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SUPERINTENDENT

DEPT. COMM. NO. 324

STATE OF HAWAI'I
DEPARTMENT OF EDUCATION
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HONOLULU, HAWAI'I 96804

OFFICE OF THE SUPERINTENDENT

February 2, 2017

The Honorable Ronald D. Kouchi, President
and Members of the Senate
State Capitol, Room 409
Honolulu, Hawaii 96813

The Honorable Joseph M. Souki, Speaker
and Members of the House of Representatives
State Capitol, Room 431
Honolulu, Hawaii 96813

Dear President Kouchi, Speaker Souki, and Members of the Legislature:

For your information and consideration, I am transmitting a copy of the Department of Education Report Relating to Energy, pursuant to Act 176 (2016). In accordance with Section 93-16, Hawaii Revised Statutes, I am also informing you that the report may be viewed electronically at: http://www.hawaiipublicschools.org/VisionForSuccess/SchoolDataAndReports/StateReports/Pages/Legislative-reports.aspx

Very truly yours,

Kathryn S. Matayoshi
Superintendent

KSM:lm
Enclosures

c: Legislative Reference Bureau
Office of School Facilities and Support Services

Report Items Relating to HB 2569, CD1 (2016)

In the 2016 Legislative Session, HB2569 was passed and became Act 176.

As a part of this law, Section 2 (a) reads, "The department shall establish a goal of becoming net-zero with respect to energy use, producing as much renewable energy as the department consumes across all public school facilities, by January 1, 2035." The law then goes on to require annual reporting, which requires regular updates on three areas regarding the net-zero goal. Below in bolded, italicized and underlined font are the three areas:

(1) Overall progress toward the net-zero energy goal set forth in subsection:

The Hawaii Department of Education's (DOE) long-term sustainability program – Ka Hei – is a top priority for meeting the goal of becoming net-zero with respect to energy by 2035. In the past two years, the program's strategy has been to implement cost-effective, impactful and financeable solutions that drive down both the consumption and cost of energy. Due to the Net-Energy Metering (NEM) program being shut down in October of 2015, the Ka Hei program began by focusing its main efforts on submitting Photo Voltaic (PV) NEM interconnection approvals to Hawaiian Electric. Simultaneously, it also began to audit and install energy conservation measures (ECMs) across a number of schools on Oahu and beyond.

Description of Energy Conservation Measures (ECM) and kWh Savings:

31	Schools with interior Light Emitting Diode (LED) lighting completed
1,838,200	kWh subtotal projected kWh of energy reduced in one calendar year after construction completion
3	Schools with stadium LED lighting completed
259,400	kWh subtotal projected kWh of energy reduced in one calendar year after construction completion
2	Sustainable cooling model completed
160,000	kWh subtotal projected kWh of energy reduced in one calendar year after construction completion
2,212,600	**kWh total projected kWh of energy reduced in one calendar year after construction completion of above three ECMs**
102	Number of schools with completed lighting audits
108	Number of schools being examined for interior and exterior LED lighting
29	Number of schools to commence construction of exterior LED lighting
5	Number of schools with stadium LED lighting to commence construction
3	Number of schools with sustainable cooling model in development or in construction

Description of Net-Energy Metered (NEM) PV Systems and kWh Production:

NEM PV Systems in Service:

16	Number of school sites
18	Number of PV systems
2,006	Subtotal kWdc of installed PV systems
1,328,919	Subtotal kWh of renewable energy produced as of January 24, 2017

NEM PV Systems to Complete Construction Before June 30, 2017:

58	Number of school sites
63	Number of PV systems
7,289	Subtotal kWdc of PV being installed
9,830,000	Subtotal projected kWh of renewable energy produced in one calendar year after construction completion

Total NEM PV Systems:

74	Number of school sites
81	Number of PV systems
9,295	Total kWdc of PV being installed
12,668,400	**Total projected kWh of renewable energy produced in one calendar year after construction completion**

Fiscal year 2015-2016 (July 2015-June 2016) DOE baseload consumption:

135,197,184 kWh at an average blended rate of $0.2635, equating to a total energy expenditure of $35,617,865

Projected total energy reduction (e.g. through ECMs) and offset (e.g. through PV) of baseload consumption:

14,881,000 kWh, which is 11 percent of baseload consumption

(2) Plans and recommendations to advance the net-zero energy goal set forth in subsection:

The Net Zero Energy Campus (NZEC) Program

The Ka Hei Program is and will continue to integrate innovative energy technologies that reduce energy consumption and costs while also providing meaningful learning experiences with standards-aligned curricula deliverables. As part of this endeavor, each year, selected schools will be transformed into Net-Zero Energy Campuses (NZECs).

