PV technology?

A. Overall, single and poly crystalline PV modules production has grown over the years. The world production is close to 400 MW per year. However, the cost of the PV modules remains high and has even increased as the demand increased and the supply has decreased. It is the hope of the PV industry that thin-film PV module development could reduce PV module costs in the future.

Q. What advances must occur before PV systems can be used on a wide-spread commercial basis?

A. In general, PV system costs must be reduced and PV cell efficiency must increase.

<u>Photovoltaic with Energy Storage</u>

Q. Do HECO, HELCO and MECO have experience with PV coupled with energy storage?

A. Yes. HECO, HELCO, and MECO have experience with PV energy storage in both grid-connected and off-grid applications. These grid-connected PV energy storage systems include:

- Bishop Museum; and
- Kona Base Yard.

Off-grid PV systems with battery energy storage include:

- Hilo Bay Front Park;
- Catholic Charities Community and Immigrant Services shelter;
- Ahalanui Beach Park;
- Pohoiki Beach Park;
- Laupahoehoe High School;
- Lahainaluna High School;
- Maui Waena Intermediate School;
- Lokelani Intermediate School; and
- Iao Intermediate School.

Q. What type of energy storage technology can be used with distributed PV?

A. At present, DG PV systems utilize batteries to store energy generated by the PV panels. The PV panels charge the battery energy storage system during the day when there is adequate sunlight and when there is excess PV-generated power available. Lead acid battery energy storage and associated equipment are integrated with distributed PV systems when energy storage is needed.

Q. What PV applications require the use of energy storage systems?

A. Energy storage is needed when continuous power is required and/or a customer who desires to obtain most, or all, of their power from the PV system. During cloudy periods or at night, power would come from the energy storage system. The customer may or may not be connected to the utility grid.

Q. What are the advantages of a PV system with energy storage systems?

A. The advantages of PV systems with energy storage are as follows: uses no fuel other than sunlight; are commercially available with multiple manufacturers; modular; no moving parts (solid state technology); quiet; emit no pollution; and can provide energy to the user at night or during periods of low sunlight.

Q. What are the disadvantages of a PV system with energy storage systems?

A. PV with energy storage systems is even more expensive than PV systems (due to the additional cost of the energy storage system) and requires replacement of solid-state components (i.e., inverter) and battery storage system. The operation and maintenance of the energy storage system will require attention to keep its performance at an efficient level.

Q. How can PV systems provide power at night or when the sun is not shining?

A. Adding energy storage systems, such as battery banks, with PV systems can provide power at night or during cloudy periods when there is not enough sunlight to produce the power that is needed.

Q. How much could a lead acid battery energy storage system add to the PV system cost?

A. Lead acid battery energy storage and associated equipment can add roughly $2,000 to $3,000 per kW to a distributed generated PV system. Costs may vary depending on system size and installation issues.

Q. What components have to be replaced?

A. The inverter and batteries may have to be replaced every 5 to 7 years.

Q. What is the status of PV with energy storage?

A. PV with energy storage is a mature system especially for off-grid applications. In most cases, PV with energy storage in an off-grid application is the cost-effective option. Lead–acid batteries are primarily used in these applications.

Fuel Cells

Q. What are fuel cells?

A. A fuel cell is an electrochemical device that converts the chemical energy of a fuel directly to DC electricity. The fuel cell consists of an anode and a cathode separated by an electrolyte that provides an ion exchange mechanism. Hydrogen and other gases are directed to anode and cathode electrodes that are separated by an electrolyte.

Q. Describe a general fuel cell stack.

A. Multiple layers of anodes, electrolyte and cathodes are compressed together to make the fuel cell stack that can produce DC electricity at a higher voltage.

Q. Do HECO, HELCO and MECO have experience with fuel cells?

A. Yes. HECO personnel have kept abreast, and continue to keep abreast, of fuel cell technology developments by attending fuel cell technical seminars and conducting manufacturer site visits. Site visits have been conducted at: UTC Fuel Cells; Ballard; IdaTech; Proton Energy Systems; Plug Power; Dias-Analytic; Nuvera;

Siemens-Westinghouse; FuelCell Energy; MC-Power; and others.

