ECONOMIC IMPACT OF ADOPTING AN RPS IN PUERTO RICO: CASE STUDIES AND POLICY RECOMMENDATIONS

By

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ABSTRACT

This Project determines the economic impact related to the adoption of a Renewable Portfolio Standard in Puerto Rico. RPS policies have become key drivers to increase the use of renewable energy sources. However, its effectiveness hinges on the economic impact related to its adoption and enforcement. The analysis presented in this project is focused on an energy policy framework, with great weight towards the economic development component. With the objective of determining the RPS related compliance cost and its impact over retail electricity price in Puerto Rico, an economic model has been developed for the Puerto Rico electric power system. For this, the project evaluates the following: available renewable energy resource-based potential; current situation of the Puerto Rico electric power system, its electric service rate structure and financial requirements of the local electric power utility; the levelized cost of energy for the selected renewable technologies; and fossil fuel price projections. Various levels of RPS adoption have been evaluated and compared with the reference scenario, including a discussion of their economic impacts and sensitivity of the results to changes in the system. Finally, this project provides with a significant contribution towards the electric power sector in Puerto Rico, including but not limited to stakeholders from the academia, Puerto Rico Electric Power Authority (PREPA), policy-makers, and the general public.

RESÚMEN

Este proyecto presenta un análisis para determinar el impacto económico relacionado a la adopción de una cartera de energía renovable (RPS, por sus siglas en inglés) en Puerto Rico. Las Carteras de Energía Renovable se han convertido en una de las principales estrategias de política pública para lograr incrementar el uso de fuentes de energía renovable. Su efectividad depende significativamente del impacto económico relacionado a su adopción y ejecución. El análisis aquí presentado está enfocado en un marco de política pública energética, con gran énfasis en el elemento de desarrollo económico. Con el fin de determinar el costo de cumplimiento relacionado a la Cartera de Energía Renovable y su impacto hacia el costo del servicio eléctrico en Puerto Rico, se ha desarrollado un modelo económico para el sistema de potencia eléctrica en Puerto Rico. Para ello, se ha evaluado el potencial de los recursos disponibles en la isla; la situación actual del sistema eléctrico en Puerto Rico, su estructura tarifaria, el costo de producción de energía de ciertas tecnologías renovables; y las proyecciones ante el precio de los combustibles fósiles. Varios escenarios de adopción han sido evaluados y comparados con el escenario de referencia incluyendo una discusión de sus respectivos impactos económicos y sensibilidad en los resultados ante variaciones del sistema. En fin, este proyecto provee una contribución significativa hacia el sector del sistema eléctrico de Puerto Rico, sin limitarse al componente académico, la Autoridad de Energía Eléctrica de Puerto Rico (AEE), formuladores de política pública, y público en general.

Dedicated to God, my Parents, Family, and Friends.

ACKNOWLEDGMENTS

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AEO	Annual Energy Outlook 2010
ARRA	American Recovery and Reinvestment Act of 2009
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
AWEA	American Wind Energy Association
BAU	Business As Usual
BBL	Barrels of Oil
Btu	British Thermal Units
C	Coal
CBI	Capacity-Based Incentive
CH_4	Methane Gas
CO_2	Carbon Dioxide
COS	Cost of Service
DG	Distributed Generation
DOE	U.S. Department of Energy
DR	Discount Rate
DSCR	Debt Service Coverage Ratio
EE	Energy Efficiency
EECs	Energy Efficiency Certificates
EERS	Energy Efficiency Resource Standard
EEPS	Energy Efficiency Portfolio Standard

EIA	U.S. Energy Information Administration
EPAct 1992	Energy Policy Act of 1992
EPAct 2005	Energy Policy Act of 2005
EPRI	Electric Power Research Institute
EPSEM	Electric Power Sector Economic Model
FC	Fixed Charges
FCC	"Formula Compra de Combustible" or Fuel Purchase Formula
FCE	"Formula Compra de Energy" or Power Purchase Formula
GEF	Green Energy Fund
GHG	Greenhouse emissions
IEA	International Energy Agency
IECC	International Energy Conservation Code of 2009
IPP	Independent Power Producer
kW	Kilowatts
kWh	Kilowatts-hours
LCOE	Levelized Cost of Energy
MSW	Municipal Solid Waste
MW	Megawatts
MWh	Megawatts-hour
NG	Natural Gas
NO_2	Nitrogen Dioxide
NPV	Net Present Value

NREL	National Renewable Energy Laboratory
O&M	Operations and Maintenance
PPA	Power Purchase Agreement
PREAA	Puerto Rico Energy Affairs Administration
PREPA	Puerto Rico Electric Power Authority
PURPA	Power Utilities Regulatory Policy Act of 1978
PV	Photovoltaic
RE	Renewable Energy
REC	Renewable Energy Certificate
RPS	Renewable Portfolio Standard
SWT	Small Wind Turbines
T&D	Transmission and Distribution
WTE	Waste to Energy

1. INTRODUCTION

1.1. OVERVIEW

Energy is one of the most important sectors worldwide. Concerns about our environment, economy, and energy security have stressed the importance of renewable energy and energy efficiency. The electric power sector is and will continue to be essential in order to address energy-related issues and challenges. Nowadays, electricity represents the fastest-growing form of end-use energy worldwide, and accounts for a significant share of the world's total energy consumption [1].

Renewable energy sources and energy conservation have become fundamental routes as to direct the electric power sector towards a sustainable future. Their potential is unquestionable, but how quickly they will become an effective tool will depend on energy policy decisions and enforcement. Policymakers are relying on this sector to achieve economic development, environmental stewardship, and social justice. Several energy policies have been designed to enforce energy conservation and increase the adoption of renewable energy sources. One of the most often used policies is the Renewable Portfolio Standard (RPS); a legal energy policy that requires electricity providers to procure a minimum of eligible renewable energy by a specific date or according to a schedule [2]. Nonetheless, to effectively adopt and enforce such policy, one must first consider fundamental factors such as infrastructure and resource limitations, environmental and social welfare, and economic impact.

This project focuses on determining the economic impacts related to the adoption of an RPS policy in Puerto Rico. The direct impact for a utility to adopt high levels of renewable energy sources derives principally from the displacement of electricity generation from existing units. In this project, economic impact is measured using two methods: (1) comparing RPS compliance cost with the utility's avoided cost derived from the integration of renewable energy sources; and (2) determining the resulting impact towards retail electricity price in Puerto Rico, according to the local utility (PREPA) electric service rate structure. This project aims to provide with economic impact estimates for the local utility (PREPA) to adopt and meet an RPS policy, and compare results at different levels of adoption in Puerto Rico.

1.2. MOTIVATION

Puerto Rico's electricity sector accounts for a large share of the total energy demand. Nearly 99 percent of its electric power is generated using fossil fuels as primary sources, with nearly a 70 percent share from oil-based products. Thus the island has great vulnerability and dependency on fossil fuels. Moreover, this dependency has negatively impacted the environment and the society for years. Throughout the years Puerto Rico's energy policy has been unclear and ineffective. As a result, Puerto Rico is currently facing many issues and challenges, including high, unstable, and volatile electricity prices, significant reliance on fossil fuels, among other environmental and social detriments. Therefore, we must harness the potential within renewable energy sources and energy conservation through the development of energy policies to protect the environment, enhance our energy security, improve our economy, and ensure a sustainable energy future.

According to aforementioned facts regarding the electric power sector in Puerto Rico, it is clear that corrective measures need to be taken. A potential solution rests within the effective adoption and enforcement of sustainable energy policies. In Puerto Rico, there are multiple factors that clearly underline the importance of increasing the adoption of renewable energy and enforcing energy conservation and efficiency. Key drivers include:

- fossil fuel dependency; significant reliance on imported oil-based products;
- lack of diversity on fuels for electricity generation;
- high electricity prices; very unstable and volatile history trends;
- environmental impacts; mainly contribution of the electric power sector on GHG emissions, with a greater emphasis on CO_2 emissions resulting from fossil-fuel burning;
- economic development; electric utility cost is directly affecting Puerto Rico's industry and the society in general

The availability of high quality, reliable and cost efficient electricity is of great importance for economic development of Puerto Rico and to ensure a sustainable energy future. The adoption of an RPS policy provides with an alternative to increment the use of renewable energy sources in the island. Furthermore, the greatest opportunity for increasing the use of renewable energy sources lies within the electric power sector. However, RPS effectiveness hinges on the economic impact related to its adoption and enforcement. Therefore, it is essential to assess the economic impact related to the adoption on an RPS policy in Puerto Rico.

1.3. OBJECTIVES AND CONTRIBUTIONS

The main purpose of this project is to determine the economic impact related to the adoption of an RPS policy in Puerto Rico. This includes, comparing RPS compliance cost with the utility's avoided cost; and determining its impact towards retail electricity price according to the electricity rate structure used by PREPA. Another purpose is to measure the potential integration of energy efficiency measures to reduce RPS compliance cost and hence provide reduction towards the retail electricity price in Puerto Rico.

Specifically, we strive to achieve the following objectives:

- Understand how the development and increased integration of renewable sources will impact the ultimate cost of electricity for customers in Puerto Rico
- Quantify the economic impact for the local electric power utility to comply with RPS, at different levels, according to their annual revenue requirements, avoided cost, and medium to long term demand projections.
- Evaluate the potential contribution of energy efficiency measures on achieving renewable energy targets and reducing an RPS compliance cost in Puerto Rico.
- Provide policy recommendations, based on results, as to the most effective way to adopt, implement and enforce an RPS policy and energy efficiency measures.

1.4. PROJECT OUTLINE

This project is organized as follows: An introduction as well as the project objectives and contributions are given in Chapter 1. Chapter 2 offers a conceptual review of energy, electricity and economics; an overview of statistics, trends and outlooks is also provided. Chapter 3 provides a literature review on energy policy. Chapter 4 provide an overview of Puerto Rico electric power sector including history and current status; followed by a description of the Puerto Rico Electric Power Authority (PREPA), performance characteristics, electricity rate structure, and financial facts. Chapter 5 reviews renewable energy and energy efficiency development in Puerto Rico, including current policies. Chapter 6 describes the Electric Power System Economic

Model developed in this project, followed by methodology description. Chapter 7 describes RPS case scenario development, including taken assumptions; resource-based potential, and cost & performance characteristics for the selected renewable energy technologies. Potential development prospects are identified, levelized costs of energy are calculated, and a set of supply mix assumptions are presented. Chapter 8 provides with results from the economic analysis, followed by a discussion regarding RPS compliance cost, electricity rate impact, energy efficiency potential, and utility's financial impact results analyzed in the project. Finally, Chapter 9 presents general conclusions, policy recommendations, and future work.

2. ENERGY, ELECTRICITY, AND ECONOMICS

2.1. INTRODUCTION

Energy is defined as the capacity to do work. Energy sources are grouped into, renewable and nonrenewable sources. Renewable sources are those that can be easily replenished. Renewable energy sources include solar energy, wind, geothermal, hydro, and biomass. On the other hand, nonrenewable energy sources are those that once consumed cannot be recreated, e.g. fossil fuels–oil, coal, and natural gas. Energy sources such as the element uranium used in nuclear fission are also nonrenewable sources. Although renewable energy sources are highly abundant, the reality is that the world gets most of its energy from nonrenewable sources, with great emphasis on fossil fuels.

There are many end-use forms of energy such as heat, motion, and electricity. [3]. The modern era of electricity as an end-use form of energy began on September 4, 1882 when Thomas Edison enlighten Pearl Street Station with four hundred incandescent light bulbs [4]. Nowadays, electricity represents the fastest-growing form of end-use energy worldwide. It is crucial to understand that while electricity is a common need, it is also considered as one of the key inputs for economic development. Mainly, energy is responsible of three fundamental issues: (1) security and reliability of supply; (2) fair market prices; and (3) environmental protection and climate change [5]. Thus, ensuring affordable, reliable, and environmentally friendly electric energy to all citizens has become the primary objective of both electric utilities and policy makers.

Electricity is not a natural resource, but rather an end-use product derived from the use of available natural resources. Electricity is considered a secondary energy source that is dependent on a primary source as an input. For example, energy sources such as natural gas, oil, and coal are burned to create steam, which turns a turbine shaft that is ultimately coupled to an electricity generator. It is important to understand that considerable amount energy is lost through the conventional conversion, transmission, and distribution of electricity.

The electric power industry is comprised of three main sectors – generation, transmission and distribution, and end-use. The generation consists of electric power generation units that provide enough capacity and generation to preserve a balance between supply and demand. The transmission and distribution sector mainly serve as the interconnection channel through which electricity is transmitted and then distributed for its final use. The end-use sector consist of retail electric power customers, including but not limited to residential, commercial, and industrial customers.

In the following sections we will review statistics for energy and electricity, their trends and outlooks. Furthermore, statistics included will encompass important facts about current market tendencies and projections regarding energy sources, electricity demand, energy prices, and environmental impacts, among other useful indicators.

2.2. TRENDS: FACTS AND PRIORITIES

According to [6], electricity generation is expected to increase its share of the world's total energy demand. It is considered the fastest growing form of end-use energy in all sectors, except transportation. As of 2008, electricity represented 17.2 percent of the world's total energy consumption [1]. However, the expected increase demand of electricity, will ultimately outpace energy use growth rate; hence increasing its overall share [6].

From a global perspective, the mix of primary fuels used to generate electricity has transformed over the past decades. Statistics have shown a gradual decline on the use of oil for electricity generation due to oil prices. With world oil prices projections to return to relatively high levels, reaching almost $200 per barrel in 2035, short-term price volatility is likely to remain high [6]. Hence, most nations are expected to respond to higher oil prices by reducing or eliminating their use of oil for generation and thus opt for more economical sources of electricity. Coal continues to be the fuel most widely used for electricity generation. Nonetheless a reduction of its share might be expected due to its carbon-intensive characteristics. A significant increase is expected from natural gas use for electricity generation. The total amount of electricity generated from natural gas continues to be less than one-half of coal's contribution for 2035 projections [6]. Nuclear power is expected to have a moderate growth. Still issues such as plant safety, rising construction cost, investment risks, and radioactive disposal, among other concerns may hinder the development of new nuclear power reactor plants in many countries.

According to 2035 projections renewable energy will be the fastest-growing source of electricity generation, increasing from 19% in 2008 to 23% in 2035. This suggests that renewable energy is becoming more popular in many countries. A greater interest is expected to continue due to rapid increase in world energy prices, energy independence and security concerns, and environmental issues related to greenhouse gases (GHG) emission [6]. Figure 1 illustrates how countries are recognizing the common need of diversifying energy resources, through clean energy investment funding.

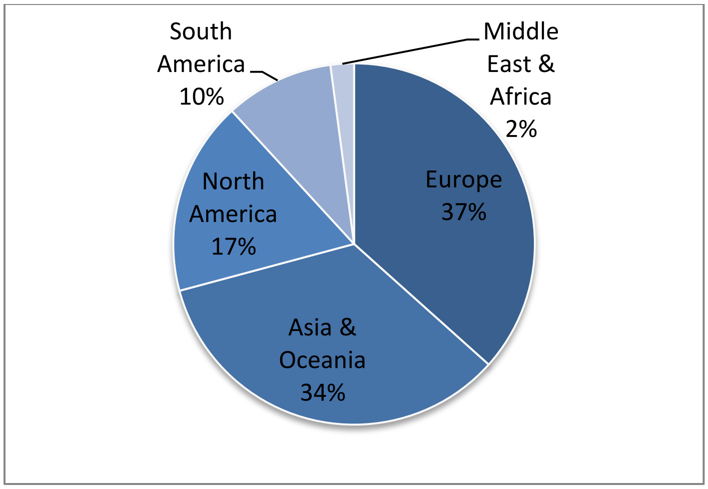


Figure 1 Global Clean Energy Investments by Region, 2009 Source: [7]

In general, the world's energy model faces unprecedented uncertainty. Although the economic situation has improved over the past months, we are far away from a total recovery. As we know, the global economic crisis affected greatly energy markets throughout the world. Furthermore, the pace at which the global economy recovers holds the key to energy prospects for the next several years [8]. Renewables are expected to become highly competitive as fossil fuel prices rise and renewable technologies mature. Outlooks have projected that the scale at which energy policies are enforced and government support is provided will considerably enhance their contribution to the global energy mix increase [8].

From a national perspective, U.S. energy markets have continued to show an aftermath from the economic recession that began in late 2007 [9]. Total U.S. primary energy consumption is expected to increase although its growth rate will be significantly lower than the Nation economic output rate (GDP). Hence, a reduction on energy intensity is expected to occur on all sectors.

As of 2009, electricity generation accounted nearly 41 percent of U.S. total energy demand [10]. Whereas 83 percent of the total energy demand in the U.S. was produced through the combustion of fossil fuels. According to [11], the actual electricity generation mix consist on a 67 percent fossil fuel share (44.6% Coal, 23.3% Natural Gas, and 0.9% Petroleum), 20.2 percent Nuclear, 6.9 percent Hydro, 3.6% Renewables, and the remaining 0.5 percent other gases. Please refer to Figure 2.

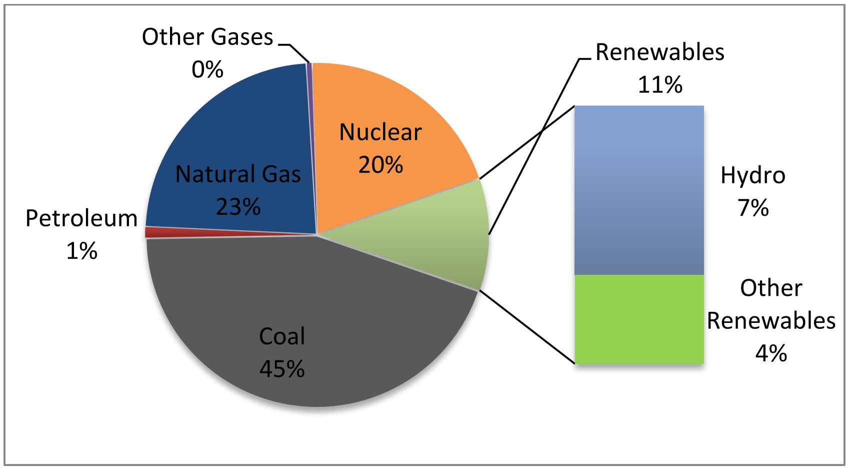


Figure 2. U.S. Net Electricity Generation by Sources, 2009

Lately, energy-related activities have shown a significant impact towards the environment. In 2008, energy related activities accounted for 86 percent of total U.S. GHG emissions, 37 percent of U.S. CH_4 emissions and 13 percent of U.S. N_2O emissions. Furthermore, fossil fuel based electricity generation was responsible for a substantial share of U.S. total energy-related CO2 Emissions [12].

Figure 3 illustrates how over the past decades oil-based fuels prices have significantly increased. In the U.S., as in many other countries, measures have been taken to reduce the reliance on imported petroleum.

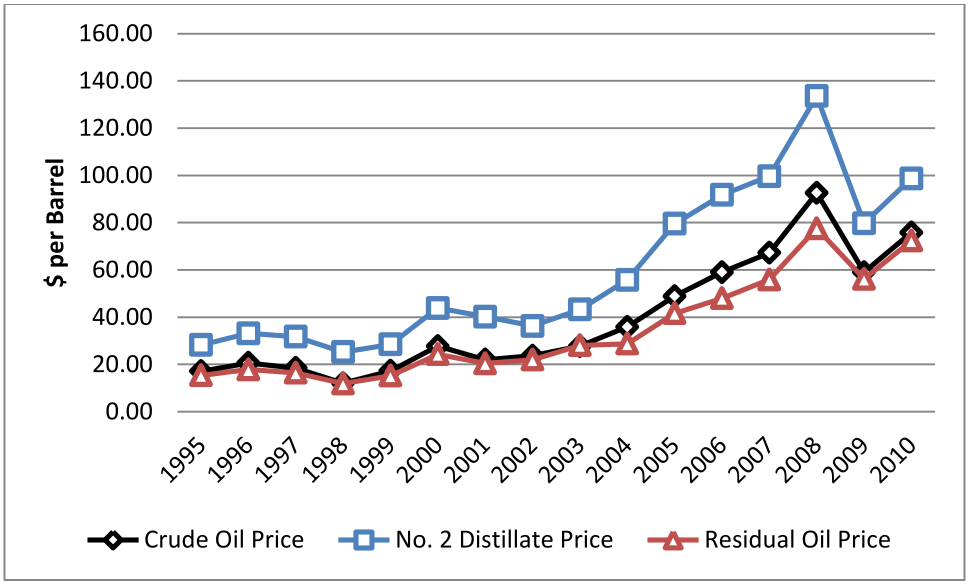


Figure 3 Oil Price Trends 1995-2010, Source: [9]

In addition, outlooks have shown a continuous increase on oil-based fuel prices. According to the Energy Information Administration oil prices are expected to increase up to $200 per barrel (see Figure 4).

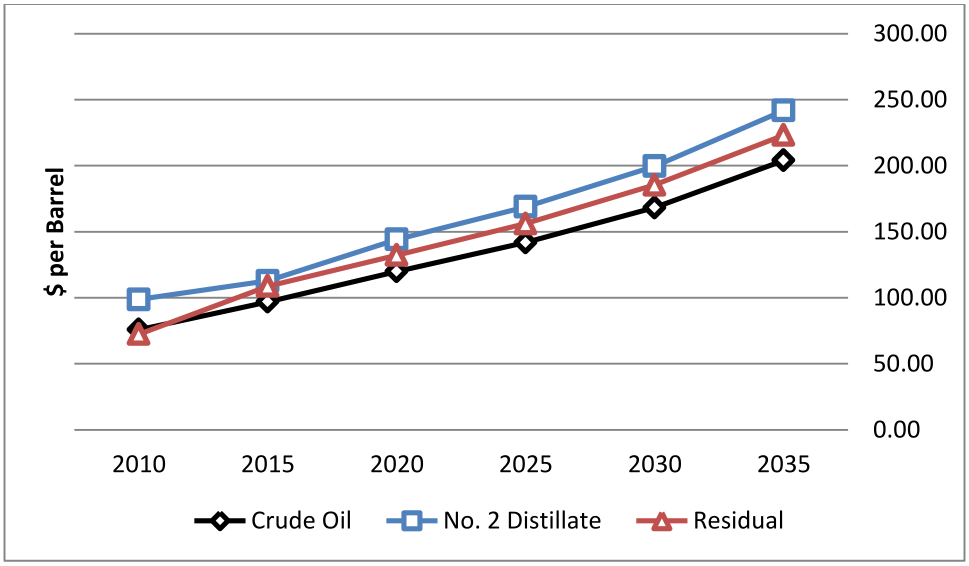


Figure 4 Imported Crude Oil and Petroleum Product Price Projections to 2035, Source: [9]

It is evident that countries with high reliance on oil fuel for electricity generation will be directly impacted if no action is taken. Although rising oil prices have served as drivers to significantly reduce reliance on oil-based fuels for electricity generation and other end-use sectors, it is not enough; more measures must be taken to address global issues regarding energy, economics, environment, and the society.

In conclusion, energy has become one of the most important sectors around the world, and is crucial for economic development and competitiveness. Renewable energy and energy efficiency measures are key alternatives to achieve a more secure, reliable and sustainable energy model. The scale at which energy policies are enforced and government support is provided will considerably enhance the contribution of these alternatives to the global energy mix increases [8]. Furthermore, the greatest opportunity for increasing the use of renewable energy sources lies within the electric power sector. Renewables are expected to become highly competitive as fossil fuel prices rise and renewable technologies mature. Renewable energy sources potential is unquestionably large, but how quickly their share is going to meet world's energy needs will significantly depend on the strength and support of energy policies and government support [13].

It is clear that without an effective change in policy, not only our environment will be significantly impacted but the growth of the economy will stall.

3. ENERGY POLICY

3.1. OVERVIEW AND HISTORY

Energy policy can be defined as long-term comprehensive strategies to address all energy-related direct and in-direct issues. Through history energy policy has been designed, implemented, and enforced with the premise that a link exists between levels of energy production and the gross national product (GNP). In other words, as more energy is produced, prices shall remain low, or at least stable, and the nation's economy shall grow [4]. These fundamental beliefs represented favoritism toward economies of scale; with great emphasis on large-scale energy producers, centralized energy generation, fossil fuels, among others. It was based on the assumption that as long as energy production, demand, and prices were stables, there was no need to look upon alternative measures. That is, if we are comfortable now why change, or as T. Bert Lance said under President Carter's Administration in 1977, "if it ain't broke don't fix it". Furthermore, this energy policy was also rooted in the assumption of cheap and accessible energy sources.

Since the beginning of 1960's environmental issues were brought to public attention, resulting on a marked movement towards environmental policies. Therefore, a new energy policy model was sought, based on environmental and social issues. The integration of environmental issues into the dominant energy policy model became to be known as alternative energy policies [4]. Alternative energy policies had three peak periods of prominence. The first was on late 1960's and early 1970's where policies were aggressively design to address clean air, water, coal, and promotion of renewable resources. The second was the result of the energy "crisis" on mid-1970, where policies were centered on energy conservation and promotion of renewable as alternate solution to the limited supply of fossil fuel. The third period was on late 1980’s when Global Warming and Climate Change became a public discussion and reinvigorated policies on energy conservation and renewable energy sources [4].

3.2. ENERGY POLICY | TODAY, TOMORROW, AND FUTURE

The development and enforcement of energy policies towards renewable energy integration, as well as for energy efficiency and conservation exemplify strategic tools to enable a change in our conventional energy supply and use model. Around the world policy makers have targeted the renewable energy industry in a very aggressive way by developing policies directed to establish renewable energy goals and incentives programs as part of their economic development plan.

Energy policy today stands in a very challenging juncture; sustainable measures need to be designed and implemented to solve multiple correlated problems at a time of considerable economic uncertainty [14]. As stated in [15], energy policies should not only be based on sustainable goals or targets but rather to define the best path to reach them. A well-designed energy policy shall analyze thoroughly the current situation in order to define a reference point. It should be developed embedding its effect on a larger social, economic, and environmental perspective [16], thus energy policy must deal with multiple, and sometimes contradicting objectives.

The proper engagement of all three sectors (i.e. society, economy, and environment) is referred by some authors as a sustainable approach [17] [18]. Yet, other authors state that sustainability deals mainly with the environment, arguing that without the environment neither society nor the economy would exist (this can be viewed as three concentric circles). The concept itself implies a multidisciplinary point of view. One of the most accepted definition for a sustainable development was given in [19] by the World Commission on Environment and Development, and it states the following: "*A sustainable development is considered a development that meets the needs of current generations without compromising the ability of future generations to meet their need and aspirations*".

In this project sustainability means that full accountability must be taken to address all social, economic, and environmental issues through an integrated approach. Figure 5 represents a sustainable approach as one that incorporates social, economics, and environment aspects equally. Ethical principles are often used among many definitions of sustainability as a guide to sustainable practices, technologies, and policies [20].

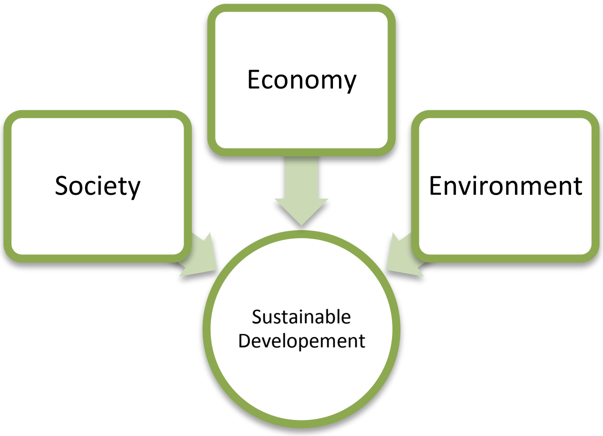


Figure 5 Sustainability Representation Adapted from [21].

A sustainable energy policy is one that integrates three main concepts: reliability, cost-effectiveness, and environmental protection within a social justice framework, in both the supply and end-use sectors. This is known as balancing the energy triangle, and considered by policy-makers to be decisive in order to shift towards a sustainable energy system [16]. There are several strategies to attain a proper balance when designing policies; still three main steps must be properly addressed. The first is to diversify and optimize the energy supply mix to reduce reliance in fossil fuels for electricity generation and the integration of renewable energy sources. The second, to enforce a greater efficiency in both the supply and end-use sectors; this can significantly reduce fossil fuel consumption and increase the contribution from clean energy sources. Third, but equally important, to ensure all actions and improvements are consistent with sustainable practices; economically viable, environmental friendly, and socially acceptable. Figure 6 shows the basics of the "Energy Triangle" concept where it can be correlated to the sustainable development.

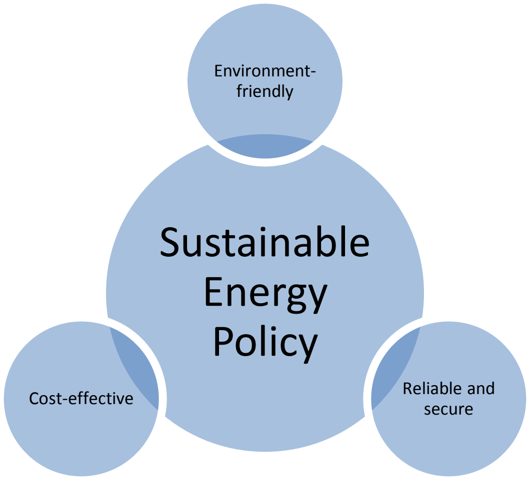


Figure 6 "Energy Triangle" – Sustainable Energy Policy Concept

There are many energy policies today addressing energy conservation and renewable sources. Different mechanisms and strategies have been built and modified to address specific needs. One of the most often used policies to support the integration of renewable energy sources in electricity generation is the Renewable Portfolio Standard (RPS). It typically requires all electricity generators, sellers, or both, to achieve certain percentage of the electricity production by means of renewable energy sources [22]. Also, an often-used strategy to achieve energy efficiency and demand reductions is the establishment of an energy efficiency resource and performance standard. This latter, can be effectively integrated with renewable energy targets to achieve common goals.

3.3. RENEWABLE PORTFOLIO STANDARDS (RPS)

The Renewable Portfolio Standard (RPS) is a legal energy policy that requires electricity providers to procure a minimum of eligible renewable energy by a specific date or according to a schedule [2]. It creates a regulatory mechanism to increment renewable energy production through the use of wind, solar, biomass and geothermal among others. RPSs are designed in a way so that electricity providers could comply with the established targets through an alternative mechanism, to avoid the need of purchasing renewable energy electric power up to a minimum standard. This alternative mechanism is known as Renewable Energy Certificates or Credits (RECs).

RECs are a relatively new market instrument created by separating the “attributes” of renewable electricity generation from the end product (electricity), enabling RECs as tradable commodities [23]. RECs are defined as an economic asset that can be bought, sold or transferred; one REC represents environmental and social attributes equivalent to one (1) megawatt-hour (MWh) of electricity generated from a renewable energy. RECs values will depend on a number of factors, including whether they are bought for RPS compliance or at voluntary markets. For compliance markets REC prices will fluctuate according to supply and demand dynamics. RECs offer electricity providers a mechanism to achieve RPS compliance, while providing an additional revenue source to renewable energy projects. Hence, RECs enable renewable energy projects to compete with conventional generation sources, and attracts new renewable producers into the electricity generation business.

In the recent days, RPS policies have become major drivers to increase the use of renewable energy sources. Currently, twenty-nine (29) states and the District of Columbia (DC) have established an RPS; 7 states have adopted state-mandated targets; and three (3) electric power authorities have set goals for renewables energy in the U.S. (refer to Figure 7). Furthermore, several countries have established their own specific policies and programs with similar objectives [14].

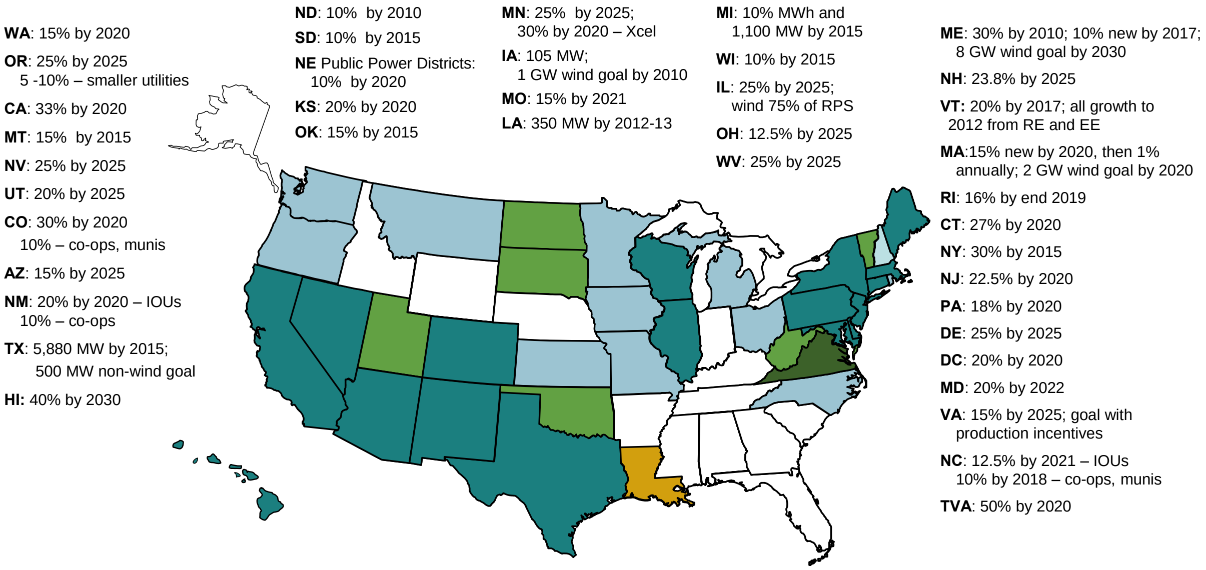


Figure 7 Renewable Portfolio Standards (RPS) and Goals in the U.S., 2010 Source: FERC 2011 [24]

The main policy drivers behind an RPS include achieving economic development, reducing energy-related environmental impact, and providing greater energy security by reducing fossil fuel dependency.

In order to effectively design and adopt an RPS policy the following must be employed to ensure enforcement, compliance, and cost-effectiveness of its implementation [25].

- Resource Assessment: Identify available renewable energy sources and quantifies their potential. A precise measure of their potential development can help policy makers to design optimum implementation strategies.
- Transmission Access: Determine if transmission infrastructure expansions are needed to achieve renewable resource integration. Lack of transmission capabilities can significantly hinder RPS goals.
- . It must provide recommendations as to how an RPS shall be implemented and Economic Impact Assessment: Evaluate RPS compliance economic impacts. Ensure a proper balance among ratepayers and renewable energy investors enforced in order to maximize investment attraction while minimizing significant increase in electricity price. In addition, it should underline and determine the financial support needed to secure project financing, such as capacity based incentives (CBI), production-based incentives (PBI) (e.g. RECs), long-term contracts, and power purchase agreements, among others.

Therefore, the effective adoption of an RPS hinges on quantifying its related cost and benefits [26]. As mentioned above, policy makers must ensure a proper balance between local economic growth and potential ratepayer impacts.

3.4. ENERGY EFFICIENCY POLICIES

Energy efficiency can be defined as the ability to provide same levels of energy needs, at lower energy consumption and cost [27]. Energy efficiency is considered a proven mean to reduce dependence on conventional energy sources, such as fossil fuels, and used them in a more efficient manner, hence reducing waste energy. It is commonly refer as “low hanging fruit” strategies.

Since most of our energy comes from fossil fuels, any reduction on energy consumption, and/or energy efficiency increase, will result in a proportional reduction on fossil fuel use. For example, if a building or industry consumes a specific amount of kilowatt-hours per year, and through internal policies they target to reduce energy consumption down to a specific point, then the reduction will be directly contributing towards a lower energy demand for electric power plants to supply, transmit, and distribute. Many other examples can be given; still it is more than clear that energy efficiency strategies and mechanisms play an essential role within a nation, country, or state energy policy.

One of the most often used strategies to enforce energy efficiency is an Energy Efficiency Resource Standard (EERS), also known as Energy Efficiency Portfolio Standard (EEPS). An EERS is a policy mechanism that encourages energy efficiency in both the electricity generation and end-use sectors [28]. It requires by mandate that energy providers meet an established amount of energy savings through efficiency and conservation measures. Energy efficiency, by reducing energy demand or load, can ultimately reduce the amount of renewable energy that must be procured through an RPS compliance target. Thereby its integration to RPS policies provide a potential cost-effective mechanism to reduce supply-side RPS compliance cost [29]. The mechanisms employed to facilitate monitoring and compliance within EERS policies is known as energy Efficiency Certificates (EECs) or White Tags. Similar to RECs within the RPS, EECs are considered tradable commodities representing one (1) megawatt-hour (MWh) of energy savings. EECs are capable of reducing the cost of compliance under an EERS policy. Electricity providers will then have the flexibility of either procuring EECs from industries, buildings, third parties, or others, for less than their own cost for investment on energy efficiency; or investing on their own if considered more cost-effective. Both ways will enable them to meet mandatory targets set forth by EERS policies.

As of September 2010, twenty-four (24) states have an EERS in place, two (2) have integrated EERS and RPS, four (4) has a voluntary energy efficiency goal, and at least four (4) are considering to adopt such policy [24]. EERS are relatively new policies; Texas was the pioneer state to adopt an EERS on 1999, followed by Vermont on 2000.

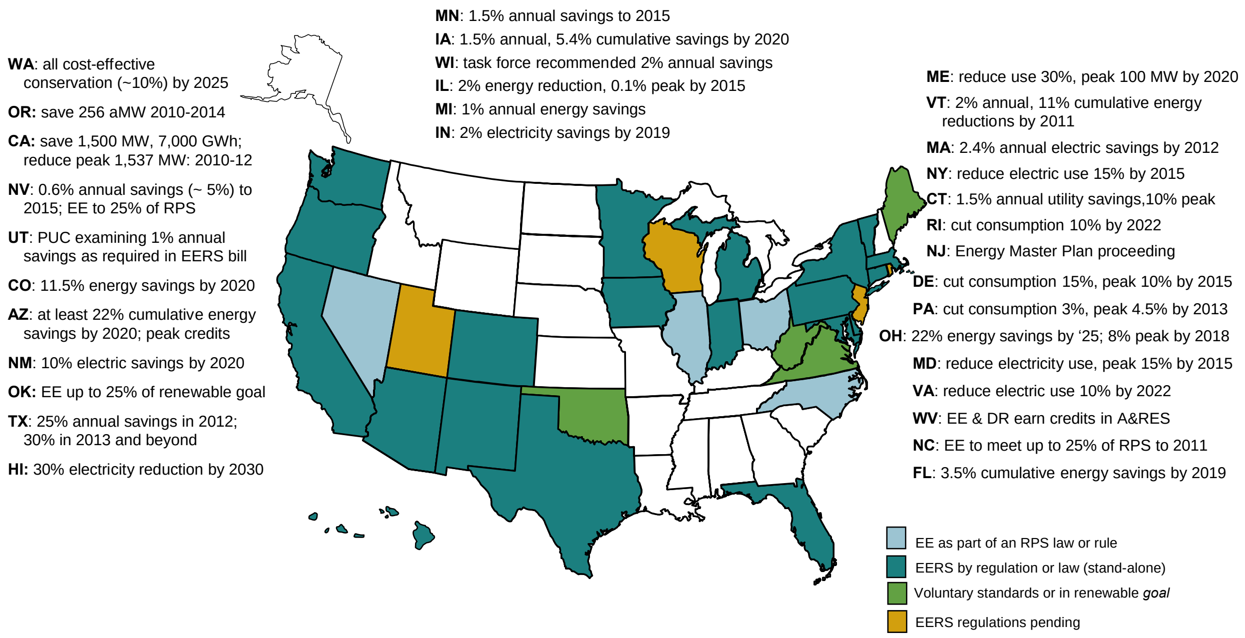


Figure 8 Energy Efficiency Resource Standard (EERS) and Goals in the U.S., 2010 Source: FERC 2011 [24]

Although many states have already adopted EERS policies, it is important to understand that in order to design the most effective EERS policy one must ensure the following considerations are taken. EERS goals should be well defined and benchmarked against a specific reference point. This will enable policy-makers to measure the ongoing progress or final success of programs within. These goals must be established according to studies that quantify achievable energy efficiency potential. The latter shall be measured not only by the technical potential for implementation but also the economic potential which takes into account cost-effectiveness and financial limitations [30]. Incentive programs and financial aids are very important for an EERS success. One must also consider how EERS policies could interact or integrate with RPS policies. For example, Hawaii has permitted under their RPS policy that up to 50% of their RPS targets may come from energy efficiency measures until 2015. This may be considered as a ramp-up period to ensure proper compliance of both legislations, still promoting both pillars (energy efficiency and renewable energy) as one single policy. Also, energy efficiency can be seen as a cost-containment measure for electricity providers to comply with aggressive targets.

Ultimately, as stated in [28], a successful EERS policy is one that pushes electricity providers to implement efficiency measure that surpass business-as-usual improvements; provides an effective monitoring and verifications process, and provides the necessary financial assistance or incentives to meet the established targets. As a final note, human consumption patterns are a key factor on either strategy [31]. If reducing energy consumption through technology fosters an indiscriminate use of energy sources, then the main objective of reducing environmental and social impact is defeated. There are many social factors involved in how people or companies use energy; however those are beyond the scope of this project. Therefore, consumer behavior should be addressed as much as technologies. Moreover, at some point in the establishment of an energy policy, consumption patterns and their causes must be studied and considered [32].

4. **PUERTO RICO | ELECTRIC POWER SECTOR**

4.1. OVERVIEW

Puerto Rico's electric power sector accounts for a significant share of the total energy demand. Nearly nighty-nine percent (99%) of its electric power is generated using fossil fuels as primary sources, with nearly a seventy percent (70%) share from oil-based fuels. Furthermore, the cost of oil has been increasing lately, and estimates are that it will continue to increase. Likewise, energy prices have been directly impacted due to the high dependency on oil as primary energy source for electricity generation. Fossil fuel reliance, specifically in our case oil-based fuels, has contributed significantly to the volatility of energy prices in our jurisdiction. Moreover, it has negatively impacted the environment and the society for years.

Until recently, Puerto Rico's energy policy has remained somehow inactive and ineffective. Furthermore, throughout the years objectives and goals within the energy sector have proved to be fruitless and misleading. As a result, Puerto Rico is currently facing many issues within the energy sector, including but not limited to high and unstable energy prices, environmental impacts related to GHG emissions, and energy security issues due to our substantial reliance on imported fossil fuels, with oil-based products representing the greatest share of them all. Under this scenario, we have no control over the price of imported fossil fuels, resulting in highly unstable and volatile electricity prices. Thus, our economy is then subject to the constant fluctuations of world market fuel prices and to the flight of local capital due to imported fuel procurements.

In the next sections a review is provided including history, characteristics, and deficiencies of the electric power sector in Puerto Rico. Based on the facts presented within this section we have highlighted the key drivers for the development of the project, herein.

4.2. History

The history of Puerto Rico Electric power system goes way back to the late 1800's. To be precise, in 1893 the first lighting system was installed in the municipality of Villalba, Puerto Rico. Prior to the first Hydroelectric Plant in 1915, business as usual was based on relatively small providers were producing and distributing energy in Puerto Rico. As a result of regulatory changes within the U.S. electric power sector, governments adopted the idea that greater efficiency and service could be attained by allowing a single company to provide the specific service, in this case electricity. At that time, it became evident that electricity generation, transmission, and distribution had the characteristics of a natural monopoly. Hence vertically-integrated utilities became the industry standard for most of the twentieth (20th) Century.

Puerto Rico was no exception, on May 2, 1941, Act. No. 83 created the Puerto Rico Electric Power Authority (PREPA) as a public corporation and governmental instrumentality; granting PREPA with full market power over electricity generation, transmission and distribution in the Commonwealth of Puerto Rico. In 1978, the passage of the Federal Power Utilities Regulatory Policy Act (PURPA) had little impact in Puerto Rico electric power system model; the Act only permitted independent power producers to sell energy to respective area's monopoly utilities, in our case being PREPA. As of mid-1990's Oil-fired electric power plants accounted for 98 % of the total electricity generation. As a result of many issues related to significant oil dependency, price volatility, environmental consequences the Energy Policy Act

(EPAct) was enacted in 1992. EPAct 1992 provided with provisions enabling open access interstate electricity commerce, and general suggestions regarding distributed generation. In the early 2000's two private independent power cogeneration plants were built; AES, a coal-fired plant in the municipality of Guayama, Puerto Rico, and EcoEléctrica, a natural gas fired plant in the municipality of Peñuelas, Puerto Rico. Then, with the passage of EPAct 2005 the concept of distributed generation was furthered stimulated by requiring electric companies (including unregulated companies like PREPA) to consider and justify stances on DG and gain lots of interest within the society; interconnection regulations, incentives programs, net metering agreements, among other policies were enacted as a response to that Act.

4.3. Puerto Rico Electric Power Authority (PREPA)

The Puerto Rico Electric Power Authority (PREPA) provides electricity service to all customers in Puerto Rico, including the municipality of Vieques and Culebra. According to 2009 data from [33], PREPA is responsible for most of the generation plant, and all transmission and distribution infrastructure in Puerto Rico. Hence when we refer to the Puerto Rico electric power sector, we are basically referring to PREPA's system.

4.4. Current Electric Power Supply Mix

Puerto Rico, like most islands, relies on importing fossil fuels as primary energy sources to supply and meet its energy demand. In fact, petroleum products comprise the largest share as a primary energy source within our island. PREPA's own generations accounted nearly sixty nine percent (~69%) of the total net electricity generation in Puerto Rico; the remaining thirty one percent (31%) was purchased from cogeneration plants: EcoEléctrica, L.P. and AES-PR.

EcoEléctrica and AES net electricity generation shares for 2009 are shown in Figure 9 [34]. Although EcoEléctrica and AES cogeneration plants are considered as Independent Power Producers (IPPs), PREPA has dispatch control over both facilities, and energy produced by them is sold directly to PREPA by means of Power Purchase Agreements (PPAs).

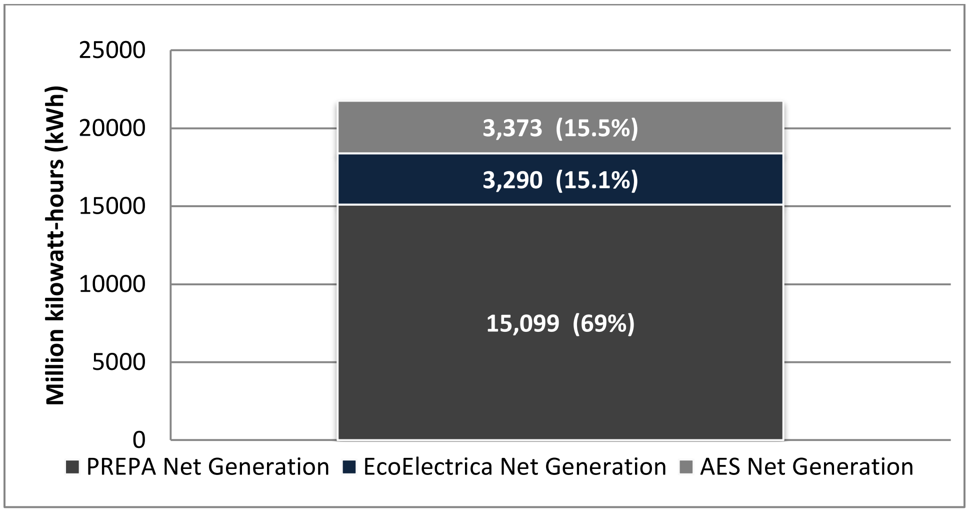


Figure 9 2009 Net Electricity Generation by Producer, using data from [33]

Based on the total net electricity generation reported in [33], PREPA's current fuel diversification with respect to electricity production is shown in Figure 10.

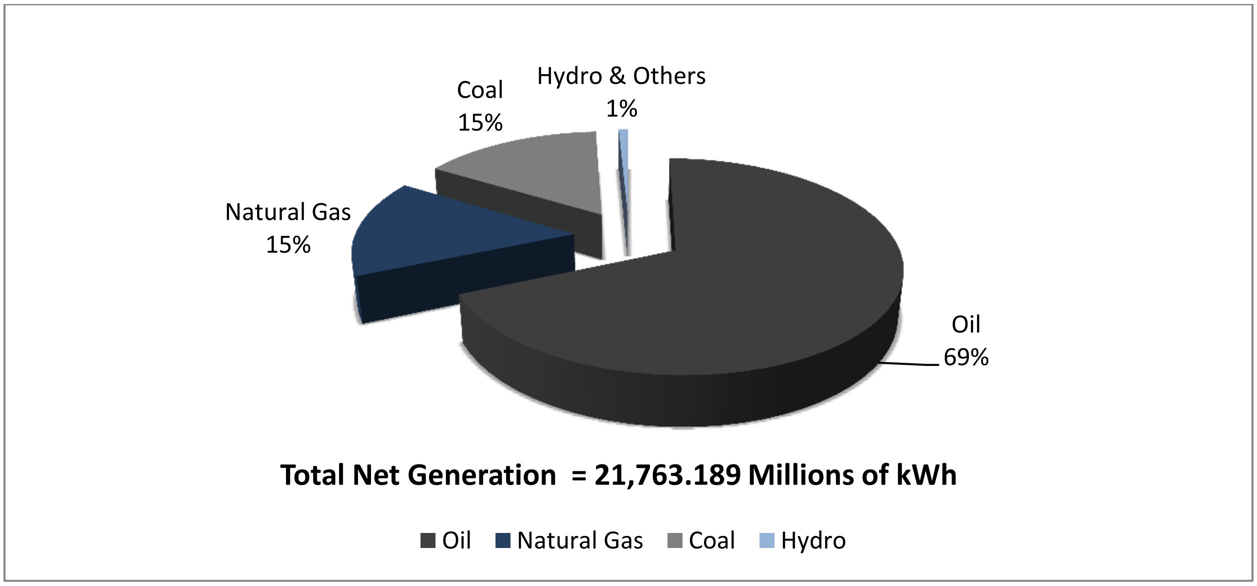


Figure 10 2009 Net Electricity Generation by Fuel, Source: [33]

In terms of the total electric power system capacity, PREPA's generating capacity was estimated to be 4,903 MW consisting of 2,892 MW of steam-electric production units; 1,056 MW of combined-cycle units; 846 MW of combustion-turbine power units; 100 MW hydro; and 9 MW of diesel generators. As of January 2011, according to PREPA's fuel diversification timeline, 820 MW of capacity were retrofitted to burn natural gas (Costa Sur Units 5 and 6) and allegedly scheduled online. Through power purchase agreements, PREPA supplements its own capacity with 454 MW (coal-fired) from AES, and 507 MW (gas-fired) [33]. In addition, according to the Puerto Rico Energy Affairs Administration (PREAA), solar PV distributed generation approximately account for nearly 4 MW of capacity in 2009. Figure 11 summarizes the aforementioned facts, in terms of capacity-based fuel diversification.

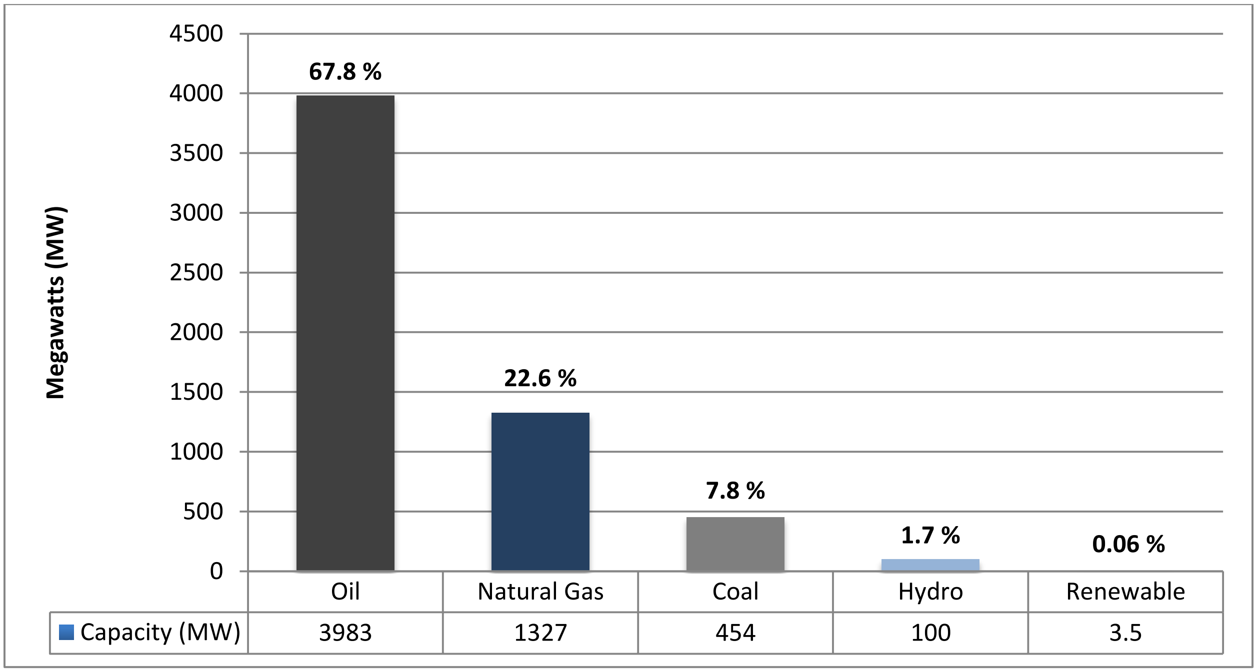


Figure 11 2009 Net Capacity-Based Fuel Diversification, Source: [33]

4.5. ELECTRICITY AND FUEL COST

Electricity price is directly related to fuel cost, this is based on the simple fact that most base-load electric power plants burn fuel to generate electricity. It is even more severe in our case since 99% of our electricity is generated through burning fossil fuels, including oil (mainly residual and distillate fuel oil), natural gas, and coal.

Due to our heavy reliance on oil liquids, our overall in electricity cost ($/kWh) is highly sensitive to any variation in the price of fuel oil ($/barrel). History has taught us how volatile and unstable oil prices can be; we may recall oil prices on July-August 2008 when they ascended to an all-time high price of approximately $147 per barrel. In recent years we have experienced an increase in the electricity price almost proportional to price changes in the oil industry (See Figure 12).

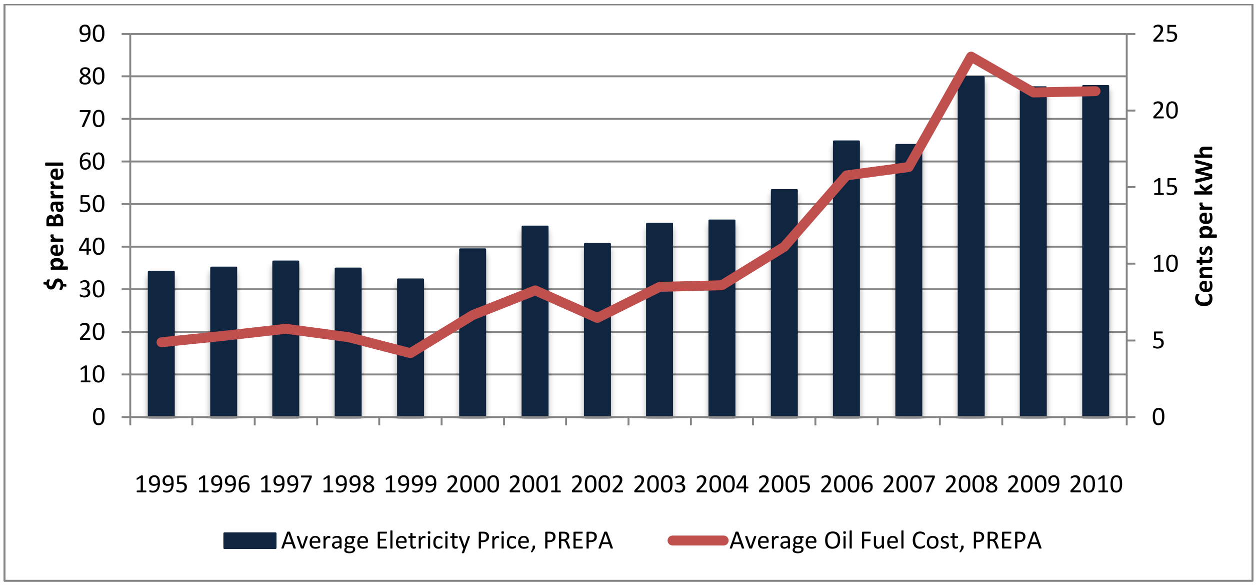


Figure 12 Average Electricity Price in PR (¢/kWh) vs. Average Oil Fuel Cost ($/BBL), Source: PREPA

An interesting remark is to observe how average electricity prices correlates almost proportionally to fluctuations in oil fuel prices from 1995-2010. As of 2010, average electricity price in P.R. is approximately 21.6 cents per kilowatt-hour; more than twice the average electricity price in the U.S. according to the Annual Energy Outlook 2010. As shown in Figure 12, electricity price averaged nearly 23 cents per kilowatt-hour (kWh) in 2008, corresponding to the significant increase on oil prices during that year. Specifically, from 2007 to 2008 Puerto Rico experienced a 125% increase in electricity cost, and a 144% increase in oil fuel price.

4.6. ELECTRIC SERVICE RATE STRUCTURE

According to Article 196 of Act No. 83 of 1941, PREPA has the power to determine, alter, establish, and collect reasonable rates for electric service in Puerto Rico. It is also stated within the Act, that PREPA shall only charge reasonable rates for the electric service, and that it must provide Puerto Rico citizens with affordable, efficient, reliable and cost-effective electric service.

Furthermore Section 502 of the 1974 Trust Agreement states that PREPA is responsible with respect to rates as to:

"at all times fix, charge, and collect reasonable rates and charge for the use of the services and facilities furnished by the System and that from time to time, and as often as it shall appear necessary, it will adjust rates and charges so that the revenues will at all times be sufficient

(a) To pay the current expenses of the System, and

(b) To provide an amount at least equal to one-hundred twenty per centum (120%) of the aggregate Principal and Interest Requirements for the next fiscal year on account of all the bonds then outstanding under this Agreement, reduced by any amount deposited to

the credit of the Bonds Service Accounts from the proceeds of bonds to pay interest to accrue thereon in such fiscal year. "

Therefore and according to the 1974 Trust Agreement PREPA various rate schedules must provide the money necessary for it to meet its financial obligations, including but not limited to paying current operational expenses, financing future growth through Power Revenues Bonds; making deposits to specified funds, maintaining the minimum specified debt service ratio,; and paying Contributions in Lieu of Taxes.