NZECs are one of the critical components of Ka Hei, optimizing the most cost-effective solutions in one comprehensive and integrated program.

These NZECs will serve as a model for Ka Hei's overall vision in providing clean energy and power reliability. The modernization of the facility will result in a transformation of the learning environment, while reducing operational expenses and providing engaging educational opportunities for our students and community.

A NZEC is a facility with zero energy consumption on a netted basis. In other words, the total amount of energy used on an annual (or daily) basis is approximately equal to the amount of renewable energy generated on campus. As a result, these buildings do not contribute to the emission of greenhouse gases and can become “islanded utilities” completely independent from the grid. The schools evaluated for NZEC status are designed to be net zero on an annual basis, so there will be some days when a minimal amount of power will be purchased from the utility.

In order to leverage this concept of NZEC, a detailed feasibility assessment was initiated at each of the five schools (listed below). Historical billing data was gathered and energy meters were installed at schools to determine baseline energy usage.

A detailed energy audit was conducted to document all the equipment at the schools that consume energy. This process included interviewing the school staff and estimating run time hours for the equipment.

The most cost effective measures – LED lighting and HVAC equipment efficiency upgrades – were considered first. At several schools aging or obsolete equipment was found, and it was recommended that this equipment be replaced with new high-efficiency equipment.

The proposed on-site PV systems were sized to offset the remaining load after the energy efficiency measures are installed. An energy storage and control system was appropriately sized to allow the PV generated energy to be delivered when it is needed by the school. The energy storage control system will prevent energy from being exported to the utility grid and minimize the energy purchased from the local utility.

With the exception of the energy storage and control systems, all of the energy technologies put forth in the feasibility assessments are currently being installed or have been installed at other DOE schools. The Ka Hei Program will carefully select the energy storage technology vendor most qualified, and evaluate the overall value and risks of the energy storage systems.

The first phase of NZECs under development include the following schools:

Maui High School:
Photovoltaic System: 400 kW AC
Energy Storage Power Conditioning System (PCS): 500 kW
Energy Storage Battery: 600 kWh
Load that will be served by NZEC is approximately 75 percent

Pōmaikaʻi Elementary School:
Photovoltaic System: 438 kW AC
Energy Storage Power Conditioning System (PCS): 250 kW
Energy Storage Battery: 300 kWh
Load that will be served by NZEC is approximately 80 percent

Kamaliʻi Elementary School:
Photovoltaic System: 300 kW AC
Energy Storage Power Conditioning System (PCS): 250 kW
Energy Storage Battery: 300 kWh
Load that will be served by NZEC is approximately 85 percent

Waiākea High School:
Photovoltaic System: 370 kW AC
Energy Storage Power Conditioning System (PCS): 500 kW
Energy Storage Battery: 600 kWh
Load that will be served by NZEC is approximately 70 percent

Kahakai Elementary School:
Photovoltaic System: 275 kW AC
Energy Storage Power Conditioning System (PCS): 150 kW
Energy Storage Battery: 200 kWh
Load that will be served by NZEC is approximately 85 percent

Plans for future NZEC development

The NZEC strategy provides a clear, cost-effective path to achieving the DOE's Net Zero goal. In 2017 the five NZEC projects under development are expected to be installed and placed into service. This will provide a solid demonstration of the NZEC strategy and set the course for future project development. In 2017 the next phase of NZECs will begin development. Initial school site assessments will be performed to determine the next 10 schools targeted for NZEC project development. Replicating and expanding this yearly development cycle in the subsequent years will provide a consistent, predictable strategy for the DOE to meet the Net Zero goal. This aggressive schedule presumes that legislative and regulatory policies enable the DOE to achieve its goals without challenges that delay the development timeframe such as lengthy interconnection approvals from the utilities. This schedule could also potentially be accelerated or decelerated due to market forces both from a technological advancement perspective, as well as from a comfort level from financiers. Below is an aggressive schedule for the decade-long NZEC strategy to enable the DOE to meet its 2035 goal.

Calendar Year	NZEC Schools in Development	NZEC Schools in Service	Total Percentage of NZEC Schools NEZC
2017	5	5	2%
2018	10	15	6%
2019	20	35	14%
2020	30	65	25%
2021	30	95	37%
2022	30	125	49%
2023	30	155	61%
2024	30	185	72%
2025	30	215	84%
2026	30	245	96%
2027	11	256	100%

Additional benefits from NZECs:

Providing power reliability for our islands is a state-wide priority. Energy storage systems are being proposed for all five schools being evaluated. These five NZECs also have *high potential to become strategic assets for the Hawaii Civil Defense system*, once they achieve microgrid status. In the future, these schools could provide robust learning environments that will also stand as beacons of clean energy and community shelter in the case of natural disasters.

