Understanding and Communicating the Environmental Impacts of Seawater Air Conditioning in Waikīkī Relative to Conventional Air Conditioning and Other Renewable Technology Options

Submitted to

Strategic Industries Division
State of Hawaiʻi Department of Business, Economic Development, and Tourism

Submitted by

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Center for Sustainable Coastal Tourism
The Center for Sustainable Coastal Tourism was established in 2009 as a university collaboration between the School of Ocean and Earth Science and Technology, the College of Social Sciences, School of Travel Industry Management, Hawaiʻinuiākea School of Hawaiian Knowledge, and the School of Architecture. In partnership with local businesses, government, and the community, the center conducts research, education, and outreach on Hawaiʻi tourism and the various economic, cultural, and environmental impacts of the visitor industry. Signature projects of the Center of Sustainable Coastal Tourism serve to improve the quality of Hawaiʻi's environment, restore habitats and ecosystems, and reduce the energy and water needed to support the tourism industry resulting in positive impacts on both Hawaiʻi's economy and quality of life for local residents.

The University of Hawaiʻi Sea Grant College Program has served Hawaiʻi and the Pacific for over 40 years and is dedicated to achieving resilient coastal communities characterized by vibrant economies, social and cultural sustainability, and environmental soundness.

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Introduction

This report provides a summary of an investigation by the University of Hawaiʻi Sea Grant College Program into the viability and effectiveness of installing a seawater air conditioning district cooling system in Waikīkī. Seawater air conditioning (SWAC) harnesses the cooling properties of cold seawater to provide cool air for air conditioning purposes. In doing so, SWAC reduces the amount of electricity needed for air conditioning. SWAC is particularly relevant to Hawaiʻi for two reasons: first, the proximity of deep, cold, ocean water to areas of high population make Hawaiʻi an obvious location for implementing the technology; and secondly, with approximately 90% of its electricity generated from fossil fuels, Hawaiʻi is the most fossil fuel dependent state in the nation. Unlike the rest of the U.S. where coal, natural gas, and nuclear power are called upon to meet a substantial proportion of the electricity demand, Hawaiʻi relies heavily on residual fuel oil (the by-product of refining crude oil for jet fuel, gasoline, and other distillates). As a result, Hawaiʻi has very high electricity prices compared to the rest of the country. SWAC has the potential to both cut the cost of air conditioning and reduce the amount of harmful emissions that are released as a by-product of generating electricity from fossil fuels.

Seawater air conditioning works by pumping cold (44-45°F), deep (1,600-1,800 feet) seawater into a cooling station (Figure 1). Here, the cold seawater is used to chill fresh water flowing in nearby pipes. The chilled fresh water is then piped into hotels for cooling purposes while the seawater (slightly warmed to 53-58°F) is pumped back into the ocean at a shallower depth (120-150 feet).