Q. Does HECO have experience with fuel cells in Hawaii?

A. Yes. HECO provides warehouse space and water, electrical, and drainage services to the Hawaii Fuel Cell Test Facility ("HFCTF") operated by the University of Hawaii's Hawaii Natural Energy Institute (see Docket No. 01-0480). The HFCTF is used to conduct research in the development and testing of fuel cells and fuel cell systems, including the use of alternate fuels. HECO personnel regularly meet with university researchers to keep abreast of HFCTF activities, research issues, and fuel cell technology developments.

Q. What are the advantages of fuel cell systems?

A. The advantages of fuel cells include: high efficiency; modularity; co-generation potential; site flexibility; environmental acceptability; nominal permitting requirements; small land requirements; and potential fuel flexibility.

Q. What are the disadvantages of fuel cell systems?

A. Fuel cell equipment is still expensive and not commercially available. In addition, the cost in Hawaii for the fuels that can be used in the currently available fuel cells is also high. The life of a fuel cell stack is limited to 5 years or less. In general, the fuels cell stacks are very sensitive to contamination by certain chemicals (i.e., sulfur, chloride, etc.) that can poison or drastically reduce the life of the fuel cell stack. Certain fuel cell stacks (proton exchange membrane fuel cell stacks) are also sensitive to carbon monoxide. The longevity, reliability and cost of the fuel cell units all must be proven before fuel cells enter into widespread commercial use.

Q. What kind of fuel is needed for fuel cells?

A. In general, hydrogen is needed by the fuel cell to generate power. Hydrogen is directed to one electrode and air is directed to the other electrode in the stack to produce DC electricity at a higher voltage. Fuel cells require pure hydrogen with very low sulfur content and other contaminants.

Q. If hydrogen is not available, what other fuels could be used?

A. The fuel cell industry has been looking at natural gas as the initial fuel cell feedstock. Propane is also being tested as a feedstock for fuel cells. Other fuels such as light distillates, methanol, and biogas have also been tested. A reformer to convert methane gas, propane or the other types of fuels to hydrogen and other gases is required upstream of the fuel cell stack.

Q. Describe how a fuel cell is similar to a battery.

A. Fuel cells and batteries both use electrochemical processes to produce electricity. They have similar components, such as an anode, electrolyte and cathode.

Q. Describe how a fuel cell is different from a battery.

A. A fuel cell can operate as long as the fuel is available to the fuel cell stack. A battery has finite energy storage, so it will cease operation once the storage has been exhausted.

Q. Is there other equipment in the fuel cell systems?

A. Yes. Other balance-of-system equipment is needed to operate a fuel cell system, including an inverter to produce AC electricity, gas purge, thermal management components, and other equipment.

Q. Are there different types of fuel cells?

A. Yes. The type of electrolyte, anode and cathode material, ion exchange mechanism, and operating temperature vary depending on the type of fuel cell. There are four major types of fuel cells that have potential for stationary electricity generation: phosphoric acid ("PAFC"); proton exchange membrane

("PEMFC"); molten carbonate ("MCFC"); and solid oxide ("SOFC") fuel cells. The following table summarizes the operating temperatures of various fuel cells.

Fuel Cell Type	Exhaust Temperature
PEMFC	<120°C
PAFC	220°C
MCFC	600°C to 700°C
SOFC	650°C to 1000°C

Q. What is the status of PAFC technology?

A. The PAFC, the most mature of the stationary fuel cells, has been developed for the commercial market by UTC Fuel Cells (formerly International Fuel Cells). Over 200 demonstration projects and commercial installations worldwide of the 250 kW units support a small demand. The high cost, about $4,500 per kW installed, has limited its commercial viability. In addition, UTC Fuel Cells has stated that it plans to end production of the PAFC.