The Department of Education is making great strides as a pioneer in sustainability, clean energy, and transformational learning experiences through Ka Hei. These achievements *poise the DOE for potential high-profile recognition through the Living Building Challenge (LBC) Net-Zero Energy Building certification*. Not an easy accolade, this acknowledgment would distinguish the DOE in its strive for sustainability, energy independence, education, and natural beauty – concepts that resonate deeply with the way of life on our islands. While there will be additional costs accrued to document and certify the LBC certification, the cost of this pursuit may be accounted for in the financing options of this program.

NZECs, as part of Ka Hei, are the model for how we achieve long-term sustainability. The *DOE can be the leader for other stakeholders* in the hospitality, commercial, and industrial sectors to follow suit in our islands' journey towards sustainability.

Furthermore, a foundational pillar of the Ka Hei Program is its *ability to leverage technology and campus improvements for educational enhancement*. Just as professional development sessions have been built around solar PV and energy efficiency efforts, NZECs are no exception. NZEC concepts will be integrated into learning experiences to bolster student success.

In short, the NZECs allow Hawaii to make progress towards energy independence, create unique learning opportunities for our keiki, and prepare today for tomorrow's challenges.

Recommendations

In addition to providing the means to meet the energy goals, the NZEC systems provided by DOE have the potential to provide significant value to the Hawaiian Electric grid.

The NZEC technology solution has the ability to enhance the reliability, stability and performance of the utilities' power systems while providing low cost, renewable power to the DOE based on a combination of power electronics, solar PV, and storage. The NZEC solution could serve immediate needs in Hawaii (for both Hawaiian Electric and Kauai Island Utility Cooperative (KIUC), as well as the public schools that seek low-cost power from low carbon and renewable sources) and will be of broader value to utilities and communities that share the ambitions of Hawaii. The integration of significant NZEC resources has the capability to improve the reliability and performance of Hawaiian Electric and KIUC's grid operations.

This proposed solution and strategies will be of immense value to communities both within Hawaii and U.S. regions where penetrations of renewables will continue to follow the same pattern of growth shown in Hawaiʻi.

Presently, Hawaiian Electric experiences over-generation events caused by significant and increasing quantities of solar that occur during midday when load tends to be lower and production is the highest, and a reciprocal lack of solar production when load tends to be higher in the afternoon as the sun wanes. Additionally, the intermittent nature of solar PV causes voltage and frequency excursions that reduce power quality and jeopardize the stability of distribution feeders. These issues, already apparent in Hawaii, will become more severe as the cost of renewables decline and end user demand increases for low-carbon sources of energy.

By developing a new solution that integrates controls, storage and intelligent PV inverter strategies into a scalable, cost-competitive, controls solution the DOE's NZEC systems could address the grid impacts above, provide immediate value to end users in Hawaii, and provide a lasting model for other regions to implement the same technology to meet their needs and encourage the integration of renewable energy resources. This model would be easily replicable and deployable to other customers and could serve as a new business model for the utility.

This could be a significant demonstration of the concept of utilizing local energy storage coupled with distributed PV systems to enhance the performance of the grid. Installing battery systems at schools can provide the ability for the schools (a community resource) to increase their on-site PV generation while providing benefits to the distribution system.

By intelligently employing several strategies to control PV production, using storage to absorb frequency and voltage transients, and by enabling the utilities to leverage distributed storage to support system-wide objectives, the Ka Hei Program hopes to strengthen the technical and economic case for continued integration of renewable and distributed energy resources.

(3) Any challenges or barriers encountered:

By far, the biggest challenge and barrier to successfully reaching the 2035 Net Zero goal is receiving interconnection approval from the Hawaiian Electric Utilities. The NZEC systems are designed to not export power to the utility grid. The main reason for the non-export design is to eliminate any impact to the utility grid. This type of non-export design should require very little utility technical evaluation prior to the approval of the interconnection application.

One potential reason for the delay or denial of a Standard Interconnection Application (SIA) approval is the utilities' concern about load departing from their grid. In this case, the utilities' concerns about departing load and the DOE's goal of Net Zero Energy are in direct conflict.

If the SIAs are denied by Hawaiian Electric due to departing load impacting distribution or transmission circuits then the Hawai'i Department of Education Net Zero goal will not be achievable.