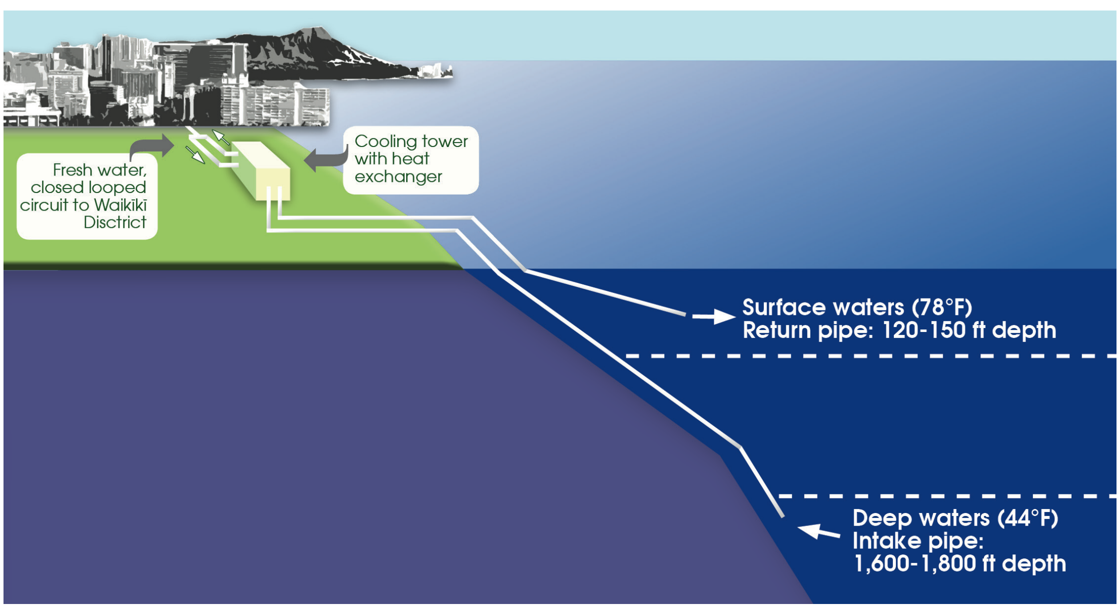

Figure 1: Seawater Air Conditioning

Discussion of Accomplishments

This section first outlines the project goals and objective before discussing the significant results, major findings, and conclusions of the project. The overarching goal of the project was to provide an extended, independent analysis of implementing a district-wide SWAC system for

Waikīkī compared to business as usual and a selection of alternative renewable energy and energy efficiency options. The project was structured around four tasks:

1. A comprehensive written report evaluating the environmental costs and benefits of a district-wide SWAC system for Waikīkī.
    a. Overview of Hawai'i's energy infrastructure.
    b. Examination of appropriateness of technology.
    c. Analysis, to the extent possible, based on the results of independent work described in the *Assessing Environmental Impacts* section of Exhibit A.
2. Written recommendations for the development of an environmental monitoring program for both the construction phase and the operating phase of a Waikīkī District SWAC system.
3. Develop, plan, and initiate a public outreach program to facilitate information exchange and stronger community acceptance of the development of SWAC technology.
    a. A report on the public position of SWAC, identification of reasons for support and opposition, and recommendations for ways to mitigate opposition.
    b. Developing a choice model to explain public preferences and willingness to pay for SWAC development in Hawai'i.
    c. Conducting a public outreach campaign.
4. Technical and other appendices to explain methodologies used.

Task 1: Evaluating the environmental costs and benefits of SWAC in Waikīkī

To provide context for the project, we began by providing a summary of key regulations, pieces of legislation, and Public Utility Commission dockets that relate to renewable energy development and the adoption of energy efficiency measures in Hawai'i. Most relevant to SWAC are the Hawai'i Clean Energy Initiative (HCEI) and the accompanying renewable energy portfolio standards (RPS) and energy efficiency portfolio standards (EEPS). Passed in 2008, the HCEI is an agreement between the US Department of Energy and the state government that helped to establish the guidelines to move the state's energy infrastructure away from fossil fuels. To reach the ultimate goal of reducing Hawai'i's oil consumption by 70% in 2030 (40% through renewable energy development and 30% through energy efficiency technologies) a number of milestones were agreed upon. The renewable portfolio standard milestones were updated in 2010 and set as: 10% of net electricity sales by December 31, 2010; 15% by December 31, 2015; 25% by December 31, 2020; and 40% by December 31, 2030. Up until January 1, 2015, energy efficiency technologies can account for up to half of the renewable energy portfolio. After that date, only renewable energy will be counted towards the portfolio. Although SWAC is technically a demand displacement technology, for HCEI purposes it falls under the broader rubric of energy efficiency.

As part of examining the appropriateness of SWAC technology, we compared SWAC to business as usual and various renewable energy and other energy efficiency options. To do so, we analyzed each option in terms of: 1) generation capacity; 2) applicability to existing policy standards; 3) economic factors; 4) environmental and social factors; and, 5) energy and supply security. Table 1 lists all resources and technologies that relate to the state's energy system, either through energy supply (e.g., fossil fuels and renewable energies) or energy demand reductions through energy efficiency and conservation measures (e.g., solar water heaters and SWAC). The resource list was compiled from options commonly identified by Hawaiʻi's energy stakeholders. The potential capacities for conventional and renewable energy generation are subject to debate, but we consider the estimates to be reasonable enough to allow for this analysis. While the numbers may be an estimate of the real numbers, we believe the potential variance does not discount our analysis.

In Table 1, the first group of measures lists existing, under consideration/proposed, and potential capacities. The existing capacities confirm the overdependence of Hawaiʻi's current energy system on fossil fuels in general and, more specifically, petroleum products. The second column displays the plans or projects that have been listed or proposed by state, utilities, or other companies. Finally, the third column determines the state's potential capacity for that resource, regardless of the policy constraints. In other words, it sets the limit of each resource to its natural availability constraint, if any.

