Honolulu Seawater Air Conditioning LLC Comments

on

"Proposals for Implementing Renewable Portfolio Standards in Hawaii"

Executive Summary

The following commentary provides Honolulu Seawater Air Conditioning LLC's (HSWAC) assessment of how well the subject report by Economists Incorporated ("EI Report") addresses each of the study objectives, and makes some recommendations on how the report, and Act 95, can be improved.

The EI Report provides a comprehensive review and summary of various Renewable Portfolio Standard (RPS) Programs throughout the U. S. The EI Report identifies key features of various state RPS programs, identifies the advantages and disadvantages of these key features, and makes recommendations for Hawaii's RPS.

In its review of the EI Report, HSWAC has attempted to identify the best features of state RPS programs and how to incorporate them into Hawaii's RPS.

The EI Report author's conducted a preliminary analysis of potential alternative resources in Hawaii. However, a thorough review of the EI Report shows that seawater air conditioning (SWAC) has not been fully discussed as an eligible renewable energy technology, in spite of its great potential.

As a result, HSWAC has provided Appendix A – Introduction to Seawater Air Conditioning, to provide additional information about SWAC and ongoing projects on Oahu.

Appendix A provides an overview of: (1) What is Seawater Air Conditioning?, (2) Applications of Seawater Air Conditioning in Hawaii; (3) SWAC Potential in Hawaii; (4) Downtown Honolulu and Waikiki SWAC Systems; and (5) Benefits of Seawater Air Conditioning (SWAC) District Cooling Systems in Hawaii.

A companion technical paper to the EI Report, describing the approach to planned computer simulations of electric power production in Hawaii was not completed in time for a thorough review. Appendix B - Seawater Air Conditioning Value Analysis provides information concerning the value of SWAC using solar water heating as a base case for comparison.

Appendix C - Renewable Energy Potential on Oahu, shows that the contributions of SWAC and solar water heating, towards meeting the RPS on Oahu, are approximately equal. And, these two technologies together can provide more than 25% of the RPS requirement of 20% renewables for Oahu by the year 2020.

In Appendix B, a proxy value for an estimate of externalities costs (value) has been assigned to carbon dioxide (CO_2), based on subsidies provided to the petroleum industry, and summarized in a study by Dr. Jenny B. Wahl entitled “Oil Slickers: How Petroleum Benefits at the Taxpayer’s Expense” (Ref: http://www.ethanol.org/pdfs/oil_slickers.pdf).

For solar water heating systems in Hawaii, this proxy value was found to be approximately $0.038/kWh of avoided, oil-generated electricity, production. HSWAC has used this proxy as an initial value for a System Benefits Charge (SBC) adder that would be used to support development of renewable energy technologies beginning in 2007.

This proxy SBC adder is less than the amount that many states charge for Renewable Energy Credits (REC), Alternativecompliance Payments (ACP), or penalties ($0.040 - $0.055/kWh.)

Appendix D - Analysis of the Costs of a System Benefits Charge (SBC) Adder to Oahu Ratepayers, provides an estimate of the cost of System Benefits Charge adders if applied to renewable energy technologies under Hawaii's Renewable Portfolio Standard.

HSWAC’s analysis shows that even with a System Benefits Charge adder of nearly $0.038/kWh of renewable energy-generated (or fossil fuel generated electricity displaced), the average cost increase for both residential and commercial customers will be only about 1.85% over the period of 2007 to 2020. For a typical residential customer, this would amount to only $2.99/month more on an average bill of $161.64/month. For a typical commercial customer, the additional monthly cost would be only $44 on an average bill of $2,385/month.

The maximum additional cost in the year 2020 would be about 2.75%. (An additional $5.24/month on a typical residential customer's bill of $190.46/month, and an additional $74 on a typical commercial customer's bill of $2,673/month.)

A residential customer could eliminate any additional cost, created by incorporation of System Benefits Charge costs, by simply replacing one 100-watt and one 60-watt incandescent light bulb with compact fluorescents that provide the same amount of lighting while saving 75% of the energy required.

Similar, no- or low-cost energy efficiency measures can be employed by commercial customers to mitigate or eliminate the costs of System Benefits Charge adders.

HSWAC's comments address the following topics:

Examination of Potential Alternative Resources in Hawaii

- Seawater Air Conditioning
- SWAC Developments on Oahu
- SWAC and Integrated Resources Planning
- SWAC and Hawaii's RPS
- Seawater Air Conditioning Value Analysis
- Modeling of Renewable Energy Projects
- Eligibility of Alternative Renewable Energy Resources
- Energy Efficiency or Energy Conservation Measures
- Proposed Energy Efficiency Portfolio Standard
- Renewable Energy Electricity Generation or Displacement of Fossil Fuel-Generated Electricity
- Capacity Value of Renewable Energy Resources
- Externalities Value of Renewable Energy Resources
- Customer Impacts of a System Benefits Charge

Avoided Costs

Identification of Proposed or Potential Utility Ratemaking Structures

- Performance-Based Ratemaking
- Financial Incentives to the Utility

Identification of Incentive Regulations (IR) for RPS Programs

- Renewable Energy Credit (REC) Trading
- Alternative Compliance Payments (ACP) or Fees
- Penalties and Enforcement

Deviations from RPS

Utility Profits

Independent Studies

Timeline of RPS Activities

Characteristics of the State's Electric Power Market

Objectives of the Subject Paper

The objectives of the EI Report were to: (1) survey and analyze the design and implementation of various RPS programs in the U.S., (2) examine potential alternative renewable energy resources in Hawaii, and (3) identify proposed or potential ratemaking structures and incentives consisting of candidate RPS components and IR mechanisms for implementing Hawaii's RPS [EI - pg i].

Analysis of the Design and Implementation of Various Renewable Portfolio Standard (RPS) Programs in the U. S.

The EI Report provides a comprehensive review and summary of various Renewable Portfolio Standard (RPS) Programs throughout the U. S. The EI Report identifies key features of various state RPS programs, identifies the advantages and disadvantages of these key features, and makes recommendations for Hawaii's RPS.

Examination of Potential Alternative Resources in Hawaii

Seawater Air Conditioning

The EI Report author's have conducted an analysis of potential alternative resources in Hawaii. However, a thorough review of the subject report shows that seawater air conditioning (SWAC) has not been fully discussed as an eligible renewable energy technology, in spite of its great potential.

As a result, HSWAC has provided Appendix A – Introduction to Seawater Air Conditioning, to provide additional information about SWAC and ongoing projects on Oahu.

SWAC Developments on Oahu

In the EI Report, the authors stated that, "[a]t the moment, there is no specific location for candidate SWAC facilities, which can in principle be sited in a flexible manner. ... SWAC, may be considered as eligible renewable energy under Act 95" [EI - pg 44, ¶ 120]."

This is not correct. There are, indeed, specific locations for SWAC facilities in Hawaii.

Honolulu Seawater Air Conditioning LLC (HSWAC) has been working on a 25,000-ton SWAC project for downtown Honolulu for the last 22 months and is actively working towards making this facility operational by December 1, 2007. HSWAC is also developing a similar 25,000-ton seawater air conditioning district cooling system for Waikiki, which is expected to be completed prior to the end of 2009.

Additional information about the status of the Downtown Honolulu SWAC Project and the Waikiki SWAC project are presented in Appendix A (pages A-5 through A-6).

These two projects, together, represent only one-half of the 100,000 tons of SWAC potential on Oahu. Other potential projects are discussed in Appendix A (pages A-4 through A-5).

SWAC and Integrated Resources Planning

HSWAC has previously commented on Hawaiian Electric Company, Inc – DRAFT INTEGRATED RESOURCE PLAN: 2006 – 2025 [Docket No. 03-253, July 7, 2005, Hawaiian Electric Company, Inc.].

HECO has proposed a number of DSM programs in its Preferred IRP Plan. The two programs that are of primary interest to HSWAC are: (1) Commercial and Industrial Energy Efficiency (CIEE) and (2) Commercial and Industrial Customized Rebate (CICR). These are the programs where SWAC can have the greatest impact.

HECO projects cumulative energy savings of more than 2,700,000 MWh, and a cumulative demand reduction of 28.3 MW, over the 20-year Preferred IRP Plan period, for the CIEE Program and cumulative energy savings of more than 2,600,000 MWh and a cumulative demand reduction of 26.2 MW, for the CICR Program.

HECO has projected that, its eight proposed energy efficiency programs, implemented over the Preferred Plan's 20-year period will provide a cumulative energy savings of more than 9,900,000 MWh, and a cumulative demand reduction of 151.1 MW.

SWAC, which has not been included in HECO's Preferred IRP Plan, can provide cumulative energy savings of more than 3,000,000 MWh, and a cumulative demand reduction of 68 MW, over the 20-year Preferred IRP Plan period.

The benefits of SWAC are potentially greater than the total benefits of either of HECO's CIEE or CICR Programs. And, incorporating SWAC could increase the total energy saving and capacity reduction benefits of all of HECO's DSM programs by, 31%, and 45%, respectively.

In its review of this document, HSWAC concluded that the largest single improvement to HECO's Preferred IRP Plan would be the acknowledgment and incorporation of an existing technology that is currently being developed in Honolulu – seawater air conditioning (SWAC) district cooling. Ongoing SWAC developments, and proposed SWAC projects, as well as the benefits of these SWAC projects, are discussed in detail. This discussion also included a detailed summary of how SWAC can help HECO meet IRP goals and objectives.

The bottom line is that SWAC should be prominently featured in HECO's DSM program.

SWAC and Hawaii's RPS

HSWAC believes that a similar acknowledgment and incorporation of SWAC technology in the Act 95 Workshops, and related documents, would also be very beneficial to the development, implementation, and fulfillment of a better Renewable Portfolio Standard for Hawaii.

Seawater Air Conditioning Value Analysis

Based on the fact that the companion technical paper describing the approach to planned computer simulations of electric power production in Hawaii was not completed in time for a thorough review, HSWAC has provided a copy of the attached Appendix B - Seawater Air Conditioning Value Analysis, to the authors, with the expectation that their analysis will include SWAC. Appendix B provides information concerning the value of SWAC using solar water heating as a base case for comparison.

Appendix B shows that each ton of SWAC provides renewable energy and energy efficiency benefits equal to that of a residential solar water heating system. Hopefully, Economist Incorporated will be able to incorporate some of this information into their computer simulations.

Renewable Energy Potential on Oahu

Appendix C - Renewable Energy Potential on Oahu, shows that the contributions of SWAC and solar water heating, towards meeting the RPS on Oahu, are approximately equal. And, these two technologies can provide more than 25% of the RPS requirement of 20% renewables for Oahu by the year 2020.

SWAC and solar water heating have great potential and should be thoroughly and adequately addressed in the Act 95 Workshops, and related documents.

Modeling of Renewable Energy Projects

According to the authors, "[s]takeholders expressed a concern about the modeling of renewable energy projects. First, there were questions on the eligibility of alternative renewable energy resources. There appears to be at least three types of renewable energy projects: a stand-alone central power station attached to a utility's system; a renewable energy project installed at customer premises; and an energy efficiency program implemented by the customer, the utility, or both. Second, some renewable energy projects may deserve a capacity credit in view of their expected contribution to system reliability. Third, there is a strong need to address the volatility of energy prices. Fourth, one proxy for environmental externalities is the price, expected to be around $10/ton to $40/ton, of carbon dioxide emission permits. Fifth, a reasonable time period for the planned production simulations, such as 20 years, is necessary to capture the effects of incentives. Sixth, it is important to reflect the constraints related to site permitting and land use policies, including transmission constraints. And seventh, there

may be a need to determine the minimum efficient scale of renewable projects, especially in the context of technological change {EI – pg 4, ¶ 14)."

HSWAC shares other stakeholders' concerns about the modeling of renewable energy resources.

Eligibility of Alternative Renewable Energy Resources

With respect to the eligibility of alternative renewable energy resources, HSWAC believes that a Renewable Energy Portfolio Standard should be limited to renewable energy resources.

The definition of renewable energy should not include energy efficiency or energy conservation measures, unless such technologies use renewable energy resources.

Energy Efficiency or Energy Conservation Measures

SECTION 4. Section 269-91, Hawaii Revised Statutes, states that "Renewable energy" also means electrical energy savings brought about by the use of "… ice storage, quantifiable energy conservation measures, use of rejected heat from co-generation and combined heat and power systems excluding fossil-fueled qualifying facilities that sell electricity to electric utility companies, and central station power projects …"

None of these are renewable energy resources and, as such, do not belong in a Renewable Portfolio Standard.

Ice storage does not use renewable energy and may, in fact, use more energy than conventional air conditioning. It is a technology used to shift utility peak demand to off-peak times and should be dealt with in utility demand side management programs.

Rejected heat from co-generation and combined heat and power systems is <u>not</u> a renewable energy resource. This reject heat is more than likely to come from fossil fuels.

Only reject heat from co-generation and combined heat and power systems that use a renewable energy fuel for most (e.g., more than 75%), or all, of their fuel source should be eligible under this Renewable Portfolio Standard. And, only that portion of reject heat that comes from a renewable energy resource should be counted.

Proposed Energy Efficiency Portfolio Standard

While the above energy efficiency technologies are an important and necessary part of any comprehensive energy strategy, none of these are renewable energy and, as such, do not belong in a renewable portfolio standard.

HSWAC would support the development of a separate, but complementary, “Energy Efficiency Portfolio Standard.” Separate, but complementary, renewable and energy efficiency portfolio standards would have the greatest potential for reducing Hawaii’s over-dependence on imported fossil fuels.

Renewable Energy Electricity Generation or Displacement of Fossil Fuel-Generated Electricity

Renewable energy credits should be given for renewable energy sources that generate electricity or that displace the use of electricity.

This follows an important precedent and principle established by solar water heating – displacement of electrical use by thermal applications of renewable energy technologies is just as important as electricity generation from renewable resources.

Including such displacement technologies will help the utilities to more easily reach RPS mandates and will increase the number of candidate renewable energy technologies. This is particularly important for a high population, high electricity use location with limited land area, such as Oahu.

Potential SWAC system developments in Hawaii can provide energy and generation capacity displacement capabilities equal to that of all the solar water heating systems in the State. As such, HSWAC maintains that this important renewable and efficient energy technology should be included in any RPS for Hawaii.

In the EI Report, SWAC is given as an example of a decentralized facility. A decentralized facility is defined as a type of renewable energy resource such as "sea water air conditioning units" that are “typically located on a customer’s premises.” SWAC actually fits better in the third category describing **programs** that **reduce electrical energy demand** [EI - pg 34, ¶ 79]. SWAC consists of a central cooling station that distributes chilled water for air conditioning through a distribution network connecting multiple building. A better description of SWAC is as an off-grid technology that typically has “the effect of reducing load in a particular area and therefore may be included in the planned power market simulations as load reduction [EI - pg 44, ¶ 120].”

Capacity Value of Renewable Energy Resources

Current avoided cost evaluations do not include, or pay to the producer, all of the value that renewable energy technologies provide (e.g., avoided capacity credits for intermittent renewables).

