DEVELOPMENT OF COST – EFFECTIVENESS TEST FOR ENERGY EFFICIENCY IN THE BUILDING CONSTRUCTION INDUSTRY

By

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Abstract

This document presents the methodology to evaluate cost effectiveness of energy efficiency measures for Puerto Rico, using to the cost effectiveness tests suggested in the document National Action Plan for Energy Efficiency Vision for 202 that is sponsored by the US Department of Energy that intends to promote energy efficiency as a resource to reduce electricity consumption in the USA, including Puerto Rico. A literature review in energy efficiency legislation and incentives for USA and Puerto Rico was performed. Current legislation on energy efficiency was analyzed to determine the Puerto Rico situation in this matter. Technical and economic data was used to select the residential sector as the target group to be evaluated, and a portfolio of energy efficiency initiatives was considered. This portfolio had to fulfill a requirement of decreasing 1% of the electricity consume by the residential sector, per year, from 2013 to 2025. Implementation costs and potential benefits were determinate based on data collected from the local market, USA and Puerto Rico financial and government institutions, including a study on the potentials for energy efficiency for Puerto Rico. Decreasing ratios were selected according to Vision 2025 document suggestions of benefits and costs, then calculating the present value to sustain the cost effectiveness tests. The results showed that the suggested energy efficiency initiatives portfolio can reach the goal of reducing 1% per year of the consumed electricity in the residential sector, but only if the right legislation is created to include energy efficiency as a resource to reduce energy costs.

Resumen

Este documento presenta la metodología para evaluar el costo – efectividad de medidas de eficiencia energética para Puerto Rico, utilizando las pruebas de costo efectividad propuestas en los documentos del Plan Nacional de Acción para la Eficiencia Energética Vision 2025, el cual es patrocinado por el Departamento de Energía de EE.UU. Dicho Plan tiene la finalidad de promover la eficiencia energética como un recurso para reducir el consumo de electricidad en los EE.UU., incluyendo Puerto Rico. Se llevó a cabo una revisión de literaria de las leyes sobre eficiencia energética e incentivos para EE.UU. y Puerto Rico. Se analizó la legislación actual sobre eficiencia energética, para determinar la situación de Puerto Rico en esta materia. Utilizando datos técnicos y económicos, se seleccionó el Sector Residencial, como el grupo objetivo a evaluar, además de una cartera de iniciativas de eficiencia energética. Esta cartera en conjunto, tenía que cumplir con el requisito de disminuir en 1% por año, el consumo de electricidad en el sector residencial, desde el año 2013 hasta el 2025. Los costos de implementación y los beneficios potenciales fueron determinados sobre la base de la información recopilada en el mercado local, en instituciones financieras y gubernamentales de EE.UU. y Puerto Rico, incluyendo además el Estudio sobre el Potencial de Eficiencia Energética para Puerto Rico. Tasas de descuento fueron seleccionadas de acuerdo a las sugerencias de los documentos de costo – beneficio de Visión 2025, y con esto se calculó el valor presente de las cifras de los factores involucrados en las pruebas de costo - efectividad. Los resultados mostraron que la cartera de medidas de eficiencia energética propuesta, puede alcanzar el objetivo de reducir 1% anual de la electricidad consumida en el sector residencial, pero sólo si la correcta

legislación es creada, para incluir la eficiencia energética, como un recurso para reducir los costos asociados a la energía

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1. Introduction

1.1 Justification

Energy efficiency (EE) technologies and programs have been around for decades. Its first official mention was on the 1975 Conservation Energy Policy Act to be part of the solution to reach fuel independency, but no initiative was issued in that opportunity. Puerto Rico has address tax credits to incentive people, industries and business to adopt energy efficient technology but there is not a research if anyone has taken advantage of these initiatives and neither its impact in Puerto Rico electricity consume.

At the end of 2010 a joint venture between Puerto Rico Energy Power Authority (PREPA) and University of Puerto Rico was signed to develop for the first time energy efficiency public policy in the Island: “The Integrated Process to stimulate Energy Efficiency Action in Puerto Rico”. The goal of this initiative is to achieve an annual minimum target electricity savings of 1 percent through energy efficiency. “The proposal presented is a prime opportunity to set new targets in the field of energy efficiency where saving targets have not been incorporated yet into formal public policy and responds to the ten goals presented in the National Action Plan for Energy Efficiency Vision 2025 with a manageable and feasible process to accomplish energy efficiency that integrates the goals and needs of the local utility as well as all the stakeholders of the industry” (32).

