DIRECT TESTIMONY OF N. RICHARD FRIEDMAN

Q. What is your name, affiliation and role in this proceeding?

A. My name is N. Richard Friedman. I am Chairman & Chief Executive Officer (CEO) of the Resource Dynamics Corporation headquartered in Vienna, Virginia. My address, telephone number and e-mail address are 8605 Westwood Center Drive, Suite 410, Vienna, Virginia 22182, Phone: (703) 356-1300 x203, E-mail: nrf@rdcnet.com. I have been engaged by Kauai Island Utility Cooperative (KIUC) as a consultant and expert witness in the field of distributed generation. My professional and educational background is described in Exhibit No. KIUC-200.

Q. Have you addressed all the issues noted in Docket No. 03-0371?

A. All issues relevant to KIUC have been addressed in my testimony. Exhibit No. KIUC-201 cross-references the issues posed in the docket by Prehearing Order No. 20922 to the testimony responses provided herein and their page numbers.

Q. Please list the key points you intend to present in your testimony.

A. The key elements of my testimony include:

- The technology status of distributed generation (DG);
- The generation capacity situation on Kauai;
- Ownership of DG;
- Which DG technologies are feasible for Hawaii;
- Interconnection of DG; and
- Backup power charges to customers with DG.

Q. What is the status of DG technology today?

A. DG should be viewed as a potential electrical energy supply resource that can be economically applied under the correct conditions. Both the technology and its commercial availability are evolving.

Q. Please describe the generation capacity situation in Kauai.

A. All of the Hawaiian Islands are isolated electrical systems, consisting of generation, transmission and distribution. KIUC has built sufficient generation capability to offer reliable power supply to its members and customers, and is not projecting a need for new generating capacity to meet load until 2012. As a result of this situation, no new generating capacity is now needed on Kauai. If DG is built by KIUC's customers on Kauai, this customer owned and interconnected DG will likely have a significant impact on operations and system stability due to lightly loaded feeders. KIUC will have difficulty absorbing the impact of these lost revenues. KIUC's members and customers will as a result individually experience greater costs to absorb these lost revenues, either through increased rates, or, for members, through a decrease in patronage capital refunds/credits.

Q. What is the significance of this capacity situation on Kauai in terms of DG ownership?

A. If generation is to be built on Kauai, even though no new capacity is needed, KIUC ownership of DG would offer certain benefits; all the cooperative's members and customers will share in any costs and benefits (and members in any profits through patronage capital refunds/credits), payments to support the revenue requirement planned for any T&D system upgrades would be maintained, and the KIUC system would gain another generation resource, increasing overall system flexibility. With this in mind, utility ownership of DG projects should be allowed and even encouraged on Kauai. In this case, KIUC and its members and customers could also benefit from the strategic deployment of DG around the island to optimize the design and operation of the T&D system.

Q. Could you summarize which DG technologies are feasible and viable for Hawaii?

A. No general determination of what DG technologies are feasible and viable for either Hawaii or Kauai can be made at the current time except on a case-by-case basis. The same situation pertains nationwide.

Q. Please describe the impacts of interconnecting a DG unit with the KIUC distribution system?

A. From a technical perspective, any time the owner/operator of a DG project seeks interconnection with KIUC's grid, KIUC is obligated to consider impacts on personnel and public safety and system stability. KIUC's T&D system was originally designed for the one-way flow of power, i.e., from the generators to the customer. In assessing system performance in the case of two-way power flow, KIUC must study the impacts as well as prescribe specific requirements for protective relaying, grounding, coordination and other factors as needed. The engineering and system impact studies are intended to assess the need for any system modifications or upgrades needed to accommodate the DG. Both the cost of the engineering study, and any system modifications and upgrades should be the responsibility of the DG owner/beneficiary. Of course, if KIUC is the owner, then all members and customers will share in these costs and any resulting benefits as mentioned above.

Q. How do backup/standby charges apply to a customer who has installed DG?

A The situation could arise in which a customer installs DG and only remains a customer or member of KIUC in order to obtain backup and maintenance power. In such a case, as further discussed below in my testimony, in order to be fair to all members and customers of the cooperative, KIUC would apply a standby tariff based on the cost of providing this backup service, including the actual cost of reserving capacity for the DG customer's use when needed. KIUC's "Rider S", although outdated, is currently available for this purpose. A similar argument applies to exit fees that an end-user should pay if they decide to entirely quit the system.

Q. How would you define DG in terms of this proceeding?

A. DG has been defined for purposes of this proceeding (in Order No. 20582) as involving the "use of small-scale electric generating technologies installed at, or in close proximity to, the end-user's location." The meaning of "small scale" warrants some discussion. The NRECA "Business and Contract Guide for Distributed Generation (DG) Interconnection, March 2002"[1] covers systems up to 3 megawatt (MW), seen as a logical break for small-scale projects. However, in terms of a small, isolated system such as may exist on the island of Kauai, even a 3 MW unit would be a large project on almost any of KIUC's distribution feeders when compared to the peak load being served. Thus, I would favor not assigning a size range to DG, but retaining the flexibility to evaluate a project in terms of its

[1] The Business and Contract Guide is part of the NRECA DG Toolkit. The complete Toolkit is available at http://www.nreca.org/nreca/Policy/Regulatory/DGToolkit/index.html.

impact on feeder peak demand. In any case, a large combined heat and power project (CHP) of tens of megawatts would escape the definition of DG.

This DG definition would also exclude wind farms and other forms of DG located in remote locations with long distances to the loads being served.