The second category divides the resources into those that do not meet the requirements set by RPS and EEPS, those that meet RPS requirements, and those that meet EEPS requirements. Of course, not addressing either RPS or EEPS requirements puts the resource on hold or subject to extinction, as HCEI calls for new demand to be supplied by excess supply due to energy efficiency and for the existing fossil fuel demand to be converted into renewable fuel/energy demand.

The third category comprises economic (cost) factors and is divided into capital costs, fuel costs, and operations and maintenance costs. Cost factors are compared on a per-unit-of-energy basis. In the fourth category, resources are compared with respect to environmental and social factors. It is worth mentioning that the environmental impacts are considered on a global and life cycle basis. For example, biofuels rank low in terms of land use as the land used to produce the feedstock is taken into account. The last category evaluates the resources based on energy security concerns, which are basically divided into different factors that can affect the viability and continuity of each resource in Hawaiʻi, including natural, political, and technological factors.

In the comparisons, each source is given a ranking of "1" to "4" for each of the measures in the economic, environmental/social, and energy security categories. As the table legend explains, a measure is ranked "1" if the source has a very negative impact or a very bad status in terms of that measure. A ranking of "2" has a less negative connotation compared with a ranking of "1". When a resource is considered viable with respect to a measure (or the measure is not relevant to that resource), then it is given a ranking of "3". Finally, a good status or positive impact of the resource on each measure is distinguished by a rank of "4". Some measures have no rankings of "4" meaning that no energy resource can improve that measure.

The first group is comprised of petroleum products, coal (which together with petroleum products represents business as usual), and liquefied natural gas. These resources can theoretically be exploited at any potential capacity with a capacity factor close to 100%; however, as this group satisfies neither RPS nor EEPS requirements, none of the fuels are considered a viable option for the future.

Table 1
Comparison of Resource Options for Hawai'i's Energy Systems

Resource	State-wide Capacity (Existing / Under Consideration / Potential)			Policy Standards		Economic (Costs) Factors			Environmental and Social Factors							Energy/Supply Security								
	Existing Capacity (MW)	Under Consideration/ Proposed Capacity (MW)	Potential Capacity (MW)[a]	Address EEPS	Address RPS	Capital Cost	Fuel Cost	Operational/ Maintenance Cost	Land Use	GHG Emission	Solid Waste	Ocean Impacts	Noise	Visual/ Aesthetics	Social Acceptance	Natural Fuel Availability	Fuel Cost Volatility	Site Availability	Raw Material Avail.	Int'l Political Stability Risk	National Political Stability Risk	Local Political Stability Risk	Technology Maturity	Capacity Factor/ Intermittency
Petroleum Products[b]	2022	17	No limit	N	N	3	1	3	3	1	3	2	3	2	2	1	1	3	3	1	2	1	4	4
Coal	180	0	No limit	N	N	2	3	3	3	1	2	3	3	2	1	2	2	3	3	3	2	1	4	4
Liquefied Natural Gas (LNG)	0	0	No limit	N	N	3	3	3	3	2	3	3	3	2	2	2	2	3	3	3	1	1	4	4
Geothermal	30	30	> 1000		Y	2	4	2	2	4	3	3	2	2	1	4	4	1	3	3	3	3	4	4
Wind	93	521	> 800		Y	2	4	2	1	4	3	3	1	1	3	4	4	1	3	3	2	2	4	2
Hydro	29	11	> 100		Y	2	4	3	1	4	3	3	3	2	3	4	4	1	3	3	3	3	4	4
Solar (PV, Thermal)	20	190	> 2000		Y	1	4	1	1	4	2	3	4	3	4	4	4	3	1	3	2	2	3	1
Biofuels (Biodiesel)	113	?	No limit		Y	3	1	3	1[c]	3	3	2	3	2	3	2	2	3	3	2	2	1	2	4
Biomass	66	82	?		Y	3	3	3	2	3	4	3	3	2	3	2	3	2	3	3	3	3	3	3
OTEC	0	50-125	No limit		Y	1	4	2	4	4	3	2	3	2	3	4	4	3	3	3	3	3	1	4
Wave	0	1	No limit		Y	1	4	2	4	4	3	2	3	2	3	4	4	3	3	3	3	3	1	3
Demand Side Management				Y		3	4	3	4	4	3	3	4	3	4	4	4	4	3	3	2	2	3	3
Solar Water Heater				Y	Y[d]	2	4	3	1	4	3	3	4	3	4	4	4	2	3	3	3	2	4	3
SWAC	0	15-50	200	Y	Y[d]	1	4	2	3	4	3	2	4	3	4	4	4	2	3	3	3	3	3	4