Commercial and residential buildings are widely accepted to account for about 40% of the world's energy consumption and a similar level of global CO2 emissions. Figure 1 (37) represents the cost of 1 ton reduction in CO2 by different kinds of measures; notice solutions concerning buildings have negative costs in utilization phase.

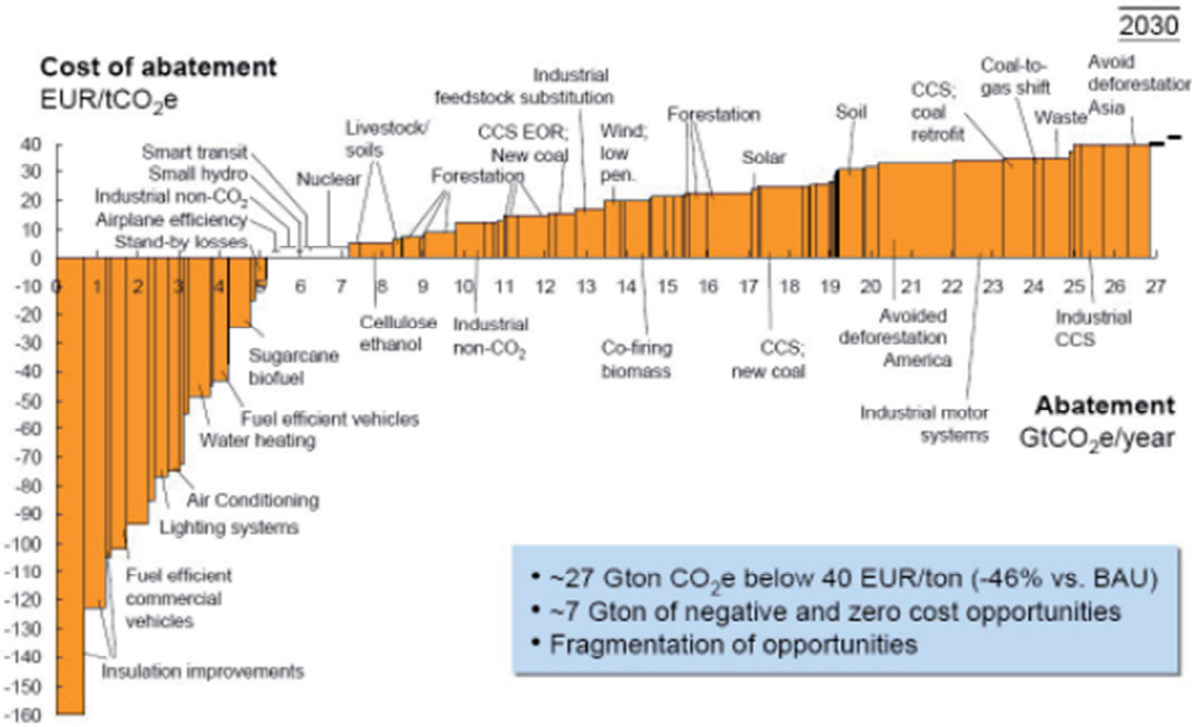

Figure 1: Reduction in CO2 by different measures (29)

There is a huge potential for energy efficiency measures to save resources, especially those referred to the construction industry (37), but those kind of measures are not the most popular because they require a great amount of studies, effort and resources, they are also difficult to implement because of the lack of interest in making changes in construction industry and the results can only be appreciated in the medium and large term. Puerto Rico energy laws since 2004 mention tax incentives for energy efficiency equipment purchases for common citizens, commerce or industry but not initiatives or founds are addressed.

PREPA (Puerto Rico Electric Power Authority) have not conducted studies to develop neither energy efficiency public policies nor its tools to measure potential of energy efficiency initiatives, something that has to be developed or adopted from states that have used them, but considering Puerto Rico's unique characteristics (social, political, economic, geographic, etc). In the framework of "The Integrated Process to stimulate Energy Efficiency Action in Puerto Rico", the intention of the project is, to develop a calculating tool that would permit measure cost-effectiveness when energy efficiency initiatives are implemented following the directives mentioned by documents of the National Action Plan for Energy Efficiency – Vision 2025.

