

HONOLULU CITY LIGHTS: HOW THE HAWAIIAN ELECTRIC COMPANY (HECO) FLIPPED THE SWITCH ON HAWAII'S SOLAR POWER BOOM.

David Bechtold, College of Business, Metropolitan State University of Denver, Denver, CO, 80217, 303-556-3580, dbechto3@msudenver.edu

Victor Kiss, College of Business and Economics, University of Pecs (PTE) Rakoczi ut 80, HU-7622 Pecs, Hungary, 36-72-501-599 ext 23259, kissv@tk.pte.hu

ABSTRACT

The following describes the challenges Hawaii has faced in creating an electrical utility provider that derives 100% of its energy through renewable energy resources. We describe how the rise of distributed solar electrical generation units created a safety and financial crisis for Hawaii Electric Company (HECO). Hawaii is the first state in the country where the success of solar and distributed power generation has become a potential existential threat to the company. The lessons learned in Hawaii can serve as a guide for other states as they strive to become less dependent on fossil fuel and more reliant on renewable energy resources for electrification.

Keywords: Solar energy, smart grids, Hawaii,

INTRODUCTION

In 1973, the oil embargo raised global prices for petroleum by 400% (1). Gasoline shortages and rising prices may have been the most memorable effect of the embargo for the mainland United States but for some places like the state of Hawaii the impact was much more far reaching than long lines at a gas station. For Hawaii, the embargo increased the cost of all forms of energy available to the island including electrical production and became not only an inconvenience and economic burden to the populace but also a security risk to the state (2).

In 1976, Hawaii enacted the Hawaii Energy Tax Credits which allowed individuals and corporations to claim an income tax credit of 20% of the cost of equipment and installation of renewable energy systems. The intent of this rebate was not based upon environmental concerns but rather to reduce the amount of fossil fuels imported by Hawaii from foreign sources (3).

Over the last forty years Hawaii has become a leader in the U.S. in renewable energy development and adoption. The reduction in the cost of PV systems, coupled with the continuation of state and federal tax incentives, shifted the adoption of renewable energy on the island from a state policy initiative to a market driven phenomenon (4). Hawaii was looked upon as a success story for advocates of renewable energy until, in 2012, the Hawaiian Electric Company (HECO), a long-time champion of residential solar panel adoption by its customers on the island of Oahu, abruptly announced that they would no longer allow their customers in some parts of the island to connect their roof-top PV panels to the island wide grid (5).

THE USE OF FOSSIL FUELS IN ELECTRIC POWER GENERATION IN HAWAII

Hawaii is the only state in the Union that derives virtually all its energy from foreign petroleum (6). The islands have no fossil fuel resources that can be developed domestically. Hydro-electric generation is

limited (7) and the power grid consist of 4 independent area grids supported by 6 companies (8). Compounding Hawaii's energy/electricity problems is the fact that there is no place on earth that is further removed from any continental landmass than these islands (9).

The distance between the islands and the continental United States makes energy pipelines and electrical cables extremely problematic. The distance also created policy decisions such that oil powered electrical generation plants were chosen over coal fired power plants creating a dependence on oil most of which is supplied by foreign producers. The states reliance on foreign oil has put the state at risk every time there is a price increase in the global oil supply chain. Approximately 1/6th of all discretionary spending in the state is on energy which has resulted in Hawaii's electricity being the most expensive in the United States (26.17 cents per kw hour compared to the national average of 10.42 cents per kw hour) (10). On Oahu, the extensive military presence meant that high energy costs were not only a hardship on the local economy but also posed a risk to national security (11).

It was these concerns that created the shift in policy to try to encourage the use of renewable energy. It began with the 1976 Hawaii Energy Tax Credits to promote the use of solar power and continued with additional tax credits and rebates, as well as the advent of net metering and other incentives from HECO, that positioned Hawaii as a national leader in becoming energy independent (12). The stage was set for the boom years of 2005 to 2012 when distributed energy in the form of rooftop PV units became a common site around the islands, particularly on the island of Oahu, and Hawaii was being championed as the country's leader in moving from a fossil-based to a renewable energy economy (13).