Q. Are you aware of any special characteristics of Kauai or with KIUC that may impact the deployment of DG?

A. Yes. As mentioned above, all of the Hawaiian Islands are isolated electrical systems, consisting of generation, transmission and distribution. Kauai is an isolated system with a current peak electrical demand of approximately 72 MW, with no interconnections with other systems for emergency and economy power exchanges as typically found with mainland transmission systems. With no capability to receive backup and emergency power from other systems, KIUC is required to build, operate and maintain a stand-alone system of generators capable of serving the island's peak load, while meeting the "adequacy of supply" criteria specified by the Public Utilities Commission in General Order No. 7, i.e., "The generation capacity of the utility's plant, supplemented by electric power regularly available from other sources, must be sufficiently large to meet all reasonably expectable demands for service and provide a reasonable reserve for emergencies." On Kauai, no "electric power regularly available from other sources" exists, thereby compelling KIUC to build sufficient generation capability to offer reliable power supply to its members. KIUC owns approximately 123 MW of capacity on Kauai, sufficient to sustain the loss of the single largest unit during its annual peak load, and also the loss of both the largest unit and the third largest unit to scheduled maintenance during morning peak hours. Additionally, as mentioned above, KIUC is projecting no need for new generating capacity to meet member load until 2012.

The small isolated nature of Kauai affects the potential structure of the electric system and the use of DG within the system. KIUC serves an average of 23 customers per mile of transmission and distribution system lines, and KIUC's total annual revenue is less than $100 million, characteristics of a small generation and T&D system. Accordingly, DG will likely have a significant technical impact on KIUC's operations and system stability due to lightly loaded feeders, and KIUC will have difficulty absorbing the impact of lost revenues due to a customer leaving the system. KIUC's members and customers will also experience greater costs as mentioned above, including for members the reduction in or loss of potential patronage capital refunds/credits.

Finally, the relatively small size of the entire electric system means that a single customer can potentially materially affect the entire cooperative. For example, a 3 MW turbine installed at a hotel resort represents a significant percentage of the 72 MW peak demand of KIUC's entire system.

Q. Are there any opportunities for DG in spite of Kauai's capacity situation?

A. Yes. The above concerns being noted, there may be opportunities to install DG to serve new loads located at the end of a long feeder or remote customer loads if the feeder is already or will become heavily loaded as a result of the new load addition. However, if existing feeder capacity is sufficient, DG may not offer any significant benefits to utility operations. Further, DG may be used to support voltage requirements and other distribution system ancillary services, provided KIUC is able to control the operation of the unit (which argues in favor of KIUC ownership of any DG located on the island).

Q. How does KIUC's status as a cooperative affect the use of DG on Kauai?

A. KIUC is the only electric cooperative in Hawaii, with about 29,000 member-consumers. As a cooperative, KIUC has special characteristics that can impact its response to DG. In particular, as a member-owned cooperative, KIUC is guided by a set of seven principles that reflect the best interests of its members:

A. Voluntary and Open Membership — Cooperatives are voluntary organizations, open to all persons able to use their services and willing to accept the responsibilities of membership, without gender, social, racial, political, or religious discrimination.

B. Democratic Member Control — Cooperatives are democratic organizations controlled not by investors, but by the cooperative's members who use the cooperative's services. The members actively participate in setting policies and making decisions. The elected representatives on the cooperative's Board of Directors are accountable to the membership.

C. Members' Economic Participation — Members contribute equitably to, and democratically control, the capital of their cooperative. Money left over after KIUC's bills are paid each year (the margin between income and expenses) is designated as the members' patronage capital. These net margins are distributed annually to all members in the form of cash or credits to the member's patronage capital account, or any combination thereof, in proportion to the value or quantity of the services purchased by the member from KIUC during the applicable fiscal year.

D. Autonomy and Independence — Cooperatives are autonomous, self-help organizations controlled by their members. If the cooperative enters into agreements with other organizations, including governments, or raises capital from external sources, the cooperative does so on terms that continue to ensure democratic control by their members and that maintain their cooperative autonomy.

E. Education, Training, and Information — Cooperatives provide education and training for their members, elected representatives, managers, and employees so they can contribute effectively to the cooperative's development.

F. Cooperation Among Cooperatives — Cooperatives serve their members most effectively and strengthen the cooperative movement by working together through local, national, regional, and international structures. The National Rural Electric Cooperative Association supports KIUC's efforts, including sharing the results of DG planning and R&D efforts.

G. Concern for Community — While focusing on member needs, cooperatives work for the sustainable development of their communities through policies accepted by their members.

As a result of the above principles, KIUC does not have to satisfy the needs of any shareholders, nor deal with the natural tension that exists between shareholders and ratepayers. Instead, KIUC seeks to meet the needs of its member-consumers. Thus, as it applies to DG, all the cooperative's members will share in any costs or revenues associated with a DG unit that is owned and operated by KIUC and installed at a member's location.

Q. You indicated that DG is evolving. Please describe the main DG technologies available today.

A. DG has been deployed using several technologies since the 1920s. The main technologies are reciprocating internal combustion engines, combustion turbines including microturbines, steam turbines, fuel cells, hydropower, wind turbines, and photovoltaics. As further discussed below, varying characteristics make some technologies more suitable than others for DG, depending on the installation application and site.

<u>Reciprocating Internal Combustion Engines</u>

Reciprocating engines, developed more than 100 years ago, were the first of the fossil fuel-driven DG technologies to be widely employed. Both Otto (spark ignition) and Diesel cycle (compression ignition) engines have gained widespread acceptance in almost every sector of the economy and are in applications ranging from fractional horsepower units powering small hand-held tools to 30 MW baseload electric power plants. Reciprocating engines employ pistons that move back and forth in cylinders. Smaller engines (less than 2 MW) are primarily designed for land transportation applications but can be converted to power generation with little modification. Larger engines are, in general, designed for power generation, mechanical drive, or marine propulsion. Reciprocating engines are currently available from many manufacturers in all DG size ranges. For DG applications, reciprocating engines offer low costs and good efficiency, but maintenance requirements are high. CHP configurations are available with heat recovery from both the gaseous exhaust and from water and oil jackets.

Combustion Turbines

Combustion turbines have been used for power generation for decades and range in size from small microturbines to large utility-sized turbines over a hundred MW. Units from 1-15 MW are generally referred to as industrial turbines, a term which differentiates them from larger utility grade turbines and smaller microturbines. Microturbines are manufactured in the 30 to 100 kW range. Combustion turbines have relatively low installation costs, low emissions, heat recovery through steam and infrequent maintenance requirements, but low electric efficiency. With these traits, combustion turbines are typically used for CHP when a continuous supply of steam or hot water and power is required, as peakers (limited yearly operating hours), and in combined cycle configurations (exhaust heat used for additional power generation).