This electric service regulatory regime is known as a Cost-of-Service (COS), where the utility is permitted to recover all of its cost, plus a rate of return on their investment. Additionally, as explained earlier PREPA as a self-regulated monopoly is not held accountable to an independent regulator. Under this type of structure utilities are not usually incentivized to improve their performance, efficiency, and/or minimize their cost.

The latest electric service tariff revision was held on 2000. Specifically on March 28th of that year, Resolution No. 2812, Exhibits 1599 and 1600 of PREPA Governing Board was approved. On June 2000 an updated version of the electric service tariff regulation was officially adopted, with the main purpose of including a power purchase adjustment clause and other minor changes. Before that, the last actual increase in the basic rate charges occurred in 1989.

The electric service cost consists of a base rate and an adjustment charge. Thus, the methodology to calculate the overall electric service cost consists in the addition of three main components: (1) basic charges; (2) purchased fuel charges; and (3) purchased power charges.

4.6.1. Basic Charges

Basic charges consist of three sub-components: fixed customer charges, energy charges, and demand charges. Demand charges are only applicable to primary distribution and transmission clients. Clients served at secondary voltage include only of a fixed customer charge and energy-related charges.

Fixed charges are used to cover those costs that are independent of the consumption and energy demand from customers, such as meter reading, billing, administrative, customer service and overhead associated with metering and accounting services. Energy and demand charges are designed to cover the costs related to the generation, transmission, and distribution of electricity in order to serve customers up to the delivery point.

Furthermore basic charges are strictly dependent on the type of client and its respective electricity rate schedules. PREPA’s electric services are classified into six main classes; Commercial, Residential, Industrial, Public Lighting, Public Authorities, and Agricultural. Commercial, Residential, and Industrial accounted for 98% of the total electricity revenues in 2009. Moreover, four rate schedules apply to most of PREPA’s clients. These are: General Residential Service (GRS), General Service at Secondary voltage (GSS), General Service at Primary voltage (GSP), and General Service at Transmission voltage (GST). These four rate schedules accounted for almost 87% of PREPA’s total electricity sales in 2009. Still, there are multiple rate schedules within the main 6 categories presented earlier; Table 1 includes those within the Commercial, Residential, and Industrial Classes.

PREPA Electricity Rates				
Rate Schedule	Average # Clients	Total Consumption (million of kWh)	Total Revenue ($ X 1000)	Average Cost (₵/kWh)
Residential Class				
RH-3 (103/104)	41004	150.962	27797	18.41
LRS (109/110)	145044	485.418	94478	19.46
GRS (11/112)	1138704	5731.181	1252068	21.85
Total Residential Class	**1324752**	**6367.561**	**1374343**	**21.58**
Commercial Class				
Telephone Booth	59	0.011	3	27.27
Cable TV	3	12.747	3054	23.96
Security Cameras (082)	133	0.256	66	25.78
GSS (211)	118857	2330.512	574299	24.64
GSP (212)	10118	4527.901	1012550	22.36
GST (213)	321	1616.749	304675	18.84
SBS-P (282)	0	8.943	2048	22.90
SBS-T (283)	0	-7.426	-1432	19.28
862	1	8.426	1758	20.86
Total Commercial Class	**129492**	**8498.119**	**1897021**	**22.32**
Industrial Class				
GSS (311)	215	16.108	4432	27.51
GSP (312)	379	207.54	47804	23.03
GST (313)	257	1641.045	308521	18.80
LIS (333)	2	181.043	23106	12.76
PPBB (343)	2	1.425	2128	149.33
TOU-T (363)	10	356.902	64550	18.09
SBS-TOU-T (393)	1	37.332	8062	21.60
SR-GST (603)	13	257.949	43301	16.79
SR-GST (613)	12	323.261	54360	16.82
SR-TOU-T (633)	1	10.304	1667	16.18
SR-TOU-T (643)	3	95.047	15502	16.31
SR-TOU-T (653)	1	102.787	17419	16.95
SR-LIS (673)	0	22.013	4492	20.41
TOU-T (963)	3	35.847	6640	18.52
Total Industrial Class	**899**	**3288.603**	**601984**	**18.31**

Table 1 PREPA's Residential, Commercial, and Industrial Electric Rate Schedule Data for 2009, Source: [33]

In general, through their tariff regulation document, PREPA provides a general methodology as to each specific schedule and respective class. For example, if we examine the General Residential Service (GRS), the following rates are described:

(1) Energy-Related Charges
   a. 4.25 cents per kWh, for the first 425 kWh consumed.
   b. 4.97 cents per kWh, for additional consumption.

(2) Fixed Charge
   a. $3.00 per Client

(3) Adjustment Charges
   a. Fuel Purchase Charge
   b. Power Purchase Charge

(4) Minimum Bill
   a. $3.00 per month.

On the other hand, if we examine the General Service at Transmission voltage (GST), the following rates are described:

I. Demand Charges

The greater of:

a. $7.70 per KVA for 60% of the contracted demand
b. $7.70 per KVA for 60% of the peak demand thru the previous 11-month period.
c. $7.70 per KVA of the peak demand sustained for a 15 minutes period on a month.

Any excess from the contracted demand will be billed at $9.60 per KVA.

II. Energy Charges

   a. 2.8 cents per kWh, for the first 300 kWh consumed for each kW of peak demand.
   b. 2.4 cents per kWh, for additional consumption.

III. Fixed Charge

   a. $450 per Client

IV. Adjustment Charges

   a. Fuel Purchase Charge
   b. Power Purchase Charge

V. Minimum Bill

   a. $2,375 plus the Adjustment Charges for each month.

To conclude, when reviewing historical data with regards to the basic rates, trends have shown to be very consistent, with either a negative or insignificant growth rate (Refer to Figure 13). Even more, Base Rates have not changes since 1989, hence resulting variation and increase on the overall electricity cost are due to adjustment charges, with primary emphasis on fuel purchase charges [35]. Finally, due to the high reliance on oil fuel, and its potential impact towards the adjustment charges, basic rates have been kept relatively constants avoiding any additional impact to the overall electricity rates. Therefore, sacrificing reasonable basic rate increases that would have been helpful to invest on the system, provide with a more efficient operation, and thus avoid additional bond issuance for capital improvements.

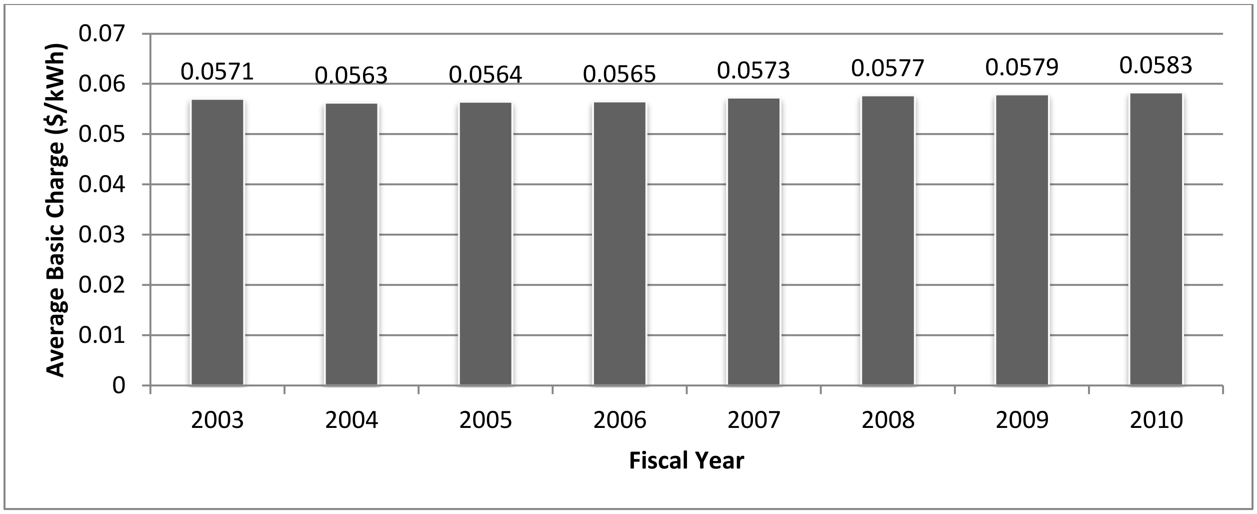


Figure 13 Average Basic Charge from 2003-2010, Source: [33], [36], & [35].

4.6.2. Fuel Adjustment Clause

Prior to 1999, the electric service rate was based only on a base charge and a fuel adjustment charge. As EcoEléctrica and AES entered the Electric Power Sector as Independent Power Producers (IPPs), PREPA was required to revise the rate structure and enable an additional component to recover the cost of purchasing power from those two IPPs. Hence, on March 28, 2000 a permanent revision of the electric rate structure was approved. [33]

The main purpose of the fuel adjustment charge is to recover all costs related to the purchase and transportation of fuel consumed within PREPA's electric power generating plants [37]. The formula adopted, and included within the Electric Service Tariff Regulation of June 5, 2000 is the following:

$$\boldsymbol{FCC\left(\$/_{kWh}\right) = \frac{\$/_{BBL} \times BBLs(estimated) \pm Adjustment_C}{0.89 \times Total\ Net\ Generation\ \times\ E_i}} \tag{4.1}$$

Where,

$^{\$}/_{\boldsymbol{BBL}}$ *is the fuel price per barrel of oil applicable to the month of the invoice. It consists of the average of (1) the estimated fuel cost for the month of the invoice and (2) the actual fuel cost for the second month prior to the month of the invoice.*

$\boldsymbol{BBLs}(\boldsymbol{estimated})$ *is the estimated amount of oil barrels that will be used by PREPA power generation plants during the month of the invoice.*

$\boldsymbol{Adjustment_C}$ *is the difference between (1) the actual cost of the fuel used by PREPA and (2) the money recovered through the fuel adjustment charge, excluding the portion corresponding to recovery of PREPA's payments in lieu of taxes. Both amounts correspond to the second month prior to the month of invoice.*

$\boldsymbol{0.89}$ *is a factor used to recover payments in lieu of taxes made by PREPA to the central government and the municipalities.*

$\boldsymbol{Total\ Net\ Generation}$ *is the estimated net electric energy generated and purchased by PREPA corresponding to the invoiced month.*

$\boldsymbol{E_i}$ *is a factor representing the average efficiency for the 12 month ending two months prior to the invoiced month. This is the efficiency from the generation bus to the client connection point.*

4.6.3. Purchased Power Adjustment Clause

The main purpose of the purchased adjustment charge is to recover all costs related to the purchased power from from IPP’s, currently from EcoEléctrica and AES. The formula adopted, and included within the Electric Service Tariff Regulation of June 5, 2000 is the following:

$$\boldsymbol{FCE}\left({}^{\$}\!/_{\boldsymbol{kWh}}\right)=\frac{\boldsymbol{Purchased\ Power\ Cost}\ (\boldsymbol{estimated},\$)\pm\boldsymbol{Adjustment_C}}{\boldsymbol{0.89}\times\boldsymbol{Total\ Net\ Generation}\ \times\ \boldsymbol{E_i}} \tag{4.2}$$

Where,

$\boldsymbol{Purchased\ Power\ Cost}\ (\boldsymbol{estimated},\$)$ *is the estimated amount that PREPA will pay independent power producers (EcoElectrica and AES-PR) for electric power purchased during that month corresponding to the invoice.*

$\boldsymbol{Adjustment_C}$ *is the difference between (1) the actual cost of the electric power purchased by PREPA and (2) the amount recovered through the purchased power charge, excluding the portion corresponding to recovery of PREPA’s payments in lieu of taxes. Both amounts correspond to the second month prior to the month of invoice.*

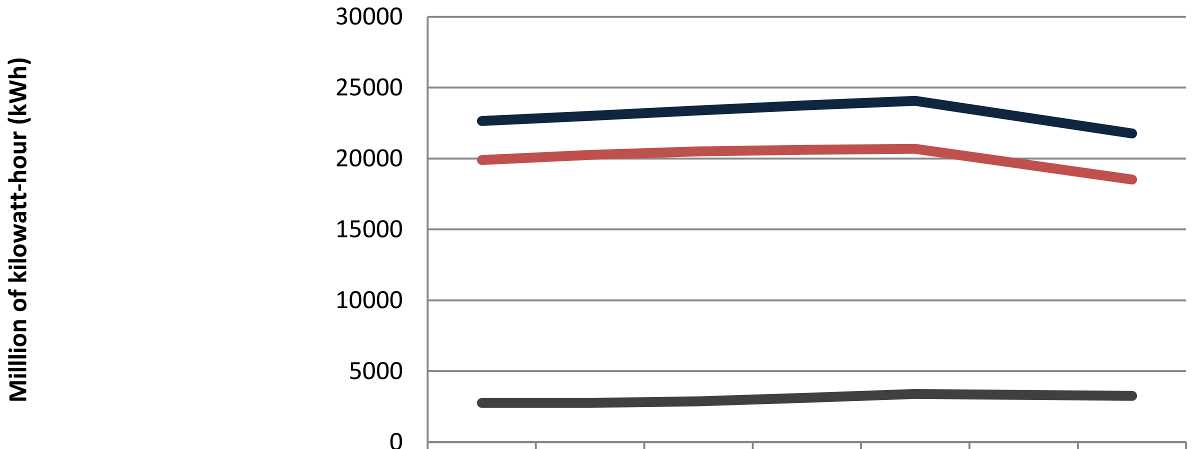
$\boldsymbol{0.89}$ *is a factor used to recover payments in lieu of taxes made by PREPA to the central government and the municipalities.*

$\boldsymbol{Total\ Net\ Generation}$ *is the estimated net electric energy generated and purchased by PREPA corresponding to the invoiced month.*

$\boldsymbol{E_i}$ *is a factor representing the average efficiency for the 12 month ending two months prior to the invoiced month. This is the efficiency from the generation bus to the client connection point.*

4.6.4. Interesting Facts

According to [35] statistics have shown an increase in electric power system losses, including but not limited to conversion efficiency, transmission and distribution heat and transformation losses, unaccounted electricity, and theft. In 2009, losses accounted 15% of the total energy production, and it represents a ratio that is 3.7 times greater than the average loss ratio in the U.S. (Refer to Figure 14).

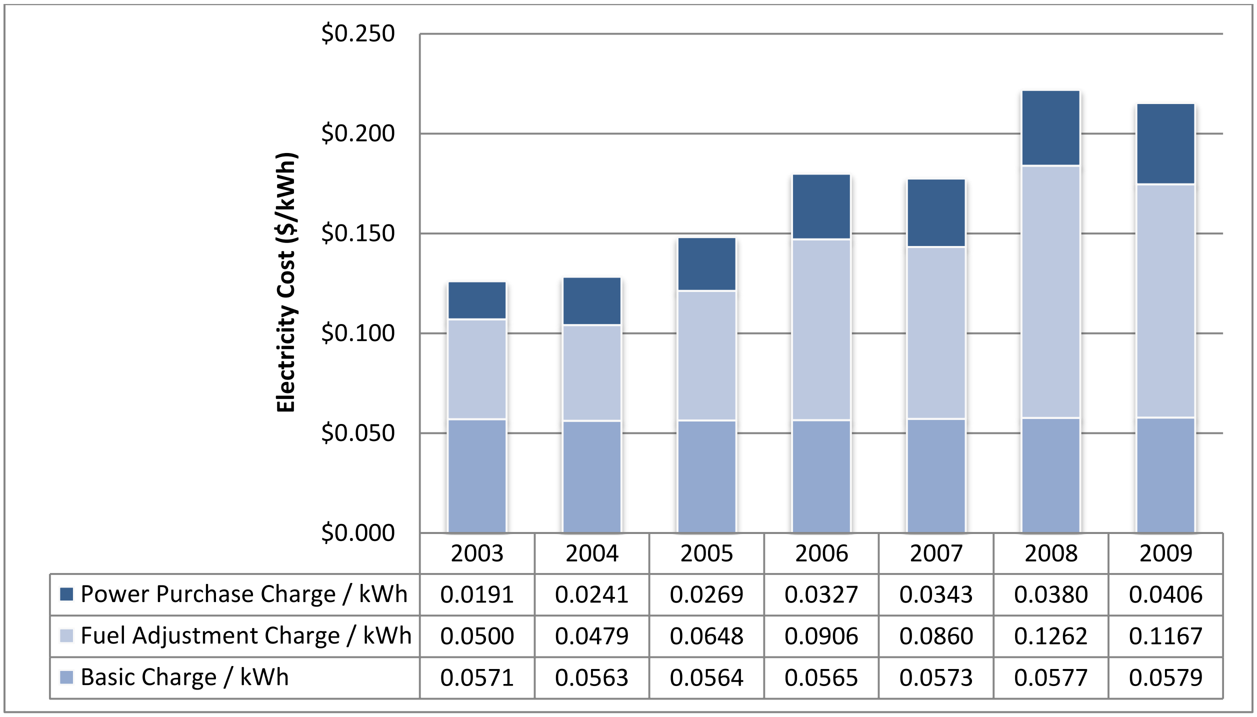


	2003	2004	2005	2006	2007	2008	2009
Net Electricty Generation	22641	23015	23378	23754	24062	22924	21763
Total Electricity Consumption	19887.3	20260	20507.4	20620.3	20671.6	19601.6	18515.8
Electricity losses (Unaccounted, T&D, theft, among others)	2753.7	2755	2870.6	3133.7	3390.4	3322.4	3247.2

Figure 14 Electric Power Losses = Net Generation - Total Consumption, 2002-2009, Source [35]

It should be noted that under the fuel adjustment formula, all losses are recovered. Thus, all cost related are ultimately transferred to customers through the average efficiency factor within the fuel adjustment charge formula.

Furthermore, of all three components under the rate structure, fuel adjustment charges represent the largest contributor to the overall cost. As shown in Figure 15 more than 55 % of the overall cost of electricity in Puerto Rico derives from fuel adjustment charges, reaffirming our excessive dependence on oil for electricity generation and its direct impact towards ultimate electricity cost.



	2003	2004	2005	2006	2007	2008	2009
■ Power Purchase Charge / kWh	0.0191	0.0241	0.0269	0.0327	0.0343	0.0380	0.0406
■ Fuel Adjustment Charge / kWh	0.0500	0.0479	0.0648	0.0906	0.0860	0.1262	0.1167
■ Basic Charge / kWh	0.0571	0.0563	0.0564	0.0565	0.0573	0.0577	0.0579

Figure 15 Average Electricity Cost in PR, by Component, 2003-2009. Data from: [35] & [33]

This increase in the cost of electricity has adversely impact our economic development potential. It is so, that thousands of manufacturing jobs have been lost in Puerto Rico due, at least in part, to high energy cost and price instability. Statistics have shown that the total number of industrial clients declined from 1,668 in 2005 to 898 in 2009 [35].

The aforementioned facts show that there is urgent need to reform the electric power sector. We must harness the potential available in renewable energy sources to meet our energy needs and use more efficiently available resources in order to reduce our fuel dependency, diversify our energy portfolio, enhance economic development, and mitigate energy-related environmental issues.

4.7. PREPA'S FINANCIAL STRUCTURE

In order to understand how the overall electricity cost affects PREPA's financial operations we must review general concepts such as revenues sources, expenses, and contractual obligations. Therefore the following subsections will describe each concept included herein.

4.7.1. Sources of Revenues

Sources of revenues mainly include electricity sales. Other income such as Rural Electrification provides additional sources of revenue but almost negligible when compared to revenues from electricity sale. During recent years we have experience an increase in electricity sales revenues even though electricity consumption has declined. This fact explains the direct effect of increasing fuel cost towards the overall electricity price. As an example, during fiscal year 2009 electricity revenues totaled $3.98 Billion, while in 2010 electricity revenues were approximately $4.15 Billion, resulting in a 4.2% increase.

4.7.2. Current Expenses

As mentioned above, PREPA is required under Act No. 83 of 1941, as amended, and under the 1974 Trust Agreement to recover all current expenses of the system. Current expenses mainly include the following:

(1) Fuel Cost

(2) Purchased Power
(3) Other Expenses
(4) Transmission and Distribution
(5) Maintenance
(6) Customer Accounting & Collection
(7) Administrative & General
(8) Interest Charges

It is a clear fact that among all components, fuel cost represents the greatest share of them all. During fiscal year 2009 it represented 57% of total system expenses. Thus, during fiscal year 2010, it accounted for 59%.

4.7.3. Contractual Obligations

Sinking Fund Appropriations – Consist of the following components:

(1) Interest and Principal Power Revenue Bonds – Current year requirements for principal of and interest on Power Revenue Bonds.
(2) Reserve Account – is a reserve for payments of principal and interest on Power Revenue Bonds in the event moneys in Bond Service Account or Redemption Account are insufficient for such purpose.

Self-Insurance Fund – Fund to pay the cost of repairing, replacing or reconstructing any property damage or destroyed from, or extraordinary expenses incurred as a result of a cause, which is not covered by the insurance required under the 1974 Agreement. It also serves as an additional reserve for the payment of the principal of and interest on the Power Revenue Bonds.

Reserve Maintenance Fund – Fund to pay the cost of unusual or extraordinary maintenance or repairs, nor recurring annually, and renewals and replacements, including major items of equipment. It also serves as an additional reserve for the payment of the principal of and interest on the Power Revenue Bonds.

1974 Capital Improvement Fund – is an special fund created by the 1974 Trust Agreement to proceeds of any Power Revenue Bonds issued for the purpose of paying the cost of acquiring or constructing improvements [38].

4.7.4. Contributions in Lieu of Taxes and Others

Under Act No. 83 of 1941, PREPA is required to pay to the Secretary of Treasury of Puerto Rico certain contributions in lieu of taxes. Originally and prior to an amendment on 2004, PPREPA was required to pay 6% of its gross electricity sale revenues and an addition 5% was set aside under the 1974 Trust Indenture for capital improvement and other purposes. Under the Act amendment on September 2004, PREPA was required to set aside 11% of the gross electricity sale revenue to fund government subsidy programs, pay contributions in lieu of taxes to municipalities, and finance capital improvement programs, among other purpose. Furthermore, contributions in lieu of taxes to municipalities were defined as the greater of the following amounts:

(1) 20% of PREPA’s Net Revenues
(2) Actual electricity consumption by municipalities
(3) Average contributions in lieu of taxes paid to municipalities during the prior five (5) years.

Also, as stated in the Act, and respective amendments, in the case that PREPA does not have sufficient funds to pay contributions in lieu of taxes for municipalities, the difference will be accrued and carried forward for a maximum of three years. In addition contributions in lieu of taxes to Municipalities can be used to offset accounts receivable balance owed by the Municipalities to the Authority. In fiscal year 2009, the total contributions in Lieu of Tax were $187.7 million, taken as the electricity consumption by municipalities. Still, as of the end of fiscal year 2009 the unpaid balance totaled $97.9 million.

5. PUERTO RICO | RENEWABLE ENERGY & ENERGY EFFICIENCY

5.1. INTRODUCTION

It is the Government's obligation to foster Puerto Rico's sustainable energy development. It is set forth in the Constitution of Puerto Rico adopted in 1952. Section 19 of Article VI of the Constitution provides that: *"It shall be the public policy of the Commonwealth of Puerto Rico to conserve its natural resources as efficiently as possible and to develop and utilize them to their full potential for the general benefit of the community..."* Although this constitutional mandate exists, history has shown that Puerto Rico has not fully enforced an effective energy policy, hence the energy sector lacks of concrete objectives to guide us towards a more sustainable energy model. So far, we are not exploiting or developing our natural and abundant resources to their full potential for our common benefit, meaning society, economy, and the environment.

According to the Puerto Rico Energy Policy of 1993, energy policy and strategies should be focused on encouraging energy efficiency and conservation measures framed in our economic growth and fulfillment of the constitutional mandate for employing optimal use of natural resources in harmony with the requirements of public health. Similarly, strengthen energy security, environmental quality, and economic development in Puerto Rico, using the integration of alternative and renewable energy to reduce our high dependence on oil, achieve environmental stewardship, and promote competitiveness within the energy industry to foster our island economy.

5.2. CURRENT POLICIES AND EFFORTS

It was not until recently, that through the federal stimulus package from the American Reinvestment and Recovery Act (ARRA) of 2009, other local initiatives, and policies; Puerto Rico is pursuing several strategies and initiatives leaning towards energy conservation and efficiency, as well as to the integration of renewable energy sources.

Supported by the funds from the American Reinvestment and Recovery Act of 2009, Puerto Rico was able to launch several initiatives and programs. Although, programs are relatively small, they serve as icebreakers, mainly promoting and encouraging energy efficiency within the end-use sector.

Renewable energy has also become a key player within the Puerto Rico's electric power sector. As presented earlier, Puerto Rico lacks of fuel diversity for electricity generation, and moreover depends significantly on oil as primary fuel. Recently, as of July 19th of 2010, two laws were enacted; the first, enforces for the first time, diversification within electric power generation mix by adopting a Renewable Portfolio Standard (RPS), legal energy policy that requires an increment in renewable energy production through the use of wind, solar, biomass and geothermic among others. The second provides new incentive programs for enabling investments in renewable energy.

5.3. ENERGY DIVERSIFICATION ACT

According to Act No. 82, also known as the Energy Diversification by Means of Sustainable and Alternative Renewable Energy Act, provisions within the Act were created to foster renewable energy generation, by means of mandatory targets or goals, known as the

Renewable Portfolio Standard. In addition, it establishes and adopts a Renewable Energy Certificates ("RECs") market. It also creates a Renewable Energy Commission as the entity in charge of enforcing, managing and overseeing the Renewable Portfolio Standard. Last but not least, Act No. 82 adopts the use of a renewables registry, an electronic platform to manage the issuance, tracking, and trading of RECs.

5.3.1. Eligible Renewable and Alternative Energy Sources

The Act recognizes several sources of renewable energy, specifically categorizing them among sustainable or alternative energy sources and technologies. Specifically, through its definitions it states the following:

"Sustainable Renewable Energy" - means energy derived from the following sources (as stated in the Act):

a. solar energy;
b. wind energy;
c. geothermal energy;
d. renewable biomass combustion (renewable biomass is also defined within the law);
e. combustion of gas derived from renewable biomass;
f. combustion of biofuels derived exclusively from renewable biomass (renewable biomass is also defined within the law);
g. qualifying hydroelectric energy, means the energy produced by: (i) an increase in efficiency or in production capacity, achieved at a hydroelectric facility built prior to the

effective date of this Act, or (ii) a hydroelectric facility built after the effective date the Act;

h. marine and hydrokinetic renewable energy, as this term is defined in Section 632 of the "United States Energy Independence and Security Act of 2007," Pub.L. 110-140, 42 U.S.C. § 17211);
i. oceanic thermal energy;

"Alternative Renewable Energy" - means energy derived from the following sources (as stated in the Act):

a. conversion of municipal solid waste;
b. combustion of gas derived from a landfill system;
c. anaerobic digestion;
d. fuel cells;

5.3.2. Renewable Portfolio Standard (RPS)

Article 2.3, Act No. 82 of 2010 orders the following mandatory targets: 12% of renewable energy production by 2015, 15% by 2020, and a requirement for retail energy providers to establish a plan to reach 20% renewable energy production by 2035.

A retail electricity provider, as defined in the Act, means the Electric Power Authority and any other retail energy provider that sold more than fifty thousand 50,000 megawatt-hours (MWh) of electricity to consumers in Puerto Rico during the preceding calendar year.

5.3.3. Compliance with the Renewable Energy Portfolio

Article 2.11, every retail energy provider must submit to the Renewable Energy Commission an Annual Compliance Report. The required amount of sustainable or alternative renewable energy applicable to a retail energy provider in a given year, and with respect to the RPS established targets, is obtained by multiplying the target percentage by the total amount of electric power sold by the retail energy provider in the same year. Moreover, for compliance purposes, non-qualified hydroelectric based electricity generation shall not count as to the total amount of electricity sold annually used for the aforementioned calculation methodology.

Therefore, compliance with the RPS is achieved any of or a combination the following:

(1) Acquiring the total amount of RECs to account for every megawatt hour (MWh) of electricity from sustainable or alternative renewable energy sources in Puerto Rico, in accordance to the mandatory target for the respective year and/or;

(2) A report indicating the total amount of electricity produced by, and purchased from, distributed renewable energy producers (up to 1MW of capacity) located in Puerto Rico through a net metering program (shall be used as an alternative when it becomes impossible to obtain required, or to supplement total REC acquisition).

5.4. GREEN ENERGY INCENTIVES ACT

Act No. 83, also known as the Green Energy Incentives Act, creates a Green Energy Fund ("GEF") through which the government of Puerto Rico will direct $290 million to incentivize renewable energy projects, mainly distributed generation, over the next 10-years. In addition, for companies dedicated to an eligible activity as defined in Article 1.4 of Act. No. 83 of 2010, the law also provides tax benefits.

5.4.1. Green Energy Fund (GEF)

Starting as of fiscal years 2011-2012, funds will be collected from motor vehicles tax consistent with Sec. 2011 of the Internal Revenue Code of PR. These funds will be received by the Department of Treasury (DT) and will be distributed as it follows:

Fiscal Year	Funds
2011-2012	$20,000,000
2012-2013	$20,000,000
2013-2014	$25,000,000
2014-2015	$30,000,000
2015-2016	$35,000,000
2016-2020	$40,000,000 (each year)
Total	290 Millions

Table 2 Green Energy Fund Distribution, Source: Act 83 of July 19th, 2010

Furthermore, as established in Article 2.8 of the Act, through the GEF the Energy Affairs Administration (PREAA) will offer cash rebates of up to 60% on the cost of installing Tier 1 or small projects (0 – 100 kW) for residences and small businesses and up to 50% on the cost of Tier 2 projects (100 kW – 1 MW) for commercial or industrial use.

5.4.2. Tax Incentives

Companies dedicated to an eligible activity will be eligible to receive a tax decree for the following:

(1) Fix income tax rate of 4% for under eligible Green Energy Revenue.

(2) Significant deduction from property, and municipal taxes;

(3) Super depreciation of buildings, structures, machinery, and equipment; and

(4) Eligibility for tax-credits related to the use of locally-manufactured products, job creation, and research and development

(5) Tax Exemption periods of (25) years, directly related to typical green energy technologies equipment lifespan.

To be precise, and according to Article 1.4 of this Act, an Eligible Activity includes:

a. Any business engaged in the production and sale of green energy on a commercial scale for consumption in Puerto Rico;

b. A producer of green energy, to be consumed in Puerto Rico, provided that it is the person's main business;

c. Assembly of green energy generation equipment, including installation thereof at the facilities of the user of green energy to be generated by such equipment; and

d. Property dedicated to the production of green energy, according to its definition within the Act.

5.5. CURRENT RENEWABLE ENERGY DEVELOPMENT AND ENERGY EFFICIENCY MEASURES

This section describes the current status of renewable energy and energy efficiency in Puerto Rico. As of today, renewables, excluding hydro, represent less than 0.1% of the generation capacity and accounted for about 0.04% of the net electricity generation in Puerto Rico. Nonetheless recent efforts are aiming to increase its share and levels of integration.

5.5.1. Renewable energy Projects

Nowadays, hydroelectric has the highest installed capacity with 100 megawatts (MW). Solar photovoltaic (PV), mostly distributed generation (DG), accounts for the second largest renewable energy source with nearly 4 megawatts (MW) of capacity. Still, due to solar resource intermittency, its electricity generation share is not directly proportional to its capacity.

In the recent days, large-scale wind and solar projects have captured much of the public attention with some projects under development and others under a conceptual stage. Table 1 shows a list of renewable energy projects under development, regardless of their completion or progress. According to information provided by both, the Puerto Rico Energy Affairs Administration (PREAA) and PREPA, some of the projects include herein have already signed a Power Purchase Agreement (PPA), or are currently under negotiations. Also, some have completed environmental permits and/or construction permits. However, we will solely present them as potential renewable energy projects to be developed in the near future and to be included as a reference point for our short-term projections.

Renewable Energy Source (Sustainable & Alternate)	Number of Projects (independent of their respective status or progress)	TOTAL CAPACITY [MW]	Estimated Capacity Factor	Total Expected Annual Generation [MWh]	% Contribution to RPS (using FY 2009 as base)
Solar PV	6	172	18%	271,210	1.0%
Wind	5	225	25%	492,750	1.8%
Geothermal	0	0		0	0.0%
Biofuel	0	0		0	0.0%
Hydro (Eligible)	0	0		0	0.0%
Ocean (Kinetic)	0	0		0	0.0%
Ocean Thermal Energy Conversion (OTEC)	0	0		0	0.0%
Waste to Energy	5	206	85%	1,533,876	5.64%
Fuel Cells					
DG *Solar PV*	Multiple	~6	18%	9,461	0.35%
TOTAL	**14**	**609**	**N/A**	**2,297,836**	**8.8%**

Table 3 Renewable Energy Large-Scale Projects Under Development* as of February 2011, Source: PREAA & PREPA

5.5.2. Energy Efficiency Measures

Several initiatives and programs have been created to reduce our energy demand and consumption, and thus achieve greater energy efficiency, supported the American Reinvestment and Recovery Act (ARRA) of 2009. These include the following: Weatherization Assistance Program (WAP), Energy and Efficiency Conservation Block Grant (EECBG), State Efficiency Appliance Rebate Program (SEARP), and the State Energy Program (SEP). The Weatherization Assistance Program (WAP) is enabling low-income families to permanently reduce their energy consumption and electricity bills by effectively employing energy efficient appliances and equipment. The Energy and Efficiency Conservation Block Grant (EECBG), provides funds to the central government and to municipalities for projects that reduce energy consumption and improve energy efficiency. The State Efficiency Appliance Rebate Program (SEARP), offered consumer rebates for purchasing certain ENERGY STAR® appliances to reduce consumption within the residential end-use sector. The State Energy Program (SEP) promotes energy conservation, and demand growth reduction through various programs including the Building Energy Efficiency Retrofit program, and the Solar Water Heater program.

In addition, the 2011 Puerto Rico Building Code was adopted in January 1st, 2011. The energy conservation chapter adopts the International Energy Conservation Code (IECC) 2009 with amendments for residential construction, and the ASHRAE 90.1-2007 standard for commercial construction. If implemented and enforced successfully, these are designed to achieve at least 30 percent energy savings in new construction. Furthermore, under the requirements from ARRA provisions, 90 percent compliance of the energy conservations codes is required by 2017.

6. PUERTO RICO ELECTRIC POWER SYSTEM MODEL (EPSEM)

So far we have discussed many topics including the importance of energy, electricity and their economic implications. It is evident that renewable energy and energy efficiency are key alternatives to achieve a more secure, reliable and sustainable energy model. Furthermore, the greatest opportunity for increasing the use of renewable energy sources lies within the electric power sector.

In Puerto Rico, nearly 99 percent of its electric power is generated using fossil fuels as primary sources, with nearly a 70 percent share from oil-based products. Thus the island faces high, unstable, and volatile electricity prices directly affecting Puerto Rico's industry and the society in general. As mentioned earlier, Renewable Portfolio Standards have become key drivers to increase the use of renewable energy sources in many states and countries. However, RPS effectiveness hinges on the economic impact related to its adoption and enforcement.

Therefore, this project aims to determine the economic impact related to the adoption of an RPS in Puerto Rico. In order to pursue our objectives an economic model was developed by the author to determine the variations on retail electricity prices according to the integration of renewable energy based on the adoption of RPS policies at different levels. Efforts have been directed to quantify retail electricity rate impact resulting from different levels of RPS adoption. This chapter provides with the methodology, characteristic, and assumptions to the developed economic model.

6.1. ECONOMIC MODEL DEVELOPMENT

6.1.1. Introduction

A mathematical model was designed and constructed in order to determine the economic impact of adopting an RPS policy in Puerto Rico. Economic impact will solely be measure through retail electricity prices variations, and mainly using as a reference the Puerto Rico Electric Power Authority (PREPA) electricity rate structure and regulatory regime previously presented. The Electric Power Sector Economic Model (EPSEM) consists primarily of the following modules: Total Generation by Fuel, Net Electricity Generation by Plant, Overall System Efficiency, Total Electricity Consumption, Fuel Price, PREPA – Power Plant Characteristics, PREPA – Fuel Expenses, and Average Total Electricity Cost.

The EPSEM was designed to determine the annual average electricity price per year according to the Case Scenario under evaluation and its respective inputs, characteristics, and constraints. Thus, the determined annual average electricity price for each studied RPS adoption case scenarios will be compared to the base case scenario.

6.1.2. Case Scenarios

This project has used a case study approach. Case scenarios were developed to represent a range of possible scenarios as to the increase in renewable energy generation and/or integrate energy efficiency measures. As we know, there is a level of uncertainty about what governments and utilities will undertake as course of action over the next years.

Given these uncertainties, we have assumed conservative projections for the base-case scenario taking into account only those policies and/or actions already adopted and implemented.

In summary, the case-scenario approach enabled a method to evaluate the impact towards retail electricity price from different levels of renewable energy adoption.

A base case scenario, also known as Business As Usual (BAU) was built. This scenario was used as a reference for the economic impact analysis. In addition, we have included a case scenario assuming PREPA's Costa Sur Units 5 and 6 are retrofitted and completely operational using natural gas as primary fuel. Likewise, RPS adoptions at 3 different levels were built to compare their impact on retail electricity cost. Additional scenarios were studied as to determine the economic potential of integrating energy efficiency as an alternate technology to comply with respective levels of renewable energy adoption. In a nutshell, the base-case scenario is a realistic representation of our current Electric Power System model.

6.1.3. Study period

The study period was established as a twenty-five (25) year period beginning in 2010 and extending through 2035. Short-term projections will be evaluated from 2011-2014 on an annual basis. Long-term projections will be evaluated from 2015 to 2035 on a 5 year scale-up basis.

6.2. DESCRIPTION OF MODULES

6.2.1. Total Generation by Fuel

This module provides the specific share from primary fuels used to supply the total Net Electricity Generation. Fuels listed in this module include only those used or to be considered for our study; including: Oil (both residual No. 6 and distillate No. 2), Coal, Natural Gas, and renewables. Renewable shares, expressed in percentage (%), are based on the case scenario under study. As mentioned earlier, we have included two base case scenarios. One of them being what we refer to the BAU. The other is assuming PREPA's Costa Sur Units 5 and 6 (Base Case) are retrofitted and completely operational using natural gas as primary fuel.

The BAU scenario assumes a share of 15.8% from Natural Gas (EcoEléctrica), a share of 16% in Coal (AES), a 0.75% from existing Hydro, and the remaining 67.4% from oil-based generation. On the contrary, under the Base Case scenario assumes a share of 25.8% from Natural Gas (EcoEléctrica, and PREPA Units 5 and 6 Costa Sur Power Plant), a share of 16% in Coal (AES), a 0.75% from existing Hydro, and the remaining 57.4% from oil-based generation.

However, one must point out that oil–based generation share projections will strictly depend on the annual addition of renewable energy plants according to each case scenario under study. Hence, the author uses the following proportion formula:

$$Oil_{share} = 100\% - NG_{share} - C_{share} - RE_{share} \tag{6.1}$$

In addition, this module provides the total annual Net Electricity Generation for each year. Data from years 2006 until 2010 are based on PREPA's Consulting Engineers Annual Reports and Reports to PREPA's Governing Board, among other sources. Furthermore it provides with short-term and long-term projections. Short-term projections (2011-2014) are based on the "PREPA's 36th Annual Report under terms of Trust Agreement", specifically in accordance with the least optimistic forecast statistics from PREPA's independent economic consultants (Econométrica, Inc.; Inter-American University, and PR Planning Board). Likewise, projections from 2015 to 2035 are based on a 0.9% growth rate using EIA Annual Energy

Outlook 2010 as a reference. Projected Net Electricity Generation in Puerto Rico is shown below in Figure 16.

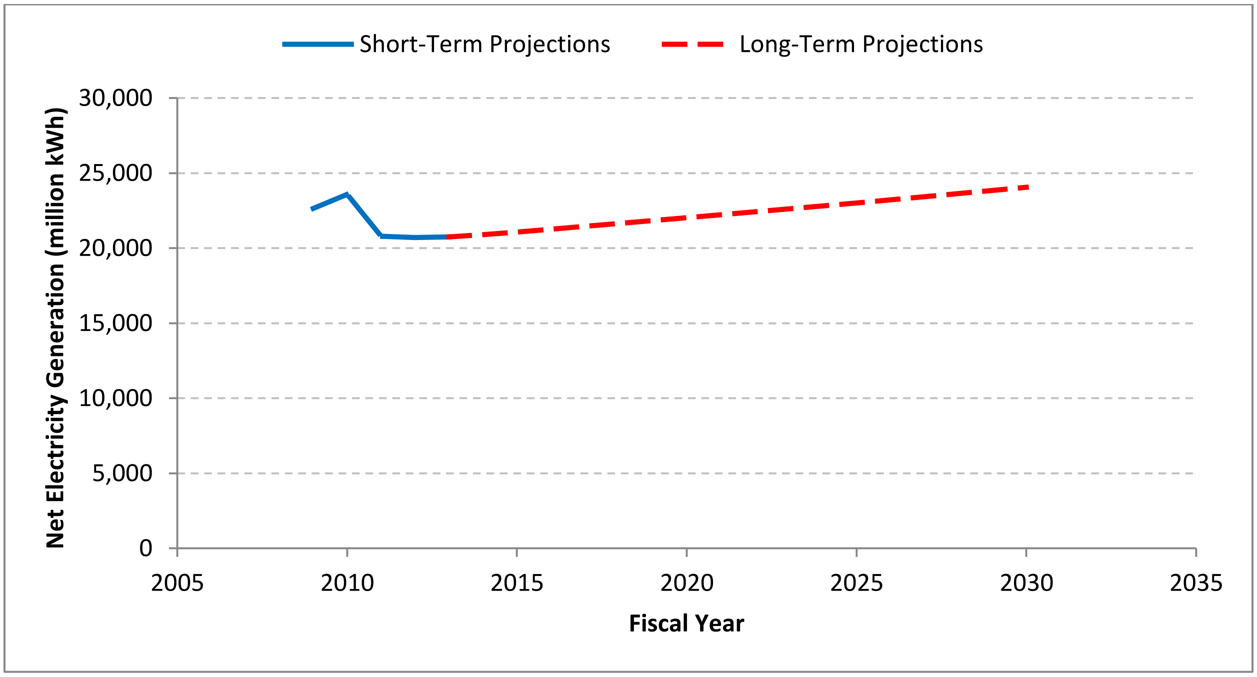


Figure 16 Net Electricity Generation data and Projections (2006-2035)

6.2.2. Net Electricity Generation by Plant

The "Net Electricity Generation by Plant" module calculates specific shares by generation source. Calculations are based on input data from the "Total Generation by Fuel" module and the total net electricity generation applicable to the year under study. Namely, electricity production has been distributed into: (1) PREPA, (2) EcoEléctrica, (3) AES, and (4) Renewable Energy Producers. Moreover, PREPA sources are divided into oil-based, natural gas, and hydro units. Similarly, renewable energy production has been segregated mainly into renewable Independent Power Producers (IPPs) and distributed generation. IPPs include those with technologies that were selected for the purpose of this study.

6.2.3. Overall System Efficiency

The “Overall System Efficiency” module provides data on PREPA’s system efficiency according to available data from previous years. Projections were made taking as a reference PREPA’s independent economic consultants projections from 2011-2014, specifically those regarding Net Electricity Generation (as presented earlier) and electricity sales (consumption). Hence the overall system efficiency has been calculated through the ratio of the total sales (kWh) and total electricity generation (kWh). Furthermore, constant overall system efficiency was taken from year 2014 until 2035.

6.2.4. Total Electricity Consumption

This module provides annual data on the total electricity consumption; also referred to as total electricity sales. Furthermore it provides with short-term and long-term projections. Short-term projections (2011-2014) are based on the “PREPA’s 36th Annual Report under terms of Trust Agreement”, specifically in accordance with the least optimistic forecast statistics from PREPA’s independent economic consultants (Econométrica, Inc.; Inter-American University, and PR Planning Board). Similarly, projections from 2015 to 2035 are based on a 0.7% growth rate according to EIA Annual Energy Outlook 2010 projections on energy consumption by sector and source. Figure 17 illustrates data, short-term, and long-term projections on Total Electricity Consumption.

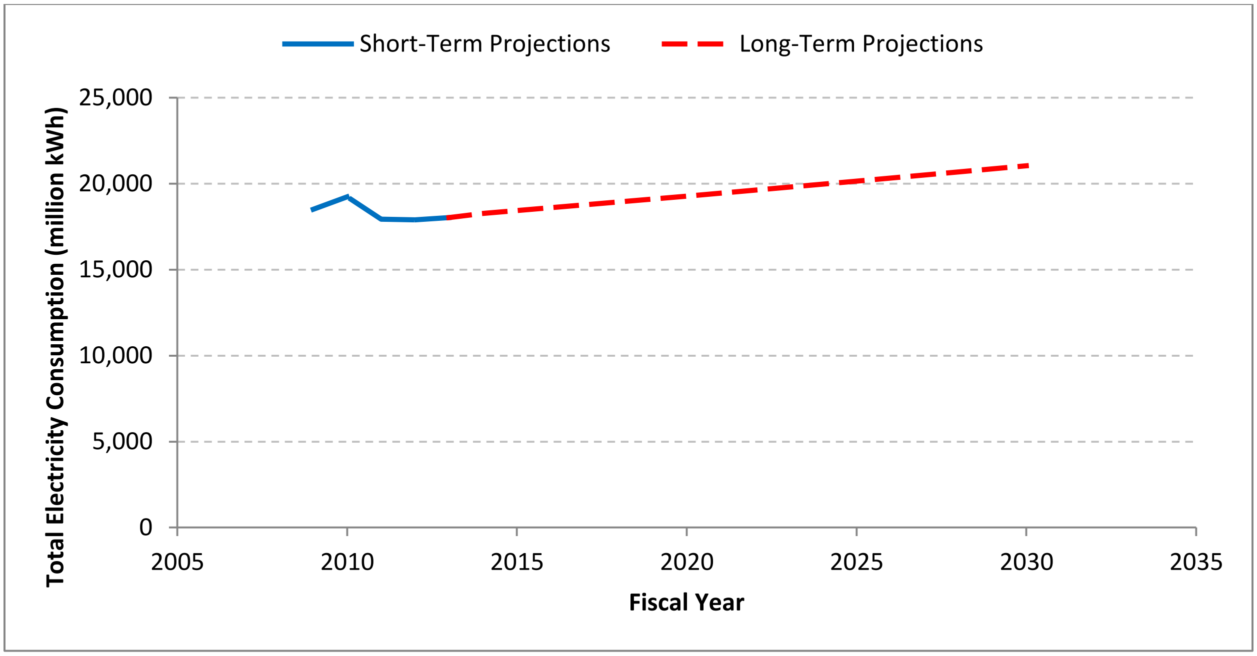


Figure 17 Total Electricity Consumption data and Projections, in Million kWh (2006-2035)

6.2.5. Fuel Price

The fuel price module provides with current fuel prices, as well as short-term and long-term projections. Specifically, oil and natural gas prices are included within this module. Oil prices are provided in terms of a weighted-average price which consists on respective prices from residual fuel No. 6 and distillate fuel No. 2, expressed in dollars per barrel ($/BBLs). The weighted average value represents a more precise cost ($/BBLs) based on the respective share of fuel consumption. In Puerto Rico, according to PREPA's 36th Annual Report, from the total oil share for electricity generation approximately 87.06% is residual fuel No. 6 and 12.94% is Distillate fuel No. 2. The project assumes a constant fuel share throughout the study period. On the other hand, natural gas prices are expressed in dollars per millions of BTUs ($/MMBtu).

In order to access the cost incurred by PREPA's conventional resources, it was important to develop a realistic set of assumptions with respect to future fuel cost projections for Puerto

Rico. Therefore, short-term projections were based on forecast statistics from PREPA's independent economic consultants. Though, long-term projections are based on EIA Annual Energy Outlook (AEO) 2010 [9]. Figure 18 and Figure 19 reflect the trends of oil price and natural gas price projections for the study period, respectively. It is important to disclaim that the author is using Annual Energy Outlook (AEO) 2010 reference case scenarios for fuel price projections; therefore fuel prices could be higher or lower.

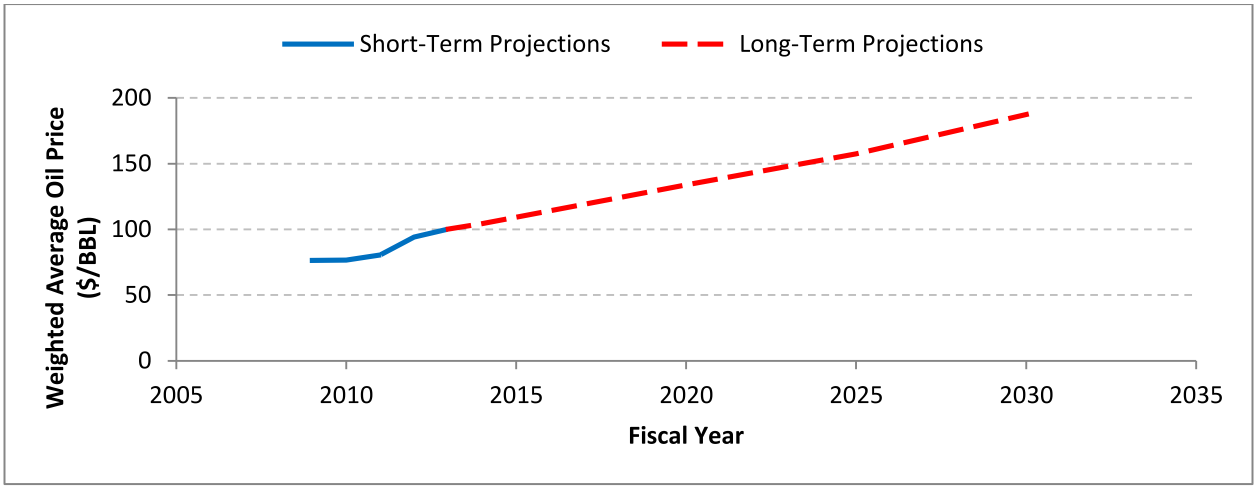


Figure 18 Weighted Average Oil Price Projections ($/BBL)

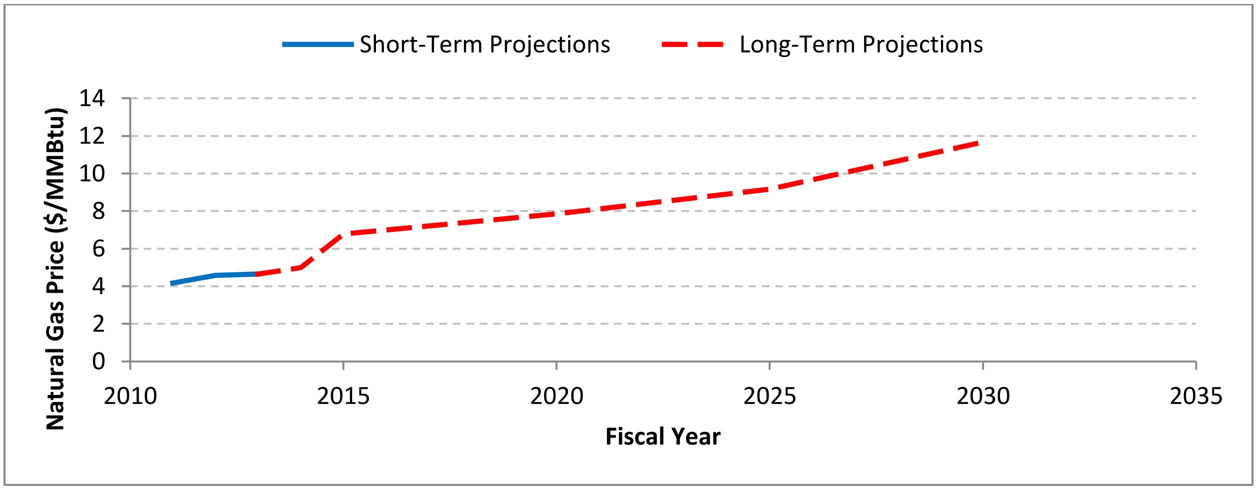


Figure 19 Natural Gas Price Projections ($/MMBtu)

6.2.6. PREPA – Power Plant Characteristics

This module provides with thermal and physical characteristics of PREPA power plants. Specifically, it provides the weighted average heat rate, consumption factor (kWh/Barrel), and heat contents (BTU/Barrel) for PREPA's units. Weighted average was calculated for fiscal year 2009 and 2010 based on available data including specific unit annual rated and available capacities, thermal performance, generation, system availability, capacity factors, and share contribution from each unit. Specific data was collected from the 36th Annual Report and Monthly Reports to PREPA's Governing Board [33] & [34].

Oil-fired units average heat rate was approximately 9,946 (Btu/kWh) during 2009 and 10,598 Btu/kWh for 2010. Heat rates for oil-fired units has been assumed to be constant throughout the study period and equal to FY 2010 average heat rate, described above.

Natural gas units average heat rate was taken as 8,157 Btu/kWh according to the latest U.S. power plant statistics on average natural gas heat rates [11]. Heat rates for natural gas units have been assumed to be constant throughout the study period.

6.2.7. PREPA – Fuel Expenses

This module calculates PREPA's fuel related cost based on the annual fuel consumption, respective fuel price, and units' performance characteristics. Hence it determines PREPA's fuel related expenses to be further input into the fuel adjustment formula under the adjustment clause mechanism.

In order to determine fuel consumption related to PREPA generation units, the following formulas has been used:

For Oil-Fired Electric Power Units:

$$\boldsymbol{Oil\ Fuel\ Consumption} = \frac{\boldsymbol{Electricity\ Generation_{Oil-Based}} \times \boldsymbol{Heat\ Rate_{Oil-Fired\ Units}}}{\left[\boldsymbol{BTU}/_{\boldsymbol{Barrel}}\right]}$$

(6.2)

Where,

$\boldsymbol{Oil\ Fuel\ Consumption}$ *expressed in thousand barrels (thousand BBLs) of Oil.*

$\boldsymbol{Electricity\ Generation_{Oil-Based}}$ *is the net electricity generation from PREPA's oil-fired units for the fiscal year under review.*

$\boldsymbol{Heat\ Rate_{Oil-Fired\ Units}}$ *is the weighted average heat rate from oil-fired units in operation during the fiscal year under review*

$\boldsymbol{BTU}/_{\boldsymbol{Barrel}}$ *a conversion factor resulting from PREPA's oil-fired units characteristics and according to a weighted average value for the fiscal year under review.*

For Natural Gas (NG) Fired Electric Power Units:

$$\boldsymbol{NG\ Fuel\ Consumption} = \boldsymbol{Electricity\ Generation_{NG-Based}} \times \boldsymbol{Heat\ Rate_{NG\ Units}}$$

(6.3)

Where,

$\boldsymbol{Natural\ Gas\ Fuel\ Consumption}$ *expressed in Million Btu (MMBtu) of Natural Gas.*

$\boldsymbol{Electricity\ Generation}_{\boldsymbol{NG-Based}}$ *is the net electricity generation from PREPA's natural gas-fired units for the fiscal year under review.*

$\boldsymbol{Heat\ Rate}_{\boldsymbol{NG\ Units}}$ *is the weighted average heat rate from Natural Gas units in operation during the fiscal year under review*

6.2.8. Purchased Power Cost

The "Purchased Power Cost" module calculates PREPA's expenses related to the purchase of energy through power purchase agreements (PPAs) with independent power producers (IPPs). IPPs included in this module are EcoEléctrica, AES, and Renewable Energy Producers. An important disclaimer is that the author is assuming renewable energy projects will be privately owned. PREPA has publicly expressed they don't have the needed capital to invest on utility-scale renewable energy projects.

PREPA's purchased power cost for EcoEléctrica and AES was calculated by multiplying the share of the electricity generation (Million kWh) for each plant and its respective energy price ($/kWh) during the year under analysis. Moreover, energy prices for EcoEléctrica and AES were determined from energy sales during years 2008-2010 according to available data on PREPA's power purchase expenses, specifically regarding total power purchase cost and the electricity generation from each plant. Then, based on 2010 estimates for AES and Ecoeléctrica, the author projected the energy prices throughout the study period according to respective fuel price projections. Based on EIA 2010 Annual Energy Outlook long-term projections – natural gas and coal prices were projected to increase with at a 1.7% and 2.0% annual growth rate, respectively.

Likewise, the electricity output from utility-scale renewable energy projects was assumed to be sold to PREPA, under long-term PPAs. PPAs prices depend primarily on the renewable technology used, together with market prices being offered by PREPA. Energy prices offered by PREPA under PPA's were be supplemented with an additional cost, also known as a premium, for the purchase RECs as to comply with RPS required renewable energy production as established within the RPS legal framework. Hence, environmental and green energy attributed will be accounted through the purchase of RECs. However, the project only includes a REC value, if needed to achieve the determined Levelized Cost of Energy (LCOE) for each respective technology. Then, the total purchase cost from renewable energy producers is equal to the RPS compliance cost according to each case scenario and year under analysis. Specific calculations regarding final PPA energy price for renewable energy IPPs are presented in Appendix G.

6.2.9. Annual Average Total Electricity Cost

This module calculates the total average electricity rate in accordance with the Puerto Rico Electric Power Authority rate structure and regulatory regime. Hence, the methodology used was designed in accordance with PREPA's Electric Rate Structure, as discussed earlier in Chapter 4. For the purpose of calculating the annual average electricity price the author has adapted minor changes as to the adjustment clause, specifically referring to the fuel adjustment charge and purchased charge as it follows:

First, the fuel purchase charge formula was slightly altered to calculate results on an annual basis, and to use accurate input values, rather than estimates. Also, the Adjustment Factor (Ac) was removed from the calculation. Therefore, the modified formula, and included is the following:

$$\boldsymbol{FCC}\left(\$/_{\boldsymbol{kWh}}\right)=\frac{\left[\$/_{\boldsymbol{BBL}}\times \boldsymbol{BBLs}\right]_{\boldsymbol{Oil\ Fuel}}+\left[\$/_{\boldsymbol{MMBtu}}\times \boldsymbol{MMBtu}\right]_{\boldsymbol{Nat.\ Gas\ Fuel}}}{\boldsymbol{0.89}\times \boldsymbol{Total\ Net\ Generation}\ \times\ \boldsymbol{E_i}}$$

(6.4)

Where,

$\boldsymbol{FCC}$ is Fuel Purchase Formula (Formula Compra de Combustible).

$\$/_{\boldsymbol{BBL}}$ is the average fuel price per barrel of oil applicable to the fiscal year under review.

$\boldsymbol{BBLs}$ is an estimate amount of oil barrels used by PREPA's Oil-Based power generation plants during the fiscal year under review.