According to Datta, *Supra* Note 15 at 15, “geographically distributing wind resources has the potential to reduce the variability of the portfolio output to such an extent that the portfolio is worthy of capacity credit.” According to Lazar, *Supra* Note 167at 8, “extensive hourly simulation modeling of the Hawaii utilities…” teaches that “wind

resources deserve a ‘firm capacity credit’ roughly equal to their annual capacity factors” [EI – pg 41, footnote 171].

The capacity value of intermittent resources depends on match between resource and load. A number of approaches have been employed to determine this capacity value. Wind energy is an intermittent renewable resource which has been analyzed in great detail. Capacity valuation is a critical one for both the utility and the wind project. Additional analysis has been done for photovoltaics in areas where the availability of solar radiation closely matches utility demand profiles (e.g., high utility demand for air conditioning during the daytime when solar energy is at its maximum).

HSWAC agrees with Mr. Datta, and Mr. Lazar, that even intermittent renewable energy resources provide capacity value, and should receive capacity credits.

SWAC is analogous to a baseload power plant and is available all of the time. Each ton of SWAC displaces the need for up to 0.68 kW of likely-to-be fossil-fueled electricity generation.

Externalities Value of Renewable Energy Resources

The total value of renewable energy, such as SWAC, is the sum of several components: (1) avoided demand value (i.e., a delay or elimination of the need for new, likely-to-be-fossil-fueled electricity generation); (2) economic value (which includes tax revenues; job creation; and the ability to keep money, previously used to purchase imported fossil fuels, within the State); and (3) externalities value (reduction in costs associated with petroleum – tax subsidies, costs of protecting supplies, and environmental and health costs).

HSWAC believes that there is a need to identify, monetize, and incorporate externalities values into Hawaii’s RPS. Appendix B - Seawater Air Conditioning Value Analysis, attempts to do this (see page B-13).

In Appendix B, a proxy value for an estimate of externalities costs (value) has been assigned to carbon dioxide (CO_2), based on subsidies provided to the petroleum industry, and which are summarized in a study by Dr. Jenny B. Wahl entitled “Oil Slickers: How Petroleum Benefits at the Taxpayer’s Expense” (Ref: http://www.ethanol.org/pdfs/oil_slickers.pdf).

For solar water heating systems in Hawaii, this proxy value was found to be approximately $0.038/kWh of avoided oil-generated electricity production. HSWAC has used this proxy as an initial value for a System Benefits Charge (SBC) adder that could be used to support development of renewable energy technologies beginning in 2007.

Customer Impacts of a System Benefits Charge

Appendix D - Analysis of the Costs of a System Benefits Charge (SBC) Adder to Oahu Ratepayers, provides an estimate of the cost to customers of a System Benefits Charge adder if applied to renewable energy technologies under Hawaii's Renewable Portfolio Standard.

Contrary to some claims, these costs will not be prohibitive and can readily be mitigated by simple, small-scale, no- or low-cost energy efficiency initiatives. Keep in mind that the adder evaluated is an average. Some renewable technologies may receive less, and some more than, the average SBC adder. But in all cases, the SBC adder is designed to stimulate renewable energy development.

HSWAC's analysis shows that even with a System Benefits Charge adder of nearly $0.038/kWh of renewable energy-generated (or fossil fuel generated electricity displaced), the average cost increase for both residential and commercial customers will be only about 1.85% over the period of 2007 to 2020. For a typical residential customer, this would amount to only $2.99/month more on an average bill of $161.64/month. For a typical commercial customer, the additional monthly cost would be only $44 on an average bill of $2,385/month.

The maximum additional cost in the year 2020 would be about 2.75%. (An additional $5.24/month on a typical residential customer's bill of $190.46/month, and an additional $74 on a typical commercial customer's bill of $2,673/month.)

This should be compared to projected increases of nearly 41%, and 27% (in real terms - corrected for inflation), in residential and commercial customer's bills, respectively, over the period of 2007 to 2020.

A residential customer could eliminate any additional cost, created by incorporation of System Benefits Charge costs, by simply replacing one 100-watt and one 60-watt incandescent light bulb with compact fluorescents that provide the same amount of lighting while saving 75% of the energy required.

Residential Customer Example

Replacing one 100-watt bulb + one 60-watt bulb saves 0.120 kW (= 160 W - 40 W). If these lights are used only 4 hours per day, every day, the energy savings are 175.2 kWh/yr, or 14.6 kWh/month. For a typical residential bill of 739.8 kWh/month, this represents ~2.0% savings. The amount of money saved is about $3.19/month and more than the cost of the System Benefits Charge adders.

Similar, no- or low-cost energy efficiency measures can be employed by commercial customers to mitigate or eliminate the costs of System Benefits Charge adders.

The net cost of System Benefits Charge adders to Oahu's electric utility customers is very small, and can easily be zero (or even negative - customers can save even more money) by combining energy efficiency with renewable energy.

Avoided Costs

The EI Report mentions avoided costs a number of times.

"One of the most prominent aspects of Hawaii's RPS is the provision that the rate paid to a renewable energy generator is capped at 100% of avoided cost. One implication is that, by design, the RPS program in Hawaii is unlikely to be a cause of an increase in retail rates in future [EI - pg i]."

"… In each of the Hawaiian islands and over an adequate time horizon, the avoided cost estimate provided by the utility is the price at which a renewable energy resource, whether its own or from an independent developer, is paid. Renewable energy resources are added until the RPS is satisfied. The utility bears the risk of an avoided cost estimate that is artificially high or low. The avoided cost calculation allows for all types of generation technologies. The methodology for calculating avoided cost can be determined from an avoided cost docket currently on-going in the Commission, or from the current approaches used by utilities in recent submissions to the Commission [EI - pg v]."

"The fifth candidate IR mechanism calls for the Commission to produce, through a collaborative process, an estimate of avoided cost without the RPS. The Commission's avoided cost estimate becomes a benchmark for comparing the utility's cost of acquiring renewable energy resources. If the Commission's avoided cost estimate exceeds the renewable energy resource cost, then the utility is allowed to recover 50%, or some reasonable share, of the difference from ratepayers. The renewable energy resource may be installed through the additional cost-recovery until the RPS is satisfied. If the Commission's avoided cost estimate is less than the renewable energy resource cost, then the power plant associated with the Commission's avoided cost estimate, rather than the renewable energy resource, would be installed. The Commission may grant a temporary waiver to a utility that is unable to satisfy the RPS cost-effectively [EI - pg v]."

"An approach to the calculation of avoided cost may have to be developed (see Appendix E on the issue of avoided cost calculation). Under Act 95, the rate paid to a renewable generator may not exceed 100% of avoided cost. Several states allow the flexible implementation of their RPS programs in the event of excessive costs that are typically determined by their regulatory commissions. Under Act 95, the Commission may have to compare a utility's procurement cost of renewable energy to avoided cost, and an approach to avoided cost calculation may have to be developed. The Commission is advised to obtain inputs from an on-going avoided cost docket, Docket No. 7310, on the calculation of avoided cost in Hawaii. The Commission is also advised to rely on a competitive procurement process that could play a key role in ensuring least-cost resource acquisition [EI - pg 48, ¶ 132]."

The definition of a cost-effective renewable energy resource strongly depends on an appropriate definition of “avoided costs.”

The bottom line with regard to ultimate potential for renewable energy technologies is their life cycle cost of energy vs. the amount that the utility is willing, or required, to pay. Current payments for renewable energy are based primarily on avoided energy costs. Some renewable energy technologies (e.g., base-load biomass and geothermal and, in the near future, OTEC) are also provided avoided capacity payments.

Current avoided cost evaluations do not include, or pay to the producer, all of the value that renewable energy technologies provide (e.g., avoided capacity credits for intermittent renewables; energy cost stability; energy supply diversity and security; and health, environmental, and other externality benefits).

Honolulu Seawater Air Conditioning LLC recommends that a detailed evaluation of all of the avoided costs (i.e., value) provided by renewable energy technologies, as well as methods of incorporating such values into the payment price, be an integral part of the proposed study.

Identification of Proposed or Potential Utility Ratemaking Structures

“The Hawaii Public Utilities Commission (“Commission”) is required to develop and implement, by December 31, 2006, an electric utility ratemaking structure that provides incentives encouraging electric utilities in Hawaii to use cost-effective renewable energy resources in order to meet the established renewable portfolio standards (“RPS”). [EI – pg i].”

“The ratemaking structure may include performance-based ratemaking (“PBR”), which is a form of incentive regulation (“IR”) typically providing rewards or penalties upon meeting or falling short of performance standards. [EI - pg i].”

Performance-Based Ratemaking

Honolulu Seawater Air Conditioning LLC supports Performance-Based Ratemaking (PBR) for Hawaii.

Performance-Based Ratemaking (PBR) decouples profits from sales and, as a result, eliminates current utility disincentives for energy efficiency and renewable energy development.

PBR maintains utility requirements for service obligation, reliability, safety, strong and effective customer service, and cost-effectiveness, while imposing new requirements (such as this Renewable Portfolio Standard) for providing a cleaner, and more diverse, resource mix.

PBR is a concept presented as a regulatory alternative. Rather than frequent reviews of utility costs and setting rates to reimburse utilities for what they spend, PBR takes a longer term view and focuses on how utilities perform.

In a well-designed PBR, good performance should lead to higher profits. Poor performance should lead to lower profits.

Under PBR, it is not appropriate to guarantee the current level of profit margins. Profit margins should be based on utility performance. Therefore, this clause should be deleted from Hawaii's RPS and the acceptable level of profit margin should be established as part of the development and implementation of PBR by the PUC.

Financial Incentives to the Utility

HSWAC will address the topic of financial incentives to the utilities in the context of PBR. HSWAC believes that a utility should receive a higher rate of return if, and only if, they meet or exceed RPS performance requirements. Utility customers would benefit through an overall reduction in costs (as distinguished from price, although the price of electricity might also be reduced) for the utility services they receive.

Identification of Incentive Regulations (IR) for RPS Programs

"A central feature of all three IR mechanisms is the introduction of financial incentives supporting investments in renewable power generation [EI - pg 38, ¶ 101]. The three most common IR mechanisms used in the states with RPS are renewable energy credit ("REC") trading, alternative compliance payments or fees, and penalties [EI - pg ii]. The vast majority of programs, in 17 of the 22 states, are using or planning to use a REC trading system [EI - pg 35, ¶ 87]."

In general, HSWAC prefers incentives to penalties to ensure compliance with RPS requirements.

Renewable Energy Credit (REC) Trading

"Under a REC trading system, a utility may purchase RECs in order to meet some or all of its RPS requirements [EI - pg ii]."

Typically, one REC = one MWh. For Hawaii, that would be equivalent to $75.50 with LSFO at $50.00/bbl (= $50.00 x $0.00151/$).

"A utility can meet its RPS requirements by acquiring a sufficient number of RECs obtained from the unbundled attributes of its own renewable energy generation, or from renewable energy generators, specialist brokers, or purpose-built REC markets [EI - pg v]."
HSWAC supports the concept of RECs and would encourage the PUC to strongly consider this approach.

Intrastate Renewable Energy Credits Trading Program for Hawaii

HSWAC generally supports the concept of an intrastate renewable energy credits (REC) trading program. This would allow entities other than the State's electric utilities to contribute towards meeting the State's renewable portfolio standards and would help to finance renewable energy projects.

However, the EI Report authors have pointed out that "[t]here are a couple of potential disadvantages of a statewide REC trading system in Hawaii. Firstly, consider one island that may have much of the renewable energy generation, but another island that may have little renewable energy generation but has purchased certificates. One possible result is that the first island may have little of any adverse environmental effects of fossil fuel-fired generation, but the second island may have much of any adverse environmental effects of fossil fuel-fired generation. Secondly, the HEI utilities and KIUC are the only two entities that are potential buyers of certificates. The potentially small number of participants may prevent the emergence of competitive outcomes in the REC market [EI - pg 50, ¶ 138]."

Simply purchasing the RECs available from a neighbor island utility does not mitigate the negative impacts of the production of fossil fuel generated electricity. Oahu is the only island that may have any difficulty achieving RPS requirements, but only if a concerted effort is not made to develop the many renewable energy resources that exist here. Intrastate RECs should only be used in rare situations.

Inter-island trading of RECs could be minimized by charging a premium (e.g., 50 to 100% of the REC value for each island) for REC purchases from a neighbor island. This would require the local utility to develop renewable resources in its own territory, or to look first for RECs from other entities in their own local service territories, before purchasing neighbor island RECs. If such REC purchases were necessary, the additional premium cost could help to offset any additional costs incurred to develop these additional renewable resources on the neighbor islands. The additional (premium) cost would be a further stimulus to develop renewable energy resources on Oahu.

HSWAC believes that each island can, and should, independently meet the renewable portfolio standards of HRS Section 269-92. In the event that an intrastate renewable energy credits trading program is approved, HSWAC would recommend that this section be amended as follows:

"(b) The commission shall establish and monitor an intrastate renewable energy credits trading program. Any electric utility company that does not satisfy the requirements of section 269-92 by directly owning or purchasing renewable energy shall purchase sufficient renewable energy credits to satisfy the requirement by holding renewable energy credits in lieu of kilowatt-hours from renewable energy technologies. Any person that produces renewable energy will receive credit for each kilowatt-hour of renewable energy generated<u>, or for each kilowatt-hour of fossil fuel-generated electricity saved by renewable energy</u>. Any person generating renewable energy may sell their renewable

energy credits to any renewable energy credit trading program. Renewable energy credits purchased outside of a utility's service territory will be assessed a premium cost of XX [e.g. 50 to 100] percent of the renewable energy credit cost in the area from which they are purchased."

This amendment would provide renewable energy credits to persons that use renewable energy technologies to displace (i.e., save) fossil fuel-generated electricity. This would make this section consistent with the proposed definition of "renewable energy" in HRS Section 269-91 which states that " '[r]enewable energy' also means electrical energy savings brought about by the use of solar water heating, seawater air-conditioning district cooling systems, solar air-conditioning." And, it would provide additional stimulus to utilities to meet RPS requirements within their local service territory.

HSWAC does not believe that the assumed risks associated with Hawaii's smaller market and location will be a problem if the RECs provided adequately reflect the benefits that various renewable energy technologies provide to Hawaii utility systems. If this is the case, there will be a sufficient number of entities other than the State's electric utilities that can, and will, contribute towards meeting the State's renewable portfolio standards.

HSWAC has identified certain features of state RPSs that it believes the PUC should evaluate and consider:

Arizona

- Producing or purchasing eligible kWh in excess of its RPS requirement so it can save or bank the excess kWh for use or sale in future [EI - pg 24, ¶ 56]. This would help to stimulate the develop of SWAC and solar water heating systems sooner in Hawaii.
- Meeting up to 20% of the RPS requirement with solar water heating systems or solar air conditioning systems purchased for its customers' use, or purchased by its customers and paid through bill credits or other similar mechanisms [EI - pg 24, ¶ 56]. A utility financing mechanism would help market penetration of low income markets.
- RPS cost recovery through system benefits charges, an environmental portfolio surcharge on each customer's monthly bill, and a re-allocation of demand-side management ("DSM") funding [EI - pg 24, ¶ 56]. A System Benefits Charge has already been proposed by HSWAC. Re-allocation of DSM funding is a good idea and may be appropriate based on the utility's own assessment of meeting its current DSM goals.