1.2 Theoretical Background

Improving energy efficiency in every user sector, residential, commerce, institutional, and industrial, is one of the most constructive, cost-effective ways to address the challenges of high energy prices, energy security and energy independence, greenhouse gas (GHG) emission, and global warming. Despite these benefits and the potential success of energy efficiency programs, energy efficiency remains critically as a policy tool used not in its full potential.

It has to be recognized that energy is essential: "The availability of energy and fuel is essential for the development and sustainment of modern economies" (39). Its importance lies in the shelter of the people, its daily life and the performance of social and economic systems. The fact, that the main sources of energy in Puerto Rico (PR) are imported and they are not renewable.

Figure 2 shows the variable cost of crude oil in the last years; this brings the issue of dependency on expensive imported fuels, a problem because electricity in Puerto Rico depends on oil (more expensive oil, more expensive electricity). With oil prices constantly rising, renewable energy such as solar and wind are being looked at as the alternative power generation sources, but these new sources of renewable energy have high implementation costs in terms of research and development, involving technology and infrastructure required, which must be massive to make up the characteristics of nearly 4 million people: PREPA's Ex-Executive Director Hector Rosario stated (31) "Nobody has yet proposed a renewable, alternative project that complies with the concept of avoided cost (a technical term that refers to the price of electricity sold to PREPA at or below the authority's cost to produce the same electricity). It makes no sense for PREPA to pay more than it would cost to produce it" (this refers to the production cost where is also charged new infrastructure costs).

In 2010, the KWH (Kilo Watt Hour) cost was 21 cents for final users (59), energy that was mainly generated with petroleum fuels. At the same time in USA the KW price was 10 cents (coal based electricity generation). It is expected in USA by 2016 (Table 1) that electricity generation based on natural gas will be the cheapest (66.1 – 103.5 $/MWH); coal still will have an important place because of its relevance in the US electricity generation industry ($94.8 /MWH – $109.4 /MWH), while renewable sources will vary from $97 /MWH to $243.2 /MWH. Renewable sources as wind and biomass could turn into competitive to conventional sources, but while the capital costs are compared: coal $65.3 /MWH to $92.7 /MWH, gas $17.5 /MWH to $45.8 /MWH, renewable $83.9 /MWH to $259.4 /MWH, there is a difference from 79.1% to 82.3% between gas and renewable, this

means that final prices for the consumer could be cheaper with some renewable energy sources as wind or biomass, but initial costs to build new infrastructure would be much higher than a conventional.

