New Ideas for Bermuda’s Energy Model

by

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Executive Summary

The world energy industry is in the throes of significant technological and policy change, providing Bermuda with an unprecedented opportunity to move toward a sustainable energy model. Presently, electricity on the island is supplied almost entirely by a diesel fuel oil utility, Belco, which is expecting to retire almost 50% of their generators in the next six years. At the same time, Bermuda's Department of Energy is developing a new Energy Policy and establishing an independent Regulatory Authority. This study asks what Bermuda can learn from other island states which have committed to a sustainable energy portfolio.

The first section of the report describes the current energy model in Bermuda and two currently proposed plans for the future. The local monopoly utility, Belco, generates 97% of Bermuda’s electricity using heavy diesel fuel oil with the balance purchased from an independent waste-to-energy plant. Renewable energy has barely penetrated the island; there are no commercial-scale renewable energy installations, and fewer than 200 (0.5%) residences have installed rooftop solar systems. Given the cost of renewable technology, particularly solar, is now competitive with fossil fuel generation in many situations, Bermuda has the opportunity to invest in an alternative energy infrastructure at a lower price than was possible a few years ago, allowing for the displacement of a meaningful portion of Belco’s diesel oil capacity with renewable energy.

The second section of the report develops case studies for the islands of Kaua’i and Aruba, which expect to supply >50% and 100%, respectively, of their electricity using renewable energy sources by 2020. While technological challenges inherent to implementing high levels of renewable technology exist, Kaua’i and Aruba demonstrate similar policy and regulatory approaches, which contrast with Bermuda in the following ways:

- Policy commitment to renewable energy
- Aggressive pursuit of energy efficiency, both in generation and end-use
- Aligning utility incentives with energy efficiency
- Including environmental and social externalities in energy decisions
- Embrace of innovation
• Stable indirect incentives, such as power-purchase agreements for renewable energy

These case studies highlight the importance, and relative cost-effectiveness, of end-user energy efficiency as an alternative to generation; while the third section of the report reviews statutory approaches to energy efficiency in Vermont and California, two states particularly successful at reducing electricity demand. The discussion starts with the establishment of an “efficiency utility” in Vermont, and explores the success of other programs in both states.

The third section recommends policy and regulatory changes for Bermuda, based on the island and Vermont/California case studies:

• Set aggressive efficiency goals and building efficiency standards, and invest in energy efficiency
• Invest in a ‘smarter grid’ to increase system efficiency
• Set renewable energy targets and support them with appropriate legislative action

The report concludes by estimating the potential impact of these approaches on Bermuda’s energy production. The results suggest that it may be possible to defer, possibly indefinitely, investment in new oil–based generating infrastructure and reduce fossil fuel electricity generation from the current 97% to below 50%.

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1 Introduction

Bermuda has an unprecedented opportunity today to rethink our energy model. The local utility, Belco, generates 97% of Bermuda’s electricity using fossil fuel (heavy diesel fuel oil) with the balance purchased from a waste-to-energy plant which uses municipal waste (BELCO, 2013). Belco urgently needs to reinvest in energy generation; the electricity generation plant is aging with almost 50% of its generators scheduled for retirement in the next few years (BELCO, 2013). This will be discussed in detail in Section 3.1.

Renewable energy has barely penetrated the island with fewer than 200 homes (about 0.5%) installing rooftop solar panels (Jones, 2015) and no commercial scale renewable installations are currently in place. The cost of renewable technology, particularly solar, has fallen over time and is now competitive with fossil fuel generation in many situations (McKenna, 2015) for example. Thus, Bermuda has the opportunity to invest in alternative energy infrastructure at a lower price than was possible a few years ago.

Other island case studies (Kaua’i and Aruba) suggest that Bermuda has a significant opportunity to have an electricity model based on a much higher contribution from renewable energy and concomitantly a much lower impact on the local and global environment. These case studies will be reviewed in Section 4. While there are technological challenges inherent to implementing high levels of renewable technology, Kaua’i and Aruba show similar policy and regulatory approaches, which contrast with those of Bermuda in this area.

The island case studies highlight the importance, and relative cost-effectiveness, of energy efficiency as a response to electricity demand. Section 5 of the report explores in more detail the approach to energy efficiency in Vermont and California, two states which have been particularly successful in this area. The discussion starts with the establishment of an “efficiency utility” in Vermont, and explores ways in which both California and Vermont have been successful at encouraging efficiency by energy consumers. At
the same time new approaches to energy tariff structures may help align utilities’ incentives with energy efficiency programs (see Section 5.4).

Finally, Bermuda is currently writing a new Energy Policy (Energy, 2015) and is about to put in place an independent Regulatory Authority to replace the current very light regulation and rate-setting oversight through the Energy Commission. So the time is right to involve both the Government and the Public in the debate about the future of Bermuda’s electricity sector. A brief overview of the elements of policy making are discussed in Section 2 (below).

The ideas in this thesis have been presented to the Bermuda Department of Energy, in the setting of the Bermuda Energy Working Group, as part of the consultation process for the new Energy Policy.

2 The Basis for Policy Decisions

“The big ideas and strategies for how we should manage society and thrive with the planet are not a set of rules handed down from on high … change must begin with an agreement about principles” (Bittman, 2015). Thus policy making is as much about culturally-defined values as economic imperatives. Orbach proposes that policy-making can be considered as the interaction between “biophysical, human, and institutional” systems (Orbach, 2013):

![Figure 1: "Total Ecology" relationships for energy policy (adapted from (Orbach, 2013))](image)
Although these factors will not be considered explicitly in the body of this report, it is helpful to take a moment to consider their role.

Traditionally energy policy emphasizes the *economics* of energy generation and distribution. It is rooted in the assumption that abundant energy is tightly coupled with economic growth (J. P. Tomain, 1990). The Bermuda Energy Act of 2009, which is currently in force ([Energy, 2009] Section 13(2)), and the proposed Energy Policy ([Energy, 2015]) both prioritize cost-effectiveness and cost recovery as the basis for energy investment and rate-setting decisions (see also Appendix 1).

In contrast, the US Department of Energy in their publication *The Energy Transition Initiative (Playbook)* emphasize *authority* and *public trust* as the starting point for energy policy decisions. They recommend that to begin “community leaders ... must express their commitment to the public and to potential investors. With an expression of commitment, the challenge then becomes selecting a path, rather than whether the transition is possible at all” (DOE, 2014). Both Kaua’i and Aruba explicitly include *public trust* when balancing energy options by allowing for socioeconomic externalities such as weighing whether the investment creates opportunities for economic multipliers through local job creation, vs possibly a lower cost option of importing assets and fuel from overseas.

The Kaua’i and Aruba case studies also illustrate the importance of *cultural beliefs* and *behavior* in policy decisions. Both islands explicitly value energy independence, and the environment, and have actively involved their populations in energy efficiency: Aruba has established a ‘smart community’ to study behavior, and in Kaua’i the utility is cooperatively owned so residents benefit from lower energy use both directly through their bills and indirectly through lower fuel prices. Although Bermuda has a proud cultural tradition of self-reliance, as shown by the island’s use of rainwater tanks for every house, and the pride in the common catch-phrase that “Bermuda is another world”, this has not been extended to discussions in the energy sector.

Energy policy in Bermuda (and elsewhere) does not take into account the full *climate* or *biophysical* impacts of energy production. Energy generation is a significant source of greenhouse gas emissions.
which contribute to global climate change (IPCC, 2013c), and in fact *The Economist* in 1991 claimed that “using energy in today’s ways leads to more environmental damage than any other peaceful human activity.” (cited in footnote 51, (Sovacool & Dworkin, 2014)). Bermuda has remained detached from most of the social and environmental costs because of its geography. Fossil fuels are all imported, leaving the physical externalities of extraction at the point of origin, pollution is controlled at the generating plant, and consistent Atlantic winds blow emitted pollution well away from local residences (Halcrow, 2008).

Despite its isolation, global climate change will increasingly have an impact on Bermuda. *The Stern Report* (Stern, 2007) projected that “the overall costs and risks of climate change will be equivalent to losing at least 5 percent of the world’s GDP ... and that these damages could exceed 20 percent of GDP ($13 trillion) if more severe scenarios unfold”. Bermuda is vulnerable to global economic health, as demonstrated by the current recession (Richards, 2015), and will experience the physical impact of climate change, including rising sea level (Glaspool, 2008), and an increase in natural catastrophes such as hurricanes (IPCC, 2013a). There are also local environmental impacts which are largely ignored; for example, development of new generating assets could cause visual pollution at a potential cost to tourism, or they may have an impact on endangered species.

The Bermuda Government has institutional authority as a steward of the human and biophysical resources of Bermuda; therefore energy policy should take these factors, as well as strictly economic factors, into account when formulating energy policy. Some of these factors will be discussed further in Section 6.3.

### 3 Proposed models for Bermuda’s Energy Future

#### 3.1 Where we are today

97% of Bermuda’s energy needs are provided by Belco’s current 168MW plant in Hamilton, Bermuda (see Figure 2). The engines in the East Power Station and the Old Power Station are all fueled with heavy fuel oil, while those in the West Power Station (the ‘Gas Turbines’) use regular fuel oil. The heavy fuel oil
engines, whenever possible, provide baseload power for the island, while the more expensive gas turbines in the West Power station generally used for fast response to peak demand.

Summer demand in Bermuda is around 120MW throughout the day, largely driven by air-conditioning; winter demand is lower, at around 90MW, with an evening peak as people return home and turn on stoves, heaters, and other appliances (see Figure 3 below).
It can be seen from Figure 2 that nine of Bermuda’s nineteen fossil fuel generators are at or past their ‘normal service life’. The proposed retirement schedule (see Figure 4, with data from 2011) shows that up to half of Bermuda’s generating capacity will need to be replaced at current demand by 2018.