In a combustion turbine, air is compressed and a gaseous or liquid fuel is burned at pressure to raise the air temperature. The combustion products are expanded directly through the blades in a turbine to drive an electric generator. The compressor and turbine in industrial combustion turbines usually have multiple stages and axial blading. This differentiates them from smaller microturbines that have radial blades and are single staged.

Steam Turbines

Steam turbines were invented in 1884 by Charles Parsons as an alternative to the reciprocating steam engines that dominated that era. Steam turbines generate rotary motion directly, and are extensively used in installations in the 10-60 MW range. Steam turbines were brought to America in the early 1900s for power generating applications. Steam turbines operate in much the same way as industrial combustion turbines, except steam is the operating fluid. Instead of using a combustor, a high-pressure boiler is used to generate steam. Water is pumped into the boiler and is evaporated at high temperature and pressure, creating the steam that enters the turbine. The high velocity steam causes the turbine blades to rotate, creating power that can easily be converted into electricity. A condenser and pump are used to collect the leftover steam, turn it back into liquid water and feed it into the boiler, completing the cycle.

Fuel Cells

A fuel cell consists of two electrodes (an anode and a cathode) separated by an electrolyte. Hydrogen fuel is fed into the anode, while oxygen (or air) enters the fuel cell through the cathode. With the aid of a catalyst, the hydrogen atom splits into a proton (H+) and an electron. The proton passes through the electrolyte to the cathode, and the electrons travel through an external circuit connected as a load, creating a DC current. The electrons continue on to the cathode, where they combine with protons and oxygen, producing water and heat.

Most of the currently installed fuel cells are manufactured by UTC Fuel Cells (formerly International Fuel Cells), the major manufacturer of commercially available fuel cells, and are 200 kW phosphoric acid-type fuel cells. Other fuel cell technologies are being developed which differ primarily in the electrolyte employed, and may be sized for smaller residential and commercial applications. Each different electrolyte has both benefits and disadvantages, based on materials and manufacturing costs, operating temperature, achievable efficiency, power to volume (or weight) ratio, and other operational considerations. The part of a fuel cell that contains the electrodes and electrolytic material is called the "stack," and is a major component of the cost of the total system.

Fuel cells require hydrogen for operation. However, it is generally impractical to purchase hydrogen as a fuel. It is most commonly extracted onsite from hydrogen-rich sources such as gasoline, propane, or natural gas using a reformer. Fuel cells have had difficulty gaining market share due to their relatively high capital cost.

<u>Hydropower</u>

Hydropower converts the energy from water flowing downhill into electricity using a spinning turbine that drives a generator. Hydropower was one of the earliest electric generation technologies, dating back to the 19th century. However, it necessarily has limited DG potential because most hydropower production cannot be used near the water source. A small number of DG hydropower units exist. More importantly, some low head hydro and run-of-river DG projects are being installed today.

<u>Wind Turbines</u>

Wind turbines are packaged systems that include the rotor, generator, turbine blades, and drive or coupling device. As the wind blows through the blades, the air exerts aerodynamic forces that cause the blades to turn the rotor. Most systems have a gearbox and generator in a single unit behind the turbine blades. The output of the generator is processed by an inverter that changes the electricity from DC to AC so that the electricity can be used. Most of the turbines in service today have a horizontal axis configuration. Wind conditions limit the amount of electricity that wind turbines are able to generate, and the minimum wind speed required for electricity generation determines the turbine rating. Generally, the minimum wind speed threshold is attained more frequently when the turbine is placed higher off of the ground. Also important to consider when siting a wind turbine is the terrain. Coastlines and hills are among the best places to locate a wind turbine, as these areas typically have more wind. The intermittent nature of wind limits its full-time use.

Photovoltaic (PV)

PV solar panels are composed of discrete cells connected together that convert light radiation into electricity. The PV cells produce direct-current (DC) electricity that is normally converted from DC to AC using an inverter. In some instances, additional power conditioning equipment may be required if the solar panel is connected to the electric grid. The available solar energy that can be converted to electricity depends upon the intensity of the light and the operating temperature of the PV cells. Another major factor is the position of the solar panel. In order to maximize light intensity, the panel should be positioned to maximize the duration of perpendicular incident light rays.

* * * *

A number of observations can be made regarding the state of DG technology today:

- Technology improvements have increased commercial availability and use of microturbines and fuel cells.
- Many smaller users have been installing renewable energy systems, especially under state sponsored net metering programs.
- The number of DG manufacturers has been increasing. Caterpillar, Cummins, Waukesha Engine Dresser, and Wartsila, among others, continue to produce reciprocating engines of all sizes. Plug Power, IdaTech and others have joined UTC Fuel Cells in targeting potential fuel cell users. Capstone and Turbec are selling microturbines, and these units are beginning to compete with General Electric, Siemens, Rolls

Royce, Solar and other firms in the combustion turbine market.

Q. What are the economics of the most common technologies, and how has this influenced DG use in various applications?

A. The economics of common DG technologies are compared in Exhibit No. KIUC-202.

Nationally – with their higher installed capital cost – fuel cells, photovoltaics, and wind have been deployed relatively infrequently compared to reciprocating engines and combustion turbines. Since only the renewables (PV and wind) create an opportunity to significantly reduce the use of fossil fuels, these high capital costs suggest DG's impact in reducing fossil fuel consumption in Kauai is limited. Nonetheless, as these more expensive technologies develop further, economies of scale may make their use more common.

No general determination of what DG technologies are feasible and viable for either Hawaii or Kauai can be made at the current time except on a case-by-case basis. The same situation pertains nationwide.

Q. Could you describe the main DG applications today?

A. There are 6 main types of market applications today: baseload non-CHP, baseload CHP, peaking, spinning, non-interconnected emergency/standby, and other non-interconnected units used for various operations. Each is described below:

<u>Baseload Power</u>

In this application, the DG technology is operated most of the year to allow a facility to generate some or all of its power on a relatively continuous basis.