Q. What is the status of PEMFC technology?

A. The PEMFC is under research, development, and demonstration. No commercial units are available. Plug Power, Idatech, Ballard/Ebarra, and Toshiba have pre-commercial products under development.

Q. What is the status of MCFC technology?

A. FuelCell Energy, the only manufacturer of MCFC in the U.S., has built a factory capable of manufacturing 50 MW of fuel cells per year and has installed about 30 units worldwide. System sizes between 250 kW and 1 MW have been designed, built, and tested. FuelCell Energy is currently demonstrating its 250 kW unit for combined heat and power applications at various field test sites. Capital cost is relatively high at about $4,000 per kW.

Q. What is the status of SOFC technology?

A. The SOFC is under research, development, and demonstration. Siemens Westinghouse Power Corp. is developing and demonstrating a tubular SOFC design with several demonstration projects (up to 250 kW) underway.

Q. What advances must occur before fuel cells can be used on a commercial basis?

A. Various challenges must be overcome before commercial application of fuel cells can occur. Further development in membrane durability and reliability in PEMFC and thermal cycling ability, durability, and load following capability in MCFC and SOFC is needed. Advances in fuel purity and significant cost reductions in all fuel cell technologies also must take place. The longevity, reliability and cost of the fuel cell units all must be proven before fuel cells enter into widespread commercial use.

Q. What type of existing fuels could be used in fuel cell operation in Hawaii?

A. The only fuels that could be used with fuel cells operations in Hawaii are synthetic natural gas and propane.

Q. Are there any issues in using these fuels for fuel cells in Hawaii?

A. Yes. Availability at the site, cost and level of contaminants are issues that need to be addressed in detail for the various types of fuel cells. Thus, the infrastructure of the fuel system must also be developed as well as the fuel cell system itself.

Small Wind Turbines

Q. How do wind turbines work?

A. Wind turbines convert the kinetic energy in the wind to mechanical energy and electricity. The movement of air (kinetic energy) turns the blades of a tower-mounted wind turbine, which spin a shaft (mechanical energy) connected to a generator that makes electricity.

Q. Does HECO have experience with wind turbines in Hawaii?

A. Yes. HECO, HELCO and MECO have collaborated on various wind projects throughout Hawaii. These include wind projects are:

- HELCO owns the Lalamilo wind farm on the Big Island (has 17 and 20 kW wind turbines);
- HECO participated in the MOD-OA wind turbine demonstration, which led to an eventual wind farm development at Kahuku;
- Hawaiian Electric Renewable Systems, a one-time sister company to HECO, owned and operated the 12 MW wind farm at Kahuku and 2 MW wind farm at Kahua Ranch;
- MECO operated and maintained a wind turbine at its Maalaea power generating facility for a number of years. Although, the wind machine did have problems, it provided MECO valuable information about the state of this technology; and
- HECO, HELCO and MECO along with the Hawaii Department of Business, Economic Development & Tourism and the U.S. Department of Energy's National Renewable Energy Laboratory funded a project to develop high-resolution wind resource maps for the islands of Oahu, Hawaii, Maui, Molokai, and Lanai.

Q. What are the advantages of wind systems?

A. The advantages of a wind system include: non-polluting, producing no emissions, help reduce the State's use of fossil fuels, proven technology, and equipment and services for wind turbines are commercially available.

Q. What are the disadvantages of wind systems?

A. Wind turbines must be located where winds are strong and accessible so siting and grid interconnection of wind turbines may be challenging, and winds do not blow all the time so wind energy is considered 'intermittent', that is, it comes and goes. Therefore, wind turbines cannot be counted upon to provide energy when we need it. Fluctuating output from wind turbines can negatively impact voltage and frequency of the electric utility system and some people may not like how the wind turbines look and how they affect the landscape.