Figure 4: Retirement schedule for BELCO plant (Source, (BELCO, 2011), BELCO annual reports 2010-2013)

3.2 Proposals for a future energy system

In 2011 the Bermuda Government published an “Energy White Paper” (Energy, 2011) with ambitious goals for renewable energy and energy efficiency. The tone is set in the introduction where they state that “As a small island community, the Government believes it is imperative for Bermuda to set a

1 Diesel generating capacity has been shown reduced by the N-3 engineering margin currently allowed for reliability.
responsible example and therefore has adopted a goal of reducing emissions to less than 1 metric tonne CO2 equivalent per capita by 2050” (Energy, 2011). The authors (the newly formed Department of Energy) proposed a target of 30% renewable energy (including 5,000 homes with solar photovoltaic technology) by 2020 and a goal of reducing electricity demand by 20% by 2020.

In order to achieve these targets the Department of Energy anticipated extensive deployment of renewable energy resources (see Figure 5).

![Figure 5: Electricity consumption/generation scenario to reach the 2020 emissions target (Energy, 2011)](image)

The most recent proposal for Bermuda’s energy future comes from a new draft Energy Policy (Energy, 2015). This document emphasizes cost-effectiveness when planning energy resources, and proposes much lower contributions, in the short term, from renewable energy than the 2011 White Paper.

In Figure 6, the “aspirational matrix” shows the mix of generation and demand reduction used when planning the new Energy Policy. The document assumes a very small contribution from solar or wind
energy, flat or growing demand, and proposes that Bermuda waits for “a future base load [renewable] technology ... on the assumption that a technology can reach a generating cost of BMD 0.14 per kWh by 2025” (ibid, p. 4) – this is the blue section in the figure speculatively labelled OTEC (Ocean Thermal Energy Conversion).

This is the energy plan used as the base case for modelling the proposed impact of policy changes in Section 7 and Appendix 2.

The Energy White Paper recommended a number of policy steps needed to support the transition to a more sustainable energy model, including:

1. A comprehensive set of interconnection standards [for renewable energy]
2. Independent regulatory authority [to] maintain regulatory oversight of interconnected entities.
3. An expedited planning process for small-scale renewable energy, with renewable energy resource data available to the public.
4. Minimum efficiency standards for imported appliances
5. Public education and mandatory energy performance labelling
6. Energy auditing and energy management for the general public
7. Amendments to the building code that will include requirements for energy efficiency and renewable energy
8. A legal framework that will better align incentives between landlords and tenants
9. An energy performance rating systems to benchmark building energy consumption
10. Legally require priority use for renewable energy
11. A new energy act which [among other goals] regulates pricing of all electricity rates.
12. Changes to the rate structure

Only #5 (education) and #7 (some amendments to the residential building code include energy efficiency requirements) have been implemented, and #11 (a new Energy Act) is underway. The policy proposals above are consistent with policy changes in other jurisdictions which have successfully reduced their reliance on fossil fuel (see Sections 4 and 5, and Figure 7 below). It is hoped that the case studies described in this document will help to spur change in Bermuda by providing evidence that a more sustainable energy model is possible, effective, and not cost-prohibitive.
4 Island Case Studies – Whole System Overview

Two case studies can give us insight into the process of moving to a more environmentally sustainable energy system: Aruba and Kaua‘i. These case studies were chosen with the following characteristics: They are genuinely islanded systems with no physical connection to any other generating capacity, they are a similar size to Bermuda in terms of population, industry, climate, and electricity demand. This means that energy decisions are based on a single centralized generation plant, demand for electricity is largely based around residential and commercial buildings (as opposed to manufacturing plants), and consumer decision-making is likely to be similar. They were also chosen because both islands have made a significant commitment to renewable energy, and gone some way towards achieving their goal. Thus they can provide insight into not only policy, but economics and the response of the population.
The two case studies also show significant differences. In Aruba the utility is publicly owned, and changes have been made largely through persuasion, public-private partnerships and a willingness to innovate – with a minimum of regulation and legislation. In Kaua’i the changes have been made within the framework of US regulation and through leveraging that regulation. However both islands demonstrate political will, explicit commitment, and extensive bureaucratic support.

4.1 Aruba

“Our goal is an ambitious one: to increase the social, environmental, and economic resilience of Aruba through an efficient use of natural resources and an implementation of projects that will create and sustain high-quality local jobs for current and future generations. Ultimately, we hope that Aruba will become the model for a low-carbon, sustainable, and prosperous economy that can be replicated in other island nations.”
—Aruba Prime Minister Mike Eman (McMahon, 2013)

Aruba shares a number of physical similarities with Bermuda; It has no natural source of freshwater, it has abundant sunshine and wind resources but no other natural resources, it has no opportunity for geothermal power, a similar size population to Bermuda, and a peak electricity demand of 100MW (McMahon, 2013). It differs dramatically from Bermuda in the electricity arena as it has made a commitment to become fully independent from fossil fuel by 2020 (Aruba, 2015a). This ambitious goal was reiterated in 2012 at the Rio summit and would mean replacing the equivalent of more than 6,000 barrels of oil a day used to generate electricity (DOE, 2014).

The Government of Aruba has not provided direct incentives or financial support for renewable energy, but set up a central authority, the Green Aruba Forum, to identify technical and cultural drivers behind energy consumption, and to work with all stakeholders to develop a map for transitioning to a renewable energy model. The Forum concluded that moving away from fossil fuel to generate electricity had benefits well beyond the reduction of greenhouse gases, and that it would: “deliver important societal benefits, including jobs, monetary savings, community engagement, health and well-being” (McMahon, 2013).
The Green Aruba Forum calculated that transitioning to 80% renewable energy could be done without increasing the cost of electricity on the island (in 2010 Aruba’s electricity price sat at about 28 US cents per kWh (McMahon, 2013)). The proposed approach was not to increase renewable energy sources, but also to deploy “substantial upgrades to the power control systems” (a ‘smart grid’) as well as “careful consideration of a wide variety of generation, storage, demand response, and systems control technologies” (Aruba, 2014).

![Figure 8: Installed energy sources in Aruba in 2015 (Source: McMahon, 2013)](image)

The Aruba model relies on a government owned utility, clear goal setting and public support. They do not have an Energy Law, an Energy Policy (with a legislative framework) or a Regulatory Authority. The negotiation of Power Purchase Agreements for commercial scale renewables relies on private investment putting pressure on the utility with the implicit or explicit support of the government. Richard Arendts, Chief of Staff to the Minister of Economic Affairs, Communication, Energy & Environment, and Senior Advisor to the Prime-Minister of Aruba stated that “The Government of Aruba has chosen strategies of stimulation and collaboration with stakeholders rather than forcing our 2020 Vision forward. This last point has not been easy, but we believe it has been crucial in engaging the participation of all levels of our community” (Arendts, 2015).
4.1.1 Reaching the Renewable Energy Target

Aruba has abundant natural resources on which to draw for renewable energy: it has more than 2,500 hours of sunshine a year, and the steady wind means that its wind power has one of the highest capacity factors in the world at 47% (Shirley & Kammen, 2013). It is interesting to note that there are no direct financial incentives for renewable power; investment in renewable energy has been spurred by the fact that the levelized cost of electricity (LCOE) for wind power in Aruba is below the avoided cost of electricity (Shirley, 2013). NuCapital (the owner of the two wind farms) negotiated a ‘take or pay’ power purchase agreement (PPA) with WEB NV, which resulted in a reduction in the cost of electricity for Aruba residents (ibid).

In 2015 Aruba is more than half way towards achieving its target of 100% fossil fuel free electricity while keeping costs at or below previous levels (ArubaNV, 2014). However, the challenge for Aruba is that with current storage technology its stated goal of a “green day” or even a “green hour” means that they will have to over-invest in intermittent renewable energy options (see Figure 9), as they have no ‘firm’ or ‘base-load’ renewables such as hydro or geo-thermal.
The need to overinvest is driven by peak power demand, so Aruba is focusing heavily on options to reduce the expected energy demand and manage intermittency. Initiatives include energy efficiency for buildings, energy efficient appliances (supported by reduced import duty), residential based technology such as ‘smart’ thermostats, and ice-cooling for hotels. Almost ¾ of Aruba’s economic activity is tourism related (McMahon, 2013), and therefore there is an major focus on ways to change the behavior of visitors (e.g. notices, key cards to activate HVAC systems in rooms) as well as reducing water use which is supplied by energy intensive desalination plants.

4.1.2 The role of the utility

After Aruba achieved independence from the Netherlands in 1986, a government owned holding company, Utilities Aruba N.V., took over the privately owned utility and brought electricity generating and transmission capacity under state ownership (Shirley & Kammen, 2013). In 2004, the Government of Aruba unbundled generation from transmission and distribution so that WEB (Water-en-Energiebedrijf) Aruba NV generates electricity and also water, and Elmar NV manages the distribution network.

The focus for the utility is summed up by O.J. Boekhoudt, General Manager of WEB Aruba (Aruba, 2014) “The greatest challenge on the road ahead is the volatility of the energy industry and rapid price changes in heavy fuel oil ... The goal is to achieve higher efficiency with every change we implement, and if we have to use conventional fuels, use them as efficiently as we can.”