1: Very Negative/Bad	3: OK/Not applicable
2: Negative/Bad	4: Positive/Good

[a] Without policy constraints
[b] Petroleum products include fuel oil, diesel, naphtha, and liquefied petroleum gas (LPG)
[c] Takes into account the land being used for growing biofuel crops
[d] Through 2014

The second group consists of renewable energy options and is made up of geothermal, wind, hydro, solar, biofuels, biomass, ocean thermal energy conversion (OTEC), and wave energy. Currently 14% of existing and installed nameplate capacity comes from renewable energy sources, with wind, biofuels and biomass comprising the majority. As opposed to fossil fuels, most renewable energy resources have capacity constraints which limit the maximum potential capacity in the state. However, the benefits of renewable energy (availability, applicability to the RPS, and reduced greenhouse gas emissions) are major drivers for almost all planned and proposed capacities associated with this group. The most common negative factors of renewable energy sources in general are their high capital costs, land use intensity, site availability issues, and lower capacity factor.

The third group in the table consists of energy efficiency options (demand side management, solar water heaters, and SWAC). These options are generally supposed to be the least costly options – the cheapest energy is that not being consumed. Efficiency and conservation measures only apply to some options (e.g., SWAC and solar water heaters) and they rely on behavioral change or systematic change in energy production, distribution, or consumption. As can been seen from Table 1, SWAC is one way of achieving greater energy conservation and efficiency. By cutting the electricity demand for air conditioning, it shares many positive aspects of this group with demand side management and solar water heaters. Having an offshore component, SWAC brings some ocean impact concerns with it (see below). However, whereas other marine technologies (e.g., OTEC and wave energy) are not particularly site specific, SWAC is extremely site specific. SWAC can only be economically feasible in areas with a certain number of subscribers to the grid, preferably with buildings larger than single-residence houses. With its huge upfront capital cost and relatively large operations and maintenance costs, SWAC may not be as cheap and economically attractive as other efficiency and conservation options. However, the reliability of SWAC gives it a solid advantage over more intermittent renewable energy technologies (such as wind and solar) especially for an area like Waikīkī, where there is a constant demand for air conditioning services.

The environmental benefits of a Waikīkī SWAC system can be estimated from a similar project proposed for downtown Honolulu. According to the final environmental impact statement, the Honolulu SWAC project is expected to save 77.5 million kWh/year, 260 million gallons of potable water, and 84 million gallons of wastewater. Additionally, it is expected that the downtown project will reduce CO_2 emissions by 84,000 tons, VOC by 5 tons, CO by 28 tons, PM_{10} by 19 tons, and NO_2 by 169 tons (TEC, 2009).

Despite these environmental benefits, there remains some uncertainty about the potential environmental impacts of SWAC – particularly with regard to the return of nutrient dense deep ocean water at, or close to, the surface of the ocean. While any environmental impacts could be mitigated by placing the outflow pipe beneath the euphotic zone (the depth that receives enough sunlight for photosynthesis to occur) this increases the cost of a SWAC system. As such, there was interest in assessing what, if any, impacts might occur from the release of deep ocean water at the ocean's surface. Two locations were proposed for study – offshore from Waikīkī Beach and the Ala Wai Canal.

As stated in the original proposal, much of the work that Sea Grant hoped to undertake in this area was to be based upon independent research conducted by C-MORE. In December 2011, C-MORE partnered with the Leibniz Institute of Marine Sciences (Kiel, Germany) to conduct the first open ocean deployment of three free-floating mesocosms (Figure 2). This collaboration – named BAG-1 (Biogeochemistry and Genomes) – provided the unique opportunity to not only test the feasibility of utilizing mesocosms in the open ocean, but also to examine the response of open ocean plankton assemblages to the addition of nutrients in different sized incubation vessels ranging from 1L bottles to 60,000L mesocosms enclosures. The overall scientific aim was to study the response of ocean plankton to additions of nutrient mixtures containing NO3-, PO43-, Si(OH)4, and trace metals, relative to responses to nutrient mixtures containing NO3-, Si(OH)4, and trace metals (+P vs. –P mixtures).