Texas

- In Texas, the RPS aims to ensure that the cumulative installed renewable energy capacity in Texas is at least 2,880 MW by 2009 [EI - pg 8, ¶ 27]. This is a very

large amount of renewable energy in a state that has considerable fossil fuel resources. Hawaii has no fossil fuel resources, but very large renewable energy resources. Hawaii should try to emulate Texas.

- RECs may be generated, transferred, or retired by market participants [EI - pg 8, ¶ 27].
- A REC is awarded to the owner of a renewable energy resource when a MWh is metered at that renewable energy resource [EI - pg 8, ¶ 27]."

General

According to the EI Report, "[r]enewable energy generators are granted RECs corresponding to their renewable energy generation. In this context, electricity generated from renewable resources may be viewed to consist of two distinct commodities: the electricity itself, and the "green" attributes associated with and unbundled from it. The "green" attributes of renewable energy may be traded independently as RECs embodying the "green" attributes of renewable energy. A renewable generator can be considered to have two income streams: one from renewable energy sales, and another from REC sales. In this way, RECs bring a revenue stream on top of renewable energy sales, and therefore provide additional incentives to renewable energy investments [EI - pg 49, ¶ 135]."

HSWAC strongly agrees that renewable energy represents "… two distinct commodities: the electricity [or avoided electricity) itself, and the 'green' attributes of renewable energy …" RECs can serve as the proxy value for these "green" attributes. And, RECs can be funded from a System Benefits Charge.

Alternative Compliance Payments (ACP) or Fees

According to the EI Report [EI - pg ii]:

- Under a system of alternative compliance fees, a utility can meet the RPS through the payment of fees to a renewable energy development fund.
- The fee may be established on a per kWh basis.
- The fund may be earmarked to support investments in renewable energy projects, and specific rules may be formulated to identify both eligible projects and *bona fide* users of the fund, such as renewable energy developers seeking to invest in power generation in Hawaii

A Renewable Energy Development Fund that is used to support investments in renewable energy development in Hawaii is of particular interest to HSWAC. Such financial assistance would allow HSWAC to reduce its costs to customers and to help market SWAC technology.
HSWAC concurs with the authors' assessment that the "positive features of a compliance fee system may be worth the potential effort for the Commission to acquire levy and allocation powers, if it does not possess such powers under Act 95. The

Commission is advised to consider a compliance fee system for further assessment [EI - pg vii]."

Massachusetts

In Massachusetts, electricity suppliers can meet the RPS in several ways [EI - pg 8, ¶ 27]:

- Renewable energy certificates traded through a market-priced bid-based power exchange system may be purchased.
- The RPS can be met through banked compliance. Excess compliance in one year can be used to satisfy compliance in another year.
- The RPS can also be met through Alternative Compliance Payments ("ACP"). The ACP rises with inflation and can be used to advance renewable energy development in the state. The adjusted rate for the ACP for 2005 has been determined to be $0.05319/kWh.

It should be noted that the above ACP is about 40% greater than the SBC adder proposed by HSWAC for Hawaii.

Rhode Island

- Compliance with the RPS may be achieved through the purchase of certificates or the provision of ACPs to a renewable energy development fund [EI - pg 10, ¶ 30].
- The ACP, adjusted annually for inflation, is $50/MWh of renewable energy obligation in 2003 dollars [EI - pg 10, ¶ 30].

Rhode Island's ACP is about the same as Massachusetts'. Both Rhode Island and Massachusetts have developed Renewable Energy Development Funds (REDF). HSWAC recommends that the Hawaii PUC strongly consider the development of such a REDF for Hawaii.

Connecticut

- The cost of the RPS is covered through the rate base that includes a renewable energy investment charge and a system benefits charge [EI - pg 11, ¶ 32].
- Electricity distribution companies failing to comply with the RPS within an annual period are required to pay $0.055/kWh of RPS shortage to the DPUC [EI - pg 11, ¶ 32].
- Such payments are to be allocated to a Renewable Energy Investment Fund ("REIF") for the development of Class I renewable energy resources [EI - pg 11, ¶ 32].

HSWAC supports the rate basing of an SBC (or renewable energy investment charge).

Pennsylvania

- If a distribution company or supplier fails to comply with the RPS, the Pennsylvania Commission may impose an ACP [EI - pg 13, ¶ 36].
- ACPs are to be paid into a special fund, to be used solely for projects that increase electricity generation from renewable resources, and are $45 per alternative energy credit [EI - pg 13, ¶ 36].

HSWAC supports the requirement for using these funds solely for renewable energy projects.

Penalties and Enforcement

Penalties have been promoted as a means of ensuring compliance with RPS requirements. Hawaii's RPS has no penalties (or other means of ensuring compliance). As such, Hawaii's RPS is a basically a voluntary one.

"Under a system of penalties, a utility is charged a fine for energy generation that falls short of the RPS [EI - pg ii]."

HSWAC generally favors incentives over penalties, but acknowledges that a penalty system will be necessary and useful to ensure compliance. Penalties should be viewed as only one component of a more comprehensive RFP. HSWAC also believes that the need for such a penalty system may be greatly reduced if entities other than the utilities are allowed to develop renewable energy resources and are provided appropriate and adequate incentives for doing so. HSWAC believes that all of the burden of achieving RPS requirements should not be placed on the utilities, and that there are a number of entities that can help the State achieve its RPS requirements.

HSWAC agrees that the penalty, if any, should be set at "the level needed to accomplish the deterrent effect that it is supposed to achieve." It should be set at a level where the cost of non-compliance significantly exceeds the cost of complying.

HSWAC concurs with authors that the Commission should try to identify an optimal penalty system.

Waivers

HSWAC is concerned about the concept of waivers. According to the EI Report, in Montana "[a] public utility may petition the commission for a short-term waiver from full compliance with the RPS and the penalties levied. The petition must demonstrate that (a) the public utility has undertaken all reasonable steps to procure RECs under long-term contract, but full compliance cannot be achieved either because RECs cannot be procured or for other legitimate reasons that are outside the control of the public utility; or (b) integration of additional eligible renewable resources into the electrical grid will clearly and demonstrably jeopardize the reliability of the electrical system, and the

public utility has undertaken all reasonable steps to mitigate the reliability concerns [EI - pg 17, ¶ 43]."

HSWAC believes that the PUC needs to develop a set of specific guidelines required to grant a waiver and to ensure that the utilities have "undertaken all reasonable steps to procure" renewable energy resources from all sources before they can qualify for a waiver.

Deviations from RPS

"The ratemaking structure allows for deviations from the RPS if it cannot be achieved in a cost-effective manner, or if it cannot be achieved as a result of circumstances beyond the control of the utility [EI - pg i]."

HSWAC is concerned with the vague nature of this clause. There are least two problems.

- The definition of cost-effective strongly depends on an appropriate definition of "avoided costs." HSWAC has provided a number of comments on what it believes is the appropriate definition of "avoided cost".
- Furthermore, there needs to be a much better definition of what constitutes "circumstances beyond the control of the utility."

Utility Profits

"Under the RPS of Hawaii, the Commission is to determine the impact of any proposed utility ratemaking structure on the profit margins of electric utilities, and to ensure that such profit margins do not decrease as a result of implementing the proposed utility ratemaking structure [EI - pg i]."

And accoriding to the EI Report authors, "[d]uring the 2005 Legislative session, the Commission sought only one amendment to the RPS law, namely, the removal of the provision that electric utility profit margins would not decrease. However, the legislature did not amend the law as requested, and the Commission is required to implement the law as written [EI - pg 47, ¶ 126]."

HSWAC is confident that there will be future successful attempts to change Hawaii's RPS law and concurs with the PUC's proposed amendment.

Honolulu Seawater Air Conditioning LLC supports Performance-Based Ratemaking (PBR) for Hawaii. Under PBR, it is not appropriate to guarantee the current level of profit margins. Profit margins should be based on utility performance. Therefore, this clause should be deleted from Hawaii's RPS and the acceptable level of profit margin should be established as part of the development and implementation of PBR by the PUC. (See HSWAC's comments regarding Performance-Based Ratemaking.)

Independent Studies

"The Commission is required to contract with the University of Hawaii in order to conduct independent studies on the capability of Hawaii's electric utilities to achieve the RPS in a cost-effective manner, and on a variety of other factors potentially affecting RPS implementation, including those deemed appropriate by the Commission [EI - pg i]."

Act 95 should be amended to include a review by local energy and environmental organizations, businesses, and individuals that have considerable expertise in renewable energy technologies and local conditions.

HSWAC has unique knowledge of, and experience with, seawater air conditioning and should be included as one of the entities that should provide information to, and review and comment on, these independent studies.

Timeline of RPS Activities

"The Hawaii Public Utilities Commission ("Commission") is required to develop and implement, by December 31, 2006, an electric utility ratemaking structure that provides incentives to encourage electric utilities in Hawaii to use cost-effective renewable energy resources to meet the established renewable portfolio standards ("RPS") [EI – pg 1]."

HSWAC believes that this a reasonable timetable for development a utility ratemaking structure that will facilitate the implementation of the RPS.

However, HSWAC would like to see an accelerated development and implementation of incentive programs to facilitate renewable energy development. HSWAC believes that such incentive programs could be developed during the 2006 legislative for session and be made effective by January 1, 2007.

Characteristics of the State's Electric Power Market

The contiguous United States are able to create regional multi-state REC markets that may be able to take advantage of the benefits of larger markets (i.e., a larger number of buyers and sellers might enhance the "enhance the prospects of satisfying demand at competitive prices").

Hawaii's electric power market is not connected to any other state, and is not even connected island-to-island. Hawaii's market is unique. As a result, Hawaii needs to develop a unique scheme.

HSWAC believes that each island needs to try to meet, and is able to meet, the state's RPS.

Appendix A

Introduction to Seawater Air Conditioning

Seawater Air Conditioning (SWAC) is a renewable energy technology that has the potential to provide a very significant contribution to Hawaiian Electric Company's (HECO) Integrated Resources Planning objectives, and the State of Hawaii's Renewable Portfolio Standard requirements.

HECO has identified SWAC as an emerging technology. In fact, SWAC, and the related deep lake water cooling technology, are commercially-available today and have been used extensively worldwide.

Sweden is a world leader in SWAC development. There are currently more than 80,000 tons of deep lake/SWAC in Stockholm, Sweden. Several other cities in Sweden, such as Jonkoping, Upplands Vasby, Solna, Sollentuna and Sodertalje, have SWAC systems with up to 15,000 tons.

Anders Rydaker and Ingvar Larsson, two members of the Honolulu Seawater Air Conditioning, LLC (HSWAC) Management Team, were actively involved in the development of these systems in Sweden. In 2003, Rydaker received Sweden's Prestigious Energy Prize for developing numerous district cooling systems in Sweden.

More recently, Phase 1 of Enwave's Toronto deep lake cooling project was completed. The system combines district cooling and municipal water supply and is designed for 58,000 tons. Deep, cold lake water is delivered to the shore with three 63-inch diameter high density polyethylene (HDPE) pipes. The length of these pipes is of the same order of magnitude as the seawater supply pipe for the downtown Honolulu SWAC Project. These pipes were designed by Makai Ocean Engineering, one of HSWAC's partners in Hawaii and the world's leading designer and installer of deep water pipes.

Makai Ocean Engineering was also involved in a 20,000-ton deep lake cooling project at Cornell University and has installed all of the pipes at the Natural Energy Laboratory of Hawaii Authority (NELHA) at Keahole Point on the Big Island.

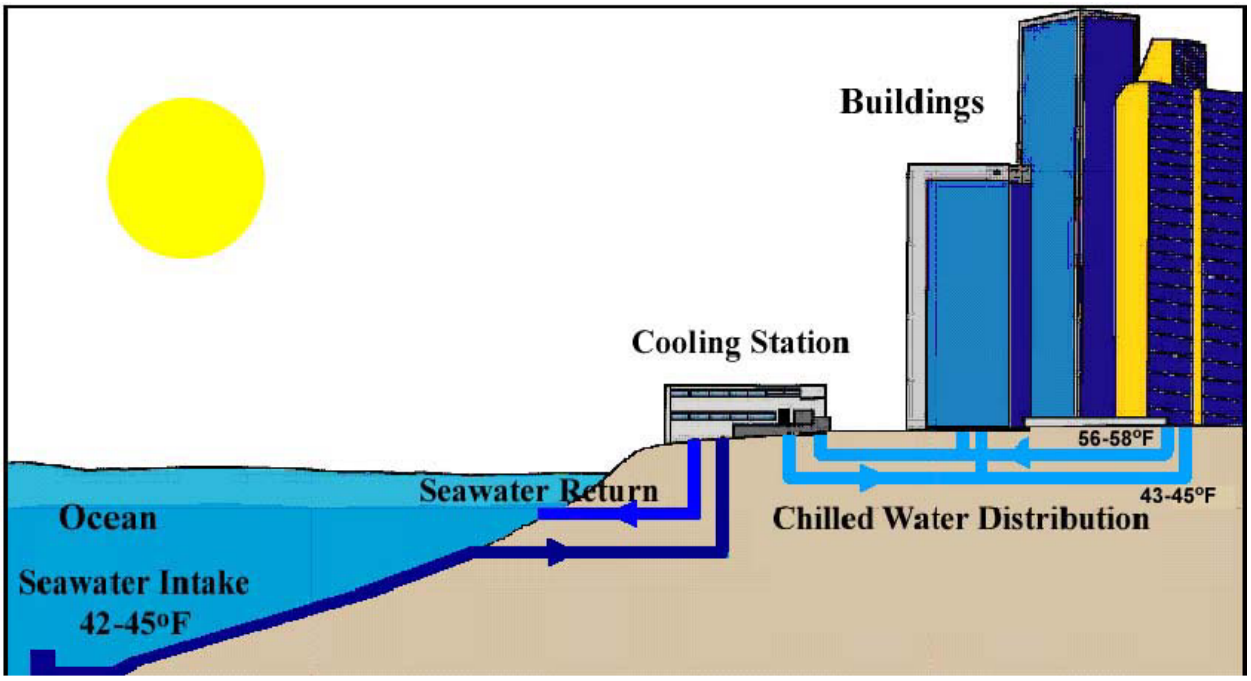
What is Seawater Air Conditioning?

A typical SWAC system is quite simple, and is illustrated on the next page. Cold seawater is pumped up from the bottom of the sea (i.e., a depth of 1,600 to 3,000 feet in Hawaii). This cold seawater is passed through a heat exchanger where it cools chilled water that is circulated to buildings.

Basic components include:

- A seawater supply distribution system including the pipeline, pumps, and discharge pipe;
- A closed-loop, fresh-water circulation distribution network, including pumps. This network provides chilled water that circulates through each building; and
- Heat exchangers that transfer heat from the circulating water in the distribution loop to the seawater.

These basic components are optimized for each specific location, climate, and building.



An Elevation of a Basic Seawater Air Conditioning System.