$\$/_{\boldsymbol{MMBtu}}$ is the average Natural Gas price per Million of Btu applicable to the fiscal year under review.

$\boldsymbol{MMBtu}$ is an estimate amount Million Btu used by PREPA's Natural Gas power generation plants during the fiscal year under review.

$\boldsymbol{0.89}$ is a factor used to recover payments in lieu of taxes made by PREPA to the central government and the municipalities.

$\boldsymbol{Total\ Net\ Generation}$ is the estimated net electric energy generated and purchased by PREPA corresponding to the fiscal year under review.

$\boldsymbol{E_i}$ is a factor representing the average efficiency for the 12 month prior to the fiscal year under review. This is the efficiency is assumed as the overall system efficiency for PREPA's Electric Power System.

Second, in order to recover all costs related to the purchased power from power from IPP's, the author has modified the existing Power Purchased Adjustment Clause. Therefore, the modified formula, and included is the following:

$$\boldsymbol{FCE}\left(\$/_{\boldsymbol{kWh}}\right)=\frac{\boldsymbol{Total\ Purchased\ Power\ Cost}\ (\boldsymbol{estimated},\$)}{\boldsymbol{0.89}\times\boldsymbol{Total\ Net\ Generation}\ \times\ \boldsymbol{E_i}} \tag{6.5}$$

Where,

$\boldsymbol{FCE}$ is Power Purchase Formula (Formula Compra de Combustible).

$\boldsymbol{Purchased\ Power\ Cost}\ (\boldsymbol{estimated},\$)$ is an estimated amount of the total power purchase cost incurred by PREPA under power purchase agreements with Independent Power Producers during the fiscal year under review. This will include power purchases to EcoEléctrica and AES-PR, and any other Renewable Energy or Alternative Energy Power Producer under case-scenarios assumptions.

$\boldsymbol{0.89}$ is a factor used to recover payments in lieu of taxes made by PREPA to the central government and the municipalities.

$\boldsymbol{Total\ Net\ Generation}$ is the estimated net electric energy generated and purchased by PREPA corresponding to the fiscal year under review.

$\boldsymbol{E_i}$ is a factor representing the average efficiency for the 12 month prior to the fiscal year under review. This is the efficiency is assumed as the overall system efficiency for PREPA's Electric Power System.

6.3. BASE-CASE MODEL CALIBRATION

To assure EPSEM outputs were correct and precise; model results were compared with data from fiscal year 2003 up to fiscal year 2009 from available statistics and referenced sources. An adequate result has been defined as, any output that results in a percentage difference or accuracy level of ±2% when compared to data from reference sources.

Using fiscal years 2009 and 2010, results were verified to ensure outputs were reasonable approximates when compared to 2009 and 2010 available data. For example, data from [33] and [34] was compared with model results based on derived outputs and calculations; comparison is shown in Table 4 and Table 5.

Item	**FY 2009 Data According to [33] & [34]**	**FY 2009 EPSEM Output**	**% Difference**
Fuel Consumption	25,184 (thousand BBLs)	25,166 (thousand BBLs)	**-0.07 %**
Fuel Expenses	$1,919,800,000	$1,918,469,398	**-0.07 %**
Fuel Consumption Clause	$0.1168 per kWh	$0.1165 per kWh	**-0.26 %**
Purchased Power Clause	$0.0406 per kWh	$0.0408 per kWh	**0.49 %**
Average Total Electricity Cost ($/kWh)	$0.2153 per kWh	$0.2151 per kWh	**-0.09 %**

Table 4 FY 2009 EPSEM Calibration Results, Output Accuracy %

Item	**FY 2010 Data According to [33] & [34]**	**FY 2010 EPSEM Output**	**% Difference**
Fuel Consumption	26,217 (thousand BBLs)	26,723 (thousand BBLs)	**1.9%**
Fuel Expenses	$2,006,931,000	$2,006,905,835	**-0.001%**
Fuel Consumption Clause	$0.1173 per kWh	$0.1172 per kWh	**-0.09%**
Purchased Power Clause	$0.0404 per kWh	$0.0405 per kWh	**0.25%**
Average Total Electricity Cost ($/kWh)	$0.2160 per kWh	$0.21595 per kWh	**-0.02%**

Table 5 FY 2010 EPSEM Calibration Results, Output Accuracy %

Based on the previously mentioned, the economic model was proven to achieve a certain precision level on its derived outputs and results. Thus, short-term and long-term projections were based on adequate levels of projection and calculation accuracy.

7. RPS CASE-SCENARIO DEVELOPMENT

In order to determine the economic impact related to the adoption of an RPS in Puerto Rico three case scenarios were developed. The author has begun by describing general assumptions taken with regards to the RPS legal framework used for our analysis. Then, a description of selected technologies and their respective application provided. This was followed by a summary of resource availability and potential in the island; it consisted of a review from available studies as well as to several assumptions and determinations from the author for the purpose of this study.

A review of cost and performance characteristics for the selected renewable energy technologies is provided. This review includes assumptions and future projections taken by the author for the purpose of the study. Based on presented cost, performance, economic, and finance assumptions a LCOE analysis was done for each of the selected technologies and respective application. The LCOE allows determining the real cost of producing energy from renewable technologies allowing a levelized comparison among them. Lastly, assumptions regarding the technology supply mix are presented based on the RPS targets under each scenario. Therefore, the required generation (million kWh) and capacity needs (MW) from renewable technologies is provided for each of the RPS case scenario. Notwithstanding the above, the determined supply mix is solely based on performance and cost characteristics of renewable and alternative technologies. It does not consider technical constraints, such as transmission interconnection issues, and does not simulate a power system dispatch.

Finally, this chapter provides a description of the methodology performed by the author for the development of RPS Case Scenarios analyzed in this study.

7.1. RPS POLICY ASSUMPTIONS

In order to evaluate the economic impact resulting from the adoption of an RPS policy at different levels, assumptions have been taken using conventional RPS regulatory and legal frameworks together with the use of provisions included in Act. No 82 of 2010.

For the purpose of this study, the following legal framework was assumed:

(1) *Compliance with the Renewable Energy Portfolio is mandatory*. Renewable energy targets or goals are required to every retail electricity provider. At this moment the PREPA is the only retail electricity provider, according to its definition.

(2) *Renewable Energy Targets in a given year are met according to established percentages by year multiplied by the total electricity sales from the retail electricity provider.* For compliance purposes, non-qualified hydroelectric based electricity generation shall not count as to the total amount of electricity sold annually used for the aforementioned calculation methodology.

(3) *Compliance Mechanism is based on the purchased of Renewable Energy Certificates (RECs).* RECs will represent the total amount of energy generated from a renewable energy source, the year it was generated, and its respective source. Thus, retail electricity providers shall acquire RECs from renewable energy sources to show compliance with the Renewable Portfolio Standard. Such RECs shall be then withdrawn and cancelled to avoid double counting. In addition, total amount of electricity produced by, and purchased from, distributed renewable energy producers (up to 1MW of capacity) located in Puerto Rico through a net metering program could be used for compliance purposes (As stated in Act No. 82 of 2010).

(4) *Eligible Sources include all renewable energy sources including* solar, wind, hydro, geothermal, wave, and tidal, among others as defined by Act No. 82 of 2010. However, for the purpose of this project we have narrowed eligible sources to the selected technologies presented below.

(5) *Location of resources is limited to Puerto Rico only.* All renewable energy must be produced and sold in Puerto Rico

7.2. SELECTED TECHNOLOGIES

Renewable energy technologies are highly abundant and most derived their energy from the sun. Typically, they include solar, wind, geothermal, biomass, hydro, and ocean energy. For the purpose of this project, only commercially available and promising renewable energy technologies have been selected. In addition, energy recovery from Municipal Solid Waste (MSW) has been included as defined in Act No. 82 of 2010 and the Energy Policy Act of 2005 (EPAct 2005). EPAct 2005 classifies MSW as a renewable energy source when used to produce electricity.

Selected technologies were used to produce a supply curve to comply under different levels of RPS adoption, also referred to as RPS Case Scenarios. An important disclaimer is that technology selection was based on the author discretion and consideration upon eligible technologies included under Act No. 82 of 2010, resource-based potential, application suitability, commercial availability, and cost-effectiveness. Selected resources include solar energy, wind energy, and energy conversion from MSW. Furthermore, specific technologies and respective applications included in this project are the following:

(1) Utility-Scale Solar Photovoltaic (PV) – defined as Solar PV projects from Independent Power Producers with system capacity greater than or equal to 10 megawatts (MW).
(2) Utility-Scale Wind
(3) Energy Conversion from MSW (Waste to Energy or "WTE")
(4) Large Scale Commercial Onsite Solar PV
(5) Distributed Generation (DG)
    a. Solar PV
    b. Small Wind
(6) Energy Efficiency and Conservation

7.3. RESOURCE-BASED POTENTIAL

In the following sections a review of the existing resource-based potential for the selected renewable energy sources is provided. The author has focused on the following resources: solar, wind, and MSW as sources for electricity generation. Moreover, specific technologies evaluated include solar PV, wind turbines, and WTE. In addition, DG potential has been evaluated through the integration of solar PV and small wind turbine technologies. Also, an estimated potential has been provided for the integration of energy efficiency measures in the end-use sector.

One must recognize that renewable energy sources, such as solar and wind, are limited as to their resource availability when compared to base-load generation including oil, natural gas, coal, and waste to energy electric power plants. In order to take full advantage of intermittent renewable resources, one must capture, convert, deliver and consume energy upon availability. Notwithstanding, with today's available meteorological data and advances on resource forecast, projection for solar and wind energy sources are improving substantially.

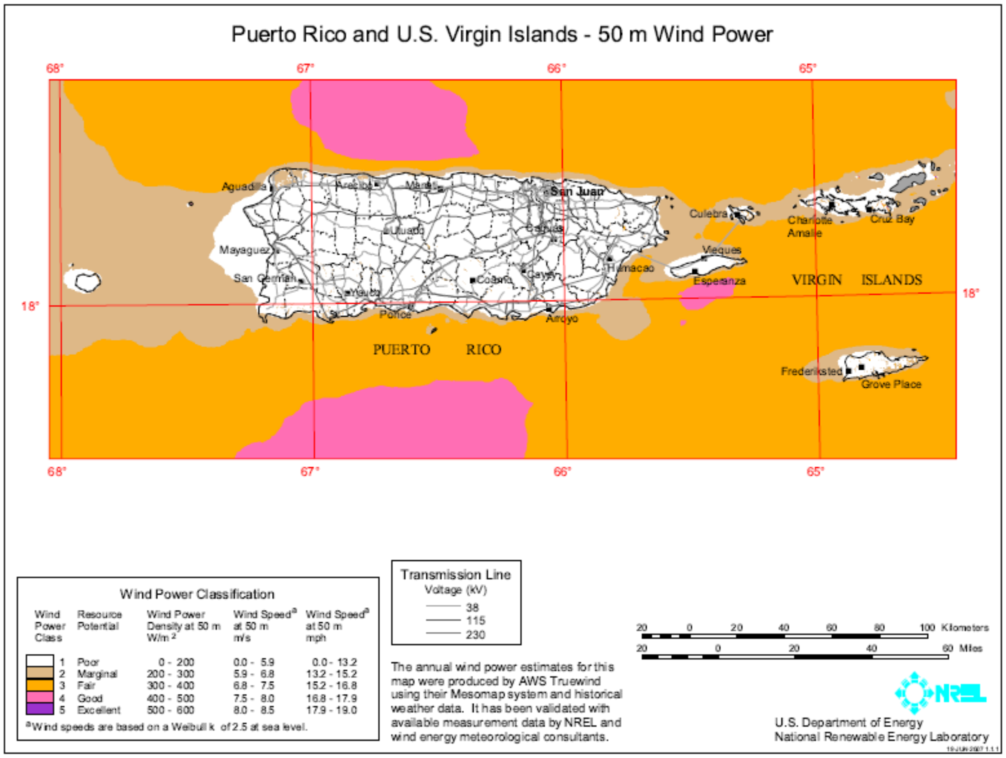
7.3.1. Wind

Wind energy systems are considered to be one of the most mature renewable technologies. Moreover, onshore wind technology is already proven and shown to be competitive on sites with favorable resource availability. On the contrary, offshore wind technology has further to go to mature as a wind technology. Although it is commercially available, their investment costs could be present can be twice of those on land. Still, wind resource is better in offshore sites.

Understanding wind turbines, as well as wind resource availability is crucial as to understand the potential for development of such technology. Wind turbine are limited to efficiencies much lower than 59%, which is the theoretical limit for the extraction of power from wind determined by German aerodynamicist Albert Betz (Betz Law, 1966). A wind turbine extracts kinetic energy from the wind and converts it to mechanical energy by means of a horizontal rotor; then it is coupled via a gearbox to a generator in order to convert mechanical energy to electricity. According to [39], the average grid connected turbine has a rated capacity of approximately 1.6 MW and generates electricity starting from winds speeds of at least 4 m/s. Manufacturers nowadays provide with power curves that characterize turbine efficiency at different wind speeds. Hence, with available wind speed at a specific site and number of turbines to be installed, we are capable of determining the average power or system capacity, expressed in kW or MW, depending on the project scale.

It is also vital to comprehend wind resource as the most important element in order to determine or project a system energy production at a given site. In addition, as an intermittent resource it varies with respect to time, location, elevation height, and weather conditions. In

Puerto Rico, prevailing winds come from northeast trade winds. Based on a collaborative effort between the U.S. Department of Energy (DOE), National Renewable Energy Laboratory (NREL), AWS Truewind, and the Energy Affairs Administration (EAA), an annual average wind map has been developed for Puerto Rico at a 50 meters altitude.



Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m ^{2}	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
⬜ 1	Poor	0 - 200	0.0 - 5.9	0.0 - 13.2
🟫 2	Marginal	200 - 300	5.9 - 6.8	13.2 - 15.2
🟧 3	Fair	300 - 400	6.8 - 7.5	15.2 - 16.8
🟥 4	Good	400 - 500	7.5 - 8.0	16.8 - 17.9
🟪 5	Excellent	500 - 600	8.0 - 8.5	17.9 - 19.0

[a] Wind speeds are based on a Weibull k of 2.5 at sea level.

The annual wind power estimates for this map were produced by AWS Truewind using their Mesomap system and historical weather data. It has been validated with available measurement data by NREL and wind energy meteorological consultants.

Figure 20 Annual Average Wind Speed Map (50m), Source: NREL [40]

Average annual wind speeds are mainly identified by wind speed Classes according to the wind power classification used by the U.S. Department of Energy – National Renewable Energy Laboratory. Higher Class rating represents a higher capacity factor for the same amount of installed capacity, hence reducing cost of energy. The map indicates that Puerto Rico, including the municipalities of Vieques and Culebra, have wind resources that can be considered for utility-scale production. Puerto Rico has mostly Class 2 and Class 3 wind speeds throughout the coastal regions, with greater emphasis on the south, east, and north. Moreover, best wind resource areas are concentrated on the highest ridge crests and on exposed capes. In addition, wind speeds vary by season and month, whereas in Puerto Rico summer season prevails with higher wind speeds [41]. As shown in Figure 20, Vieques and Culebra are capable of achieving Class 3 wind due to their location and exposure to northeast trade winds. Northeast trade winds average speeds of approximately 6.5 m/s.

According to “Achievable Renewable Energy Targets”, a study performed by the University of Puerto Rico - Mayaguez Campus and sponsored by the Energy Affairs Administration, Puerto Rico’s geographic location provides fair wind resource potential throughout the coast of Puerto Rico, with some areas reaching good resource potential. Thus, as presented in [41], selecting a three (3) kilometer wide band along the south, east, and north coast regions, there is approximately 960 square kilometers (km^2) or almost 11% of Puerto Rico total land area. Further on, taking into account already developed and incompatible or environmentally sensitive land areas, which account to almost 50% or 480 km^2, considering spacing requirements for wind farm development, and assuming we use only 50% of available area or 240 km^2 to be conservative, **Puerto Rico is capable of developing a wind generation capacity ranging from 1,200 to 3,000 MW.** In order to determine each turbine energy production, [41] has combined the power curve and probability density function of wind speed at a given site. Last but not least, in order to determine specific energy production with respect to the presented potentially developable wind capacity, specific assumptions as to wind turbine model and characteristics, site layout, among many other project development key elements, were taken by the authors.

One must mention that wind resource intermittency and variability will become increasingly significant as wind higher penetrations levels, where power system operation and, eventually, design, will need to be modified to maintain reliability. Still, this is beyond the scope of this project and was not considered within our analysis.

7.3.2. Solar

Of all the renewable resources, solar is by far the most abundant. With 162,000 terawatts reaching Earth from the sun, just 1 hour of sunlight could theoretically provide all of society’s energy needs for 1 year [42]. Solar photovoltaic (PV) is one of the many available solar energy technologies; others include concentrating solar power (CSP), and solar thermal collectors, among other derived technologies. A solar PV system converts solar energy to electric energy by means of the photovoltaic effect. As of 2010, electricity produced from solar PV sources account for 0.1% of the total world electricity generation [43].

Solar PV is a commercially available and reliable technology with a significant potential for long-term growth. Besides, the technology is well understood, and markets are maturing very rapidly. It is considered to be less intrusive in comparison with other renewables technologies.

According to the “Achievable Renewable Energy Targets” study, most suitable locations for solar PV development lie in the south and southwest regions. In addition, the aforementioned regions are drier and less populated, resulting on a greater potential for further development. Still, it shows high solar radiation levels in the metropolitan areas (including Bayamon, San Juan, Guaynabo, Toa Alta, and Aguas Buenas, among many others).

Understanding solar radiation is very important for the development of solar PV, resources can vary with respect to time, location and weather conditions [44]. Resource data, mainly solar radiation and irradiation levels, are used to estimate energy production for a solar PV system. Solar irradiation is the total amount of solar energy accumulated on an area over time, commonly expressed in kWh/m^2. Form a mathematical perspective, solar irradiation is the solar irradiance (power) multiplied by the total number of hours or period of availability. When analyzed over a period of time, it is referred to as solar insolation, commonly expressed in kWh/m^2/day or available peak sun hours.

According to the National Renewable Energy Laboratory (NREL) through its Renewable Resource Data Center (RReDC), average solar insolation in Puerto Rico, based on San Juan data, is approximately 5.52 kWh/m^2/day, or 5.52 peak sun hours per day. Table 6 presents a summary average annual solar insolation levels (kWh/m^2/day), from eighteen (18) different measurement sites in Puerto Rico [41].

Location	**Avg. Annual Solar Insolation (kWh/m^2/day)**
Aguadilla	4.97
Cabo Rojo	5.53
Carolina	5.11
Catano	5.14
Ceiba	4.45
Fajardo	4.86
Guanica	5.03
Guilarte	1.72
Gurabo	4.64
Isabela	5.31
Juana Diaz	5.56
Lajas	5.11
Manati	5.17

Maricao	2.78
Mayaguez	4.44
Ponce	5.36
Rio Grande	3.05
San Juan	4.61

Table 6 Solar Insolation Data adapted from [41]

Solar PV technologies have been identified as very promising technologies for our analysis. However, we must recognize its resource intermittency, which results in average capacity factors ranging from 16 to 23 percent. Moreover, capacity factors strictly depend on several elements such as project site or location, resource availability, and performance characteristics. Finally, the study concludes that Puerto Rico's geographic location provides excellent levels of solar resource and recommends exploiting available resources to its maximum. The authors in [41], strongly recommends minimizing the use of non-developed lands, and focus solar PV development in available areas from existing buildings and structures, with great emphasis on available roof space. Nonetheless, our focus will be on both, utility-scale projects and distributed generation solar PV integration.

Solar resource is not limited, but rather highly abundant in Puerto Rico. Thus, solar PV development will not be limited in terms of resource-based perspective. Although solar resource is intermittent, a huge potential lays within solar PV technology due to its favorable correlation between the resource availability – thus energy output – and overall load demand profiles. As a result, non-dispatchable characteristics of solar PV technologies do not pose a significant problem upon its integration to the electric power system. In addition, advances in solar PV technology, conversion efficiency and system installation have allowed utility-scale projects to achieve competitive levels for energy production when compared with other intermittent energy sources. Still, it is vital to balance land use with the system capacity factor to deliver the best utility-scale solar PV development.

To estimate the potential of utility-scale solar PV in Puerto Rico, only 0.5% or 45 km^2 of the total land area will be used (assumption used for this Masters' project), taking into account already developed and incompatible land. For instance, Puerto Rico is mostly mountainous, with mountains accounting for approximately 60% of the land area. Furthermore, it is recommended that solar PV Utility-scale projects are sited on relatively uneven land with up to 5 percent slope, while also minimizing the amount of land and vegetation disturbance [45]. In addition, depending on the specific technology, a utility-scale project may require between 0.02 and 0.04 km^2 per MW of generating capacity (or equivalent to 5-10 acres per MW) [45]. Hence, based on the presented assumptions, **Puerto Rico is capable of developing Utility-Scale Solar PV Projects up to a generation capacity ranging from 1,125 MW to 2,250 MW,** without significantly affecting land use. Potential estimates, determined by the authors in [41], as to solar PV development in the distributed generation sector are presented further in this section.

Notwithstanding the above, one must comprehend that there is a remarkable solar PV potential in Puerto Rico due to its abundant and high quality resources. Still, its development will strictly be subject to technology's economic trends and resulting cost of energy.

7.3.3. Municipal Solid Waste

Municipal Solid Waste also referred to as trash or garbage, typically consist on the following compositions: plastic, paper, metals, yard waste, food craps, metals, and organic, among others. The U.S. Environmental Protection Agency (EPA) has developed a solid waste management hierarchy to provide policy makers, and the general public with a ranking as to the most environmentally preferable strategies to manage waste. It clearly emphasize waste reduction, prevention and reuse; followed by recycling and composting; then, combustion of waste with energy recovery; and last, landfilling and incineration of waste without energy recovery [46].

WTE facilities have proven to be a viable option on islands, yet more in densely populated and isolated areas, such as Puerto Rico. In addition to reducing excess in MSW volume, WTE plants are capable of supplying clean energy. Furthermore, WTE has grown mature, becoming safe, effective and environmentally acceptable technology. Currently, there are 87 WTE facilities operating in the U.S. and accounting for nearly 2,700 MW, and using about 6-13 percent (%) of the total MSW produced [47]. WTE is considered to have base-load dispatch characteristics, hence it enable the development of intermittent renewable energy technologies, such as wind and solar, providing significant base-load generation. Nevertheless, it is widely accepted that WTE is mainly a technology to deal with the waste problem. Its uses for electricity are a secondary benefit, as will be seen in the potential for electricity production assumed later on for this study.

Puerto Rico currently relies on 32 landfills for the majority of waste disposal [48]. According to [49], 27 out of the existing 32 landfills are failing to comply with U.S. Environmental Protection Agency regulations. In 2008, Puerto Rico produced nearly 3,500,000 tons of MSW, or an equivalent of ~ 5 pounds of MSW per person per day [48]. Moreover, MSW production is expected to increase at a similar pace with population growth projections. However, sitting new and additional landfills in Puerto Rico is not considered a viable option, due to land scarcity and related high cost. As years have gone by, landfills tipping fees has risen, and are expected to continue to increase, due to land scarcity, increasing fuel cost, and compliance with more strict environmental regulations. Tipping fees are those fees charged to dispose a ton of MSW, expressed in dollars per ton ($/ton). Moreover, these fees are charged to cover a facility related cost such as, land purchase or lease, construction, equipment operation and maintenance, labor, facility closing, compliance under environmental regulations, and investor profit.

Although the export of MSW is not prohibited locally, and is sometimes referred as a solid waste management alternative, Puerto Rico has exported a limited amount in the past due to financial reasons. Key deterrence factors include the volatility of shipping cost and standard tipping fees for the receiving facility. Based on the aforementioned, the use of MSW as an energy source represents an alternative for addressing landfill issues in Puerto Rico. WTE technologies have become more attractive and economically viable as their facility-related tipping fees have come within reach of landfill related tipping fees. In addition to tipping fees, developers may derive revenue from the sale of energy production (electricity and heat), and resale of metals.

The potential of using MSW for energy recovery in Puerto Rico depends strictly in the total waste production projected over the next years, due to the fact that MSW represents the input fuel for WTE plants to produce energy. There has been a huge concern with regards to impact of WTE towards recycling and waste reduction efforts. Even so, many experts debate that the use of WTE technology is capable of promoting and encouraging recycling at greater success than other waste management strategies [50]. Moreover, there are various social and environmental concerns that need to be dealt with in the process of establishing any of these facilities

According to [49], a study prepared for the U.S. Environmental Protection Agency by the Columbia University on 2007, Puerto Rico has the potential of using MSW as a source for WTE facilities; achieving both, a waste management strategy and alternative energy source. It also points out that there may be issues associated to waste stream in some particular areas. However, it mentions that they could be overcome through proper understanding of the composition of local waste stream and logistics in order to develop a waste stream inventory and projection to provide accurate estimates as to the potential energy production from WTE in Puerto Rico. In [49], an economic analysis has determined that a WTE facility is economically competitive with landfills in Puerto Rico.

For the purpose of this project, we will assume that today Puerto Rico produces approximately 11,100 tons of MSW per day. Therefore, using only 50% for energy recover processes we have 5,550 tons of MSW per day for energy conversion and the remaining 50% is reserved for recycling and other waste management strategies. Thus, assuming a higher heating value (HHV) of 11 MBtu/ton or 5,500 Btu per pound of MSW, an average energy recovery rate of 550 kWh per ton of MSW, and an overall capacity factor of 0.85 or 85% [51] & [52], **Puerto Rico is capable of developing up to 150 MW of WTE capacity to be distributed in different facilities and locations** throughout the island without affecting or limiting current waste stream and availability. However, due to uncertainties in population, economic growth, waste management policies, and recycling trends, the amount of available MSW available in the future is projected with low levels of certainty.

7.3.4. Distributed Generation

Distributed generation will play a key role within the renewable energy industry in Puerto Rico. Hence, below we have summarized their respective potential, according to the technologies presented.

As presented earlier, solar energy sources, such as photovoltaic, have been proven to be a potential option in Puerto Rico. According to [41], if we use only 10% of the available resource to produce electricity we are capable of providing nearly 20% of the overall electricity demand in 2006. Based on the results provided by [41], and converted into solar PV resource-based capacity, expressed in megawatts, Puerto Rico is capable of developing approximately 2,000 MW of Solar PV in distributed generation (DG). However, the study clearly states that based on the available resource even greater generation capacities could be attained.

For the purpose of this project we will use the following approach; assuming only 10% of available roof space in households, commercial buildings, and industrial facilities is used for onsite distributed generation solar PV systems. According to [41], the total roof space approximately accounts to 190,800,000 m^2. Then, assuming only 10% of that area is available to consider any uncertainty regarding areas usage, available roof space for distribute generation development is 19,080,000 m^2. Depending on the specific technology, a distributed generation solar PV project typically requires 0.01 km^2 per MW of generating capacity (or equivalent to a solar irradiance of 0.1 kW per m^2) [53]. Hence, based on the presented assumptions, **Puerto Rico has the potential to develop 1,900 MW of Solar PV in distributed generation (DG)**.

A huge opportunity exists within this sector when taking into account industries, and commercial buildings or facilities and the existing potential integration of solar PV technologies as non-intrusive and commercially available renewable energy sources. However, as explained earlier, a bolder growth will be achieved as markets continue to mature towards more advanced and cost-effective technologies.

In addition, small wind energy system comprises a segment of distributed generation. According to AWEA, an average home could install small wind turbine (SWT) with a generation capacity ranging from 2 kW to 10 kW, depending on its energy use, available wind speed, and site elevation, among other factors. The average height of a SWT is about 80 ft. (~25m), with a rotor diameter averaging around 18 ft. (~5.5m). Small wind turbines are generally cost effective when installed in Class 3, and in some cases Class 2 winds [54]. Installers typically recommend installing SWT on sites with average wind speeds ranging from 4.4 to 5.6 m/s (~ 10-12 mph), and with unobstructed access to winds. In fact, less than 1% of all SWT installations are done in urban location. This is mostly because wind resource and quality is limited through obstruction in densely developed areas, hence requiring towers, and excessive land use that may conflict with zoning and sitting requirements and regulations [55].

Based on the aforementioned, SWTs can represent a limited potential that primarily hinges upon resource adequacy, efficient land use, and zoning issues. According to authors in [41], using a very conservative estimate (an average land use of 0.02 km2 per turbine), SWTs through distributed generation are capable of producing nearly 36,000 MWh of electricity. However, if we assume a SWT required clearance area not less than 1.5 times the tower height plus the rotor radius, the average land use for a SWT is approximately 1,200 m2 per installed turbine (per kW). In addition, SWT shall only be considered in areas with adequate wind speeds, unobstructed access, and low density urban development (assumed as 10% out of the 3 km wide band along the south, east, and north coast regions; or 1% of Puerto Rico's total land area) there is approximately 96 km^2 for the integration of SWT. Hence, **Puerto Rico has the potential to install a generation capacity of 80 MW through Small Wind Systems**. Thus, assuming a 22% capacity factor, using a conservative approach, SWT are capable of producing around 154,000 MWh of electricity.

7.3.5. Energy Efficiency

As presented on our literature review, energy efficiency is considered to be a proven mechanism to reduce dependence on conventional energy sources, such as fossil fuels, and employ the use of existing resources in a more efficient manner, hence reducing waste energy. As an essential contribution of this project, the author was interested in understanding the implications of including energy efficiency as an eligible technology and potential option to meet RPS requirements. This project has only focused on near-term, achievable, and proven to be cost-effective energy efficiency measures as to provide with a general estimate of its potential contribution towards common objectives within the energy and electric power sector.

Energy efficiency potential has been analyzed according to their respective sectors, and with greater emphasis in end-users, that has been broken into residential, and commercial and industrial.

For the residential sector we have identified the following achievable measures:

(1) Residential Energy Conservation Codes (IECC 2009)

(2) Solar Water Heaters

(3) Energy Star ® Appliances (Lighting, A/C Units, and Domestic Appliances)

For the commercial and industrial sectors we have identified the following cost-effective and achievable measures:

(1) Commercial Energy Conservation Codes (ASHRAE 90.1-2007)

(2) Industrial Energy Efficiency Retrofits

The methodology used to determine energy efficiency technical potential, was adapted from [56]; it provides a general approach as to the available technical potential calculated as it follows:

$$Technical\ Potential_{per\ EE\ measure} = kWh_{Total} \times BC_{\ factor} \times R_{\ factor} \times C_{factor} \times S_{\ factor} \tag{7.1}$$

Where,

kWh_{Total} is the total consumption (according to electricity sales) per sector under analysis

$BC_{\ factor}$ is the base case factor or fraction of the end use electricity applicable for the measure under evaluation in a given sector or market.

$R_{\ factor}$ is the remaining factor or fraction of applicable total kWh sales that are associated but has not yet been addressed by the energy efficiency measure under evaluation.

C_{factor} is the conversion factor or fraction of the applicable market segment that is technically feasible to undergo the energy efficiency measure under study

$S_{\ factor}$ is the energy savings factor or applicable percentage energy reduction resulting from energy efficiency measure under study.

To develop an achievable potential estimate from energy efficiency measures included within this study we have used a conservative achievable penetration rate of 60 percent by 2035 for the residential, and commercial and industrial sectors. This directly implies that the determined technical potential will be multiplied by 60% to estimate achievable savings by 2035. Additional assumptions and related data were included in Appendix A.

For the residential sector, technical potential is estimated to be approximately 7,950 million of kWh and based on the assumed market penetration rate; achievable potential is estimated to be 4,770 million kWh. Table 7 shows the potential savings in terms of cumulative annual (million kWh) and in percentage using fiscal year 2010 as the baseline or reference year. In addition, Figure 21 shows the potential savings contribution by each measure considered in this study.

Residential Sector Potential Energy Savings by 2035		
Energy Efficiency Potential	*Cumulative Annual Energy Savings by 2035 (Million kWh)*	*Percentage of FY 2010 (% of Baseline Year)*
Technical	7,950	41.3%
Achievable	4,770	24.8%

Table 7 Potential Electricity Savings from Energy Efficiency Measures in the Residential Sector

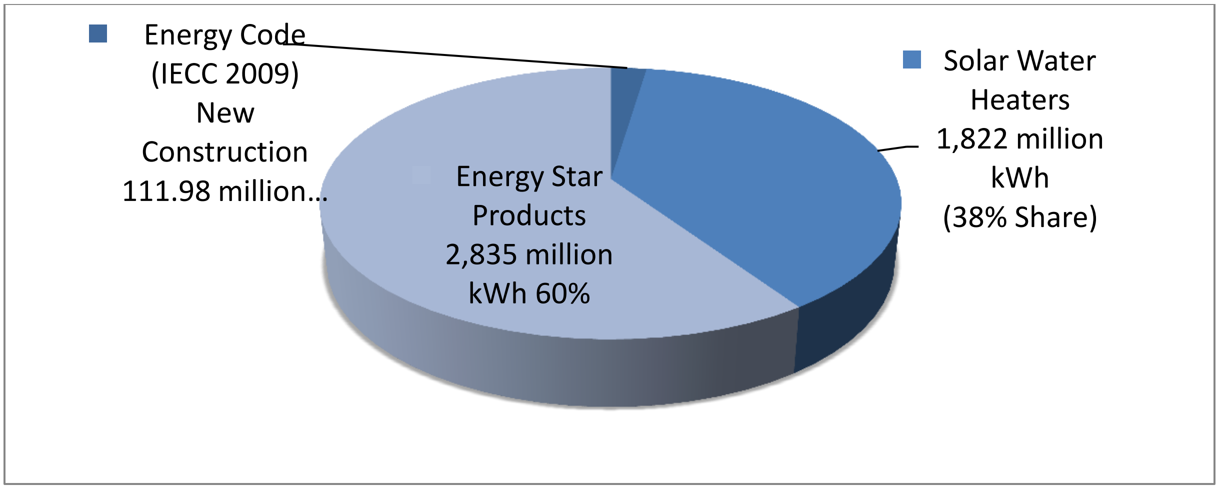


Figure 21 Residential Sector - Achievable Potential Savings By Measure Type

For the commercial and industrial sector, technical potential is estimated to be approximately 5,535 million kWh and based on the assumed market penetration rate; achievable potential is estimated to be 3,321 million kWh. Table 8 shows the potential savings in terms of cumulative annual (million kWh) and in percentage using fiscal year 2010 as the baseline or reference year. Also, Figure 22 shows the potential savings related to each measure considered in this study.

Commercial and Industrial Sectors Potential Energy Savings by 2035		
Energy Efficiency Potential	*Cumulative Annual Energy Savings by 2035 (Million kWh)*	*Percentage of FY 2010 (% of Baseline Year)*
Technical	5,535	28.8%
Achievable	3,321	17.3%

Table 8 Potential Electricity Savings from Energy Efficiency Measures in the Commercial & Industrial Sectors

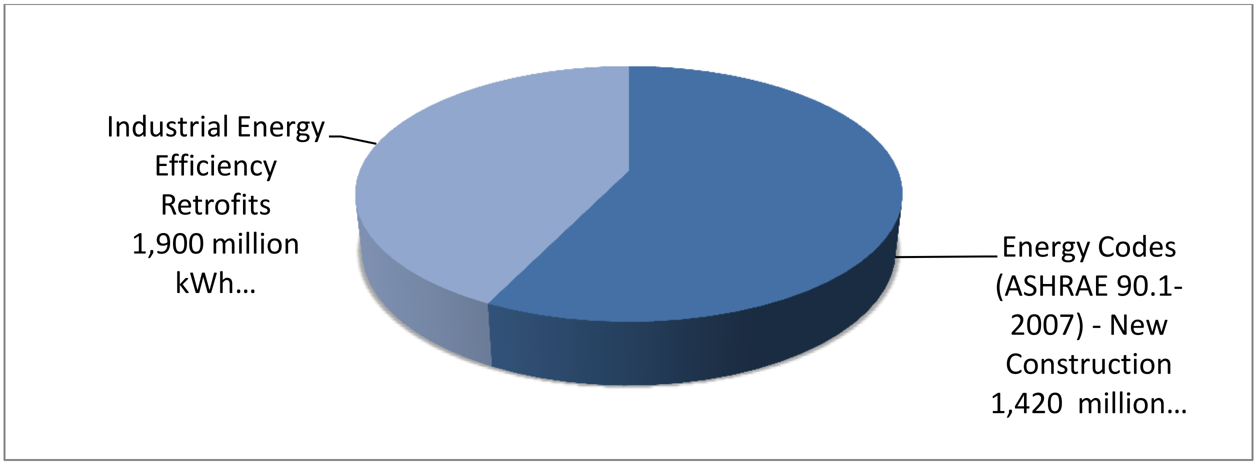


Figure 22 Commercial and Industrial Sectors - Achievable Potential Savings by Measure Type

Summarizing, and based on the methodology described in this section, we estimate an overall achievable potential for energy efficiency in Puerto Rico is nearly 42% by 2035, using fiscal year 2010 as a reference or baseline. Table 9 below displays the energy efficiency potential savings (million kWh) by 2035 for Puerto Rico. Results also indicate that that there is sufficient energy efficiency potential to contribute towards RPS targets.

Energy Efficiency Potential	**Cumulative Annual Energy Savings by 2035 (Million kWh)**	**Percentage by 2035 (% of Baseline Year, FY 2010)**
Technical	13485.74	70.11%
Achievable	8091.44	42.07%

Table 9 Overall Potential Energy Savings from Energy Efficiency Measures in Puerto Rico

In fact, the determined energy efficiency achievable potential, presented above, provides enough resources to comply with an RPS target of nearly 40% by 2035. Still, one must recognize that the achievable potential determined in this study has not yet included the necessary programmatic support to ensure proper enforcement and effectiveness of the analyzed energy efficiency measures. Programmatic support typically includes incentive programs, and respective administrative cost.

In addition, there are also social factors such as consumer consumption patterns and consumer perceptions that might influence, positively or negatively, whether the efficiency goals are met or not. Figure 23 presents projections for energy efficiency related savings under various case scenarios including, base case scenario projections.

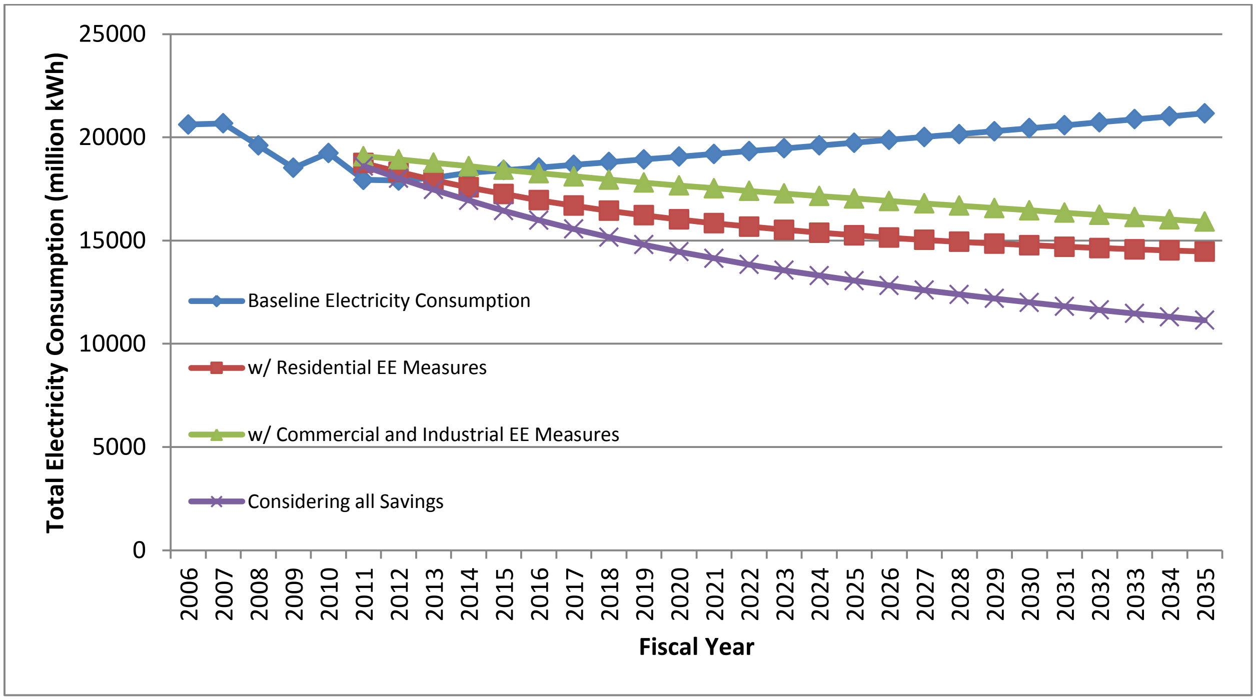


Figure 23 Energy Efficiency Potential Savings Projections from 2011-2035

Potential economic savings related to the integration of energy efficiency as an eligible technology to comply with RPS targets are typically measured through their respective avoided costs: both energy-related and capacity-related. In addition, environmental benefits frequently included and accounted in avoided costs analysis includes GHG emission reductions. Energy, capacity and environmental related avoided cost are summarized as shown in Table 10.

Energy Efficiency in the Electric Power Sector	
Energy-Related Avoided Cost	*Capacity-Related Avoided Cost*
Fuel, production, and maintenance cost	Energy Purchases
Generation, T&D losses	New Generation Capacity Construction
Ancillary Services	T&D New Capacity build
Emission Reductions	Land Use

Table 10 Energy Efficiency Avoided Cost, Adapted from [57]

Energy efficiency, by reducing energy demand and consumption, directly reduces the amount of renewable energy required according to RPS targets, thereby reducing RPS compliance cost. When the cost of achieving higher levels of renewable energy production is significantly higher than the avoided cost for conventional generation plants, energy efficiency provides a huge potential for to reduce RPS compliance costs. Furthermore, from a social perspective, energy efficiency provides a better quality of life, by reducing the environmental quality deterioration derived from fossil fuels. In order to attain the aforementioned energy efficiency potential savings government support will be required. This includes financial incentives to customers, marketing, administration, planning, and program evaluation activities provided to ensure the delivery of energy efficiency products and services to consumers.

There are many social factors involved in how people or companies use energy. Therefore, energy policies should address consumer behavior as much as any efficiency technology or measure. Moreover, at some point in the establishment of an energy policy, consumption patterns and their causes must be studied and considered [32] Therefore, although it is beyond the scope of this project, energy efficiency policies should consider social factors, such as energy consumption patterns and customer perception. In addition, studies should be performed to determine the impact of consumer behavior towards energy efficiency enforcement.

7.4. Cost and Performance Assumptions for Renewable Energy Technologies

This section provides a summary of current capital and operating costs for the selected technologies under this study. It also describes performance characteristics for each technology included. The data presented is based on information from available sources such as the U.S. Department of Energy –Renewable Energy and Energy Efficiency, National Renewable Energy Laboratory (NREL), Lawrence Berkeley National Laboratory, Energy Information Administration (EIA), International Energy Agency (IEA), and the Electric Power Research Institute (EPRI), among others. Each technology is described according to their cost and performance characteristics.

Although most of the selected renewable and alternative technologies are commercially available, one must highlight that some are still not in a mature market stage, hence their respective initial investment cost may be greater when compared to other renewables and conventional power generation technologies. Nonetheless, according to national and worldwide outlooks, these costs are expected to decline as renewable technologies increase their penetration within renewable energy markets.

7.4.1. Wind

*Capital Cost - W*ind energy has emerged to become the second largest source of renewable energy worldwide. By the end of 2009, global installed capacity totaled 159 MW, whereas 38 GW were installed added that year [58]. One of the main drivers for its rapid growth and development was the reduction in capital cost. Lately, the wind industry has shown some cutbacks in the development of wind energy projects. According to [59], the Installed Cost of wind energy projects has continued to rise since 2009, but reductions are foreseen in the near-term. It is clear that the development of the wind power industry is affected by numerous factors, with capital costs and performance being key contributors. In general, a wind project's installed cost includes equipment purchase, installation, and other additional components such as labor, permitting and fees, interconnection expenses, shipping, overhead, and profit.

Through history, the installed cost of wind power projects has declined dramatically, specifically from the 1980's through early 2000's. In 2010, capital cost for wind energy projects were around \$2,230 per kW, but has recently increased. Trends have shown that a huge share of the installed project cost increase has come from turbine prices. Furthermore, the increases in turbine prices and hence installed cost over this period has resulted from several factors including but not limited to the value of the U.S. dollar, increased cost in materials and commodities, and shortages in turbine and components within the manufacturing industry, among others [59].

In addition, small wind turbines, generally ranging in size from a few hundred watts to up to 100 kW, and used in residential, commercial and light industrial applications. In the U.S., this market has shown a significant growth in sales, and accumulated capacity reaching 100 MW by year 2009. Market growth within the aforementioned sector has been positively impacted with the variety of incentive programs adopted in recent years. According to [60], the installed cost for small wind turbines range from \$3,000-\$6,000 per kW; specifically the average cost during 2009 was \$4,039 per kW.

For the purpose of determining the levelized cost of energy for the selected technologies under our study we have selected the highest cost to assume the worst case-scenario. In addition, Puerto Rico lacks of wind energy technologies manufacturing industries, and thus an additional import cost to be incurred by developers was assumed. For utility-scale projects we have used $2,600 per kW, according to IEA and NREL high reference cost during 2009. For small wind projects we have used $6,000 per kW, according to AWEA high-reference cost in 2009. However, we have consider an additional $1,000 per kW due to shipping costs, and foundation requirements that require towers and foundations to be heavier and more expensive than normal to sustain hurricane winds (or have a tilt-down tower). Thus, the reference capital cost for small wind turbines (SWT) was taken by this author as $7,000 per kW. Table 11 shows a summary of wind projects capital cost according to various sources used as reference.

Source	Description	Capital Cost (2009 $/kW)
American Wind Energy Association (AWEA),	Small Wind (Low) Small Wind (High)	$3,000 $6,000
Lawrence Berkeley National Laboratory	Weighted-Average	$2,230
National Renewable Energy Laboratory (NREL), [61]	Utility-Scale (Low) Utility-Scale (Base) Utility-Scale (High)	$1,240 $1,710 $2,600
International Energy Agency (IEA), [43]	Utility-Scale (Low) Utility-Scale (High)	$1,450 $2,600
Energy Information Administration – AEO 2010, [62]	Utility-Scale (Low) Utility-Scale (High)	$1,759 $1,966
Lazard 2009 Analysis, [63]	Utility-Scale (Low) Utility-Scale (High)	$1,900 $2,500
KEMA Market Analysis, [64]	Utility-Scale	$1,870
EPRI - MERGE, [52]	Utility-Scale	$2,350
EPA 2009 (IPM), [52]	Average	$1,831

Table 11 Wind Power Systems Capital Cost from various sources (2009 $/kW)

Furthermore, for the purpose of determining future cost projections an annual growth rate of 5% was assumed for the period between 2011- 2014 according to manufacturing and supply chain limitations [64]. Then, from 2015-2035 an annual reduction rate of 1.5% was assumed taking into consideration significant technology improvements and cost reductions, as presented in [64] and used by the Energy Information Administration – National Energy Modeling System.

Operation and Maintenance – It is important to understand that operations and maintenance (O&M) costs represent a significant component when determining the overall levelized cost of wind energy. Furthermore, according to market studies, O&M cost can vary substantially among projects [59]. Operations and maintenance (O&M) cost in wind energy projects typically include service, spare parts, insurance, administration, site rent, and any utility service related cost [39].

Operations and maintenance charges are typically distributed between fixed and variable components of the total O&M cost. For this analysis, variations in O&M expenditures are tested as changes within the variable charges only. Although, market reports have highlighted the difficulty to quantify O&M cost for wind energy projects, they have been estimated to range from \$12 to \$32 per MWh [39]. Other market reports, present O&M cost for wind energy projects, as fixed cost expressed in \$/kW per year [52]. For the purpose of this study, operation and maintenance (O&M) cost was taken as a fixed cost of \$30.98 per kW/year escalated with a 1% inflation rate, based on Annual Energy Outlook 2010, National energy Modeling System assumptions.

Performance Characteristics – According to [59], capacity factors for wind energy projects have generally increased over time due to several factors such as an increase in hub heights and rotor diameters, and technology advances. For the purpose of our study, and based on the resource availability presented earlier, we have assumed wind energy capacity factor as 30% for utility-scale projects and 25% for small wind turbines. In both cases we have assumed capacity factors to remain constant through the economic life of the project.

7.4.2. Solar PV

Capital Cost – Solar PV is a commercially available technology with a significant potential and highly abundant resource for long-term growth. The solar PV industry has experienced impressive growth rates in production, shipment, and sales through recent years. Solar PV has emerged as the fastest growing of all renewable power technologies, with annual growth rates exceeding 40% [65]. Short-term projections foresee various emerging technologies, known as third-generation PV, achieving very high efficiency and substantial cost reductions. As of today, PV modules have attained major improvements and cost due to product demand growth in response to renewable energy policies, and financial incentives encouraging solar energy development.

The cost of installing a solar PV is typically measured in dollars per installed capacity (mainly expressed in \$/w, or \$/kW). In 2008, the averaged installed cost for a solar PV system was \$7,500 per kW [42] while in 1998 it used to be close to \$10,000 per installed kW. Total system costs consist in the addition of module cost, balance of system cost, and other additional components such as labor, permitting and fees, shipping, overhead, and profit. The term "balance of system" includes mounting structures, inverters, cabling and power management devices. In year 2009, the PV industry showed major price declines for PV modules, reaching values of \$1.85-\$2.25 per watt from \$3.50-\$4.00 per watt in 2008 [66]. Hence, with module prices being nearly 50% of the total installed cost of a PV system, it resulted in lower solar PV installation costs. In 2010, solar PV system cost ranged from \$4,000-\$6,500 per installed kilowatt. Thus, it is very important to mention that variations within solar PV system cost, referenced herein, strictly depend on the economies of scale, type of application, and source of information [43].

For the purpose of determining the levelized cost of energy for solar PV projects in Puerto Rico we have reviewed data from available sources and selected a conservative reference cost for each respective application. It is also worth mentioning that Puerto Rico currently has no solar PV manufacturing industries, hence developers will incur an additional import cost. For utility-scale projects we have used $4,000 per kW; for commercial large-scale distributed generation projects we have used $5,000 per kW; and $7,000 for small-scale solar PV distributed generation (DG). Table 12 shows a summary of solar PV projects capital cost according to various sources used as reference.

Source	Description	Capital Cost (2009 $/kW)
National Renewable Energy Laboratory (NREL), [64]	Low High	$5,534 $6,279
International Energy Agency (IEA), [43]	Utility-Scale Commercial Residential	$4,000 $5,000 $6,000
Energy Information Administration – AEO 2010, [62]	Low High	$5,468 $6,171
Lazard 2009 Analysis, [63]	Utility-Scale (Low) Utility-Scale (High)	$4,500 $5,000
KEMA Market Analysis	Utility-Scale	$4,550
EPA 2009 (IPM), [52]	Average	$5,614

Table 12 Solar PV Capital Cost from various sources (2009 $/kW)

Furthermore, for the purpose of determining future cost projections an annual decline rate of 2% was assumed for the period between 2011- 2014 taking into consideration conservative technology cost reductions, and manufacturing improvements [64]. Then, for the period between 2015-2035 a more aggressive annual reduction rate of 3.4% was assumed, mainly emphasizing major technology improvements and cost reductions in accordance with NREL Annual Change assumptions under the Strategic Energy Analysis Center (SEAC) [64]. In fact, according to DOE’s Energy Efficiency and Renewable Energy Office, the goal is to reduce the total cost of solar energy systems by about 75 percent, or roughly $1 per watt, before the end of the decade [67].

Operation and Maintenance –PV systems do not have moving parts, thus operating and maintenance (O&M) costs are relatively small when compared to other renewable technologies. These costs typically include conventional maintenance (inverter and panel cleaning), land cost, insurance, and field repairs, among others. As any other economy of scales, the larger the PV system size, the lower its respective O&M cost per kW/year.

According to [42], annual O&M costs in 2008, expressed as a percentage of installed system cost ranged from 0.12% for utility-scale generation to 1.4% for small-scale systems. Others, such as [43], are estimate O&M cost to be approximately 1% of capital investment per year. For the purpose of this study, operation and maintenance (O&M) cost was taken as a fixed cost of 0.1% and 1% of the capital cost per kW/year for large-scale (including utility and commercial) and distributed generation solar PV projects, respectively. In addition we have projected O&M cost to escalate with a 1% inflation rate.

Performance Characteristics – The levelized costs of energy for solar PV systems depends heavily on the amount of solar irradiation, and thus the resulting overall capacity factor. For the purpose of our study, and based on the resource availability presented earlier, we have taken solar PV capacity factors as 22% for utility-scale projects and 20% for large small scale distributed generation projects. In both cases we have assumed capacity factors to remain constant through the economic life of the project.

7.4.3. Waste to Energy

Capital Cost – WTE capital cost is commonly expressed in terms of capital cost per annual design ton and varies according to the respective WTE technology, location, size, and other factors [51]. Most common types of WTE technologies include Combustion (mass burn / water wall, mass burn / starved air, and refused-derived fuel); gasification of MSW; plasma gasification; and pyrolysis. It should be noted that conventional combustion is considered to be commercially proven, mature, and often used in large WTE facilities [51]. In contrast, Pyrolysis, gasification, and plasma-arc gasification are considered to be emerging new technologies still under a commercialization and market development stages [47].

WTE facilities serve two main purposes: waste management and disposal, and electricity generation. In fact, WTE facilities are mainly funded through annual revenues from MSW tipping fees, sales of electricity and excess capacity, and resale of recycled materials. They are mainly seen as two separate businesses within a single facility, one being the disposal and management of MSW, the other electricity sale. The disposal of MSW is a vital component for the operation of a WTE plants, whereas WTE plants would not exist if the fuel (MSW) had to be paid for (e.g. oil, natural gas, and coal), instead of being a source of revenue.

According to the Waste to Energy Research and Technology Council (WERTC), the average capital cost is estimated to be about $650 per annual ton of capacity. Therefore, with a WTE plant capacity factor of 85%, capital cost could be expressed as $200,000 per daily ton of capacity. According to DOE’s Energy Information Administration under their report on Capital Cost Estimated for Electricity Generation Plants for 2010 provides an average capital cost expressed in dollars per installed kW for the location of Puerto Rico [68]. Capital costs referenced above include thermal equipment (e.g. boiler and incinerators), energy production units (e.g. turbines and generators), building-related work, Air Pollution Control (APC) equipment, and permits, approvals, among others.

For the purpose of determining the levelized cost of energy for WTE projects in Puerto Rico the author has taken as a reference a capital cost of $600 per annual ton of capacity, or 8,055 per installed kW according to estimates provided in [68]. Furthermore, an annual decline rate of 1% from 2011-2035 was assumed taking into consideration conservative technology advances as well as manufacturing cost reductions. An important disclaimer is to recognize that the capital cost used by the author represents the total investment cost to construct a WTE facility with the necessary equipment of operate both businesses (waste disposal and management, and electricity sale).

Operation and Maintenance – Operation and maintenance (O&M) cost for a WTE facility typically include annual expenses such as labor, maintenance, utilities, replacements parts, administration, management and disposal of residues, required to operate the facility on a daily basis. O&M cost varies substantially according to the technology and project specifics. According to [69]& [49], annual O&M cost range from $40 to $65 per annual ton or approximately 6-10% of the total project cost. Converted in terms of dollars per installed kilowatts of electric power capacity is around $500-800 per kW per year. For the purpose of this study, operation and maintenance (O&M) cost was taken as a fixed cost of 6% of the capital cost, or nearly $40 per annual ton (or 607 expressed in $/kW/year). In addition the author has projected O&M cost using a 1% inflation rate.

Although O&M cost are relatively high, WTE facilities also derive revenues from their daily operations. As mentioned earlier, revenue sources include MSW tipping fees, and sale of metals, ash, and electricity. Since, our objective is to determine the levelized cost of energy for a WTE project in Puerto Rico we have considered a fix price for tipping fees and metals sale. To provide with assumptions, the author has undertaken a tipping fee of $45 per ton, a ferrous metals resale price of $50 per ton, and non-ferrous metals resale price of $1,000 per ton. A 5% metal recovery rate of was also assumed with the following distribution: 4.75% ferrous and 0.25% non-ferrous.

Performance Characteristics – WTE plant performances are mainly characterized by thermal efficiency and energy recovery rates. Furthermore, several factors influence a plants overall energy efficiency including type of waste being treated and their respective calorific values; plant design; energy production sale potential (both electricity and heat). It should be noted that highest levels of waste energy utilization are achieved in cases where it is possible to recover heat from thermal processes together with electricity generation. Conventional energy recovery rates for the main types of WTE technologies are summarized in Table 13.

For the purpose of our study, and based on the technology and market availability, the author has assumed an average energy production rate of 550 kWh/ton for utility-scale WTE projects. In addition, a WTE Plant capacity factor as 85% was assumed to remain constant through the economic life of the project [64].

Technology (Thermal Process Type)	**Net Energy Production (kWh/ton of MSW)**
Combustion	544
Gasification	685
Plasma Gasification	816
Pyrolysis	571

Table 13 WTE Technologies and Net Energy Production Characteristics, Adapted from [69]

7.4.4. Summary of Cost and Performance Assumptions

This section summarizes cost and performance characteristics for the selected technologies, expressed in 2010 USD. We have employed a very conservative approach whereas the total capital cost includes the technology capital cost, presented above, and multiplied by a Project Contingency Factor. Then, a project land-related cost is added to attain the Total Capital Cost. Moreover, Project Contingency is defined by the American Association of Cost Engineers as the "specific provision for unforeseeable elements if cost within a defined project period”. Hence, the formula used is the following:

$$\mathit{Total\ Capital\ Cost} = \mathit{Capital\ Cost}\ \times \mathit{Project\ Contingency} \times (1 + 10\%) \tag{7.2}$$

Table 14 provides with a summary of cost and performance characteristics used in our study to determine their respective levelized cost of energy.