Important DG characteristics for continuous power include:

- High electric efficiency,
- Low variable maintenance costs, and
- Low emissions.

Currently, DG is being utilized most often in a continuous power capacity for industrial applications in facilities with low thermal demands. Commercial sector usage, while a fraction of total industrial usage, includes sectors such as grocery stores, hotels, and hospitals, usually in facilities where the building has a heating, ventilating, and air conditioning system that makes cogeneration installation costly or there is little need for space conditioning.

<u>Combined Heat and Power (CHP)</u>

Also referred to as Cooling, Heating, and Power or cogeneration, this DG technology is operated most of the year to allow a facility to generate some or all of its power. A portion of the DG thermal output is used for water heating, space heating, steam generation or other thermal loads. In some instances, this thermal energy can also be used to operate cooling equipment. Important DG characteristics for combined heat and power include:

- Readily recoverable thermal output,
- Low variable maintenance costs, and
- Low emissions.

CHP characteristics are similar to those of baseload power, and thus the two applications have almost identical customer profiles, although the high thermal demand necessary for CHP is not a requisite for baseload applications. As with baseload applications, CHP is most commonly used by industrial clients, with a small portion of overall installations in the commercial sector. Because of their superior life-cycle economics, CHP applications are much more common than baseload applications.

Peaking Power

In a peaking power application, DG is operated to reduce overall electricity costs, but the DG is not operated on a continuous basis. Units can be operated to reduce the utility's demand charges, to defer buying electricity during high-price periods, or to allow for lower rates from power providers by smoothing site demand. Important DG characteristics for peaking power include:

- Low installed cost,
- Quick startup, and
- Low fixed maintenance costs.

Peaking power applications can be offered by energy companies to clients who want to reduce the cost of buying electricity during high-price periods.

Spinning Reserve

A limited amount of DG units are applied as spinning reserve for electric grid support. They may operate anywhere from a few hours per year to nearly full-time, yet produce relatively little generation. Most are owned and operated by municipals or rural electric cooperatives. Many are located at substations.

Premium Power

DG may be used to provide "premium" electricity service at a higher level of reliability and/or power quality than is typically available from the grid. Customers typically demand uninterrupted power for a variety of applications, and for this reason, premium power is broken down into three categories:

Emergency/Standby Power System - This is an independent system that automatically provides electricity within a specified time frame to replace the normal source if it fails. This system is used to power equipment whose failure would result in the shutdown of business operations and/or threatened health and safety. Customers include apartment, office and commercial buildings, hotels, schools, and a wide range of public gathering places.

Safety and Security Power System - This independent system provides electricity to replace the normal source if it fails and thus allows the customer's entire facility to continue to operate satisfactorily. Such a system is critical for clients including airports, fire and police stations, military bases, prisons, water supply and sewage treatment plants, natural gas transmission and distribution systems and dairy farms.

Mission Critical Power System - Clients who demand uninterrupted power, free of all power quality problems such as frequency variations, voltage transients, dips, and surges, use this system. Power of this quality is not available directly from the grid – it requires both auxiliary power conditioning equipment and either emergency or standby power. Alternatively, a DG technology can be used as the primary power source and the grid can be used as a backup. Premium power systems are used by mission critical systems like airlines, banks, insurance companies, communications stations, hospitals and nursing homes.

The growing premium power market may present the utility with an opportunity to provide a value-added service to their customers.

Important DG characteristics for premium power applications are summarized in Exhibit No. KIUC-203.

<u>Other Non-Interconnected</u>

A number of DG units greater than 1 MW in size are used in the field in either temporary or non-permanent locations. As such, they are not interconnected with the grid. Primary applications of these DG units include special operations such as offshore oil platforms, oil field drilling, entertainment sites (e.g., Hollywood sets, circuses, county fairs), construction sites, and other temporary or mobile applications. Many of these DG units are designed to be transported by truck or rail to the job site. Fuel is provided either by temporarily connecting a gas line or via tanked storage.

Q. How much DG has been installed in the U.S.?

A. Table 1 below provides an indication of the relative size of the DG market by application, as of the end of 2003. As noted therein, the largest market application is emergency/standby generators, which are generally operated independently and are not interconnected with a utility grid. CHP is the largest interconnected market application, due to its frequently superior efficiency and associated operational economics.

Table 1. U.S. Installed DG Capacity 2003

Gigawatts (GW)

Category	GW
Baseload	4
CHP	22
Peaking	6
Spinning reserves	1
Emergency/standby non-interconnected	188
Other non-interconnected	13
Total DG	234

Source: *The Installed Base of U.S. Distributed Generation, 2004 Edition,* Resource Dynamics Corporation, Vienna, Virginia.

Q. How would ownership of the DG unit affect KIUC's member-consumers and customers?

A. As noted earlier in my testimony, KIUC has built sufficient generation capability to offer reliable power supply to its members and customers, and is not projecting a need for new generating capacity to meet load until 2012. If generation is to be built on Kauai, even though no new capacity is needed, the DG unit may be owned by 1) individual end-use customers, 2) third party investors, or 3) KIUC. A customer may be interested in installing their own generation to lower costs and/or improve reliability. For the reasons discussed above, this option may be most attractive to the customer in the case of CHP applications where a significant thermal load may be served by the DG unit, as in the case of a large hotel complex. In some cases, a third party might approach a resort hotel and offer to provide them power for a rate lower than the applicable KIUC tariff. In either case, the hotel would own or lease, operate (or pay for operation as part of their power rate), and in most cases control output from the DG unit.

In the above situation, it is likely that the hotel would remain a member or customer of KIUC in order to receive backup and maintenance power when needed. An open issue here is the rates that KIUC should charge the customer for backup/standby power when needed, especially when KIUC must 1) reserve a fixed amount of generating capacity for this customer, 2) maintain the transmission and distribution system to serve this customer when needed, and 3) still meet its revenue requirement necessary for T&D construction and its operations with reduced revenues from the hotel. In this case, the revenue requirement must be spread over the remaining smaller customer base, thereby incrementally increasing costs for all other members and customers. All other cooperative members and customers would then have to pay more to cover the utility's fixed costs, including costs associated with the T&D system. The hotel, if still a customer of KIUC, would also see the resulting increased costs (and if still a member, would see the corresponding reduction in patronage capital refunds/credits), which would most likely not be anticipated or taken into consideration by the hotel when the DG/CHP feasibility study was conducted.