Denial of SIAs due to departing load should not be allowed. The solution of utilizing the school site battery systems to support the grid as described above can address the departing load conditions. The school-located energy system can be used by the utility as an energy load or an energy source dependent on the needs of the grid.

The proposed technology, including its basic operating principles

The proposed technology is a stand-alone control solution that allows coordinated control of dispersed PV inverters and co-located storage to simultaneously meet site and system-wide objectives in a reliable, low-cost manner. Although many of these strategies have been employed either for a utility or for end users, an integrated system of sites serving their own local load and the utility simultaneously is a novel application.

By providing power from end-use sites such as DOE schools to the grid (Hawaiian Electric and KIUC) would demonstrate a strong economic case for the co-location of PV and storage managed by a common control system by better aligning distributed production with load, smoothing intermittent power from renewable sources, absorbing transients and providing the grid frequency and voltage support. In so doing, the Ka Hei Program will seek to reduce significant peak charges associated with operating peaker power plants and avoid adverse impacts that reduce the life of grid infrastructure, thereby prolonging their useful life.

Basic Operating Principles

The DOE schools are great sites for this technology based on their ability to support local distribution and transmission needs.

The system, to be operated by Hawaiian Electric and KIUC, will monitor each site's generation potential, state of charge (storage), site load and actively stabilize production from each site to support the selected distribution feeders. The technology will interface directly with the utilities' control center and will be able to utilize excess capacity to support system-wide grid objectives.

By interfacing with the utilities' existing DMS/SCADA systems and the site-specific distributed energy resources (PV and storage), the solution is able to provide situational awareness (by continuously assessing the positive or negative impact that available distributed energy resources will have on grid operations, availability, reliability, locational value) and actionable steps that can be used to optimize both site operation and system objectives.

The novel attributes of the proposed solution are as follows:

- Using a networked control system to allow the battery systems to provide local services to the distribution system and providing island wide frequency control, spinning reserve and energy (during the time it takes to restore power plant generation) by dispatching the batteries in aggregate.
- Using distributed PV and storage to provide voltage control, frequency control to support system objectives (e.g. employing innovative curtailment strategies to reduce PV production based on grid or weather conditions, adapting ramp rate control algorithms to ensure "smooth" production profiles).
- Using distributed battery storage systems to absorb adverse grid impacts of high penetration PV solar.
- Collaboratively selecting distributed public school sites to locate the distributed battery systems where they will provide the most value to the distribution grid.

Each school will net meter generation that is not consumed at the time of production. At the same time, daily peak production from customer-sited PV systems will be stored in each on-site battery to reduce the impact to the distribution system; this energy will be discharged during the peak load in the evening to reduce the need for peak power fossil fuel generation.

There are several value streams that are available from this dispersed control of sites including but not limited to:

- active voltage control,
- transient overvoltage control,
- frequency regulation,
- smoothing for renewable resources,
- generation curtailment,
- grid power support during power plant trips,
- renewable energy time shifting, and
- others.

Although the aggregate value of these features has not been calculated yet, a detailed economic study could identify the aggregate value in comparison to prevailing and conventional approaches.

The current state-of-the-art technology in the relevant field and application

Currently, the mechanism to control voltage on a distribution feeder is via a load tap changer at the distribution substation. Utility grids have challenges maintaining system voltage and frequency when there are high penetrations of distributed generation systems. For example, cloudy days will cause the distributed PV inverters' output to fluctuate rapidly that results in rapid changes in the distributed feeder voltage. Load tap changers work well for slowing changing loads on feeder circuits but do not have the capability to respond to rapid generation changes from PV generation systems.

Distribution feeders were not designed for reverse power flow from the distribution feeder to the transmission system. During periods of high reverse flow conditions there is the potential that a transient overvoltage condition could result from the substation protection breaker opening and isolating the feeder circuit from the transmission system.

Frequency regulation is currently provided by the central generation power plants. Due to the fact that each island is isolated electrically, a fault condition at of any single power plant can result in frequency excursions that propagate across the island and cause a loss of load and system instability over a large area.

How proposed technology will overcome the shortcomings, limitations, and challenges

Utilizing energy storage technology on the distribution system has the potential to provide active local control over the critical performance parameters of the grid. This control at the distribution level will significantly increase the resiliency of the distribution and transmission systems. It will also allow distributed generation resources to interact with the grid to provide support and help stabilize the grid.

Distributed storage systems have the additional benefit of allowing the deferral or elimination of increasing the capacity of the distribution and transmission infrastructure. Over-generation can be stored and utilized locally.