	Units	**Utility-Scale Wind**	**Utility-Scale Solar PV**	**Utility-Scale WTE**	**Large-Scale Commercial Solar PV**	**Solar PV DG**	**Small Wind DG**
Net Generation Capacity	MW	>10	>10	>1	>1 <10	≤1	≤1
Capital Cost	$/kWh	$2,730	$3,920	$8,015	$4,900	$6,370	$5,904
Project and Land Cost	%	10%	10%	—	10%	—	—
Project Contingency	Factor	1.07	1.05	1.0	1.05	1.05	1.07
Total Capital Cost	$/kWh	$3,213	$4,528	$8,055	$5,390	$6,689	$6,317
Fixed O&M	$/kW/yr	$31	$12	$808	$25	$66	$31
Variable O&M	$/kWh	—	—	—	—	—	—
Capacity Factor	%	30%	22%	85%	20%	20%	25%
Project Life	Years	25	25	25	25	25	25
Heat Rate	Btu/kWh	—	—	18000	—	—	—

Table 14 Renewable Energy Technologies Cost and Performance Assumptions taken for FY 2011

7.4.5. Renewable Energy Technologies - Future Cost Projections

Since most of the renewable energy technologies selected in this study are still developing and in some cases maturing, we have projected cost characteristics to consider potential changes in the near and long term future. We have evaluated and provided projections specifically for Total Capital Cost (overnight, development and land, and contingency cost); and O&M Cost.

Figure 24 shows Total Capital Cost projections for each of the selected technologies and respective applications, expressed in 2010 USD. Likewise, Figure 25 show variable O&M cost projections for applicable technologies and respective applications. Annual growth and decline rates used for the figures presented below were based on cost and performance assumptions presented for each renewable energy technology and respective application.

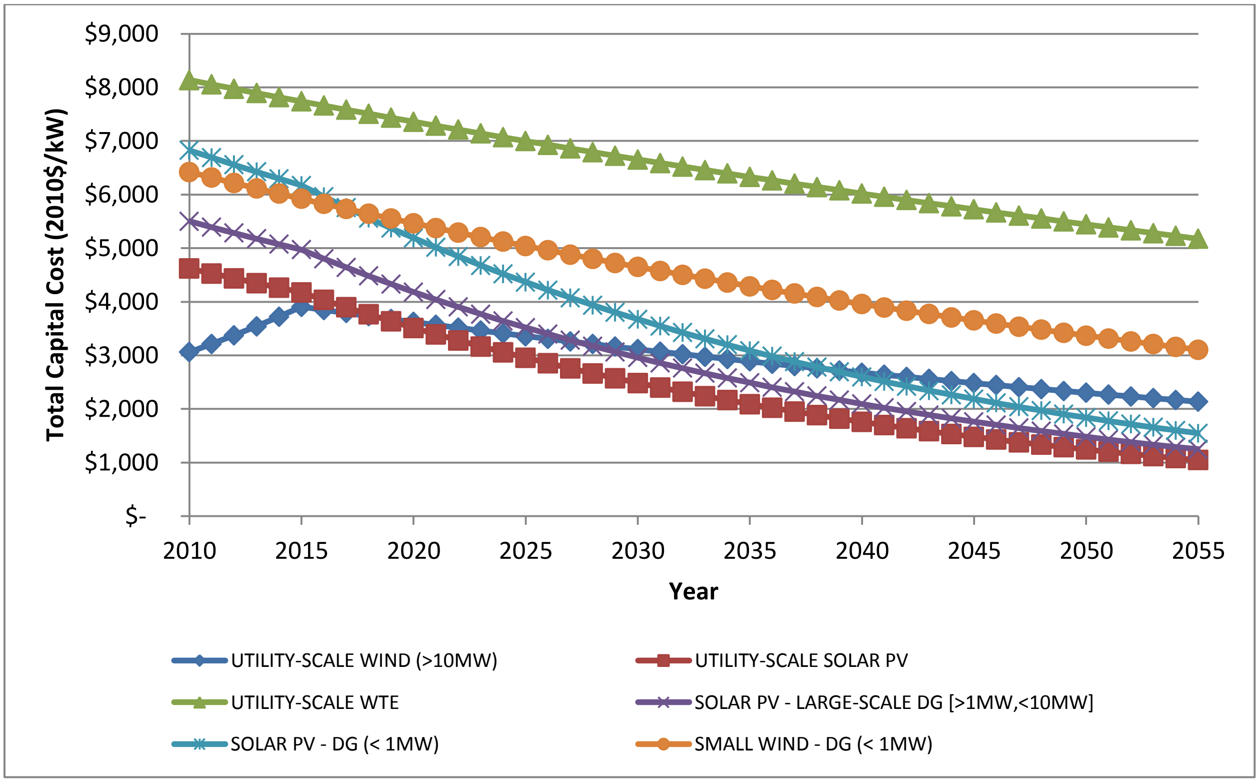


Figure 24 Renewable Energy Technologies - Total Capital Cost (2010$/kW) projections from 2011-2055.

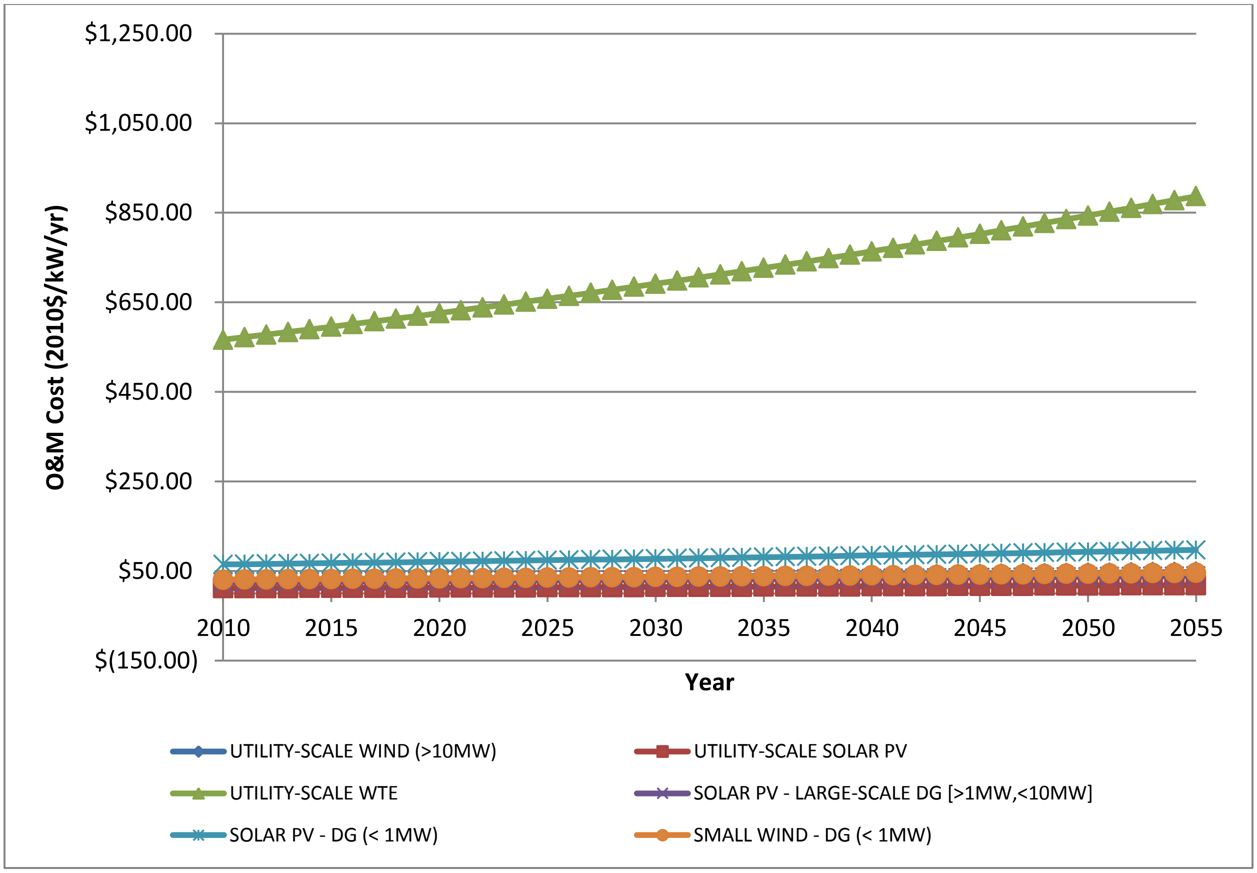


Figure 25 Renewable Energy Technologies - O&M Cost (2010$/kW) projections from 2011-2055.

7.5. FINANCING ASSUMPTIONS

Certain financial assumptions were made to estimate the cost of renewable and alternative energy technologies. Financing assumptions are critical in renewable energy projects due their respective high cost of capital. Hence, assumptions were made for the following items:

- Financing Structure (debt/equity)
- Debt and Equity Cost
- Project Economic Life
- Taxes, depreciation and tax incentives
- Inflation

- Discount Rates
- Fixed Charges
- Depreciation

In general, the following assumptions listed in Table 15 were made to determine the levelized cost of energy for each selected renewable energy technologies.

Financial Assumptions	
Project Economic Life (years)	25
Inflation Rate	1.6%
Nominal Discount Rate	12.0%
Real Discount Rate	10.2%
Debt (%)	60%
Debt Cost	8.0%
Debt Term (years)	15
Equity (%)	40%
Equity Cost	12%
State Tax (Fix tax rate under Act No. 83, 2010)	4%
Federal Tax (when applicable)	35%

Table 15 Financial and Economic Assumptions for LCOE Analysis

Financing Structure – For modeling purposes, a standard financing structure for renewable and alternative project development was assumed. Essentially, a combination of debt and equity investments was used. Specifically with a debt/equity ratio of 60/40, meaning project financing is based on 60% debt and 40% equity.

Debt and Equity Cost – According to industry standards a debt cost of 8% and equity cost of 12% has been assumed. Project equity, is capital typically supplied by project sponsors, including but not limited to private equity firms or developers. On the other side, project debt is typically supplied by bank or a group banks who lend according to the project expected revenues and respective cash flows. It very important to understand that private sector financing is strictly hinges around the concept of attractive and risk-adjusted Return of Investment (ROI), hence the availability of incentives and supporting energy policy directly benefits developer's ROI [70].

Economic Life– Regarding renewable energy project life, an economic and tax life of 25 years has been assumed the selected technologies.

Debt Terms – The debt term is assumed to be 15 years based on current market information. According to [71], markets have shown debt terms typically less than the expected economic life of the project when financing renewable and alternative energy projects.

Taxes, depreciation and tax incentives – For those projects assumed to be granted with the Cash Grant in Lieu of Tax Credit under Section 1603 of the American Reinvestment and Recovery Act of 2009 (ARRA), the project has assumed the developer(s) will be paying taxes at a federal and state level. A federal tax rate of 35% was used, and a 4% fix tax rate was used locally (state) according to Act No. 83 of 2010.

Inflation – Inflation rates were taken as 1.6% according to the latest inflation rate provided for January 2011, based on the consumer price index [72]. Inflation rates were used to determine project-related fixed charges by means of financial pro-forma cash-flow sheets (refer to Appendix C).

Discount Rates – discount rates were taken as nominal values since our study was based on current dollar value. These rates were used to compute present values on our LCOE analysis. Although discount rates vary depending on the industry and market conditions, for commercial and industrial sectors, most experts recommend a discount rate equal to the opportunity cost of capital (also refer to as rate of return). For the purpose of the LCOE analysis, nominal dollar values were used at a discount rate of 12% (assuming a 12% rate of return for utility-scale renewable energy projects). [73]

Fixed charges – account for the amount of annual revenue required that must be to pay project carrying charges on the investment. Carrying charges include return on debt, insurance, income and property tax, and depreciation. For each technology, and based on the aforementioned assumptions, fixed charges were calculated and included within our LCOE analysis (refer to Appendix E).

Depreciation – When applicable, such as for projects developed in 2011 and assuming they are benefiting from ARRA Section 1603 Cash Grant in Lieu of Tax, we have used Section 168 of the Internal Revenue Code which contains a Modified Accelerated Cost Recovery System (MACRS) through which certain renewable energy investments can be recovered through accelerated depreciation deductions. For projects paying state tax only the super depreciation method has been used as established in Article 2.10(b) of Act No. 83 of 2010. It provides a full depreciation during the first year over the equipment depreciation basis.

Renewable Energy Incentives – For utility-scale renewable projects we have included the following incentives as applicable incentives under the LCOE analysis.

(1) Section 1603 of ARRA authorizes the Department of the Treasury to issue renewable energy project developers a cash grants in lieu of the investment tax credit (ITC). It offers an equivalent 30% cash grant based on the project capital [74]. Projects to be developed prior to the end of 2011 were considered eligible to receive this investment-based incentive due to the recent program deadline extension until January 1st, 2012 [75].

(2) Production Based Incentives in the form of Renewable Energy Certificates (RECs) were considered as eligible incentives for renewable energy projects, nonetheless they were not included within the LCOE analysis. This is based on the fact that there is no price certainty on RECs due to its market-based behavior. Furthermore, RECs were considered to be valued upon the difference between the offered price paid by the electric power utility under power purchase agreements (PPA) and the respective technology LCOE.

7.6. LEVELIZED COST OF ENERGY ANALYSIS

In order to estimate the electricity rate impact under different levels of RPS adoption in Puerto Rico, the author has conducted an LCOE analysis for the selected renewable energy technologies.

The LCOE analysis under this study included all cost related capital investment, construction, operation and maintenance, and financing of a renewable energy project over its lifetime. From an economic perspective, it represents the annualized costs of energy production over the life of the project discounted back to present value dollars. In fact, an LCOE is defined as the net present value of total life cycle costs of the project divided by the quantity of energy produced over the system life [73]. The following formula describes general methodology to calculate an LCOE. However specific details regarding the methodology used by this author are presented in Appendix D.

$$LCOE = \frac{NPV(Total\ Life\ Cycle\ Cost)}{NPV\ (Total\ Life\ Energy\ Production)} \tag{7.3}$$

An LCOE analysis is considered a very useful tool to measure the cost of electricity generation for different technologies. From a corporate perspective, an LCOE not only represents the operation and maintenance over the entire life cycle of an installation; but also the sum of capital amortization, interest payments to creditors and dividends to investors [65]. One must recognize that the calculation of an LCOE is highly sensitive to the aforementioned factors. Thus, in order to ensure accurate results the author has used assumptions and technology characteristics discussed in previous sections.

Based on the results, Table 16 provides a summary of the LCOE analysis for the selected renewable energy technologies included in this study. Furthermore, Figure 26 illustrates a graphical comparison among technologies and their respective applications. The LCOE shown in Figure 26 can also be refer to as an applicable LCOE for renewable projects to be developed in 2011 or based on 2011 cost reference and assumptions.

It is evident that renewable energy technologies deployed for utility-scale projects, such a wind, solar, and WTE provide a lower cost of energy when compared to smaller distributed generation renewable energy projects. In addition to the advantages from economies of scale, the cost of energy for each technology varies in accordance to it cost and performance characteristics. Furthermore, although not covered in this project, the effects on from interconnecting large renewable installations to the electric power system must be carefully studied to determine any additional integration cost, issue or constraint.

	Units	Utility-Scale Wind	Utility-Scale Solar PV	Utility-Scale WTE	Large-Scale Commercial Solar PV	Solar PV DG	Small Wind DG
Net Generation Capacity	MW	>10	>10	>1	>1 <10	≤1	≤1
Capital Cost	$/kWh	$2,730	$3,920	$8,015	$4,900	$6,370	$5,904
Project and Land Cost	%	10%	10%	—	10%	—	—
Project Contingency	Factor	1.07	1.05	1.0	1.05	1.05	1.07
Total Capital Cost	$/kWh	$3,213	$4,528	$8,055	$5,390	$6,689	$6,317
Fixed O&M		$31	$12	$572	$25	$66	$31
Variable O&M	-	—	—	—	—	—	—
Capacity Factor	%	30%	22%	85%	20%	20%	25%
Project Life	Years	25	25	25	25	25	25
Heat Rate	Btu/kWh	—	—	18000	—	—	—
Investment Based Incentive	%	30%	30%	—	30%	50%	50%
Production Based Incentive	$/MWh	—	—	—	—	—	—
Levelized Cost of Energy (LCOE)	$/MWh	$139	$195	$131	$259	$283	$198
LCOE	**Cents/kWh**	**13.85**	**19.48**	**13.15**	**25.92**	**28.26**	**19.79**

Table 16 Levelized Cost of Energy Analysis - Key Assumptions for 2011 LCOE Analysis

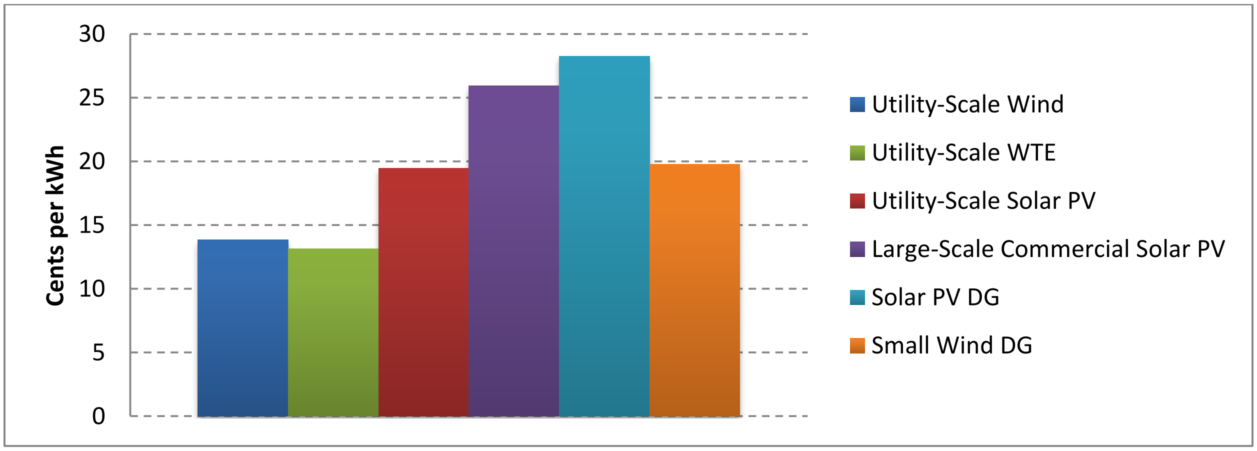


Figure 26 Levelized Cost of Energy (LCOE) for Selected Renewable Energy Technologies in 2011.

When reviewing the cost of energy for utility-scale projects given the cost, performance, and economic assumptions discusses earlier, wind presents the lowest LCOE from the selected technologies, followed by WTE, and solar PV.

Our methodology has employed a dynamic calculation to determine LCOE for renewable energy projects to be developed in the long-term future. Although our long-term definition includes the period from 2015 to 2035 on a 5-year scale-up basis, we have not calculated an LCOE for 2035 since we are not considering a project will start operation on the last year of our study but rather prior to that date. Indeed, we have determined the LCOE for selected technologies for years 2015, 2020, 2025, and 2030.

Results are summarized in Table 17 (expressed in $/MWh) and graphical illustrations with LCOE (expressed in Cents/kWh) are provided in Figure 27, Figure 28, Figure 29, and Figure 30.

Levelized Cost of Energy (LCOE)						
LCOE	Utility-Scale Wind	Utility-Scale Solar PV	Utility-Scale WTE	Large-Scale DG Solar PV	Solar PV -DG	Small Wind - DG
2011	$138.54	$194.85	$131.46	$259.19	$282.61	$197.88
2015	$170.89	$222.88	$130.30	$271.83	$265.24	$187.02
2020	$160.49	$189.99	$128.56	$232.89	$231.60	$174.47
2025	$150.93	$162.39	$127.96	$200.27	$203.69	$162.99
2030	$142.14	$139.25	$127.82	$173.00	$180.62	$152.48

Table 17 Summary of Results for LCOE Analysis

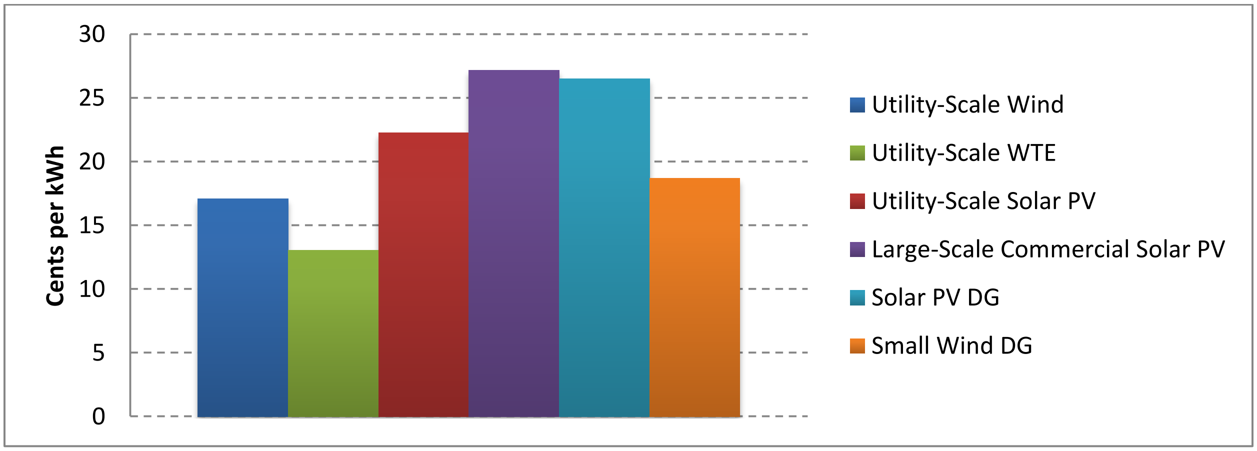


Figure 27 Levelized Cost of Energy (LCOE) for Selected Renewable Energy Technologies in 2015

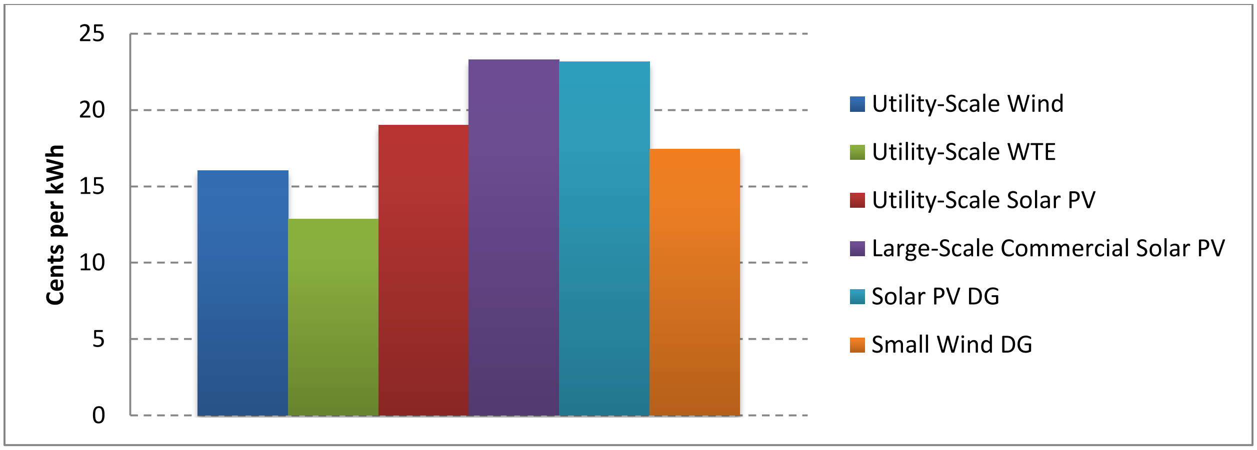


Figure 28 Levelized Cost of Energy (LCOE) for Selected Renewable Energy Technologies in 2020

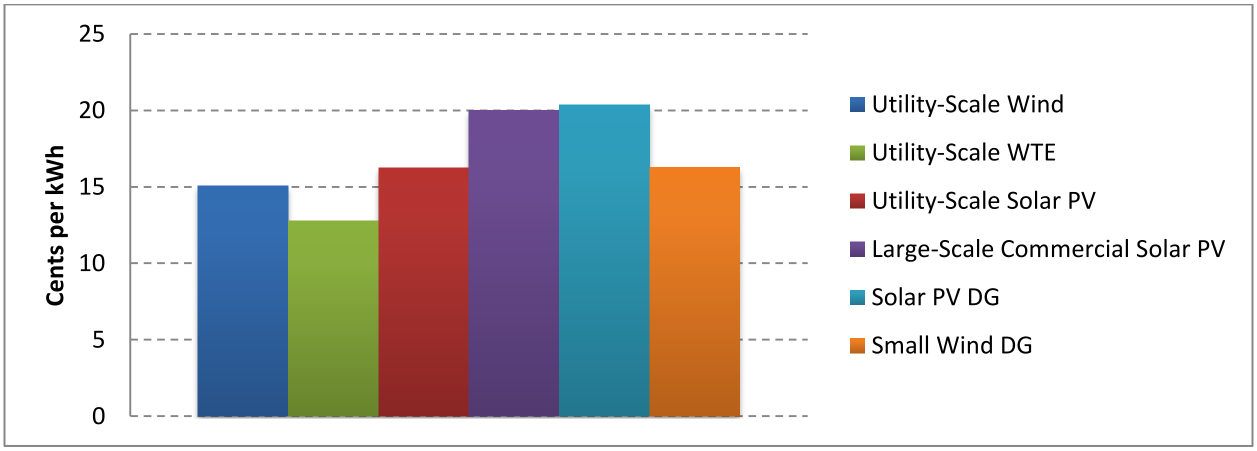


Figure 29 Levelized Cost of Energy (LCOE) for Selected Renewable Energy Technologies in 2025

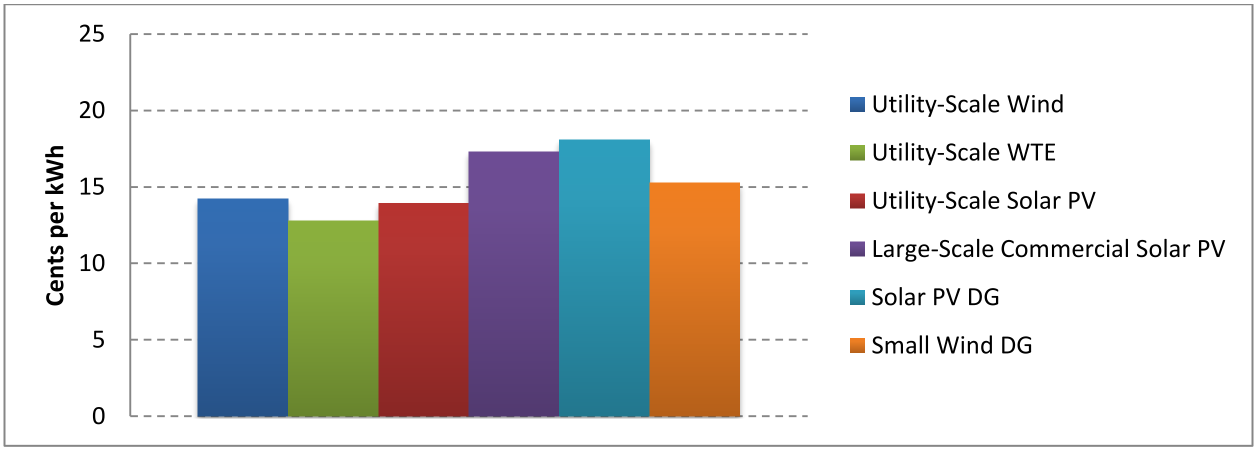


Figure 30 Levelized Cost of Energy (LCOE) for Selected Renewable Energy Technologies in 2030

Although there have been major LCOE reductions over the past few years; renewables are still slightly higher than conventional power sources. Nonetheless, we must also highlight the fact that the costs of most renewable technologies, including those included within this study, are expected to decrease significantly. Thus, LCOE are expected to decrease with time, consistent with our analysis and long-term projections presented above. Social and environmental costs of conventional power sources were not included in this analysis. Nevertheless these externalities can have a dramatic impact in the economic analysis. In addition, infrastructure improvements needed on the electric power grid to support high levels of penetration from renewables were not included within the scope of this project. Therefore, it remains an open question whether Puerto Rico will establish a policy to address and support the investment needed to improve the existing electric power system infrastructure. Finally, the analysis in this project is based on the assumption of integrating renewable energy sources to the electric power system. A different perspective would be to adapt the way the electric power system is planned, designed, constructed, and operated in order to maximize the use of renewable energy, efficiency, and conservation. The former puts emphasis on the grid as it is traditionally viewed; the latter shifts the focus to a new, more holistic view of using to the largest extent possible, the local resources of the island and adapting the electric power grid functionality to that new objective.

7.7. RPS CASE SCENARIOS

In order to determine the economic impact of adopting an RPS three case scenarios have been developed to represent different levels of adoption. Basically, the approach has aimed to provide with a conservative, moderate, and aggressive RPS adoption structures.

RPS Case Scenario 1 has been defined as a conservative adoption and a direct representation of RPS targets adopted through Act No. 82 of 2010 (Energy Diversification Act). Then, RPS Case Scenario 2 and 3 represent the moderate and aggressive RPS adoption levels respectively. Table 18 provides a summary of the three RPS case scenarios and their respective targets by compliance year.

Results provided in this section were inputted to the Total Generation by Fuel module of the EPSEM, to further determine the respective electricity generation requirements by technology and year.

Year	**Adoption Levels (Renewable Portfolio Standard Targets)**		
Case Scenario	RPS Case 1	RPS Case 2	RPS Case 3
2011	0%	0%	0%
2012	3.0%	3.8%	4.5%
2013	6.0%	7.5%	9.0%
2014	9.0%	11.3%	13.5%
2015	**12.0%**	**15.0%**	**18.0%**
2020	**15.0%**	**18.0%**	**25.0%**
2025	**16.0%**	**22.0%**	**30.0%**
2030	**18.0%**	**25.0%**	**35.0%**
2035	**20.0%**	**30.0%**	**40.0%**

Table 18 Renewable Portfolio Standard (RPS) Case Scenarios description

Next, we the required renewable energy generation from each RPS case scenarios has been determined by the author. Using RPS policy standard practices, as well as provisions within Act No. 82 of 2010; RPS renewable energy generation requirements are the percentage of the Net Electricity Sales less the Existing Hydro electricity production by the applicable RPS percentage (target). Thus, expressed mathematically it is as follows:

$$Required\ Generation_{\ kWh} = [Total\ Electricity\ Sales_{kWh} - Existing\ Hydro_{kWh}]\ \times \%(RPS\ Target) \tag{7.4}$$

Therefore, according to electricity sale projections presented in Chapter 6 the required electricity generation from renewable energy sources under each of the adoption scenarios presented below in Table 19.

Required Renewable Electricity Generation (Million kWh)									
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
RPS Case Scenario 1	-	533	1,073	1,631	2,194	2,866	3,195	3,756	4,361
RPS Case Scenario 2	-	666	1,341	2,039	2,743	3,440	4,393	5,217	6,542
RPS Case Scenario 2	-	799	1,609	2,447	3,291	4,777	5,991	7,303	8,722

Table 19 Required renewable electricity generation from RPS Case Scenarios (Million kWh)

7.8. RENEWABLES SUPPLY MIX

Based on data presented on previous sections a renewable technology supply mix has been developed. For the purpose of this study, assumptions were based on developable and selected technologies, their respective resource availability and existing potential, and their respective LCOE.

The approach begins by examining the existing resource-based potential from each of the selected technologies. Then each capacity-based potential was converted into electricity generation using the respective capacity factors discussed earlier in this chapter. Therefore, an overall electricity generation potential was determined. A summary of results is provided below in Table 20.

Technology / Application	**Resource-Based Potential (MW)**	**Average Capacity Factor (%)**	**Maximum Electricity Generation Potential (Million KWh)**
Wind	1,200 - 3,000	30%	7,884
Solar PV	1,125 - 2,250	20%	3,942
WTE	~150	85%	1,116
Solar PV - DG	~1,900	20%	3,329
Small Wind -DG	~80	25%	175

Table 20 Resource-Based Electricity Generation Potential (Million kWh)

Next, a reference supply mix from each technology has been determined based on the total electricity generation potential (refer to Table 21).

Technology / Application	**Electricity Generation Potential (Million KWh)**	**2011 LCOE ($/kWh)**	**% Contribution of Total Electricity Generation Potential from selected renewbles**
Wind	5,256	$ 13.85	38%
Solar PV	3,942	$ 19.48	29%
WTE	957	$ 13.15	8%
Solar PV - DG	3,329	$ 25.92	24%
Small Wind -DG	175	$ 28.26	1%

Table 21 Resource-Based Electricity Supply Contribution by Technology

LCOE for each technology under analysis was evaluated. While wind's provides with one of the lowest LCOE, there might be additional potential concerns with sitting, intermittency, and its integration. Therefore, we will use a lower developable capacity potential (2,000MW) as a reference. WTE is also capable of generating electricity at relatively low cost; however it will be limited to the available resourced-base potential for purpose of this project. Solar PV was considered to its maximum resource-based potential given that the potential was determined using highly conservative assumptions. Lastly, we have used the estimated resource-based potential for distributed generation to its total. Figure 31 illustrates the renewable technology supply mix developed by this author and according to the aforementioned criteria.

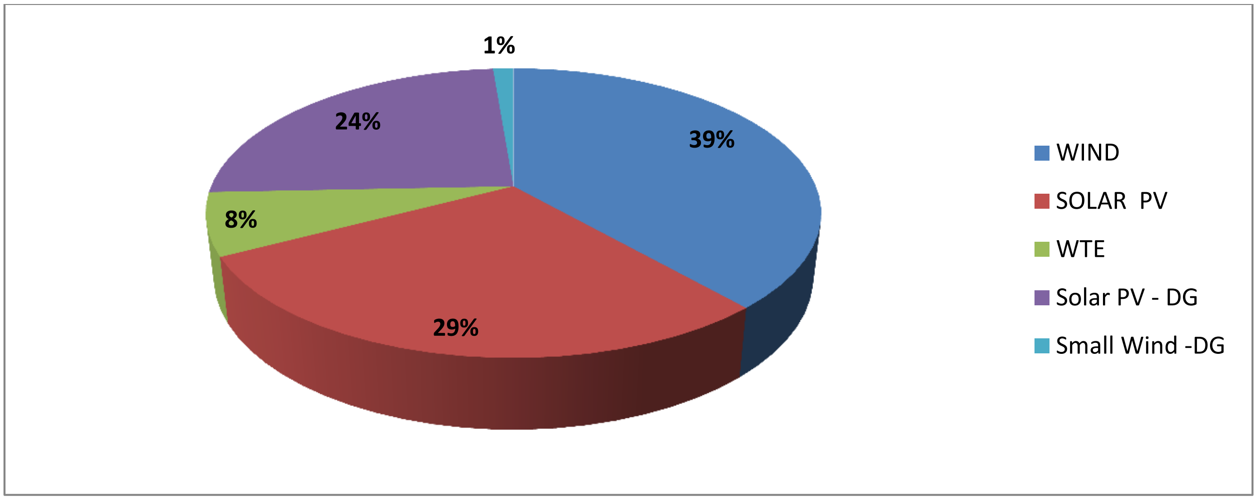


Figure 31 Renewable Technology Supply Mix developed for this study

Furthermore, the author has assumed the technology supply mix to be constant throughout the study period. Notwithstanding the above, one must recognize that technology adoption will vary according to market and industry advances, including but not limited to performance improvements and cost reductions, as well as to public perception and acceptance [76].

An important disclaimer is to recognize that the purpose of this project is not to favor any specific technology but rather evaluate their contribution towards the RPS targets. Our approximation is solely based on resource availability and potential, current markets, cost, and performance characteristics.

7.9. RENEWABLE ENERGY GENERATION REQUIREMENTS

Based on the developed technology supply mix, electricity generation requirements under each RPS case scenario were determined. As provided below, specific renewable resource contributions are based on the technology supply mix and the respective to the RPS scenario. Specifically, Table 22 provides electricity generation requirements from renewable energy sources under RPS Case Scenario 1. In addition, Figure 32 illustrates the resulting supply curve throughout the study period. Furthermore, results on RPS case scenario 2 and RPS Case Scenario 3 are also provided in Table 23 and Table 24, respectively. Likewise, Figure 33 and Figure 34 provide their respective required renewable energy supply curves.

Results provided hereunder, define specific characteristics regarding each RPS Case Scenario evaluated in this project. Furthermore, they are used to determine displaced electricity generation from fossil fuels, hence its interaction towards the electricity rate structure. As presented earlier, the required electricity generation from each renewable technology considered in this study has been used to determine the annual purchased power cost to be incurred by PREPA according to the respective technology LCOE as described in Appendix G.

RPS Case Scenario 1 - Required Generation (Million kWh)									
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Wind	-	203	408	621	835	1,091	1,216	1,430	1,660
Solar PV	-	152	306	466	627	818	912	1,072	1,245
WTE	-	43	86	130	175	229	255	300	349
Distributed Generation	-	135	272	414	557	727	811	953	1,107
Solar PV - DG	-	128	259	393	529	691	770	906	1,052
Small Wind -DG	-	7	14	21	28	36	41	48	55
Total	-	**533**	**1,073**	**1,631**	**2,194**	**2,866**	**3,195**	**3,756**	**4,361**

Table 22 Required Electricity Generation under RPS Case Scenario 1

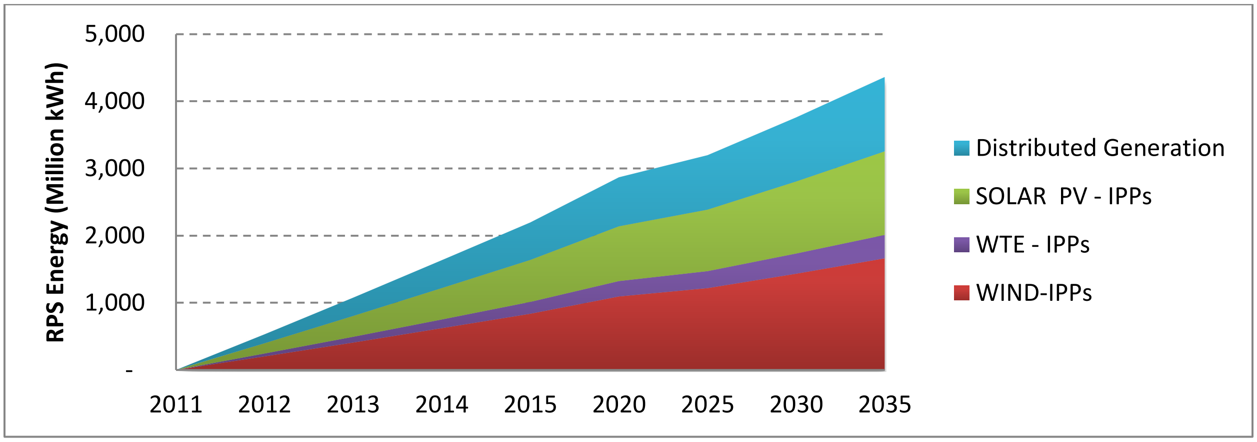


Figure 32 Renewable energy supply curve based on targets from RPS Case Scenario 1

RPS Case Scenario 2 - Required Generation (Million kWh)

Year	2011	2012	2013	2014	2015	2020	2025	2030	2035
Wind	-	253	511	776	1,044	1,309	1,672	1,986	2,491
Solar PV	-	190	383	582	783	982	1,254	1,490	1,868
WTE	-	53	107	163	219	275	351	417	523
Distributed Generation	-	169	340	517	696	873	1,115	1,324	1,660
Solar PV - DG	-	161	323	492	661	829	1,059	1,258	1,577
Small Wind -DG	-	8	17	26	35	44	56	66	83
Total	-	**666**	**1,341**	**2,039**	**2,743**	**3,440**	**4,393**	**5,217**	**6,542**

Table 23 Required Electricity Generation under RPS Case Scenario 2

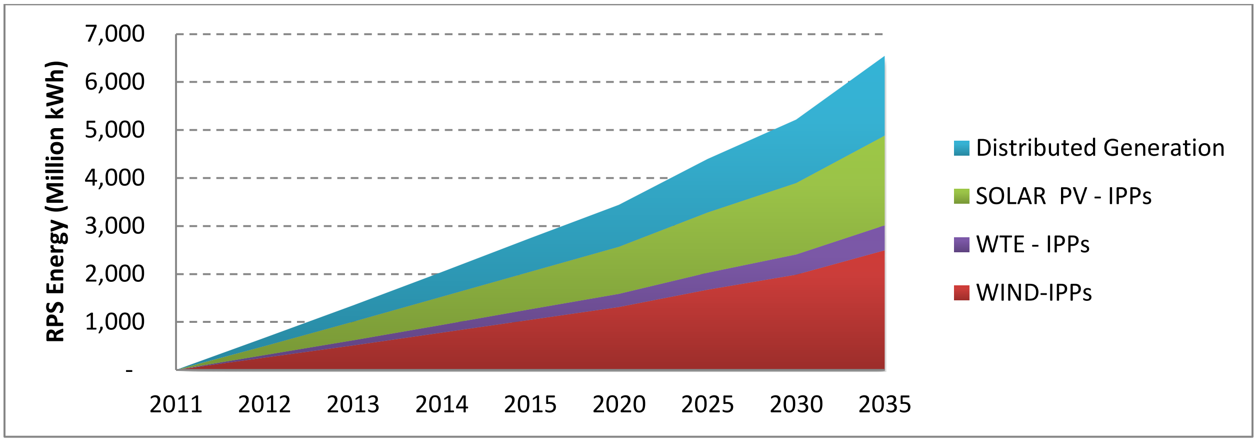


Figure 33 Renewable energy supply curve based on targets from RPS Case Scenario 2

RPS Case Scenario 3 - Required Generation (Million kWh)

Year	2011	2012	2013	2014	2015	2020	2025	2030	2035
Wind	-	304	613	931	1,253	1,819	2,281	2,781	3,321
Solar PV	-	228	459	699	940	1,364	1,710	2,085	2,491
WTE	-	64	129	196	263	382	479	584	697
Distributed Generation	-	203	408	621	835	1,212	1,520	1,854	2,214
Solar PV - DG	-	193	388	590	794	1,152	1,444	1,761	2,103
Small Wind -DG	-	10	20	31	42	61	76	93	111
Total	-	**799**	**1,609**	**2,447**	**3,291**	**4,777**	**5,991**	**7,303**	**8,722**

Table 24 Required Electricity Generation under RPS Case Scenario 3

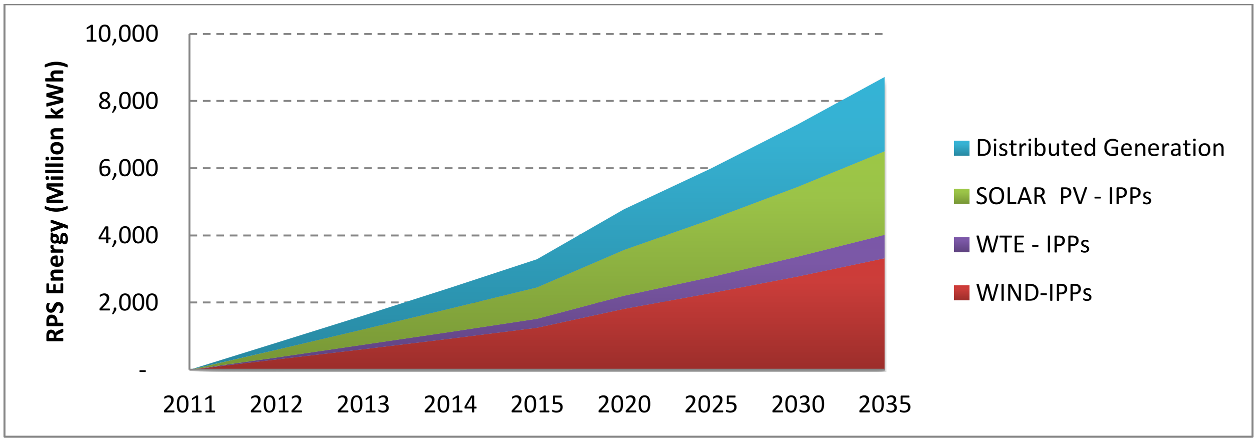


Figure 34 Renewable energy supply curve based on targets from RPS Case Scenario 3

7.10. RENEWABLE ENERGY CAPACITY NEEDS (MW)

Based on the required electricity generation from each RPS case scenario under study, the author has calculated the required capacity from renewable energy sources to be developed and installed through various projects. This provides a useful reference as to determine the respective resource needs, Installed capacity requirements (expressed in MW) were determined by means of respective technology capacity factors (presented in Section 7.4 Cost and Performance Assumptions) and their respective renewable energy generation requirements (million kWh) presented above. Also, the development of renewable energy projects was assumed distributed throughout the island according to technology-related resource potential and land availability. However, specific siting is not considered within the scope of this study, neither were related social and environmental considerations. Cumulative capacity requirements for each RPS Case Scenario evaluated in this study are presented below.

RPS Case Scenario 1 - Required Capacity (MW)									
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Wind	-	77	155	236	318	415	463	544	632
Solar PV	-	79	159	242	325	425	473	556	646
WTE	-	6	12	18	24	31	34	40	47
Distributed Generation	-	76	153	233	314	410	457	537	624
Solar PV - DG	-	73	148	224	302	394	440	517	600
Small Wind -DG	-	3	6	9	13	17	19	22	25
Total	**-**	**238**	**479**	**729**	**981**	**1,281**	**1,428**	**1,678**	**1,949**

Table 25 Cumulative Capacity, MW Required under RPS Case Scenario 1

RPS Case Scenario 2 - Required Capacity (MW)									
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Wind	-	96	194	295	397	498	636	756	948
Solar PV	-	99	199	302	406	510	651	773	969
WTE	-	7	14	22	29	37	47	56	70
Distributed Generation	-	95	192	292	392	492	629	746	936
Solar PV - DG	-	92	185	281	377	473	605	718	900
Small Wind -DG	-	4	8	12	16	20	25	30	38
Total	**-**	**297**	**599**	**911**	**1,226**	**1,537**	**1,963**	**2,331**	**2,923**

Table 26 Cumulative Capacity, MW Required under RPS Case Scenario 2

RPS Case Scenario 3 - Required Capacity (MW)									
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Wind	-	116	233	354	477	692	868	1,058	1,264
Solar PV	-	118	238	362	488	708	888	1,082	1,292
WTE	-	9	17	26	35	51	64	78	94
Distributed Generation	-	114	230	350	471	684	857	1,045	1,248
Solar PV - DG	-	110	221	337	453	657	824	1,005	1,200
Small Wind -DG	-	5	9	14	19	28	35	42	51
Total	**-**	**357**	**719**	**1,093**	**1,471**	**2,135**	**2,677**	**3,263**	**3,898**

Table 27 Cumulative Capacity, MW Required under RPS Case Scenario 3

In addition, based on the required cumulative capacity from renewables the author has calculated the annual capacity additions from each technology and source. Specifically, results were focused on annual capacity additions from utility-scale projects to determine its related purchase cost to be incurred by PREPA annually in order to meet RPS targets under each case scenario. Figures Figure 35, 38, and 39 provide a graphical illustration of renewable generation capacity additions required under the studied scenarios.

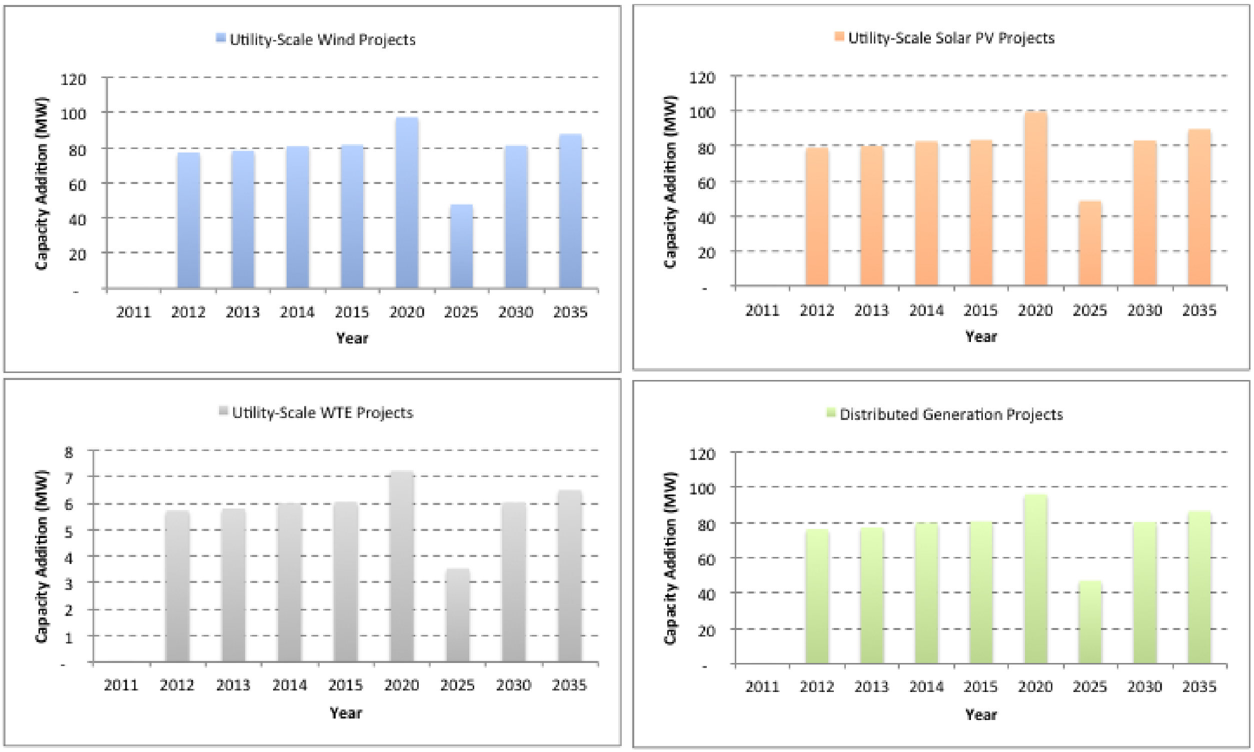


Figure 35 Capacity Addition (MW) by Source under RPS Case Scenario 1

Figure 36 Capacity Addition (MW) by Source under RPS Case Scenario 2

Figure 37 Capacity Addition (MW) by Source under RPS Case Scenario 3

Results presented above were used to compare required generation capacity with the available resource-based potential described in Chapter 7. Specifically, the author has compared required generation capacities by 2035 under each RPS case scenario with the existing resource-based potential. Table 28 provides a summary of the comparison.

	Wind	Solar PV	WTE	Distributed Generation	
				Solar PV	Small Wind
RPS Case Scenario 1	632	646	47	600	25
RPS Case Scenario 2	948	969	70	900	38
RPS Case Scenario 3	1,264	1,292	94	1,200	51
Resource-Based Potential	1,200-3,000	1,125-2,250	150	1,900	80

Table 28 Required generation capacity by 2035 versus estimated resource-based potential expressed in (MW)

Based on the comparison we can observe how selected renewable energy technologies under the studied RPS case scenarios resulted on a generation capacity lower than the estimated resource-based potential.

8. RPS COST AND ELECTRICITY RATE IMPACT

Using the developed Electric Power System Economic Model (EPSEM), RPS case scenarios have been modeled to determine the annual average electricity price throughout the study period using the formulations presented in Chapter 6. The direct impact for a utility to adopt high levels of renewable energy sources derives principally from (1) the displacement of electricity generation from existing units and (2) the displacement of any required capacity additions. Therefore, it is very important to measure its economic implications with great emphasis to the utility operation and revenue requirements.

The project has focused only on the displacement of electricity generation from conventional sources and not on displacement of capacity additions or requirements. Initially, the author has relied on the utility’s avoided cost for assessing the economic impact or cost related to an RPS adoption at different levels. Still, one must recognize the use of avoided cost comparison is known to be a conservative approach since it is not considering benefits or savings related to the displacement of potential capacity needs. Although many renewable technologies are not considered or accounted as firm capacity but rather as potential peak shaving units, others are capable of providing base-load generation.

In addition, the author has directly measured the impact towards electricity retail price in Puerto Rico according to the local utility (PREPA) electric service rate structure. It is important to understand that this project aims to provide with economic impact estimates for the local utility (PREPA) to adopt and meet an RPS policy, and compare results at different levels of adoption in Puerto Rico. It is evident that variations within factors and/or assumptions taken by this author can imply changes in results presented herein. Nonetheless results determined in this study provide good estimates and indicators towards the related economic impact of adopting an RPS policy in Puerto Rico. Furthermore, it provides with a variety of possible scenarios and their respective economic impact in terms of utility electricity rate variations and respective compliance cost

8.1. RPS COMPLIANCE COST

Using the Electric Power System Economic Model (EPSEM) the author has determined RPS compliance cost for each RPS case scenario under evaluation. Results are illustrated below in Figure 38. As described earlier in Chapter 5 and Chapter 7 – specifically in sections 5.3.3 and 7.1, RPS compliance is achieved through the procurement of RECs representing the total amount of energy generated from a renewable energy source, including electricity produced by, and purchased from, distributed renewable energy producers (up to 1MW of capacity) located in Puerto Rico through a net metering program. This project has assumed that the local utility (PREPA) will purchase energy form IPPs through a PPA (currently all proposed renewable energy projects are IPP, none are from PREPA). Furthermore, this project has assumed all renewable energy DG units to be operating under a net metering agreement, therefore are automatically accounted for PREPA's compliance. One must disclaim that the assumptions taken by the author regarding compliance methodology are strictly based on provision within Act No. 82 of 2010 ("Energy Diversification Act") thus they do not constitute any specific endorsement from the author.

PPA unit prices encompass the standard purchase price for electricity offered by PREPA supplemented by an additional premium paid for the environmental and social attributes (RECs). Final PPA prices paid to IPPs consist on a bundled price per kilowatt-hour of electricity sold representing the required LCOE for each technology. Therefore, RPS Compliance cost is defined as the direct cost incurred by the local utility (PREPA) to purchase the required electricity generation from renewable energy sources based on the LCOE for each technology.

$$RPS\ Compliance\ Cost = \sum Electriciy\ Generation_{by\ technology} \times LCOE_{by\ technology} \tag{8.1}$$

One of the most used methods to determine the economic impact that an RPS would have on the electricity cost is through the evaluation of RPS compliance cost and utilities' avoided cost. For those reasons, it is important to compare the cost of complying with an RPS policy with the avoided cost under the base case scenario.

Avoided cost related to the adoption of an RPS in Puerto Rico mainly derives from fuel related cost that would have been incurred through the purchase of fossil fuels; in our case with a significant reliance on oil-derived products. Hence, when comparing RPS cost with the avoided cost of utilities it should be noted that the RPS adoption is not cost-effective in terms of direct cost whenever the avoided cost is lower than the RPS cost. On the other hand, if avoided costs are higher, then the RPS is cost-effective on displacing fossil fuel and conventional generation sources. For the purpose of this study avoided cost has been determined according to PREPA's cost and operational assumptions for avoided units as provided in earlier sections.

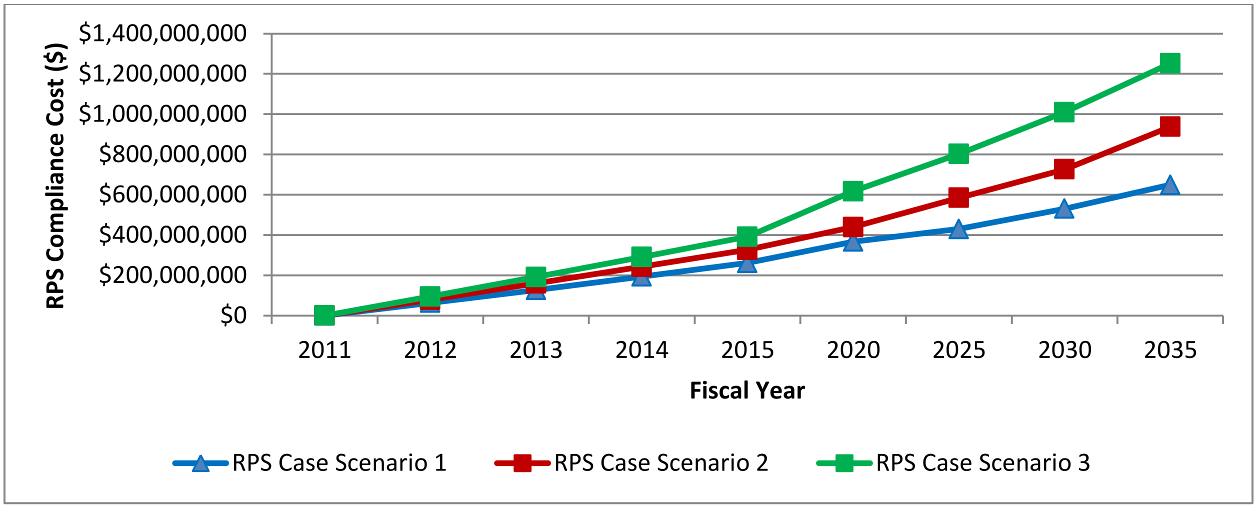


Figure 38 RPS Compliance Cost under each RPS Case Scenario

Since our analysis incorporated two different reference scenarios, one being the BAU and the other the Base Case scenario, PREPA's avoided cost under each reference scenario has been evaluated and compare to the three RPS cases under evaluation. Results from the comparison of RPS cost and utility avoided cost under each RPS case scenario are shown in Figure 39, Figure 40, and Figure 41.