Figure 10: WEB Aruba NV "Our Road to 2020". (Source: (Aruba, 2014))
Significant efforts on the part of the utility include (Aruba, 2014):

1. Internal efficiency, including the investment in more efficient generating engines
2. Education and support for customer efficiency – primarily through the “Hunto Nos Ta Spaar” (Together We Save) project (Aruba, 2015a) where 120 student from the local technical institute visited 10,000 homes with efficiency tools, such as LED bulbs and home meters, and information on energy efficiency. This was funded by local business partners and the Government (via the utility).
3. Investment in renewable energy, including:
   i. Two new wind power stations
   ii. A new waste-to-energy plant
   iii. Plans for a large scale solar plant
4. In 2012 the Aruba utility launched a new grid policy which allowed distributed power for residential customers up to 10kWp per residence with a monthly peak of 1500 kWp, and for commercial customers up to 100kWp with a total of 15,000kWp.
5. Investment in a ‘smart grid’ with the intention ultimately of micro-management of residential and commercial appliances to reduce demand
6. Investment in flywheel technology to manage short-term intermittency underwater compressed air storage (UWCS) for diurnal management of peaks and troughs.
7. Exploration of other innovations such as tidal power and ice storage for larger and industrial energy users (Aruba, 2015a)

When planning, the utility uses a framework that balances Reliability and Sustainability (“RAS – framework”), and which also includes a Macro-Economic Impact (MEI) component to include the external impact on the Aruba economy (Aruba, 2015).

The fact that the utility is publicly owned may have made the transition to sustainable energy easier than it would have been for an investor-owned utility. The Minister of Economic Affairs, Communications, Energy and Environment, Mike E. De Meza, has cited involvement of the utility as a critical factor in the move towards a fossil-free electricity system: “Utilities Aruba NV, together with
WEB Aruba NV, NV Elmar and all the other energy stakeholders are essential in realizing the sustainable vision ... and they have all been determined to execute it along with us” (Aruba, 2015). In Bermuda the utility cites “ownership risks” as a factor to evaluate in its forward planning for electricity (BELCO, 2014), and has a fiduciary responsibility to consider narrow economic returns to its shareholders, which makes it more challenging to incorporate broader societal benefits in its planning.

4.1.3 Energy Policy and the success of Green Aruba Forum

There is no formal Energy Policy beyond the Government establishing short and long-term goals for the island. These are reported on and revised annually at the Green Aruba Forum, and have been supported by a suite of initiatives including:

1. Tariff reductions:
   a. From 40% to 2% for electric cars and a cut in road taxes (Aruba, 2015a). The ultimate goal is to use an electric vehicle system as a giant battery to smooth power demand (McMahon, 2013)
   b. 2% import tariff on selected energy efficient appliances (with an Energy Star label), solar panels, solar hot water heaters, LED lights, windmill, and other efficiency components.

2. The establishment of a “Smart Community” of 20 sustainably designed and constructed homes (Aruba, 2015h) With the intention of:
   a. Understanding and managing renewable power intermittency
   b. Involving community residents and understanding the interaction between consumers and the electricity system

3. Attracting innovation through a number of mechanisms:
   a. Annual Green Aruba Conference, starting in 2010 – both to attract innovation and to showcase Aruba’s initiatives, and also review last year’s goals and set new ones.
   b. “‘Green Aruba’ – the goal of becoming a platform for information exchange at an expert level” (Aruba, 2015). With this goal the Green Aruba conference in 2014 was merged with the Europe Meets the Americas Conference (EMA) to form GA-EMA 2014 (Aruba, 2015) – see Figure 11)
c. Attracted Partnership with TNO, a Dutch Innovation Organization, in 2011, which has set up the Caribbean Branch Office of TNO (CBOT). The goals of this are
   i. Technology innovation in energy, water and waste management specifically adapted to the Caribbean
   ii. Strategy development and an energy road map for the island
   iii. Participation in the Smart Community and efficiency education for the community
   iv. Training, networking, testing and certification services, in partnership with the University of Arizona and the local Aruba Technical College Colegio EPI. To ‘upskill’ the workforce. With the plan of offering a Bachelor’s degree in Environment, Energy, and Entrepreneurship (Aruba, 2015a)

d. Partnerships with Harvard University (Center for Innovation) and the University of the District of Columbia (College of Agriculture, Urban Sustainability and Environmental Sciences) (Aruba, 2015a)

e. Memorandum of Innovation with Royal Phillips to “revamp the island’s entire public lighting system by completing an in depth assessment and providing solutions for public buildings and outdoor lighting systems.” (Aruba, 2015a)

By the end of 2016 Aruba expects to have achieved almost 50% of penetration of renewables in both energy and water production (ArubaNV, 2014), and believe they are well on its way to its 2020 goal.

4.2 Kaua’i

In 2008 Governor Lingle of Hawaii signed the “Energy Agreement” in partnership with the Government of Hawaii and the Hawaii Electric Company Inc. This declared that “the future of Hawaii requires that we move more decisively and irreversibly away from imported fossil fuel for electricity and transportation and towards indigenously produced renewable energy and an ethic of energy efficiency” (Codiga, 2009). The agreement set a goal of 70% clean, renewable electricity and transportation by 2030\(^3\). However, even before this commitment was made, Kaua’i had already made significant progress towards the integration of renewable energy

“For reasons related to high electricity rates and rate stability, but also as matter of security and environmental benefit, KIUC has placed a priority on pursuing cost-effective alternatives to fossil fuel-based conventional resources.”


Like Bermuda, Kaua‘i is a true islanded electricity system, with a slightly smaller electricity demand than Bermuda (typical daytime demand is 55-65MW, compared with about 100MW). There are a variety of renewable energy sources available: the steep volcanic topography makes both small scale hydro plants, and geothermal power readily available. Kaua‘i’s solar resources (daylight hours, angle of sun) are similar to Bermuda but, in contrast to Bermuda, up to 80-90% of the island daytime demand can be provided by solar energy (see Figure 12).

Figure 12: Daytime Energy mix for Kaua‘i, showing solar contribution (KIUC, 2014a)

4.2.1 Factors supporting renewable energy on Kaua‘i

Kaua‘i Island Utility Cooperative (KIUC) has 21MW of solar power online and another 10MW in the interconnection queue. There are also two utility scale (12MW) solar projects that are expected to come online in 2015 (KIUC, 2014a). With this new capacity Kaua‘i expects to be able to supply 50% of its electricity demand with renewable energy (see Figure 13).
Three main factors have led to the boom in renewable energy on Kaua‘i. First, the aggressive renewable portfolio standard set by the state of Hawaii, secondly the favorable economics for renewable energy driven by the Public Utility Regulatory Policies Act of 1978 (PURPA), and thirdly the culture of the cooperative owned monopoly utility on the island of Kaua‘i.

In 1978 the US Congress passed the Public Utility Regulatory Policies Act (PURPA) with the intention of supporting the development of renewable resources (Coffman, 2014). PURPA required utilities to purchase energy from renewable sources at the “avoided cost” of producing power. As Hawaii generates most of its power using oil-fired utilities, with the oil imported by ship, electricity in Hawaii is comparatively expensive, with consumers paying 3 to 4 times more for their electricity than consumers in the contiguous US states (ibid). The PURPA requirement and the high cost of oil-fired electricity generation on the islands means that renewable energy is very cost competitive; for example in 2013 the 12MW Koloa utility scale solar array was constructed on Kaua‘i; this generates electricity as about 12 c/kWh, less than half the cost of oil (KIUC, 2013).

The third driver for Kaua‘i adopting renewable power has been the culture of the utility. In 2002 a group of local residents formed the Kaua‘i Island Utility Cooperative (KIUC) and bought their investor-owned
utility from Citizens Utilities (Blair, 2012). Part of the motivation for this purchase was that Kaua‘i had very high electricity rates, with the profits leaving the state (ibid). The newly formed co-op set the goal of pursuing alternatives to fossil-fuel “as a matter of security and environmental benefit” (KIUC, 2008).

4.2.2 Policy and Regulatory Environment

A commitment to the environment is evident in KIUC’s 2008 Integrated Resource Plan (IRP) which laid out the path for energy generation for the next 20 years. This built sustainability into the decision-making in a number of ways (KIUC, 2008).

1. Alternatives were assessed on three dimensions with equal weight (1/3) given to Cost of Energy, Reliability, and Sustainability; with ‘Sustainability’ defined as:
   a. “Society takes no more from the Earth’s crust than can be returned to the crust by natural process (Infinite Resource)
   b. “Society does not produce persistent synthetic compounds that build up in nature (Hazardous Byproducts)
   c. “Society draws on renewable resources no faster than they can be regenerated, and does not reduce the productive capacity of nature by detrimental manipulation of green surfaces (Harmonious Coexistence)
   d. “Human Society is efficient, population is stabilized, and basic human needs are met (Socioeconomics)”

2. The Cost of Energy methodology (Total Resource Cost, or TRC methodology) did not include environmental externalities, but in order to account for this KIUC “made provisions to consider externalities in two ways. First the KEMA study selected a benefit to cost ratio of 0.8 instead of 1.0 as an acceptable score for a demand-side measure ... and supply-side options, in turn, [were] scored according to a detailed methodology that considers economic and non-economic factors ... to account for externalities” (KIUC, 2008, section 6.2.1)
Thus wherever there was uncertainty the KIUC biased decisions towards more environmentally friendly options.

The initiatives on Kaua‘i also have high level policy support in the State of Hawaii. In 2008 the US Department of Energy and the State of Hawaii established the Hawaii Clean Energy Initiative (HCEI) with the non-binding goal of increasing its renewable and clean energy production capabilities, and transitioning the smaller islands to the exclusive use of renewable energy. The HCEI brought together a number of stakeholders to help define a pathway to a clean energy future (Codiga, 2009).

The State has sets feed-in tariffs for residential solar at ‘net’ — meaning that a residential customer is only billed for the difference between the energy that they generate on their residential solar array, and the electricity supplied to them by the grid (Haw. Rev. Stat. § 269-101) (Codiga, 2009). This feed-in tariff exceeds the avoided cost standard set in PURPA, and ‘net’ metering is generally considered to be a form of subsidy for renewable energy (Bronski, 2015).

Finally, Hawaii is also seeking to change the rate structure for electricity bills and to ‘de-couple’ sales revenue from the volume of electricity sold (EIA, 2015a), (see Section 5.4 for further discussion).