Recommendations to overcome the Interconnection Application challenges and barriers

- Modify Hawaiian Electric Rule 22 to remove the 100 kW cap on Customer Self Supply applications.
- Require Hawaiian Electric to approve the no export interconnection applications within 90 days.
- Implement projects to demonstrate the recommendations described above that utilize batteries at schools to support the utility grid.

Doing the above will enable the utilities to realize the technical and financial benefits that NZECs provide them, and importantly, ensure that the DOE achieves its 2035 goal.

Subsection (d) reads: d) the department shall expedite the cooling of all public school classrooms to a temperature acceptable for student learning. The report shall include the following information:

(1) The number of completed classrooms in which cooling measures were implemented and the number of classrooms remaining that require cooling:

204 classrooms have been completed. There are still 796 classrooms remaining that require cooling. The following is a breakdown of the completed classrooms:

151 DOE installed (New installations through Form 6700)
49 DOE installed (Including installations from Ka Hei program)
4 Donated

(2) The different types of cooling measures implemented:

The following are the types of cooling measures implemented by the DOE thus far:

Mechanical Cooling
PV Air Conditioning
Standard Air Conditioning

High Efficiency Split Air Conditioning System (Sustainable Cooling Model Schools)
Portable Air Conditioning Systems

Passive Cooling
Installation of ceiling fans
Roof Cooling Paint

(3) The approximate cost per classroom for planned cooling measures, including installation, upgrades, equipment, maintenance, and projected operating costs over the life of the installed cooling measures and (4) The approximate cost per completed classroom for cooling measures implemented, including installation, upgrades, equipment, maintenance, and projected operating costs over the life of the installed cooling measures:

The DOE is currently in the midst of bidding out these projects, therefore these estimates cannot be projected accurately at this time. The initial bids for the projects came in very high. Those bids were rejected. Since then, the projects have been re-sent out for bidding and the costs coming in now are more reasonable. As the DOE moves forward with the contracts, the department will get better pricing information that will more accurately approximate the planned and completed costs for these projects. Once the department has the pricing information that is able to approximate these costs accurately, the information can be provided at that time.

(5) The number of completed classrooms in which energy efficiency measures were installed or implemented and the number of classrooms remaining that require energy efficiency measures:

In relation to energy efficiency measures, a total of 1,456 classrooms (from the top 33 schools) have had LED lights installed. There are 272 classrooms remaining that require energy efficiency measures. The following is a breakdown of the completed classrooms:

1,287	DOE installed through Ka Hei (23 of 33) schools that make up the 1,000 classrooms
169	DOE installed by the Facilities Maintenance Branch (4 of 33) schools that make up the 1,000 classrooms
129	DOE installed through Ka Hei (pilot schools)
*36	DOE Offices installed by Facilities Maintenance Branch

(6) The different types of energy efficiency measures installed/implemented:

	Type of Efficiency Measure	Notes
Sustainable Cooling Model	Interior and Exterior LED Lighting Retrofits	
	Refrigeration Upgrades and Controls System	
	Upgraded Existing AC Controls	
	Kitchen Cooking Hood Exhaust Fan Electronically-Commutated Motor Retrofit	
	Kitchen Ventilation Fan Electronically-Commutated Motors Retrofit	
	Retro-commissioning of Package Unit AC	Optimizes set points and controls without unnecessarily replacing parts or the entire existing AC unit
	EnergyStar Ceiling Fans	Allows higher temperature set points because evaporative cooling enables a feeling that it is 3-4 degrees Fahrenheit cooler than the actual ambient room temperature, thereby saving energy and ensuring no hot/cold spots in classroom
	Limited Electrical Upgrades	
Additional Services Provided at Honowai Elementary Sustainable Cooling Model Demonstration Project	Educational Engagement and Contest	All-day professional development session to provide educators with standards-aligned curricula that makes real connections between the students and the energy efficiency and renewable energy technologies on campus through hands-on, project-based learning.
	300+ electric circuits metered on the installed efficiency measure and AC	5,000,000 data point are collected each month to provide a detailed understanding of when, where and how much energy is consumed pre- and post-installation
High-Efficiency Ceiling Fan Demonstration Project	Demonstration project at Palisades ES to show how high-efficiency, whisper quiet ceiling fans with electronically-commutated motors may be able to provide sufficient evaporative cooling where all classrooms not require AC units to achieve desired comfort levels.	
High School Field LED Retrofits	King Kekaulike HS, Kea'au HS, Kahuku HS and Moanalua HS have or will soon have their entire field halogen lighting system retrofited with LED lighting systems.	Four other schools (Nānākuli HS, Campbell HS, Pearl City HS and Waipahu HS) are also being developed for the same efficiency solution.