SWAC is suitable for coastal developments with large air conditioning demand and reasonable access to deep, cold seawater. The main factors that influence the economic viability of a seawater air conditioning system are:

- Distance offshore to cold water in the 40 - 45°F range;
- Size of the air conditioning load;
- Percent utilization of the air conditioning system;
- Local cost of electrical power; and
- Size of the onshore distribution system.

Other factors also influence the design, economics, and ultimate success of SWAC system. These include:

- Local seafloor bathymetry;
- Wave and storm data;
- Local climate;
- Existing vs. new buildings;
- Environmental requirements, and
- Secondary uses of the seawater.

Applications of Seawater Air Conditioning in Hawaii

As a tropical island state, Hawaii has a year-round, relatively-uniform need for air conditioning. Air conditioning systems are energy intensive and represent 35% to 45% of energy use in typical office and hotel buildings in Hawaii. Hawaii also has some of the highest electricity rates, and air conditioning costs, in the country. And, Hawaii relies on expensive imported fossil fuels for more than 90% of its energy needs. At the same time, all islands have some shorelines that have good access to deep, cold seawater used in a SWAC system.

SWAC is suitable for coastal developments with large air conditioning demand and reasonable access to deep, cold seawater. Notable areas are southern Kauai, several areas of Oahu, and the southern 60% or more of the Big Island.

The air conditioning load for commercial buildings on Hawaii is about 2 tons per 1,000 square feet building space. A single hotel room requires about 0.8 ton of air conditioning, and a typical apartment may require 2 tons.

In some cases, the temperature of the seawater supplied is not low enough to provide the desired chilled water temperature. In this case, some auxiliary chillers are used to reduce the chilled water supply temperature. Energy requirements for this type of system are still about 25%, or less, of what is needed for the conventional A/C system.

Auxiliary chillers can serve other important functions for enhancing the commercial development of SWAC district cooling systems. They can serve as potential peaking cooling capacity and/or as emergency back-up cooling capacity.

A number of studies have been conducted to evaluate the potential of SWAC in Hawaii, and there is an operating system at the Natural Energy Laboratory of Hawaii Authority (NELHA) at Keahole Point, Hawaii. These studies all show that there is significant potential for SWAC in Hawaii. More recent studies show that combining SWAC with thermal energy storage and auxiliary chillers increases the cost effectiveness and applicability of such systems.

Benefits to be derived from the use of cold, deep seawater resources include: (1) air conditioning, (2) auxiliary cooling for industrial facilities and cooling systems, (3) cool and cold water aquaculture and agriculture, and (4) water quality improvement. SWAC systems eliminate the need for cooling towers and, as a result, reduce potable water use, toxic chemical use, and the production of sewage.

Exhaust seawater can be used for cold water aquaculture and agriculture. Lack of land availability would likely prevent this for any urban Honolulu SWAC systems, but it may be feasible for neighbor island systems (if sufficient adjacent land is available). This dual-use application may also help to make these generally smaller systems more cost effective.

Finally, SWAC system exhaust seawater is unpolluted and pathogen-free. Its discharge into various receiving water bodies (e.g., the Ala Wai canal, Honolulu Harbor, and Pearl Harbor) could contribute to water quality improvement.

SWAC Potential in Hawaii

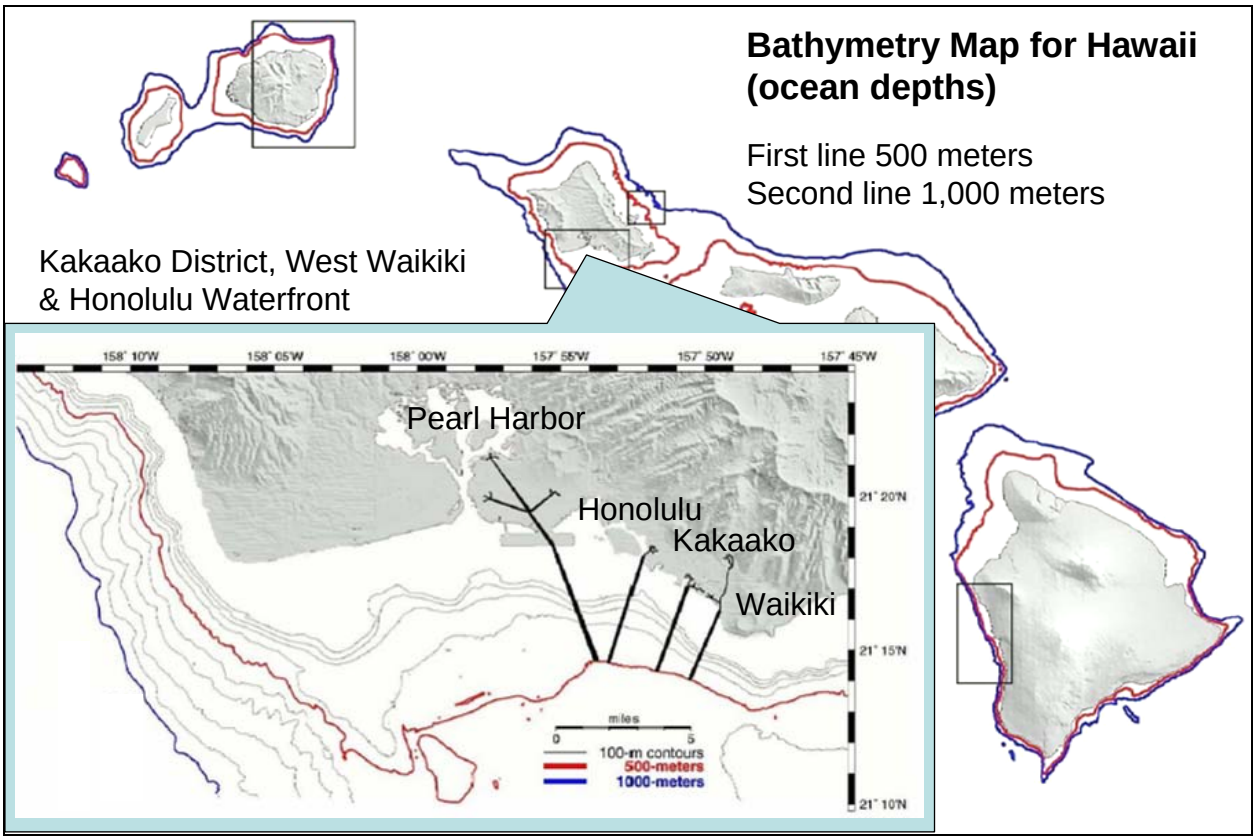
SWAC systems provide numerous benefits to many Hawaii stakeholders. More than 100,000 tons (of cooling load) have been identified throughout the Hawaiian Islands as technically feasible SWAC developments. Most of this potential exists along the South shore of Oahu, the most populated island. The potential in the Downtown Honolulu/Kakaako/Waikiki corridor is currently estimated to be in excess of 70,000 tons.

Honolulu Seawater Air Conditioning, LLC (HSWAC) is developing a 25,000-ton SWAC system for downtown Honolulu. The downtown Honolulu SWAC system will provide 25% of the benefits of the SWAC potential in Hawaii. The projected start-up date for this project is December 1, 2007.

HSWAC is currently exploring the potential for a SWAC district cooling project for Waikiki. HSWAC has contacted the owners of the ten largest customers in the Waikiki area. These customers represent a cooling load of least 16,000 tons. The total potential in this area exceeds 30,000 tons.

Once the downtown Honolulu and Waikiki SWAC systems have been developed, there is a potential to serve customers in the area between these areas (i.e., Kakaako). Kakaako is a rapidly growing area that is undergoing redevelopment under the auspices of the State of Hawaii – Hawaii Community Development Authority (HCDA).

There is also significant SWAC development potential (>16,000 tons) in the Pearl Harbor area. Pearl Harbor is being considered for deployment of an aircraft carrier group. This will double the number of personnel stationed there and will significantly increase the demand for air conditioning. There is also some potential in the rapidly developing Ko’olina area on west Oahu.



Possible pipeline crossings for potential SWAC projects in Honolulu.

Downtown Honolulu and Waikiki SWAC Systems

HSWAC is currently developing a 25,000-ton seawater air conditioning ("SWAC") district cooling system for downtown Honolulu. HSWAC is also developing a similar 25,000-ton seawater air conditioning district cooling system for Waikiki. Both of these projects are expected to be completed prior to the end of 2009.

Downtown Honolulu Project

The status of the Downtown Honolulu Project is as follows:

- Thirty-nine of 65 potential customers in the Downtown service area (Kakaako Makai to Downtown Honolulu) have been contacted. Customer response has been very favorable. These customers represent 82.3% of the total air conditioning demand of nearly 33,000 tons. The potential tonnage is expected to increase with the on-going development of properties in the Kakaako area. More detailed evaluations of customer interconnection requirements are underway.

- Conceptual designs of the seawater distribution system, the chilled water distribution system, and the cooling station have been completed. Final designs

of these system components have begun. Negotiations for a cooling station site are underway.

- A Permit Manager has been contracted. Discussions have been held with all affected federal, State, and City & County of Honolulu agencies. Permit requirements have been identified. The preliminary scoping process has begun, with presentations to numerous government agencies, and energy, environmental, technical and public groups. A Draft Environmental Impact Statement is being prepared and is undergoing internal review, and several surveys to support the completion of this document have been completed.

- The State of Hawaii has authorized $80 million in tax-exempt Special Purpose Revenue Bonds and has granted seawater air conditioning district cooling systems and exemption from Public Utilities Commission regulation. Act 95 (Renewable Portfolio Standard), of the 2004 State legislature, has defined seawater air conditioning as an eligible renewable energy technology. The State of Hawaii – Department of Taxation has provided HSWAC with a comfort letter stating that these projects qualify for Act 221/215 tax benefits under the renewable energy classification. A business plan has been prepared and negotiations are underway for an additional $24 million in equity capital and $16 million in additional bond funding.

- This project is planned to be operational BY December 1, 2007.

Waikiki Project

The status of the Waikiki Project is as follows:

- Eleven of 38 potential customers in the Waikiki service area (Waikiki to Ala Moana) have been contacted. Customer response has been very favorable. These customers represent 62.8% of the total air conditioning demand of nearly 37,000 tons. The potential tonnage is expected to increase with the on-going development of properties in the Waikiki-Ala Moana area.

- Preliminary evaluations of the seawater distribution and the chilled water distribution system are being made. Potential cooling station sites are being identified. Several potential customers have suggested potential sites for the cooling station, including some situated on the customers' sites and incorporated into existing or planned facilities.

- There are a number of synergies between the Downtown Honolulu and Waikiki Projects that may help to reduce the development time for both projects (e.g., similar permitting requirements, similarities in design of seawater distributions systems, etc.)

- The Waikiki Project is planned to be complete by the end of 2009.

Benefits of Seawater Air Conditioning (SWAC) District Cooling Systems in Hawaii

SWAC systems provide numerous benefits to many Hawaii stakeholders. More than 100,000 tons (of cooling load) have been identified throughout the Hawaiian Islands as technically feasible SWAC developments. Most of this potential exists along the South shore of Oahu, the most populated island. The potential in the Downtown Honolulu/Kakaako/Waikiki corridor is currently estimated to be in excess of 70,000 tons.

Honolulu Seawater Air Conditioning, LLC is developing a 25,000-ton SWAC system for downtown Honolulu. A SWAC development here would provide the following benefits:

- **Stable Cooling Costs.** Honolulu has some of the highest electricity costs in the nation. And, these costs have been increasing faster than the rate of inflation. SWAC systems will provide customers with reduced and stable cooling costs.
    - Average commercial electricity costs in Honolulu in 2004 were close to 14 cents/kWh.
    - These costs have increased at a real (inflation-adjusted) rate of more than 1.4%/year over the period of 1990 to 2003. Annual increases, with inflation, are nearly 3.3%/yr.
    - At this rate, real electricity costs will increase by more than 32% over the 20-year book life of a SWAC project (with inflation, the cost increase is nearly 90%).
    - Energy costs are a small fraction of total costs for a SWAC system and SWAC life cycle costs will, therefore, remain stable.
- **Renewable Energy Use.** SWAC uses an infinite, 100% renewable energy resource - cold, deep seawater.
    - SWAC will greatly help the State of Hawaii, and HECO, meet new Renewable Portfolio Standard (RPS) Standards.
    - More than 90% of the energy savings from SWAC are due to the use of an abundant, infinite renewable energy resource – cold, deep seawater.
    - With limited land area and high electrical demand, Oahu will have the greatest challenge in meeting RPS Standards. SWAC is the renewable energy technology that can provide the greatest benefits to Oahu in the near term.
    - The 25,000-ton HSWAC project will provide renewable energy benefits equal to:

- 34 MW of photovoltaics (at a Capacity Factor [CF] = 0.21);
- 22 MW of wind (at a CF = 0.32); or
- 11 MW of MSW or biomass combustion (at a CF = 0.65).

- **Reduced Oil Dependence.** Hawaii is more than 90% dependent on imported fossil fuels, most of this is oil. A SWAC system can significantly reduce imports of crude oil.

  - The 25,000-ton HSWAC project will reduce crude oil imports by up to 145,000 barrels per year.

- **Reduced Potable Water Use.** SWAC systems eliminate the need for cooling towers and, as a result, reduce potable water use, toxic chemical use, and the production of sewage.

  - The 25,000-ton HSWAC project will save up to 265 million gallons of potable water per year.

  - The 25,000-ton HSWAC project will reduce sewage generation by up to 83 million gallons per year.

  - SWAC systems eliminate the need for cooling water treatment chemicals.

- **Environmental Benefits.** Reduced use of fossil fuels provides for significant reductions in greenhouse gas emissions and other air and water pollutants. SWAC systems greatly reduce the use of harmful chemicals (refrigerants) used in conventional cooling systems.

  - The 25,000-ton HSWAC project will reduce the production of pollutants from fossil fuel combustion by up to the following amounts:

    - Carbon Dioxide (CO_2) Emissions 69,600 tons/year
    - Volatile Organic Compounds (VOC) Emissions 4 tons/year
    - Carbon Monoxide (CO) Emissions 23 tons/year
    - Particulate Matter under 10 microns (PM_{10}) Emissions 15 tons/year
    - Nitrogen Oxides (NOx) Emissions 138 tons/year
    - Sulfur Oxides (SOx) Emissions 135 tons/year

- **Energy Efficiency and Demand Side Management Benefits.** Energy savings with SWAC systems are 75%, or more, compared to conventional A/C.

  - Each ton of SWAC eliminates the need for more than 2,500 kWh/year of energy use.

- The 25,000-ton HSWAC project will save up to 63 million kWh per year. This is equivalent to nearly 25,600 residential solar water heating systems.

- Each ton of SWAC eliminates the need for up to 0.68 kilowatts of new (likely-to-be-fossil-fueled) generation capacity.

- The 25,000-ton HSWAC project will eliminate the need for up to 17 megawatts of new generation. This is equivalent to nearly 23,100 residential solar water heating systems.

- This reduced demand for new energy generation is equivalent to 1.0 to 1.2 years of HECO's projected load growth.