4.3 Lessons for Bermuda from the island case studies:

Kaua‘i and Aruba demonstrate that islands can reduce the contribution to electricity from fossil fuel without increasing the cost to rate-payers. KIUC in particular has made a commitment to low cost; one of their strategic goals is to “decrease the average residential energy bill by 10 percent, after adjusting for oil prices, over the next 10 years” (KIUC, 2013).

Table 1 shows that there are common policy and regulatory approaches between the two island case studies which differentiate them from Bermuda.
<table>
<thead>
<tr>
<th>Kaua‘i and Aruba</th>
<th>Bermuda</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Commitment to a sustainable energy model and ongoing political support:</strong></td>
<td>Reluctant Government, no renewable energy or efficiency targets (despite recommendations going back to 2009)</td>
</tr>
<tr>
<td>Both set challenging renewable energy portfolio goals</td>
<td>Bermuda is suffering from an economic recession and is focusing on investment growth and cutting government spending (Richards, 2015), energy prices and the environment are not a high priority for the Government or Bermuda residents</td>
</tr>
<tr>
<td>Hawaii has established the Hawaii Clean Energy Initiative and other working groups to support sustainable energy</td>
<td></td>
</tr>
<tr>
<td>Aruba supported the initiatives at the highest political level and made it a pillar of the economy</td>
<td></td>
</tr>
<tr>
<td><strong>Emphasis on Efficiency:</strong></td>
<td>Little interest in efficiency</td>
</tr>
<tr>
<td>Aruba in particular emphasizes both generating efficiency, and efficient usage of electricity. Both Aruba and Kaua‘i have building efficiency standards, and Aruba has a pilot “Smart Community” to study behavior.</td>
<td>While the Department of Energy and the local utility both provide informational pamphlets on energy efficiency, there are no loan programs, very few favorable tariff programs and no efficiency goals.</td>
</tr>
<tr>
<td><strong>Environmental and social externalities included in energy decisions</strong></td>
<td>Utility decisions don’t include social or environmental externalities</td>
</tr>
<tr>
<td><strong>Willingness to innovate</strong></td>
<td>Risk averse culture</td>
</tr>
<tr>
<td>Both have explored alternative storage systems.</td>
<td>Belco requires technology which is commercial proven and for which support is widely available</td>
</tr>
<tr>
<td>Aruba has emphasized partnerships with research institutions to bring innovation on to the island</td>
<td></td>
</tr>
<tr>
<td><strong>Utilities incentives aligned with the new model</strong></td>
<td>Utility and government incentives aligned with higher electricity sales</td>
</tr>
<tr>
<td>KIUC has maintained a commitment to lower energy prices, but sustainability and community are a core part of their mission.</td>
<td>Sales are volumetric for all sectors (beyond a small fixed charge) with an inclined block tariff for residential consumers, but a reverse incline block structure for hotels (lower prices the more electricity consumed).</td>
</tr>
<tr>
<td>Hawaii has applied to change the energy rating structure to decouple revenue from volumetric sales</td>
<td>Government receives $15.10/barrel of oil in government duty and Foreign Currency Purchase Tax (Belco Annual Report 2013)</td>
</tr>
<tr>
<td>While publicly owned utilities in Aruba are still expected to make a profit, they are not held to account by shareholders</td>
<td></td>
</tr>
<tr>
<td><strong>Stable indirect incentives, such as feed-in-tariffs and long-term power-purchase agreements</strong></td>
<td>Bermuda has no standard licenses or power purchase agreements – lack of standardized agreement makes it hard to find potential investors for commercial scale renewable energy projects</td>
</tr>
</tbody>
</table>
4.3.1 The challenge of storing energy

For both Aruba and Kaua‘i, as the amount of solar generated electricity increases it creates significant challenges. This is because of the variable nature of the power source, and the lack of synchronicity between energy generation and energy demand.

In Kaua‘i the net electrical demand during clear sun times is less than the combination of the lowest level at which the conventional power plant can run (about 10MW) and the “energy-only Power Purchase Agreements (PPAs)”, resulting in an oversupply of electricity at times of low demand (KIUC, 2014a). If Kaua‘i continues to invest in solar energy, which it plans to do to meet its target of 50% of its total energy supplied by renewable energy, then it will have find ways to store the solar energy.

The supply of solar energy drops towards the end of the day while demand tends to rise in the evening, resulting in an early evening demand peak which must be covered by ‘firm’ base-load generation (see Figure 14). In 2014 KIUC issued a Request for Proposals for new storage technology to manage variability and to store solar generated power to use during peak demand times. They found that no novel storage technologies were likely to be cost effective in the short term compared with oil generation (Kelly, 2015) and so they are installing a large pumped hydro project to store excess solar-generated energy during the daytime and use it during the evening and nighttime. KIUC estimates that the new system would produce about 13% of the electricity used on Kaua‘i at about 35% below the cost of oil (KIUC, 2014f).
The intermittency of solar and wind resources means that by themselves they cannot be relied upon for steady, or ‘baseload’, power (see Figure 15). This means that it becomes necessary to overbuild renewable energy sources, and to calculate a ‘capacity factor’ – roughly the reliable availability – when factoring in the likely contribution of renewable energy. In Bermuda that capacity factor is considered to be 17% for solar energy and 38% for offshore wind turbines (Energy, 2015). The capacity factor can be increased through a number of approaches:

- Conventional Li-ion batteries are currently used to for both short and long-term energy storage, however, these are expensive, environmentally undesirable, and the high cycling needed to manage daily or hourly variability limits their life-time.
- Fly-wheels can be used to manage short- and medium-term intermittency (Aruba is planning for about 15MW of fly-wheel storage (McMahon, 2013)), and high resolution forecasting can also mitigate the effect of short-term variability, particularly when used with high capacity information technology to manage demand.
- Ice storage and flow batteries can shift energy from peak supply to peak demand periods, while peak or real-time pricing can change the shape of, or reduce, peak demand.
Newer storage approaches include compressed air energy storage (for example, deep ocean compressed air storage) or grid to electric vehicle storage. (For a discussion of storage options see for example “Reinventing Fire” Chapter 5 (Lovins, 2011), or the Carbon War Room report on Aruba, “Smart Growth Pathways” (McMahon, 2013)).

As jurisdictions move towards a higher contribution from renewable energy sources, ways of storing energy becomes more important and generally more expensive. In Aruba, the Government acknowledges that in order to move towards 100% energy supply by renewable energy “it becomes necessary to greatly overbuild renewable generation and storage capacity in order to meet demand in periods of unusually low inputs, and much energy will consequently be wasted during periods of higher inputs.” (McMahon, 2013).

Intermittent renewable resources also have implications for grid stability and managing a constant voltage supply. In Bermuda there is no opportunity for pumped hydro (because of the topology of the island) and these challenges are likely to limit the opportunity for renewable energy to contribute to the overall energy supply in the short term.
5 A Closer look at Energy Efficiency

Energy efficiency is a significant tool in the arsenal for moving to a more sustainable energy system, but energy use is multi-faceted and affected by the individual choices of every member of the population, so there is little agreement on the best approach. 10 US states have set aggressive energy efficiency goals (3-5% of total use each year) (C2ES, 2014), and two, California and Vermont, provide illuminating case studies.

Vermont ranks 46 in energy consumption in the US and has the lowest carbon dioxide emissions – primarily due to the high contribution of electricity from nuclear power (70% of consumption, and a further 20% from hydroelectricity) (EIA, 2015d). Its approach to energy efficiency has been innovative, intensive and strictly value-driven. In 2000 they created two “Efficiency Utilities” which are regulated by the Vermont Department of Public Service in the same way that electricity supply services are regulated, and are treated as an energy suppliers (VTPSB, 2012a). The motivation is primarily economic and locally focused: Efficiency Vermont claims to be “the cleanest, least expensive, and most locally-acquired way to … meet the state’s energy needs” (EfficiencyVermont, 2013).

California residents use the least amount of energy per capita of all US States (EIA, 2015a). The State has a deeply embedded societal impetus towards energy conservation and the environment, and it was the first state to require Building Energy Efficiency Standards; adopted in 1978 (CEC, 2014). The California Energy Commission was established in 1974 with advancing energy efficiency as one of its core responsibilities (CEC, 2015). In recent years Californians have used the imperative of Global Warming to continue to drive energy efficiency in the interest of reducing their greenhouse gas emissions.

5.1 Vermont

In 2000, in order to provide energy efficiency information to Vermonters and to oversee efficiency investments, the Vermont Public Service Board set up two “Energy Efficiency Utilities”: Efficiency
Vermont⁴, and the Burlington Electricity Department (BED). These “EE Utilities” are regulated in the same way as other energy suppliers and submit to an independent audit of savings and cost-effectiveness every 3 years, and include only savings from actions that are directly attributable to their programs. Energy efficiency has fully offset demand growth since these utilities were established (see Figure 16), with energy efficiency supplying 13.1% of Vermont’s power in 2013 (EfficiencyVermont, 2014a).

Key efficiency concepts (www.publicservice.vermont.gov):

In 2010 the VT General Assembly passed 10 V.S.A. §581 which set a number of explicit goals including to improve the energy efficiency of 80,000 homes by 2020 (VSA, 2012). When it looked as though this goal would be missed by about 50% they established the Thermal Efficiency Taskforce to report at the end of 2012.

The brief was rigorously economic: to identify challenges, including funding deficits, which were preventing the state from reaching the goal, and to quantify the likely economic benefit. The Taskforce reported back with the conclusion that for every $1 spent on building efficiency, homeowners would save $6.18 in direct fuel price benefits over the lifetime of the improvements, and that Gross State Product would increase $1.47 for every $1 invested (VTPSB, 2012c).