THE GOVERNMENT'S ROLE IN SOLAR DEVELOPMENT IN HAWAII

While the 21st century saw explosive growth in solar and other renewable energies, the government actively supported the use of renewable energy, and particularly solar, since the middle of the 1990's (14). Beginning with the Hawaii Energy Tax Credit in 1976 the state enacted several initiatives that were designed to promote renewable energy and subsequently reduce the states reliance on foreign oil. The Energy Tax Act (1978), a Federal tax credit, was a national response to the oil embargo earlier in the decade. Including a credit for solar power systems and water heaters the continued until the middle 1980's when they were phased out. In 1996, the Hawaii Solar Water Heating rebate resulted in over 50,000 solar powered water heaters being installed throughout the islands (15).

It was in the mid-2000's that renewable energy began to experience rapid development with the Federal Renewable Energy Tax credit in 2006. Hawaii followed that legislation with a bill in 2008 that allowed for the establishment of solar farms (HB 2502), a bill that would, by 2010, prohibit new housing construction that did not include a solar powered water heater units (SB 644), a bill authorizing the Hawaii Public Utility Commission to offer a rebate for photovoltaic systems (SB 988) as well as a bill that allowed for net metering to be offered to residential and small business customers (HB 2550) (16).

Finally, in July of 2008 Governor Linda Lingle approved three landmark bills that would set the stage for the solar explosion in the 2010's. The first was a bill to streamline the permitting process for renewable energy facilities (HB 2863), the second was to create a full-time facilitator to help the state quickly approve these renewable projects (HB 2505) and HB 2261 that would provide state funds to help facilitate the creation of renewable energy projects across the state (17).

HAWAII'S EMBRACE OF RENEWABLE ENERGY

The effort of Hawaii to take advantage of the Federal and State support of renewable energy positioned Hawaii to be one of the country's leaders in the use of renewable energy. In 2001 Hawaii launched the world's largest hybrid energy power plant on the Big Island of Hawaii. The world's first photovoltaic power plant that included a battery storage system was launched in 2009 and the largest roof-mounted solar installation became operational in Kona, Hawaii (18).

Not only were large solar projects becoming common in Hawaii so too was distributed solar PV generation. Residential solar power units saw a 20-fold increase in the amount of cumulative installed capacity from 2005 to 2010. 2010 was also a hallmark year in that these Federal, State, and corporate initiatives from HECO allowed solar power to reach grid parity with the average residential price for energy (\$.25 per kw hour for solar to \$.28 per kw hour for fossil fuel generated power). This parity created another explosion in residential solar systems which increased cumulative capacity by 400% from 2010 to 2012 (19).

Hawaii was looked upon as proof that renewable energy can be a cost-effective alternative to fossil fuels. With 12% of Oahu residents having solar panels on their rooftops and over 20% having some form of solar powered units in place or on order it was a shock when in September of 2012 HECO told solar contractors on Oahu that they would no longer be able to connect any new rooftop PV units onto the HECO grid (20). The response created an uproar as customers of HECO claimed that this was a money grab on the part of the utility while HECO claimed it was necessary to maintain the integrity of the grid and the safety of its workers (21).

THE PROBLEMS WITH SOLAR

Net metering was considered a way to encourage the adoption of solar energy by private homeowners and small businesses. The ability to generate more power than what was being used personally and then sell the excess back to the power company made all distributed renewable energy, but particularly solar PV systems, more attractive to consumers and, initially, to utility companies. However, the fact that most grid systems on the mainland United States offered electricity at rates far below that of most residential PV systems made the mass conversion to a distributed system seem unlikely when the first net metering programs were offered in the 1980's. With less than 1% of all residential customers having rooftop PV systems and utilities having large scale integrated grids that would allow excess power to be shipped to other regions of the country the idea of net metering seemed like a good marketing strategy for all utility companies (22).