- The reduced need for expensive new electricity generation capacity will help to keep electric rates lower for longer.

- **Reduced Operations and Maintenance Costs.** Large-scale, district cooling systems have lower operating and maintenance costs than individual building air conditioning systems.

- **Local Economic Development.** A SWAC project will generate millions of dollars in construction project spending. In addition to construction jobs, a significant number of long-term, well-paid jobs will also be created. Other local economic development benefits will accrue from money that stays in Hawaii, and is not used to purchase oil.

- **Government Energy Goals and Mandates.** SWAC systems will help the City & County of Honolulu, the State of Hawaii, and the federal government to meet goals and mandates for energy efficiency and renewable energy use.

  - Government buildings will be able to meet more than 80% of State and Federal mandates for energy efficiency and renewable energy use by just connecting to a SWAC system.

- **Secondary Benefits.** There are a number of potential uses of the seawater that leaves the SWAC system. Among these are: (1) auxiliary cooling for power plants, industrial facilities, and cooling systems; (2) flushing of harbors and canals; and (3) cold water agriculture and aquaculture.

- **Reliable Cooling.** SWAC systems are simple, and technically and economically feasible today. SWAC systems use industrial-grade, off-the-shelf components. Seawater supply systems have many years of use and demonstrated reliability in sometimes hostile environments. Deep water cooling systems have been successfully installed and operated in a number of areas worldwide from Stockholm, Sweden to NELHA on the Big Island, Hawaii. Large-scale district cooling systems with, or without, thermal energy storage are successful, low

cost, energy efficient, environmentally friendly and have been used worldwide. District cooling and heating provided by Market Street Energy Company, LLC have a reliable record of 99.99% reliability, much superior to the typical reliability of local electric utilities, or conventional, building on-site air conditioning.

- **Customers.** SWAC systems provide convenient, reliable, low, 20-year very stable-cost cooling.

Appendix B

Seawater Air Conditioning Value Analysis

Executive Summary

Introduction

Dr. Tom Loudat conducted a detailed analysis of "The Economic and Fiscal Impacts of the Hawaii Energy Conservation Income Tax Credit," for the State of Hawaii (Ref: http://www.state.hi.us/dbedt/ert/symposium/loudat/loudat.html). The overall objective of Dr. Loudat's research was to assess the impact to the State of Hawaii of the Energy Conservation Income Tax Credit (ECITC).

Solar water heating has arguably been the most successful element of the State of Hawaii's renewable energy development program, and the Demand Side Management (DSM) programs of the state's public utilities. In his analysis, Dr. Loudat found that "a solar system provides benefits for its entire life (25 years) as opposed to the year of its purchase only" and that benefits provided by solar water heating greatly exceed the incentives provided (a $750 rebate on Oahu and a 35% State of Hawaii ECITC on the balance of system costs).

The subject analysis ("Seawater Air Conditioning Value Analysis") analyzes the value of solar water heating systems and seawater air conditioning (SWAC) district cooling systems, on a side-by-side basis. The total value of these renewable energy and energy efficiency systems is the sum of several components: (1) avoided demand value (i.e., a delay or elimination of the need for new, likely-to-be-fossil-fueled electricity generation); (2) economic value (which includes tax revenues; job creation; and the ability to keep money, previously used to purchase imported fossil fuels, within the State); and (3) externalities value (reduction in costs associated with petroleum – tax subsidies, costs of protecting supplies, and environmental and health costs).

A proxy value for an estimate of externalities costs (value) has been assigned to carbon dioxide (CO2), based on subsidies provided to the petroleum industry, and summarized in a study by Dr. Jenny B. Wahl entitled "Oil Slickers: How Petroleum Benefits at the Taxpayer's Expense" (Ref: http://www.ethanol.org/pdfs/oil_slickers.pdf).

Finally, SWAC provides additional benefits through the elimination of cooling towers. The use of potable water and generation of sewage are significantly reduced through the use of SWAC. The value of these additional benefits further increases the value of SWAC.

The results of the Seawater Air Conditioning Value Analysis, and Conclusions and Recommendations based on these results, are presented in this Executive Summary.

Results

The value of solar water heating systems was determined and was used as base case for determining the value of SWAC.

Total Avoided Capacity, Economic, and Externalities Value of Solar Water Heating Systems

Avoided Capacity Value =	**$0.024**	**per kWh***	**$691**	**per SWH System**
Economic Value =	**$0.048**	**per kWh**	**$1,404**	**per SWH System**
Externalities Value =	**$0.038**	**per kWh**	**$1,097**	**per SWH System**
Total Value =	**$0.110**	**per kWh**	**$3,192**	**per SWH System**

*Note: Value per kWh saved at end user site.

Dr. Loudat has determined that the "net fiscal impact of each system purchased with no ECITC claim is a positive $3,169 [in 2000$]." And, this estimate did not include any externalities value. Thus, the above total value is likely to be a conservative estimate.

The same approach used to determine the value of solar water heating systems, was used to determine the value of SWAC.

Total Avoided Capacity, Economic, and Externalities Value of SWAC Systems

Avoided Capacity Value =	**$0.012**	**per ton-hr***	**$638**	**per ton**
Economic Value =	**$0.029**	**per ton-hr**	**$1,516**	**per ton**
Externalities Value =	**$0.023**	**per ton-hr**	**$1,185**	**per ton**
Total Value =	**$0.064**	**per ton-hr**	**$3,338**	**per ton**

*Note: Value per ton-hr saved at end user site.

Finally, the additional value of reduced potable water use and reduced sewage generation was determined and added to the value of SWAC.

Total Value of SWAC Systems

Avoided Capacity Value =	**$0.012**	**per ton-hr**	**$638**	**per ton**
Economic Value =	**$0.029**	**per ton-hr**	**$1,516**	**per ton**
Externalities Value =	**$0.023**	**per ton-hr**	**$1,185**	**per ton**
Reduced Potable Water Use =	**$0.007**	**per ton-hr**	**$343**	**per ton**
Reduced Sewage Generation =	**$0.005**	**per ton-hr**	**$268**	**per ton**
Total Value =	**$0.076**	**per ton-hr**	**$3,950**	**per ton**

Conclusions

The value of solar water heating systems is at least $3,192. The total incentives provided to solar water heating systems are only $2,095 ($750 in rebates on Oahu and an average 35% State of Hawaii ECITC of $1,273). Solar water heating systems warrant increased incentives that would further stimulate their sales and increase cumulative benefits.

SWAC systems provide benefits that are similar to those provided by solar water heating systems. The benefits provided by one ton of SWAC are approximately equal to those provided by a typical solar water heating system (i.e., within 5%).

SWAC systems provide additional benefits (i.e., reduced potable water use and reduced sewage generation). The additional net present value of these benefits, over the lifetime of a SWAC system, is more than $600.

SWAC is eligible for an average HECO rebate of only $140 - $300/ton. The actual amount is customer-specific and could be significantly less than this. This rebate is only 4 - 9% of the avoided demand, economic, and externalities value of SWAC systems, and is significantly less than that provided to other DSM technologies based on the relative benefits provided. SWAC systems also warrant increased incentives that would stimulate SWAC developments in Hawaii.

SWAC systems reduce the use of potable water. Each ton of SWAC saves more than 10,000 gallons of potable water each year. The net present value of these water savings, over the lifetime of a SWAC system, is more than $340. The Honolulu Board of Water Supply needs to conserve the use of potable water and should consider providing a rebate for demand side management of potable water resources, with SWAC as an eligible technology.

SWAC systems reduce the generation of sewage by eliminating the need for cooling tower blowdown. Each ton of SWAC reduces the generation of sewage by up to 3,300 gallons each year. The net present value of reduced sewage generation, over the lifetime of a SWAC system, is nearly $270. The City & County of Honolulu needs to reduce the demand on its sewage transmission and treatment system and should consider providing a rebate for reduced sewage generation, with SWAC as an eligible technology.

Recommendations

Incentives provided to DSM technologies should be based on, and proportional to, the value that they provide to the utility, to Oahu, and to the State.

The Hawaii Public Utilities Commission, and HECO, should consider an increase in incentives provided for solar water heating and SWAC systems. Based on the results of the subject analysis, the incentive for SWAC should be at least twice what is being currently proposed.

The rebate proposed for SWAC is to be provided under a customized incentive program managed by HECO. Based on the fact that the value of SWAC is far greater than the proposed rebate, SWAC should be provided a prescriptive rebate (i.e., a fixed amount per ton that is significantly more than $300/ton), rather than a customized rebate.

Large-scale development of SWAC (and accelerated development of solar water heating systems) has the potential to significantly increase the impact of HECO's proposed DSM programs, and to contribute towards meeting the State of Hawaii's Renewable Portfolio Standard. Greater emphasis should be placed on the development and implementation of these technologies.

Each of the above recommendations should be addressed in the Energy and Efficiency Docket (PUC Docket No. 05-0069).

The Honolulu Board of Water Supply should consider a rebate for demand side management of its potable water resources, with SWAC as an eligible technology.

The City & County of Honolulu should consider a rebate for reduced sewage generation to reduce the demands on its sewage transmission and treatment system, with SWAC as an eligible technology.

Approach

The following analysis determines the value of Seawater Air Conditioning (SWAC) district cooling systems.

Pathway analysis is used to determine the total fossil fuel energy displacement of solar water heating systems, and SWAC systems, from the fuel source to the end use.

The Hawaii Solar Energy Association (HSEA) has conducted extensive studies that demonstrate that the value of solar water heating systems greatly exceeds the cost of income tax incentives and utility rebates provided for this technology (Ref: http://www.state.hi.us/dbedt/ert/symposium/loudat/loudat.html). These data are used to determine various components of the value of solar water heating systems.

Solar water heating systems are then used as a base case to determine the value of SWAC systems. Additional value for SWAC systems is created by determining the value of potable water savings and a reduction in the generation of sewage.

Pathway Analysis for Solar Water Heating

Electricity Production (Crude Oil ➔ Low Sulfur Residual Fuel Oil [LSRFO] ➔ Electricity)

Electricity Generation Efficiency

		Notes:
Crude Oil Shipping Efficiency =	0.980	1
Crude Oil Refining Efficiency =	0.900	1
Electrical Generation Efficiency =	0.325	1,2
Transmission & Distribution Efficiency =	0.888	3
Overall Efficiency =	0.255	4

Where: Overall Efficiency is the electricity generation efficiency from crude oil at the source to electricity at the end use (see Figure 1).

1/Overall Efficiency = 3.93

Calculated Heat Rate of Electricity Generation

Heat Rate = 13,405 Btu/kWh 5

Notes:
1 Typical value
2 Approximate efficiency of HECO's electricity generation
3 T&D efficiency used by HECO in PUC Docket No. 00-0209
4 Overall electricity generation efficiency from crude oil at source to end user
5 Heat Rate = (3,412.13 Btu/kWh) / (Overall Efficiency)

Production of CO2 from Combustion of Fossil Fuels for Electricity Generation

= Heat Rate x Specific CO2 Production

			Notes:
= Carbon Dioxide Production =	2.19	lb CO2/kWh	6
Where:	3.66	lb CO2/lb C	
	259	lb C/bbl crude oil	7
	947	lb CO2/bbl	
	5.80	mmBtu/bbl	8
Specific CO2 Production =	163	lb CO2/mmBtu	

Notes: 6 = (Heat Rate) x (Specific CO2 Production)
7 Typical carbon content for a barrel of crude oil (Energy Information Administration)
8 Typical energy content (HHV) for a barrel of crude oil (Energy Information Administration)

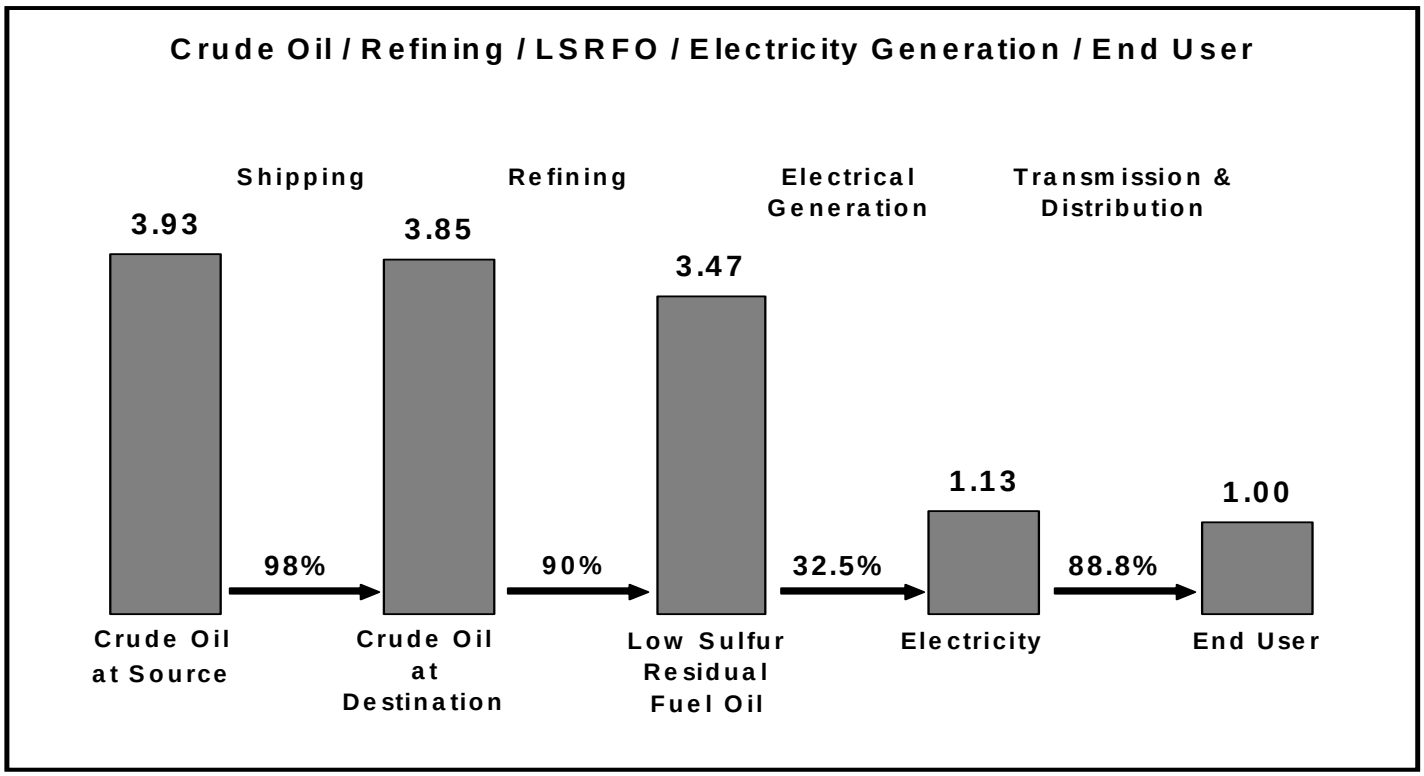


Figure 1. Pathway analysis for solar water heating.