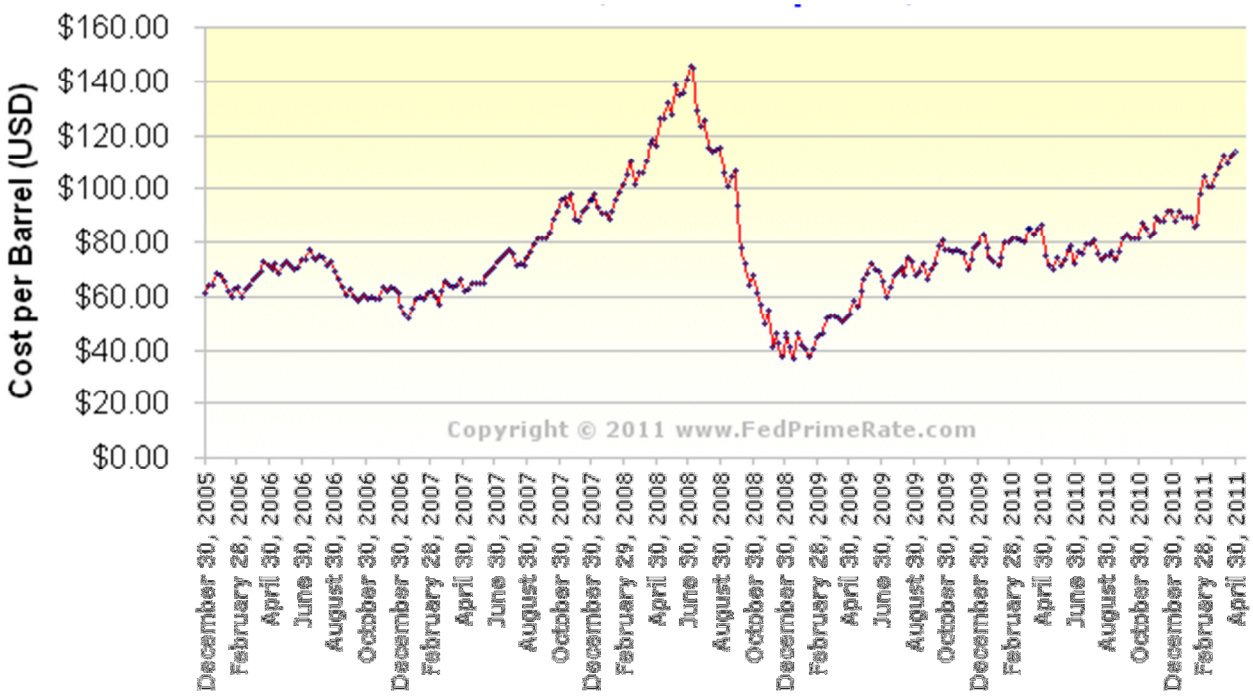

Figure 2: Crude Oil Price History Chart (55)

How cost-effectiveness is defined substantially affects how much of a region efficiency potential will be accessed and whether consumers will benefit from the lower energy costs and environmental impacts that would result. How to define cost-effectiveness or which test to use, are decisions largely made by state utility commissions and their utilities, and with critical input from consumers and other stakeholders.

Table 1: Estimated Leveled Costs of New Generation Resources, 2016 - US Department of Energy (49).

Plant Type	Capacity Factor (%)	U.S. Average Levelized Costs (2009 $/megawatthour) for Plants Entering Service in 2016				
		Levelized Capital Cost	Fixed O&M	Variable O&M (including fuel)	Transmission Investment	Total System Levelized Cost
Conventional Coal	85	65.3	3.9	24.3	1.2	94.8
Advanced Coal	85	74.6	7.9	25.7	1.2	109.4
Advanced Coal with CCS	85	92.7	9.2	33.1	1.2	136.2
Natural Gas-fired						
Conventional Combined Cycle	87	17.5	1.9	45.6	1.2	66.1
Advanced Combined Cycle	87	17.9	1.9	42.1	1.2	63.1
Advanced CC with CCS	87	34.6	3.9	49.6	1.2	89.3
Conventional Combustion Turbine	30	45.8	3.7	71.5	3.5	124.5
Advanced Combustion Turbine	30	31.6	5.5	62.9	3.5	103.5
Advanced Nuclear	90	90.1	11.1	11.7	1.0	113.9
Wind	34	83.9	9.6	0.0	3.5	97.0
Wind – Offshore	34	209.3	28.1	0.0	5.9	243.2
Solar PV[1]	25	194.6	12.1	0.0	4.0	210.7
Solar Thermal	18	259.4	46.6	0.0	5.8	311.8
Geothermal	92	79.3	11.9	9.5	1.0	101.7
Biomass	83	55.3	13.7	42.3	1.3	112.5
Hydro	52	74.5	3.8	6.3	1.9	86.4

NOTE:

Total System Levelized Cost gives $/MWH (Mega Watt - hour) that must be charged over time in order to pay for the total cost

O&M = operation and maintenance / CC = combined cycle / CCS = carbon capture and sequestration / PV = photovoltaic.

1.3 Energy Efficiency Definition

There are still discussions about the meaning of Energy Efficiency (also called Efficient Energy Use). The EIA summarizes it with an example (52):

"Take the Stairs - Be More Energy Efficient"

Person A interprets the sign as the "true" definition of energy efficiency. To Person A, the elevator is not being used. He is still getting to where he wants to go and using less energy in doing so.

Person B considers the fact that she is not getting to where she is going with the same ease. She does not believe that she is being energy efficient, but instead she believes that she is "conserving energy" at a reduced level of service, she has to walk instead of ride.

When it comes to trying to define "to be energy efficient" or "energy efficiency", there does not seem to be a single commonly - accepted definition of energy efficiency. Along the lines of Person B's thinking, it is generally thought that an increase in energy efficiency is when either energy inputs are reduced for a given level of service, or there are increased or enhanced services for a given amount of energy inputs.