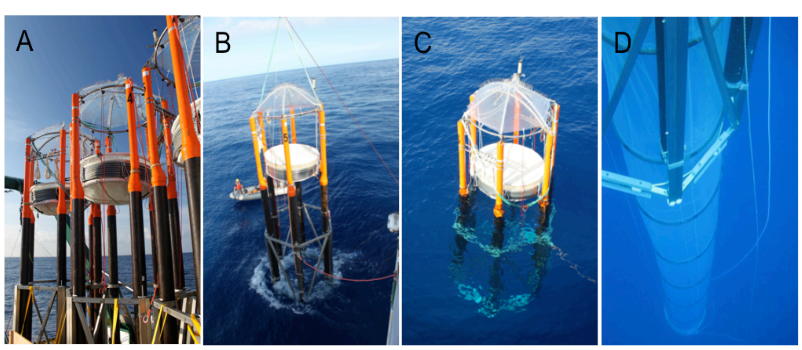

Figure 2: Photographs of the Mesocosms (Photo Credit: K. Björkman)

The greatest response of the phytoplankton community in the mesocosms was observed with the addition of a “+P nutrient mixture” (BAG#6 in Figure 3). Photosynthetic biomass and production were approximately twofold higher compared to the mesocosm that was amended with the “–P nutrient mixture” (BAG#5) and about fourfold higher with respect to the “unperturbed” mesocosm (BAG#4). The addition of phosphate to smaller sized incubations (20L bottles) led to a faster but not greater response of the phytoplankton community. Photosynthetic biomass and production were similar towards the end of the experiment and nearly fourfold higher compared to the controls. Overall, the research found that the response of the phytoplankton community was to some extent in agreement between small- and large-scale incubations but it is anticipated that further investigations in future mesocosms experiments in Hawaiian waters will be needed.

Based on the findings of these preliminary field experiments, it appears likely that an algal bloom could occur if nutrient dense SWAC effluent water is released into the euphotic zone. From an environmental perspective, the deeper and more diffuse the effluent the better. While it was not feasible for this study to conduct field experiments into the release of deep ocean water into the Ala Wai Canal, it is believed that releasing SWAC effluent into the Ala Wai could potentially result in nutrient discharge off Magic Island which, due to the generally eastward flow of water, could in turn lead to an algal bloom off Waikīkī Beach. It is important to stress that no data currently exists to prove this thesis but, based on the results of C-MORE’s open ocean research, it is recommended here that further research into the discharge of deep ocean water into the Ala Wai be undertaken before developing a Waikīkī SWAC system that releases effluent into the canal.

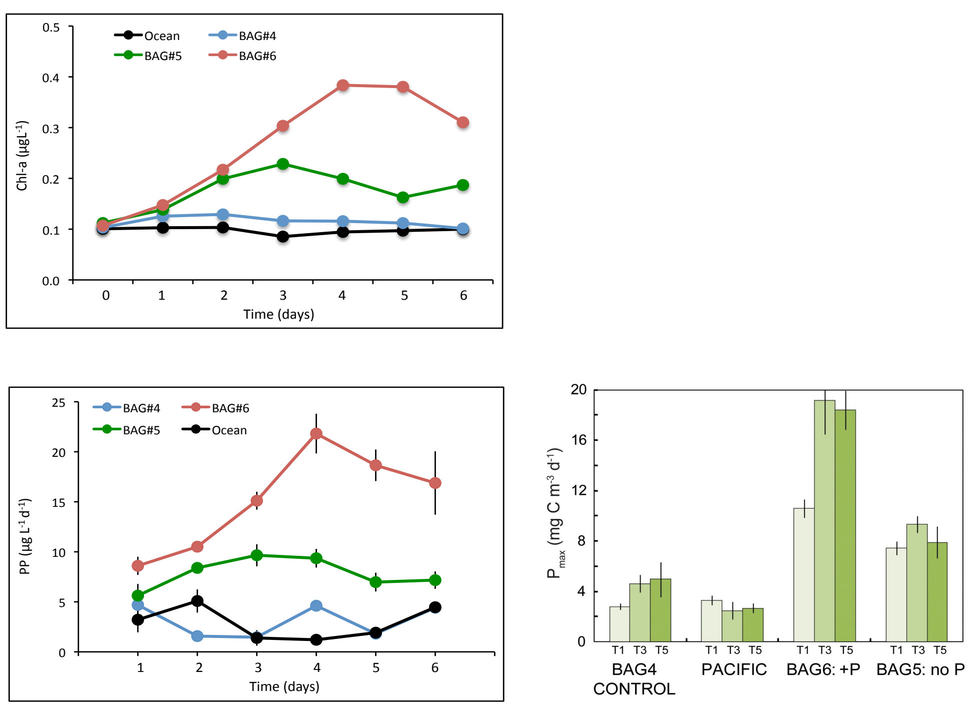

Figure 3: Total chlorophyll (upper panel) and primary production (lower panels; left from ^{14}C incubations, right from photosynthesis irradiance experiments) measured in and outside the three mesocosms