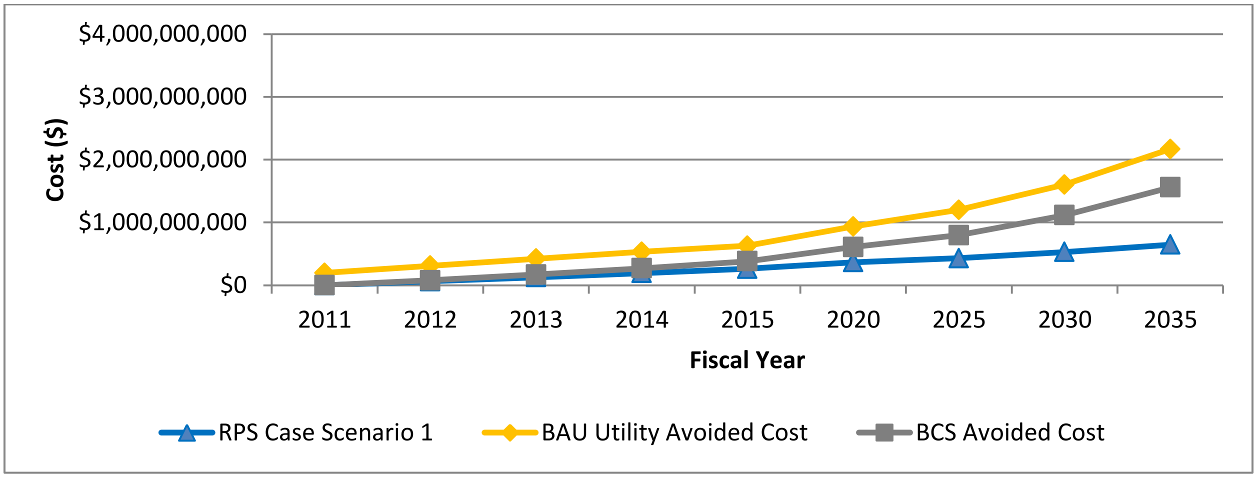


Figure 39 RPS Compliance Cost versus Utility avoided cost - RPS Case Scenario 1

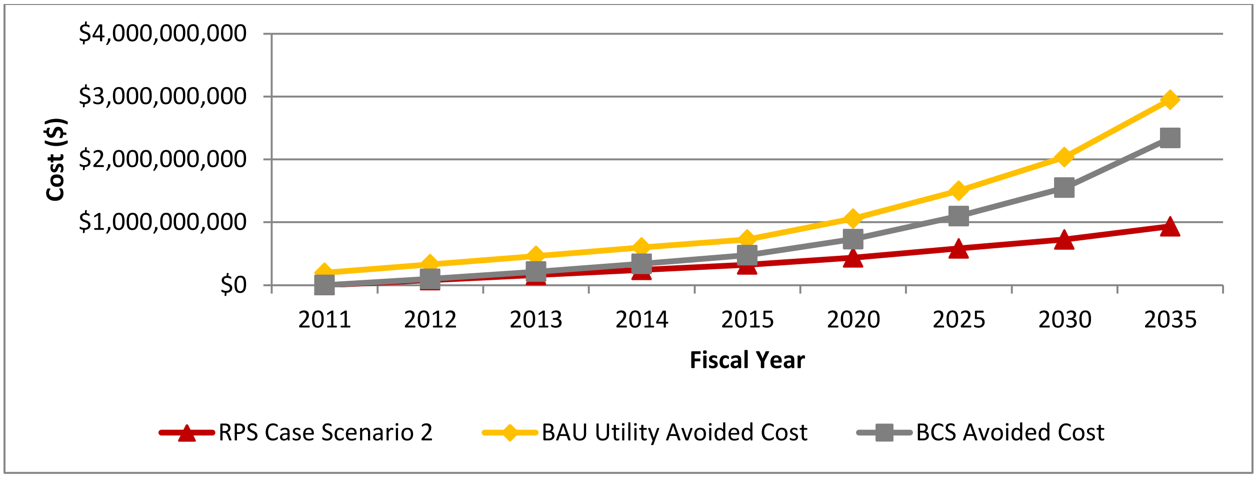


Figure 40 RPS Compliance Cost versus Utility avoided cost - RPS Case Scenario 2

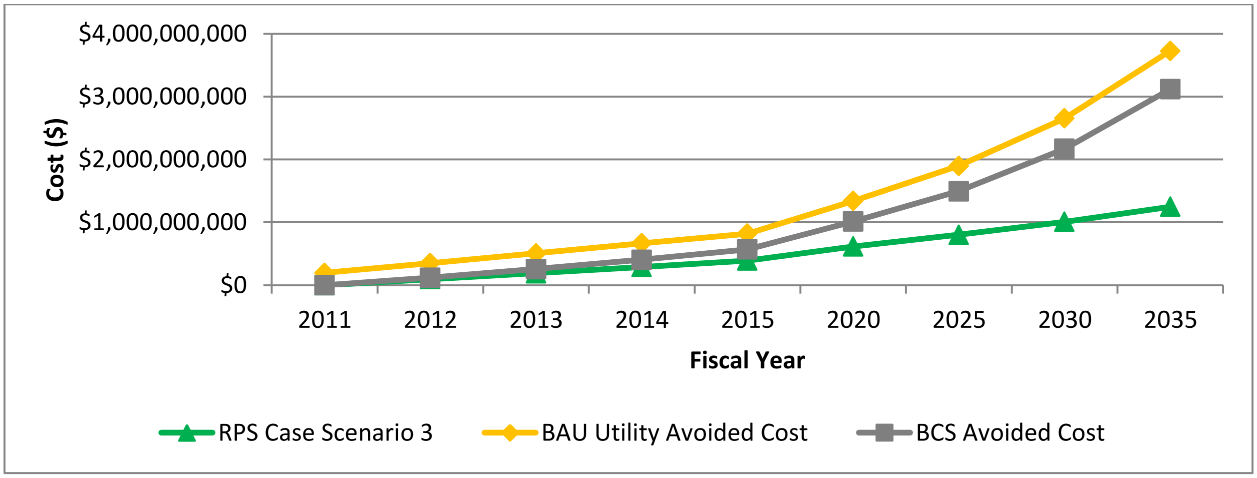


Figure 41 RPS Compliance Cost versus Utility avoided cost - RPS Case Scenario 3

These results explicitly illustrate that under all RPS case scenarios evaluated, the utility-related avoided cost is always higher throughout the study period (2011-2035). Taken into context, results provide numerical confirmation that adopting an RPS, even at aggressive levels such as those used under RPS Case Scenario 3 will not represent an increase or premium when compared to electricity generation from conventional sources. In essence, the difference between the avoided cost and the respective RPS compliance cost represents the cost benefit or value added to utilities' finance (not accounting for any needed grid infrastructure improvements).

8.2. ELECTRICITY RATE IMPACT

Using the Electric Power System Economic Model (EPSEM) the author was able to estimate the impact that an RPS, at different levels, would have on retail electric rates in Puerto Rico. Moreover, a calculation of average annual retail electricity cost for each RPS case scenario under evaluation was performed.

As mentioned earlier, one of the primary objectives if this study was to determine the impact towards retail electricity cost as to provide a comparison with electricity rate projections for the base case scenarios. Three different RPS scenarios have been considered: a conservative, a moderate, and a more aggressive level of adoption. These cases were examined and compared to the reference case scenarios. BAU and Base Case scenarios have served as the reference point for analysis purposes. As noted earlier, the Base Case scenario is based on the assumption that units 5 and 6 of PREPA's Costa Sur power plant are already operating with natural gas as primary fuel. On the contrary, the BAU scenario is based on the current fuel diversification mix according to PREPA's latest statistics. A summary of results on average electricity cost under all case scenarios studied is provided in Figure 42.

Furthermore, to avoid any external interpretation as to imply that base case assumptions are favorable to the economic impact analysis of adopting an RPS the author has used the Base Case scenario as a reference point to determine the rate impact from each RPS Case Scenario. Electricity rate impacts results are shown below in Figure 43.

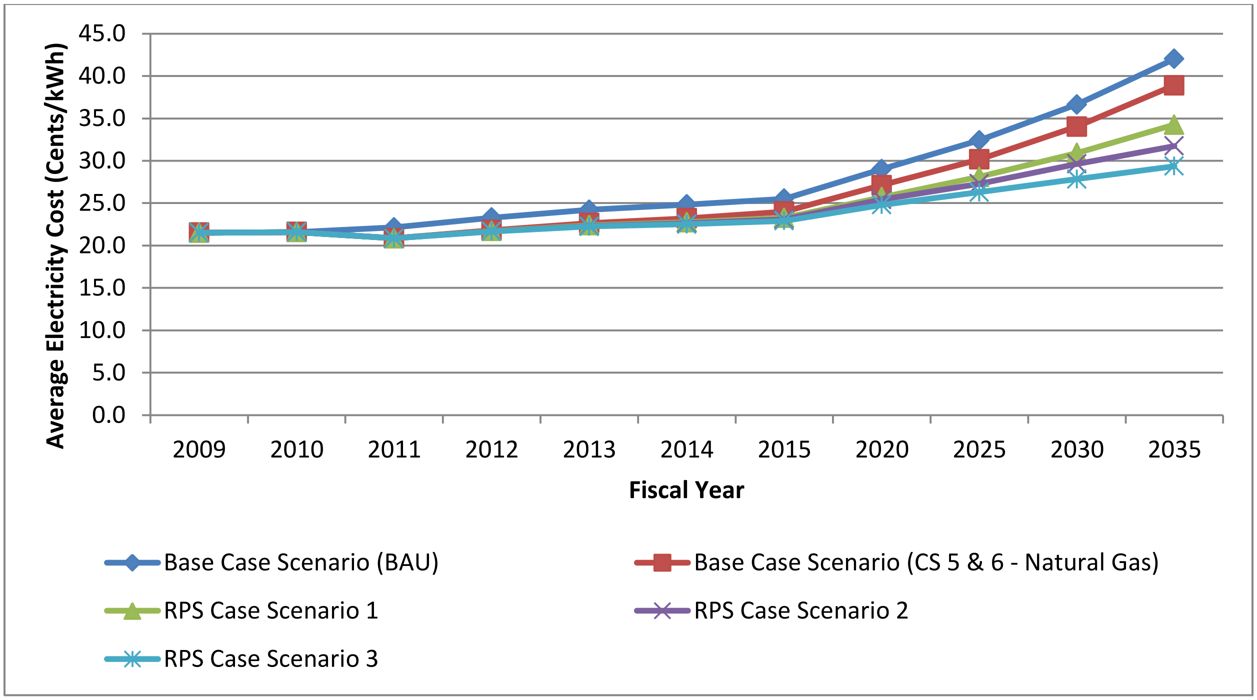


Figure 42 EPSEM Average Electricity Cost Analysis Results (Cents/kWh)

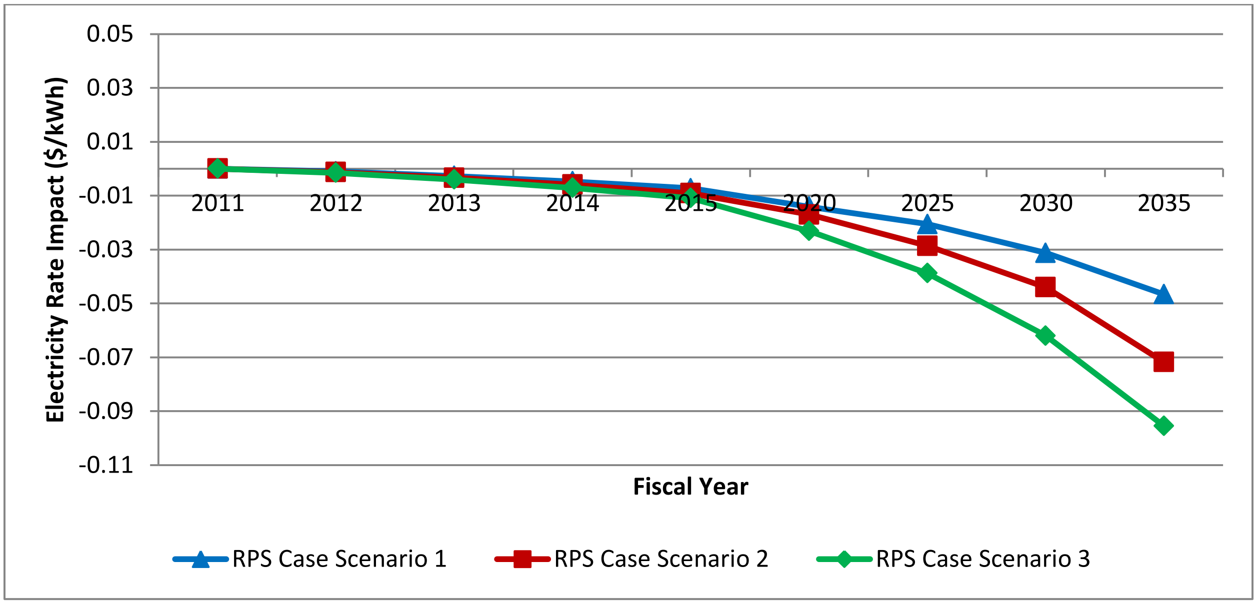


Figure 43 EPSEM Annual Electricity Rate Impact Results ($/kWh)

Taken into context, results confirm that the adoption of an RPS, even at relatively high levels of adoption, will not impact negatively retail electricity cost in Puerto Rico but rather will provide with economic benefits or savings when comparing to retail electricity rate projections under the base case scenario. Using the Base Case scenario as a reference, results showed electricity prices reaching nearly 39 cents per kilowatt by 2035. Whereas under the BAU reference case, retail electricity prices extended to 42 cents per kilowatt by 2035.

RPS case scenarios resulted in retail electricity prices reaching 34, 31, and 29 cents per kilowatt respectively by 2035. Furthermore, short-term projections provide with similar results at a lesser degree of difference between case scenarios. By 2014, retail electricity prices are projected to reach 23.2 cents per kilowatt for the BAU case scenario, while achieving an average cost of 22.7, 22.6, and 22.5 cents per kilowatt through the RPS case scenarios, respectively. Hence, in both, short-term and long-term projections renewable energy integration provides a potential opportunity to reduce retail average electricity cost in Puerto Rico.

In addition, since the overall electricity cost in Puerto Rico consists of a base rate and an adjustment clause (fuel adjustment charges; and purchased power charges) each component varies according to the case scenario under analysis. However, since basic charges are fixed rates, fuel and purchased power charges are responsible for any variation. Figures shown below provide with numerical and graphical results. Note that the fuel cost charges for both reference scenarios, BAU and Base Case, represent a significant share of annual average electricity cost expressed in dollars per kilowatt-hour. As shown in figures below, fuel cost charges for both case scenarios reached more than 70% from the total average electricity cost in 2035. It is clear that the significant reliance on fossil fuel, with great emphasis in oil-derived products continues to affect the electric power system model if no change is implemented. Ultimately increasing the annual average electricity cost as fossil fuel prices rise throughout the study period.

Conversely, from Figure 44 to Figure 48 we can observe how the integration renewable energy sources proportionally contribute on hedging the continued bold growth of the fuel cost charges as it occurs in the base case scenarios. As expected, the higher RPS adoption levels the less contribution from fuel cost related charges towards the total average electricity cost. Purchased power charges increment as RPS adoption levels increase, shifting the weight and importance originally held on fuel cost related charges. Since purchased power charges originate from the electricity generation bought by PREPA through executed PPAs as described earlier, then an LCOE exist throughout the contract period Therefore, it provides with the capability of stabilizing the cost of electricity and reducing its significant dependency on fuel price variations.

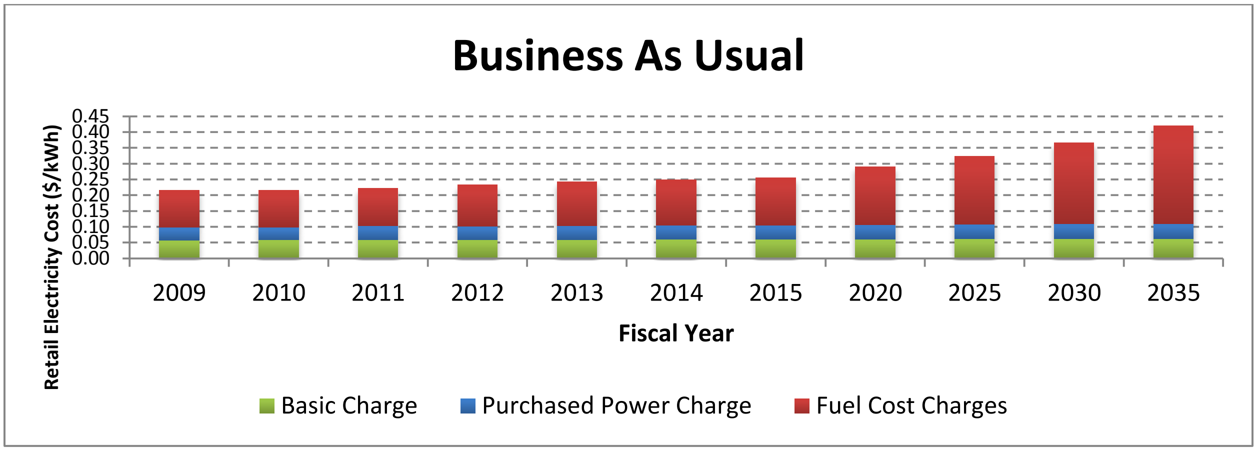


Figure 44 Average electricity cost projections by components – Business As Usual

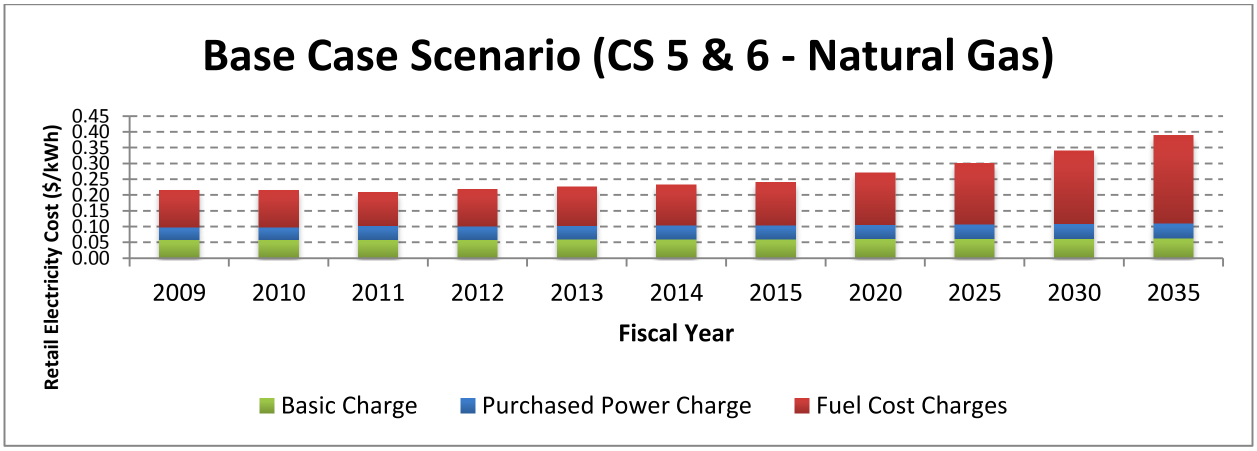


Figure 45 Average electricity cost projections by components - Base Case Scenario

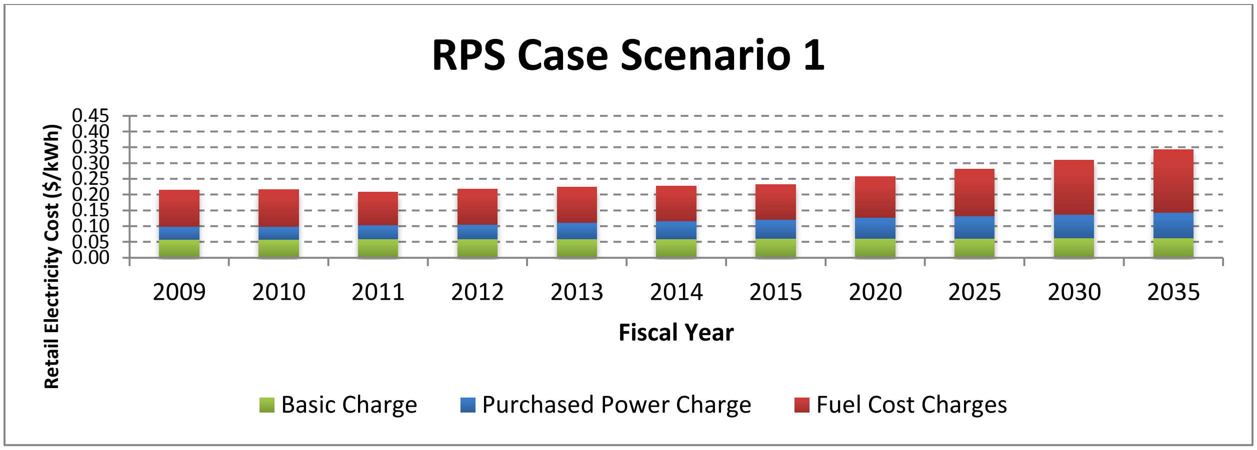


Figure 46 Average electricity cost projections by components - RPS Case Scenario 1

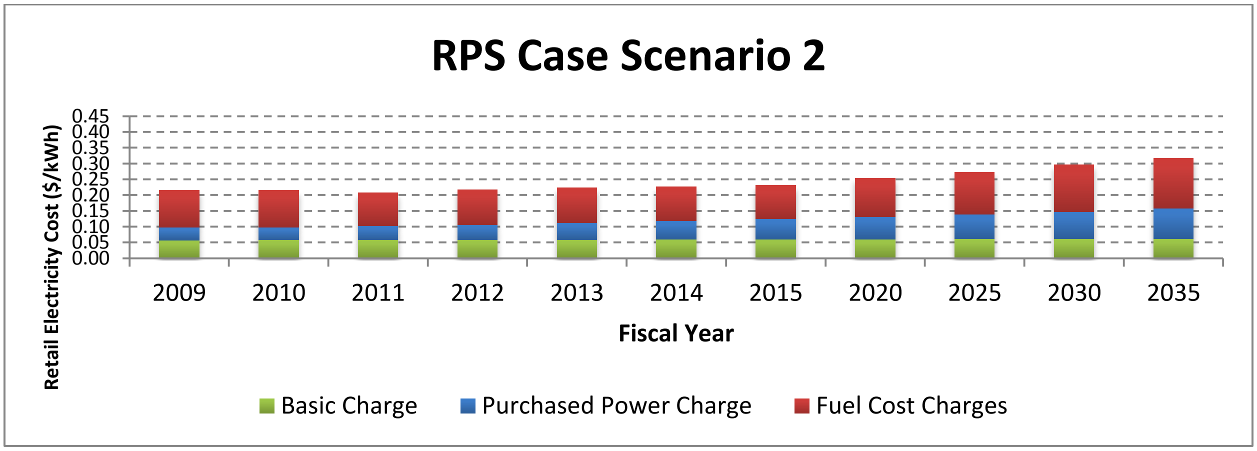


Figure 47 Average electricity cost projections by components - RPS Case Scenario 2

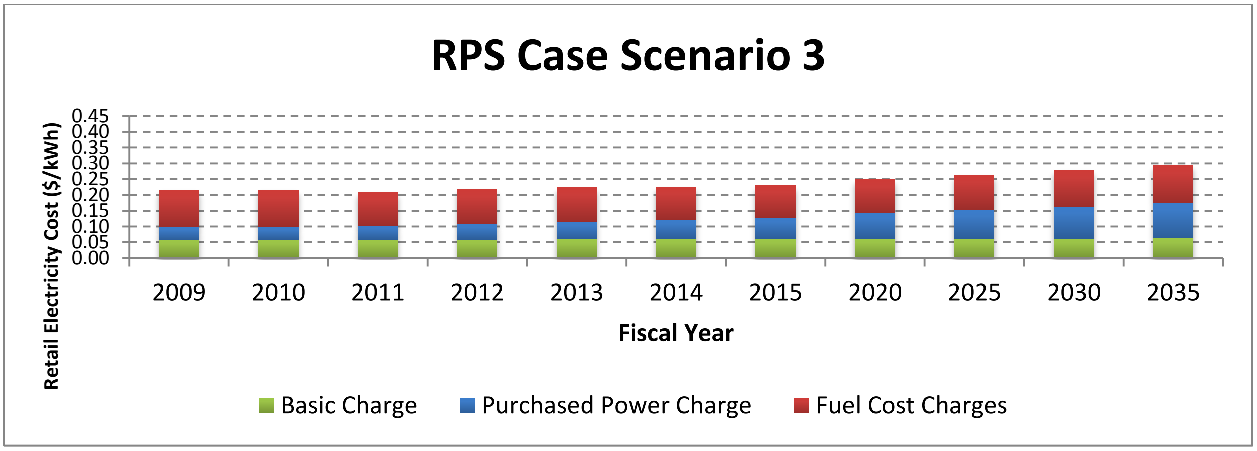


Figure 48 Average electricity cost projections by components - RPS Case Scenario 3

In fact, electricity rate impact results dependent on many factors and assumptions. Therefore, there are unlimited scenarios to be examined. In this project, we have identified two key elements as the most important and contributing factors towards results provided herein. These are: (1) changes in fuel price forecast assumptions; (2) changes in electricity generation fuel shares.

Notwithstanding the above, this study has evaluated an additional reference case with conservative fuel price assumptions to determine results sensitivity towards overall retail electricity cost in Puerto Rico. Changes in electricity generation portfolio regarding fossil fuel conversions were not considered due to the degree of uncertainty upon significant fuel share variations, additional unit conversions in the electric power sector and utility's capital investment plans. For example, a possible scenario would be to consider a greater share from less expensive fossil fuels such as natural gas, hence reduce the contribution from oil derived products. Though, in our study we have consider an optimistic approach through the Base Case scenario by assuming almost 26% of the net electricity generation is supplied by natural gas fired plants, whereas EcoEléctrica represents nearly 16%, and an additional 10% has been attributed to Costa Sur Units 5 & 6 conversion. Furthermore, as described in Chapter 6 Section 6.2.5, fuel prices assumptions (oil and natural gas) were based on EIA Annual Energy Outlook (AEO) 2010 reference case scenario [9]

Therefore, this study will only consider the effect from changes in fossil fuel price forecasts. Furthermore, we have assumed oil prices to increase from 2015-2035 with an average annual growth rate of 2% (lower growth rate than projections from EIA 2010 Annual Energy Outlook). Natural gas prices were assumed to increase with an average annual growth rate of 1%

from 2015 to 2035. Figure 49 provides with results and a graphical comparison with RPS Case Scenarios evaluated in this study.

As observed in the figure below, based on optimistic fossil fuel price forecast results have varied accordingly. Under this scenario, only an aggressive RPS adoption level (RPS Case Scenario 3) will result in lower average retail electricity prices by 2035. Furthermore, Figure 50 summarizes resulting electricity rate impacts, expressed in percentage of the conservative fuel prices reference scenario described above.

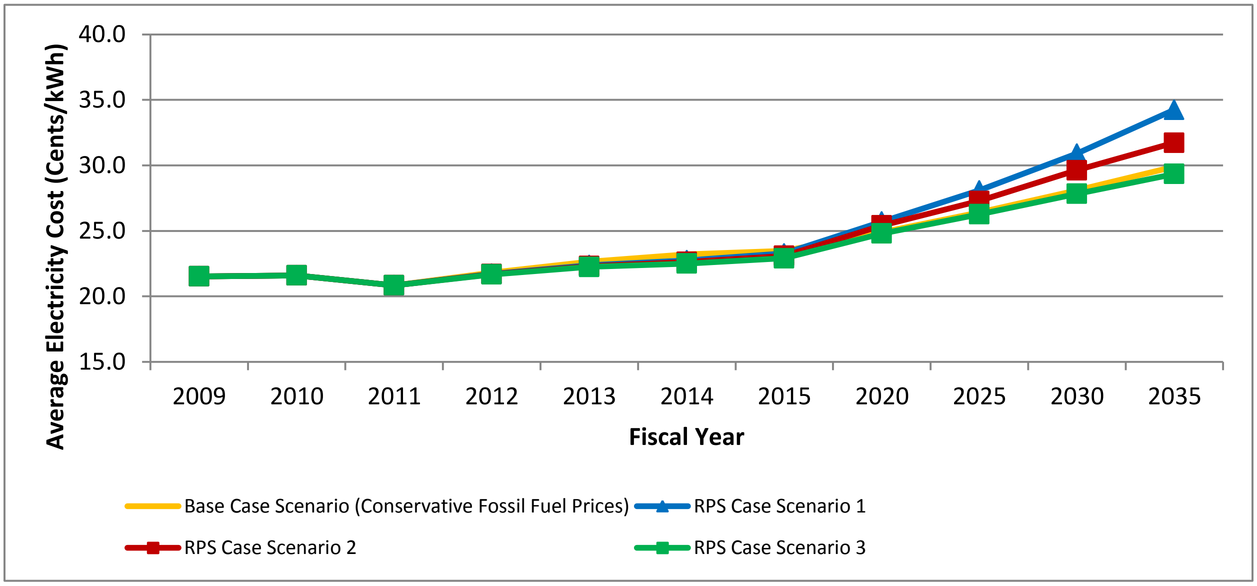


Figure 49 EPSEM Average Electricity Cost Results under Conservative Fossil Fuel Price Assumptions

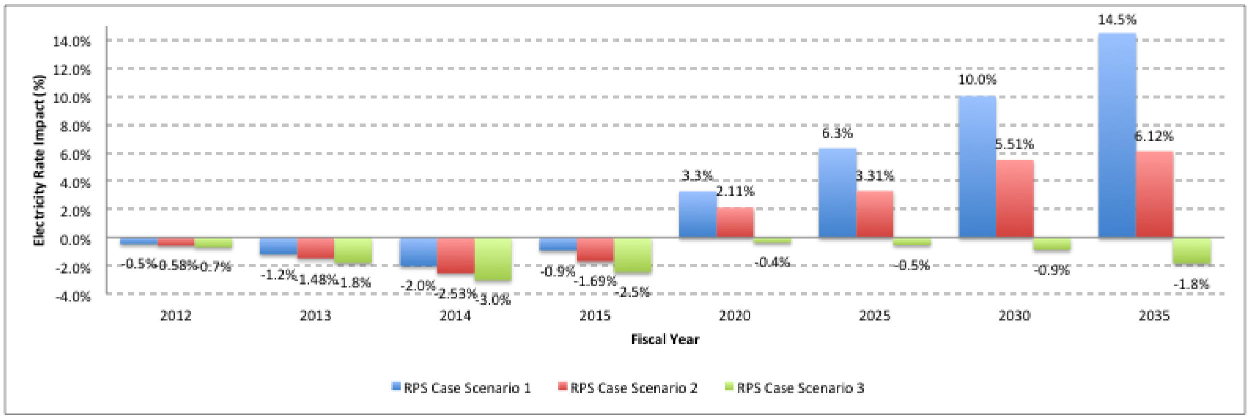


Figure 50 Electricity Rate Impact Analysis based on Optimistic (Fuel Price Projections) Base Case Scenario

8.3. ENERGY EFFICIENCY CONTRIBUTION TOWARDS RPS COMPLIANCE

Energy efficiency measures were evaluated as to determine their potential to reduce RPS compliance cost and hence benefit the overall average electricity cost in Puerto Rico. In order to evaluate and account energy efficiency measures the author has used the estimated potential savings determined in Section 7.3.5. Using the Electric Power System Economic Model (EPSEM) energy efficiency (EE) economic impact has been evaluated under each of the RPS case scenarios included in this project.

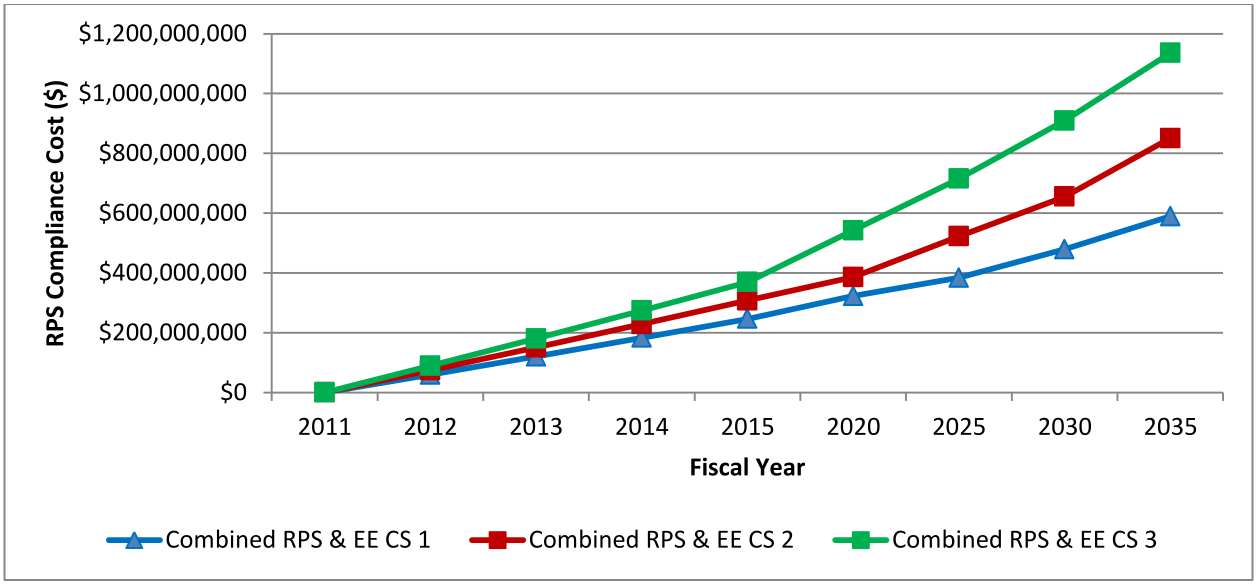


Figure 51 RPS Compliance Cost under Combined RPS & EE Case Scenarios

Results regarding RPS compliance cost under each Combined RPS and EE scenarios are provided above in Figure 51. Likewise, Table 29 provides specific annual savings in RPS compliance cost due to Energy Efficiency integration.

RPS Compliance Annual Savings			
Fiscal Year	Combined RPS & EE Case Scenario 1	Combined RPS & EE Case Scenario 2	Combined RPS & EE Case Scenario 3
2011	$ -	$ -	$ -
2012	$ 1,099,978.39	$ 1,374,972.99	$ 1,649,967.58
2013	$ 2,215,707.87	$ 2,769,634.83	$ 3,323,561.80
2014	$ 3,368,634.96	$ 4,210,793.70	$ 5,052,952.44
2015	$ 4,533,213.84	$ 5,666,517.30	$ 6,799,820.76
2020	$ 33,727,515.16	$ 40,446,063.26	$ 56,302,375.05
2025	$ 37,725,758.34	$ 51,421,398.31	$ 70,234,701.86
2030	$ 44,504,187.43	$ 61,119,005.65	$ 85,296,891.50
2035	$ 53,841,987.84	$ 78,442,200.41	$ 105,163,308.82

Table 29 RPS Compliance Cost Savings per year under study

As presented above, combined RPS & EE case scenario provide with economic savings upon compliance with RPS targets. Energy efficiency and conservation measures lower the total electricity consumption; consequently less electricity has to be generated (from both renewable and conventional generation units). RPS Compliance Cost will then be reduced due to the direct proportionality between the total electricity consumption and required renewable energy generation to meet with RPS targets. As shown below, if a reduction is experienced it the Net electricity sales (total electricity consumption) then a reduction will be seen in the required renewable generation and thus its related purchase cost.

$$Required\ Renewable\ Generation_{\ kWh} = [Net\ Electricity\ Sales_{kWh} - Existing\ Hydro_{kWh}]\ \times \%(RPS\ Target) \tag{8.2}$$

In addition, the integration of energy efficiency and conservation measures also provides with a reduction on fossil fuel consumption and thus its related cost. In general, results confirmed the existing economic potential under a combined RPS and Energy Efficiency policy scenario.

To further discover energy efficiency potential economic contribution towards RPS adoption we have calculated the average electricity cost under combined RPS & EE case scenarios. Results have shown no reduction in average electricity cost when compared to RPS only scenarios. This is due to the fact that electric utility rates are based on a cost-of-service ratemaking regulation. Moreover, traditional regulatory mechanisms keep electricity rates constant between different case scenarios. The only factors that ultimately affect electricity rates are fuel price, purchased power cost, and overall system efficiency. Hence, when reviewing the fuel purchase and power purchase formulas used by PREPA one can observed that the factor "Total Net Generation" is implicitly repeated in the nominator and explicitly in the denominator of both equations.

$$\boldsymbol{FCC}\left(\$/_{\boldsymbol{kWh}}\right) = \frac{\$/_{\boldsymbol{BBL}} \times \boldsymbol{BBLs}(\boldsymbol{estimated}) \pm \boldsymbol{Adjustment_C}}{\mathbf{0.89} \times \boldsymbol{Total\ Net\ Generation} \times \boldsymbol{E_i}} \tag{8.3}$$

That is, taking the fuel purchase formula (shown above) as a reference we can notice that the fuel consumption (BBLs) will directly depend on the total electricity generated by PREPA. Therefore any reduction made through energy efficiency measures has no effect towards the electricity rate derived from the fuel and purchased power formulas, respectively.

Given these facts, although the enforcement of energy efficiency measures in the end-use sector provides an opportunity to reduce RPS compliance cost, it has no effect towards average electricity cost in Puerto Rico. Rather, it reduces electricity sales to the utility, hence reducing the electricity related revenues. Therefore, the author suggests that the electricity rate structure must be evaluated and redesigned to promote energy efficiency and incentivize utilities to enforce such measures.

Although energy efficiency and conservation measures has no effect towards average electricity cost in Puerto Rico due to the current electricity rate structure, a huge opportunity exists within the integration of distributed generation using renewable energy technologies. In recent years, the use of distributed generation has become a solution to the current pricing situation of fossil fuel, world population growth, environmental concerns, and continuous increase in energy demand, among. Specifically, distributed generation has proven to be an effective tool to reduce transmission and distribution (T&D) system losses mainly due to their proximity to the customer or load.

Distributed Generation (DG), also known as distributed energy resource (DER) and/or dispersed power (DP) can have various definitions or interpretations including;

- Small-scale renewable energy Systems such as photovoltaics (PV), fuel Cells, micro-turbines, or wind turbines installed and designed to serve a specific load (customer).
- Any type of generation facility near the load point.
- Any facility under the “Public Utility Regulatory Policies Act 1978 (PURPA)”.
- Co-generation Systems designed to supply loads during peak times, for cost saving purposes.

For the purpose of this project, we have defined distributed generation (DG) as small power generators (1 MW or less) located near the customer end (load), operating either stand-alone or interconnected to the distribution network [77]. According to Section 7.8 distributed generation was assumed to account for 25% of the RPS supply mix. Specifically, solar PV accounts for a 24% share and the remaining 1% comes from small wind turbine systems. Therefore its integration provide with a significant contribution towards the total RPS target. Moreover, the fact that DG is located near the customer or load provides with the potential benefit of avoiding and/or reducing T&D losses, through the displacement of electricity generation from utility's conventional generation units and reduction typical equipment loading (heat losses).

In fact, when evaluating the contribution from DG renewable energy sources given PREPA's current electricity rate structure, the author has observed that any reduction in T&D losses will ultimately lower the retail electricity price in Puerto Rico. That is, using the fuel purchase formula (shown below) as a reference we can notice that the factor Ei is located in the denominator of the equation; referring to the overall system efficiency.

$$\boldsymbol{FCC}\left(\$/_{\boldsymbol{kWh}}\right) = \frac{\$/_{\boldsymbol{BBL}} \times \boldsymbol{BBLs(estimated)} \pm \boldsymbol{Adjustment_C}}{\boldsymbol{0.89} \times \boldsymbol{Total\ Net\ Generation} \times \boldsymbol{E_i}} \tag{8.4}$$

Therefore any reduction on T&D system losses resulting from the integration of distributed generation sources will ultimately lower the electricity rates derived from the fuel and purchased power formulas.

To quantify the related savings, the author has used as a reference an overall system efficiency of 81.6% according to data provided in [34]. In other words, total losses accounted approximately 18% of the net electricity generation in 2010. As presented in Chapter 4 the electric power system losses typically include conversion efficiency, transmission and distribution heat and transformation losses, unaccounted electricity, and theft. Assuming, T&D losses account for 12% of the total 18%, this project has estimated a potential reduction of 50% through the integration of DG. Thus, the new overall system efficiency is taken as 88% for year 2010, or 1.078 times greater than the overall efficiency projections throughout the study period as described in Section 6.2.3.

When comparing the overall electricity cost between an RPS case scenarios and combined RPS and EE scenario (considering efficiency improvement due to T&D losses reduction from the integration of DG) results have shown a 5.9 % reduction for case scenario 1, a 5.8 % for case scenario 2, and a 5.8 % for case scenario 3. Figure 52 provides a graphical illustration comparing the average electricity cost under different case scenarios including one considering system efficiency increases resulting from T&D losses reductions due to the integration of DG.

Although assumptions were taken by the author regarding the estimated reduction on T&D losses, results provided with evidence showing a direct relation between T&D losses, increase in overall system efficiency, and thus retail electricity prices based on the current electricity rate structure used by the local utility (PREPA). Therefore, as more distributed generation sources are integrated to the grid, resulting avoided system losses will enable a lower retail electricity price.

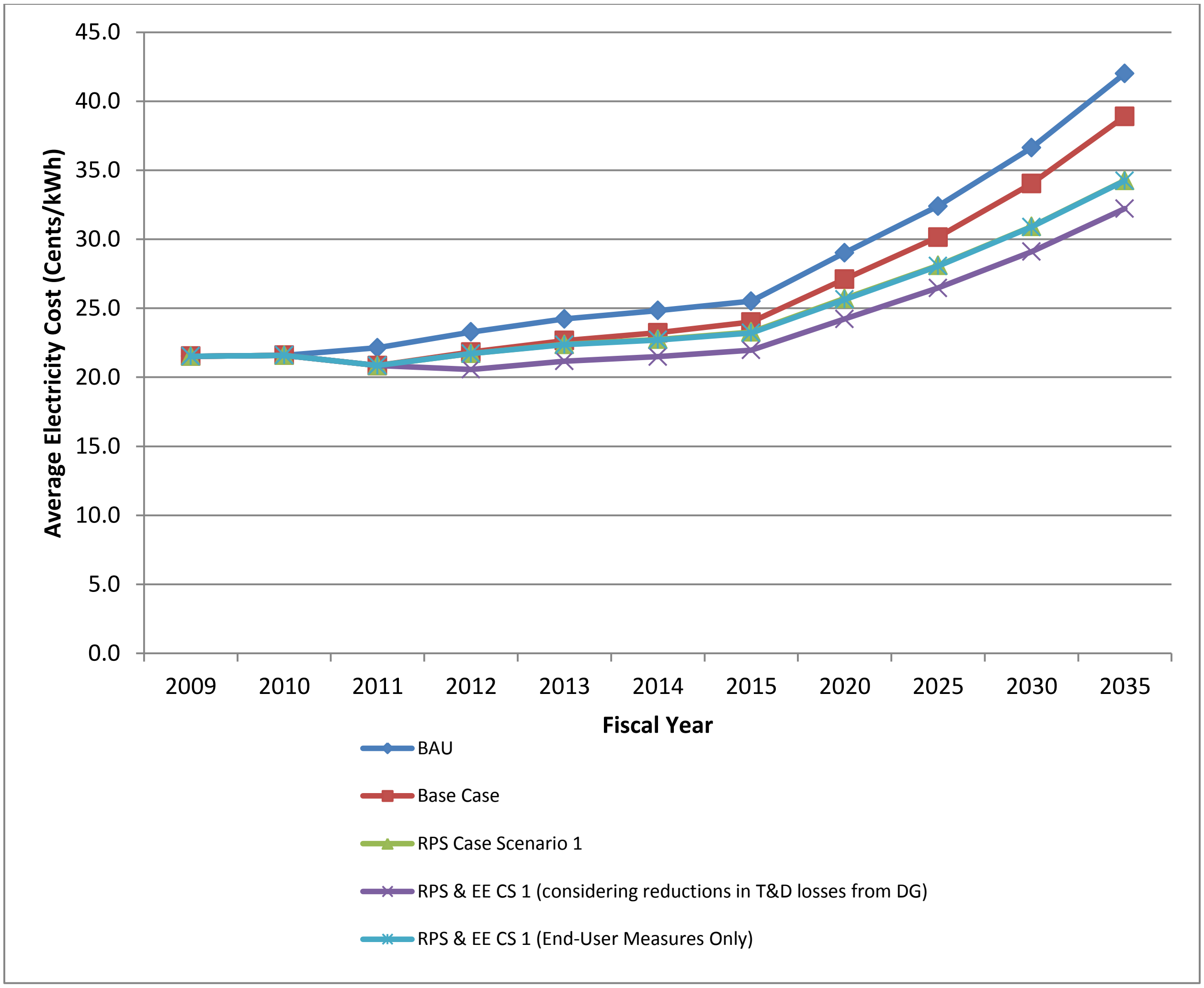


Figure 52 Average Electricity Cost under RPS & EE CS 1 considering reductions in T&D losses from the integration of DG

8.4. UTILITY REVENUE REQUIREMENT AND FINANCE IMPLICATIONS

Under a Cost-of-Service regulatory structure, the overall electricity cost is directly related to a utility financial operations and revenue requirements. As presented earlier in this study, PREPA is required under Act No. 83 of 1941, as amended, and under the 1974 Trust Agreement to recover all current expenses of the system. These expenses typically include fuel cost, purchased power, T&D, O&M, and administrative cost. In fact, in the last decades fuel cost has represented the biggest share of them all. In addition, PREPA is required to fulfill with its contractual obligations under the terms of the 1974 Trust Agreement. Furthermore, PREPA is also required, under Act No. 83 of 1941, to set aside 11% of the gross electricity sale revenue to fund government subsidy programs, pay contributions in lieu of taxes to municipalities, and finance capital improvement programs, among other purpose, commonly refer to as "contributions in lieu of taxes"

Hence, given these limitations and based on our current electric service rate structure the author has briefly reviewed projections regarding PREPA revenue requirements and financial security upon the adoption of an RPS policy. Therefore, the attention has been directed towards debt service coverage ratio, considered to be one of the key elements to understand PREPA's operation. As required by the 1974 Trust Agreement, PREPA shall provide an amount at least 1.20 of the aggregate Principal and Interest Requirements for the next fiscal year on account, also refer to as debt service coverage ratio.

Using the Electric Power System Economic Model (EPSEM) the author has evaluated PREPA's financial operation and revenue requirements for each scenario under evaluation. In order to determine the debt service coverage ratio (DSCR) the following financial assumptions were taken:

(1) Reference financial data regarding current expenses and contractual obligation was taken from PREPA's 36th Annual Report

(2) Contractual appropriation increased with an escalation factor of 2% using PREPA's 2014 projections as a reference point to determine projections from 2015 to 2035

(3) Interest on Notes and Capital Improvement funds were averaged using both, historic and projected data, from 2006-2014 to assign values from 2015 to 2035.

Then, the debt service coverage ratio (DSCR) was determined using the following equation:

$$Debt\ Service\ Coverage\ Ratio\ (DSCR) = \frac{Net\ Revenues}{Total\ Contractual\ Obligations} \tag{8.5}$$

Debt service coverage ratio (DSCR) projections under all scenarios evaluated in this study are provided below.

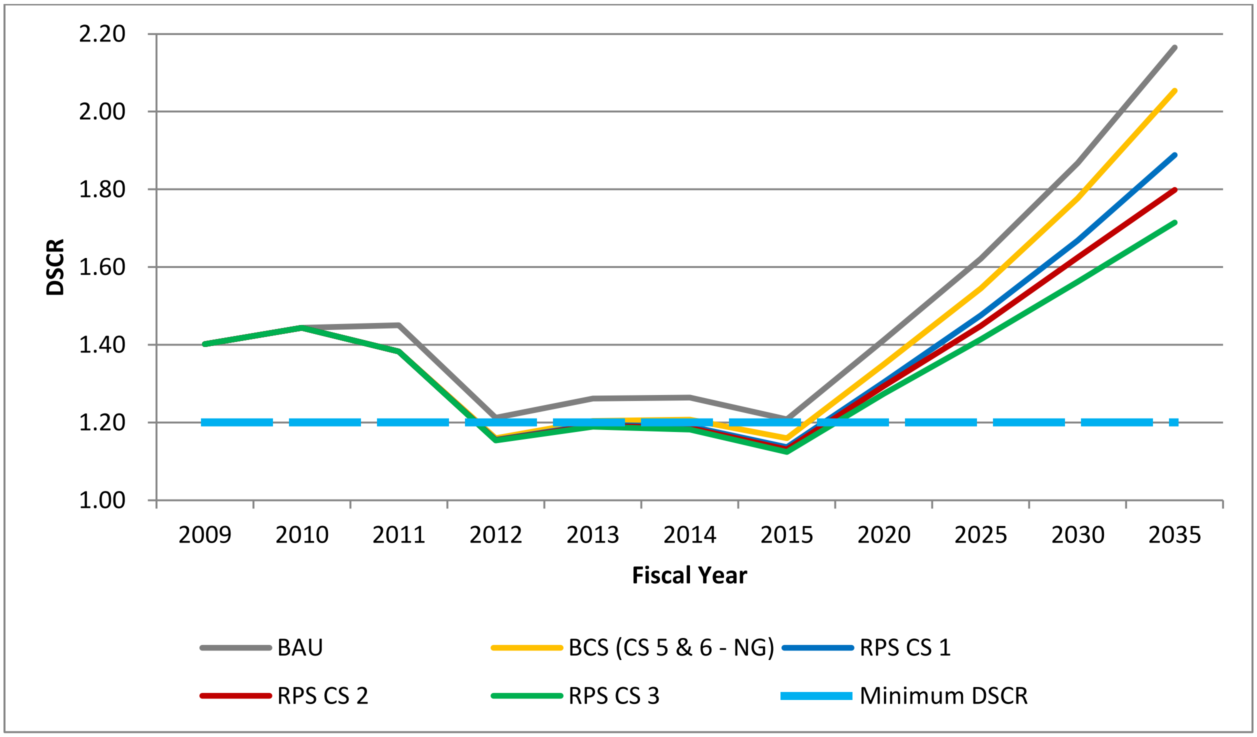


Figure 53 EPSEM Results on PREPA's Debt Service Coverage Ratio - All Case Scenarios

From the results presented above, one can observed that the DSCR is slightly below the minimum required value (1.20) from years 2012 to 2015 under all RPS case scenarios. These results are based on assumptions taken by this author regarding future contractual obligation projections and the electricity rate structure currently used by PREPA. Therefore, certain levels of uncertainty exist with respect the PREPA's current expenses and contractual obligations for future years. Moreover, it is expected that annual expenses related to T&D and maintenance vary according to each scenario. For example, as renewable energy penetration increases through the construction and operation of IPP and DG projects, PREPA's operation and maintenance cost is expected to decrease due to the respective displacement in electricity generation. Still, additional cost may also be experienced if T&D investment is needed to accommodate higher levels of renewable energy generation.

To conclude, special attention must be taken to assure compliance with revenue requirements under the 1974 Trust Agreement. In addition, the current electricity rate structure should be evaluated to consider alternatives such as decoupling revenue requirements from electricity sales; thus avoid necessary electricity rates increase in order to maintain the required DSCR. A temporary or transitional solution would be to adapt basic rates on an annual basis to ensure proper recovery of fix cost related to system expenses. Under this assumption a separate entity must be used to oversee and regulate basic rates to permit acceptable levels of returns. Still, the creation of a new ratemaking authority would require revisions to provisions within Act No. 83 of 1941. However, as it has been shown in this project, potential economic benefits to Puerto Rico should serve as a driver to pursue alternatives regarding this matter.

9. CONCLUSIONS AND FUTURE WORK

Puerto Rico relies nearly 99 percent on fossil fuel as primary sources for electricity generation, whereas oil-derived products account for almost 70 percent of the total net electricity generation share. Throughout the years, the permanence of this model has resulted primarily in high, unstable, and volatile electricity prices, and a prevailing reliance on fossil fuels; thus a direct vulnerability to fuel prices.

For such reasons, there is an unquestionable necessity to exploit the use of renewable energy sources, and to enforce energy efficiency and conservation. Lately, RPS policies have become major drivers to increase the use of renewable energy sources in many states and countries. However, to effectively adopt an RPS policy one must determine its feasibility, cost-effectiveness, and further ensure a proper balance between the integration of renewable development and its potential impacts toward the electricity price.

In this study, we have determined the economic impact of adopting an RPS at different levels, including the existing economic potential of integrating energy efficiency in Puerto Rico. Furthermore, we have evaluated and compared the RPS compliance cost with the utility avoided cost. An electricity rate impact analysis has been performed to quantify the RPS economic impact toward retail electricity prices. In addition we have considered PREPA’s general and contractual obligations, as well as their revenue requirements to determine the effect of adopting an RPS over the local utility’s financial operations.

This chapter provides with a summary of major findings resulting from this study. Then, policy recommendations are given in order to effectively implement and enforce an RPS in Puerto Rico.

9.1. CONCLUSIONS

Results have shown that Puerto Rico is capable of adopting an RPS policy without increasing the overall electricity cost. Still measures must be taken with regards to the electricity rate structure and financial implications to assure compliance with revenue requirements under the 1974 Trust Agreement. In fact, most of the studied cases have shown short and long-term overall economic benefits towards the retail electricity price. Specifically, when compared to both reference cases, the BAU and Base Case scenarios results, confirmed that the integration of renewable energy towards the electric power system provides with significant economic benefits including but not limited to (1) reductions in overall electricity generation cost; and (2) stabilization and thus reduction of retail electricity prices.

Therefore, it has been validated that the integration of renewable energy sources not only reduces our dependency on fossil fuels by displacing generation, but also provides a hedging mechanism against fossil fuel price projections with great emphasis on oil-derived fuels. Furthermore, due our ratemaking structure, any avoided electricity-related fuel expenses will directly and ultimately benefit customers with lower retail electricity cost.

Under the assumption of a conservative fossil fuel price scenario, results revealed an existing sensitivity towards key assumptions such as fossil fuel price projections. Specifically, only an aggressive RPS adoption (RPS Case Scenario 3, or 40% by 2035) provided with short and long-term reductions in retail electricity price. Nonetheless, the electricity rate impact resulting from the conservative and moderate RPS adoption scenarios was accounted to be relatively small. In fact, though long-term projections showed a slight increase towards electricity prices, short-terms projections (2011-2014) resulted in slight reductions or savings.

Based on the results provided in this study, major findings and conclusions are summarized below:

- Renewable energy technologies are maturing fast and thus capital cost is projected to decrease substantially; therefore as we thrive with public perception and acceptance, renewable energy adoption is expected to increase substantially.
- Renewable energy technologies capital cost reductions, and thus their respective LCOE will significantly affect the economic impact (positive or negative) of adopting an RPS in Puerto Rico.
- Since most of the renewable energy technologies included in this study (i.e., wind and solar) have no fuel costs, they serve as hedging instruments against fossil fuel price spikes and future projections.
- Under our current electric power system model, referred to as BAU, retail energy prices are expected to increase almost proportionally to fossil fuel prices projections; reaching 42 cents per kilowatt-hour by 2035.
- Under a more optimistic reference scenario, referred to as Base Case, retail electricity prices are expected to increase as well, however up to 39 cents per kilowatt-hour by 2035.

- Using both, the BAU and Base Case scenarios as references, utility's avoided cost resulted to be higher the RPS compliance cost throughout the study period, under all RPS adoption levels evaluated in this study.
- A substantial share of the utility's avoided cost derives from the displacement of electricity generation, mainly from oil-fired power plants.
- The higher an RPS adoption level, a greater economic benefit or savings is achieved due to the difference increase between the utility's avoided cost and the RPS compliance cost.
- The higher an RPS adoption level, the greater reductions are experienced in short-term electricity prices. Specifically, providing with a 2.1% reduction under a conservative RPS policy, 2.6% reduction under a moderate RPS policy, and a 3.4% reduction under an aggressive RPS policy.
- The higher an RPS adoption level, the greater reductions are experienced in long-term electricity prices. Specifically, providing with a 12% reduction under a conservative RPS policy, 18.5% reduction under a moderate RPS policy, and a 24.6% reduction under an aggressive RPS policy.
- Under the assumption that fossil fuel price projections are more conservative than those presented in national outlook (e.g. EIA AEO 2010), only an aggressive RPS adoption (RPS Case Scenario 3) will result on a reduction towards retail electricity prices by 2035.
- Energy efficiency has proven to be cost effective mechanism. Furthermore, its inclusion can significantly reduce RPS compliance cost. In addition, energy efficiency measures can drastically ease peak demand reducing PREPA electric power supply costs and delay or eliminate the need for new generating resources.

- Due to our current electric service rate structure and regulatory regime, the integration of energy efficiency measures in the end-use sector has no effect towards average electricity cost in Puerto Rico.
- Distributed generation can also be seen as an efficiency enhancement tool; the integration of renewable energy generation sources at small-scale and near the customer premises provide with several economic, environmental and technical benefits. Specifically, avoided T&D losses enable greater overall system efficiency through the displacement of electricity generation from conventional sources and thus avoiding T&D, and any necessary transformation of electricity delivered to the end-user. Therefore, based on the current electricity rate structure used by PREPA, DG is capable of enabling a reduction towards retail electricity price in Puerto Rico.
- Successful energy efficiency measures decrease PREPA’s electricity sales, thus reduces net generation requirements. Since our electricity rate is based on a cost-of-service structure depending on the sales volume, it also decreases the utility’s revenues. Therefore, the current electricity rate structure disincentive PREPA to promote energy efficiency programs.

In general, the adoption of an RPS policy in Puerto Rico will not result on an electricity rate impact but rather it will provide with a short and long-term reductions towards retail electricity prices projections as determined in this study. In addition, energy efficiency has proven to be a potential mechanism to reduce RPS compliance cost by means of cost-effective measures. Still, due to our current electricity rate structure end-user energy efficiency measures show no effect towards retail electricity price. Therefore, the current rate structure should be evaluated and decupling mechanisms should be pursued.

Moreover, based on the results provided in this project and the assumptions taken by this author, the permanence of our current electric power sector model will drive us to an unsustainable operation of our system directly affecting our economic growth through significantly high and unstable energy prices, deterring Puerto Rico’s economy and society in general. To conclude, if we take no action or corrective measures towards this sector an economic disrupt may occur over the next 25 years. Therefore, we must harness the potential within renewable energy sources and promote energy efficiency and conservation aggressively to ensure a sustainable energy future.

Results from this study provide with a significant contribution to the Puerto Rico electric power sector, including the local electric power utility (PREPA), policy-makers, the academia, and the general public. In addition, an economic model has been developed to quantify the impact of increasing renewable energy generation through RPS policies. This model provides a flexible and generic tool to evaluate countless scenarios and thus determine their economic effect towards the Puerto Rico electric power sector. On the other hand, this project has provided with valuable and transparent information, analysis, results, and policy recommendations for the development, implementation, and enforcement of an RPS policy and the potential integration of energy efficiency measures, from an energy and economic development perspective.

9.2. POLICY RECOMMENDATIONS

RPS policies should be implemented and enforce to encourage the use of renewable energy sources given the developable resource potential, interconnection and transmission constraints, as well as the needed financial support for project development. It is clear that there is no ideal way to design and implement an RPS; rather it must be tailored in accordance to Puerto Rico's needs and limitations, among other circumstances. Below a list of policy recommendations is provided regarding RPS adoption and energy efficiency enforcement.

- An RPS policy will require minimum financial support to assist on the development of renewable energy projects and enable their financing. Therefore, the REC market adopted through Act No. 82 of 2010 should provide with a robust regulatory framework as to establish market rules.
- A ramp-up period should be sought in early years so that sufficient renewable energy projects can be developed in a cost-effective manner. Furthermore, this should take into account renewable energy project currently under development and available incentives or financial support.
- A REC floor price should be established for each eligible technology to ensure their economic feasibility and further development. This floor price shall at minimum be the required amount or difference between the PPA price and the LCOE based on the current year technology's characteristics. Each year this price should be updated according to each technology market status.
- Notwithstanding the above, policy makers shall seek to establish ceiling prices to avoid any significant impact towards utility financial operations, or ultimately over retail

electricity price. Alternative Compliance Payments (ACP) or penalty prices must be enforced to assure RPS compliance.