But, what is certain is that EE is not energy conservation. Energy conservation is reducing or going without a service to save energy. For example: turning off a light is energy conservation. Replacing an incandescent lamp with a compact fluorescent lamp (which uses much less energy to produce the same amount of light) is energy efficiency.

The target of this document is not to define the EE true meaning. But according to the characteristics of the reviewed EE policies in USA, this document accomplished with the Lawrence Berkeley National Laboratory (LBNL) definition:

Energy efficiency is "using less energy to provide the same service".

Not a definition, but a consideration: “Efficiency improvements have been characterized in terms of their cost of conserved energy ($/kWh), for convenient comparison with the cost of competing electricity generating technologies.” (25)

For the purpose of this document, the interpretation is:

> “To reduce the amount of electricity used in a specific purpose, using the technology, procedures, systems and techniques that spend comparatively less energy but provide the same service or results, considering an investment to be recovered through energy savings.”

1.4 Developing Energy Efficiency Public Policy

Before try implementing energy efficiency policies, there are four targets to address main barriers in the implementation of energy efficiency policies (14):

- **Leadership on energy efficiency is necessary at each level of government.**

Policies initiated at state and local levels, within diverse political and economic contexts, can inform how similar policies can be employed and scaled-up in other places and jurisdictions. California, for example, has repeatedly designed efficiency programs that have served as models. Federal Government leadership is also important, not only for the benefit of consumers and manufacturers, but also to provide the impetus for the country as a whole to realize its energy efficiency potential.

- **There is no widely accepted methodology for evaluating energy efficiency policies.**

Measuring policy impact is critical for evaluating the effectiveness of policies at all levels of government. But such measurement is difficult due to the overlapping nature of policy implementation, the lack of coordination of intended impacts, and the challenge of calculating and attributing whether actual energy savings result from a particular policy. This will be discussed.

- **Coordination among the three levels of government, and across sectors, is increasingly important, and there are opportunities to significantly improve policy performance through a unified strategy.**

There is currently no comprehensive policy strategy for energy efficiency in the US Policies. They are conceived within narrow political constraints based on some specific

need, and without a thorough consideration of the policies interaction with other policies. A strategic approach to improving energy efficiency in the US would be to coordinate efforts across jurisdictions and sectors, as occurred under the National Action Plan for Energy Efficiency.

- **There are efficiencies to be gained by informing policies in one sector with experience from others.**

In each sector, similar energy policy tools are employed, but the relative use of each tool within overall policy varies significantly by sector. These differences reflect a number of factors, including the relative strengths of governing jurisdictions, political expediency, and technological and economic limitations. A more effective policy approach would find ways to move beyond these established constraints toward a comprehensive assessment of energy efficiency barriers and the policies needed to address them.

> "The benefits of energy efficiency are manifold — lower energy bills, improves air quality, reduces greenhouse gases, increases energy security, and a defers need to invest in new infrastructure. Numerous studies document the prevalence of economically attractive, energy - saving opportunities that have yet to be widely adopted. The failure to implement these opportunities indicates persistent market and other barriers to efficiency. Government policies should be designed to target these barriers and enable the benefits of energy efficiency to be realized." (15)

There is a wide variety of energy policies applied along US, but little quantitative evidence of success of them. Quantification has always been difficult and most since there are situations where there is a bunch of initiatives applied by more than one institution in the same region. With federal initiatives to restructure electricity industry since 80's, states have had freedom to experiment the way that they believe better suits them in matter of administrative structures to manage energy efficiency programs, and its incentives chain. Although there are many experiences in US, "no single administrative structure for energy efficiency programs has yet emerged that is clearly superior to all of the other alternatives. And, in our view, this is not likely to happen: first, policy environments differ significantly among the states. Second, the structure and regulation of the electric utility industry differs among the regions of the US. (8)"

1.4.1 Energy Efficiency Strategies in US: Resource Acquisition and Market Transformation

In 1992 the Energy Policy Act (EPACT) was issued. This Act encouraged utilities to conduct the Integrated Resource Planning (also known as Least-Cost Planning). Under this Act, the main energy efficiency program is one in which a utility's customers were provided with technical assistance, information, and financial incentives to purchase or invest in energy-efficient building materials, equipment or appliances. Such programs were commonly referred to as "resource acquisition" programs; they were expected to meet the demand for energy services at a cost that was lower than the cost of acquiring generation resources. In this program framework, energy savings and benefits were directly attributable to the program can be easily quantified, so success grade can be determined.