Task 2: Recommendations for the development of an environmental monitoring program
While the research conducted by C-MORE was not detailed enough to generate specific recommendations for a SWAC environmental monitoring program, it was possible to provide more general guidelines regarding the indicators that would need to be tracked for such a program. Ideally, measurements of temperature, dissolved oxygen and carbon dioxide, pH, nitrate, chlorophyll, and total suspended particulate matter could be used to monitor the clarity, productivity and general health of the coastal ecosystem. All of these parameters could be measured remotely and continuously, using an array of fixed moorings (at least three) deployed in the region of the effluent discharge compared to one mooring in a control region well outside the influence of the outfall. An alternative approach would be to deploy a small fleet (at least two) of instrumented robots (e.g., commercially available Seagliders) that would carry an identical suite of sensors. The latter approach would be preferable because it could provide a 4-D map of the plume and any biological response to effluent discharge even as the plume moves in time and space (e.g., in response to tides, coastal currents, or storms) and could map/track the plume as it ages. Both the moorings and the fleet of remote sensing robots would require periodic research vessel support for maintenance and sensor calibration. If a bloom were detected, it would also be imperative to obtain discrete water samples for more sophisticated, shore-based analysis.

Task 3: Public outreach program
Initially, it was proposed to develop a choice model to examine public preferences and willingness to pay for SWAC development in Hawai‘i. However, based on an initial pretest of the survey instrument it was apparent that a substantial number of O‘ahu residents are not familiar with SWAC. Indeed, only 40% (15/38) of pretest respondents had even heard of SWAC prior to filling out the survey. As such, it was suspected that levels of knowledge concerning different project options (e.g., distance of intake pipe to shore, depth of intake pipe, location and depth of outflow pipe) are very low and that most members of the general public would not be able to make informed decisions if presented with such options in a choice model. Given this assumption, we decided to use an alternative approach in which survey respondents were provided with a list of potential benefits and costs of installing a SWAC system in Waikīkī. Further, given that any SWAC development in Waikīkī will be primarily privately financed (with the possibility of some public support), rather than ask whether survey respondents would be willing to pay for SWAC directly, it was decided to ask whether they would agree with public funds being used for SWAC development. Respondents were also asked whether they would be willing to pay more for their electricity if a greater percentage of it came from renewable sources.

To generate the survey data, 2,000 questionnaires were mailed to O‘ahu residents. To the greatest extent possible, Dillman's Tailored Design Method was followed (Dillman, 2007). A balanced stratified random sample was drawn to ensure people from all parts of O‘ahu were sampled and to allow for comparisons across the island (Kish, 1995). Some regions were oversampled and others undersampled to ensure enough data were collected from each region.

Of the 2,000 surveys mailed out, 541 were completed and sent back. An additional 227 were returned as undeliverable. This bad address rate of less than 14% was slightly higher than average (a rate of 10% is more typical) but this is likely due to the transient nature of people living in Hawai‘i. Taking the undeliverable questionnaires into consideration, the survey yielded a response rate of 31%. In order to ensure the sample data accurately represented O'ahu residents and to thus apply inferences drawn from the sample to the broader population, the data were first weighted according to strata population, gender, age, race, and income.

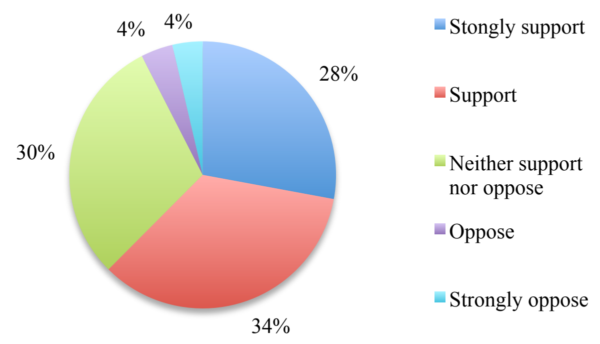

Figure 4: Support for SWAC in Waikīkī

A full description of the survey findings is presented in the project's Final Report. Due to space constraints, only a few highlights are discussed here. From the survey data we can state that a majority of O'ahu residents support the idea of developing a SWAC system for Waikīkī. As shown above in Figure 4, 28% of O'ahu residents strongly support the idea and a further 34% support the concept. Only 8% of respondents oppose the idea (4% strongly) and the remaining 30% neither support nor oppose.