- PREPA or any retail electricity provider (as defined in Act No. 82 2010) should standardize PPA contracts to provide with market certainty and transparency. These shall be designed and structured according to the specific renewable technology characteristics.
- Long-term purchasing agreements for RECs should be established, supported, and encouraged by PREPA or any other retail electricity provided, to mitigate existing market and financial insecurities related to REC pricing and expected cost recovery. A common practice is bundling electricity purchase price with REC prices within PPA contracts.
- Energy efficiency can be included as an eligible technology for compliance with an RPS policy. However, careful consideration and analysis must be employed to determine whether an RPS or a separate policy mechanism should be used to promote energy efficiency measures.
- Current policies and regulatory frameworks should be modified to align utility incentives with the enforcement of energy efficiency and conservation measures by removing regulatory and management disincentives to energy efficiency
- Ratemaking structures and practices should be evaluated and re-designed to promote energy efficiency investments by eliminating any criteria that discourages or neglects benefits from energy efficiency and conservation.
- Consider removing utility’s disincentive to promote energy efficiency through a decoupling mechanism that ensures full recovery of the utility’s revenue requirement.

The basic idea of revenue decoupling is to weaken the link between a utility's base rate revenue and customer use.

9.3. FUTURE WORK

Areas of further study include enhancements and modifications to the economic model developed by this author, as well as other related areas of study. In addition, we have provided with a list of recommended areas for future work that could lead to a better understanding of benefits RPS policies and energy efficiency.

- Since it is evident that Puerto Rico has its own abundant, accessible, and achievable renewable energy resources, one must ensure that the transmission system is capable of accepting high levels of renewable energy integration. Therefore, a suggestion would be to pursue a transmission access study to determine if transmission infrastructure expansions are needed to achieve renewable resource integration. We must recognize that the lack of transmission capabilities can significantly compromise RPS goals.
- In addition, it is suggested to develop a more detailed assessment on energy efficiency potential to determine realistic goals and achievable technical potential for each applicable energy efficiency specific measures. This study could serve as a reference point to design energy efficiency and conservations policies and further enforce its practice in a cost-effective manner.
- Also, we suggest performing an in-depth study capable of determining external costs of energy in Puerto Rico, including social and environmental values or benefits resulting from renewable energy source integration. This will definitely result in better outlook for renewable energy sources.

- Further studies should be employed to evaluate and consider scenarios using different electricity market structures, such as wholesale and retail competition, to explore how the production, T&D, and sale of electricity can be separated conceptually from the operation of the electric power system, and under a scenario different to a vertically-integrated monopoly utility structure. These should consider the interplay of supply and demand, and the marginal cost of producing, transmitting and distributing electricity to determine transaction prices.
- Last, but not least, a very interesting area for future work would be to elaborate and perform an assessment to provide with potential recommendations and suggested models regarding the ratemaking structure for the electric power service.

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11. Appendix A – Energy Efficiency Potential Calculation

Energy Conservation Codes (IECC 2009) - Residential Energy Efficiency Potential

Year	Total Electricity Sales (million kWh)	Residential Sector Total Electricity Sales (million kWh)	Total Number of Clients	Consumption Per Client (kWh/yr)	Base Case Factor	Remaining Factor	Conversion Factor	Savings Factor	Technical Potential (million kWh)	Energy Savings Percent
2006	20620	7,250.3								
2007	20672	7,243.6								
2008	19602	6,757.1								
2009	18516	6,367.5	1324752	4,806.6						
2010	19235	7,056.8	1335928	5,282.3						
2011		6,979.2	1335928	5,224.2	1	0.0037	0	0.3	0.00	0.00%
2012		6,951.3	1335928	5,203.3	1	0.0037	0	0.3	0.00	0.00%
2013		6,965.2	1335928	5,213.7	1	0.0037	0.25	0.3	1.96	0.01%
2014		7,013.9	1335928	5,250.2	1	0.0037	0.5	0.3	3.94	0.02%
2015		7,070.0	1335928	5,292.2	1	0.0037	1	0.3	7.94	0.04%
2016		7,126.6	1335928	5,334.6	1	0.0037	1	0.3	8.00	0.04%
2017		7,183.6	1335928	5,377.2	1	0.0037	1	0.3	8.07	0.04%
2018		7,241.1	1335928	5,420.3	1	0.0037	1	0.3	8.13	0.04%
2019		7,299.0	1335928	5,463.6	1	0.0037	1	0.3	8.20	0.04%
2020		7,357.4	1335928	5,507.3	1	0.0037	1	0.3	8.26	0.04%
2021		7,416.2	1335928	5,551.4	1	0.0037	1	0.3	8.33	0.04%
2022		7,475.6	1335928	5,595.8	1	0.0037	1	0.3	8.39	0.04%
2023		7,535.4	1335928	5,640.6	1	0.0037	1	0.3	8.46	0.04%
2024		7,595.7	1335928	5,685.7	1	0.0037	1	0.3	8.53	0.04%
2025		7,656.4	1335928	5,731.2	1	0.0037	1	0.3	8.60	0.04%
2026		7,717.7	1335928	5,777.0	1	0.0037	1	0.3	8.67	0.05%
2027		7,779.4	1335928	5,823.2	1	0.0037	1	0.3	8.73	0.05%
2028		7,841.7	1335928	5,869.8	1	0.0037	1	0.3	8.80	0.05%
2029		7,904.4	1335928	5,916.8	1	0.0037	1	0.3	8.88	0.05%
2030		7,967.6	1335928	5,964.1	1	0.0037	1	0.3	8.95	0.05%
2031		8,031.4	1335928	6,011.8	1	0.0037	1	0.3	9.02	0.05%
2032		8,095.6	1335928	6,059.9	1	0.0037	1	0.3	9.09	0.05%
2033		8,160.4	1335928	6,108.4	1	0.0037	1	0.3	9.16	0.05%
2034		8,225.7	1335928	6,157.3	1	0.0037	1	0.3	9.24	0.05%
2035		8,291.5	1335928	6,206.5	1	0.0037	1	0.3	9.31	0.05%
						Achievable Potential by 2035			**111.98**	**0.58%**

Solar Water Heater - Residential Energy Efficiency Potential

Year	Total Electricity Sales (million kWh)	Residential Sector Total Electricity Sales (million kWh)	Total Number of Clients	Consumption Per Client (kWh/yr)	Base Case Factor	Remaining Factor	Conversion Factor	Savings Factor	Technical Potential (million kWh)	Energy Savings Percent
2006	20620	7,250.3								
2007	20672	7,243.6								
2008	19602	6,757.1								
2009	18516	6,367.5	1324752	4,806.6						
2010	19235	7,056.8	1335928	5,282.3						
2011		6,979.2	1335928	5,224.2	0.25	0.60	1	0.3	314.06	1.63%
2012		6,951.3	1335928	5,203.3	0.25	0.54	1	0.3	281.53	1.46%
2013		6,965.2	1335928	5,213.7	0.25	0.49	1	0.3	253.88	1.32%
2014		7,013.9	1335928	5,250.2	0.25	0.44	1	0.3	230.09	1.20%
2015		7,070.0	1335928	5,292.2	0.25	0.39	1	0.3	208.74	1.09%
2016		7,126.6	1335928	5,334.6	0.25	0.35	1	0.3	189.37	0.98%
2017		7,183.6	1335928	5,377.2	0.25	0.32	1	0.3	171.79	0.89%
2018		7,241.1	1335928	5,420.3	0.25	0.29	1	0.3	155.85	0.81%
2019		7,299.0	1335928	5,463.6	0.25	0.26	1	0.3	141.39	0.74%
2020		7,357.4	1335928	5,507.3	0.25	0.23	1	0.3	128.27	0.67%
2021		7,416.2	1335928	5,551.4	0.25	0.21	1	0.3	116.36	0.60%
2022		7,475.6	1335928	5,595.8	0.25	0.19	1	0.3	105.57	0.55%
2023		7,535.4	1335928	5,640.6	0.25	0.17	1	0.3	95.77	0.50%
2024		7,595.7	1335928	5,685.7	0.25	0.15	1	0.3	86.88	0.45%
2025		7,656.4	1335928	5,731.2	0.25	0.14	1	0.3	78.82	0.41%
2026		7,717.7	1335928	5,777.0	0.25	0.12	1	0.3	71.51	0.37%
2027		7,779.4	1335928	5,823.2	0.25	0.11	1	0.3	64.87	0.34%
2028		7,841.7	1335928	5,869.8	0.25	0.10	1	0.3	58.85	0.31%
2029		7,904.4	1335928	5,916.8	0.25	0.09	1	0.3	53.39	0.28%
2030		7,967.6	1335928	5,964.1	0.25	0.08	1	0.3	48.43	0.25%
2031		8,031.4	1335928	6,011.8	0.25	0.07	1	0.3	43.94	0.23%
2032		8,095.6	1335928	6,059.9	0.25	0.07	1	0.3	39.86	0.21%
2033		8,160.4	1335928	6,108.4	0.25	0.06	1	0.3	36.16	0.19%
2034		8,225.7	1335928	6,157.3	0.25	0.05	1	0.3	32.81	0.17%
2035		8,291.5	1335928	6,206.5	0.25	0.05	1	0.3	29.76	0.15%
						Achievable Potential by 2035			**1822.77**	**9.48%**

Energy Star Products (Lighting, A/C, and Domestic Appliances) - Residential Energy Efficiency Potential										
Year	Total Electricity Sales (million kWh)	Residential Sector Electricity Sales (million kWh)	Total Number of Clients	Consumption Per Client (kWh/yr)	Base Case Factor	Remaining Factor	Conversion Factor	Savings Factor	Technical Potential (million kWh)	Energy Savings Percent
2006	20620	7,250.3								
2007	20672	7,243.6								
2008	19602	6,757.1								
2009	18516	6,367.5	1324752	4,806.6						
2010	19235	7,056.8	1335928	5,282.3						
2011		6,979.2	1335928	5,224.2	0.7	0.50	1	0.2	488.54	2.54%
2012		6,951.3	1335928	5,203.3	0.7	0.45	1	0.2	437.93	2.28%
2013		6,965.2	1335928	5,213.7	0.7	0.41	1	0.2	394.92	2.05%
2014		7,013.9	1335928	5,250.2	0.7	0.36	1	0.2	357.92	1.86%
2015		7,070.0	1335928	5,292.2	0.7	0.33	1	0.2	324.71	1.69%
2016		7,126.6	1335928	5,334.6	0.7	0.30	1	0.2	294.57	1.53%
2017		7,183.6	1335928	5,377.2	0.7	0.27	1	0.2	267.24	1.39%
2018		7,241.1	1335928	5,420.3	0.7	0.24	1	0.2	242.44	1.26%
2019		7,299.0	1335928	5,463.6	0.7	0.22	1	0.2	219.94	1.14%
2020		7,357.4	1335928	5,507.3	0.7	0.19	1	0.2	199.53	1.04%
2021		7,416.2	1335928	5,551.4	0.7	0.17	1	0.2	181.01	0.94%
2022		7,475.6	1335928	5,595.8	0.7	0.16	1	0.2	164.21	0.85%
2023		7,535.4	1335928	5,640.6	0.7	0.14	1	0.2	148.98	0.77%
2024		7,595.7	1335928	5,685.7	0.7	0.13	1	0.2	135.15	0.70%
2025		7,656.4	1335928	5,731.2	0.7	0.11	1	0.2	122.61	0.64%
2026		7,717.7	1335928	5,777.0	0.7	0.10	1	0.2	111.23	0.58%
2027		7,779.4	1335928	5,823.2	0.7	0.09	1	0.2	100.91	0.52%
2028		7,841.7	1335928	5,869.8	0.7	0.08	1	0.2	91.54	0.48%
2029		7,904.4	1335928	5,916.8	0.7	0.08	1	0.2	83.05	0.43%
2030		7,967.6	1335928	5,964.1	0.7	0.07	1	0.2	75.34	0.39%
2031		8,031.4	1335928	6,011.8	0.7	0.06	1	0.2	68.35	0.36%
2032		8,095.6	1335928	6,059.9	0.7	0.05	1	0.2	62.01	0.32%
2033		8,160.4	1335928	6,108.4	0.7	0.05	1	0.2	56.25	0.29%
2034		8,225.7	1335928	6,157.3	0.7	0.04	1	0.2	51.03	0.27%
2035		8,291.5	1335928	6,206.5	0.7	0.04	1	0.2	46.30	0.24%
						Achievable Potential by 2035			**2835.42**	**14.74%**

Energy Conservation Codes (ASHRAE 90.1-2007) - Commercial Buildings Energy Efficiency Potential										
Year	Total Electricity Sales (million kWh)	Residential Sector Total Electricity Sales (million kWh)	Total Number of Clients	Consumption Per Client (kWh/yr)	Base Case Factor	Remaining Factor	Conversion Factor	Savings Factor	Technical Potential (million kWh)	Energy Savings Percent
2006	20620	8,734.6								
2007	20672	8,909.4								
2008	19602	8,743.5								
2009	18516	8,498.0	129492	65,625.7						
2010	19235	8,759.1	129208	67,790.7						
2011		8,662.7	129208	67,045.0	0.8	0.0588	0	0.3	0.00	0.00%
2012		8,628.1	129208	66,776.8	0.8	0.0588	0.25	0.3	30.45	0.16%
2013		8,645.4	129208	66,910.4	0.8	0.0588	0.5	0.3	61.02	0.32%
2014		8,705.9	129208	67,378.7	0.8	0.0588	0.75	0.3	92.17	0.48%
2015		8,819.0	129208	68,254.7	0.8	0.0588	1	0.3	124.50	0.65%
2016		8,933.7	129208	69,142.0	0.8	0.0588	1	0.3	126.11	0.66%
2017		9,049.8	129208	70,040.8	0.8	0.0588	1	0.3	127.75	0.66%
2018		9,167.5	129208	70,951.4	0.8	0.0588	1	0.3	129.42	0.67%
2019		9,286.7	129208	71,873.7	0.8	0.0588	1	0.3	131.10	0.68%
2020		9,407.4	129208	72,808.1	0.8	0.0588	1	0.3	132.80	0.69%
2021		9,529.7	129208	73,754.6	0.8	0.0588	1	0.3	134.53	0.70%
2022		9,653.6	129208	74,713.4	0.8	0.0588	1	0.3	136.28	0.71%
2023		9,779.1	129208	75,684.7	0.8	0.0588	1	0.3	138.05	0.72%
2024		9,906.2	129208	76,668.6	0.8	0.0588	1	0.3	139.84	0.73%
2025		10,035.0	129208	77,665.3	0.8	0.0588	1	0.3	141.66	0.74%
2026		10,165.4	129208	78,674.9	0.8	0.0588	1	0.3	143.50	0.75%
2027		10,297.6	129208	79,697.7	0.8	0.0588	1	0.3	145.37	0.76%
2028		10,431.4	129208	80,733.8	0.8	0.0588	1	0.3	147.26	0.77%
2029		10,567.1	129208	81,783.3	0.8	0.0588	1	0.3	149.17	0.78%
2030		10,704.4	129208	82,846.5	0.8	0.0588	1	0.3	151.11	0.79%
2031		10,843.6	129208	83,923.5	0.8	0.0588	1	0.3	153.08	0.80%
2032		10,984.6	129208	85,014.5	0.8	0.0588	1	0.3	155.07	0.81%
2033		11,127.4	129208	86,119.7	0.8	0.0588	1	0.3	157.08	0.82%
2034		11,272.0	129208	87,239.2	0.8	0.0588	1	0.3	159.12	0.83%
2035		11,418.5	129208	88,373.3	0.8	0.0588	1	0.3	161.19	0.84%
						Achievable Potential by 2035			**1900.59**	**9.88%**

Industrial Energy Retrofits (HVAC, Motors, Heat Recovery, Envelope, Etc.) - Industrial Sector Energy Efficiency Potential

Year	Total Electricity Sales (million kWh)	Residential Sector Total Electricity Sales (million kWh)	Total Number of Clients	Consumption Per Client (kWh/yr)	Base Case Factor	Remaining Factor	Conversion Factor	Savings Factor	Technical Potential (million kWh)	Energy Savings Percent
2006	20620	4,241.8								
2007	20672	4,136.3								
2008	19602	3,741.6								
2009	18516	3,288.4	129492	25,394.6						
2010	19235	3,047.2	129208	23,583.7						
2011		3,013.7	129208	23,324.3	0.7	0.60	1	0.2	253.15	1.32%
2012		3,001.6	129208	23,231.0	0.7	0.54	1	0.2	226.92	1.18%
2013		3,007.6	129208	23,277.4	0.7	0.49	1	0.2	204.64	1.06%
2014		3,028.7	129208	23,440.4	0.7	0.44	1	0.2	185.46	0.96%
2015		3,031.7	129208	23,463.8	0.7	0.39	1	0.2	167.08	0.87%
2016		3,034.7	129208	23,487.3	0.7	0.35	1	0.2	150.53	0.78%
2017		3,037.8	129208	23,510.8	0.7	0.32	1	0.2	135.61	0.71%
2018		3,040.8	129208	23,534.3	0.7	0.29	1	0.2	122.17	0.64%
2019		3,043.9	129208	23,557.8	0.7	0.26	1	0.2	110.06	0.57%
2020		3,046.9	129208	23,581.4	0.7	0.23	1	0.2	99.16	0.52%
2021		3,049.9	129208	23,604.9	0.7	0.21	1	0.2	89.33	0.46%
2022		3,053.0	129208	23,628.5	0.7	0.19	1	0.2	80.48	0.42%
2023		3,056.1	129208	23,652.2	0.7	0.17	1	0.2	72.50	0.38%
2024		3,059.1	129208	23,675.8	0.7	0.15	1	0.2	65.32	0.34%
2025		3,062.2	129208	23,699.5	0.7	0.14	1	0.2	58.84	0.31%
2026		3,065.2	129208	23,723.2	0.7	0.12	1	0.2	53.01	0.28%
2027		3,068.3	129208	23,746.9	0.7	0.11	1	0.2	47.76	0.25%
2028		3,071.4	129208	23,770.7	0.7	0.10	1	0.2	43.03	0.22%
2029		3,074.4	129208	23,794.4	0.7	0.09	1	0.2	38.76	0.20%
2030		3,077.5	129208	23,818.2	0.7	0.08	1	0.2	34.92	0.18%
2031		3,080.6	129208	23,842.1	0.7	0.07	1	0.2	31.46	0.16%
2032		3,083.7	129208	23,865.9	0.7	0.07	1	0.2	28.34	0.15%
2033		3,086.7	129208	23,889.8	0.7	0.06	1	0.2	25.53	0.13%
2034		3,089.8	129208	23,913.7	0.7	0.05	1	0.2	23.00	0.12%
2035		3,092.9	129208	23,937.6	0.7	0.05	1	0.2	20.72	0.11%
						Achievable Potential by 2035			**1420.68**	**7.39%**

Year	Project Electricity Consumption (w/o Energy Efficiency Measures) (million kWh)	Estimated Electricity Consumption (w Residential EE Potential Savings) (million kWh)	Estimated Electricity Consumption (w C&I EE Potential Savings) (million kWh)	Estimated Electricity Consumption (w/ Overall EE Potential Savings) (million kWh)
2006	20620			
2007	20672			
2008	19602			
2009	18516			
2010	19235			
2011	17939	18753	19083	18601
2012	17909	18322	18929	18015
2013	18036	17931	18769	17465
2014	18280	17576	18603	16944
2015	18408	17251	18428	16444
2016	18537	16956	18262	15983
2017	18666	16688	18104	15557
2018	18797	16444	17953	15162
2019	18929	16222	17808	14795
2020	19061	16021	17669	14455
2021	19194	15837	17535	14137
2022	19329	15670	17404	13840
2023	19464	15518	17278	13562
2024	19600	15380	17155	13300
2025	19738	15254	17035	13054
2026	19876	15139	16917	12821
2027	20015	15034	16801	12600
2028	20155	14939	16687	12391
2029	20296	14852	16574	12191
2030	20438	14772	16462	12000
2031	20581	14699	16352	11816
2032	20725	14633	16242	11639
2033	20870	14572	16132	11469
2034	21016	14516	16023	11304
2035	21164	14465	15914	11143
Achievable Potential		**24.80%**	**17.27%**	**42.07%**

12. Appendix B – RE Cost and Performance Assumption Example

UTILITY-SCALE SOLAR PV

Year	Hear Rate (Btu/kWh)	Capacity Factor (%)	Capital Cost ($/kW)	Project and Land Cost ($/Kw)	Project Contingency (factor)	Total Capital Cost	Fixed O&M ($/kW/yr)	Variable O&M ($/MWh)	Fuel Cost ($/MMBtu)	CBI Eligible (%)	PBI / RECs ($/MWh)
2010	N/A	22%	$ 4,000	$ 420.00	1.05	$ 4,620	$ 12.00	$ -	N/A	30%	$ -
2011	N/A	22%	$ 3,920	$ 411.60	1.05	$ 4,528	$ 12.12	$ -	N/A	30%	$ -
2012	N/A	22%	$ 3,842	$ 403.37	1.05	$ 4,437	$ 12.24	$ -	N/A	0%	$ -
2013	N/A	22%	$ 3,765	$ 395.30	1.05	$ 4,348	$ 12.36	$ -	N/A	0%	$ -
2014	N/A	22%	$ 3,689	$ 387.39	1.05	$ 4,261	$ 12.49	$ -	N/A	0%	$ -
2015	N/A	22%	$ 3,616	$ 379.65	1.05	$ 4,176	$ 12.61	$ -	N/A	0%	$ -
2016	N/A	22%	$ 3,493	$ 366.74	1.05	$ 4,034	$ 12.74	$ -	N/A	0%	$ -
2017	N/A	22%	$ 3,374	$ 354.27	1.05	$ 3,897	$ 12.87	$ -	N/A	0%	$ -
2018	N/A	22%	$ 3,259	$ 342.22	1.05	$ 3,764	$ 12.99	$ -	N/A	0%	$ -
2019	N/A	22%	$ 3,148	$ 330.59	1.05	$ 3,636	$ 13.12	$ -	N/A	0%	$ -
2020	N/A	22%	$ 3,041	$ 319.35	1.05	$ 3,513	$ 13.26	$ -	N/A	0%	$ -
2021	N/A	22%	$ 2,938	$ 308.49	1.05	$ 3,393	$ 13.39	$ -	N/A	0%	$ -
2022	N/A	22%	$ 2,838	$ 298.00	1.05	$ 3,278	$ 13.52	$ -	N/A	0%	$ -
2023	N/A	22%	$ 2,742	$ 287.87	1.05	$ 3,167	$ 13.66	$ -	N/A	0%	$ -
2024	N/A	22%	$ 2,648	$ 278.08	1.05	$ 3,059	$ 13.79	$ -	N/A	0%	$ -
2025	N/A	22%	$ 2,558	$ 268.63	1.05	$ 2,955	$ 13.93	$ -	N/A	0%	$ -
2026	N/A	22%	$ 2,471	$ 259.49	1.05	$ 2,854	$ 14.07	$ -	N/A	0%	$ -
2027	N/A	22%	$ 2,387	$ 250.67	1.05	$ 2,757	$ 14.21	$ -	N/A	0%	$ -
2028	N/A	22%	$ 2,306	$ 242.15	1.05	$ 2,664	$ 14.35	$ -	N/A	0%	$ -
2029	N/A	22%	$ 2,228	$ 233.92	1.05	$ 2,573	$ 14.50	$ -	N/A	0%	$ -
2030	N/A	22%	$ 2,152	$ 225.96	1.05	$ 2,486	$ 14.64	$ -	N/A	0%	$ -
2031	N/A	22%	$ 2,079	$ 218.28	1.05	$ 2,401	$ 14.79	$ -	N/A	0%	$ -
2032	N/A	22%	$ 2,008	$ 210.86	1.05	$ 2,319	$ 14.94	$ -	N/A	0%	$ -
2033	N/A	22%	$ 1,940	$ 203.69	1.05	$ 2,241	$ 15.09	$ -	N/A	0%	$ -
2034	N/A	22%	$ 1,874	$ 196.76	1.05	$ 2,164	$ 15.24	$ -	N/A	0%	$ -
2035	N/A	22%	$ 1,810	$ 190.07	1.05	$ 2,091	$ 15.39	$ -	N/A	0%	$ -
2036	N/A	22%	$ 1,749	$ 183.61	1.05	$ 2,020	$ 15.54	$ -	N/A	0%	$ -
2037	N/A	22%	$ 1,689	$ 177.37	1.05	$ 1,951	$ 15.70	$ -	N/A	0%	$ -
2038	N/A	22%	$ 1,632	$ 171.34	1.05	$ 1,885	$ 15.86	$ -	N/A	0%	$ -
2039	N/A	22%	$ 1,576	$ 165.51	1.05	$ 1,821	$ 16.01	$ -	N/A	0%	$ -
2040	N/A	22%	$ 1,523	$ 159.89	1.05	$ 1,759	$ 16.17	$ -	N/A	0%	$ -
2041	N/A	22%	$ 1,471	$ 154.45	1.05	$ 1,699	$ 16.34	$ -	N/A	0%	$ -
2042	N/A	22%	$ 1,421	$ 149.20	1.05	$ 1,641	$ 16.50	$ -	N/A	0%	$ -
2043	N/A	22%	$ 1,373	$ 144.12	1.05	$ 1,585	$ 16.66	$ -	N/A	0%	$ -
2044	N/A	22%	$ 1,326	$ 139.22	1.05	$ 1,531	$ 16.83	$ -	N/A	0%	$ -
2045	N/A	22%	$ 1,281	$ 134.49	1.05	$ 1,479	$ 17.00	$ -	N/A	0%	$ -
2046	N/A	22%	$ 1,237	$ 129.92	1.05	$ 1,429	$ 17.17	$ -	N/A	0%	$ -
2047	N/A	22%	$ 1,195	$ 125.50	1.05	$ 1,381	$ 17.34	$ -	N/A	0%	$ -
2048	N/A	22%	$ 1,155	$ 121.23	1.05	$ 1,334	$ 17.51	$ -	N/A	0%	$ -
2049	N/A	22%	$ 1,115	$ 117.11	1.05	$ 1,288	$ 17.69	$ -	N/A	0%	$ -
2050	N/A	22%	$ 1,077	$ 113.13	1.05	$ 1,244	$ 17.87	$ -	N/A	0%	$ -
2051	N/A	22%	$ 1,041	$ 109.28	1.05	$ 1,202	$ 18.05	$ -	N/A	0%	$ -
2052	N/A	22%	$ 1,005	$ 105.57	1.05	$ 1,161	$ 18.23	$ -	N/A	0%	$ -
2053	N/A	22%	$ 971	$ 101.98	1.05	$ 1,122	$ 18.41	$ -	N/A	0%	$ -
2054	N/A	22%	$ 938	$ 98.51	1.05	$ 1,084	$ 18.59	$ -	N/A	0%	$ -
2055	N/A	22%	$ 906	$ 95.16	1.05	$ 1,047	$ 18.78	$ -	N/A	0%	$ -

13. Appendix C – Renewable Energy Project Financial Sheet Model

Year	0	1	2	3	4	5	6
Electric Output (kWh)		1,927,200.00	1,917,564.00	1,907,976.18	1,898,436.30	1,888,944.12	1,879,499.40
Electricity Sales Price ($/kWh)		0.135	0.138375	0.141834375	0.145380234	0.14901474	0.152740109
Operating Revenues							
Cost plus financing expense and profit (CFP)		260,172.00	265,342.92	270,616.61	275,995.11	281,480.52	287,074.94
Operating Expenses							
Fixed (Annual) O & M Expense		12,120.00	12,229.08	12,339.14	12,450.19	12,562.25	12,675.31
Fixed O & M Expense		12,120.00	12,350.28	12,584.94	12,824.05	13,067.71	13,315.99
Variable O & M Expense		0.00	0.00	0.00	0.00	0.00	0.00
Fuel O & M Expense		0.00	0.00	0.00	0.00	0.00	0.00
Insurance		**22,638.00**	**22,841.74**	**23,047.32**	**23,254.74**	**23,464.04**	**23,675.21**
Property Taxes		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Operating Expenses		34,758.00	35,192.02	35,632.25	36,078.79	36,531.74	36,991.20
Operating Income		225,414.00	230,150.90	234,984.36	239,916.32	244,948.77	250,083.74
Financing							
Debt Funds	1,901,592.00						
Equity Funds	1,267,728.00						
Total Capital Investment	3,169,320.00						
Cash Available Before Debt		225,414.00	230,150.90	234,984.36	239,916.32	244,948.77	250,083.74
Debt Interest Payment		152,127.36	146,524.58	140,473.57	133,938.49	126,880.60	119,258.08
Debt Repayment		70,034.77	75,637.55	81,688.55	88,223.64	95,281.53	102,904.05
Total Debt Payment		**222,162.13**	**222,162.13**	**222,162.13**	**222,162.13**	**222,162.13**	**222,162.13**
Tax Effect on Equity (State)							
Operating Income		225,414.00	230,150.90	234,984.36	239,916.32	244,948.77	250,083.74
Investment Based Incentives (IBI)		1,358,280.00					
Federal IBI		1,358,280.00					
State IBI		0.00					
Capacity Based Incentives (CBI)		0.00					
Federal CBI		0.00					
State CBI		0.00					
Performance Based Incentives (PBI)		0.00	0.00	0.00	0.00	0.00	0.00
Federal PBI		0.00	0.00	0.00	0.00	0.00	0.00
State PBI		0.00	0.00	0.00	0.00	0.00	0.00
Super Depreciation Schedule		1.00	0.00	0.00	0.00	0.00	0.00
Depreciation		3,169,320.00	0.00	0.00	0.00	0.00	0.00
Interest Payment		152,127.36	146,524.58	140,473.57	133,938.49	126,880.60	119,258.08
Sales Tax		0.00					
Total Income		-1,737,753.36	83,626.32	94,510.78	105,977.83	118,068.18	130,825.66
Total Taxable Income		-1,737,753.36	83,626.32	94,510.78	105,977.83	118,068.18	130,825.66
Income Taxes		**-69,510.13**	**3,345.05**	**3,780.43**	**4,239.11**	**4,722.73**	**5,233.03**
Production Tax Credit		0.00	0.00	0.00	0.00	0.00	0.00
Investment Tax Credit		0.00					
Tax Savings (Liability)		69,510.13	-3,345.05	-3,780.43	-4,239.11	-4,722.73	-5,233.03
Total Income w/o incentives		-3,096,033.36	83,626.32	94,510.78	105,977.83	118,068.18	130,825.66
Total Taxable Income		-6,417,480.72	-62,898.26	-45,962.79	-27,960.66	-8,812.42	11,567.58
Income Taxes		-256,699.23	-2,515.93	-1,838.51	-1,118.43	-352.50	462.70
Tax Effect on Equity (Federal)							
Operating Income		225,414.00	230,150.90	234,984.36	239,916.32	244,948.77	250,083.74
Investment Based Incentives (IBI)		1,358,280.00					
Federal IBI		1,358,280.00					
State IBI		0.00					
Capacity Based Incentives (CBI)		0.00					
Federal CBI		0.00					
State CBI		0.00					
Performance Based Incentives (PBI)		0.00	0.00	0.00	0.00	0.00	0.00
Federal PBI		0.00	0.00	0.00	0.00	0.00	0.00
State PBI		0.00	0.00	0.00	0.00	0.00	0.00
Utility PBI		0.00	0.00	0.00	0.00	0.00	0.00
Other PBI		0.00	0.00	0.00	0.00	0.00	0.00
Depreciation Schedule		0.35	0.26	0.16	0.11	0.11	0.01
Depreciation		1,109,262.00	824,023.20	494,413.92	348,942.13	348,942.13	43,736.62
Interest Payment		152,127.36	146,524.58	140,473.57	133,938.49	126,880.60	119,258.08
Sales Tax		0.00					
State Tax Savings (Liability)		69,510.13	-3,345.05	-3,780.43	-4,239.11	-4,722.73	-5,233.03
Total Income		391,814.77	-743,741.93	-403,683.57	-247,203.41	-235,596.68	81,856.02
Total Taxable Income		-966,465.23	-743,741.93	-403,683.57	-247,203.41	-235,596.68	81,856.02
Income Taxes		**-338,262.83**	**-260,309.68**	**-141,289.25**	**-86,521.19**	**-82,458.84**	**28,649.61**
Production Tax Credit		0.00	0.00	0.00	0.00	0.00	0.00
Investment Tax Credit		0.00					
Tax Savings (Liability)		338,262.83	260,309.68	141,289.25	86,521.19	82,458.84	-28,649.61
State and Federal Tax Savings (Liability)		407,772.96	256,964.62	137,508.82	82,282.08	77,736.11	-33,882.63
Total Income w/o incentives		-966,465.23	-743,741.93	-403,683.57	-247,203.41	-235,596.68	81,856.02
Total Taxable Income		-2,227,854.59	-1,714,289.71	-1,038,571.06	-730,084.04	-711,419.41	-81,138.68
Income Taxes		-779,749.10	-600,001.40	-363,499.87	-255,529.41	-248,996.80	-28,398.54
`							
After Tax Net Equity Cash Flow	-1,267,728.00	411,024.84	264,953.39	150,331.05	100,036.28	100,522.76	-5,961.02
After Tax Net Equity Cost Flow	-1,267,728.00	150,852.84	-389.53	-120,285.56	-175,958.84	-180,957.76	-293,035.97
Pre-tax Debt Coverage Ratio		1.01	1.04	1.06	1.08	1.10	1.13

Year	7	8	9	10	11	12
Electric Output (kWh)	1,870,101.90	1,860,751.39	1,851,447.63	1,842,190.40	1,832,979.44	1,823,814.55
Electricity Sales Price ($/kWh)	0.156558611	0.160472577	0.164484391	0.168596501	0.172811413	0.177131699
Operating Revenues						
Cost plus financing expense and profit (CFP)	292,780.56	298,599.57	304,534.24	310,586.85	316,759.77	323,055.37
Operating Expenses						
Fixed (Annual) O & M Expense	12,789.38	12,904.49	13,020.63	13,137.81	13,256.05	13,375.36
Fixed O & M Expense	13,569.00	13,826.81	14,089.52	14,357.22	14,630.00	14,907.97
Variable O & M Expense	0.00	0.00	0.00	0.00	0.00	0.00
Fuel O & M Expense	0.00	0.00	0.00	0.00	0.00	0.00
Insurance	**23,888.29**	**24,103.28**	**24,320.21**	**24,539.10**	**24,759.95**	**24,982.79**
Property Taxes	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Operating Expenses	37,457.29	37,930.09	38,409.73	38,896.31	39,389.95	39,890.76
Operating Income	255,323.27	260,669.48	266,124.51	271,690.54	277,369.82	283,164.61
Financing						
Debt Funds						
Equity Funds						
Total Capital Investment						
Cash Available Before Debt	255,323.27	260,669.48	266,124.51	271,690.54	277,369.82	283,164.61
Debt Interest Payment	111,025.75	102,134.84	92,532.66	82,162.30	70,962.32	58,866.33
Debt Repayment	111,136.38	120,027.29	129,629.47	139,999.83	151,199.81	163,295.80
Total Debt Payment	**222,162.13**	**222,162.13**	**222,162.13**	**222,162.13**	**222,162.13**	**222,162.13**
Tax Effect on Equity (State)						
Operating Income	255,323.27	260,669.48	266,124.51	271,690.54	277,369.82	283,164.61
Investment Based Incentives (IBI)						
Federal IBI						
State IBI						
Capacity Based Incentives (CBI)						
Federal CBI						
State CBI						
Performance Based Incentives (PBI)	0.00	0.00	0.00	0.00	0.00	0.00
Federal PBI	0.00	0.00	0.00	0.00	0.00	0.00
State PBI	0.00	0.00	0.00	0.00	0.00	0.00
Super Depreciation Schedule	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation	0.00	0.00	0.00	0.00	0.00	0.00
Interest Payment	111,025.75	102,134.84	92,532.66	82,162.30	70,962.32	58,866.33
Sales Tax						
Total Income	144,297.52	158,534.64	173,591.85	189,528.24	206,407.50	224,298.28
Total Taxable Income	144,297.52	158,534.64	173,591.85	189,528.24	206,407.50	224,298.28
Income Taxes	**5,771.90**	**6,341.39**	**6,943.67**	**7,581.13**	**8,256.30**	**8,971.93**
Production Tax Credit	0.00	0.00	0.00	0.00	0.00	0.00
Investment Tax Credit						
Tax Savings (Liability)	-5,771.90	-6,341.39	-6,943.67	-7,581.13	-8,256.30	-8,971.93
Total Income w/o incentives	144,297.52	158,534.64	173,591.85	189,528.24	206,407.50	224,298.28
Total Taxable Income	33,271.77	56,399.79	81,059.19	107,365.94	135,445.18	165,431.94
Income Taxes	1,330.87	2,255.99	3,242.37	4,294.64	5,417.81	6,617.28
Tax Effect on Equity (Federal)						
Operating Income	255,323.27	260,669.48	266,124.51	271,690.54	277,369.82	283,164.61
Investment Based Incentives (IBI)						
Federal IBI						
State IBI						
Capacity Based Incentives (CBI)						
Federal CBI						
State CBI						
Performance Based Incentives (PBI)	0.00	0.00	0.00	0.00	0.00	0.00
Federal PBI	0.00	0.00	0.00	0.00	0.00	0.00
State PBI	0.00	0.00	0.00	0.00	0.00	0.00
Utility PBI	0.00	0.00	0.00	0.00	0.00	0.00
Other PBI	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation Schedule	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation	0.00	0.00	0.00	0.00	0.00	0.00
Interest Payment	111,025.75	102,134.84	92,532.66	82,162.30	70,962.32	58,866.33
Sales Tax						
State Tax Savings (Liability)	-5,771.90	-6,341.39	-6,943.67	-7,581.13	-8,256.30	-8,971.93
Total Income	138,525.62	152,193.25	166,648.17	181,947.11	198,151.20	215,326.34
Total Taxable Income	138,525.62	152,193.25	166,648.17	181,947.11	198,151.20	215,326.34
Income Taxes	**48,483.97**	**53,267.64**	**58,326.86**	**63,681.49**	**69,352.92**	**75,364.22**
Production Tax Credit	0.00	0.00	0.00	0.00	0.00	0.00
Investment Tax Credit						
Tax Savings (Liability)	-48,483.97	-53,267.64	-58,326.86	-63,681.49	-69,352.92	-75,364.22
State and Federal Tax Savings (Liability)	-54,255.87	-59,609.02	-65,270.53	-71,262.62	-77,609.22	-84,336.15
Total Income w/o incentives	138,525.62	152,193.25	166,648.17	181,947.11	198,151.20	215,326.34
Total Taxable Income	27,499.86	50,058.41	74,115.51	99,784.81	127,188.88	156,460.01
Income Taxes	9,624.95	17,520.44	25,940.43	34,924.68	44,516.11	54,761.00
`						
After Tax Net Equity Cash Flow	-21,094.72	-21,101.67	-21,308.16	-21,734.20	-22,401.53	-23,333.67
After Tax Net Equity Cost Flow	-313,875.28	-319,701.24	-325,842.39	-332,321.06	-339,161.30	-346,389.04
Pre-tax Debt Coverage Ratio	1.15	1.17	1.20	1.22	1.25	1.27

Year	13	14	15	16	17	18	19
Electric Output (kWh)	1,814,695.47	1,805,622.00	1,796,593.89	1,787,610.92	1,778,672.86	1,769,779.50	1,760,930.60
Electricity Sales Price ($/kWh)	0.181559991	0.186098991	0.190751466	0.195520252	0.200408259	0.205418465	0.210553927
Operating Revenues							
Cost plus financing expense and profit (CFP)	329,476.09	336,024.43	342,702.92	349,514.14	356,460.73	363,545.39	370,770.85
Operating Expenses							
Fixed (Annual) O & M Expense	13,495.74	13,617.20	13,739.75	13,863.41	13,988.18	14,114.08	14,241.10
Fixed O & M Expense	15,191.23	15,479.86	15,773.98	16,073.68	16,379.08	16,690.28	17,007.40
Variable O & M Expense	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fuel O & M Expense	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Insurance	**25,207.63**	**25,434.50**	**25,663.41**	**25,894.38**	**26,127.43**	**26,362.58**	**26,599.84**
Property Taxes	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Operating Expenses	40,398.86	40,914.36	41,437.39	41,968.06	42,506.51	43,052.86	43,607.24
Operating Income	289,077.24	295,110.07	301,265.53	307,546.07	313,954.22	320,492.53	327,163.61
Financing							
Debt Funds							
Equity Funds							
Total Capital Investment							
Cash Available Before Debt	289,077.24	295,110.07	301,265.53	307,546.07	313,954.22	320,492.53	327,163.61
Debt Interest Payment	45,802.67	31,693.91	16,456.45	0.00	0.00	0.00	0.00
Debt Repayment	176,359.46	190,468.22	205,705.67	0.00	0.00	0.00	0.00
Total Debt Payment	**222,162.13**	**222,162.13**	**222,162.13**	**0.00**	**0.00**	**0.00**	**0.00**
Tax Effect on Equity (State)							
Operating Income	289,077.24	295,110.07	301,265.53	307,546.07	313,954.22	320,492.53	327,163.61
Investment Based Incentives (IBI)							
Federal IBI							
State IBI							
Capacity Based Incentives (CBI)							
Federal CBI							
State CBI							
Performance Based Incentives (PBI)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Federal PBI	0.00	0.00	0.00	0.00	0.00	0.00	0.00
State PBI	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Super Depreciation Schedule	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interest Payment	45,802.67	31,693.91	16,456.45	0.00	0.00	0.00	0.00
Sales Tax							
Total Income	243,274.57	263,416.16	284,809.08	307,546.07	313,954.22	320,492.53	327,163.61
Total Taxable Income	243,274.57	263,416.16	284,809.08	307,546.07	313,954.22	320,492.53	327,163.61
Income Taxes	**9,730.98**	**10,536.65**	**11,392.36**	**12,301.84**	**12,558.17**	**12,819.70**	**13,086.54**
Production Tax Credit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Investment Tax Credit							
Tax Savings (Liability)	-9,730.98	-10,536.65	-11,392.36	-12,301.84	-12,558.17	-12,819.70	-13,086.54
Total Income w/o incentives	243,274.57	263,416.16	284,809.08	307,546.07	313,954.22	320,492.53	327,163.61
Total Taxable Income	197,471.90	231,722.25	268,352.62	307,546.07	313,954.22	320,492.53	327,163.61
Income Taxes	7,898.88	9,268.89	10,734.10	12,301.84	12,558.17	12,819.70	13,086.54
Tax Effect on Equity (Federal)							
Operating Income	289,077.24	295,110.07	301,265.53	307,546.07	313,954.22	320,492.53	327,163.61
Investment Based Incentives (IBI)							
Federal IBI							
State IBI							
Capacity Based Incentives (CBI)							
Federal CBI							
State CBI							
Performance Based Incentives (PBI)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Federal PBI	0.00	0.00	0.00	0.00	0.00	0.00	0.00
State PBI	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Utility PBI	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other PBI	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation Schedule	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Depreciation	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interest Payment	45,802.67	31,693.91	16,456.45	0.00	0.00	0.00	0.00
Sales Tax							
State Tax Savings (Liability)	-9,730.98	-10,536.65	-11,392.36	-12,301.84	-12,558.17	-12,819.70	-13,086.54
Total Income	233,543.59	252,879.51	273,416.71	295,244.23	301,396.05	307,672.82	314,077.07
Total Taxable Income	233,543.59	252,879.51	273,416.71	295,244.23	301,396.05	307,672.82	314,077.07
Income Taxes	**81,740.25**	**88,507.83**	**95,695.85**	**103,335.48**	**105,488.62**	**107,685.49**	**109,926.97**
Production Tax Credit	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Investment Tax Credit							
Tax Savings (Liability)	-81,740.25	-88,507.83	-95,695.85	-103,335.48	-105,488.62	-107,685.49	-109,926.97
State and Federal Tax Savings (Liability)	-91,471.24	-99,044.48	-107,088.21	-115,637.32	-118,046.79	-120,505.19	-123,013.52
Total Income w/o incentives	233,543.59	252,879.51	273,416.71	295,244.23	301,396.05	307,672.82	314,077.07
Total Taxable Income	187,740.92	221,185.60	256,960.26	295,244.23	301,396.05	307,672.82	314,077.07
Income Taxes	65,709.32	77,414.96	89,936.09	103,335.48	105,488.62	107,685.49	109,926.97
`							
After Tax Net Equity Cash Flow	-24,556.13	-26,096.53	-27,984.81	191,908.75	195,907.43	199,987.34	204,150.09
After Tax Net Equity Cost Flow	-354,032.22	-362,120.96	-370,687.73	-157,605.39	-160,553.30	-163,558.05	-166,620.76
Pre-tax Debt Coverage Ratio	1.30	1.33	1.36				

Year	20	21	22	23	24	25	Total
Electric Output (kWh)	1,752,125.95	1,743,365.32	1,734,648.49	1,725,975.25	1,717,345.37	1,708,758.65	
Electricity Sales Price ($/kWh)	0.215817775	0.221213219	0.22674355	0.232412139	0.238222442	0.244178003	
Operating Revenues							
Cost plus financing expense and profit (CFP)	378,139.92	385,655.45	393,320.36	401,137.60	409,110.21	417,241.27	
Operating Expenses							
Fixed (Annual) O & M Expense	14,369.27	14,498.60	14,629.08	14,760.74	14,893.59	15,027.63	
Fixed O & M Expense	17,330.54	17,659.82	17,995.36	18,337.27	18,685.68	19,040.71	
Variable O & M Expense	0.00	0.00	0.00	0.00	0.00	0.00	
Fuel O & M Expense	0.00	0.00	0.00	0.00	0.00	0.00	
Insurance	**26,839.24**	**27,080.79**	**27,324.52**	**27,570.44**	**27,818.57**	**28,068.94**	**631,506.96**
Property Taxes	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Operating Expenses	44,169.78	44,740.61	45,319.88	45,907.71	46,504.25	47,109.65	
Operating Income	333,970.14	340,914.84	348,000.48	355,229.89	362,605.96	370,131.63	
Financing							
Debt Funds							
Equity Funds							
Total Capital Investment							
Cash Available Before Debt	333,970.14	340,914.84	348,000.48	355,229.89	362,605.96	370,131.63	
Debt Interest Payment	0.00	0.00	0.00	0.00	0.00	0.00	
Debt Repayment	0.00	0.00	0.00	0.00	0.00	0.00	
Total Debt Payment	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3,332,431.92**
Tax Effect on Equity (State)							
Operating Income	333,970.14	340,914.84	348,000.48	355,229.89	362,605.96	370,131.63	
Investment Based Incentives (IBI)							
Federal IBI							
State IBI							
Capacity Based Incentives (CBI)							
Federal CBI							
State CBI							
Performance Based Incentives (PBI)	0.00	0.00	0.00	0.00	0.00	0.00	
Federal PBI	0.00	0.00	0.00	0.00	0.00	0.00	
State PBI	0.00	0.00	0.00	0.00	0.00	0.00	
Super Depreciation Schedule	0.00	0.00	0.00	0.00	0.00	0.00	
Depreciation	0.00	0.00	0.00	0.00	0.00	0.00	
Interest Payment	0.00	0.00	0.00	0.00	0.00	0.00	
Sales Tax							
Total Income	333,970.14	340,914.84	348,000.48	355,229.89	362,605.96	370,131.63	
Total Taxable Income	333,970.14	340,914.84	348,000.48	355,229.89	362,605.96	370,131.63	
Income Taxes	**13,358.81**	**13,636.59**	**13,920.02**	**14,209.20**	**14,504.24**	**14,805.27**	**162,536.90**
Production Tax Credit	0.00	0.00	0.00	0.00	0.00	0.00	
Investment Tax Credit							
Tax Savings (Liability)	-13,358.81	-13,636.59	-13,920.02	-14,209.20	-14,504.24	-14,805.27	
Total Income w/o incentives	333,970.14	340,914.84	348,000.48	355,229.89	362,605.96	370,131.63	
Total Taxable Income	333,970.14	340,914.84	348,000.48	355,229.89	362,605.96	370,131.63	
Income Taxes	13,358.81	13,636.59	13,920.02	14,209.20	14,504.24	14,805.27	
Tax Effect on Equity (Federal)							
Operating Income	333,970.14	340,914.84	348,000.48	355,229.89	362,605.96	370,131.63	
Investment Based Incentives (IBI)							
Federal IBI							
State IBI							
Capacity Based Incentives (CBI)							
Federal CBI							
State CBI							
Performance Based Incentives (PBI)	0.00	0.00	0.00	0.00	0.00	0.00	
Federal PBI	0.00	0.00	0.00	0.00	0.00	0.00	
State PBI	0.00	0.00	0.00	0.00	0.00	0.00	
Utility PBI	0.00	0.00	0.00	0.00	0.00	0.00	
Other PBI	0.00	0.00	0.00	0.00	0.00	0.00	
Depreciation Schedule	0.00	0.00	0.00	0.00	0.00	0.00	
Depreciation	0.00	0.00	0.00	0.00	0.00	0.00	
Interest Payment	0.00	0.00	0.00	0.00	0.00	0.00	
Sales Tax							
State Tax Savings (Liability)	-13,358.81	-13,636.59	-13,920.02	-14,209.20	-14,504.24	-14,805.27	
Total Income	320,611.34	327,278.25	334,080.46	341,020.69	348,101.72	355,326.36	
Total Taxable Income	320,611.34	327,278.25	334,080.46	341,020.69	348,101.72	355,326.36	
Income Taxes	**112,213.97**	**114,547.39**	**116,928.16**	**119,357.24**	**121,835.60**	**124,364.23**	**889,911.99**
Production Tax Credit	0.00	0.00	0.00	0.00	0.00	0.00	
Investment Tax Credit							
Tax Savings (Liability)	-112,213.97	-114,547.39	-116,928.16	-119,357.24	-121,835.60	-124,364.23	
State and Federal Tax Savings (Liability)	-125,572.77	-128,183.98	-130,848.18	-133,566.44	-136,339.84	-139,169.49	
Total Income w/o incentives	320,611.34	327,278.25	334,080.46	341,020.69	348,101.72	355,326.36	
Total Taxable Income	320,611.34	327,278.25	334,080.46	341,020.69	348,101.72	355,326.36	
Income Taxes	112,213.97	114,547.39	116,928.16	119,357.24	121,835.60	124,364.23	
`							
After Tax Net Equity Cash Flow	208,397.37	212,730.86	217,152.30	221,663.45	226,266.12	230,962.13	
After Tax Net Equity Cost Flow	-169,742.55	-172,924.59	-176,168.06	-179,474.15	-182,844.09	-186,279.14	
Pre-tax Debt Coverage Ratio							
						Total FC	**$ 5,016,387.77**
						Avg Annual FC	**$ 200,655.51**

14. Appendix D – LCOE Methodology

$$LCOE = \frac{ICI + \left[\sum_{n=1}^{N} [FC + OM^n - PBI^n - AR^n] \times \frac{1}{(1+DR)^n}\right]}{\sum_{n=1}^{N} [MWh \times (1-DF)^n] \times \frac{1}{(1+DR)^n}}$$

Where,

ICI - Initial Capital Investment *less any available capital based incentive* expressed in USD ($); Calculated as follows:

FC = Annual Fixed Cost expressed in USD ($); Calculated the cash flow financial sheet presented in Appendix C.

OM^n = Operating and Maintenance Cost expressed in USD ($); Calculated as follows:

$$OM^n = FOM + VOM \times MWh \times (1-DF)^n$$

PBI^n = Production Based Incentives expressed in USD ($); Calculated as follows:

$$PBI^n = {}^{\$}/_{MWh} \times MWh \times (1-DF)^n$$

AR^n = Additional Revenue Sources expressed in USD ($) (Only used to account for MSW tipping fees and resale of metals in WTE facilities.)

MWh = Estimated Energy Production expressed in Megawatts-hours (MWh); Calculated as follows:

$MWh = Capacity\ Factor * 8{,}760\ {}^{hrs}/_{yr}$

DR = Nominal Discount Rate expressed in percentage (%)

DF = Degradation Factor expressed in percentage (%)

n = Analysis year.

N = Period under study.