Q. Can wind turbines provide power on demand?

A. No. The amount of electricity generated by the wind turbine system is dependent on the wind resource at the site. Wind turbine output is highly variable, can be zero or low on calm days, and difficult to accurately predict. Therefore, wind turbine systems may not be able to generate electricity at the instant when it is needed. This is why wind turbine systems are as-available generation sources and not firm generation sources (i.e., generation systems that can be counted upon to generate power when needed).

Q. How can wind turbine systems provide power when the wind is not blowing?

A. Energy storage systems could be used with wind turbine systems to provide power when there is not enough wind to produce the power that is needed.

Q. Are wind turbines with energy storage in commercial use now?

A. A large commercial wind turbine with pumped energy storage is being built in California. This would be the first, large-scale commercial wind/energy storage system in the United States.

Q. How much do small wind turbines cost?

A. As stated on page 1 of HECO, HELCO and MECO's Preliminary Statement of Position, with respect to DG size, "the Companies have not attempted to define 'small' for purposes of this proceeding, but note that 'small' should be construed relative to the utility's system loads, and to the loads of large customers." HECO is not aware of specific definition of capacity rating for the lower limit and upper limit of distributed generation. For the purposes of this discussion on small wind turbines, the size is limited to the wind manufacturer's products; therefore, this would be in the 10 to 30 kilowatt range. It is estimated that a small wind turbine system for a residential application can cost about $1,000 to $3,000 per kW depending on the size, application, and service agreements with the turbine manufacturer.

Q. What are the siting issues with small distributed wind generation?

A. Small DG is sited at or near the customer load. The siting issues related to wind resource, land availability, zoning, bird kills, aesthetics and noise, and interconnection and safety.

Q. What is the issue with wind resource?

A. The performance of the wind turbine system is highly dependent on the available wind resource. The installation site must be in a suitable area with adequate wind speeds and low turbulence. Small wind turbines (e.g., 10 to 30 kW) will start to operate when winds reach about 6-8 mph and generate their rated output at wind speeds of about 26-31 mph. In addition, smooth, non-turbulent winds are needed for stable operation.

Q. What is the issue with land availability?

A. As a rule of thumb, the wind turbine should be mounted on a tower such that the bottom of its blades are at least 30 feet above any obstacle or structure that is within 300 feet of the tower. This is needed to ensure access to smooth, non-turbulent winds. In addition, adequate space is needed to accommodate wind turbine installation and maintenance. These issues are particularly important for small DG applications because of the wind turbine's close proximity to the customer and surrounding structures.

Q. What is the issue with zoning?

A. Zoning restrictions may limit the height of the wind turbine tower and distances to adjoining property lines.

Q. What is the issue with bird kills?

A. Early commercial wind farms on the mainland had experienced bird kills of endangered species. As a result of these bird kills, avian surveys are normally conducted about a one year period or more to learn more about the bird flight and nesting patterns near potential wind sites.

Q. What is the issue with aesthetics and noise?

A. Neighbors of distributed wind turbine systems may have concerns with aesthetics and potential obstructions to views. Concerns about noise levels, especially during the night, may also be raised. The smaller wind turbine blades will spin at a higher revolution per minute than the larger wind turbines, which could lead to higher noise levels.

Q. What is the issue with interconnection and safety?

A. Generating and interconnection systems must be compliant with all applicable safety and performance standards of the National Electrical Code (NEC), Institute of Electrical and Electronic Engineers (IEEE), and accredited testing laboratories such as the Underwriters Laboratories (UL). Where applicable, grid-connected systems must comply with the rules of the Hawaii Public Utilities Commission or other applicable governmental laws and regulations, and the electric utility's Rule 14.H interconnection requirements. This ensures that the wind turbine system is safe and will not negatively impact electric utility operation.

Differences Between Commercial Wind Farms and Small Distributed Generation Wind Turbine Applications

Q. Can you compare the size differences between large and small wind turbines?

A. The following table provides a comparison between large and small wind turbines (see Exhibit-201 for photographs of these wind turbines).