As was the case with the survey pretest, a substantial number of respondents (in this case 50%) had not heard of SWAC prior to receiving the survey booklet. As might be expected, people who had heard of SWAC prior to receiving the survey were more likely to support its development than people who were not familiar with the technology (Figure 5). This is a positive finding for SWAC development as it indicates that increased awareness and understanding of SWAC result in increased support and that the information people have received to date typically engenders a positive attitude toward SWAC.

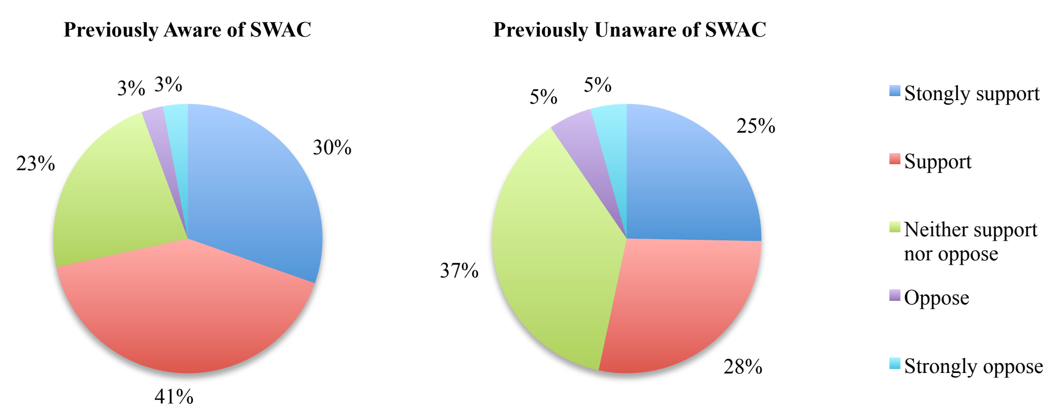

Figure 5: Comparison of Support for SWAC in Waikīkī between O'ahu Residents Who Were Previously Aware of SWAC and Residents Who Were Previously Unaware of SWAC

After stating whether they support or oppose SWAC development in Waikīkī, respondents were asked to briefly provide a reason for their answer choice. Among supporters of SWAC, key reasons for support include: a belief that SWAC will be more cost-effective; an understanding that SWAC utilizes a renewable resource, saves energy, reduces fossil fuel use, and will thus contribute towards Hawai‘i being more energy self-sufficient; and an acknowledgement that it simply makes sense to implement SWAC in a place like Hawai‘i.

For opponents of SWAC development in Waikīkī, the main concern was what environmental impacts SWAC might have on both the ocean and the land environment. A few people were worried about what impacts SWAC might have on local residents and whether locals would receive any benefits from the installation of a SWAC system. The potential cost of SWAC development was also given as a reason for opposition.

Respondents who were undecided about whether they support or oppose SWAC in Waikīkī listed similar issues to those given by opponents. The potential impact on the environment was again the most commonly cited reason behind a person's response; cost and the potential impact on local residents were again key issues for people. Also noted by people undecided about SWAC was the potential use of public money; a number of people who support the concept of SWAC do not agree with the use of any public funds to develop such a system. Lastly, there were some concerns about the viability and maintenance of the technology.

In an attempt to gauge the effect that knowledge of the benefits and potential impacts of SWAC has on public opinion, survey respondents were presented with six statements (three positive and three negative) and asked whether each statement affected their opinion of SWAC. Respondents were asked whether each statement made them more or less supportive, more or less opposed, or had no effect on their position. The following two tables show the percentage of people who changed their opinion when presented with this information. That is, Table 2 lists opponents of SWAC, along with neutrals (those who were undecided), and shows what percentage of them would be more supportive of (or less opposed to) SWAC if they knew about three potential benefits of the technology.