This is not to say, however, that the customer would not see any benefits in the above application. It is just that these realized benefits from electricity generation might be limited by other factors. For example, the customer may end up paying higher fuel costs due to the loss of the buying power of the cooperative, maintenance and repair expenses, and replacement (backup/standby) power. The customer would also have to either rely on a relatively unknown third party for equipment operation and maintenance (O&M), or train its own staff to conduct the O&M. Further, if the customer is a KIUC member, they would see a material reduction in their patronage capital refunds/credits. Nevertheless, the customer would gain control of the generator output, and may benefit from the thermal output of the unit. The detailed customer economics of whether the DG is feasible for that customer's purposes must be determined on a case-by-cases basis.

Perhaps most significantly, only the hotel, in this example, would benefit from the installation of the DG project. Any savings would only accrue to the hotel, and no benefit would be realized by the KIUC system (or any of KIUC's other members or customers) from the increased supply diversity represented by the DG installation.

It must also be kept in mind that since Kauai is an isolated system, there is no real market to which the customer could sell excess power, especially because KIUC already has a sufficient generation capacity margin. As such, the purchase of excess power from the customer would have little to no benefit to KIUC's other members and customers.

However, if KIUC owned the DG unit, all the cooperative's members and customers will share in the costs and benefits (and the members in any profits), payments to support the revenue requirement planned for any T&D system upgrades would be maintained, and the KIUC system would gain another generation resource, thereby increasing overall system flexibility. KIUC could then negotiate a business arrangement with the hotel allowing them to share in the benefits flowing from DG unit operation. The customer would also benefit from having the DG unit operated by KIUC staff with generation equipment O&M experience. However, it should be noted that general policies that require KIUC to always share presumed cost savings with end-users who install DG are inappropriate. Instead, any sharing of savings should be based on actual cost reductions to KIUC that are site dependent.

With KIUC ownership, an additional benefit to members and customers would result from KIUC having control over the operation of the DG unit. In addition to the increased diversity of supply, KIUC would gain the value of ancillary services such as voltage support.

In light of the above discussion, utility ownership of DG projects should be allowed and even encouraged on Kauai. In this case, KIUC and its members and customers could also benefit from the strategic deployment of DG around the island to optimize the design, operation and diversity of KIUC's T&D system.

Q. Which technologies might work best in Kauai?

A. As noted earlier in my testimony, any of the common DG technologies could be implemented on Kauai, depending on specific site and operational characteristics, fuel availability and environmental impacts. Generally, technology options with the following characteristics would be best for KIUC and its members and customers:

A. Dispatchable,

B. Reliable and constant supply source (the intermittent nature of renewables is a concern),

C. Fully-commercialized technology with responsive after-sale service support, and

D. Special treatment of renewables may be warranted due to their lower emission levels; CHP may also be attractive due to its higher efficiency.

Dispatchable units controlled by KIUC can be used when and as often as needed to handle peak demand periods and any system emergencies. This could also help defer any T&D system upgrade costs if the DG unit is strategically located on the grid.

A reliable and constant fuel supply source is an important characteristic of KIUC's existing generation, and any DG units integrated into the KIUC supply system should have this same characteristic. The generation needs to be available when called upon.

Fully commercialized technology is inherently more proven and reliable than experimental technologies. Similarly, strong service support, including availability of spare parts and technical expertise on a local basis, is a necessary component of a reliable system.

Using renewables and CHP can directly lead to lower air emissions, offering a positive societal benefit. The intermittent nature of renewables is a concern, however, and options for incorporating energy storage into renewable system design may be useful to explore.

Q. What impacts would DG have on the T&D system?

A. The impacts of interconnected DG units on the T&D system are very real. These impacts must be evaluated on a case-by-case basis, requiring careful engineering study. Typically, the larger the DG unit, the more impact it will have on the system.

It should be noted that KIUC's T&D system was originally designed for the one-way flow of power, from the generators to the customer. As such, integrating DG into this system can complicate system operations and offer unexpected impacts affecting system stability and personnel and customer safety, thus necessitating the need for engineering and system impact studies to determine any system modifications or upgrades that may be required to accommodate the DG.

Impacts from DG will also arise due to the cost of the engineering study and any resulting system modifications and upgrades needed to interconnect the DG units to the T&D system. These costs should be the responsibility of the DG owner/beneficiary. That is, such costs should not be borne by all of the cooperative member-consumers/customers, but only those that directly benefit from the DG. This policy is applied in nearly all the states. Of course, if KIUC is the owner, then all customers would share in these costs and any resulting benefits (and members in any profits through patronage capital refunds/credits).

Sometimes, DG can lower T&D costs, or at least allow the deferral of upgrades to existing T&D investment. This is a prime motivator for many cooperatives and other utilities to encourage the use of DG. To achieve these savings, however, the DG must be located at a constrained substation or along a feeder where it can be used to support the grid. As a result, the availability of these benefits are highly variable and site specific.

In the short run, distributed generation deployment may result in only minimal cost savings at best due to a small reduction in transmission line losses from providing generation at the customer location rather than having to transmit bulk energy over long distances. In the long run, DG may result in a tangible benefit if the utility will not be required to build or can delay the building of its next large increment of power plant or T&D facilities as a result of the DG.

Also, by distributing the generation sources geographically, DG can increase overall system security, from both natural disasters and from a terrorist attack perspective. In fact, the U.S. Department of Homeland Security may eventually require state or local plans to be put in place that increase the security of electric systems.