Large wind turbine	Size, kilowatt	Tower Height, Feet	Rotor Diameter, Feet	Total Height, Feet
Vestas	660	164	154	241
GE	1,500	262	229	376
Small wind turbine				
Bergy	10	60	23	72
Fuhrlander	30	110	43	110

Q. What is the fundamental difference between commercial wind farms and DG wind turbine installations?

A. Commercial wind farms are connected to the electric utility grid at transmission or sub-transmission voltage levels for the purpose of providing bulk power to the utility grid (i.e., a large wind farm is like a central station power plant). DG wind turbine systems, on the other hand, are much smaller installations sited at the end-user's location, typically connected at distribution-voltage levels and providing power to the end-user.

Q. Will new transmission or sub-transmission lines be needed to accommodate commercial wind farms?

A. Commercial wind farms, located in remote areas rich in wind resource, may require new power lines if located far away from existing infrastructure.

Q. Will new transmission or sub-transmission lines be needed to accommodate small DG wind systems?

A. Small DG wind energy systems are sited close to the end-user; therefore, they may not require new transmission or sub-transmission lines. Depending on the installation, some equipment upgrades may be required at the DG wind generation site.

Q. Are there other differences between large commercial wind turbine and small wind turbine?

A. In general, most commercial wind farm installations are large megawatt-sized systems where substantial numbers of wind turbines are installed. These wind farms are usually located in areas that have strong, sustainable winds. The trend for wind turbine design and size is moving towards larger megawatt-sized, variable speed wind turbines with power electronics. Thus, taking advantage of economies of scale, these wind farms with large wind turbines can be economically feasible. For DG applications, smaller wind turbines may have to be used. There are only a few wind turbine manufacturers building smaller kilowatt sized units (10 to 30 kW sized wind turbines). These smaller DG wind turbines can be less efficient with simpler designs than the larger wind turbines. Thus, separate studies would be needed to identify the wind resource and evaluate the small wind turbine performance, cost and other impacts with the customer needs.

Q. What has been the trend in the large wind turbine design?

A. Wind manufacturers are moving to larger, megawatt-sized wind turbines. This movement to larger wind turbines is due to a number of reasons: gaining better economies of scale for building large commercial wind farms; scarcity of land; and the move to off-shore wind installations.

Q. Are the large wind turbine designs different from small wind turbine designs?

A. Various types of generators and ancillary equipment are used depending on the wind turbine design and application. Unlike large wind turbines used for commercial applications, small wind turbines do not have sophisticated systems to control operation. For example, small wind turbines use a tail downwind of the turbine blades to keep the turbine facing into the wind.

Q. Is wind resource verification needed for commercial wind farms?

A. For commercial wind farm applications, the magnitude of the capital outlay and other costs for commercial wind farms, wind measurement is required to help confirm the siting and financial projections of the power plant. Wind data and corresponding analysis is needed to secure project financing for commercial wind farms.

Q. Is wind resource verification needed for small DG wind systems?

A. Yes. It is recommended that the wind resource be verified to justify the wind turbine cost and ensure its performance during operation. However, the cost of taking wind measurements can be as much or more than the cost of the wind turbine.

Discussion on Renewable Technology Feasibility and Viability

Q. What is your definition of feasible and viable?

A. As stated on page 1 of HECO, HELCO and MECO's Preliminary Statement of Position, with respect to the definition of feasible and viable, "In order for a form of DG to be 'feasible and viable for Hawaii', it must be

1) Technically feasible;
2) Commercially available;
3) Economically viable (i.e., cost-effective versus other options);
4) Price competitive in the long-term;
5) Sustainable in the long-term; (i.e., backed up by adequate infrastructure support with respect to operation and maintenance and fuel);
6) Able to address site-specific constraints (e.g., with respect to permitting); and
7) Able to meet the perceived needs of customers."

Q. In addition to the renewable DG technologies previously mentioned, are there other renewable DG technologies that some renewable energy advocates consider to be feasible and viable for Hawaii?