The solar boom in Hawaii was quite different, and more impactful, than anywhere in the mainland United States. Net metering allowed residential PV systems to provide virtually free power to the homeowner with the utility company power always there as a back-up during times when the solar systems were not functional at night or during cloudy days. This meant that the number of HECO customers, particularly on the island of Oahu, that opted for a net metering home PV system reduced significantly the amount of revenue the company was generating to maintain their island grid (23).

An added risk was the fact that there was no outlet for grid over-capacity (or over-voltage), a problem that occurs when excess electricity from distributed PV systems is placed onto the grid. In regions with large connected grids this regional excess capacity can be routed to other areas in need. Hawaii however, and particularly Oahu, did not have that capability with the resultant outcome being potential grid

shutdowns and blackouts, long term damage to transformers, or at its most extreme placing HECO employees at risk as they worked on the grid that suddenly experiences high power surges (24).

It was these risks, both economic and to its infrastructure, that prompted the quick suspension of additional residential systems being added to the grid. The public outcry from homeowners and the renewable industry was swift. Homeowners complained that not being able to connect to the grid and take advantage of net metering was forcing them to pay twice for their electrical power, with one payment to HECO and the other to the leasing company or bank that financed their rooftop PV system (25).

The renewable industry in Hawaii also suffered significantly as customers could no longer connect to the grid and potential customers were no longer interested in purchasing a system that was rendered useless. The industry saw a 50% decline in business and a corresponding reduction in jobs (27). These changes in the marketplace stopped the solar explosion in Hawaii and in the minds of many industry observers and experts effectively killed the market (28).

A rethinking of how to handle over-voltage on a regional grid would be necessary if Hawaii was to achieve its goal of generating 100% of its electrical energy by the year 2045 (29). One solution was for HECO to develop a smart grid system that could handle overloads.

A SMART GRID SOLUTION TO "OVER-VOLTAGE"

The rapid growth of recent PV (Photovoltaic) deployments has led to numerous positive effects in energy security - by decreasing the need for imported energy – and helping to decrease the effect of environmental pollution through clean electricity production.

However, as described previously the widespread use of PV distributed energy has created technical issues that are not easily solvable with traditional power system control methods. The traditional electric power systems - used almost excessively around the globe – match the demand for electricity by carefully monitoring changes and adjusting the demand accordingly. This has worked quite well with the use of power plants whose power output is relatively easy to adjust due to the nature of the input fuel. The input fuels used (coal/peat/shale, oil, biofuels and nuclear material) are relatively easily storable and can be made available when needed.

When introducing a large amount (large relative to the size of the power system it is serving) of capacity producing electricity intermittently due to the nature of the input it uses, the system stability can suffer. Unexpected load changes, power backflow, and other operational issues can cause major problems in the uninterrupted supply of electricity.

The challenge for Hawaii was if the state wanted to achieve its goal of obtaining 100% of its power from renewable energy by 2045 (30), it would need to create a system where energy management was utilized in a state of the art way. A first step in resolving the generation of "over-voltage" and developing a smart-grid was a public-private partnership between HECO and the National Renewable Energy Laboratory (NREL) in Golden Colorado (31). This collaboration paved the way for a larger penetration of intermittent renewable sources such as solar and wind energy and could be the benchmark for other states who wish to move away from fossil fuels and towards a renewable energy platform (33).

HECO, NREL AND SOLAR CITY

The National Renewable Energy Laboratory is a federally funded research program supported by the Department of Energy. Created as a national laboratory in 1991, NREL has become a national leader in all aspects of renewable energy research. In 2014, NREL collaborated with HECO to analyze and validate PV inverter technology to enhance the utility's power grid efficiency and stability (34). An additional collaborator, Solar City, had been working with NREL in their Energy Systems Integration Facility to determine the effectiveness of how residential solar power generation systems can integrate with a power grid (35).