HECO's Calculated Solar Rebate (in 2000$)

			Notes:
Nominal Interest (Discount) Rate =	8.09	%	9,10
Inflation Rate =	3.00	%	9
Real Interest (Discount) Rate =	4.94	%	11
Annual Energy Cost Escalation Factor =	1.62	%	9
Transmission & Distribution (T&D) Efficiency =	0.888		9
Avoided Energy (w/o T&D losses) =	2,485	kWh/yr	9
Avoided Energy (w/ T&D losses) =	2,798	kWh/yr	12
Avoided Demand (w/o T&D losses) =	0.650	kW	9
Avoided Demand (w/ T&D losses) =	0.732	kW	13

Notes:
9 Value used by HECO in PUC Docket No. 00-0209
10 Discount Rate = HECO's Weighted Average Cost of Capital in the Year 2000
11 = (1 + Discount Rate) / (1 + Inflation Rate)
12 = (Avoided Energy [w/o T&D Losses]) / (T&D Efficiency)
13 = (Avoided Demand [w/o T&D Losses]) / (T&D Efficiency)

Year	Energy (2000$/MWh)	PV of Energy (2000$/MWh)	Capacity (2000$/kW)	PV of Capacity (2000$/kW)	
1998	$27.32	$0.00	$0.00	$0.00	9
1999	$28.57	$0.00	$0.00	$0.00	
2000	$30.42	$30.42	$0.00	$0.00	
2001	$29.70	$27.47	$0.00	$0.00	
2002	$31.13	$26.64	$0.00	$0.00	
2003	$32.36	$25.62	$0.00	$0.00	
2004	$33.12	$24.26	$0.00	$0.00	
2005	$36.18	$24.52	$0.00	$0.00	
2006	$37.17	$23.30	$0.00	$0.00	
2007	$38.55	$22.36	$0.00	$0.00	
2008	$41.03	$22.02	$0.00	$0.00	
2009	$42.79	$21.24	$0.00	$0.00	
2010	$46.31	$21.27	$195.81	$89.93	
2011	$49.91	$21.20	$218.84	$92.98	
2012	$52.84	$20.77	$204.65	$80.44	
2013	$54.94	$19.98	$194.71	$70.81	

2014	$60.72	$20.43	$260.61	$87.68
2015	$66.79	$20.79	$66.54	$20.71
2016	$58.46	$16.83	$97.86	$28.18
2017	$63.96	$17.04	$108.74	$28.97
2018	$68.02	$16.76	$163.43	$40.28
2019	$0.00	$0.00	$0.00	$0.00
2020	$0.00	$0.00	$0.00	$0.00

					Notes:
Net Present Value =	$423	$/MWh	$540	$/kW	14,15
Avoided Energy Cost =			**$1,184**	**per system**	16
Avoided Capacity Cost =			**$395**	**per system**	17
Total Avoided Cost =			**$1,579**	**per system**	18
HECO Rebate =			**$750**	**per system**	19
Rebate as Percentage of Total Avoided Cost =			**47.5**	**%**	20

Notes: 14 Net Present Value of energy savings over the period of 1998 to 2020
15 Net Present Value of capacity (demand) savings over the period of 1998 to 2020
16 = (Avoided Energy Savings [w/ T&D losses]) x (NPV of energy savings)
17 = (Avoided Capacity Savings [w/ T&D losses]) x (NPV of capacity savings)
18 = (Avoided Energy Cost) + (Avoided Capacity Cost)
19 Rebate provided by HECO for residential solar water heating systems
20 = (HECO Rebate) / (Total Avoided Cost)

Avoided Costs of Solar Water Heating Systems (2005$)

			Notes:
Real Interest (Discount) Rate =	7.00	%	21
Average Annual Inflation Rate (1990 - 2003) =	1.79	%	22
Nominal Interest (Discount) Rate =	8.92	%	23
Average Annual Energy Cost Escalation Factor (1990 - 2003) =	1.40	%	22
Initial Oil Cost =	$50.00	2005$/bbl	24

Notes: 21 Typical and reasonable assumed value
22 From DBEDT Data Book information -
http://www3.hawaii.gov/DBEDT/index.cfm?section=statistics_and_economic_information378
23 = (1 + Real Interest [DR]) x (1 + Average Annual Inflation Rate [1990 - 2003])
24 Estimated average LSRFO cost for 2005

			Notes:
Energy Cost of Electricity =	$83.89	2005$/MWh	25
	$0.084	2005$/kWh	26
Specific Electricity Production Rate =	596	kWh/bbl	27
Transmission & Distribution (T&D) Efficiency =	0.888		28
Avoided Energy (w/o T&D losses) =	2,485	kWh/yr	28
Avoided Energy (w/ T&D losses) =	2,798	kWh/yr	29
Avoided Demand (w/o T&D losses) =	0.650	kW	28
Avoided Demand (w/ T&D losses) =	0.732	kW	30

Notes:
25 = 1,000 x (Initial Oil Cost) / (Specific Electricity Production Rate)
26 = (Initial Oil Cost) / (Specific Electricity Production Rate)
27 Value based on energy content (HHV) of LSRFO and HECO heat rate
28 Value used by HECO in PUC Docket No. 00-0209
29 = (Avoided Energy [w/o T&D Losses) / (T&D Efficiency)
30 = (Avoided Demand [w/o T&D Losses) / (T&D Efficiency)
31 Capacity Value corrected for inflation for the period of 2000 to 2005

Year	Energy Value (2005$/MWh)	Present Value of Energy (2005$/MWh)	Capacity Value ($/kW)	Present Value of Capacity (2005$/kW)	
2005	$83.89	$83.89	$0.00	$0.00	
2006	$85.07	$79.51	$0.00	$0.00	
2007	$86.27	$75.35	$0.00	$0.00	
2008	$87.48	$71.41	$0.00	$0.00	
2009	$88.71	$67.67	$0.00	$0.00	
2010	$89.95	$64.13	$213.98	$152.56	31
2011	$91.22	$60.78	$239.14	$159.35	
2012	$92.50	$57.60	$223.64	$139.27	
2013	$93.80	$54.59	$212.77	$123.83	
2014	$95.11	$51.74	$284.78	$154.90	
2015	$96.45	$49.03	$72.71	$36.96	
2016	$97.80	$46.47	$106.94	$50.80	
2017	$99.18	$44.04	$118.83	$52.76	
2018	$100.57	$41.73	$178.59	$74.11	
2019	$101.98	$39.55	$0.00	$0.00	
2020	$103.42	$37.48	$0.00	$0.00	
2021	$104.87	$35.52	$0.00	$0.00	

2022	$106.34	$33.66	$0.00	$0.00
2023	$107.83	$31.90	$0.00	$0.00
2024	$109.35	$30.24	$0.00	$0.00
2025	$110.89	$28.65	$0.00	$0.00
2026	$112.44	$27.16	$0.00	$0.00
2027	$114.02	$25.74	$0.00	$0.00
2028	$115.62	$24.39	$0.00	$0.00
2029	$117.25	$23.12	$0.00	$0.00
2030	$118.89	$21.91	$0.00	$0.00

					Notes:
Net Present Value =	$1,207	$/MWh	$945	$/kW	32,33

Avoided Energy Cost =	**$3,378**	**per system**	34
Avoided Capacity Cost =	**$691**	**per system**	35
Total Avoided Cost =	**$4,070**	**per system**	36
2005 Rebate	**$750**	**per system**	37
2005 Rebate as a Percentage of Total Avoided Cost =	**18.4**	**%**	38

Notes:
32 Net Present Value of energy savings over the period of 2006 to 2030
33 Net Present Value of capacity (demand) savings over the period of 2006 to 2030
34 = (Avoided Energy Savings [w/ T&D losses]) x (NPV of energy savings)
35 = (Avoided Capacity Savings [w/ T&D losses]) x (NPV of capacity savings)
35 = (Avoided Energy Cost) + (Avoided Capacity Cost)
37 Rebate provided by HECO for residential solar water heating systems
38 = (HECO Rebate) / (Total Avoided Cost)

Use of Solar Water Heating as a Base Case for Incentives

			Notes:
Annual Energy Savings per Solar Water Heating System =	2,798	kWh/yr	39
Avoided Capacity per Solar Water Heating System =	0.732	kW	39

Average Rebate

	Systems	Rebate	Total
Oahu	2,453	$750	$1,839,750
Hawaii	398	$1,000	$398,000
Maui	597	$1,000	$597,000
State (HEI only)	3,448		$2,834,750

Average Rebate per Solar Water Heating System =	$822	40

Average Solar Water Heating System Cost

	Systems	Cost per System	Total
New Construction	2,329	$3,176	$7,396,904
Retrofits	7,691	$4,847	$37,278,277
Totals	10,020		$44,675,181

Average Solar Water Heating System Cost =	$4,459	40

Average Net Solar Water Heating System Cost

Average Solar Water Heating System Cost =	$4,459		
Average Rebate per Solar Water Heating System =	$822		
Net Solar Water Heating System Cost After Rebate =	$3,636		
35% Energy Conservation Income Tax Credit (ECITC) =	$1,273		41
Average Net Solar Water Heating System Cost After Incentives =	$2,364		42
	53.0	%	
Total Value of Incentives =	$2,095		43
	47.0	%	

Notes:
39 Value used by HECO in PUC Docket No. 00-0209
40 Information provided by HECO
41 State income tax credit (ECITC) is applied to the remaining system cost after rebate
42 = (Average Net Solar Water Heating System Cost) - (Total Value of Incentives)
43 = (Average Rebate per Solar Water Heating System) + (35% ECITC)

Avoided Capacity Value

			Notes:
Net Present Value of Avoided Capacity =	$945	$/kW	
Avoided Capacity =	0.732	kW	
Avoided Capacity Value =	$691	per system	44
	$0.024	per kWh	45

Avoided Energy Value (= "Economic Value")

= Total Cost of Incentives - Avoided Capacity Value = UPV =	$1,404	per system	46
System Lifetime (n) =	25	years	47
Interest (Discount) Rate (i) =	7.00	%	48
NPVF(i, n) = [(1 + i)^n - 1]/[(i)(1 + i)^n] =	11.7		49
A =	$120	per year	50

Annual Energy Savings at End Use

Annual Energy Savings per Solar Water Heating System x Heat Rate =	33,310,952	Btu/yr
	33.3	mmBtu/yr
Annual Crude Oil Savings =	5.74	bbl/yr

Economic Value (per mmBtu, per bbl Crude Oil, and per kWh)

A=			$120	per year
	Amount	Units		
A / Annual Energy Savings =	33.3	mmBtu	$3.62	per mmBtu
	5.74	bbl/yr	$20.97	per bbl Crude Oil
	2,485	kWh/yr	$0.048	per kWh

Notes:
44 = (Net Present Value of Avoided Capacity) x (Avoided Capacity)
45 = (Avoided Capacity Value) / [(Annual Energy Savings per Solar Water Heating System) x (NPVF)]
46 Uniform Present Value (UPV)
47 Estimated Solar Water Heater lifetime (from Hawaii Solar Energy Association)
48 Typical and reasonable assumed value
49 Net Present Value Factor (NPVF)
50 Annualized Avoided Energy Value (= "Economic Value")

Externalities Costs (Value)

					Notes:
Wahl maintains that gasoline prices are subsidized at			$0.322	per gallon (1995$)	51
Consum. Price Index (1995) =	152.5	CPI (2005) (Est.) =	195.7		52
This is equivalent to			$0.413	per gallon (2005$)	53
For gasoline at	125,100	Btu/gal, the subsidy =	$3.30	per mmBtu	54
Shipping Efficiency =			0.980		55
Refining Efficiency =			0.900		55
Distribution Efficiency =			0.970		55
Overall Efficiency =			0.856		56
Subsidy (crude oil @ source) =	$2.83	per mmBtu	$16.39	per barrel	57

Proxy Externalities Value of CO2 Based on Crude Oil Subsidy

Crude oil produces	163	lb CO2 per mmBtu			
This is equivalent to	$0.017	per lb of CO2	$34.61	per ton of CO2	58
	$0.063	per lb of C	$126.81	per ton of C	58

Externalities Benefits (Value) of Solar Water Heating Systems

= Carbon Dioxide Production x Cost Per Pound of CO2 =	$0.038	per kWh	59
Annual Energy Savings x Externality Value =	$94	per year	60
NPVF(i,n) =	11.7		61
NPV of externalities benefits (value) for a SWH System =	$1,097		62

Notes:
51 Source: http://www.ethanol.org/pdfs/oil_slickers.pdf
52 From Hawaii State Data book information (see note 22)
53 = (Gas subsidy price [1995$] x [CPI {2005}) / (CPI {1995})]
54 HHV for gasoline from Energy Information Administration
55 Typical value
56 = (Shipping Efficiency) x (Refining Efficiency) x (Distribution Efficiency)
57 Subsidy at the source of the crude oil
58 Externalities values per unit of CO2 or C
59 = (Carbon Dioxide Production/kWh) x (Cost Per Pound of CO2)
60 = (Annual Energy Savings) x (Externality Value)
61 Net Present Value Factor (NPVF)
62 = (Annualized Externalities Value) x (NPVF)

Total Avoided Capacity, Economic, and Externalities Value of Solar Water Heating Systems

Avoided Capacity Value =	**$0.024**	**per kWh**	**$691**	**per SWH System**
Economic Value =	**$0.048**	**per kWh**	**$1,404**	**per SWH System**
Externalities Value =	**$0.038**	**per kWh**	**$1,097**	**per SWH System**
Total Value =	**$0.110**	**per kWh**	**$3,192**	**per SWH System**

Seawater Air Conditioning (SWAC) Systems

The following analysis provides a comparison of conventional (chiller-based) air conditioning and seawater air conditioning (SWAC) district cooling systems.