Q. What are the economic impacts of DG on the member-consumers and customers of KIUC?

A. When an end-user deploys a DG unit, they will pay KIUC less revenue because they will be purchasing less power from the cooperative. As indicated above, all other cooperative members and customers will then have to pay more to cover the utility's fixed costs, including costs associated with generation and the T&D system

In addition, KIUC's members and customers would also be impacted if they were required to pay for, or in other words subsidize, all costs associated with accommodating the interconnection of the DG unit. To avoid this, as mentioned above, it is KIUC's position that the particular DG owner/beneficiary should be required to pay for all costs associated with accommodating the interconnection of the DG unit.

Finally, KIUC believes that nearly all DG end-users will expect to be provided power from KIUC as a backup service to their own generation. This backup power might be purchased during peak demand periods, or as a backup when the DG unit is being maintained or is otherwise out of service. Since the wires, transformers, switches etc. for these two-way power flows must continue to be sized by KIUC to meet the full power demand of the end-user, grid costs will not decrease for KIUC even though their resulting revenue will decrease as a result of the end-user's use of less power from KIUC. To address this and to be fair to all members and customers of the cooperative, KIUC has a "Rider S, Standby, Auxiliary, Supplementary or Breakdown Service for Customers with Demands of 30 Kilowatts or More", which was established by its predecessor and designed to reflect the then cost of providing this backup service, including the actual cost of reserving capacity for the DG customer's use when needed. A similar argument applies to exit fees that an end-user should pay if they decide to no longer interconnect with KIUC's grid.

Q. Please elaborate on issues that must be considered when interconnecting DG with the KIUC grid?

A. Because of the above noted system and economic impacts, there are a number of primary issues that must be considered when interconnecting the DG unit to KIUC's grid. These include, without limitation:

- Personnel and public safety.
- System stability.
- Relevant standards to be applied (e.g., IEEE 1547).
- Need for early notification to the utility by a customer of his/her/its interest/intent to install DG.
- Interconnection process and requirement issues, including:
  - Utility guidelines;
  - Application forms;
  - Fees;
  - Engineering and system impact studies;
  - Customer contract;
  - System modifications and upgrades (if needed); and
  - Customer payment for any studies, modifications/upgrades, testing and acceptance.
- The appropriateness of developing a streamlined process for small systems.

The interconnection of DG to the grid is regulated by certain codes and standards put in place to address safety and power quality issues. These codes and standards set forth requirements for the manufacture, installation and operation of DG interconnection equipment. The following three organizations are major players in the DG interconnection codes and standards arena:

- Institute of Electrical and Electronics Engineers (IEEE),

- National Fire Protection Association (NFPA), and
- Underwriters Laboratories (UL).

The IEEE approved Standard 1547, *Standard for Distributed Resources Interconnected with Electric Power Systems,* in June 2003. This has been adopted as a requirement in several states.

Underwriters Laboratories Inc. (UL) is an independent, not-for-profit product safety testing and certification organization. UL has tested products for public safety for more than a century and is the leader in U.S. electrical product safety and certification. UL has a number of certifications that apply to DG interconnection equipment. The principle one is *UL 1741 – Inverters, Converters, and Controllers for Use in Independent Power Systems.* These requirements cover inverters, converters, charge controllers, and output controllers intended for use in stand-alone (not grid connected) or utility-interactive (grid-connected) power systems.

Interconnection includes both technical requirements (as included in IEEE 1547), and business and contract requirements. The NRECA DG Toolkit referenced earlier in my testimony includes sample contracts, application flow charts, fee schedules and a customer guide to help explain utility interconnection requirements. This provides a good foundation for development of any interconnection requirements.

Q. What should be the role of DG in Integrated Resource Planning (IRP)?

A. Since KIUC is a fairly new member-owned cooperative, it is currently in the process of developing an integrated resource plan framework to present to the

Commission for their review and approval by the end of 2004, which will replace the existing framework prepared when all Hawaii electric utilities were investor owned. At a minimum, this revised framework will require KIUC to scope how DG will impact its system needs.

System benefits and costs can be optimized only when considered holistically. Since DG is one possible solution to not only generation, but also to meet and/or replace the need for T&D upgrades, KIUC favors inclusion of DG in the IRP process. Specifically, within any IRP, it may be useful to consider how effective DG may be to allow the deferral of a T&D upgrade project.

Looking forward, a survey of, or information collection about existing backup generation on the island (not interconnected) would prove useful. Such data may assist in any discussions of homeland security issues as well as planning for use of these generators as part of a KIUC dispatchable virtual power plant. Thus, KIUC is in the process of considering whether its next IRP study should include such a survey.

Q. How do siting and permitting issues impact the deployment of DG?

A. When siting DG at a customer location, a number of different building codes and other governmental requirements must be complied with at a local level, many of which are enforced for safety and health reasons. DOE's Office of Energy Efficiency and Renewable Energy maintains a web site with links to over a dozen resources about codes and standards related to DG.[2] These codes and permits

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[2] http://www.eere.energy.gov/de/deployment/dep_road_resources.shtml.

have a large impact on DG siting costs because they impose unique siting requirements for each DG project. In other words, having to meet varying building codes may prevent a DG developer from quickly repeating a permit process learned during a previous project.

The costs of applying for and complying with zoning permits, building permits (including electrical, plumbing, HVAC, and other specialized building permits) can be minimal compared to that of insuring that the DG unit meets air emission standards. Indeed, most developers are somewhat familiar with these traditional processes and costs, since they occur on most construction projects including the types of buildings or pads where DG is normally sited. However, air emission standards and permits are a special aspect of installing DG.

Air permitting procedures for DG sites have evolved over recent years. As more DG units are installed and operated, state and local officials are increasingly implementing new regulations and procedures specifically designed to address the needs and requirements of DG units. For example, some states have recently enacted revised Best Available Control Technology standards for DG generators. Emission limits constrain the deployment of some types of DG technologies in some regions, possibly limiting the choice of DG technology available to a utility or end-user.

In addition, the National Fire Protection Association (NFPA) has been a worldwide leader in providing fire, electrical, and life safety to the public since 1896. The NFPA publishes the National Electrical Code (NEC) (NFPA-70), which covers electrical equipment wiring and safety on the customer's side of the point of common coupling. DG owners/operators must comply with the requirements of the NEC for all electrical installations, typically subject to inspection and approval by the county electrical inspector.