Charged by the State of Hawaii to achieve a power grid that is supported by 100% renewable resources by the year 2045 this collaboration was an essential first step to achieving that goal or, if unsuccessful, to allow the utility enough time to plan a strategy that did not include distributed renewable energy. The success of the collaboration has led to a modernization of the grid that is expected to increase the number of rooftop PV systems from 79,000 in 2016 to 165,000 by 2030 (36). The merging of public/private research with improving technology now makes Hawaii's goal of achieving 100% energy output through renewable resources a technical possibility. However, the traditional business model that utility companies have utilized for over a century has now become a primary obstacle to achieving energy independence by using distributed energy generation as a primary contributor.

WHO PAY'S FOR POWER?

For over a century the traditional business model for utilities has been to provide customers with power and then add additional power sources and networks to the grid as warranted by customer demand. Power flow was one way, from producer to user, and adjustments to power flow, both over the short and long term, was controlled by the utility. Net metering was introduced in the 1980's to encourage the use of renewable energy. Since then it has been a little used opportunity to promote residential power generation. However, in Hawaii as solar PV technology costs went down and the cost of traditional retail power from HECO continued to be the highest in the country, a rush to install residential PV systems created a boom in Hawaii leading HECO to stop connecting units to their grid in 2012 (37). Much of the technical obstacles of distributed energy generation has since been rectified through smart grid technology (38). To solve the financial crisis caused by large portions of HECO's customer base no longer paying for service or maintenance the state of Hawaii's Public Utilities Commission (PUC) eliminated net metering in 2015 (39).

When, in 2015, the Hawaii PUC eliminated net metering program offered by HECO they replaced it with a program that charged a monthly fee to residential and commercial customers who had PV solar systems and were still connected to HECO power grid (40). The ruling was widely criticized by solar power companies on the island and has had the effect of slowing to a virtual standstill the installation of new PV residential systems (41).

THE FUTURE OF RENEWABLE ELECTRICAL POWER IN HAWAII AND WHAT IT COULD MEAN TO THE REST OF THE UNITED STATES

Hawaii is a state unique unto itself and there are many reasons why it was in Hawaii that the opportunity of distributed renewable power being a significant contributor to a state's energy plans became a reality and why it also had to be abruptly stopped. Traditional costs of electricity in Hawaii was the highest in the country and subject to global variations in price for oil, the state's primary energy resource. Due in

part to a lowering in the price of PV systems the cost of solar power continued to drop. State and federal tax credits, legislation to allow for net metering, as well as additional credits provided by HECO to enhance the use of renewable energy and reduce reliance on foreign oil further enhanced the attractiveness of solar power distributed power systems. Finally, Hawaii with its collection of small regional grids that are not connected to each other or to the mainland which meant that over-voltage generation from distributed power generation on home rooftops could not be dissipated leading to damage to the grid and physical risk to utility workers (42). So, while the reasons why the experiences of Hawaii may not be felt as significantly in other parts of the country it does not mean that these lessons have no impact on the rest of the country.

Everyday more and more cities and states are declaring their intent on have all, or a majority, of their energy coming from renewable resources (43). Strategic choices by utility companies will include power generation from traditional fossil-fuel systems as well as mega-watt sized renewable power generation from solar, wind, bio-mass, tidal, and other renewable sources. Arguments will continue to be made in favor of one technology or the other and government policy will shift from being a supporter of large scale renewable mega-watt projects to broader roof-top distributed energy (44). However, the key lesson from Hawaii's experience will be that these opportunities and obstacles must be addressed concurrently to reduce the risk of catastrophic grid collapse and increase the possibility of a city, county or state providing clean and renewable energy it's people at affordable costs to all.

References available upon request from the authors