Conventional Air Conditioning (Crude Oil ➔ LSRFO ➔ Electricity ➔ A/C)

Specific Energy Use for Conventional Air Conditioning

					Notes:
Specific Energy Use =	0.80	kWh/ton-hr	2,730	Btu/ton-hr	63

Electricity Generation Efficiency

Shipping Efficiency =	0.980	64
Refining Efficiency =	0.900	64
Electrical Generation Efficiency =	0.325	64
Transmission & Distribution Efficiency =	0.888	64
Overall Efficiency =	0.255	64
1/Overall Efficiency =	3.93	

Fossil Fuel Energy Requirement for Conventional Air Conditioning

Fossil Fuel Energy Use =	10,724	Btu/ton-hr	65

Production of CO2 from Fossil Fuels Used to Generate Electricity for Conventional Air Conditioning

Carbon Dioxide Production =	1.75	lb CO2/ton-hr	66

Notes:
63 Assumes a weighed average value of 0.63 kW/ton for chillers and 0.17 kW/ton for cooling towers and condensing water pumps
64 See notes 1 - 4
65 = (Specific Energy Use) / (Overall Efficiency)
66 = (Specific CO2 Production) x (Fossil Fuel Energy Use)

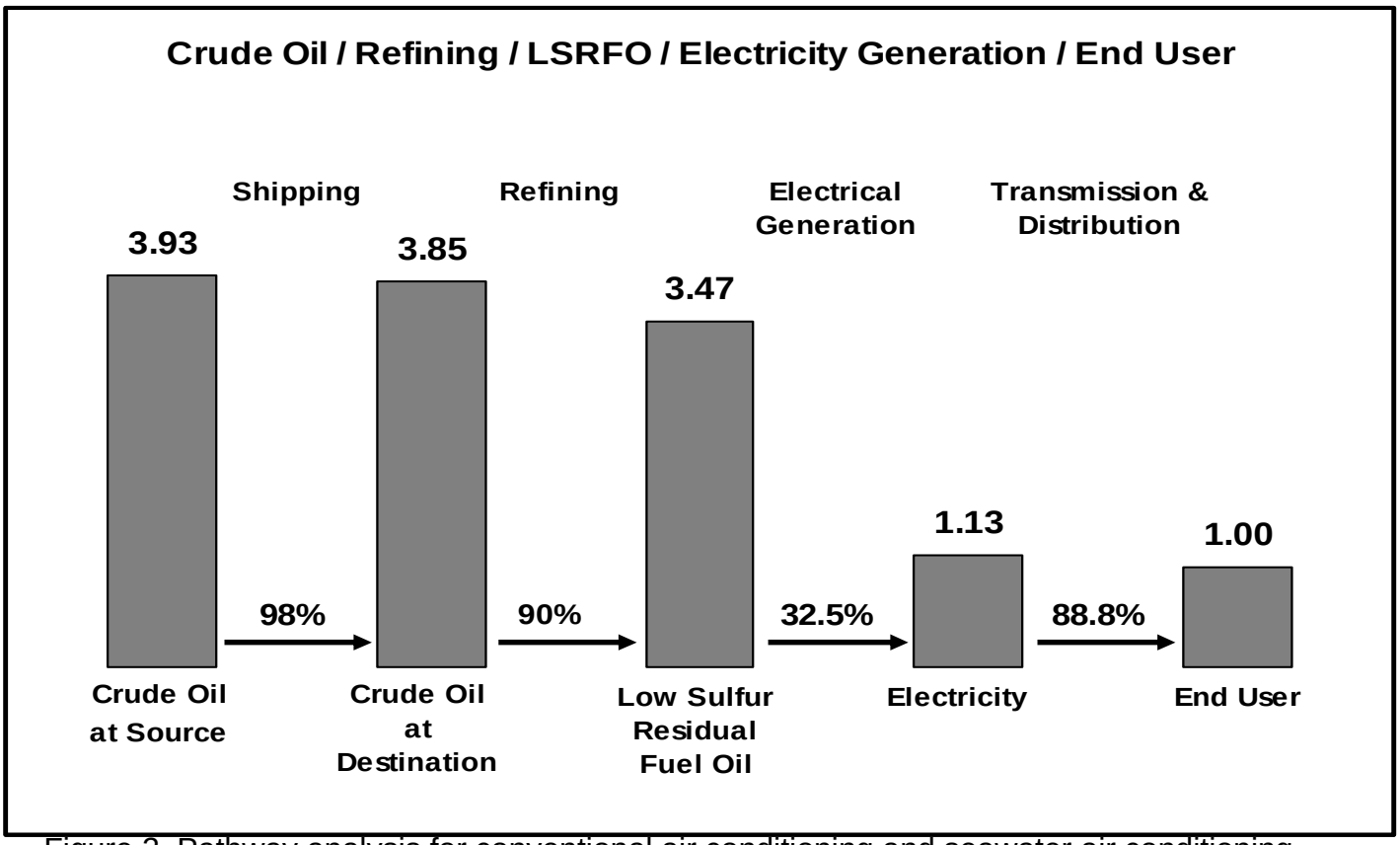


Figure 2. Pathway analysis for conventional air conditioning and seawater air conditioning.

Seawater Air Conditioning (Crude Oil ➔ LSRFO ➔ Electricity ➔ A/C)

Specific Energy Use for Seawater Air Conditioning

					Notes:
Specific Energy Use =	0.20	kWh/ton-hr	682	Btu/ton-hr	67

Electricity Generation Efficiency

Shipping Efficiency =	0.980	68
Refining Efficiency =	0.900	68
Electrical Generation Efficiency =	0.325	68
Transmission & Distribution Efficiency =	0.888	68
Overall Efficiency =	0.255	68
1/Overall Efficiency =	3.93	

Notes: 67 Calculated specific energy use for SWAC systems (includes seawater pumps, chilled water pumps, and auxiliary chillers)
68 See notes 1 - 4

Fossil Fuel Energy Requirement for Seawater Air Conditioning

			Notes:
Fossil Fuel Energy Use =	2,681	Btu/ton-hr	69

Production of CO2 from Fossil Fuels Used to Generate Electricity for Seawater Air Conditioning

Carbon Dioxide Production =	0.44	lb CO2/ton-hr	70

Capacity Savings and Value

Capacity Savings (kW/ton) = (Conventional Cooling [kW/ton]) - (SWAC [kW/ton])

Capacity Value ($/ton) = (Capacity Savings [kW/ton]) x	$945	per kW	71

Base Case:

Capacity Savings =	0.676	kW	72
Capacity Savings Value =	$638	per ton	73
Annual Full Load Operating Hours =	4,200	hours per year	74
System Lifetime (n) =	30	years	75
Interest (Discount) Rate (i) =	7.00	%	76
NPVF(i, n) = [(1 + i)^n - 1]/[(i)(1 + i)^n] =	12.4		77
Capacity Value =	$0.012	per ton-hr	78

Notes:
69 = (Specific Energy Use) / (Overall Efficiency)
70 = (Specific CO2 Production) x (Fossil Fuel Energy Use)
71 See note 33
72 = [(Specific Energy Use for Conventional A/C) - (Specific Energy Use for SWAC)] / (Transmission & Distribution Efficiency)
73 = (Capacity Value) x (Capacity Savings)
74 Composite SWAC system annual full load operating hours
75 Conservative estimate of SWAC system lifetime
76 Typical and reasonable assumed value
77 Net Present value Factor (NPVF)
78 = (Capacity Savings Value) / [(Annual Full Load Operating Hours) x (NPVF)]

Avoided Costs of Seawater Air Conditioning Systems

			Notes:
Real Interest (Discount) Rate =	7.00	%	79
Inflation Rate =	1.79	%	80
Annual Energy Cost Escalation Factor =	1.40	%	81
Initial Oil Cost (2005$) =	$50.00	$/bbl	82
Specific Electricity Production Rate =	596	kWh/bbl	83
Transmission & Distribution (T&D) Efficiency =	0.888		84
Avoided Energy (w/o T&D losses) =	2,520	kWh/yr	85
Avoided Energy (w/ T&D losses) =	2,838	kWh/yr	86
Avoided Demand (w/o T&D losses) =	0.600	kW	87
Avoided Demand (w/ T&D losses) =	0.676	kW	88

Notes:
79 Typical and reasonable assumed value
80 See note 22
81 See note 22
82 Estimated average LSRFO cost for 2005
83 Value based on energy content (HHV) of LSRFO and HECO heat rate
84 T&D efficiency used by HECO in PUC Docket No. 00-0209
85 = (0.8 kWh/ton-hr - 0.2 kWh/ton-hr) x (4,200 hrs/yr)
86 = (Avoided Energy [w/o T&D Losses]) / (Transmission & Distribution Efficiency)
87 = (0.8 kW/ton - 0.2 kW/ton)
88 = (Avoided Demand [w/o T&D Losses]) / (Transmission & Distribution Efficiency)

Year	Energy (2005$/MWh)	PV of Energy (2005$/MWh)	Capacity (2005$/kW)	PV of Capacity (2005$/kW)
2005	$83.89	$0.00	$0.00	$0.00
2006	$85.07	$0.00	$0.00	$0.00
2007	$86.27	$75.35	$0.00	$0.00
2008	$87.48	$71.41	$0.00	$0.00
2009	$88.71	$67.67	$0.00	$0.00
2010	$89.95	$64.13	$213.98	$152.56
2011	$91.22	$60.78	$239.14	$159.35
2012	$92.50	$57.60	$223.64	$139.27
2013	$93.80	$54.59	$212.77	$123.83
2014	$95.11	$51.74	$284.78	$154.90
2015	$96.45	$49.03	$72.71	$36.96

2016	$97.80	$46.47	$106.94	$50.80
2017	$99.18	$44.04	$118.83	$52.76
2018	$100.57	$41.73	$178.59	$74.11
2019	$101.98	$39.55	$0.00	$0.00
2020	$103.42	$37.48	$0.00	$0.00
2021	$104.87	$35.52	$0.00	$0.00
2022	$106.34	$33.66	$0.00	$0.00
2023	$107.83	$31.90	$0.00	$0.00
2024	$109.35	$30.24	$0.00	$0.00
2025	$110.89	$28.65	$0.00	$0.00
2026	$112.44	$27.16	$0.00	$0.00
2027	$114.02	$25.74	$0.00	$0.00
2028	$115.62	$24.39	$0.00	$0.00
2029	$117.25	$23.12	$0.00	$0.00
2030	$118.89	$21.91	$0.00	$0.00
2031	$120.56	$20.76	$0.00	$0.00
2032	$122.26	$19.68	$0.00	$0.00
2033	$123.98	$18.65	$0.00	$0.00
2034	$125.72	$17.67	$0.00	$0.00
2035	$127.48	$16.75	$0.00	$0.00

					Notes:
Net Present Value =	$1,137	$/MWh	$945	$/kW	89,90
Avoided Energy Cost =			**$3,228**	**per system**	91
Avoided Capacity Cost =			**$638**	**per system**	92
Total Avoided Cost =			**$3,866**	**per system**	93

Economic Value

Fossil Fuel Savings vs. Conventional A/C (= Fossil Fuel Displacement)

Fossil fuel savings =	8,043	Btu/ton-hr	94
Economic Value of Energy Savings =	$0.029	per ton-hr	95
	$1,516	per ton	96

Notes:
89 Net Present Value of energy savings over the period of 2005 to 2030
90 Net Present Value of capacity (demand) savings over the period of 2005 to 2030
91 = (Avoided Energy Savings [w/ T&D losses]) x (NPV of energy savings)
92 = (Avoided Capacity Savings [w/ T&D losses]) x (NPV of capacity savings)
93 = (Avoided Energy Cost) + (Avoided Capacity Cost)
94 = (Fossil fuel energy use for conventional A/C) - (Fossil fuel energy use for SWAC)
95 = (Value of Energy Savings) x (fossil fuel savings)
96 = (AFLOH) x (NPVF) x (Economic Value of Energy Savings)

Externalities Value

Reduction in CO2 Emissions vs. Conventional A/C

			Notes:
Reduction in CO2 Emissions =	1.31	lb CO2/ton-hr	97
Externalities Value =	$0.023	per ton-hr	98
	$1,185	per ton	99

Total Avoided Capacity, Economic, and Externalities Value of SWAC Systems

Avoided Capacity Value =	**$0.012**	**per ton-hr**	**$638**	**per ton**
Economic Value =	**$0.029**	**per ton-hr**	**$1,516**	**per ton**
Externalities Value =	**$0.023**	**per ton-hr**	**$1,185**	**per ton**
Total Value =	**$0.064**	**per ton-hr**	**$3,338**	**per ton**

Total Value of Avoided Water Use and Wastewater Generation

Specific Power Requirement of Conventional Chillers =			0.63	kW/ton	100
Thermal Load of Cooling Tower =			14,150	Btu/ton	101
Average Number of Concentrations =			3.07		102
Evaporation =	1.20	%	1.70	gal/ton-hr	103
Drift =	0.02	%	0.03	gal/ton-hr	104
Blowdown =	0.56	%	0.79	gal/ton-hr	105
Total Water Use =			2.52	gal/ton-hr	106
			10,577	gal/ton-yr	107

Notes:
97 = (CO2 emissions for conventional A/C) - (CO2 emissions for SWAC)
98 = (Externalities Value of CO2 emissions) x (Reduction in CO2 emissions)
99 = (Externalities Value(x (AFLOH) x (NPVF)
100 Weighted average of chiller power requirements
101 = 12,000 Btu/ton + [(3,412 Btu/kWh) x (Specific Power Requirement of Chillers)]
102 = Weighted average of sampling of large customers
103 = (Thermal Load of Cooling Tower) / [(8.33 lb/gal) x 1,000 Btu/lb)]
104 = [Evaporation (gal/ton-hr)] x [Drift (%)] / [Evaporation (%)]
105 = [Evaporation (gal/ton-hr)] x [Blowdown (%)] / [Evaporation (%)]
106 = (Evaporation) + (Drift) + (Blowdown)
107 = (Total Water Use) x (AFLOH)

Value of Avoided Water Use

Honolulu Water Rates (in 2005$)

	Water Fee ($/1,000 gal)	Water Fee (2005$/1,000 gal)	Notes:
2005	$1.98	$1.98	108
2006	$2.24	$2.20	
2007	$2.43	$2.35	
2008	$2.77	$2.63	
2009	$2.77	$2.63	
2010	$2.77	$2.63	
2011	$2.77	$2.63	
2012	$2.77	$2.63	
2013	$2.77	$2.63	
2014	$2.77	$2.63	
2015	$2.77	$2.63	
2016	$2.77	$2.63	
2017	$2.77	$2.63	
2018	$2.77	$2.63	
2019	$2.77	$2.63	
2020	$2.77	$2.63	
2021	$2.77	$2.63	
2022	$2.77	$2.63	
2023	$2.77	$2.63	
2024	$2.77	$2.63	
2025	$2.77	$2.63	
2026	$2.77	$2.63	
2027	$2.77	$2.63	
2028	$2.77	$2.63	
2029	$2.77	$2.63	
2030	$2.77	$2.63	
2031	$2.77	$2.63	
2032	$2.77	$2.63	
2033	$2.77	$2.63	
2034	$2.77	$2.63	
2035	$2.77	$2.63	
2036	$2.77	$2.63	

Average Cost of Water (2007 - 2036) = $2.62 per 1,000 gallons 109

Notes: 108 Source: http://hbws.org/cssweb/display.cfm?sid=1175
Assumes water rates increase at the inflation rate for the years of 2009 - 2036.
109 Average water rate in 2005$ for the period of 2007 to 2036

			Notes:
Value of Avoided Water Use =	$0.0066	per ton-hr	110
	$27.68	per ton-yr	111
NPV of Avoided Water Use Over SWAC System Lifetime =	$343	per ton	112

Notes: 110 = [(Average Cost of Water {2007 - 2036}) x (Total Water Use)] / 1,000
111 = (Value of Avoided Water Use) x (AFLOH)
112 = (Value of Avoided Water Use) x (AFLOH) x (NPVF)
113 Sources: http://www.co.honolulu.hi.us/env/sewerservicecharges2005.doc and http://the.honoluluadvertiser.com/article/2005/May/19/ln/ln02p.html/?print=on

Value of Avoided Wastewater Generation

Honolulu Sewer Rates (in 2005$)