The key findings of the Task Force echo the most successful approaches in all efficiency programs. Key recommendations of the Task Force include (VTPSB, 2012c):

- **Make it simple.** Coordinate existing programs and implement a statewide “clearinghouse” to facilitate easy access to information.
- **Ensure affordability.** Ease the energy burden for Vermonters and maintain robust investment in low-income programs to assist the most vulnerable.
- **Leverage private capital.** Increase the use of financing to offset upfront costs.
- **Build the industry.** Develop industry partnerships to build the trained workforce needed to scale up efficiency work.

In 2013, the levelized cost of energy supplied by Efficiency Vermont was 4.2 cents per kWh while traditional electricity sources supplied power at 8.4 cents per kWh (EfficiencyVermont, 2013). As the savings occur largely in the home this results in significant savings to consumers: “Taking into account

⁴ Operated by a private, non-profit company, Vermont Energy Investment Corporation, under an appointment to the Vermont Public Service Board (EfficiencyVermont, 2014a)
participating customers’ additional costs and savings, the levelized net resource cost of saved electric energy in 2013 was 1.2 cents per kWh” (EfficiencyVermont, 2013). Jim Merriam, Director of Efficiency Vermont, claimed with some justification on Vermont Public Radio that “we generate the cheapest and cleanest energy in Vermont” (Lindholm, 2014).

Efficiency Vermont’s approach to conservation has been bottom up and highly focused; they identify barriers to energy efficiency, and geographic areas of high potential, and then target those. The approach has also been rigorously economic: in 2014 the Director stated that the goal of Efficiency Vermont was “to generate $350M of energy savings for Vermonters” (Lindholm, 2014).

Figure 16: Savings from efficiency as a percentage of VT statewide electric resource requirements (EfficiencyVermont, 2013)

Efficiency Vermont’s initiatives include (EfficiencyVermont, 2014a):

- **Providing Energy Efficiency education and information.** According to a study by the American Council for an Energy Efficient Economy, programs that provide consumers with detailed feedback on their energy usage resulted in households reducing their electricity usage by an average of 4 to 12 percent (York, 2015). Generally speaking, the more detailed and frequent the feedback, the higher the savings for consumers (Merriam, 2011).
Community Energy & Efficiency Development Fund – which provides loans to individuals for efficiency measures

Geographic Targeting – this initiative directs energy efficiency program to areas of the state where the transmission and distribution system is under strain. Reducing the load defers investment in system upgrades, benefitting all rate-payers across the state. In 2012/2013 two critical regions were targeted, and for a total cost of $6,363,156 direct savings of $21,921,479 were attributed to this program (EfficiencyVermont, 2013). These savings do not include indirect savings from deferred capital expenditure on the transmission and distribution system. The major saving was in lighting, with HVAC savings coming in a distant second.

Property Assessed Clean Energy (PACE) – this is an alternative way of accessing funding for efficiency investments. A municipality agrees to offer property taxpayers funding for a suite of efficiency measures (such as energy audits, installing new efficient water heating systems, replacing doors and windows). The program is administered and funded by the municipality, which may, if needed, fund the program through a bond issue. Property taxpayers may opt into the system and repay the cost of the improvements via their property tax bill (Malapan, 2011).

Smart Grid – In 2009 Vermont received a $69 million grant from the Federal Government, and matched it with equivalent investment from local utilities in order to install ‘smart meters’ in 85% of VT properties. The motivation is that better information leads to lower energy use (Merriam, 2011).

Vermont Town Energy Data – “This annual snapshot provides municipalities, energy committees, and individuals with information about a town’s historical energy usage, and can help to increase awareness about energy consumption. As part of its effort to help Vermonter’s reduce their electricity use” (EfficiencyVermont, 2014a)

Energy Savings Account (ESA) Program: Vermont Utilities administer an Energy Efficiency Charge (EEC) and businesses with an EEC over $5000 can access some of those funds against investment in energy efficiency. The requirement is that “customers assume some of the responsibility to provide the benefits of reliable electrical efficiency to Vermont and the wider electric grid” (EfficiencyVermont, 2011). Benefits must be cost-effective and reliable, and are required to meet the same cost hurdle as any other source of power. Examples of projects include lighting retrofits and replacement of aging HVAC equipment (ibid, p. 14) – the vast majority of the savings came from
lighting refits. In 2013 the program cost $3,248,727 (combining both the participants costs and EV’s costs) and TRB (Total Resource Benefits) were $5,337,102, or 74,484 MWh saved over the lifetime of the measures (EfficiencyVermont, 2013).

- **Energy Leadership Challenge** – From July 2011 to June 2013 Efficiency Vermont encouraged large businesses to participate in a challenge to reduce their energy consumption by 7.5% over the two years. They were provided with technical and educational support across 4 areas (see Figure 17). 69 large businesses signed up and together saved $54M in annual energy costs over the two years (EfficiencyVermont, 2013)

Figure 17: Efficiency Vermont approach to Continuous Energy Improvements as part of their Energy Leadership Challenge (EfficiencyVermont, 2013)

Efficiency Vermont is funded via an Energy Efficiency Charge (EEC) on electric bills, revenue from the Regional Greenhouse Gas Initiative (RGGI)\(^5\), and revenues from selling energy efficiency savings to the region’s Forward Capacity Market (EfficiencyVermont, 2014a).

\(^5\) http://www.rggi.org/
5.2 California:
California has had energy efficiency programs in place since the establishment of the California Energy Commission in 1974 (CEC, 2015). The focus on energy efficiency was motivated by energy crisis of the 1970s and by the fact that California’s population was growing fast, much of it in the hot interior of the state, increasing demand for air-conditioning and therefore draw on an “already over-burdened infrastructure” (ibid, p.3). The emphasis has not been on rigorous economic justification for EE, although Under the Warren Alquist Act⁶, which established the California Energy Commission, “the building energy efficiency standards must be cost-effective and must not cause unreasonable disruption to industry compared with the amount of energy saved” (WAA cited in (LaRue, 2013)). Despite the trend towards larger houses and more appliances, California has managed to hold its per capita electricity demand steady since 1974 (see Figure 18). According to the EIA, California has the lowest consumption of energy per capita of all US States (EIA, 2015a).

Figure 18: California per capita electricity sales in kWh per person (CES, 2007)

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⁶ http://www.energy.ca.gov/reports/Warren-Alquist_Act/
The California Public Utilities Commission (CPUC) established formal energy savings targets for the state’s investor-owned utilities (IOUs) in September 2004. The CPUC wanted to reduce its projected energy demand increase by more than half over the following 10-year period. The stated goal was for IOUs in California to capture “70% of the economic potential and 90% of the maximum achievable potential for electric energy savings over the 10-year period” (CPUC, 2004): the total cumulative savings goal was 2,847.6 MW of peak savings over 10 years.

The primary weapon was 4 “Big Bold Goals” which targeted building energy use (CEE, 2008):

1. “All new residential construction to be zero net energy by 2020
2. “All new commercial construction to be zero net energy by 2030
3. “The Heating, Venting and Air Conditioning (HVAC) industry to be re-shaped to deliver maximum performance HVAC systems
4. “All eligible low-income customers to have an opportunity to participate in the LIEE program and will be provided all cost-effective energy efficiency measures in their residences by 2020”

“In September 2009, the CPUC released a 2010-2012 Plan with revised savings targets because utilities outperformed earlier targets. The new targets reflect an updated assessment of energy savings potential available to utilities and call for nearly 1,500 Megawatts (MW) of peak savings and 7,000 gigawatt-hours (GWh) of electricity savings over the three-year period.” (C2ES, 2014).

The 4 “Big Bold Goals” were accompanied by a suite of other projects to reduce overall energy demand in existing buildings (CEC, 2014):

- **Energy Efficiency Standards in residential and non-residential buildings** – these have been in place since 1978 and are reassessed every 3 years
- **Mandated Energy Efficiency requirements for appliances** – including developing standards for appliances not covered by federal energy efficiency standard
- **Upgrading existing buildings** – including providing expertise for Home Energy Audits, partnering with schools and providing funds to local education authorities
Achieving the targets required investment in energy efficiency by the utilities: “Since 1980, IOU spending on energy efficiency programs has been at least $200 million per year (in constant 2002 dollars) every single year, averaging over $400 million annually. Much of this funding has historically taken the form of cash rebates and incentives to help defer the incremental cost of new, more efficient equipment for customers. Much effort has likewise been devoted to energy efficiency training, information, and public outreach. The programs are funded by all ratepayers. Collectively, the funding adds more than 1 percent to the cost of an average kWh in CA. However, the programs have been deemed to save consumers more money than they cost.” (LaRue, 2013)

Zero Net Efficiency (information from (LaRue, 2013)):

Commercial and residential buildings account for 22% of California’s greenhouse gas emissions, and these are targeted in two of the Four “Big Bold Goals” established in 2008.

The goal is basically a very energy-efficient building with some on-site generation by renewable energy; this is most easily achievable with low-rise buildings with large roof area.

The design challenge is very simple and has “capture[d] the imagination of builders, environmentalists and the public in a way that more modest energy efficiency and renewable energy goals have not.” (LaRue, 2013)

However, ZNE building may end up posing a challenge for the utilities as well. ‘Net’ zero buildings will still interact extensively with the grid, and extensive generating capacity may well cause grid congestion at times of peak generation. In addition, as the number of ZNE buildings increases, California’s rate structure (see Table 2) may result in electricity charges concentrating in fewer and fewer rate payers.
5.3 Lessons for Bermuda:

While most efficiency technologies save money without any subsidies, the evidence from other jurisdictions suggest that end-users are very slow to adopt new technologies, even those which save a significant amount of money. Therefore active intervention can make a dramatic difference in uptake.

High Potential Energy Efficiency Programs which could be considered in Bermuda:

- Establish an Energy Utility: Efficiency Vermont’s innovative approach and focus on rigorous cost accounting for energy efficiency improvements has helped Vermont to achieve among the highest energy savings in the US (see Figure 19).
- Set building efficiency standards: California’s emphasis on building efficiency standards has helped them to keep energy demand flat on a per capita basis since 1974.
- Create or support, and publicize financing for private sector and residential retro-fits (e.g. add-on to mortgages, recouping via electricity bill, or land-tax incentives). These have proved effective in Vermont.