15. Appendix E – LCOE Calculation

2011	**Utility Scale (≥10MW)**							
Technology	Wind							
n	**ICI**	FC	OM	PBI	**[FC+OM-PBI] * [1/(1+DR)^n]**	MWh×(1-DF)^n	**[MWh×(1-DF)^n] * [1/(1+DR)^n]**	1/(1+DR)^n
2011	$ 1,007,663	$ 216,551	$ 31,289.80	$ -	$ 247,841.02	2628.00	2628.00	1.00
2012	$ -	$ 216,551	$ 31,602.70	$ -	$ 221,565.99	2628.00	2346.43	0.89
2013	$ -	$ 216,551	$ 31,918.72	$ -	$ 198,078.72	2628.00	2095.03	0.80
2014	$ -	$ 216,551	$ 32,237.91	$ -	$ 177,083.19	2628.00	1870.56	0.71
2015	$ -	$ 216,551	$ 32,560.29	$ -	$ 158,314.87	2628.00	1670.14	0.64
2016	$ -	$ 216,551	$ 32,885.89	$ -	$ 141,537.31	2628.00	1491.20	0.57
2017	$ -	$ 216,551	$ 33,214.75	$ -	$ 126,539.21	2628.00	1331.43	0.51
2018	$ -	$ 216,551	$ 33,546.90	$ -	$ 113,131.69	2628.00	1188.77	0.45
2019	$ -	$ 216,551	$ 33,882.37	$ -	$ 101,145.92	2628.00	1061.41	0.40
2020	$ -	$ 216,551	$ 34,221.19	$ -	$ 90,431.04	2628.00	947.68	0.36
2021	$ -	$ 216,551	$ 34,563.41	$ -	$ 80,852.19	2628.00	846.15	0.32
2022	$ -	$ 216,551	$ 34,909.04	$ -	$ 72,288.81	2628.00	755.49	0.29
2023	$ -	$ 216,551	$ 35,258.13	$ -	$ 64,633.19	2628.00	674.54	0.26
2024	$ -	$ 216,551	$ 35,610.71	$ -	$ 57,789.01	2628.00	602.27	0.23
2025	$ -	$ 216,551	$ 35,966.82	$ -	$ 51,670.19	2628.00	537.74	0.20
2026	$ -	$ 216,551	$ 36,326.49	$ -	$ 46,199.81	2628.00	480.13	0.18
2027	$ -	$ 216,551	$ 36,689.75	$ -	$ 41,309.09	2628.00	428.68	0.16
2028	$ -	$ 216,551	$ 37,056.65	$ -	$ 36,936.55	2628.00	382.75	0.15
2029	$ -	$ 216,551	$ 37,427.22	$ -	$ 33,027.25	2628.00	341.74	0.13
2030	$ -	$ 216,551	$ 37,801.49	$ -	$ 29,532.07	2628.00	305.13	0.12
2031	$ -	$ 216,551	$ 38,179.50	$ -	$ 26,407.11	2628.00	272.44	0.10
2032	$ -	$ 216,551	$ 38,561.30	$ -	$ 23,613.12	2628.00	243.25	0.09
2033	$ -	$ 216,551	$ 38,946.91	$ -	$ 21,115.01	2628.00	217.18	0.08
2034	$ -	$ 216,551	$ 39,336.38	$ -	$ 18,881.42	2628.00	193.91	0.07
2035	$ -	$ 216,551	$ 39,729.74	$ -	$ 16,884.33	2628.00	173.14	0.07
2036	$ -	$ 216,551	$ 40,127.04	$ -	$ 15,098.66	2628.00	154.59	0.06

2011	**Utility Scale (≥10MW)**						
Technology	Solar PV						
n	FC	OM	PBI	**[FC+OM-PBI] * [1/(1+DR)^n]**	MWh×(1-DF)^n	**[MWh×(1-DF)^n] * [1/(1+DR)^n]**	1/(1+DR)^n
2011	$ 200,656	$ 12,120.00	$ -	$ 212,775.51	1927.20	1927.20	1.00
2012	$ 200,656	$ 12,241.20	$ -	$ 190,086.35	1926.24	1719.85	0.89
2013	$ 200,656	$ 12,363.61	$ -	$ 169,817.54	1925.27	1534.82	0.80
2014	$ 200,656	$ 12,487.25	$ -	$ 151,710.81	1924.31	1369.69	0.71
2015	$ 200,656	$ 12,612.12	$ -	$ 135,535.44	1923.35	1222.32	0.64
2016	$ 200,656	$ 12,738.24	$ -	$ 121,085.35	1922.39	1090.81	0.57
2017	$ 200,656	$ 12,865.62	$ -	$ 108,176.45	1921.43	973.45	0.51
2018	$ 200,656	$ 12,994.28	$ -	$ 96,644.32	1920.46	868.72	0.45
2019	$ 200,656	$ 13,124.22	$ -	$ 86,342.05	1919.50	775.26	0.40
2020	$ 200,656	$ 13,255.47	$ -	$ 77,138.44	1918.54	691.85	0.36
2021	$ 200,656	$ 13,388.02	$ -	$ 68,916.29	1917.59	617.41	0.32
2022	$ 200,656	$ 13,521.90	$ -	$ 61,570.89	1916.63	550.98	0.29
2023	$ 200,656	$ 13,657.12	$ -	$ 55,008.71	1915.67	491.70	0.26
2024	$ 200,656	$ 13,793.69	$ -	$ 49,146.22	1914.71	438.80	0.23
2025	$ 200,656	$ 13,931.63	$ -	$ 43,908.78	1913.75	391.59	0.20
2026	$ 200,656	$ 14,070.94	$ -	$ 39,229.72	1912.80	349.46	0.18
2027	$ 200,656	$ 14,211.65	$ -	$ 35,049.49	1911.84	311.86	0.16
2028	$ 200,656	$ 14,353.77	$ -	$ 31,314.88	1910.88	278.31	0.15
2029	$ 200,656	$ 14,497.31	$ -	$ 27,978.38	1909.93	248.37	0.13
2030	$ 200,656	$ 14,642.28	$ -	$ 24,997.53	1908.97	221.64	0.12
2031	$ 200,656	$ 14,788.70	$ -	$ 22,334.40	1908.02	197.80	0.10
2032	$ 200,656	$ 14,936.59	$ -	$ 19,955.12	1907.07	176.52	0.09
2033	$ 200,656	$ 15,085.96	$ -	$ 17,829.42	1906.11	157.53	0.08
2034	$ 200,656	$ 15,236.82	$ -	$ 15,930.25	1905.16	140.58	0.07
2035	$ 200,656	$ 15,389.18	$ -	$ 14,233.48	1904.21	125.45	0.07
2036	$ 200,656	$ 15,543.08	$ -	$ 12,717.52	1903.25	111.96	0.06

2011	**Utility Scale (≥10MW)**									
Technology	WTE									
n	**ICI**	FC	OM	WTE Tippin Fee	Revenue from Metal Sale	PBI	**[FC+OM-TF-RMS-PBI] * [1/(1+DR)^n]**	MWh×(1-DF)^n	**[MWh×(1-DF)^n] * [1/(1+DR)^n]**	1/(1+DR)^n
2011	$ 3,608,692	$ 631,770	$ 808,000.00	$ 676,909.09	$ 65,998.64	$ -	$ 696,862.52	7446.00	7446.00	1.00
2012	$ -	$ 631,770	$ 816,080.00	$ 676,909.09	$ 65,998.64	$ -	$ 629,412.96	7446.00	6648.21	0.89
2013	$ -	$ 631,770	$ 824,240.80	$ 676,909.09	$ 65,998.64	$ -	$ 568,481.60	7446.00	5935.91	0.80
2014	$ -	$ 631,770	$ 832,483.21	$ 676,909.09	$ 65,998.64	$ -	$ 513,439.64	7446.00	5299.92	0.71
2015	$ -	$ 631,770	$ 840,808.04	$ 676,909.09	$ 65,998.64	$ -	$ 463,718.83	7446.00	4732.07	0.64
2016	$ -	$ 631,770	$ 849,216.12	$ 676,909.09	$ 65,998.64	$ -	$ 418,805.64	7446.00	4225.06	0.57
2017	$ -	$ 631,770	$ 857,708.28	$ 676,909.09	$ 65,998.64	$ -	$ 378,236.00	7446.00	3772.38	0.51
2018	$ -	$ 631,770	$ 866,285.36	$ 676,909.09	$ 65,998.64	$ -	$ 341,590.55	7446.00	3368.19	0.45
2019	$ -	$ 631,770	$ 874,948.22	$ 676,909.09	$ 65,998.64	$ -	$ 308,490.35	7446.00	3007.31	0.40
2020	$ -	$ 631,770	$ 883,697.70	$ 676,909.09	$ 65,998.64	$ -	$ 278,592.96	7446.00	2685.10	0.36
2021	$ -	$ 631,770	$ 892,534.68	$ 676,909.09	$ 65,998.64	$ -	$ 251,588.98	7446.00	2397.41	0.32
2022	$ -	$ 631,770	$ 901,460.02	$ 676,909.09	$ 65,998.64	$ -	$ 227,198.85	7446.00	2140.55	0.29
2023	$ -	$ 631,770	$ 910,474.62	$ 676,909.09	$ 65,998.64	$ -	$ 205,169.94	7446.00	1911.20	0.26
2024	$ -	$ 631,770	$ 919,579.37	$ 676,909.09	$ 65,998.64	$ -	$ 185,274.02	7446.00	1706.43	0.23
2025	$ -	$ 631,770	$ 928,775.16	$ 676,909.09	$ 65,998.64	$ -	$ 167,304.87	7446.00	1523.60	0.20
2026	$ -	$ 631,770	$ 938,062.92	$ 676,909.09	$ 65,998.64	$ -	$ 151,076.19	7446.00	1360.36	0.18
2027	$ -	$ 631,770	$ 947,443.55	$ 676,909.09	$ 65,998.64	$ -	$ 136,419.64	7446.00	1214.60	0.16
2028	$ -	$ 631,770	$ 956,917.98	$ 676,909.09	$ 65,998.64	$ -	$ 123,183.14	7446.00	1084.47	0.15
2029	$ -	$ 631,770	$ 966,487.16	$ 676,909.09	$ 65,998.64	$ -	$ 111,229.32	7446.00	968.27	0.13
2030	$ -	$ 631,770	$ 976,152.03	$ 676,909.09	$ 65,998.64	$ -	$ 100,434.05	7446.00	864.53	0.12
2031	$ -	$ 631,770	$ 985,913.55	$ 676,909.09	$ 65,998.64	$ -	$ 90,685.21	7446.00	771.90	0.10
2032	$ -	$ 631,770	$ 995,772.69	$ 676,909.09	$ 65,998.64	$ -	$ 81,881.49	7446.00	689.20	0.09
2033	$ -	$ 631,770	$ 1,005,730.41	$ 676,909.09	$ 65,998.64	$ -	$ 73,931.41	7446.00	615.36	0.08
2034	$ -	$ 631,770	$ 1,015,787.72	$ 676,909.09	$ 65,998.64	$ -	$ 66,752.29	7446.00	549.43	0.07
2035	$ -	$ 631,770	$ 1,025,945.60	$ 676,909.09	$ 65,998.64	$ -	$ 60,269.48	7446.00	490.56	0.07
2036	$ -	$ 631,770	$ 1,036,205.05	$ 676,909.09	$ 65,998.64	$ -	$ 54,415.53	7446.00	438.00	0.06

2011 Technology	Large-Scale PV (>1MW, <10MW)							
n	**ICI**	FC	OM	PBI	**[FC+OM-PBI] * [1/(1+DR)^n]**	MWh×(1-DF)^n	**[MWh×(1-DF)^n] * [1/(1+DR)^n]**	1/(1+DR)^n
2011	$ 1,694,146	$ 233,873	$ 25,250.00	$ -	$ 259,123.19	1752.00	1752.00	1.00
2012	$ -	$ 233,873	$ 25,502.50	$ -	$ 231,585.43	1751.12	1563.50	0.89
2013	$ -	$ 233,873	$ 25,757.53	$ -	$ 206,976.01	1750.25	1395.29	0.80
2014	$ -	$ 233,873	$ 26,015.10	$ -	$ 184,983.35	1749.37	1245.17	0.71
2015	$ -	$ 233,873	$ 26,275.25	$ -	$ 165,329.03	1748.50	1111.20	0.64
2016	$ -	$ 233,873	$ 26,538.00	$ -	$ 147,764.30	1747.62	991.65	0.57
2017	$ -	$ 233,873	$ 26,803.38	$ -	$ 132,066.86	1746.75	884.96	0.51
2018	$ -	$ 233,873	$ 27,071.42	$ -	$ 118,038.09	1745.88	789.75	0.45
2019	$ -	$ 233,873	$ 27,342.13	$ -	$ 105,500.49	1745.00	704.78	0.40
2020	$ -	$ 233,873	$ 27,615.55	$ -	$ 94,295.46	1744.13	628.95	0.36
2021	$ -	$ 233,873	$ 27,891.71	$ -	$ 84,281.29	1743.26	561.28	0.32
2022	$ -	$ 233,873	$ 28,170.63	$ -	$ 75,331.33	1742.39	500.89	0.29
2023	$ -	$ 233,873	$ 28,452.33	$ -	$ 67,332.43	1741.52	447.00	0.26
2024	$ -	$ 233,873	$ 28,736.86	$ -	$ 60,183.44	1740.65	398.91	0.23
2025	$ -	$ 233,873	$ 29,024.22	$ -	$ 53,794.02	1739.78	355.99	0.20
2026	$ -	$ 233,873	$ 29,314.47	$ -	$ 48,083.40	1738.91	317.69	0.18
2027	$ -	$ 233,873	$ 29,607.61	$ -	$ 42,979.43	1738.04	283.51	0.16
2028	$ -	$ 233,873	$ 29,903.69	$ -	$ 38,417.61	1737.17	253.01	0.15
2029	$ -	$ 233,873	$ 30,202.72	$ -	$ 34,340.32	1736.30	225.79	0.13
2030	$ -	$ 233,873	$ 30,504.75	$ -	$ 30,696.07	1735.43	201.50	0.12
2031	$ -	$ 233,873	$ 30,809.80	$ -	$ 27,438.83	1734.56	179.82	0.10
2032	$ -	$ 233,873	$ 31,117.90	$ -	$ 24,527.47	1733.70	160.47	0.09
2033	$ -	$ 233,873	$ 31,429.08	$ -	$ 21,925.24	1732.83	143.21	0.08
2034	$ -	$ 233,873	$ 31,743.37	$ -	$ 19,599.30	1731.96	127.80	0.07
2035	$ -	$ 233,873	$ 32,060.80	$ -	$ 17,520.29	1731.10	114.05	0.07
2036	$ -	$ 233,873	$ 32,381.41	$ -	$ 15,661.98	1730.23	101.78	0.06

2011 Technology	Solar PV - Distributed Generation (≤1MW)							
n	**ICI**	FC	OM	PBI	**[FC+OM-PBI] * [1/(1+DR)^n]**	MWh×(1-DF)^n	**[MWh×(1-DF)^n] * [1/(1+DR)^n]**	1/(1+DR)^n
2011	$ 3,745,560	$ -	$ 65,585.00	$ -	$ 65,585.00	1752.00	1752.00	1.00
2012	$ -	$ -	$ 66,175.27	$ -	$ 59,085.06	1751.12	1563.50	0.89
2013	$ -	$ -	$ 66,770.84	$ -	$ 53,229.31	1750.25	1395.29	0.80
2014	$ -	$ -	$ 67,371.78	$ -	$ 47,953.90	1749.37	1245.17	0.71
2015	$ -	$ -	$ 67,978.13	$ -	$ 43,201.33	1748.50	1111.20	0.64
2016	$ -	$ -	$ 68,589.93	$ -	$ 38,919.77	1747.62	991.65	0.57
2017	$ -	$ -	$ 69,207.24	$ -	$ 35,062.54	1746.75	884.96	0.51
2018	$ -	$ -	$ 69,830.10	$ -	$ 31,587.59	1745.88	789.75	0.45
2019	$ -	$ -	$ 70,458.57	$ -	$ 28,457.04	1745.00	704.78	0.40
2020	$ -	$ -	$ 71,092.70	$ -	$ 25,636.74	1744.13	628.95	0.36
2021	$ -	$ -	$ 71,732.54	$ -	$ 23,095.96	1743.26	561.28	0.32
2022	$ -	$ -	$ 72,378.13	$ -	$ 20,806.98	1742.39	500.89	0.29
2023	$ -	$ -	$ 73,029.53	$ -	$ 18,744.86	1741.52	447.00	0.26
2024	$ -	$ -	$ 73,686.80	$ -	$ 16,887.11	1740.65	398.91	0.23
2025	$ -	$ -	$ 74,349.98	$ -	$ 15,213.48	1739.78	355.99	0.20
2026	$ -	$ -	$ 75,019.13	$ -	$ 13,705.71	1738.91	317.69	0.18
2027	$ -	$ -	$ 75,694.30	$ -	$ 12,347.38	1738.04	283.51	0.16
2028	$ -	$ -	$ 76,375.55	$ -	$ 11,123.67	1737.17	253.01	0.15
2029	$ -	$ -	$ 77,062.93	$ -	$ 10,021.23	1736.30	225.79	0.13
2030	$ -	$ -	$ 77,756.50	$ -	$ 9,028.06	1735.43	201.50	0.12
2031	$ -	$ -	$ 78,456.30	$ -	$ 8,133.31	1734.56	179.82	0.10
2032	$ -	$ -	$ 79,162.41	$ -	$ 7,327.24	1733.70	160.47	0.09
2033	$ -	$ -	$ 79,874.87	$ -	$ 6,601.06	1732.83	143.21	0.08
2034	$ -	$ -	$ 80,593.75	$ -	$ 5,946.85	1731.96	127.80	0.07
2035	$ -	$ -	$ 81,319.09	$ -	$ 5,357.47	1731.10	114.05	0.07
2036	$ -	$ -	$ 82,050.96	$ -	$ 4,826.51	1730.23	101.78	0.06

2011 Technology	Small Wind - Distributed Generation (≤1MW)							
n	**ICI**	FC	OM	PBI	**[FC+OM-PBI] * [1/(1+DR)^n]**	MWh×(1-DF)^n	**[MWh×(1-DF)^n] * [1/(1+DR)^n]**	1/(1+DR)^n
2011	$ 3,537,677	$ -	$ 31,258.82	$ -	$ 31,258.82	2190.00	2190.00	1.00
2012	$ -	$ -	$ 31,540.15	$ -	$ 28,160.85	2190.00	1955.36	0.89
2013	$ -	$ -	$ 31,824.01	$ -	$ 25,369.91	2190.00	1745.85	0.80
2014	$ -	$ -	$ 32,110.43	$ -	$ 22,855.57	2190.00	1558.80	0.71
2015	$ -	$ -	$ 32,399.42	$ -	$ 20,590.42	2190.00	1391.78	0.64
2016	$ -	$ -	$ 32,691.02	$ -	$ 18,549.76	2190.00	1242.66	0.57
2017	$ -	$ -	$ 32,985.23	$ -	$ 16,711.35	2190.00	1109.52	0.51
2018	$ -	$ -	$ 33,282.10	$ -	$ 15,055.13	2190.00	990.64	0.45
2019	$ -	$ -	$ 33,581.64	$ -	$ 13,563.06	2190.00	884.50	0.40
2020	$ -	$ -	$ 33,883.88	$ -	$ 12,218.87	2190.00	789.74	0.36
2021	$ -	$ -	$ 34,188.83	$ -	$ 11,007.89	2190.00	705.12	0.32
2022	$ -	$ -	$ 34,496.53	$ -	$ 9,916.93	2190.00	629.57	0.29
2023	$ -	$ -	$ 34,807.00	$ -	$ 8,934.09	2190.00	562.12	0.26
2024	$ -	$ -	$ 35,120.26	$ -	$ 8,048.66	2190.00	501.89	0.23
2025	$ -	$ -	$ 35,436.34	$ -	$ 7,250.98	2190.00	448.12	0.20
2026	$ -	$ -	$ 35,755.27	$ -	$ 6,532.35	2190.00	400.10	0.18
2027	$ -	$ -	$ 36,077.07	$ -	$ 5,884.95	2190.00	357.24	0.16
2028	$ -	$ -	$ 36,401.76	$ -	$ 5,301.71	2190.00	318.96	0.15
2029	$ -	$ -	$ 36,729.38	$ -	$ 4,776.27	2190.00	284.79	0.13
2030	$ -	$ -	$ 37,059.94	$ -	$ 4,302.91	2190.00	254.27	0.12
2031	$ -	$ -	$ 37,393.48	$ -	$ 3,876.46	2190.00	227.03	0.10
2032	$ -	$ -	$ 37,730.02	$ -	$ 3,492.28	2190.00	202.71	0.09
2033	$ -	$ -	$ 38,069.59	$ -	$ 3,146.17	2190.00	180.99	0.08
2034	$ -	$ -	$ 38,412.22	$ -	$ 2,834.36	2190.00	161.60	0.07
2035	$ -	$ -	$ 38,757.93	$ -	$ 2,553.45	2190.00	144.28	0.07
2036	$ -	$ -	$ 39,106.75	$ -	$ 2,300.39	2190.00	128.82	0.06

Economical / Technical Assumptions	**Value**
Degradation Factor (Solar PV)	0.05%
Degradation Factor (All Others)	0.00%
Capacity (MW)	1
Years (Project life)	25
Inflation Rate	1.6%
Nominal Discount Rate	12.0%
Real Discount Rate	10.2%
Fixed Charge Rate	10%
Debt (%)	60%
Interest Rate	8.0%
Equity (%)	40%
Equity Cost	12%
State Tax Rate under Act No. 83, 2010	4%
Federal Tax (when applicable)	35%

16. Appendix F - LCOE Assumptions

Levelized Cost of Energy Analysis - Key Assumptions for 2011 LCOE Analysis

	Units	Utility-Scale Wind	Utility-Scale Solar PV	Utility-Scale WTE	Large-Scale Commercial Solar PV	Solar PV DG	Small Wind DG
Net Generation Capacity	MW	>10	>10	>1	>1 <10	≤1	≤1
Capital Cost	$/kWh	$2,730	$3,920	$8,015	$4,900	$6,370	$5,904
Project and Land Cost	%	10%	10%	—	10%	—	—
Project Contingency	Factor	1.07	1.05	1.0	1.05	1.05	1.07
Total Capital Cost	$/kWh	$3,213	$4,528	$8,055	$5,390	$6,689	$6,317
Fixed O&M		$31	$12	$808	$25	$66	$31
Variable O&M	-	—	—	—	—	—	—
Capacity Factor	%	30%	22%	85%	20%	20%	25%
Project Life	Years	25	25	25	25	25	25
Heat Rate	Btu/kWh	—	—	18000	—	—	—
Investment Based Incentive	%	30%	30%	—	30%	50%	50%
Production Based Incentive	$/MWh	—	—	—	—	—	—
Levelized Cost of Energy (LCO	$/MWh	$139	$195	$156	$259	$283	$198
Levelized Cost of Energy (LC	**Cents/kWh**	**13.85**	**19.48**	**15.63**	**25.92**	**28.26**	**19.79**

Levelized Cost of Energy Analysis - Key Assumptions for 2015 LCOE Analysis

	Units	Utility-Scale Wind	Utility-Scale Solar PV	Utility-Scale WTE	Large-Scale Commercial Solar PV	Solar PV DG	Small Wind DG
Net Generation Capacity	MW	>10	>10	>1	>1 <10	≤1	≤1
Capital Cost	$/kWh	$3,318	$3,616	$7,699	$4,520	$5,875	$5,535
Project and Land Cost	%	10%	10%	10%	10%	—	—
Project Contingency	Factor	1.07	1.05	1	1.05	1.05	1.07
Total Capital Cost	$/kWh	$3,906	$4,176	$7,738	$4,972	$6,169	$5,923
Fixed O&M		$33	$13	$841	$26	$68	$32
Variable O&M	-	—	—	—	—	—	—
Capacity Factor	%	30%	22%	85%	20%	20%	25%
Project Life	Years	25	25	25	25	25	25
Heat Rate	Btu/kWh	—	—	18000	—	—	—
Investment Based Incentive	%	—	—	—	—	50%	50%
Production Based Incentive	$/MWh	—	—	—	—	—	—
Levelized Cost of Energy (LCO	$/MWh	$171	$223	$157	$272	$265	$187
Levelized Cost of Energy (LC	**Cents/kWh**	**17.09**	**22.29**	**15.65**	**27.18**	**26.52**	**18.70**

Levelized Cost of Energy Analysis - Key Assumptions for 2020 LCOE Analysis

	Units	Utility-Scale Wind	Utility-Scale Solar PV	Utility-Scale WTE	Large-Scale Commercial Solar PV	Solar PV DG	Small Wind DG
Net Generation Capacity	MW	>10	>10	>1	>1 <10	≤1	≤1
Capital Cost	$/kWh	$3,077	$3,041	$7,322	$3,802	$4,942	$5,106
Project and Land Cost	%	10%	10%	10%	10%	—	—
Project Contingency	Factor	1.07	1.05	1	1.05	1.05	1.07
Total Capital Cost	$/kWh	$3,621	$3,513	$7,358	$4,182	$5,189	$5,464
Fixed O&M		$34	$13	$884	$28	$71	$34
Variable O&M	-	—	—	—	—	—	—
Capacity Factor	%	30%	22%	85%	20%	20%	25%
Project Life	Years	25	25	25	25	25	25
Heat Rate	Btu/kWh	—	—	18000	—	—	—
Investment Based Incentive	%	—	—	—	—	50%	50%
Production Based Incentive	$/MWh	—	—	—	—	—	—
Levelized Cost of Energy (LCO	$/MWh	$160	$190	$157	$233	$232	$174
Levelized Cost of Energy (LC	**Cents/kWh**	**16.05**	**19.00**	**15.66**	**23.29**	**23.16**	**17.45**

Levelized Cost of Energy Analysis - Key Assumptions for 2025 LCOE Analysis

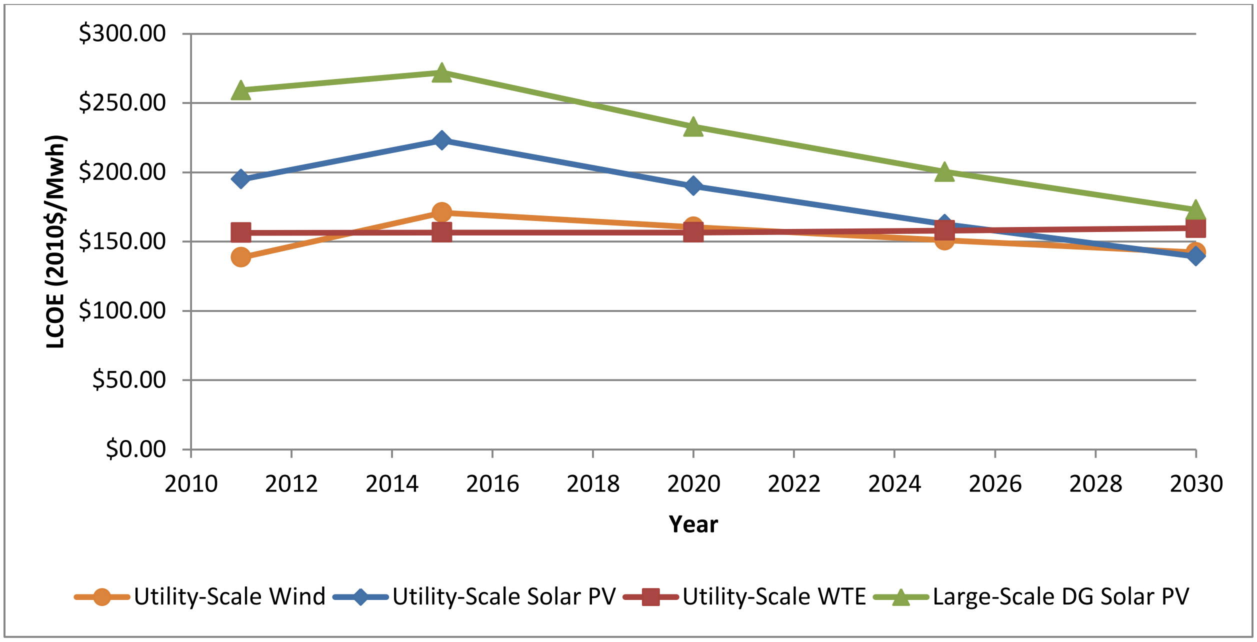
	Units	Utility-Scale Wind	Utility-Scale Solar PV	Utility-Scale WTE	Large-Scale Commercial Solar PV	Solar PV DG	Small Wind DG
Net Generation Capacity	MW	>10	>10	>1	>1 <10	≤1	≤1
Capital Cost	$/kWh	$2,853	$2,558	$6,963	$3,198	$4,157	$4,711
Project and Land Cost	%	10%	10%	10%	10%	—	—
Project Contingency	Factor	1.07	1.05	1	1.05	1.05	1.07
Total Capital Cost	$/kWh	$3,358	$2,955	$6,998	$3,518	$4,365	$5,040
Fixed O&M		$36	$14	$929	$29	$74	$35
Variable O&M	-	—	—	—	—	—	—
Capacity Factor	%	30%	22%	85%	20%	20%	25%
Project Life	Years	25	25	25	25	25	25
Heat Rate	Btu/kWh	—	—	18000	—	—	—
Investment Based Incentive	%	—	—	—	—	50%	50%
Production Based Incentive	$/MWh	—	—	—	—	—	—
Levelized Cost of Energy (LCO	$/MWh	$151	$162	$158	$200	$204	$163
Levelized Cost of Energy (LC	**Cents/kWh**	**15.09**	**16.24**	**15.79**	**20.03**	**20.37**	**16.30**

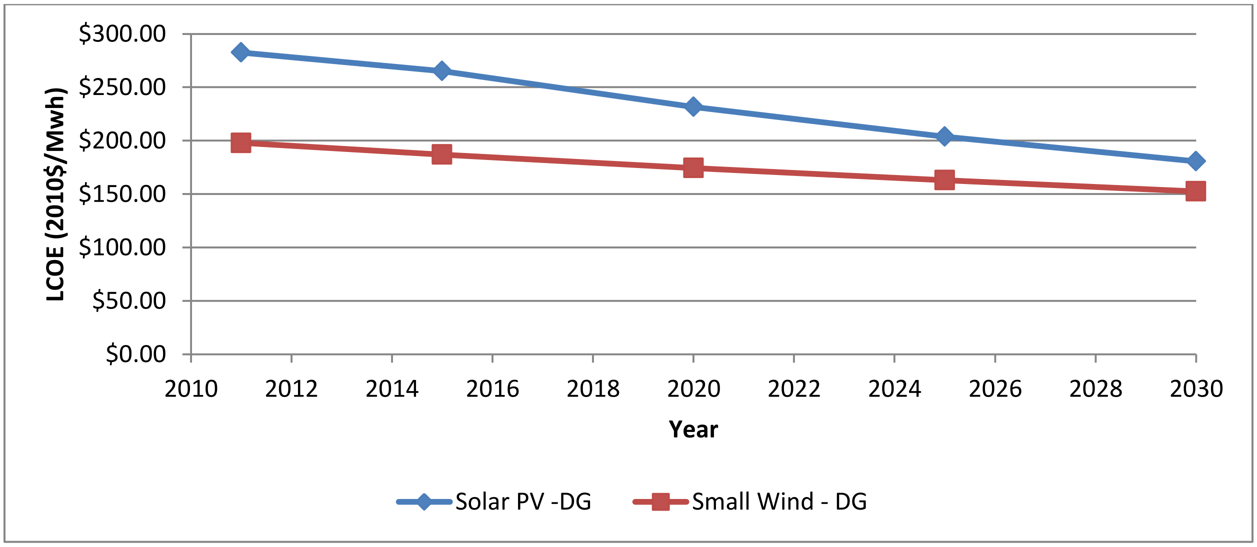
Levelized Cost of Energy Analysis - Key Assumptions for 2030 LCOE Analysis

	Units	Utility-Scale Wind	Utility-Scale Solar PV	Utility-Scale WTE	Large-Scale Commercial Solar PV	Solar PV DG	Small Wind DG
Net Generation Capacity	MW	>10	>10	>1	>1 <10	≤1	≤1
Capital Cost	$/kWh	$2,645	$2,152	$6,622	$2,690	$3,497	$4,346
Project and Land Cost	%	10%	10%	10%	10%	—	—
Project Contingency	Factor	1.07	1.05	1	1.05	1.05	1.07
Total Capital Cost	$/kWh	$3,113	$2,486	$6,655	$2,959	$3,672	$4,650
Fixed O&M		$38	$15	$976	$31	$78	$37
Variable O&M	-	—	—	—	—	—	—
Capacity Factor	%	30%	22%	85%	20%	20%	25%
Project Life	Years	25	25	25	25	25	25
Heat Rate	Btu/kWh	—	—	18000	—	—	—
Investment Based Incentive	%	—	—	—	—	50%	50%
Production Based Incentive	$/MWh	—	—	—	—	—	—
Levelized Cost of Energy (LCO	$/MWh	$142	$139	$160	$173	$181	$152
Levelized Cost of Energy (LC	**Cents/kWh**	**14.21**	**13.92**	**15.98**	**17.30**	**18.06**	**15.25**

17. Appendix G – LCOE Result Summary

Levelized Cost of Energy (LCOE)						
LCOE	Utility-Scale Wind	Utility-Scale Solar PV	Utility-Scale WTE	Large-Scale DG Solar PV	Solar PV -DG	Small Wind - DG
2011	$138.54	$194.85	$156.32	$259.19	$282.61	$197.88
2015	$170.89	$222.88	$156.54	$271.83	$265.24	$187.02
2020	$160.49	$189.99	$156.61	$232.89	$231.60	$174.47
2025	$150.93	$162.39	$157.90	$200.27	$203.69	$162.99
2030	$142.14	$139.25	$159.75	$173.00	$180.62	$152.48





18. Appendix H –Power Purchase Agreements and REC Purchase

		Wind - Utility Scale Power Purchase to comply with RPS Target for 2015 (Constructed and starting operation from 2011-2015)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ 0.120	$ 0.123	$ 0.126	$ 0.129	$ 0.132	$ 0.150	$ 0.170	$ 0.192	$ 0.217
REC Price	$/kWh	$ 0.019	$ 0.016	$ 0.012	$ 0.009	$ 0.006	$ (0.011)	$ (0.031)	$ (0.053)	$ (0.079)
LCOE	$/kWh	$ 0.139	$ 0.139	$ 0.139	$ 0.139	$ 0.139	$ 0.139	$ 0.139	$ 0.139	$ 0.139
Total Purchase Price	**$/kWh**	**$ 0.139**	**$ 0.139**	**$ 0.139**	**$ 0.139**	**$ 0.139**	**$ 0.150**	**$ 0.170**	**$ 0.192**	**$ 0.217**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	202.57	408.04	620.36	834.59	834.59	834.59	834.59	834.59
Purchase Cost (RPS CS-1)	$	$ -	$ 28,063,477.47	$ 56,528,808.56	$ 85,943,153.36	$ 115,622,188.99	$ 125,075,211.49	$ 141,511,121.51	$ 160,106,845.09	$ 181,146,199.47
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	253.21	510.05	775.45	1043.24	1043.24	1043.24	1043.24	1043.24
Purchase Cost (RPS CS-2)	$	$ -	$ 35,079,346.84	$ 70,661,010.70	$ 107,428,941.70	$ 144,527,736.24	$ 156,344,014.36	$ 176,888,901.88	$ 200,133,556.36	$ 226,432,749.34
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	303.86	612.06	930.54	1251.89	1251.89	1251.89	1251.89	1251.89
Purchase Cost (RPS CS-2)	$	$ -	$ 42,095,216.21	$ 84,793,212.84	$ 128,914,730.04	$ 173,433,283.49	$ 187,612,817.23	$ 212,266,682.26	$ 240,160,267.63	$ 271,719,299.21

		Solar PV - Utility Scale Power Purchase to comply with RPS Target for 2015 (Constructed and starting operation from 2011-2015)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ 0.135	$ 0.138	$ 0.142	$ 0.145	$ 0.149	$ 0.169	$ 0.191	$ 0.216	$ 0.244
REC Price	$/kWh	$ 0.060	$ 0.056	$ 0.053	$ 0.049	$ 0.046	$ 0.026	$ 0.004	$ (0.021)	$ (0.049)
LCOE	$/kWh	$ 0.195	$ 0.195	$ 0.195	$ 0.195	$ 0.195	$ 0.195	$ 0.195	$ 0.195	$ 0.19
Total Purchase Price	**$/kWh**	**$ 0.195**	**$ 0.195**	**$ 0.195**	**$ 0.195**	**$ 0.195**	**$ 0.195**	**$ 0.195**	**$ 0.216**	**$ 0.244**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	151.93	306.03	465.27	625.95	625.95	625.95	625.95	625.95
Purchase Cost (RPS CS-1)	$	$ -	$ 29,602,820.05	$ 59,629,536.26	$ 90,657,321.65	$ 121,964,316.73	$ 121,964,316.73	$ 121,964,316.73	$ 135,090,150.54	$ 152,842,105.80
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	189.91	382.54	581.59	782.43	782.43	782.43	782.43	782.43
Purchase Cost (RPS CS-2)	$	$ -	$ 37,003,525.07	$ 74,536,920.33	$ 113,321,652.07	$ 152,455,395.91	$ 152,455,395.91	$ 152,455,395.91	$ 168,862,688.18	$ 191,052,632.25
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	227.89	459.05	697.91	938.92	938.92	938.92	938.92	938.92
Purchase Cost (RPS CS-2)	$	$ -	$ 44,404,230.08	$ 89,444,304.40	$ 135,985,982.48	$ 182,946,475.10	$ 182,946,475.10	$ 182,946,475.10	$ 202,635,225.81	$ 229,263,158.70

		WTE - Utility Scale Power Purchase to comply with RPS Target for 2015 (Constructed and starting operation from 2011-2015)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ 0.120	$ 0.123	$ 0.126	$ 0.129	$ 0.132	$ 0.150	$ 0.170	$ 0.192	$ 0.217
REC Price	$/kWh	$ 0.011	$ 0.008	$ 0.005	$ 0.002	$ (0.002)	$ (0.020)	$ (0.039)	$ (0.062)	$ (0.087)
LCOE	$/kWh	$ 0.131	$ 0.131	$ 0.131	$ 0.131	$ 0.130	$ 0.130	$ 0.130	$ 0.130	$ 0.130
Total Purchase Price	**$/kWh**	**$ 0.131**	**$ 0.131**	**$ 0.131**	**$ 0.131**	**$ 0.132**	**$ 0.150**	**$ 0.170**	**$ 0.192**	**$ 0.217**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	43.05	86.71	131.83	177.35	177.35	177.35	177.35	177.35
Purchase Cost (RPS CS-1)	$	$ -	$ 5,658,750.64	$ 11,398,531.49	$ 17,329,672.51	$ 23,491,505.66	$ 26,578,482.44	$ 30,071,113.32	$ 34,022,704.58	$ 38,493,567.39
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	53.81	108.39	164.78	221.69	221.69	221.69	221.69	221.69
Purchase Cost (RPS CS-2)	$	$ -	$ 7,073,438.30	$ 14,248,164.36	$ 21,662,090.64	$ 29,364,382.08	$ 33,223,103.05	$ 37,588,891.65	$ 42,528,380.73	$ 48,116,959.23
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	64.57	130.06	197.74	266.03	266.03	266.03	266.03	266.03
Purchase Cost (RPS CS-2)	$	$ -	$ 8,488,125.96	$ 17,097,797.23	$ 25,994,508.77	$ 35,237,258.50	$ 39,867,723.66	$ 45,106,669.98	$ 51,034,056.87	$ 57,740,351.08

Wind - Utility Scale Power Purchase to comply with RPS Target for 2020 (Constructed and starting operation from 2016-2020)

	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ 0.132	$ 0.150	$ 0.170	$ 0.192
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ 0.038	$ 0.021	$ 0.001	$ (0.021)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ 0.171	$ 0.171	$ 0.171	$ 0.171
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.171**	**$ 0.171**	**$ 0.171**	**$ 0.192**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	202.57	408.04	620.36	834.59	255.59	255.59	255.59	255.59
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ 43,677,925.62	$ 43,677,925.62	$ 43,677,925.62	$ 49,032,721.31
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	253.21	510.05	775.45	1043.24	264.98	264.98	264.98	264.98
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ 45,282,420.85	$ 45,282,420.85	$ 45,282,420.85	$ 50,833,923.31
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	303.86	612.06	930.54	1251.89	565.09	565.09	565.09	565.09
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ 96,566,842.37	$ 96,566,842.37	$ 96,566,842.37	$ 108,405,676.36

Solar PV - Utility Scale Power Purchase to comply with RPS Target for 2020 (Constructed and starting operation from 2015-2019)

	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ 0.149	$ 0.169	$ 0.191	$ 0.216
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ 0.074	$ 0.054	$ 0.032	$ 0.007
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ 0.223	$ 0.223	$ 0.223	$ 0.223
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.223**	**$ 0.223**	**$ 0.223**	**$ 0.223**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	151.93	306.03	465.27	625.95	191.70	191.70	191.70	191.70
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ 42,725,954.61	$ 42,725,954.61	$ 42,725,954.61	$ 42,725,954.61
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	189.91	382.54	581.59	782.43	198.74	198.74	198.74	198.74
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ 44,295,479.47	$ 44,295,479.47	$ 44,295,479.47	$ 44,295,479.47
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	227.89	459.05	697.91	938.92	423.82	423.82	423.82	423.82
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ 94,462,144.54	$ 94,462,144.54	$ 94,462,144.54	$ 94,462,144.54

WTE - Utility Scale Power Purchase to comply with RPS Target for 2020 (Constructed and starting operation from 2015-2019)

	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ 0.132	$ 0.150	$ 0.170	$ 0.192
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ (0.002)	$ (0.020)	$ (0.039)	$ (0.062)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ 0.130	$ 0.130	$ 0.130	$ 0.130
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.132**	**$ 0.150**	**$ 0.170**	**$ 0.192**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	43.05	86.71	131.83	177.35	54.31	54.31	54.31	54.31
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ 7,194,273.61	$ 8,139,660.25	$ 9,209,278.45	$ 10,419,453.28
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	53.81	108.39	164.78	221.69	56.31	56.31	56.31	56.31
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ 7,458,553.05	$ 8,438,668.17	$ 9,547,578.48	$ 10,802,208.70
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	64.57	130.06	197.74	266.03	120.08	120.08	120.08	120.08
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ 15,905,706.96	$ 17,995,847.49	$ 20,360,649.64	$ 23,036,206.23

		Wind - Utility Scale Power Purchase to comply with RPS Target for 2025 (Constructed and starting operation from 2021-2025)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.132	$ 0.150	$ 0.170
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.028	$ 0.011	$ (0.009)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.160	$ 0.160	$ 0.160
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.160**	**$ 0.160**	**$ 0.170**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	202.57	408.04	620.36	834.59	1090.19	125.01	125.01	125.01
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 20,062,337.02	$ 20,062,337.02	$ 21,196,007.48
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	253.21	510.05	775.45	1043.24	1308.23	362.67	362.67	362.67
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 58,204,105.65	$ 58,204,105.65	$ 61,493,068.22
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	303.86	612.06	930.54	1251.89	1816.98	461.51	461.51	461.51
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 74,067,348.87	$ 74,067,348.87	$ 78,252,702.04

		Solar PV - Utility Scale Power Purchase to comply with RPS Target for 2025 (Constructed and starting operation from 2021-2025)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.149	$ 0.169	$ 0.191
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.041	$ 0.021	$ (0.001)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.190	$ 0.190	$ 0.190
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.190**	**$ 0.190**	**$ 0.191**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	151.93	306.03	465.27	625.95	817.64	93.76	93.76	93.76
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 17,812,503.24	$ 17,812,503.24	$ 17,884,131.31
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	189.91	382.54	581.59	782.43	981.17	272.00	272.00	272.00
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 51,676,971.61	$ 51,676,971.61	$ 51,884,776.31
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	227.89	459.05	697.91	938.92	1362.74	346.13	346.13	346.13
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 65,761,276.50	$ 65,761,276.50	$ 66,025,717.35

		WTE - Utility Scale Power Purchase to comply with RPS Target for 2025 (Constructed and starting operation from 2021-2025)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.132	$ 0.150	$ 0.170
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ (0.004)	$ (0.021)	$ (0.041)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.129	$ 0.129	$ 0.129
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.132**	**$ 0.150**	**$ 0.170**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	43.05	86.71	131.83	177.35	231.67	26.56	26.56	26.56
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,518,636.02	$ 3,981,013.69	$ 4,504,151.59
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	53.81	108.39	164.78	221.69	278.00	77.07	77.07	77.07
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 10,208,135.90	$ 11,549,568.80	$ 13,067,277.00
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	64.57	130.06	197.74	266.03	386.11	98.07	98.07	98.07
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ 12,990,313.23	$ 14,697,347.07	$ 16,628,699.18

		Wind - Utility Scale Power Purchase to comply with RPS Target for 2030 (Constructed and starting operation from 2026-2030)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.132	$ 0.150
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.018	$ 0.001
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.151	$ 0.151
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.151**	**$ 0.151**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	202.57	408.04	620.36	834.59	1090.19	1215.20	213.42	213.42
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 32,210,261.37	$ 32,210,261.37
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	253.21	510.05	775.45	1043.24	1308.23	1670.90	313.29	313.29
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 47,283,746.68	$ 47,283,746.68
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	303.86	612.06	930.54	1251.89	1816.98	2278.49	499.37	499.37
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 75,367,426.52	$ 75,367,426.52

		Solar PV - Utility Scale Power Purchase to comply with RPS Target for 2030 (Constructed and starting operation from 2026-2030)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.149	$ 0.169
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.013	$ (0.006)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.162	$ 0.162
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.162**	**$ 0.169**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	151.93	306.03	465.27	625.95	817.64	911.40	160.06	160.06
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 25,992,372.87	$ 26,986,259.14
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	189.91	382.54	581.59	782.43	981.17	1253.17	234.97	234.97
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 38,156,063.38	$ 39,615,060.13
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	227.89	459.05	697.91	938.92	1362.74	1708.87	374.53	374.53
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 60,818,452.54	$ 63,144,004.94

		WTE - Utility Scale Power Purchase to comply with RPS Target for 2030 (Constructed and starting operation from 2026-2030)								
	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.132	$ 0.150
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ (0.004)	$ (0.022)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.128	$ 0.128
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.132**	**$ 0.150**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	43.05	86.71	131.83	177.35	231.67	258.23	45.35	45.35
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6,007,150.44	$ 6,796,539.34
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	53.81	108.39	164.78	221.69	278.00	355.07	66.57	66.57
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 8,818,325.82	$ 9,977,126.26
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	64.57	130.06	197.74	266.03	386.11	484.18	106.12	106.12
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 14,055,876.91	$ 15,902,934.58

Wind - Utility Scale Power Purchase to comply with RPS Target for 2035 (Constructed and starting operation from 2031-2035)

	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.132
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.010
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.142
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.142**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	202.57	408.04	620.36	834.59	1090.19	1215.20	1428.62	230.17
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 32,716,174.49
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	253.21	510.05	775.45	1043.24	1308.23	1670.90	1984.19	503.98
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 71,637,140.70
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	303.86	612.06	930.54	1251.89	1816.98	2278.49	2777.86	539.70
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 76,713,788.46

Solar PV - Utility Scale Power Purchase to comply with RPS Target for 2035 (Constructed and starting operation from 2031-2035)

	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.149
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ (0.010)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.139
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.149**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	151.93	306.03	465.27	625.95	817.64	911.40	1071.46	172.62
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 25,723,575.14
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	189.91	382.54	581.59	782.43	981.17	1253.17	1488.14	377.99
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 56,325,759.35
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	227.89	459.05	697.91	938.92	1362.74	1708.87	2083.40	404.77
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 60,317,348.60

WTE - Utility Scale Power Purchase to comply with RPS Target for 2035 (Constructed and starting operation from 2031-2035)

	Unit	2011	2012	2013	2014	2015	2020	2025	2030	2035
PPA Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.132
REC Price	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ (0.005)
LCOE	$/kWh	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 0.128
Total Purchase Price	**$/kWh**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0.132**
RE Genneration Required under RPS Case Scenario 1	(Million kWh)	0.00	43.05	86.71	131.83	177.35	231.67	258.23	303.58	48.91
Purchase Cost (RPS CS-1)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6,478,530.03
RE Genneration Required under RPS Case Scenario 2 (Million kWh)	(Million kWh)	0.00	53.81	108.39	164.78	221.69	278.00	355.07	421.64	107.10
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 14,185,746.80
RE Genneration Required under RPS Case Scenario 3 (Million kWh)	(Million kWh)	0.00	64.57	130.06	197.74	266.03	386.11	484.18	590.30	114.69
Purchase Cost (RPS CS-2)	$	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 15,191,035.94

19. Appendix I – EPSEM Results (Business As Usual Reference Case)

Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Total Electricity Generation Share by Fuel (Million of kWh)														
Oil	71.29%	70.54%	67.70%	69.81%	70.11%	67.4%	67.4%	67.4%	67.4%	67.4%	67.4%	67.4%	67.4%	67.4%
Residual No. 6				87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%
Distillate No. 2				12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%
Natural Gas	13.78%	14.11%	15.88%	14.52%	15.55%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%
PREPA Owned Units	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ecolectrica	13.78%	14.11%	15.88%	14.52%	15.55%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%
Coal	14.31%	14.92%	15.86%	14.89%	13.73%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%
Existing Hydro	0.62%	0.43%	0.56%	0.75%	0.57%	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%
Renewable Energy (% of Net Generation - Existing Hydro)	100.00%	100.00%	100.00%	0.02%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	23753.688	24062.143	22996.542	22656.293	23588.699	20791.304	20706.808	20745.808	20894.108	21082.155	22030.852	23022.240	24058.241	25140.862
Net Electricity Generation by Generator (millions of kWh)														
PREPA	17079.965	17077.141	15698.633	15987.225	16672.640	14179.669	14122.043	14148.641	14249.782	14378.030	15025.041	15701.168	16407.720	17146.068
Oil-Fired (Residual, Distillate, Diesel)	16932.853	16973.976	15,569.672	15816.894	16538.949	14023.359	13966.368	13992.673	14092.699	14219.533	14859.412	15528.086	16226.850	16957.058
Natural Gas	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hydro	147.112	103.165	128.961	170.331	133.691	156.310	155.675	155.968	157.083	158.497	165.629	173.082	180.871	189.010
EcoElectrica	3273.86	3395.873	3650.789	3290.55	3668.55	3285.026	3271.676	3277.838	3301.269	3330.980	3480.875	3637.514	3801.202	3972.256
AES	3399.863	3589.129	3646.89	3373.152	3238.311	3326.609	3313.089	3319.329	3343.057	3373.145	3524.936	3683.558	3849.319	4022.538
Renewable Energy Production	0	0	0.22995	5.3655	9.198	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WIND-IPPs				0	0	0	0	0	0	0	0	0	0	0
SOLAR-IPPs				0	0	0	0	0	0	0	0	0	0	0
WTE-IPPs				0	0	0	0	0	0	0	0	0	0	0
Solar -DG			0.22995	5.3655	9.198	0	0	0	0	0	0	0	0	0
Small Wind - DG				0	0	0	0	0	0	0	0	0	0	0
Total	23753.688	24062.143	22996.542	22656.293	23588.699	20791.304	20706.808	20745.808	20894.108	21082.155	22030.852	23022.240	24058.241	25140.862
System Efficiency (%)														
Month				81.70%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%	87.49%
Past Twelve Month				81.70%	81.60%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%
Total Electricity Consumption (Million of kWh)														
Total	20620	20672	19602	18515.775	19234.899	17938.8	17908.7	18036.1	18279.7	18444.2	19274.2	20141.5	21047.9	21995.1
Fuel Price Module														
Oil-based Weighted Average ($/BBL)	56.38	57.55	79.5	76.23	76.55	80.38	94.04	100.22	104.4	109.29	133.83	157.50	187.31	225.53
Residual Fuel No. 6 ($/BBL)										108.78	132.30	155.82	185.47	223.10
Distillate Fuel No. 2 ($/BBL)										112.73	144.14	168.80	199.67	241.84
Natural Gas ($/ million BTU)						4.16	4.58	4.65	4.99	6.77	7.85	9.17	11.66	14.22

PREPA - Power Plant Charasteristics (From Power Plant Module)														
Heat rate (BTU/kWh)														
Oil-Fired Units				9946	10598	10598	10598	10598	10598	10598	10598	10598	10598	10598
Natural Gas fired Units				N/A	N/A	8157	8157	8157	8157	8157	8157	8157	8157	8157
Conversion Factor														
kWh/Barrel	573	569	570.8	628.05	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85
BTU/Barrel				6246592	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748
PREPA - Fuel Expenses Module														
Fuel Consumption (thousands of BBLs)														
Oil Fuel (Thousands of BBLs)				25184.13184	26216.92795	22229.3087	22138.96864	22180.66603	22339.22301	22540.28	23554.59	24614.54	25722.20	26879.70
Natural Gas (Miillion BTUs)						0	0	0	0	0.00	0.00	0.00	0.00	0.00
Fuel Expenses ($)														
Oil-based				1919786370	$ 2,006,905,834.91	$ 1,786,791,833.29	$ 2,081,948,610.81	$ 2,222,946,349.08	$ 2,332,214,882.32	$ 2,463,455,694.65	$ 3,152,370,773.33	$ 3,876,793,683.71	$ 4,817,974,543.91	$ 6,062,062,367.33
Natural Gas						$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total				$ 1,919,786,369.91	$ 2,006,905,834.91	$ 1,786,791,833.29	$ 2,081,948,610.81	$ 2,222,946,349.08	$ 2,332,214,882.32	$ 2,463,455,694.65	$ 3,152,370,773.33	$ 3,876,793,683.71	$ 4,817,974,543.91	$ 6,062,062,367.33
Purchased Power Cost														
Ecoelectrica - Natural Gas: Cost of Energy ($/kWh)				$ 0.1261	$ 0.1168	$ 0.119	$ 0.121	$ 0.123	$ 0.125	$ 0.127	$ 0.129	$ 0.131	$ 0.134	$ 0.136
AES - Coal: Cost of Energy ($/kWh)				$ 0.0761	$ 0.0819	$ 0.084	$ 0.085	$ 0.087	$ 0.089	$ 0.090	$ 0.092	$ 0.094	$ 0.096	$ 0.098
Ecoelectrica Total Power Purchase Cost ($)	$ -	$ -	$ -	$ 414,989,328.0000	$ 428,501,200.8414	$ 390,227,048.4794	$ 395,248,062.8895	$ 402,724,360.6211	$ 412,498,462.9133	$ 423,286,535.2138	$ 449,854,114.5965	$ 478,089,208.0992	$ 508,096,477.2455	$ 539,987,152.6398
AES Total Power Purchase Cost ($)	$ -	$ -	$ -	$ 256,859,563.0000	$ 265,222,799.1586	$ 277,903,606.0187	$ 282,309,687.9630	$ 288,498,228.9245	$ 296,371,749.7056	$ 305,019,877.3621	$ 325,120,687.2802	$ 346,546,140.5720	$ 369,383,531.2357	$ 393,725,905.9441
Renewable Purchase Overall Cost ($) [From PPA & REC Purchase Module]	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fuel Consumption Clause [Calculated] ($/kWh)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**0.1165**	**0.1172**	**0.1183**	**0.1309**	**0.1392**	**0.1443**	**0.1501**	**0.1838**	**0.2163**	**0.2572**	**0.3097**
Power Purchase Clause [Calculated] ($/kWh)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**0.0408**	**0.0405**	**0.0442**	**0.0426**	**0.0433**	**0.0438**	**0.0444**	**0.0452**	**0.0460**	**0.0468**	**0.0477**
Average Basic Charge ($/kWh)	**0.0565**	**0.0573**	**0.0577**	**0.0579**	**0.0583**	**0.0588**	**0.0592**	**0.0597**	**0.0602**	**0.0607**	**0.0612**	**0.0616**	**0.0621**	**0.0626**
Average Total Electricity Cost ($/kWh)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**0.2152**	**0.2159**	0.2213	0.2328	0.2422	0.2483	0.2551	0.2901	0.3239	0.3662	0.4200
Average Total Electricity Cost (¢/kWh)	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**	**21.522**	**21.595**	22.135	23.278	24.220	24.829	25.511	29.010	32.391	36.618	42.001

20. Appendix J – EPSEM Results (Base Case Scenario – CS 5 & 6 – Natural Gas)

Fiscal Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Total Electricity Generation Share by Fuel (Million of kWh)											
Oil	69.81%	70.11%	57.4%	57.4%	57.4%	57.4%	57.4%	57.4%	57.4%	57.4%	57.4%
Residual No. 6	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%	87.06%
Distillate No. 2	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%	12.94%
Natural Gas	14.52%	15.55%	25.80%	25.80%	25.80%	25.80%	25.80%	25.80%	25.80%	25.80%	25.80%
PREPA Owned Units	0.00%	0.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
Ecolectrica	14.52%	15.55%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%	15.80%
Coal	14.89%	13.73%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%	16.0%
Existing Hydro	0.75%	0.57%	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%	0.75%
Renewable Energy (% of Net Generation - Existing Hydro)	0.02%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total	22656.293	23588.699	20791.304	20706.808	20745.808	20894.108	21082.155	22030.852	23022.240	24058.241	25140.862
Net Electricity Generation by Generator (millions of kWh)											
PREPA	15987.225	16672.640	14179.669	14122.043	14148.641	14249.782	14378.030	15025.041	15701.168	16407.720	17146.068
Oil-Fired (Residual, Distillate, Diesel)	15816.894	16538.949	11944.229	11895.688	11918.092	12003.288	12111.318	12656.327	13225.862	13821.025	14442.972
Natural Gas	0	0.000	2079.130	2070.681	2074.581	2089.411	2108.215	2203.085	2302.224	2405.824	2514.086
Hydro	170.331	133.691	156.310	155.675	155.968	157.083	158.497	165.629	173.082	180.871	189.010
EcoElectrica	3290.55	3668.55	3285.026	3271.676	3277.838	3301.269	3330.980	3480.875	3637.514	3801.202	3972.256
AES	3373.152	3238.311	3326.609	3313.089	3319.329	3343.057	3373.145	3524.936	3683.558	3849.319	4022.538
Renewable Energy Production	5.3655	9.198	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WIND-IPPs	0	0	0	0	0	0	0	0	0	0	0
SOLAR-IPPs	0	0	0	0	0	0	0	0	0	0	0
WTE-IPPs	0	0	0	0	0	0	0	0	0	0	0
Solar -DG	5.3655	9.198	0	0	0	0	0	0	0	0	0
Small Wind - DG	0	0	0	0	0	0	0	0	0	0	0
Total	22656.293	23588.699	20791.304	20706.808	20745.808	20894.108	21082.155	22030.852	23022.240	24058.241	25140.862
System Efficiency (%)											
Month	81.70%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%	87.49%
Past Twelve Month	81.70%	81.60%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%
Total Electricity Consumption (Million of kWh)											
Total	18515.775	19234.899	17938.8	17908.7	18036.1	18279.7	18444.2	19274.2	20141.5	21047.9	21995.1
Fuel Price Module											
Oil-based Weighted Average ($/BBL)	76.23	76.55	80.38	94.04	100.22	104.4	109.29	133.83	157.50	187.31	225.53
Residual Fuel No. 6 ($/BBL)							108.78	132.30	155.82	185.47	223.10
Distillate Fuel No. 2 ($/BBL)							112.73	144.14	168.80	199.67	241.84
Natural Gas ($/ million BTU)			4.16	4.58	4.65	4.99	6.77	7.85	9.17	11.66	14.22

PREPA - Power Plant Charasteristics (From Power Plant Module)											
Heat rate (BTU/kWh)											
Oil-Fired Units	9946	10598	10598	10598	10598	10598	10598	10598	10598	10598	10598
Natural Gas fired Units	N/A	N/A	8157	8157	8157	8157	8157	8157	8157	8157	8157
Conversion Factor											
kWh/Barrel	628.05	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85
BTU/Barrel	6246592	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748
PREPA - Fuel Expenses Module											
Fuel Consumption (thousands of BBLs)											
Oil Fuel (Thousands of BBLs)	25184.13184	26216.92795	18933.54838	18856.60231	18892.11756	19027.16658	19198.41	20062.34	20965.14	21908.58	22894.46
Natural Gas (Miillion BTUs)			16959466.67	16890543.29	16922355.59	17043323.9	17196713.81	17970565.93	18779241.40	19624307.26	20507401.09
Fuel Expenses ($)											
Oil-based	1919786370	$ 2,006,905,834.91	$ 1,521,878,618.50	$ 1,773,274,881.03	$ 1,893,368,021.78	$ 1,986,436,190.84	$ 2,098,218,986.38	$ 2,684,994,182.38	$ 3,302,012,750.25	$ 4,103,652,314.86	$ 5,163,289,270.16
Natural Gas			$ 70,551,381.36	$ 77,358,688.25	$ 78,688,953.47	$ 85,046,186.24	$ 116,421,752.50	$ 141,068,942.57	$ 172,205,643.63	$ 228,819,422.68	$ 291,615,243.48
Total	$ 1,919,786,369.91	$ 2,006,905,834.91	$ 1,592,429,999.86	$ 1,850,633,569.28	$ 1,972,056,975.25	$ 2,071,482,377.08	$ 2,214,640,738.87	$ 2,826,063,124.95	$ 3,474,218,393.88	$ 4,332,471,737.53	$ 5,454,904,513.64
Purchased Power Cost											
Ecoelectrica - Natural Gas: Cost of Energy ($/kWh)	$ 0.1261	$ 0.1168	$ 0.119	$ 0.121	$ 0.123	$ 0.125	$ 0.127	$ 0.129	$ 0.131	$ 0.134	$ 0.136
AES - Coal: Cost of Energy ($/kWh)	$ 0.0761	$ 0.0819	$ 0.084	$ 0.085	$ 0.087	$ 0.089	$ 0.090	$ 0.092	$ 0.094	$ 0.096	$ 0.098
Ecoelectrica Total Power Purchase Cost ($)	$ 414,989,328.0000	$ 428,501,200.8414	$ 390,227,048.4794	$ 395,248,062.8895	$ 402,724,360.6211	$ 412,498,462.9133	$ 423,286,535.2138	$ 449,854,114.5965	$ 478,089,208.0992	$ 508,096,477.2455	$ 539,987,152.6398
AES Total Power Purchase Cost ($)	$ 256,859,563.0000	$ 265,222,799.1586	$ 277,903,606.0187	$ 282,309,687.9630	$ 288,498,228.9245	$ 296,371,749.7056	$ 305,019,877.3621	$ 325,120,687.2802	$ 346,546,140.5720	$ 369,383,531.2357	$ 393,725,905.9441
Renewable Purchase Overall Cost ($) [From PPA & REC Purchase Module]	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fuel Consumption Clause [Calculated] ($/kWh)	**0.1165**	**0.1172**	**0.1055**	**0.1164**	**0.1235**	**0.1281**	**0.1349**	**0.1647**	**0.1938**	**0.2313**	**0.2787**
Power Purchase Clause [Calculated] ($/kWh)	**0.0408**	**0.0405**	**0.0442**	**0.0426**	**0.0433**	**0.0438**	**0.0444**	**0.0452**	**0.0460**	**0.0468**	**0.0477**
Average Basic Charge ($/kWh)	**0.0579**	**0.0583**	**0.0588**	**0.0592**	**0.0597**	**0.0602**	**0.0607**	**0.0612**	**0.0616**	**0.0621**	**0.0626**
Average Total Electricity Cost ($/kWh)	**0.2152**	**0.2159**	0.2085	0.2182	0.2265	0.2322	0.2399	0.2711	0.3015	0.3403	0.3890
Average Total Electricity Cost (¢/kWh)	**21.522**	**21.595**	20.848	21.824	22.649	23.217	23.995	27.108	30.146	34.026	38.899