But EPACT purpose was also to restructure electricity industry in US in the belief that formal resource planning processes that authorized or approved acquisition of supply -and demand- side resources by state-regulated utilities would not be necessary because market outcomes would be better than the outcomes from plans developed by utilities and regulators (8). In 1993-94 peaked $1.7 billion, but expenditures in energy efficiency programs began a steep decline when California Public Utilities Commission (PUC) announced the restructuration of California's electricity industry. "Resource acquisition" programs were decreased or eliminated in some states although the reasons of energy efficiency programs were still there. So a new kind of strategy emerged: "market transformation". The main idea of this strategy is to make lasting changes in the market for energy consuming good and services (7).

While "resource acquisition" intends to obtain savings through individual consumer behalf by subsidizing energy efficiency measures; "market transformation" tries to reach any initiative that would last onto stakeholders (sellers, retailers, consumers, industries) behavior. Examples are: encourage retailers, distributors, contractors, and builders to change their business model to promote energy efficiency. Other targets have targeted education and training efforts at key consumers. Government also plays a main role in these initiatives creating energy efficiency standards for new buildings and by influencing the market through purchasing energy efficiency equipment.

In this text clearly says the two strategies are cleared separated and they are not mutually exclusive, distinction between them make easier the policymakers work. When they are

applied quantification of their results are very complicated, especially when there haven't been previous coordination between them.

1.4.2 Choosing Energy Efficiency Policies

Table 2 shows a list of 37 energy efficiency and renewable energy initiatives (50) implemented in US.

These initiatives have been implemented along US, and although some of them have been used during a long time, not of them have had so much success to be considered on the top of all of them, while those who involucrate economic incentives are the most popular to be implemented by local governments, because they are also the simplest. The others who need a deeper approach and try to influence the markets are not so popular, but also carry a huge potential to be exanimate. Perhaps the biggest issue is to find a total certain way to quantify their results, while anyone could think those are positive.

Quantification of benefits from the implementation of energy efficiency policies is a complex process. Stakeholders have a variety of different drivers, specific geographic resources, and needs resulting in a large number of variables. State policymakers and implementers are faced with a wide variety of energy policy choices and little quantitative evidence of policy success, especially as they are applied to the states' specific economic, baseline energy, governance, and resource situations.

Table 2: Energy Efficiency and Renewable Initiatives List (50)

1. Renewable Portfolio Standards
2. Renewable Fuels Standards
3. Energy Efficiency Resource Standards
4. Decoupling/Lost Revenues/Incentives
5. EE Tax Incentives: Personal
6. EE Tax Incentives: Corporate
7. EE Tax Incentives: Sales
8. EE Tax Incentives: Property
9. Tax Incentives: Corporate Electric
10. Tax Incentives: Corporate Auto alt fuels
11. Renewable Products Grants and rebates
12. EE Rebates
13. EE Grants
14. EE Loans
15. EE Pay As You Save
16. EE QAP Allocations for Efficiency
17. EE Bonds
18. Administration of EE Programs
19. Green Building Incentives
20. RE Tax Incentives: Personal DG/Net Metering, Property Tax Exemptions, Easements, Sales Tax Exemptions
21. RE/Alt Fuels Tax Incentives: Personal Auto
22. Demand Response Programs
23. Feed in tariffs
24. Nontraditional Rate Structures: TOU (EE and RE)
25. Nontraditional Rate Structures: Inverted Block (EE and RE)
26. EE Public Benefit Funds
27. PBF Renewable Related Policies
28. Consumer Information/Education
29. Building Codes
30. Appliance Standards
31. Performance Contracting
32. Standards for Public Buildings
33. Renewable Project Contracting and Financing
34. Transmission Policies
35. Industry Recruitment incentives
36. Loans
37. Standardized Permitting for Renewable

Figure 3, was developed by the National Renewable Energy Laboratory (NREL) in a framework of evaluation to choose an energy efficiency policy, the process developed involves participation of those who would benefit from that policy. The picture shows a

very simple process with 4 stages that should put together procedures to be chosen by those technicians who are in charge on determining the best alternative to meet the need.