Year	Annual Increase (%) from Previous Year	Multiplier Factor (2005 base)	Sewer Fee ($/1,000 gal)	Sewer Fee (2005$/1,000 gal)	
2005	25	1.0000	$3.90	$3.90	113
2006	10	1.1000	$4.29	$4.21	
2007	10	1.2100	$4.72	$4.55	
2008	10	1.3310	$5.19	$4.92	
2009	10	1.4641	$5.71	$5.32	
2010	10	1.6105	$6.28	$5.75	
2011	10	1.7716	$6.91	$6.21	
2012	6	1.8779	$7.32	$6.47	
2013	4	1.9530	$7.62	$6.61	
2014	4	2.0311	$7.92	$6.75	
2015			$7.92	$6.75	
2016			$7.92	$6.75	
2017			$7.92	$6.75	
2018			$7.92	$6.75	
2019			$7.92	$6.75	
2020			$7.92	$6.75	
2021			$7.92	$6.75	
2022			$7.92	$6.75	
2023			$7.92	$6.75	
2024			$7.92	$6.75	
2025			$7.92	$6.75	
2026			$7.92	$6.75	
2027			$7.92	$6.75	

2028	$7.92	$6.75
2029	$7.92	$6.75
2030	$7.92	$6.75
2031	$7.92	$6.75
2032	$7.92	$6.75
2033	$7.92	$6.75
2034	$7.92	$6.75
2035	$7.92	$6.75
2036	$7.92	$6.75

			Notes:
Average Sewer Rate (2007 - 2036) =	$6.50	per 1,000 gallons	114
Value of Reduced Sewage Generation =	$0.0052	per ton-hr	115
	$21.64	per ton-yr	116
NPV of Reduced Sewage Generation Over SWAC System Lifetim	$268	per ton	117

Total Value of SWAC Systems

Avoided Capacity Value =	**$0.012**	**per ton-hr**	**$638**	**per ton**
Economic Value =	**$0.029**	**per ton-hr**	**$1,516**	**per ton**
Externalities Value =	**$0.023**	**per ton-hr**	**$1,185**	**per ton**
Reduced Potable Water Use =	**$0.007**	**per ton-hr**	**$343**	**per ton**
Reduced Sewage Generation =	**$0.005**	**per ton-hr**	**$268**	**per ton**
Total Value =	**$0.076**	**per ton-hr**	**$3,950**	**per ton**

Notes: 114 = Average Sewer Rate (2007 - 2036)
Assumes water rates increase at the inflation rate for the years of 2015 - 2036.
115 = [(Average Sewer Rate {2007 - 2036}) x (Blowdown)] / 1,000
116 = [Average Sewer Rate (2007 - 2036)] x (AFLOH)
117 = [Average Sewer Rate (2007 - 2036)] x (AFLOH) x (NPVF)

Appendix C

Renewable Energy Potential on Oahu

The vast majority (>70%) of electrical (and other) energy use in Hawaii is on Oahu, where most of Hawaii's population lives.

Oahu has limited land resources for siting of renewable energy systems.

No single renewable energy resource can cost effectively satisfy these energy needs.

The following table is one possible scenario for meeting the governor’s 20% renewables goal by the year 2020 (Note: Table is for the electricity sector only).

Technology	Annual Production (Million kWh/yr)	System Size	Capacity Factor	Fraction of Oahu Renewables (%)
OTEC	700.8	100 MW	0.80	37.8
MSW +Co-firing	383.7	60 MW	0.73	20.7
Solar Thermal (SWH)	248.5	100,000 systems	-	13.4
Seawater Air Conditioning	220.5	100,000 tons	0.48	11.9
Wind	157.7	60 MW	0.30	8.5
Wave	105.1	30 MW	0.40	5.7
PV	36.8	20 MW	0.21	2.0
Totals	1,853.1	-	-	100.0
Oahu Use	9,261.7	-	-	-
RE as % of Oahu Use	20.0			

Notes:

Annual Production - In the case of OTEC, MSW + Cofiring, Wind, and PV, this is the amount of renewable energy generated annually. In the case of Solar Thermal, it is the amount of electrical energy use avoided due to use of this technology (i.e., 2,485 kWh/solar system-yr). In the case of Seawater Air Conditioning (SWAC), it is the amount of renewable energy contributed by the renewable energy resource - cold seawater (i.e., 2,205 kWh/ton-yr). An additional 315 kWh/ton-yr are saved by use of very energy efficient auxiliary chillers.

System Size - For OTEC, MSW + Co-firing, Wave, Wind, and PV, this is the rated capacity in MW. For SWAC it is the size of the displaced original AC demand in tons, for Solar Thermal, it is the number of equivalent residential size solar water heating (SWH) systems.

Capacity Factor - These are typical values under Hawaii conditions.

Fraction of Oahu Renewables (%) - Assumes that by 2020, renewables will contribute 20% of projected electrical energy demand. This is the fraction of the 20% that is supplied by each technology. Reduced demand due to energy efficiency measures will increase the percentage contribution of renewables.

OTEC (Ocean Thermal Energy Conversion) - This is one possible application for the Kalina-cycle. OTEC is a particularly attractive renewable energy technology because it has the capability to provide base-load electric power.

MSW + Co-firing - Assumes that the current Honolulu waste-to-energy plant will be replaced prior to 2020. In addition, some co-firing of biomass may occur at the existing AES coal-fired power plant.

Solar Thermal - Assumes that Oahu uses 69.1% of total solar systems statewide in 2020, and that the total number of equivalent residential solar water heating systems, on Oahu, will increase from 53,240 today to 100,000 by 2020 (a significant increase in the current penetration level). Commercial systems are represented as an unknown number of equivalent residential solar water heating systems.

Seawater Air Conditioning (SWAC) - Assumes district cooling systems replacing 100,000 tons of conventional air conditioning capacity (at a capacity factor of 0.48 and 0.80 kWh/ton-hr). SWAC provides 75% of the cooling load and very energy-efficient auxiliary chillers 25%). The annual cost of SWAC is not directly comparable to other renewable energy technologies because it displaces electricity at the retail rate rather than the avoided utility cost. A similar observation can be made for solar thermal.

Wind - Wind is the most cost effective renewable energy resource for Oahu (after MSW + Co-firing). However, limited land availability will limit total installed wind capacity.

Wave - Wave energy is in an early stage of development. However, Hawaii has a relatively good wave resource potential and on-going technology development is expected to improve the cost effectiveness of this technology.

PV - While PV seems to be the one of the most popular renewable energy technologies, it is far from the most cost-effective for utility-scale applications. PV is likely to be used in direct-use (on the end users side of the transformer), utility-intertied (net-metered) applications rather than utility-scale power generation. Costs will have to decrease significantly to provide electricity at projected commercial retail rates or at projected avoided energy costs in the year 2020.

Totals - The total Annual Production (1,853.1 Million kWh) represents 20% of the projected electricity (or equivalent) energy use for the year 2020 (Oahu Use = 9,261.7 Million kWh).

Conclusions

- In spite of some claims to the contrary, it is quite possible to displace 20% of electricity energy use with renewables by the year 2020. This could occur even earlier if we undertake a more aggressive renewable development program, combined with an energy efficiency technology implementation program.

- Ocean thermal energy conversion-related technologies (OTEC and SWAC) appear to have the greatest potential. The total contribution for these two technologies can be nearly half of the goal. A 100-MW Kalina-cycle OTEC power plant can provide nearly 38% of the renewable energy goal, while 100,000 tons of SWAC district cooling systems can contribute nearly 12 percent. Contributions from wave energy bring the total for ocean energy technologies to more than 55% of the renewable energy goal.

- MSW + Co-firing will contribute the second greatest amount (~21%), but probably not much more than it contributes today. This is due to increased recycling and reuse of its feedstock and limited potential for dedicated biomass production for co-firing with coal.

- Wind has great potential here, and is the most cost-effective. However, its potential is limited by land availability in areas with the best wind regimes.

- Solar thermal also has great potential, especially in untapped applications (low-income residential customers who are unable to take advantage of tax credits, multi-family residences, and commercial applications).

- PV is still too expensive to provide a significant fraction of the renewables goal. Significant cost reductions will be necessary to change this for utility-scale systems (although, lower cost reductions will be needed when other benefits are included in cost calculations).

Appendix D

Analysis of the Costs of a System Benefits Charge (SBC) Adder to Oahu Ratepayers

Annual Increase in Residential Electricity Use =	1.23	%/yr
Annual Increase in Commercial Electricity Use =	1.05	%/yr
Annual Increase in Number of Customers =	0.62	%/yr

Residential and Commercial Electricity Use Trends

Year	Residential Use (mmkWh.yr)	Residential Customers	Use Per Customer (kWh/yr)	Commercial Use (mmkWh/yr)	Commercial Customers	Use Per Customer (kWh/yr)	Total Electricity Use (mmkWh/yr)
2007	2,212.8	259,366	8,532	5,820.6	34,486	168,782	8,033.4
2008	2,240.1	260,974	8,584	5,881.7	34,700	169,502	8,121.8
2009	2,267.7	262,592	8,636	5,943.4	34,915	170,226	8,211.1
2010	2,295.6	264,220	8,688	6,005.8	35,131	170,953	8,301.5
2011	2,323.9	265,858	8,741	6,068.9	35,349	171,683	8,392.8
2012	2,352.6	267,506	8,795	6,132.6	35,568	172,417	8,485.2
2013	2,381.6	269,165	8,848	6,197.0	35,789	173,153	8,578.5
2014	2,410.9	270,834	8,902	6,262.0	36,011	173,893	8,672.9
2015	2,440.7	272,513	8,956	6,327.7	36,234	174,635	8,768.4
2016	2,470.7	274,202	9,011	6,394.2	36,459	175,381	8,864.9
2017	2,501.2	275,902	9,066	6,461.3	36,685	176,130	8,962.5
2018	2,532.0	277,613	9,121	6,529.1	36,912	176,882	9,061.1
2019	2,563.3	279,334	9,176	6,597.6	37,141	177,638	9,160.9
2020	2,594.8	281,066	9,232	6,666.9	37,371	178,396	9,261.7
Totals	33,588.0			87,288.8			

Averages	Average Use per Year	8,878	kWh/yr	173,548	kWh/yr
	Average Use per Month	739.8	kWh/mo	14,462	kWh/mo
	Average Cost per Month	$161.64	$/mo	$2,384.60	$/mo
	Average Electricity Cost	$0.2185	$/kWh	$0.1649	$/kWh
	Average SBC Adder Cost	$2.99	$/mo	$44.09	$/mo
		1.85	%	1.85	%
	2020 Electricity Use	769.3	kWh/mo	14,866	kWh/mo
	2020 Electricity Cost	$190.46	$/mo	$2,673.28	$/mo
	Max. SBC Adder Cost	$5.24	$/mo	$73.54	$/mo
		2.75	%	2.75	%

Residential and Commercial Electricity Cost Trends

Real Annual Electricity Cost Escalation Factor (Residential) =	2.06	%/yr
Real Annual Electricity Cost Escalation Factor (Commercial) =	1.40	%/yr

Year	Residential Electricity Cost ($/kWh)	Annual Electricity Cost (billion $/yr)	Commercial Electricity Cost ($/kWh)	Annual Electricity Cost (billion $/yr)	Total Annual Electricity Cost (billion $/yr)	Average Electricity Cost ($/kWh)
2007	$0.1900	$420.4	$0.1500	$873.1	$1,293.5	$0.1610
2008	$0.1939	$434.4	$0.1521	$894.6	$1,329.0	$0.1636
2009	$0.1979	$448.8	$0.1542	$916.7	$1,365.5	$0.1663
2010	$0.2020	$463.6	$0.1564	$939.4	$1,403.0	$0.1690
2011	$0.2061	$479.0	$0.1586	$962.6	$1,441.6	$0.1718
2012	$0.2104	$494.9	$0.1608	$986.3	$1,481.2	$0.1746
2013	$0.2147	$511.3	$0.1631	$1,010.7	$1,522.0	$0.1774
2014	$0.2191	$528.2	$0.1654	$1,035.6	$1,563.9	$0.1803
2015	$0.2236	$545.7	$0.1677	$1,061.2	$1,607.0	$0.1833
2016	$0.2282	$563.8	$0.1701	$1,087.4	$1,651.2	$0.1863
2017	$0.2329	$582.5	$0.1725	$1,114.3	$1,696.8	$0.1893
2018	$0.2377	$601.8	$0.1749	$1,141.8	$1,743.6	$0.1924
2019	$0.2426	$621.8	$0.1773	$1,170.0	$1,791.7	$0.1956
2020	$0.2476	$642.4	$0.1798	$1,198.8	$1,841.2	$0.1988
Totals		$7,338.8		$14,392.5	$21,731.3	
Averages	$0.2176		$0.1645			$0.1793
Increase (%)	30.30	52.79	19.88	37.31	42.34	23.46

	Residential	Commercial
2007 Per Customer Use (kWh/mo)	711.0	14,065
2020 Per Customer Use (kWh/mo)	769.3	14,866
Per Customer Use Increase (%)	8.21	5.70

	Residential	Commercial
2007 Per Customer Cost ($/mo)	$135.08	$2,109.77
2020 Per Customer Cost ($/mo)	$190.46	$2,673.28
Per Customer Cost Increase (%)	41.00	26.71

System Benefits Charge (SBC) Costs of Renewable Energy Technologies

System Benefits Charge (SBC) Adder $0.03788 $/kWh

	(mmkWh/yr)	(mmkWh/yr)	(mmkWh/yr)	(%)	(billion$/yr)		Total Cost (%)
2007	8,033.4	694.3	89.14	8.6	$1,293.5	$6.8	0.52
2008	8,121.8	783.4	89.14	9.6	$1,329.0	$10.1	0.76
2009	8,211.1	872.6	89.14	10.6	$1,365.5	$13.5	0.99
2010	8,301.5	961.7	89.14	11.6	$1,403.0	$16.9	1.20
2011	8,392.8	1,050.9	89.14	12.5	$1,441.6	$20.3	1.41
2012	8,485.2	1,140.0	89.14	13.4	$1,481.2	$23.6	1.60
2013	8,578.5	1,229.1	89.14	14.3	$1,522.0	$27.0	1.77
2014	8,672.9	1,318.3	89.14	15.2	$1,563.9	$30.4	1.94
2015	8,768.4	1,407.4	89.14	16.1	$1,607.0	$33.8	2.10
2016	8,864.9	1,496.6	89.14	16.9	$1,651.2	$37.1	2.25
2017	8,962.5	1,585.7	89.14	17.7	$1,696.8	$40.5	2.39
2018	9,061.1	1,674.8	89.14	18.5	$1,743.6	$43.9	2.52
2019	9,160.9	1,764.0	89.14	19.3	$1,791.7	$47.3	2.64
2020	9,261.7	1,853.1	89.14	20.0	$1,841.2	$50.7	2.75
Totals	120,876.8				$21,731.3	$401.8	1.85

Average Cost of Electricity over the Period of 2007 - 2020 = $0.1798 $/kWh

Average Cost of SBC Adder over the Period of 2007 - 2020 = $0.003324 $/kWh
1.85 %

Maximum Cost of SBC Adder over the Period of 2020+ = $0.005469 $/kWh
2.75 %