Efficiency Vermont has consistently found that significant savings are available through lighting retrofits and other simple measures. These have also proven to be effective in Bermuda (see Section 6.1).

5.4 The role of the rate-setting framework

Utilities in Bermuda and elsewhere are granted exclusive, stable access to serve a given region on a cost of service basis; that is they can recover their cost of operation plus a modest rate of return (J. P. Tomain, 1990). Historically rates have been set so that the utilities revenue requirement is divided by the forecast kWh sold. This approach minimizes the role of the customer as decision-maker by not sending a true price signal to consumers. It also creates a number of other problems: marginal profit is highest on each additional volume of electricity sold, setting incentives for the utility to increase the sale of electricity; in addition, the revenue requirement is normally based on the utility receiving a set return
on capital expenses (and passing through their operating expenses), rewarding utilities for capital investment.

There are a number of new approaches to rate-setting which are being successfully used in other jurisdictions with the goals of:

- Providing accurate price signals to customers
- Decoupling revenue from sales volume of electricity
- Aligning the incentives of “grid operators, home owners, retail competitors, energy management companies” (McDermott, 2014).

One approach is to ‘decouple’ sales from volume. There are a number of ways this can be done, each with its pros and cons (See for example discussions by McDermott (McDermott, 2012) and Tomain (J.P. Tomain, 2009)):

Table 2: Decoupling approaches for revenue recovery. Source: [ACEEE, 2013] and [C2ES, 2015a]

<table>
<thead>
<tr>
<th>Decoupling approach</th>
<th>Description</th>
<th>Pros</th>
<th>Cons</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lost Margin Recovery</td>
<td>Utilities predict their costs and regulator guarantees the revenue. Rates are regularly reassessed and adjusted up or down to compensate for changes in volume</td>
<td>The utility is indifferent to the sales volume of electricity</td>
<td>Requires a rigorous evaluation program and frequent rate case assessments</td>
<td>VT, CA, HI</td>
</tr>
<tr>
<td>Straight Fixed Variable (SFV)</td>
<td>Fixed utility costs are distributed as a fixed charge to consumers, variable costs are volumetric</td>
<td>Separates capital investment from volume of sales, decouples volume from revenue</td>
<td>Reduces the incentive for consumers to conserve energy as volumetric portion of the bill is relatively small</td>
<td>Idaho</td>
</tr>
<tr>
<td>Lost Revenue Adjustment</td>
<td>Measures the impact of energy efficiency initiatives and allows utilities to share the savings</td>
<td>Provides incentive for both consumers and utility to conserve</td>
<td>Hard to verify, and encourages gaming on the part of the utility</td>
<td>CA</td>
</tr>
<tr>
<td>Revenue Neutral Energy</td>
<td>Establishes an expected cost for consumers, then consumers who use more</td>
<td>Utility has a predictable revenue stream</td>
<td>Requires a ‘true up’ so that the utility covers</td>
<td></td>
</tr>
</tbody>
</table>
Efficient Feebate (REEF) pay a higher rate, and under-users save. Its revenue requirement. Complex to administer

Inverted Block Rates

| Creates a rate structure with progressively higher charges per kWh for progressively higher levels of consumption | Strongly discourages high consumption; makes efficiency and/or distributed generation very attractive to high-use customers | Requires multiple classes of consumers to allow for different usage patterns | CA and other |

States normally use a suite of options to decouple volume from sales, for example, California uses a high fixed cost, lost revenue adjustment with margin recovery, and an inverted block structure (LaRue, 2013) and (ACEEE, 2013). In most states which use a form of decoupling there are also performance incentives for energy efficiency and penalties for missing conservation goals.

Data from the US suggests that while savings from energy efficiency are correlated to some extent with the amount spent by the utility (see Figure 19), savings above 1% per year are easier to achieve if utility revenue is decoupled from volume of sales (states marked with a red dot in Figure 19 have decoupled electricity sales volumes from revenue).

Thus rate decoupling may be a valuable tool for Bermuda to provide incentives to improve energy efficiency; indeed the Bermuda Government Energy White Paper of 2011 pointed out that “regulation of electricity pricing is a strong and far-reaching tool for aligning the incentives of the electric utility, independent power producers and energy consumers with the energy policy goals of the Government” (Energy, 2011).

In Bermuda an additional challenge is that Government incentives are also tied to volumetric sales of electricity as the Government receives $15.10 per barrel in taxes for every barrel of fuel oil imported (Belco Annual Report 2013).
However, changing the rate structure can create perverse incentives as the penetration of renewable energy increases. There are added complications when aggressive energy efficiency programs are successful, as while these result in significant savings for consumers they reduce the total rate base and therefore increase the cost of electricity overall. For example in West Australia, steady defection of demand via renewable energy has resulted in a significant gap between the cost of generating and transmitting electricity, and the amount that they can charge rate-payers (Parkinson, 2014), which is resulting in uncertainty about the future of the utility.
6  A new Energy Model for Bermuda

Lincoln Davies, in his Stegner Symposium Essay of 2009 (Davies, 2009), argues that

“a failure to transform the way in which we regulate energy would be a missed
opportunity of enormous proportions ... Examining energy use is one of the most
fundamental ways that we can assess our success in obtaining sustainable
development’s “triple bottom line”: ... the way in which we utilize energy defines our
economic development; and access to energy is essential to social justice.”

We have that transformational opportunity in Bermuda today.

The case studies discussed in this paper give some indication of what a new energy model could look like: An energy sector which will be fit for purpose in 30 or 40 years’ time will value energy efficiency over generating power, the utility and the community will both contribute, it will reinvest in the island, and be environmentally, economically and socially sustainable so that we do not compromise our planetary environment or deplete the resources that our children and grand-children will need.

Therefore Policy recommendations from the case studies include:

6.1  Set building efficiency standards and invest in energy efficiency

The case studies in Section 5 demonstrate that in general the energy we make available through conservation is much cheaper than burning fuel to generate more. Efficiency Vermont demonstrated that the levelized cost of electricity from conservation and efficiency is about half the cost of generating new electricity. Bermuda’s Minister of Education and Economic Development Grant Gibbons (whose Ministry includes the Department of Energy) acknowledged in July 2014 that “conservation is generally the cheapest, most effective means by which the greatest impact can be made” (McGrath, 2014).
Despite this, Bermuda has not invested significantly in energy efficiency. Bermuda has not set any energy efficiency goals for the utility or the island and presents a rich opportunity for energy conservation. The per capita use of electricity in Bermuda is roughly double that of Kaua’i and about 50% higher than Aruba (see Section 4). There are no standards for building energy efficiency, which has been a major lever for conservation in California, and there are no energy efficiency requirements in the Bermuda Commercial Building code. The normal practice of landlords billing commercial tenants for electricity by the square foot (as most older buildings do not have separate meters for each floor or tenant) provides a disincentive for both the landlords, who pass through the electricity costs to the tenants, and the tenants, who will not benefit directly from conservation efforts.

Despite the lack of Government encouragement, private energy conservation projects in Bermuda have demonstrated that significant savings are available (sidebars for residential and commercial examples), and the results are consistent with reports from the US (Gravely, 2013).
Cumberland House Retrofit Program: Bermuda (Orchard, 2012)

Cumberland House, built in 1988 is a 94,000 sq ft office building in Bermuda CBD, with 6 tenants. It was retrofitted for energy efficiency in 2011/12. An energy audit recommended:

1. Switching out the lights from incandescent and fluorescent to LED
2. The installation of a metering system to allowed monitoring and management of energy consumption in 72 zones
3. The installation of an updated, remotely accessible Energy Management System

The program cost $600,000 and took 15 months; consumption of electricity was nearly halved, and the payback on the investment was 33 months.

Figure 20: The impact of the energy efficiency retrofit of Cumberland House. Cost in BD, consumption in kWh.
A Bermuda resident wanted to reduce their energy consumption in their four bedroom, average-sized house, without significant investment. Efficiency measures included:

1. Switching to Energy Star rated appliances as old appliances reached the end of their useful life
2. Switching out incandescent bulbs for CFLs or LED bulbs (approximately $600 investment)
3. Adding timers to water and closet heaters and turning the thermostat down on the hot water heater ($700 investment, including installation by an electrician)
4. Adding a smart switch to media electronics so that they could all be completely turned off with the TV when not in use

The resident made the changes starting in mid-2014 and has seen a 30% reduction in electricity use – see red line compared with earlier years. (The sharp dip in November 2014 is due to extended outages as a result of Hurricanes Fay and Gonzalo)
More than 10 US states have set energy efficiency targets of between 3 and 5% *per year*; that is, they believe that they can reach a cumulative reduction in energy demand of better than 20% by 2020 (generally off a 2009-2012 baseline) (C2ES, 2015c). Bermuda should set efficiency targets, in particular building efficiency standards; in commercial buildings in Bermuda, 70% of the electricity goes on HVAC and lighting (Energy, 2011), and in general these are productive targets for energy conservation.

Bermuda should also consider some of the options for decoupling electricity sales from revenue (see Section 5.4). Bermuda’s electricity rates today are primarily volumetric, which is a disincentive for the utility to invest in either internal generating efficiency or efficient use of electricity by consumers. This is further complicated by the fact that the government receives $15.10 per barrel of taxes on imported fuel oil, which represents a total annual income of about $15M ((Fox, 2014), Belco Annual reports, 2008 to 2013).

### 6.2 Invest in a ‘smarter grid’

Joseph Tomain describes today’s electricity distribution system as “hardly different from Edison’s first system at the end of the nineteenth century” (J.P. Tomain, 2009). We have the opportunity to evolve to a ‘smarter grid’, which allows more sophisticated communications from the producer to the consumer and in the other direction. A smarter grid will enable both the end user and the producer to respond to changes in the generating mix (e.g. clouds reducing the output of solar panels). This facilitates demand management or demand response, management of distributed generation, and increases efficiency in all parts of the grid (J.P. Tomain, 2009).