A. In general, some renewable energy advocates have mentioned that the following renewable DG technologies are feasible and viable for Hawaii: solar thermal electric, solar hot water, solar air conditioning, PV, individual wind turbines, wind farms, biomass, geothermal, run-of-the stream hydro, pumped storage hydro, advanced battery, and fuel cells.

Q. Do you agree with their position that these renewable DG technologies are feasible and viable for Hawaii?

A. I agree that PV for off-grid applications is feasible, and small wind turbines may be feasible and viable in Hawaii. (Wind farms are also feasible and viable in Hawaii, but are generally not at a customer site for use of the electricity generated, but instead developed to export bulk power to the electric grid.)

Q. Why are the other renewable DG technologies listed not feasible and viable for Hawaii?

A. The following renewable DG technologies are not feasible and viable for Hawaii for the following reasons:

- Solar thermal electric is not commercially available or economically viable, and requires large areas of relatively flat land in a clear sky (i.e., desert sunlight) environment, thus siting could be an issue;
- Solar water heating is not generating electricity at a customer site;
- Solar air-conditioning and seawater air conditioning are not generating electricity at a customer site, not commercially available, and appear not economically viable;
- Grid-connected PV is not economically viable;
- Small biomass is not commercially available and may have fuel storage and emission issues at a customer site;
- Geothermal and run-of-the-stream hydro are site specific, tending to be remotely located and generally not at a customer site for use of the electricity generated, but instead developed to export bulk power to the electric grid;
- Pumped storage hydro tends to be large MW systems that are site specific to the natural features of the terrain. Often these pumped storage systems are located in isolated areas thus they would not be serving a customer electrical need, but instead developed to export bulk power to the electric grid;
- Advanced batteries are not commercial or economically viable at this time; and

- Fuel cells and its fuel infrastructure are not commercially available or economically viable at this time.

Policies and Incentives for Renewable Energy Development

Q. What is the state energy policy in Hawaii?

A. The state energy policy has four objectives:

1) Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;
2) Increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased;
3) Greater energy security in the face of threats to Hawaii's energy supplies and systems; and
4) Reduction, avoidance, or sequestration of greenhouse gas emissions from energy supply and use.

Q. Are there other policies that can support renewable energy development in Hawaii?

A. Yes. Besides the renewable energy tax credits, the state has two laws to help renewable energy development in Hawaii: net energy metering ("NEM", Hawaii Revised Statues, Chapter 269, 101 to 111) and renewable portfolio standards ("RPS", Hawaii Revised Statues, Chapter 269, 91 to 94).

Q. Can you explain what NEM is and provide an update on the number of installations and type of renewable technology reported using the NEM law?

A. NEM means that any kilowatt-hours your renewable energy generator produces and feeds back into the grid will be subtracted from the kilowatt-hours of electricity you obtain from your utility to determine the net amount of kilowatt-hours. You will be billed only on the net kilowatt-hours (kilowatt-hours from utility minus kilowatt-hours self-generated equals net kilowatt-hours). The NEM law for renewable technology (solar, wind, biomass, hydroelectric or combinations of these technologies) took effect in mid-2001 for installations 10 kilowatts or less. At the end of 2003, the number of reported NEM installations was 31 for HECO, HELCO and MECO systems (total of about 92 kilowatts). All of these installations used PV systems and the average size was less than three kilowatt.

Q. Can you explain what RPS is and provide an update on the level of renewable energy as part of the RPS law?

A. In general, a RPS is designed to require that a specified percentage of the electricity sold by electric utilities be generated from renewable sources such as wind, solar, geothermal, hydropower, biomass and other renewable resources by a specified date. The RPS law, which also took effect in mid-2001, set a RPS goal of 7% in 2003, 8% in 2005 and 9% in 2010. At the end of 2003, the RPS level reported by HECO, HELCO and MECO was over 8%.