Table 2
Effect of Knowing the Benefits of SWAC on the Opinion of SWAC Opponents/Neutrals

Statement	Opponents % More Supportive	Neutrals % More Supportive
Reduce the amount of energy used by buildings connected to a SWAC system by 30%	11%	58%
Reduce fresh water use by 110 million gallons a year (1% of what O‘ahu uses)	20%	69%
Reduce CO_2 emissions by 120,000 metric tons (1% of what O‘ahu uses)	31%	62%

As can be seen from Table 2, opponents and neutrals have very different reactions when told of the benefits of SWAC. Upon hearing of each benefit, a majority of neutrals became more supportive (or less opposed). However, a far smaller number of opponents changed their position when informed of the same benefits. Knowing that SWAC reduces CO_2 emissions was the fact most likely to change the minds of opponents, but even then only about one-third of opponents became more supportive/less opposed. Only one in five opponents stated that knowing about SWAC's fresh water savings would positively affect their opinion of SWAC and just over one in ten stated that knowing of the energy savings would make them more supportive/less opposed to SWAC. These data imply that, among opponents, simply providing them with facts about the potential benefits of SWAC will do little to change their position. On a more positive note, presenting the same information to people who are undecided does appear to go a long way in making them more supportive (or at least less opposed) to SWAC.

In order to look at the effect on public opinion of potential negative impacts of SWAC, a similar analysis was conducted on those who favor a Waikīkī SWAC project along with those who were undecided. Table 3 shows the percentage of supporters and neutrals who stated they would be less supportive (or more opposed) to SWAC if the following potential impacts occurred.

Given the Waikīkī SWAC project is still at a conceptual stage, it is difficult to know the exact impacts of such a project. It is safe to assume there will be some disruption to traffic, but the likelihood of reef damage or the formation of algae off Waikīkī Beach is not yet known and, as mentioned above, it is possible that any environmental damage could be avoided or mitigated almost entirely depending on project design. As such, these statements were phrased as hypotheticals. Still, the data implies that *should* such impact occur then one might expect public support for SWAC in Waikīkī to drop substantially. As shown in Table 3, 64% of supporters and 75% of those undecided would be either less supportive (or more opposed) to SWAC should it damage Waikīkī's reef. Similarly, 74% of supporters and 62% of those undecided would view SWAC less favorably if it resulted in algae to form off Waikīkī Beach.

Table 3
Effect of Knowing the Impacts of SWAC on the Opinion of SWAC Supporters/Neutrals

Statement	Supporters % Less Supportive	Neutrals % Less Supportive
If SWAC caused traffic disruption for up to six months during construction	22%	41%
If SWAC caused minor damage to Waikīkī's reef during construction	64%	75%
If SWAC caused algae to form off Waikīkī Beach	74%	62%

In addition to the mail survey, we also conducted interviews with 15 key informants to obtain in-depth qualitative information about stakeholders' attitudes towards SWAC. Interviewees were either knowledgeable about SWAC or were people who might be affected by its development. The interviews enabled us to identify common themes and concerns about SWAC, gain insight into how SWAC is perceived by key stakeholders, and better understand any native Hawaiian cultural concerns that may exist concerning the development of SWAC in Waikīkī. Lastly, we held a public meeting in July 2012 to present the results of the mail survey to local residents.

Task 4: Appendices
Two appendices were attached to the final report: a copy of the public opinion mail survey, and the semistructured interview protocol used for stakeholder interviews. In addition, we created a UH Sea Grant SWAC website that can be accessed at http://sct.seagrant.soest.hawaii.edu/swac. The website is hosted by UH Sea Grant's Center for Sustainable Coastal Tourism.

Project Conclusion
Our analysis shows that while SWAC may not be as cheap and economically attractive as other efficiency and conservation options (due to significant upfront capital costs), its consistency and reliability provides it with a solid advantage over more intermittent renewable energy technologies (such as wind and solar). This is especially true for a highly developed tourist area like Waikīkī, where there is a constant demand for air conditioning. That being said, it is important to be aware that there exists the potential for algal growth in coastal waters should the SWAC outflow pipe be positioned too close to the surface. While it was not possible for this project to conduct field experiments into the release of nutrient dense deep ocean water into the Ala Wai Canal, given the results of the open ocean experiments, it is recommended here that further research into the release of deep ocean water into the Ala Wai is undertaken before developing a Waikīkī SWAC system that discharges into the canal.

A majority (62%) of Oʻahu residents support SWAC development in Waikīkī. This number increases to 71% among people who have previously heard of SWAC indicating that the information they have received to date has engendered a positive view of SWAC. On the whole, Oʻahu residents believe that SWAC will save energy and thereby reduce Hawaiʻi's dependence of fossil fuels. However, there exists some concern about both the potential environmental impacts of SWAC and the cost of the system, particularly when it comes to the spending of public funds.

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