Amory Lovins, in “Reinventing Fire” (2011), his blue-print for a restructured energy future, makes the point that a ‘smart grid’ also increases consumer participation, allowing interaction between energy producers and consumers, both directly and via price or cost signals, to reduce the overall system costs. This has a side effect of increasing grid reliability both through “cost-effectively meeting grid-balancing needs in times of system stress” ((Lovins, 2011) p. 197), and improving the ability to pinpoint and respond to small-scale outages.

The deployment of ‘smart meters’ or Automated Metering Infrastructure (AMI) is anticipated by Belco to support a number of approaches to demand management (BELCO, 2014):
• Direct load control (such as turning off customer equipment, e.g. pool pumps, hot water heaters, in response to a surge in demand)

• Price response programs, such as time-of-use pricing, critical peak pricing, or peak time rebate pricing. These influence customer behavior with pricing signals at times of generating stress

• AMI enabled customer engagement: a more sophisticated approach which may include distributed generation and load control.

The potential of demand management to contribute to the electricity supply model was recognized by FERC order 745 in 2011. This required US energy purchasers to treat energy ‘supplied by’ managing demand (sometimes referred to as ‘negawatts’) in exactly the same way as physical or chemical energy generation: “when dispatch of that demand response resource is cost-effective as determined by the net benefits test described in this rule, that demand response resource must be compensated for the service it provides to the energy market at the market price for energy ... thus ensuring just and reasonable wholesale rates.” (FERC, 2011). California has gone further and in 2003 specified a “loading order” for energy resources for the utility. This requires the utility to use energy efficiency and demand response as its first option (the full loading order is: renewable energy and distributed generation; clean fossil-fueled sources and infrastructure improvement) (CES, 2007).

Policy and regulation which supports the benefits of a smart grid in Bermuda would include: allowing real-time or variable electricity rates; requiring efficiency or demand response resources to be treated the same way as other producers of electricity; and setting and monitoring reliability requirements for the transmission and distribution network which reduce the need for redundancy of generating resources. In addition, regulators should support grid upgrades to improve grid flexibility, both for distributed generation and to balance supply and demand in real time (James, 2012). This is an important requirement to support higher levels of renewable energy (see next section)

6.3 Renewable Energy Targets – supported by standard licenses and PPAs

All of the cases studied in this paper, including California and Vermont, have set Renewable Energy Portfolio Targets. These targets are a recognition that energy policy and investment decisions are not
just narrow cost-benefit decisions, but affect all parts of the “biophysical, human, and institutional” elements of a policy system (Orbach, 2013) – this was discussed in Section 2. Bermuda should set a Renewable Energy Portfolio Target in order to access a number of benefits which are not captured in simple cost-benefit analyses.

- A hidden cost of Bermuda’s current electricity system is the impact of buying oil from overseas. More than half of each electric bill payment is being sent off the island to pay for oil (Fox, 2014). Bermuda’s balance of payments issue is a significant problem for the Bermuda economy where the current account balance (before debt servicing) has been negative for the last seven years (Richards, 2015). Thus renewable energy projects contribute to the health of the Bermuda economy by improving the balance of payments.

- Renewable energy projects also provide a direct economic benefit via an economic ‘multiplier’: Most of the total lifetime cost of energy from wind turbines and solar panels comes from initial installation costs (DOE, 2012), both capital and labor. The investment in labor not only stays on the island, but is reinvested in, for example, health insurance or buying groceries. This multiplier in the community from investing in alternative energy can be twice the actual cost of installation (CCS, 2013). This positive economic externality is not currently included in Bermuda’s energy cost-benefit calculations.

- Commercial Scale renewable energy would increase Bermuda’s energy diversity. This has a number of benefits, including reducing the island’s vulnerability to disruption in the delivery of fossil-fuels, which could occur because of both geo-political unrest and extreme weather events. Renewable energy projects spread throughout the island would improve system reliability through geographic diversity: The current concentration of all of Bermuda’s electricity generating resources in one place increases the system vulnerability to extreme weather events (such as a tornado or flooding) or to disasters such as a fire at the plant.

- The price of renewable energy is expected to continue to fall (see Figure 22), and so over time investment in renewable energy is likely to reduce the cost of electricity (Hand, 2012). In some parts of the world, including Australia and the South-East US the cost of solar energy is already lower than the average cost of fossil-fuel-based electricity generation, and Citigroup predicts that in most major markets it will achieve parity with fossil-fuel or better by 2020 (Parkinson, 2013). Currently in
the US more than half the cost of solar is ‘balance-of-system’ costs: “inverters, mounting systems, installation costs and planning approvals” (ibid), which means that, for Bermuda, over time a larger percentage of the cost of solar systems will stay in Bermuda via the labor market.

Figure 22: The cost of photo-voltaic cells since 1977 (Romm, 2013)

- Finally, fossil-fueled energy generation is a significant source greenhouse gases which drive global climate change. Belco’s plan to invest in the infrastructure and contracts to bring liquefied natural gas (LNG) to the island to replace the aging diesel generators (Kent, 2014) would reduce Bermuda’s
contribution to greenhouse gas emissions, but renewable energy sources produce essentially zero greenhouse gas emissions, and therefore do not contribute to global warming.

In order to support renewable energy, Bermuda should not only set renewable portfolio targets, but will need to standardize licenses and power purchase agreements (PPAs). The lack of standard PPAs is currently a significant contributor to the lack of commercial-scale renewable energy (McGrath, 2014), as a guaranteed PPA is generally required by investors in commercial renewable energy projects. An additional requirement for high penetration of renewable energy is equal grid access. This requires transparency – separating out the management of electricity transmission and distribution from the source of power – so that it is clear where the electricity comes from and how much it costs. In Belco’s current, vertically integrated financial structure it is not possible to separate out the cost of transmission and distribution from the cost of electricity generation.
7 Conclusion: Buying time is the best investment

In summary the policy and regulatory recommendations for Bermuda based on the lessons from case studies are:

- Set Building Efficiency Standards and invest in Energy Efficiency
  - Consider the incentives resulting from current rate structures
- Invest in a ‘smarter grid’
  - Use cost and price signals to increase system efficiency
  - Harness Demand Management (DM) to manage variability
- Set Renewable Energy Targets
  - Include social and environmental externalities in cost-benefit analyses
  - Support with standardized licenses and PPAs
  - Allow equal access to the grid

It is fair to ask whether implementing these policies would make a significant difference to the cost of Bermuda’s energy model, and whether they would ultimately reduce the need for fossil-fuel based generating capacity.

Implementing aggressive energy efficiency measures and a ‘smarter grid’ is likely to defer the need for investment to replace Belco’s aging diesel fuel oil generators (see Section 3.1). The longer this investment is deferred, the more likely that the cost of renewable energy investments reach parity with fuel oil generation (Hand, 2012). One of the critical unknowns in assessing the cost of a high renewables scenario is the advance of storage technology to manage solar and wind variability, and the mismatch between when solar and wind power generate electricity and periods of peak demand (see Section 4.3).

We can get some idea of the likely impact of the policy changes by using information from the case studies to estimate the potential impact of the policy decisions (See Appendix 2 for details of the
calculation). Figure 23 below shows the current Bermuda plan (top chart), and the possible outcome of aggressive energy efficiency, a ‘smart grid’, and a renewable energy portfolio target (bottom chart).

Figure 23: Current Bermuda Plan, and a potential Bermuda model applying some of the lessons from the case studies. See Appendix 2 for full details of assumptions, costs and outcomes.
This analysis suggests that Bermuda could significantly reduce its reliance on fossil fuel (see Table 3). While new investment in fossil-fueled based generation is likely to require a smaller capital investment than renewable energy sources, the ongoing cost of fuel for LNG-based energy is likely to negate this benefit. This may mean that when calculating the life-cycle cost of the investment, it may ultimately be more economical to invest in renewable energy sources.

**Table 3: Summary from the scenario modeling**

<table>
<thead>
<tr>
<th>Scenario:</th>
<th>Investment</th>
<th>Peak demand 2025 (MW)</th>
<th>Contribution from renewables (%)</th>
<th>Contribution from FF (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Plan</td>
<td>$200M in LNG + fuel over lifetime</td>
<td>100</td>
<td>4.3%</td>
<td>95</td>
</tr>
<tr>
<td>Investment in efficiency</td>
<td>$4M</td>
<td>93</td>
<td>4.6%</td>
<td>90</td>
</tr>
<tr>
<td>Efficiency + smart grid</td>
<td>$14-$34M</td>
<td>76</td>
<td>5.7%</td>
<td>72</td>
</tr>
<tr>
<td>Efficiency + smart grid + renewable energy</td>
<td>$300M+</td>
<td>76</td>
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<td>46</td>
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</tbody>
</table>

The assumptions in this model will need to be tested, but it does suggest that by implementing lessons learned from other jurisdictions it may be possible to defer, possibly indefinitely, the investment in new generating infrastructure and at the same time reduce the contribution to our energy from fossil fuel from the current 97% to below 50%.

More analysis is needed, but Bermuda energy stakeholders should answer important policy and value questions before it continues on a path of relying almost completely on fossil fuel for its energy. The case studies of Aruba and Kaua’i demonstrate that it is possible for islands to significantly reduce their reliance on fossil fuel to generate electricity without significantly increasing the price of electricity. The case studies also suggest that the first and most important step is commitment to this idea on the part of the Government and the utility.

Bermuda’s energy sector is currently regulated by the 2009 Energy Act.