Figure 3: Conceptual policy decision - making process (58)

This public process should facilitate an open dialogue between the project implementers and the stakeholders. This dialogue is intended to promote the most useful outcomes of the project and bring together the wealth of dispersed knowledge on policy impacts (7). The framework intends to meet a wide variety of work in an accessible way to policymakers, so coordination of the status of the evaluation work is important to success.

1.4.3 Energy Efficiency Policy Drivers

A driver can be a major issue for the stakeholders, and not necessarily be, at single sight, fully related to the policies developed to meet it. Some drivers could be: reducing GHG

emissions cut foreign oil dependency, increase investment in green research, strong commitment of a government with sustainable development, etc.; and unless other interests are involved, the correct process to choose a policy goes first in the identification for the driver, this is the policy motivation. This step is crucial and that is why the process involves the stakeholders since the beginning, to identify them at first. The resulting drivers from the debate should be general enough to cover a wide variety of state needs. They can be categorized in groups, so it can be easier for to choose a policy.

A driver doesn't have a measure itself, but from each of the primary drivers, metrics are developed for the purpose of comparing policies on impact (7). These metrics are general and provide guidelines for policy analysis that apply to energy efficiency policies in both the electric and fuels sectors. The metrics are intended to pull from the successes of policy types in any region and estimate their applicability within other regions and they are not static, because they evolve throughout any stage of the study.

Some authors considers economic development, environment and energy security as the key policies drivers for energy efficiency, that transcends jurisdictional level but may vary in their manifestations, as they can be seen in the Table 3. Also it is showed that "at each jurisdictional level there is an inherent tension between leveraging investment and tailoring policy — a trade-off that helps to shape each jurisdiction's approach to policy design" (14). In the considerations of this table for example, the three levels of government work to improve air quality, but they met this concern in different ways. Also, energy security is a goal at each jurisdictional level, but the federal government points its attention on vehicle efficiency while local governments promote fuel diversity. Brown and Mosley (7), consider

the topics mentioned before, driver categorizations in order to make easier the selection of a policy for a decision maker. Categorization can follow these parameters (See Table 3):

Economic Development - State policymakers and implementers have an interest in promoting new industries and job creation within the state and making a positive impact on state revenues.

Environmental - State policymakers and implementers have an interest in protecting and improving local air quality by decreasing the release of air pollutants, including carbon and carbon equivalent greenhouse gas emissions (GHG).

Energy Security/Fuel Diversity - Reducing dependence on foreign fuels and increasing self-sufficiency are priority goals for many states, both as a way of increasing the local economy and stabilizing energy prices.

What is important to remark is that there should be a consonance among policy goals at all government levels, with each jurisdiction having in mind its operations on its own unique geographical scope. “Understanding how the policies interact and can contribute to a comprehensive efficiency policy is critical to developing a plan to reduce energy consumption.” (15)

For the purpose of this document, economic development, environmental and energy security will be considered as categorizations and not drivers themselves.

Table 3: Prominent Jurisdictional Drivers (Doris et al; 2009)

Jurisdiction	Drivers	Ability to leverage investment	Ability to tailor policy
Federal	**Economic Development** • Support broad economic growth **Environmental Protection** • Protect public health • Reduce carbon emissions **Energy Security** • Reduce dependence on oil • Maintain reliability of grid infrastructure	High	Low
State	**Economic Development** • Attract jobs and industry • Improve power-supply reliability • Reduce need for large-scale capital investments in power supply • Reduce consumer energy bills **Environmental Protection** • Improve regional air quality • Reduce carbon emissions **Energy Security** • Fuel diversity (electric and transport) • Price stability	Medium	Medium
Local	**Economic Development** • Foster local economic development • Reduce traffic **Environmental Protection** • Improve local air quality **Energy Security** • Fuel diversity (electric and transport)	Low	High

1.5 Federal Energy Efficiency Acts and Programs

This section shows an energy efficiency policy documents that historically have been applied in USA. The programs created to fulfill the USA legislation have not beneficiated Puerto Rico because the Island did not fulfill the requirements to be considerate a “State”. The Energy Independence and Security Act of 2007 amended the mentioned definition to include the Commonwealth of Puerto Rico and the other territories and possessions of the United States.