Q. Have the NEM and RPS law been updated recently?

A. Yes. The 2004 Legislature updated the NEM and RPS laws to further help renewable energy development in Hawaii. In general, these updates were as follows:

- The allowable size of renewable energy technologies in the NEM law has been increased from 10 kW to 50 kW; and
- The RPS law was updated to increase renewable energy level to 10% by the end of 2010, 15% in 2015, and 20% in 2020. The RPS renewable energy definitions were expanded to include all of the following: wind; solar energy;

hydroelectric; landfill gas; waste-to-energy; geothermal; ocean thermal energy conversion ("OTEC"); wave energy; biomass including municipal solid waste ("MSW"); biofuels; hydrogen; fuel cells; and energy savings by solar and heat pump water heating; seawater air-conditioning; solar air-conditioning; ice storage; quantifiable energy conservation, and rejected heat from co-generation and combined heat and power systems (excluding central station power plants and large independent power producers).

Q. Can you state why a fossil-fueled technology such as heat from co-generation (i.e., combined heat and power) was included in the RPS renewable energy definition?

A. The goal of the RPS is to ultimately reduce the use of fossil fuels. Technologies like combined heat and power, while using fossil fuel, can result in meeting electrical and thermal energy needs by using less oil. Specifically, the value of combined heat and power is derived from the recovery of waste heat that would otherwise be wasted. The use of this waste heat makes it a "reusable" energy source that displaces fossil fuels. The Legislature took a big picture view and recognized the benefits of saving energy. That's why the RPS law expanded the definition of renewable energy to include the energy saved from efficient generation technologies such as combined heat and power, as well as district cooling, ice storage and energy conservation measures.

Q. What types of tax incentives are available that support renewable energy development in Hawaii.

A. The federal government offers investment tax credits for wind and geothermal. However, the wind and biomass production tax credits for wind and closed-loop biomass expired in December 2003. Efforts are currently being made to extend these tax credits and introduce other incentives in the current Congressional session. The renewable projects can also use accelerated depreciation. The State of Hawaii offers wind and solar income tax credits.

Q. Are there other incentives that support renewable energy development in Hawaii?

A. Yes. The federal government can provide research grants for renewable energy projects. Examples of renewable projects using federal grants are: MOD-OA wind turbine installation and testing at Kahuku, geothermal drilling, testing, and evaluation at Puna on the Big Island and photovoltaic installation at Mauna Lani Hotel on the Big Island.

Q. Have you testified before on HECO's renewable energy development?

A. Yes. In the 2004 Legislative session, HECO, HELCO and MECO presented and discussed its effort in renewable energy development. See Exhibit-201 for details.

Q. Can you provide a general summary of this Exhibit?

A. Yes. HECO, HELCO and MECO have a strategy to increase renewable energy development in Hawaii. The strategies are:

- Pursue commercially available renewable energy generation in the near term (including activities that can increase the number of intermittent renewable energy technologies (i.e., wind, etc.) on the electric grid; and
- Invest in research, development and demonstration for emerging technologies and resources that are not currently commercially available or economically viable in the near term.

<u>Concluding Comments</u>

Q. Do you have any closing comments?

A. Yes. The following is a summary of my closing comments:

1) Renewable DG was addressed by providing background, descriptions and

issues related to various renewable technologies. In general, most renewable technologies are not commercially available, economically viable or can not be customer-sited;

2) PV for off-grid applications is feasible and small wind may be feasible and viable in Hawaii. As the renewable energy technologies improve and cost is reduced, they may increase in their application for DG renewable energy;

3) Renewable DG should be treated as small renewable technology that can reduce customer load at the customer or end-user site and not be confused with large commercial renewable technologies (i.e., large wind farm which is similar to a central power plant) delivering power to the utility grid;

4) HECO, HELCO and MECO have in the past, and will continue in the future, to support the increased use of renewable energy resources to meet Hawaii's energy needs. Exhibit-201 summaries these strategies to increase renewable use; and

5) There are a number of policies and incentives for renewable energy development: federal and state government tax credits (to help buy-down the cost of renewable technologies); and state laws such as net energy metering and renewable portfolio standards (to help stimulate renewable development).

Q. Does this conclude your testimony?

A. Yes it does.