Customers choosing to install their own generating equipment must become familiar and comply with all siting and permitting requirements. The technical expertise and costs required to do so may be significant.

Q. What should the role of the regulated utility companies and the Commission be in the deployment of DG in Hawaii?

A. Role of KIUC. KIUC does not have a specific position at this time as to what the roles of the other regulated electric utility companies in Hawaii should be in the deployment of DG. However, because of its cooperative structure, KIUC believes that it may have an entirely different role in the DG process than the other electric utility companies because, as a member-owned cooperative, KIUC is not driven by the same factors as an investor-owned utility.

As mentioned in its Preliminary Statement of Position, KIUC is still in the process of evaluating what it means to be a member-owned cooperative and what resulting role it should have in the DG process. KIUC is hoping that the subject docket and its current preparation of the equity management plan will assist them in making these determinations. However, as discussed above, it is KIUC's position that while no new generating capacity is now needed on Kauai, if generation is to be built, utility ownership of DG projects should be allowed and even encouraged on Kauai. For example, as mentioned above, if KIUC owned the DG unit, all the cooperative's members and customers will share in the costs and benefits, payments to support the revenue requirement planned for any T&D system upgrades would be maintained, and the KIUC system would gain another generation resource, increasing overall system flexibility. KIUC and its members and customers could also benefit from the strategic deployment of DG around the island to optimize the design and operation of the T&D system.

Role of the Commission. As mentioned in its Preliminary Position Statement and discussed above, KIUC believes that it is difficult at this time to make any reasonable general determination as to what forms of distributed generation are feasible and viable for Hawaii due to various uncertainties and variables. These uncertainties and variables include, without limitation, (a) the uncertain role distributed generation will have in the electric industry in the future, (b) the fact that many forms of distributed generation are still unproven and are currently too cost prohibitive or may not yet have been generally accepted in the utility arena, (c) Hawaii's stand-alone electric systems due to its isolated location from the mainland United States, and (d) Hawaii's varying topography and population distribution. As a result and as mentioned above, KIUC believes that any determination of the specific forms of distributed generation that may be feasible and viable in Hawaii can only be made on a case-by-case basis looking at the specific proposed project and location.

As a result, KIUC believes that the role of the Commission in the DG process at the current time should be to set forth policy objectives that could assist the electric utility in making the determination on a case-by-case basis whether a specific distributed generation project or facility is feasible. In KIUC's opinion, these policies must remain fairly general at the current time to allow for sufficient flexibility as distributed generation technologies advance and the resulting costs and efficiencies are improved and can be better determined, as well as to allow KIUC to take into consideration the interests of its members. However, at a minimum, these policies should recognize the potential risk that any extensive or non-controlled infusion of distributed generation would have on an electric utility's revenues and on its ratepayers. In connection with this, these policies should provide some guidelines to allow the electric utility to, at a minimum, recover its costs of allowing or pursuing distributed generation without unduly burdening the ratepayers that are not directly benefited by the distributed generation, while also allowing the owner of the distributed generation to share in the benefits of any savings it provides to the electric utility.

Q. What revisions should be made to state administrative rules and utility rules and practices to facilitate the successful deployment of DG?

A. As further discussed above, KIUC believes that the role of the Commission to facilitate the successful deployment of distributed generation is to establish policy objectives to assist the electric utility in making a determination on a case-by-case basis of whether a specific distributed generation project or facility is feasible. These policies should remain fairly general at the current time to allow for sufficient flexibility as distributed generation technologies advance and efficiencies improve, while at the same time providing some guidelines to allow the electric utility to recover its costs related to the distributed generation facilities while also allowing the owner of the facility to share in the cost savings to the utility.

Given the above and the policy objective set forth by the Commission in Order No. 20582 opening the subject docket, it may be premature at the current time to undertake as part of the subject docket an analysis of what specific revisions should be made to any state administrative rules and utility rules and practices in connection with the above. However, some changes to these rules and practices may be ultimately warranted to incorporate the any policies that may result from this process.

Notwithstanding the above, however, as mentioned above, KIUC has an established "Rider S", a tariff that applies when a customer installs DG and remains a customer of KIUC in order to obtain supplemental, backup and maintenance power. The Rider S standby charge is to be based on the cost of providing this backup service, including the actual cost of reserving capacity for the DG customer's use when needed. Otherwise, the remaining members/customers of KIUC would be unfairly burdened with having to pay for this cost. Changes may be needed to this Rider S to better reflect KIUC's current cost of providing this backup service. A similar argument applies to exit fees that an end-user should pay if they decide to entirely quit the system.

Q: Does this conclude your testimony?

A. Yes.

N. Richard Friedman

Professional and Educational Background

Employment History, Professional Affiliations and Educational Background

I founded the Resource Dynamics Corporation in 1980 to provide energy consulting services to utility companies, research organizations, equipment manufacturers and the government. My technical and consulting responsibilities at the Resource Dynamics Corporation include the direction of strategic business assessments, advising energy companies on customer marketing strategies, and identifying opportunities for new business development ventures. I direct my firm's activities in the field of distributed generation (DG), and have been working and consulting in the DG field for over 2 decades. I am a nationally-recognized expert on commercial and industrial energy use, and over the last 3 decades have written and lectured extensively on the application of industrial technologies to process operations, customer power generation, distributed generation and cogeneration, and innovative approaches to product and service marketing.

For over a decade prior to founding the Resource Dynamics Corporation, I worked for a major electrical equipment manufacturer, for the electrical design and energy consulting division of a large professional services company, and as the Chief Operating Officer of a regional electrical construction company. In these diverse roles, I evaluated the economic and technical impact of emerging energy technologies on industrial process operations; managed energy technology development and demonstration projects; developed technical specifications for electrical power generation and distribution equipment for electric utility applications; conducted site quality control audits of manufacturing processes; developed electrical control systems and strategies; supervised construction management, industrial process control, space conditioning and energy distribution design; and developed analytical tools to evaluate the efficiency of electrical installations and developed systems to monitor and control job production and costing.