1. Part 1: Established the 5 to 6 person Energy Commission which
   a. Is appointed by the Minister to three year terms
   b. 5(1)(b) May inquire into the price or charge made for any energy related commodity
   c. Has the power under (6) to obtain information from “any person”, “and to require the production of accounts, records and other documents”
   d. Members of the Commission will be paid a fee “in accordance with the provisions of the Government Authorities (Fees) Act 1971.”

2. Part 2: “Licence for production or supply of electrical power or specified commodity”
   a. Requires a licence to produce and supply electricity (this also applies to residential ‘generators’), and sets straightforward conditions based on collecting information.
   b. The Act and the Energy Commission covers ‘specified businesses’ defined as 16(1)(a) “any business or group of businesses [that] are in substantial control of the production or supply of any energy related commodity”. The only ‘specified business’ to date is The Bermuda Electric Light Company Limited, known as Belco.

   a. Requires written notice of intention to vary the price or charge, including the amount of the variation (this excludes variations directly related to installation or repair). The Commission will respond with a direction within 60 days.
   b. Gives the Commission the ability under 13 (1) to do a number of things: approve, disallow, change the date of effect, or add terms and conditions. It does not have the option to offer alternatives, and must take into account 13(2):
      i. The cost of generation
      ii. The need of the business for working capital and “reasonable reserves”
      iii. The need for a reasonable rate of return for investors
      iv. The public interest
      v. “any other matters which, to the Commission, appear relevant”
4. Part 4: “General” allows the Minister to designate any officer of the Department of Energy as an inspector, with the ability 20(2) “to enter any premises for the purpose of inspecting any energy related apparatus ... kept by the holder of a licence granted under section 8.”

5. Section 26 Gives the Minister the power to “to exempt any person, or any class of persons, any energy related commodity or apparatus, or any class of energy related commodity or apparatus, from this Act or the regulations, or from any provision of this Act or the regulations”.

The Energy Act does not require any public consultation, but neither does it prevent the Commission from making any matters public (allowing for some information to remain confidential under section 26A(1)). Part 3 (rate setting) is a slow and cumbersome process which does not allow for flexible or real-time pricing, and no allowance is currently made for peak pricing.

Appendix 2: Estimating the opportunity for Bermuda Today

While the factors that go in to energy decisions are complex, Bermuda can learn from best practices in other jurisdictions. To provide an indication of the opportunity for Bermuda, we can apply some of the lessons from the case studies to Bermuda’s current energy model.

A1: Bermuda’s current energy plan from 2014 to 2025:

Assumptions:

(Sources: (BELCO, 2011), (BELCO, 2012), (BELCO, 2013), Belco Annual Reports, 2008 to 2013)

- 168MW of total generating capacity in 2015
- 80MW of diesel fuel engine capacity lost through planned retirements to 2021
- Current engineering surplus of ‘N-3’ needed for reliability (this is Belco policy, there is no regulatory reliability requirement – ‘N-3’ means that the plant must be able to meet demand if the 3 largest engines are not available, e.g., for planned maintenance, unplanned downtime and as ‘spinning reserve’ to meet unexpected demand spikes). N-3 = 37.5MW
- The Bermuda Draft Energy Policy (Energy, 2015) assumes that electricity demand, allowing for some increases in efficiency over the next 10 years, would be essentially flat, and that no
predicted technology or regulatory changes are likely to affect the shape of the demand or the size of the peak.

- **Power profile**
  - Baseload power is supplied by heavy fuel oil generators, and the Tyne’s Bay Waste-to-Energy facility (WTE)
  - Intermediate power is supplied by light fuel medium speed diesel generators
  - Peak power is supplied by relatively expensive gas turbines
  - A new 8MW commercial solar plant is built in 2017

- **Lost baseload capacity** will be replaced largely through new fossil-fuel investment – probably liquefied natural gas (LNG) (Kent, 2014).

Figure A1: Current Bermuda Energy Plan requires investment in new generating capacity by 2017

Cost and Outcome: New generating capacity is needed by 2018; by 2021 there is a 60-70MW short-fall in generating capacity which Belco plan to fill with new fossil-fuelled generation. The reported cost of 80MW of planned LNG-based generating capacity is $200m (Kent, 2014)
A2: Implement efficiency methods similar to VT and CA

Section 5.4 suggests that sustained demand reductions of >1.5% per year are achievable through targeted energy efficiency initiatives (VT achieves in excess of 2% per year). Energy efficiency efforts affect both peak demand and average demand.

Assumption: Use the base-level analysis from Figure A1 but add 1.5% per year reduction in both peak and average demand from 2016.

Cost and Outcome: Efficiency Vermont has a budget of about $40m per year (EfficiencyVermont, 2014f) – pro-rated on a per capita basis this would require an investment in Bermuda of about $4m per year. However, 1.5% efficiency savings per year will not change the need for investing in new generating capacity.
A3: Smart Grid investment would improve peak management and may change reliability assumptions.

Investing in new information technology – a ‘smart grid’ – can have an impact on peak demand through a number of mechanisms, and may also increase the reliability of the grid.

Assumptions (estimates of savings are for illustrative purposes only):

- ‘Smart Grid’ investments could reduce peak demand by 2% annually through dynamic pricing and direct management of customer appliances
- More sophisticated demand management techniques, and higher resolution weather forecasting could double the capacity factor (availability) of solar resources and reduce the need for diesel generator ‘spinning reserve’
- A ‘smarter grid’ would increase the response time, and reduce the operational expense of grid outages (for example weather events, pole fires, sub-station outages), and therefore the same overall reliability could be achieved without the need to maintain back-up generating units. This model assumes an ‘N-2’ engineering requirement for generating redundancy.

Figure A3: Potential impact of new IT-based solutions
Cost and Outcome: The cost of installing ‘smart grid’ technology in Bermuda is likely to be $10-30m – it is possible that most of the benefits of a smart grid could be achieved with a limited roll-out to the most densely populated parts of the island, reducing the investment needed. If the estimated savings are achieved, then new generating resources would not be needed before 2021, and the gap between baseload and peak demand would be reduced to less than 30MW.

A4: Set a Renewable Portfolio target of 30% renewable energy by 2025

Even with new efficiency and smart grid assumptions new generating capacity will likely be needed by 2021. If Bermuda adopted a renewable portfolio target of 30% (which is less than both Kaua’i and Aruba), and supported this with standardized power purchase agreements (PPA) and licenses, then the gap between supply and demand could be filled by renewable energy sources. About 75MW of wind or solar would be needed (at a capacity factor of around 35%) to ensure that peak load can be met. A limiting factor for Bermuda could be the availability of land or rooftop area for solar energy, therefore this model assumes that half of the target is met with offshore wind (cost assumptions are from the new policy proposal: (Energy, 2015)).

Deferring new investment for 5 years increases the likelihood that new renewable energy will closer to cost parity with new fossil fuel generating capacity (McKenna, 2015). New battery technology could also increase the availability of renewable energy sources and reduce the difficulty caused by intermittency.

Assumptions (building on A3):

- 35MW of commercial scale solar energy in 2020/2021 at $3/W cost fully installed (for comparison: the US Department of Energy SunShot program has a goal of $1/Watt for utility scale solar projects by 2020) (DOE, 2012)
- 35MW of offshore wind in 2020/2021 at $5.60/W (Energy, 2015)

7 Personal communication from Belco, March 2013. Smart grid rollout in Bermuda would cost “tens of millions”
Figure A4: Adding a renewable energy target of 30%

Cost and Outcome: A 35MW solar installation is estimated to cost approximately $90M in 2021, and 35MW of offshore wind is estimated to cost close to $200M (cost per Watt estimates from (Energy, 2015)). Together these investments may defer any need for further investment in fossil-fuel generation indefinitely.

Summary:

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Appendix 3: Bermuda Electricity Rate-setting today (Coehlo, 2013)

70% of the cost of electricity is fuel cost, the rest are presented for rate-setting as follows:

- Facilities charge = cost of meter, lines, cost of billing, bank fees, customer service
- FAR (Fuel Adjustment Rate) allows the utility to recover cost of fuel used in generation – this is separated from other charges because of market volatility. This has a net zero effect on Belco’s revenue recovery (the only incentive to hedge or negotiate is ‘reputational’)
- Cost of fuel includes:
  - First cost
  - Freight and vendor margin
  - Financing costs
  - $15.10/barrel of government duty and FCPT
  - Throughput (at the dock) – cost from Esso/Shell/Rubis. This is the only part of the FAR which is NOT regulated, and is subject to significant variability.
  - World Heritage Tax for St George (0.25c/litre) or about $400K per year
  - Cost of electricity generated at Tyne’s Bay Waste-to-Energy Plant
- Total cost of FAR in excess of $30/barrel (base level set by the government) included in rates.
- Belco imports about 1million barrels/year or about $100M annually. Diesel is much more expensive than heavy fuel oil – total fuel used is a mixture of both: 20% diesel/80% HFO.
- When Belco goes to the Energy Commission for a rate adjustment they project:
  - Kwh sales
  - Fuel mix
  - Actual cost of fuel (FIFO)
  - Gross-up for impact of early payment discount
  - Cost of purchased power at avoided fuel (i.e. net metering on solar panels)
  - Balance of under/over fuel recovery from the last adjustment

NB: net-metering impact for the first 9 months of 2013: 413,541 kwh purchased at a ‘net’ cost of $165,000 (‘subsidy’), which avoided 571 barrels of fuel at a cost of $75,000.
Appendix 4: Faculty

Dr Jonas Monast, J.D., Director of the Climate and Energy Program at Duke University’s Nicholas Institute for Environmental Policy Solutions has kindly agreed to supervise this Masters’ project.

Appendix 5: Source and Amount of support

This research was supported by Greenrock, a Bermuda-based Charity which focuses on sustainable solutions. The author is the former President of Greenrock and currently on the Board of Directors. She leads the Energy Committee for Greenrock and serve as Greenrock’s representative on the Bermuda Energy Working Group).
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