21. Appendix K – EPSEM Results (RPS Case Scenario 1)

Fiscal Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Total Electricity Generation Share by Fuel (Million of kWh)											
Oil	**69.81%**	**70.11%**	**57.4%**	**54.9%**	**52.3%**	**49.6%**	**47.0%**	**44.4%**	**43.6%**	**41.8%**	**40.1%**
Residual No. 6	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*
Distillate No. 2	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*
Natural Gas	**14.52%**	**15.55%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**
PREPA Owned Units	*0.00%*	*0.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*
Ecolectrica	*14.52%*	*15.55%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*
Coal	**14.89%**	**13.73%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**
Existing Hydro	**0.75%**	**0.57%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**
Renewable Energy (% of Net Electricity Sales - Existing Hydro)	**0.02%**	**0.04%**	**0.00%**	**3.00%**	**6.00%**	**9.00%**	**12.00%**	**15.00%**	**16.00%**	**18.00%**	**20.00%**
Total	**22656.293**	**23588.699**	**20791.304**	**20706.808**	**20745.808**	**20894.108**	**21082.155**	**22030.852**	**23022.240**	**24058.241**	**25140.862**
Net Electricity Generation by Generator (millions of kWh)											
PREPA	**15987.225**	**16672.640**	**14179.669**	**13589.452**	**13075.833**	**12618.746**	**12183.743**	**12158.754**	**12506.214**	**12651.652**	**12784.855**
Oil-Fired (Residual, Distillate, Diesel)	*15816.894*	*16538.949*	*11944.229*	*11363.097*	*10845.284*	*10372.252*	*9917.031*	*9790.040*	*10030.907*	*10064.957*	*10081.759*
Natural Gas	*0*	*0.000*	*2079.130*	*2070.681*	*2074.581*	*2089.411*	*2108.215*	*2203.085*	*2302.224*	*2405.824*	*2514.086*
Hydro	*170.331*	*133.691*	*156.310*	*155.675*	*155.968*	*157.083*	*158.497*	*165.629*	*173.082*	*180.871*	*189.010*
EcoElectrica	**3290.55**	**3668.55**	**3285.026**	**3271.676**	**3277.838**	**3301.269**	**3330.980**	**3480.875**	**3637.514**	**3801.202**	**3972.256**
AES	**3373.152**	**3238.311**	**3326.609**	**3313.089**	**3319.329**	**3343.057**	**3373.145**	**3524.936**	**3683.558**	**3849.319**	**4022.538**
Renewable Energy Production	**5.3655**	**9.198**	**0**	**532.591**	**1072.808**	**1631.036**	**2194.286**	**2866.287**	**3194.954**	**3756.068**	**4361.212**
WIND-IPPs	*0*	*0*	*0*	*202.7629794*	*408.4294136*	*620.9526191*	*835.3882569*	*1091.225911*	*1216.353148*	*1429.97517*	*1660.360059*
SOLAR-IPPs	*0*	*0*	*0*	*152.0722346*	*306.3220602*	*465.7144643*	*626.5411927*	*818.419433*	*912.2648613*	*1072.481378*	*1245.270044*
WTE-IPPs	*0*	*0*	*0*	*42.58022568*	*85.77017685*	*130.40005*	*175.431534*	*229.1574412*	*255.4341612*	*300.2947857*	*348.6756123*
Solar -DG	*5.3655*	*9.198*	*0*	*128.4165536*	*258.6719619*	*393.2699921*	*529.0792294*	*691.1097434*	*770.356994*	*905.650941*	*1051.56137*
Small Wind - DG	*0*	*0*	*0*	*6.758765981*	*13.61431379*	*20.69842064*	*27.84627523*	*36.37419702*	*40.54510495*	*47.665839*	*55.34533528*
Total	**22656.293**	**23588.699**	**20791.304**	**20706.808**	**20745.808**	**20894.108**	**21082.155**	**22030.852**	**23022.240**	**24058.241**	**25140.862**
System Efficiency (%)											
Month	81.70%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%	87.49%
Past Twelve Month	81.70%	81.60%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%
Total Electricity Consumption (Million of kWh)											
Total	18515.775	19234.899	17938.8	17908.7	18036.1	18279.7	18444.2	19274.2	20141.5	21047.9	21995.1
Fuel Price Module											
Oil-based Weighted Average ($/BBL)	76.23	76.55	80.38	94.04	100.22	104.4	109.29	133.83	157.50	187.31	225.53
Residual Fuel No. 6 ($/BBL)							108.78	132.30	155.82	185.47	223.10
Distillate Fuel No. 2 ($/BBL)							112.73	144.14	168.80	199.67	241.84
Natural Gas ($/ million BTU)			4.16	4.58	4.65	4.99	6.77	7.85	9.17	11.66	14.22

PREPA - Power Plant Charasteristics (From Power Plant Module)											
Heat rate (BTU/kWh)											
Oil-Fired Units	9946	10598	10598	10598	10598	10598	10598	10598	10598	10598	10598
Natural Gas fired Units	N/A	N/A	8157	8157	8157	8157	8157	8157	8157	8157	8157
Conversion Factor											
kWh/Barrel	628.05	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85
BTU/Barrel	6246592	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748
PREPA - Fuel Expenses Module											
Fuel Consumption (thousands of BBLs)											
Oil Fuel (Thousands of BBLs)	25184.13184	26216.92795	18933.54838	18012.35921	17191.54226	16441.70958	15720.11	15518.81	15900.62	15954.60	15981.23
Natural Gas (Miillion BTUs)			16959466.67	16890543.29	16922355.59	17043323.9	17196713.81	17970565.93	18779241.40	19624307.26	20507401.09
Fuel Expenses ($)											
Oil-based	1919786370	$ 2,006,905,834.91	$ 1,521,878,618.50	$ 1,693,882,259.96	$ 1,722,936,365.47	$ 1,716,514,480.41	$ 1,718,070,953.58	$ 2,076,921,774.83	$ 2,504,349,805.68	$ 2,988,424,091.62	$ 3,604,177,890.82
Natural Gas			$ 70,551,381.36	$ 77,358,688.25	$ 78,688,953.47	$ 85,046,186.24	$ 116,421,752.50	$ 141,068,942.57	$ 172,205,643.63	$ 228,819,422.68	$ 291,615,243.48
Total	$ 1,919,786,369.91	$ 2,006,905,834.91	$ 1,592,429,999.86	$ 1,771,240,948.21	$ 1,801,625,318.95	$ 1,801,560,666.64	$ 1,834,492,706.08	$ 2,217,990,717.39	$ 2,676,555,449.31	$ 3,217,243,514.29	$ 3,895,793,134.31
Purchased Power Cost											
Ecoelectrica - Natural Gas: Cost of Energy ($/kWh)	$ 0.1261	$ 0.1168	$ 0.119	$ 0.121	$ 0.123	$ 0.125	$ 0.127	$ 0.129	$ 0.131	$ 0.134	$ 0.136
AES - Coal: Cost of Energy ($/kWh)	$ 0.0761	$ 0.0819	$ 0.084	$ 0.085	$ 0.087	$ 0.089	$ 0.090	$ 0.092	$ 0.094	$ 0.096	$ 0.098
Ecoelectrica Total Power Purchase Cost ($)	$ 414,989,328.0000	$ 428,501,200.8414	$ 390,227,048.4794	$ 395,248,062.8895	$ 402,724,360.6211	$ 412,498,462.9133	$ 423,286,535.2138	$ 449,854,114.5965	$ 478,089,208.0992	$ 508,096,477.2455	$ 539,987,152.6398
AES Total Power Purchase Cost ($)	$ 256,859,563.0000	$ 265,222,799.1586	$ 277,903,606.0187	$ 282,309,687.9630	$ 288,498,228.9245	$ 296,371,749.7056	$ 305,019,877.3621	$ 325,120,687.2802	$ 346,546,140.5720	$ 369,383,531.2357	$ 393,725,905.9441
Renewable Purchase Overall Cost ($) [From PPA & REC Purchase Module]	$ -	$ -	$ -	$ 64,377,380.86	$ 129,676,610.54	$ 197,152,869.68	$ 265,275,157.32	$ 369,633,691.87	$ 430,394,401.63	$ 532,095,768.62	$ 650,669,161.83
Fuel Consumption Clause [Calculated] ($/kWh)	**0.1165**	**0.1172**	**0.1055**	**0.1114**	**0.1128**	**0.1114**	**0.1118**	**0.1293**	**0.1493**	**0.1717**	**0.1990**
Power Purchase Clause [Calculated] ($/kWh)	**0.0408**	**0.0405**	**0.0442**	**0.0467**	**0.0514**	**0.0560**	**0.0605**	**0.0667**	**0.0700**	**0.0752**	**0.0809**
Average Basic Charge ($/kWh)	**0.0579**	**0.0583**	**0.0588**	**0.0592**	**0.0597**	**0.0602**	**0.0607**	**0.0612**	**0.0616**	**0.0621**	**0.0626**
Average Total Electricity Cost ($/kWh)	**0.2152**	**0.2159**	0.2085	0.2173	0.2239	0.2277	0.2330	0.2572	0.2810	0.3091	0.3426
Average Total Electricity Cost (¢/kWh)	**21.522**	**21.595**	20.848	21.729	22.394	22.767	23.295	25.718	28.097	30.913	34.258

22. Appendix L – EPSEM Results (RPS Case Scenario 2)

Fiscal Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Total Dispatchable Generation Capacity by fuel (MW)	**5839**	**5839**	**5839**	**5839**	**5934**	**5934**	**5934**	**5332**	**5779**	**5779**	**5779**
Oil	4778	4772	3958	3958	4053	4053	4053	3451	3898	3898	3898
Natural Gas	507	507	1327	1327	1327	1327	1327	1327	1327	1327	1327
Coal	454	454	454	454	454	454	454	454	454	454	454
Hydro	100	100	100	100	100	100	100	100	100	100	100
Renewable (According to RPS Target Levels Module)	3.5	6	0	238	479	729	981	1281	1428	1678	1949
Total Electricity Generation Share by Fuel (Million of kWh)											
Oil	**69.81%**	**70.11%**	**57.4%**	**54.2%**	**51.0%**	**47.7%**	**44.4%**	**41.8%**	**38.4%**	**35.8%**	**31.4%**
Residual No. 6	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*
Distillate No. 2	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*
Natural Gas	**14.52%**	**15.55%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**
PREPA Owned Units	*0.00%*	*0.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*
Ecolectrica	*14.52%*	*15.55%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*
Coal	**14.89%**	**13.73%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**
Existing Hydro	**0.75%**	**0.57%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**
Renewable Energy (% of Net Generation - Existing Hydro)	**0.02%**	**0.04%**	**0.00%**	**3.75%**	**7.50%**	**11.25%**	**15.00%**	**18.00%**	**22.00%**	**25.00%**	**30.00%**
Total	**22656.293**	**23588.699**	**20791.304**	**20706.808**	**20745.808**	**20894.108**	**21082.155**	**22030.852**	**23022.240**	**24058.241**	**25140.862**
Net Electricity Generation by Generator (millions of kWh)											
PREPA	**15987.225**	**16672.640**	**14179.669**	**13456.305**	**12807.631**	**12210.987**	**11635.172**	**11585.497**	**11308.106**	**11190.959**	**10604.249**
Oil-Fired (Residual, Distillate, Diesel)	*15816.894*	*16538.949*	*11944.229*	*11229.949*	*10577.082*	*9964.494*	*9368.460*	*9216.783*	*8832.800*	*8604.264*	*7901.153*
Natural Gas	*0*	*0.000*	*2079.130*	*2070.681*	*2074.581*	*2089.411*	*2108.215*	*2203.085*	*2302.224*	*2405.824*	*2514.086*
Hydro	*170.331*	*133.691*	*156.310*	*155.675*	*155.968*	*157.083*	*158.497*	*165.629*	*173.082*	*180.871*	*189.010*
EcoElectrica	**3290.55**	**3668.55**	**3285.026**	**3271.676**	**3277.838**	**3301.269**	**3330.980**	**3480.875**	**3637.514**	**3801.202**	**3972.256**
AES	**3373.152**	**3238.311**	**3326.609**	**3313.089**	**3319.329**	**3343.057**	**3373.145**	**3524.936**	**3683.558**	**3849.319**	**4022.538**
Renewable Energy Production	**5.3655**	**9.198**	**0**	**665.738**	**1341.010**	**2038.794**	**2742.858**	**3439.544**	**4393.062**	**5216.761**	**6541.819**
WIND-IPPs	*0*	*0*	*0*	*253.4537243*	*510.536767*	*776.1907739*	*1044.235321*	*1309.471093*	*1672.485579*	*1986.076625*	*2490.540088*
SOLAR-IPPs	*0*	*0*	*0*	*190.0902932*	*382.9025752*	*582.1430804*	*783.1764909*	*982.1033195*	*1254.364184*	*1489.557469*	*1867.905066*
WTE-IPPs	*0*	*0*	*0*	*53.2252821*	*107.2127211*	*163.0000625*	*219.2894174*	*274.9889295*	*351.2219716*	*417.0760913*	*523.0134184*
Solar -DG	*5.3655*	*9.198*	*0*	*160.520692*	*323.3399524*	*491.5874901*	*661.3490367*	*829.3316921*	*1059.240867*	*1257.848529*	*1577.342056*
Small Wind - DG	*0*	*0*	*0*	*8.448457476*	*17.01789223*	*25.8730258*	*34.80784404*	*43.64903642*	*55.7495193*	*66.20255417*	*83.01800293*
Total	**22656.293**	**23588.699**	**20791.304**	**20706.808**	**20745.808**	**20894.108**	**21082.155**	**22030.852**	**23022.240**	**24058.241**	**25140.862**
System Efficiency (%)											
Month	81.70%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%	87.49%
Past Twelve Month	81.70%	81.60%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%
Total Electricity Consumption (Million of kWh)											
Total	18515.775	19234.899	17938.8	17908.7	18036.1	18279.7	18444.2	19274.2	20141.5	21047.9	21995.1
Fuel Price Module											
Oil-based Weighted Average ($/BBL)	76.23	76.55	80.38	94.04	100.22	104.4	109.29	133.83	157.50	187.31	225.53
Residual Fuel No. 6 ($/BBL)							108.78	132.30	155.82	185.47	223.10
Distillate Fuel No. 2 ($/BBL)							112.73	144.14	168.80	199.67	241.84
Natural Gas ($/ million BTU)			4.16	4.58	4.65	4.99	6.77	7.85	9.17	11.66	14.22

PREPA - Power Plant Charasteristics (From Power Plant Module)											
Heat rate (BTU/kWh)											
Oil-Fired Units	9946	10598	10598	10598	10598	10598	10598	10598	10598	10598	10598
Natural Gas fired Units	N/A	N/A	8157	8157	8157	8157	8157	8157	8157	8157	8157
Conversion Factor											
kWh/Barrel	628.05	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85
BTU/Barrel	6246592	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748
PREPA - Fuel Expenses Module											
Fuel Consumption (thousands of BBLs)											
Oil Fuel (Thousands of BBLs)	25184.13184	26216.92795	18933.54838	17801.29843	16766.39844	15795.34533	14850.53	14610.10	14001.43	13639.16	12524.61
Natural Gas (Miillion BTUs)			16959466.67	16890543.29	16922355.59	17043323.9	17196713.81	17970565.93	18779241.40	19624307.26	20507401.09
Fuel Expenses ($)											
Oil-based	1919786370	$ 2,006,905,834.91	$ 1,521,878,618.50	$ 1,674,034,104.69	$ 1,680,328,451.40	$ 1,649,034,052.80	$ 1,623,033,945.38	$ 1,955,307,293.32	$ 2,205,226,201.47	$ 2,554,724,227.02	$ 2,824,622,201.15
Natural Gas			$ 70,551,381.36	$ 77,358,688.25	$ 78,688,953.47	$ 85,046,186.24	$ 116,421,752.50	$ 141,068,942.57	$ 172,205,643.63	$ 228,819,422.68	$ 291,615,243.48
Total	$ 1,919,786,369.91	$ 2,006,905,834.91	$ 1,592,429,999.86	$ 1,751,392,792.94	$ 1,759,017,404.87	$ 1,734,080,239.04	$ 1,739,455,697.88	$ 2,096,376,235.88	$ 2,377,431,845.10	$ 2,783,543,649.70	$ 3,116,237,444.64
Purchased Power Cost											
Ecoelectrica - Natural Gas: Cost of Energy ($/kWh)	$ 0.1261	$ 0.1168	$ 0.119	$ 0.121	$ 0.123	$ 0.125	$ 0.127	$ 0.129	$ 0.131	$ 0.134	$ 0.136
AES - Coal: Cost of Energy ($/kWh)	$ 0.0761	$ 0.0819	$ 0.084	$ 0.085	$ 0.087	$ 0.089	$ 0.090	$ 0.092	$ 0.094	$ 0.096	$ 0.098
Ecoelectrica Total Power Purchase Cost ($)	$ 414,989,328.0000	$ 428,501,200.8414	$ 390,227,048.4794	$ 395,248,062.8895	$ 402,724,360.6211	$ 412,498,462.9133	$ 423,286,535.2138	$ 449,854,114.5965	$ 478,089,208.0992	$ 508,096,477.2455	$ 539,987,152.6398
AES Total Power Purchase Cost ($)	$ 256,859,563.0000	$ 265,222,799.1586	$ 277,903,606.0187	$ 282,309,687.9630	$ 288,498,228.9245	$ 296,371,749.7056	$ 305,019,877.3621	$ 325,120,687.2802	$ 346,546,140.5720	$ 369,383,531.2357	$ 393,725,905.9441
Renewable Purchase Overall Cost ($) [From PPA & REC Purchase Module]	$ -	$ -	$ -	$ 80,471,726.08	$ 162,095,763.17	$ 246,441,087.11	$ 331,593,946.65	$ 441,803,980.54	$ 587,146,732.52	$ 728,366,935.09	$ 940,183,888.10
Fuel Consumption Clause [Calculated] ($/kWh)	**0.1165**	**0.1172**	**0.1055**	**0.1101**	**0.1102**	**0.1073**	**0.1060**	**0.1222**	**0.1326**	**0.1486**	**0.1592**
Power Purchase Clause [Calculated] ($/kWh)	**0.0408**	**0.0405**	**0.0442**	**0.0477**	**0.0534**	**0.0591**	**0.0646**	**0.0709**	**0.0788**	**0.0857**	**0.0957**
Average Basic Charge ($/kWh)	**0.0579**	**0.0583**	**0.0588**	**0.0592**	**0.0597**	**0.0602**	**0.0607**	**0.0612**	**0.0616**	**0.0621**	**0.0626**
Average Total Electricity Cost ($/kWh)	**0.2152**	**0.2159**	0.2085	0.2171	0.2233	0.2265	0.2312	0.2543	0.2730	0.2965	0.3176
Average Total Electricity Cost (¢/kWh)	**21.522**	**21.595**	20.848	21.706	22.330	22.654	23.120	25.430	27.303	29.646	31.755

23. Appendix M – EPSEM Results (RPS Case Scenario 3)

Fiscal Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Total Dispatchable Generation Capacity by fuel (MW)	**5839**	**5839**	**5839**	**5839**	**5934**	**5934**	**5934**	**5332**	**5779**	**5779**	**5779**
Oil	4778	4772	3958	3958	4053	4053	4053	3451	3898	3898	3898
Natural Gas	507	507	1327	1327	1327	1327	1327	1327	1327	1327	1327
Coal	454	454	454	454	454	454	454	454	454	454	454
Hydro	100	100	100	100	100	100	100	100	100	100	100
Renewable (According to RPS Target Levels Module)	3.5	6	0	238	479	729	981	1281	1428	1678	1949
Total Electricity Generation Share by Fuel (Million of kWh)											
Oil	**69.81%**	**70.11%**	**57.4%**	**53.6%**	**49.7%**	**45.7%**	**41.8%**	**35.8%**	**31.4%**	**27.1%**	**22.8%**
Residual No. 6	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*
Distillate No. 2	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*
Natural Gas	**14.52%**	**15.55%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**
PREPA Owned Units	*0.00%*	*0.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*
Ecolectrica	*14.52%*	*15.55%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*
Coal	**14.89%**	**13.73%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**
Existing Hydro	**0.75%**	**0.57%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**
Renewable Energy (% of Net Generation - Existing Hydro)	**0.02%**	**0.04%**	**0.00%**	**4.50%**	**9.00%**	**13.50%**	**18.00%**	**25.00%**	**30.00%**	**35.00%**	**40.00%**
Total	**22656.293**	**23588.699**	**20791.304**	**20706.808**	**20745.808**	**20894.108**	**21082.155**	**22030.852**	**23022.240**	**24058.241**	**25140.862**
Net Electricity Generation by Generator (millions of kWh)											
PREPA	**15987.225**	**16672.640**	**14179.669**	**13323.157**	**12539.429**	**11803.228**	**11086.600**	**10247.896**	**9710.629**	**9104.255**	**8423.643**
Oil-Fired (Residual, Distillate, Diesel)	*15816.894*	*16538.949*	*11944.229*	*11096.801*	*10308.880*	*9556.735*	*8819.888*	*7879.182*	*7235.322*	*6517.560*	*5720.547*
Natural Gas	*0*	*0.000*	*2079.130*	*2070.681*	*2074.581*	*2089.411*	*2108.215*	*2203.085*	*2302.224*	*2405.824*	*2514.086*
Hydro	*170.331*	*133.691*	*156.310*	*155.675*	*155.968*	*157.083*	*158.497*	*165.629*	*173.082*	*180.871*	*189.010*
EcoElectrica	**3290.55**	**3668.55**	**3285.026**	**3271.676**	**3277.838**	**3301.269**	**3330.980**	**3480.875**	**3637.514**	**3801.202**	**3972.256**
AES	**3373.152**	**3238.311**	**3326.609**	**3313.089**	**3319.329**	**3343.057**	**3373.145**	**3524.936**	**3683.558**	**3849.319**	**4022.538**
Renewable Energy Production	**5.3655**	**9.198**	**0**	**798.886**	**1609.212**	**2446.553**	**3291.430**	**4777.145**	**5990.539**	**7303.466**	**8722.425**
WIND-IPPs	*0*	*0*	*0*	*304.1444691*	*612.6441204*	*931.4289287*	*1253.082385*	*1818.709851*	*2280.662153*	*2780.507275*	*3320.720117*
SOLAR-IPPs	*0*	*0*	*0*	*228.1083519*	*459.4830903*	*698.5716965*	*939.811789*	*1364.032388*	*1710.496615*	*2085.380456*	*2490.540088*
WTE-IPPs	*0*	*0*	*0*	*63.87033852*	*128.6552653*	*195.600075*	*263.1473009*	*381.9290687*	*478.9390522*	*583.9065278*	*697.3512246*
Solar -DG	*5.3655*	*9.198*	*0*	*192.6248305*	*388.0079429*	*589.9049882*	*793.6188441*	*1151.849572*	*1444.419364*	*1760.987941*	*2103.122741*
Small Wind - DG	*0*	*0*	*0*	*10.13814897*	*20.42147068*	*31.04763096*	*41.76941285*	*60.6236617*	*76.02207177*	*92.68357584*	*110.6906706*
Total	**22656.293**	**23588.699**	**20791.304**	**20706.808**	**20745.808**	**20894.108**	**21082.155**	**22030.852**	**23022.240**	**24058.241**	**25140.862**
System Efficiency (%)											
Month	81.70%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%	87.49%
Past Twelve Month	81.70%	81.60%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%
Total Electricity Consumption (Million of kWh)											
Total	18515.775	19234.899	17938.8	17908.7	18036.1	18279.7	18444.2	19274.2	20141.5	21047.9	21995.1
Fuel Price Module											
Oil-based Weighted Average ($/BBL)	76.23	76.55	80.38	94.04	100.22	104.4	109.29	133.83	157.50	187.31	225.53
Residual Fuel No. 6 ($/BBL)							108.78	132.30	155.82	185.47	223.10
Distillate Fuel No. 2 ($/BBL)							112.73	144.14	168.80	199.67	241.84
Natural Gas ($/ million BTU)			4.16	4.58	4.65	4.99	6.77	7.85	9.17	11.66	14.22

PREPA - Power Plant Charasteristics (From Power Plant Module)											
Heat rate (BTU/kWh)											
Oil-Fired Units	9946	10598	10598	10598	10598	10598	10598	10598	10598	10598	10598
Natural Gas fired Units	N/A	N/A	8157	8157	8157	8157	8157	8157	8157	8157	8157
Conversion Factor											
kWh/Barrel	628.05	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85
BTU/Barrel	6246592	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748
PREPA - Fuel Expenses Module											
Fuel Consumption (thousands of BBLs)											
Oil Fuel (Thousands of BBLs)	25184.13184	26216.92795	18933.54838	17590.23766	16341.25461	15148.98108	13980.96	12489.79	11469.16	10331.39	9068.00
Natural Gas (Miillion BTUs)			16959466.67	16890543.29	16922355.59	17043323.9	17196713.81	17970565.93	18779241.40	19624307.26	20507401.09
Fuel Expenses ($)											
Oil-based	1919786370	$ 2,006,905,834.91	$ 1,521,878,618.50	$ 1,654,185,949.42	$ 1,637,720,537.32	$ 1,581,553,625.19	$ 1,527,996,937.18	$ 1,671,540,169.79	$ 1,806,394,729.18	$ 1,935,152,991.89	$ 2,045,066,511.49
Natural Gas			$ 70,551,381.36	$ 77,358,688.25	$ 78,688,953.47	$ 85,046,186.24	$ 116,421,752.50	$ 141,068,942.57	$ 172,205,643.63	$ 228,819,422.68	$ 291,615,243.48
Total	$ 1,919,786,369.91	$ 2,006,905,834.91	$ 1,592,429,999.86	$ 1,731,544,637.67	$ 1,716,409,490.79	$ 1,666,599,811.43	$ 1,644,418,689.68	$ 1,812,609,112.36	$ 1,978,600,372.81	$ 2,163,972,414.56	$ 2,336,681,754.97
Purchased Power Cost											
Ecoelectrica - Natural Gas: Cost of Energy ($/kWh)	$ 0.1261	$ 0.1168	$ 0.119	$ 0.121	$ 0.123	$ 0.125	$ 0.127	$ 0.129	$ 0.131	$ 0.134	$ 0.136
AES - Coal: Cost of Energy ($/kWh)	$ 0.0761	$ 0.0819	$ 0.084	$ 0.085	$ 0.087	$ 0.089	$ 0.090	$ 0.092	$ 0.094	$ 0.096	$ 0.098
Ecoelectrica Total Power Purchase Cost ($)	$ 414,989,328.0000	$ 428,501,200.8414	$ 390,227,048.4794	$ 395,248,062.8895	$ 402,724,360.6211	$ 412,498,462.9133	$ 423,286,535.2138	$ 449,854,114.5965	$ 478,089,208.0992	$ 508,096,477.2455	$ 539,987,152.6398
AES Total Power Purchase Cost ($)	$ 256,859,563.0000	$ 265,222,799.1586	$ 277,903,606.0187	$ 282,309,687.9630	$ 288,498,228.9245	$ 296,371,749.7056	$ 305,019,877.3621	$ 325,120,687.2802	$ 346,546,140.5720	$ 369,383,531.2357	$ 393,725,905.9441
Renewable Purchase Overall Cost ($) [From PPA & REC Purchase Module]	$ -	$ -	$ -	$ 96,566,071.30	$ 194,514,915.81	$ 295,729,304.53	$ 397,912,735.98	$ 621,910,985.46	$ 805,167,307.23	$ 1,013,094,050.11	$ 1,255,789,043.39
Fuel Consumption Clause [Calculated] ($/kWh)	**0.1165**	**0.1172**	**0.1055**	**0.1089**	**0.1075**	**0.1031**	**0.1002**	**0.1057**	**0.1104**	**0.1155**	**0.1194**
Power Purchase Clause [Calculated] ($/kWh)	**0.0408**	**0.0405**	**0.0442**	**0.0487**	**0.0555**	**0.0621**	**0.0686**	**0.0814**	**0.0909**	**0.1009**	**0.1118**
Average Basic Charge ($/kWh)	**0.0579**	**0.0583**	**0.0588**	**0.0592**	**0.0597**	**0.0602**	**0.0607**	**0.0612**	**0.0616**	**0.0621**	**0.0626**
Average Total Electricity Cost ($/kWh)	**0.2152**	**0.2159**	0.2085	0.2168	0.2227	0.2254	0.2295	0.2483	0.2629	0.2786	0.2938
Average Total Electricity Cost (¢/kWh)	**21.522**	**21.595**	20.848	21.682	22.266	22.541	22.945	24.825	26.294	27.858	29.385

24. Appendix N – EPSEM Results (RPS & EE Case Scenario 1)

Fiscal Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Total Dispatchable Generation Capacity by fuel (MW)	**5839**	**5839**	**5839**	**5839**	**5934**	**5934**	**5934**	**5332**	**5779**	**5779**	**5779**
Oil	4778	4772	3958	3958	4053	4053	4053	3451	3898	3898	3898
Natural Gas	507	507	1327	1327	1327	1327	1327	1327	1327	1327	1327
Coal	454	454	454	454	454	454	454	454	454	454	454
Hydro	100	100	100	100	100	100	100	100	100	100	100
Renewable (According to RPS Target Levels Module)	3.5	6	0	240	483	734	988	1290	1438	1691	1963
Total Electricity Generation Share by Fuel (Million of kWh)											
Oil	**69.81%**	**70.11%**	**57.4%**	**54.9%**	**52.3%**	**49.6%**	**47.0%**	**44.4%**	**43.6%**	**41.8%**	**40.1%**
Residual No. 6	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*
Distillate No. 2	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*
Natural Gas	**14.52%**	**15.55%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**
PREPA Owned Units	*0.00%*	*0.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*
Ecolectrica	*14.52%*	*15.55%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*
Coal	**14.89%**	**13.73%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**
Existing Hydro	**0.75%**	**0.57%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**
Renewable Energy (% of Net Generation - Existing Hydro)	**0.02%**	**0.04%**	**0.00%**	**3.00%**	**6.00%**	**9.00%**	**12.00%**	**15.00%**	**16.00%**	**18.00%**	**20.00%**
Total	22656.293	23588.699	20791.304	20706.808	20745.808	20894.108	21082.155	22030.852	23022.240	24058.241	25140.862
Net Total Generation After EE Integration	**22656.293**	**23588.699**	**20426.880**	**20343.865**	**20382.182**	**20527.882**	**20712.633**	**20100.101**	**21004.606**	**21949.813**	**22937.555**
Net Electricity Generation by Generator (millions of kWh)											
PREPA	**15987.225**	**16672.640**	**13931.132**	**13351.260**	**12846.644**	**12397.569**	**11970.190**	**11093.180**	**11410.188**	**11542.881**	**11664.410**
Oil-Fired (Residual, Distillate, Diesel)	*15816.894*	*16538.949*	*11734.874*	*11163.928*	*10655.192*	*10190.451*	*9743.208*	*8932.056*	*9151.814*	*9182.880*	*9198.209*
Natural Gas	*0*	*0.000*	*2042.688*	*2034.387*	*2038.218*	*2052.788*	*2071.263*	*2010.010*	*2100.461*	*2194.981*	*2293.755*
Hydro	*170.331*	*133.691*	*153.570*	*152.946*	*153.234*	*154.330*	*155.718*	*151.113*	*157.914*	*165.020*	*172.446*
EcoElectrica	**3290.55**	**3668.55**	**3227.447**	**3214.331**	**3220.385**	**3243.405**	**3272.596**	**3175.816**	**3318.728**	**3468.071**	**3624.134**
AES	**3373.152**	**3238.311**	**3268.301**	**3255.018**	**3261.149**	**3284.461**	**3314.021**	**3216.016**	**3360.737**	**3511.970**	**3670.009**
Renewable Energy Production	**5.3655**	**9.198**	**0**	**523.256**	**1054.004**	**1602.447**	**2155.826**	**2615.090**	**2914.953**	**3426.892**	**3979.002**
WIND-IPPs	*0*	*0*	*0.0*	*209.3*	*421.6*	*641.0*	*862.3*	*1046.0*	*1166.0*	*1370.8*	*1591.6*
SOLAR-IPPs	*0*	*0*	*0.0*	*104.7*	*210.8*	*320.5*	*431.2*	*523.0*	*583.0*	*685.4*	*795.8*
WTE-IPPs	*0*	*0*	*0.0*	*78.5*	*158.1*	*240.4*	*323.4*	*392.3*	*437.2*	*514.0*	*596.9*
Solar -DG	*5.3655*	*9.198*	*0.0*	*115.1*	*231.9*	*352.5*	*474.3*	*575.3*	*641.3*	*753.9*	*875.4*
Small Wind - DG	*0*	*0*	*0.0*	*15.7*	*31.6*	*48.1*	*64.7*	*78.5*	*87.4*	*102.8*	*119.4*
Total	**22656.293**	**23588.699**	**20426.880**	**20343.865**	**20382.182**	**20527.882**	**20712.633**	**20100.101**	**21004.606**	**21949.813**	**22937.555**
System Efficiency (%)											
Month	81.70%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%	87.49%
Past Twelve Month	81.70%	81.60%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%
Total Electricity Consumption (Million of kWh)											
Reference Total Consumption	18515.775	19234.899	17938.8	17908.7	18036.1	18279.7	18444.2	19274.2	20141.5	21047.9	21995.1
Avg. Reduction Rate (%) from EE Measures [From EE Potential Module]	0.0%	0.0%	1.8%	1.8%	1.8%	1.8%	1.8%	8.8%	8.8%	8.8%	8.8%
Energy Reduction (Million kWh)	0	0	314.425846	313.8982623	316.1312908	320.4010378	323.2846471	1689.162281	1765.174584	1844.60744	1927.614775
Net Electricity Consumption (Million kWh)	18515.775	19234.899	17624.374	17594.802	17719.969	17959.299	18120.933	17585.045	18376.372	19203.309	20067.457
Fuel Price Module											
Oil-based Weighted Average ($/BBL)	76.23	76.55	80.38	94.04	100.22	104.4	109.29	133.83	157.50	187.31	225.53
Residual Fuel No. 6 ($/BBL)							108.78	132.30	155.82	185.47	223.10
Distillate Fuel No. 2 ($/BBL)							112.73	144.14	168.80	199.67	241.84
Natural Gas ($/ million BTU)			4.16	4.58	4.65	4.99	6.77	7.85	9.17	11.66	14.22

PREPA - Power Plant Charasteristics (From Power Plant Module)											
Heat rate (BTU/kWh)											
Oil-Fired Units	9946	10598	10598	10598	10598	10598	10598	10598	10598	10598	10598
Natural Gas fired Units	N/A	N/A	8157	8157	8157	8157	8157	8157	8157	8157	8157
Conversion Factor											
kWh/Barrel	628.05	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85
BTU/Barrel	6246592	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748

PREPA - Fuel Expenses Module											
Fuel Consumption (thousands of BBLs)											
Oil Fuel (Thousands of BBLs)	25184.13184	26216.92795	18601.68688	17696.64404	16890.21412	16153.52428	15444.57	14158.76	14507.12	14556.36	14580.66
Natural Gas (Miillion BTUs)			16662206.28	16594490.97	16625745.67	16744593.68	16895295.03	16395652.78	17133457.16	17904462.73	18710163.55
Fuel Expenses ($)											
Oil-based	1919786370	$ 2,006,905,834.91	$ 1,495,203,591.63	$ 1,664,192,405.42	$ 1,692,737,259.39	$ 1,686,427,935.17	$ 1,687,957,126.96	$ 1,894,903,499.90	$ 2,284,872,386.28	$ 2,726,523,135.84	$ 3,288,313,205.81
Natural Gas			$ 69,314,778.14	$ 76,002,768.62	$ 77,309,717.36	$ 83,555,522.48	$ 114,381,147.33	$ 128,705,874.36	$ 157,113,802.15	$ 208,766,035.45	$ 266,058,525.75
Total	$ 1,919,786,369.91	$ 2,006,905,834.91	$ 1,564,518,369.77	$ 1,740,195,174.04	$ 1,770,046,976.75	$ 1,769,983,457.65	$ 1,802,338,274.29	$ 2,023,609,374.26	$ 2,441,986,188.43	$ 2,935,289,171.29	$ 3,554,371,731.56

Purchased Power Cost											
Ecoelectrica - Natural Gas: Cost of Energy ($/kWh)	$ 0.1261	$ 0.1168	$ 0.119	$ 0.121	$ 0.123	$ 0.125	$ 0.127	$ 0.129	$ 0.131	$ 0.134	$ 0.136
AES - Coal: Cost of Energy ($/kWh)	$ 0.0761	$ 0.0819	$ 0.084	$ 0.085	$ 0.087	$ 0.089	$ 0.090	$ 0.092	$ 0.094	$ 0.096	$ 0.098
Ecoelectrica Total Power Purchase Cost ($)	$ 414,989,328.0000	$ 428,501,200.8414	$ 383,387,267.1209	$ 388,320,274.7132	$ 395,665,530.1655	$ 405,268,314.9570	$ 415,867,297.1981	$ 410,429,582.1474	$ 436,190,194.8709	$ 463,567,672.4519	$ 492,663,497.4134
AES Total Power Purchase Cost ($)	$ 256,859,563.0000	$ 265,222,799.1586	$ 273,032,595.8944	$ 277,361,449.3707	$ 283,441,519.4631	$ 291,177,035.5598	$ 299,673,581.4575	$ 296,627,603.2566	$ 316,175,362.3112	$ 337,011,318.6875	$ 359,220,364.5891
Renewable Purchase Overall Cost ($) [From PPA & REC Purchase Module]	$ -	$ -	$ -	$ 61,656,606.59	$ 124,196,102.00	$ 188,820,619.32	$ 254,098,248.68	$ 326,515,143.59	$ 385,393,803.21	$ 481,408,189.64	$ 592,337,673.31

Fuel Consumption Clause [Calculated] ($/kWh)	**0.1165**	**0.1172**	**0.1055**	**0.1114**	**0.1128**	**0.1114**	**0.1118**	**0.1293**	**0.1493**	**0.1717**	**0.1990**
Power Purchase Clause [Calculated] ($/kWh)	**0.0408**	**0.0405**	**0.0442**	**0.0466**	**0.0512**	**0.0557**	**0.0601**	**0.0660**	**0.0696**	**0.0750**	**0.0809**
Average Basic Charge ($/kWh)	**0.0579**	**0.0583**	**0.0588**	**0.0592**	**0.0597**	**0.0602**	**0.0607**	**0.0612**	**0.0616**	**0.0621**	**0.0626**
Average Total Electricity Cost ($/kWh)	**0.2152**	**0.2159**	0.2085	0.2172	0.2237	0.2274	0.2325	0.2565	0.2805	0.3089	0.3425
Average Total Electricity Cost (¢/kWh)	**21.522**	**21.595**	20.848	21.719	22.373	22.736	23.255	25.649	28.052	30.889	34.251

25. Appendix O – EPSEM Results (RPS & EE Case Scenario 2)

Fiscal Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Total Dispatchable Generation Capacity by fuel (MW)	**5839**	**5839**	**5839**	**5839**	**5934**	**5934**	**5934**	**5332**	**5779**	**5779**	**5779**
Oil	4778	4772	3958	3958	4053	4053	4053	3451	3898	3898	3898
Natural Gas	507	507	1327	1327	1327	1327	1327	1327	1327	1327	1327
Coal	454	454	454	454	454	454	454	454	454	454	454
Hydro	100	100	100	100	100	100	100	100	100	100	100
Renewable (According to RPS Target Levels Module)	3.5	6	0	240	483	734	988	1290	1438	1691	1963
Total Electricity Generation Share by Fuel (Million of kWh)											
Oil	**69.81%**	**70.11%**	**57.4%**	**54.2%**	**51.0%**	**47.7%**	**44.4%**	**41.8%**	**38.4%**	**35.8%**	**31.4%**
Residual No. 6	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*
Distillate No. 2	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*
Natural Gas	**14.52%**	**15.55%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**
PREPA Owned Units	*0.00%*	*0.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*
Ecolectrica	*14.52%*	*15.55%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*
Coal	**14.89%**	**13.73%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**
Existing Hydro	**0.75%**	**0.57%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**
Renewable Energy (% of Net Generation - Existing Hydro)	**0.02%**	**0.04%**	**0.00%**	**3.75%**	**7.50%**	**11.25%**	**15.00%**	**18.00%**	**22.00%**	**25.00%**	**30.00%**
Total	22656.293	23588.699	20791.304	20706.808	20745.808	20894.108	21082.155	22030.852	23022.240	24058.241	25140.862
Net Total Generation After EE Integration	**22656.293**	**23588.699**	**20426.880**	**20343.865**	**20382.182**	**20527.882**	**20712.633**	**20100.101**	**21004.606**	**21949.813**	**22937.555**
Net Electricity Generation by Generator (millions of kWh)											
PREPA	**15987.225**	**16672.640**	**13931.132**	**13220.447**	**12583.143**	**11996.957**	**11431.234**	**10570.162**	**10317.081**	**10210.200**	**9674.909**
Oil-Fired (Residual, Distillate, Diesel)	*15816.894*	*16538.949*	*11734.874*	*11033.114*	*10391.691*	*9789.839*	*9204.252*	*8409.038*	*8058.706*	*7850.199*	*7208.708*
Natural Gas	*0*	*0.000*	*2042.688*	*2034.387*	*2038.218*	*2052.788*	*2071.263*	*2010.010*	*2100.461*	*2194.981*	*2293.755*
Hydro	*170.331*	*133.691*	*153.570*	*152.946*	*153.234*	*154.330*	*155.718*	*151.113*	*157.914*	*165.020*	*172.446*
EcoElectrica	**3290.55**	**3668.55**	**3227.447**	**3214.331**	**3220.385**	**3243.405**	**3272.596**	**3175.816**	**3318.728**	**3468.071**	**3624.134**
AES	**3373.152**	**3238.311**	**3268.301**	**3255.018**	**3261.149**	**3284.461**	**3314.021**	**3216.016**	**3360.737**	**3511.970**	**3670.009**
Renewable Energy Production	**5.3655**	**9.198**	**0**	**654.070**	**1317.505**	**2003.059**	**2694.782**	**3138.108**	**4008.061**	**4759.572**	**5968.504**
WIND-IPPs	*0*	*0*	*0.0*	*261.6*	*527.0*	*801.2*	*1077.9*	*1255.2*	*1603.2*	*1903.8*	*2387.4*
SOLAR-IPPs	*0*	*0*	*0.0*	*130.8*	*263.5*	*400.6*	*539.0*	*627.6*	*801.6*	*951.9*	*1193.7*
WTE-IPPs	*0*	*0*	*0.0*	*98.1*	*197.6*	*300.5*	*404.2*	*470.7*	*601.2*	*713.9*	*895.3*
Solar -DG	*5.3655*	*9.198*	*0.0*	*143.9*	*289.9*	*440.7*	*592.9*	*690.4*	*881.8*	*1047.1*	*1313.1*
Small Wind - DG	*0*	*0*	*0.0*	*19.6*	*39.5*	*60.1*	*80.8*	*94.1*	*120.2*	*142.8*	*179.1*
Total	**22656.293**	**23588.699**	**20426.880**	**20343.865**	**20382.182**	**20527.882**	**20712.633**	**20100.101**	**21004.606**	**21949.813**	**22937.555**
System Efficiency (%)											
Month	81.70%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%	87.49%
Past Twelve Month	81.70%	81.60%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%
Total Electricity Consumption (Million of kWh)											
Reference Total Consumption	18515.775	19234.899	17938.8	17908.7	18036.1	18279.7	18444.2	19274.2	20141.5	21047.9	21995.1
Avg. Reduction Rate (%) from EE Measures [From EE Potential Module]	0.0%	0.0%	1.8%	1.8%	1.8%	1.8%	1.8%	8.8%	8.8%	8.8%	8.8%
Energy Reduction (Million kWh)	0	0	314.425846	313.8982623	316.1312908	320.4010378	323.2846471	1689.162281	1765.174584	1844.60744	1927.614775
Net Electricity Consumption (Million kWh)	18515.775	19234.899	17624.374	17594.802	17719.969	17959.299	18120.933	17585.045	18376.372	19203.309	20067.457
Fuel Price Module											
Oil-based Weighted Average ($/BBL)	76.23	76.55	80.38	94.04	100.22	104.4	109.29	133.83	157.50	187.31	225.53
Residual Fuel No. 6 ($/BBL)							108.78	132.30	155.82	185.47	223.10
Distillate Fuel No. 2 ($/BBL)							112.73	144.14	168.80	199.67	241.84
Natural Gas ($/ million BTU)			4.16	4.58	4.65	4.99	6.77	7.85	9.17	11.66	14.22

PREPA - Power Plant Charasteristics (From Power Plant Module)											
Heat rate (BTU/kWh)											
Oil-Fired Units	9946	10598	10598	10598	10598	10598	10598	10598	10598	10598	10598
Natural Gas fired Units	N/A	N/A	8157	8157	8157	8157	8157	8157	8157	8157	8157
Conversion Factor											
kWh/Barrel	628.05	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85
BTU/Barrel	6246592	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748

PREPA - Fuel Expenses Module											
Fuel Consumption (thousands of BBLs)											
Oil Fuel (Thousands of BBLs)	25184.13184	26216.92795	18601.68688	17489.28267	16472.52209	15518.48931	14590.24	13329.69	12774.36	12443.84	11426.98
Natural Gas (Miillion BTUs)			16662206.28	16594490.97	16625745.67	16744593.68	16895295.03	16395652.78	17133457.16	17904462.73	18710163.55
Fuel Expenses ($)											
Oil-based	1919786370	$ 2,006,905,834.91	$ 1,495,203,591.63	$ 1,644,692,142.60	$ 1,650,876,163.91	$ 1,620,130,284.04	$ 1,594,585,898.62	$ 1,783,947,127.14	$ 2,011,963,521.15	$ 2,330,832,069.72	$ 2,577,076,594.67
Natural Gas			$ 69,314,778.14	$ 76,002,768.62	$ 77,309,717.36	$ 83,555,522.48	$ 114,381,147.33	$ 128,705,874.36	$ 157,113,802.15	$ 208,766,035.45	$ 266,058,525.75
Total	$ 1,919,786,369.91	$ 2,006,905,834.91	$ 1,564,518,369.77	$ 1,720,694,911.22	$ 1,728,185,881.27	$ 1,703,685,806.52	$ 1,708,967,045.95	$ 1,912,653,001.49	$ 2,169,077,323.31	$ 2,539,598,105.18	$ 2,843,135,120.42

Purchased Power Cost											
Ecoelectrica - Natural Gas: Cost of Energy ($/kWh)	$ 0.1261	$ 0.1168	$ 0.119	$ 0.121	$ 0.123	$ 0.125	$ 0.127	$ 0.129	$ 0.131	$ 0.134	$ 0.136
AES - Coal: Cost of Energy ($/kWh)	$ 0.0761	$ 0.0819	$ 0.084	$ 0.085	$ 0.087	$ 0.089	$ 0.090	$ 0.092	$ 0.094	$ 0.096	$ 0.098
Ecoelectrica Total Power Purchase Cost ($)	$ 414,989,328.0000	$ 428,501,200.8414	$ 383,387,267.1209	$ 388,320,274.7132	$ 395,665,530.1655	$ 405,268,314.9570	$ 415,867,297.1981	$ 410,429,582.1474	$ 436,190,194.8709	$ 463,567,672.4519	$ 492,663,497.4134
AES Total Power Purchase Cost ($)	$ 256,859,563.0000	$ 265,222,799.1586	$ 273,032,595.8944	$ 277,361,449.3707	$ 283,441,519.4631	$ 291,177,035.5598	$ 299,673,581.4575	$ 296,627,603.2566	$ 316,175,362.3112	$ 337,011,318.6875	$ 359,220,364.5891
Renewable Purchase Overall Cost ($) [From PPA & REC Purchase Module]	$ -	$ -	$ -	$ 77,070,758.24	$ 155,245,127.51	$ 236,025,774.15	$ 317,622,810.85	$ 390,307,279.13	$ 526,134,764.79	$ 658,901,159.11	$ 856,392,238.62

Fuel Consumption Clause [Calculated] ($/kWh)	**0.1165**	**0.1172**	**0.1055**	**0.1101**	**0.1102**	**0.1073**	**0.1060**	**0.1222**	**0.1326**	**0.1486**	**0.1592**
Power Purchase Clause [Calculated] ($/kWh)	**0.0408**	**0.0405**	**0.0442**	**0.0475**	**0.0532**	**0.0587**	**0.0641**	**0.0701**	**0.0782**	**0.0854**	**0.0956**
Average Basic Charge ($/kWh)	**0.0579**	**0.0583**	**0.0588**	**0.0592**	**0.0597**	**0.0602**	**0.0607**	**0.0612**	**0.0616**	**0.0621**	**0.0626**
Average Total Electricity Cost ($/kWh)	**0.2152**	**0.2159**	0.2085	0.2169	0.2230	0.2262	0.2307	0.2535	0.2724	0.2961	0.3175
Average Total Electricity Cost (¢/kWh)	**21.522**	**21.595**	20.848	21.693	22.305	22.616	23.070	25.348	27.244	29.613	31.747

26. Appendix P – EPSEM Results (RPS & EE Case Scenario 3)

Fiscal Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2020**	**2025**	**2030**	**2035**
Total Dispatchable Generation Capacity by fuel (MW)	**5839**	**5839**	**5839**	**5839**	**5934**	**5934**	**5934**	**5332**	**5779**	**5779**	**5779**
Oil	4778	4772	3958	3958	4053	4053	4053	3451	3898	3898	3898
Natural Gas	507	507	1327	1327	1327	1327	1327	1327	1327	1327	1327
Coal	454	454	454	454	454	454	454	454	454	454	454
Hydro	100	100	100	100	100	100	100	100	100	100	100
Renewable (According to RPS Target Levels Module)	3.5	6	0	240	483	734	988	1290	1438	1691	1963
Total Electricity Generation Share by Fuel (Million of kWh)											
Oil	**69.81%**	**70.11%**	**57.4%**	**53.6%**	**49.7%**	**45.7%**	**41.8%**	**35.8%**	**31.4%**	**27.1%**	**22.8%**
Residual No. 6	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*	*87.06%*
Distillate No. 2	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*	*12.94%*
Natural Gas	**14.52%**	**15.55%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**	**25.80%**
PREPA Owned Units	*0.00%*	*0.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*	*10.00%*
Ecolectrica	*14.52%*	*15.55%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*	*15.80%*
Coal	**14.89%**	**13.73%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**	**16.0%**
Existing Hydro	**0.75%**	**0.57%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**	**0.75%**
Renewable Energy (% of Net Generation - Existing Hydro)	**0.02%**	**0.04%**	**0.00%**	**4.50%**	**9.00%**	**13.50%**	**18.00%**	**25.00%**	**30.00%**	**35.00%**	**40.00%**
Total	22656.293	23588.699	20791.304	20706.808	20745.808	20894.108	21082.155	22030.852	23022.240	24058.241	25140.862
Net Total Generation After EE Integration	**22656.293**	**23588.699**	**20426.880**	**20343.865**	**20382.182**	**20527.882**	**20712.633**	**20100.101**	**21004.606**	**21949.813**	**22937.555**
Net Electricity Generation by Generator (millions of kWh)											
PREPA	**15987.225**	**16672.640**	**13931.132**	**13089.633**	**12319.642**	**11596.345**	**10892.277**	**9349.786**	**8859.604**	**8306.372**	**7685.408**
Oil-Fired (Residual, Distillate, Diesel)	*15816.894*	*16538.949*	*11734.874*	*10902.300*	*10128.190*	*9389.227*	*8665.296*	*7188.663*	*6601.230*	*5946.371*	*5219.207*
Natural Gas	*0*	*0.000*	*2042.688*	*2034.387*	*2038.218*	*2052.788*	*2071.263*	*2010.010*	*2100.461*	*2194.981*	*2293.755*
Hydro	*170.331*	*133.691*	*153.570*	*152.946*	*153.234*	*154.330*	*155.718*	*151.113*	*157.914*	*165.020*	*172.446*
EcoElectrica	**3290.55**	**3668.55**	**3227.447**	**3214.331**	**3220.385**	**3243.405**	**3272.596**	**3175.816**	**3318.728**	**3468.071**	**3624.134**
AES	**3373.152**	**3238.311**	**3268.301**	**3255.018**	**3261.149**	**3284.461**	**3314.021**	**3216.016**	**3360.737**	**3511.970**	**3670.009**
Renewable Energy Production	**5.3655**	**9.198**	**0**	**784.884**	**1581.006**	**2403.671**	**3233.739**	**4358.483**	**5465.537**	**6663.401**	**7958.005**
WIND-IPPs	*0*	*0*	*0.0*	*314.0*	*632.4*	*961.5*	*1293.5*	*1743.4*	*2186.2*	*2665.4*	*3183.2*
SOLAR-IPPs	*0*	*0*	*0.0*	*157.0*	*316.2*	*480.7*	*646.7*	*871.7*	*1093.1*	*1332.7*	*1591.6*
WTE-IPPs	*0*	*0*	*0.0*	*117.7*	*237.2*	*360.6*	*485.1*	*653.8*	*819.8*	*999.5*	*1193.7*
Solar -DG	*5.3655*	*9.198*	*0.0*	*172.7*	*347.8*	*528.8*	*711.4*	*958.9*	*1202.4*	*1465.9*	*1750.8*
Small Wind - DG	*0*	*0*	*0.0*	*23.5*	*47.4*	*72.1*	*97.0*	*130.8*	*164.0*	*199.9*	*238.7*
Total	**22656.293**	**23588.699**	**20426.880**	**20343.865**	**20382.182**	**20527.882**	**20712.633**	**20100.101**	**21004.606**	**21949.813**	**22937.555**
System Efficiency (%)											
Month	81.70%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%	87.49%
Past Twelve Month	81.70%	81.60%	81.60%	86.28%	86.49%	86.94%	87.49%	87.49%	87.49%	87.49%	87.49%
Total Electricity Consumption (Million of kWh)											
Reference Total Consumption	18515.775	19234.899	17938.8	17908.7	18036.1	18279.7	18444.2	19274.2	20141.5	21047.9	21995.1
Avg. Reduction Rate (%) from EE Measures [From EE Potential Module]	0.0%	0.0%	1.8%	1.8%	1.8%	1.8%	1.8%	8.8%	8.8%	8.8%	8.8%
Energy Reduction (Million kWh)	0	0	314.425846	313.8982623	316.1312908	320.4010378	323.2846471	1689.162281	1765.174584	1844.60744	1927.614775
Net Electricity Consumption (Million kWh)	18515.775	19234.899	17624.374	17594.802	17719.969	17959.299	18120.933	17585.045	18376.372	19203.309	20067.457
Fuel Price Module											
Oil-based Weighted Average ($/BBL)	76.23	76.55	80.38	94.04	100.22	104.4	109.29	133.83	157.50	187.31	225.53
Residual Fuel No. 6 ($/BBL)							108.78	132.30	155.82	185.47	223.10
Distillate Fuel No. 2 ($/BBL)							112.73	144.14	168.80	199.67	241.84
Natural Gas ($/ million BTU)			4.16	4.58	4.65	4.99	6.77	7.85	9.17	11.66	14.22

PREPA - Power Plant Charasteristics (From Power Plant Module)											
Heat rate (BTU/kWh)											
Oil-Fired Units	9946	10598	10598	10598	10598	10598	10598	10598	10598	10598	10598
Natural Gas fired Units	N/A	N/A	8157	8157	8157	8157	8157	8157	8157	8157	8157
Conversion Factor											
kWh/Barrel	628.05	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85	630.85
BTU/Barrel	6246592	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748	6685748

PREPA - Fuel Expenses Module											
Fuel Consumption (thousands of BBLs)											
Oil Fuel (Thousands of BBLs)	25184.13184	26216.92795	18601.68688	17281.92131	16054.83006	14883.45434	13735.90	11395.20	10464.02	9425.97	8273.29
Natural Gas (Miillion BTUs)			16662206.28	16594490.97	16625745.67	16744593.68	16895295.03	16395652.78	17133457.16	17904462.73	18710163.55
Fuel Expenses ($)											
Oil-based	1919786370	$ 2,006,905,834.91	$ 1,495,203,591.63	$ 1,625,191,879.78	$ 1,609,015,068.43	$ 1,553,832,632.90	$ 1,501,214,670.28	$ 1,525,048,924.02	$ 1,648,085,034.31	$ 1,765,559,118.13	$ 1,865,839,983.54
Natural Gas			$ 69,314,778.14	$ 76,002,768.62	$ 77,309,717.36	$ 83,555,522.48	$ 114,381,147.33	$ 128,705,874.36	$ 157,113,802.15	$ 208,766,035.45	$ 266,058,525.75
Total	$ 1,919,786,369.91	$ 2,006,905,834.91	$ 1,564,518,369.77	$ 1,701,194,648.40	$ 1,686,324,785.79	$ 1,637,388,155.38	$ 1,615,595,817.61	$ 1,653,754,798.37	$ 1,805,198,836.47	$ 1,974,325,153.58	$ 2,131,898,509.28

Purchased Power Cost											
Ecoelectrica - Natural Gas: Cost of Energy ($/kWh)	$ 0.1261	$ 0.1168	$ 0.119	$ 0.121	$ 0.123	$ 0.125	$ 0.127	$ 0.129	$ 0.131	$ 0.134	$ 0.136
AES - Coal: Cost of Energy ($/kWh)	$ 0.0761	$ 0.0819	$ 0.084	$ 0.085	$ 0.087	$ 0.089	$ 0.090	$ 0.092	$ 0.094	$ 0.096	$ 0.098
Ecoelectrica Total Power Purchase Cost ($)	$ 414,989,328.0000	$ 428,501,200.8414	$ 383,387,267.1209	$ 388,320,274.7132	$ 395,665,530.1655	$ 405,268,314.9570	$ 415,867,297.1981	$ 410,429,582.1474	$ 436,190,194.8709	$ 463,567,672.4519	$ 492,663,497.4134
AES Total Power Purchase Cost ($)	$ 256,859,563.0000	$ 265,222,799.1586	$ 273,032,595.8944	$ 277,361,449.3707	$ 283,441,519.4631	$ 291,177,035.5598	$ 299,673,581.4575	$ 296,627,603.2566	$ 316,175,362.3112	$ 337,011,318.6875	$ 359,220,364.5891
Renewable Purchase Overall Cost ($) [From PPA & REC Purchase Module]	$ -	$ -	$ -	$ 92,484,909.89	$ 186,294,153.01	$ 283,230,928.98	$ 381,147,373.02	$ 549,228,216.54	$ 720,153,226.21	$ 915,129,537.60	$ 1,142,526,416.24

Fuel Consumption Clause [Calculated] ($/kWh)	**0.1165**	**0.1172**	**0.1055**	**0.1089**	**0.1075**	**0.1031**	**0.1002**	**0.1057**	**0.1104**	**0.1155**	**0.1194**
Power Purchase Clause [Calculated] ($/kWh)	**0.0408**	**0.0405**	**0.0442**	**0.0485**	**0.0552**	**0.0617**	**0.0680**	**0.0803**	**0.0900**	**0.1004**	**0.1117**
Average Basic Charge ($/kWh)	**0.0579**	**0.0583**	**0.0588**	**0.0592**	**0.0597**	**0.0602**	**0.0607**	**0.0612**	**0.0616**	**0.0621**	**0.0626**
Average Total Electricity Cost ($/kWh)	**0.2152**	**0.2159**	0.2085	0.2167	0.2224	0.2250	0.2288	0.2471	0.2621	0.2780	0.2937
Average Total Electricity Cost (¢/kWh)	**21.522**	**21.595**	20.848	21.667	22.236	22.495	22.885	24.709	26.206	27.804	29.367