I hold a Master of Engineering Administration degree from the George Washington University (Washington, D.C.) and a B.S. in Electrical Engineering from the Moore School at the University of Pennsylvania (Philadelphia, PA). I am a member of the IEEE Power Engineering Society, IEEE Industry Applications Society, and IEEE Energy Policy Committee; a member of IEEE Standard Coordinating Committee 21 covering DG interconnection, as well as Chair of IEEE Standard P1547.2 Work Group, developing the Application Guide to IEEE 1547; a member of the Executive Committee of the U.S. Combined Heat and Power Association; and a member of the Association of Energy Engineers.

Background in Distributed Generation

I began working in the distributed generation (DG) field over 2 decades ago, developing business, market and technology strategies for manufacturers, utilities, project developers, end users, and financial institutions, and having installed DG projects for both commercial and industrial end users.

I am the founder of the Resource Dynamics Corporation, a leading consulting firm in distributed generation. My firm has conducted dozens of DG and combined heat and power (CHP) studies for EPRI, DOE, utilities, manufacturers, and equipment suppliers. We have also performed over a hundred related research products covering the markets for electric power, fuel supply to the electric industry, energy conservation efforts, and electric efficiency.

I helped develop the first national interconnection standard for distributed generators in 1988 and am currently serving on the IEEE Standards Committee developing the IEEE 1547 series of interconnection standard for today's technologies. I led the development of technical requirements for IEEE 1547, and facilitated discussions and negotiations between diverse stakeholders during the 3-year standard development process (IEEE 1547 was published in July 2003). I am presently chairing the IEEE 1547.2 Committee developing an Application Guide to the IEEE 1547 Standard.

I developed the "DG Toolkit" for the National Rural Electric Cooperative Association (NRECA), focusing on the technical and business requirements for interconnecting a distributed generator with the utility grid. Also for the NRECA, I developed the "Application Guide to IEEE Standard 1547."

I am currently leading the project for EPRI entitled "Industry Application Experiences with DG Interconnection to the Utility Grid", an effort to update the original study from 2003. I led the 2004 Iowa study of interconnection guidelines, developing key recommendations to the state to remove barriers to interconnection. I also managed the development of the report "Interconnection Practices: State of the Art" for the DOE and the National Renewable Energy Laboratory. I have directed numerous other DG and interconnection projects.

I served on the Task Force on Critical Power Needs of High Tech Industries of the State of Virginia, examining the role of distributed generation for data centers and other high tech operations. I recently directed an in-depth study of the worldwide small power generation market for a major international equipment supplier. I have presented on DG and CHP topics at numerous professional conferences.

Issues and Testimony Response Location

Issues per Prehearing Order No. 20922	Testimony Response Page Number(s)
Planning Issues	
1. What forms of distributed generation (e.g., renewable energy facilities, hybrid renewable energy systems, generation, cogeneration) are feasible and viable for Hawaii?	1, 3, 9-15, 23-24, 33-34
2. Who should own and operate DG projects?	1-3, 7, 9, 20-23, 25, 32-34
3. What is the role of the regulated utility companies and the Commission in the deployment of DG in Hawaii?	32-33
Impact Issues	
4. What impacts, if any, will distributed generation have on Hawaii's electric transmission and distribution systems and market?	2, 24-25, 27-28
5. What are the impacts of DG on power quality and reliability?	24-25, 27-28
6. What utility costs can be avoided by DG?	3, 6-7, 17, 22-24
7. What are the externalities costs and benefits of DG?	2, 15, 20-21, 23-28
8. What is the potential for DG to reduce the use of fossil fuels?	9-13, 15, 16
Implementation Issues	
9. What must be considered to allow a DG facility to interconnect with the electric utility's grid?	3, 27-28
10. What is the appropriate rate design and cost allocation issues that must be considered with the deployment of DG facilities?	3-4, 26-27, 35
11. What revisions should be made to the integrated resource planning process?	29-30
12. What forms of distributed generation (e.g., renewable energy facilities, hybrid renewable energy systems, generation, cogeneration) are feasible and viable for Hawaii?	1, 3, 9-15, 23-24, 33-34
13. What revisions should be made to state administrative rules and utility rules and practices to facilitate the successful deployment of DG?	34-35

DG Economics

	Packaged Cost ($/kW)	Installation Cost ($/kW)	Fixed O&M ($/kW-yr)	Variable O&M ($/kWh)
Reciprocating Engines				
Spark Ignition	300-800	150-600	5-15	0.007-0.02
Diesel	200-700	150-600	10-18	0.005-0.01
Dual Fuel	250-550	150-450	10-18	0.005-0.01
Stirling (External Combustion)	2,000-30,000	100-500	-	0.001-0.01
[illegible]				
Microturbines	700-1,300	250-600	3-10	0.005-0.01
Industrial (Gas) Turbines	300-900	200-300	10-25	0.0025-0.004
Steam Turbines	400-1,200	200-400	15-30	0.0025-0.005
Combined Cycle Turbines	500-1,200	200-300	15-35	0.003-0.006
[illegible]				
PEM	4,000-5,000	400-1,000	3-10	0.01-0.04
Phosphoric Acid	4,000-5,000	300-500	3-10	0.013-0.016
[illegible]				
Photovoltaic	7,100-20,000	1,000-2,000	-	0.001-0.004
Wind	2,500-7,500	500-1,000	-	0.01

Packaged costs include the prime mover, generator, inverter (if needed), and ancillary equipment. Costs can vary based on size, duty cycle, and fuel.

Installation costs can vary with utility interconnection requirements, labor rates, ease of installation, and other site-specific factors. All costs in this table exclude equipment necessary for thermal utilization.

Source: *Distributed Generation Sourcebook, 2004 Edition,* Resource Dynamics Corporation, Vienna, Virginia, July 2004.

DG Characteristics for Premium Power Applications

	Quick Startup	Fast Power Transfer	Low Capital Cost	High Reliability	High Availability	Secure Fuel Supply
Emergency /Standby			✓		✓	✓
Safety & Security	✓			✓	✓	✓
Mission Critical	✓	✓		✓	✓	✓