The Weatherization Assistant Program mentioned in the subsection K, is discussed in a deeper way in the section 2.5 of this document.

A. 1975 Conservation Energy Policy Act

In the 70’s, oil crisis in USA make the Federal Government issued the 1975 Conservation Energy Policy Act (EPCA), which authorized three primary programs:

The United States involvement in the International Energy Agency (IEA)

The Strategic Petroleum Reserve (SPR)

… and all efforts to "reduce vulnerability through several energy efficiency, renewable energy, and conservation programs." (19)

This was the first time that energy efficiency was mentioned as part of a solution of the fuel independence problem, but no programs were issued at that time that would lead with it.

B. 1978 National Energy Conservation Policy Act

In the 1978 a new EPCA was issued to amend the 1975 Act. The Section 8251 mentions:

The Congress finds that:

1. The Federal Government is the largest single energy consumer in the Nation;

2. The cost of meeting the Federal Government's energy requirement is substantial;

3. There are significant opportunities in the Federal Government to conserve and make more efficient use of energy through improved operations and maintenance, the use of new energy efficient technologies, and the application and achievement of energy efficient design and construction;

4. Federal energy conservation measures can be financed at little or no cost to the Federal Government by using private investment capital made available through contracts authorized by subchapter VII of this chapter; and

5. An increase in energy efficiency by the Federal Government would benefit the Nation by reducing the cost of government, reducing national dependence on

foreign energy resources, and demonstrating the benefits of greater energy efficiency to the Nation.

Also the 1978 EPCA directed the United States Department of Energy (DOE) to set Minimum Energy Performance Standards (MEPS) to replace those set by the Energy Policy and Conservation Act (EPCA) in 1975. The amendment to the EPCA changed the energy standards from voluntary to mandatory, and these new federal standards preempted those established by state authorities. The DOE was also charged with establishing procedures for the submission, approval, implementation, and monitoring of residential energy conservation plans by state utility regulatory authorities (25).

The Act required federal agencies to perform energy surveys in order to reduce consumption of nonrenewable energy resources in buildings, vehicles, equipment, and general operation. It enabled the government to give loans to families for the purchase and installation of solar heating or cooling equipment. It also created a program to allocate grants to schools, hospitals, local government facilities, and public housing developments willing to use energy conservation techniques. Congress allocated US$100,000,000 in fiscal year 1978 for such programs. The Energy Policy Act of 1992 later amended this Act.

C. 1992 Energy Policy Act

The Department of Energy (DOE) through its Energy Efficiency and Renewable Energy Web mentions: the Energy Policy Act of 1992 (53) amended the National Energy Conservation Policy Act (NECPA) and established several energy management goals.

1. Federal Energy Efficiency Fund

Section 152 of EPAct 1992 amends Section 546 of NECPA, establishing the Federal Energy Efficiency Fund to provide agencies grants to assist them in meeting the mandated energy efficiency and water conservation requirements. The limited spending authority available in fiscal years 1994 and 1995 was applied to proposals that were most competitive, considering the following five factors:

- The cost-effectiveness of the project (saving-to-investment ratio)
- The net dollar cost savings to the Federal Government
- The amount of energy savings to the Federal Government
- The amount of funding committed by the agency requesting financial assistance
- The amount of funding leveraged from non-Federal sources

No spending authority has been provided beyond fiscal year 1995. A total of 114 proposals were received during fiscal years 1994 and 1995, and fund grants were provided for 37 projects. Of these, 35 projects provided energy savings of 5.8 trillion Btu and two projects resulted in water conservation of 738 million cubic feet, resulting in an estimated energy and water cost savings of $54 million (before payback of the initial investment) over the useful lives of the projects. The total Federal Energy Efficiency Fund investment to realize

these savings was $7.9 million, which leveraged $3.6 million in Federal agency funding and $900,000 million in non-Federal funding. The projects encompassed 14 states and the District of Columbia with one project located in the Caribbean.

2. Utility Incentive Programs

Section 152 of EPAct 1992 amends Sections 542 to 550 of NECPA. Section 546, part (c), provides specific information as it relates to utility incentive programs. The five key elements of this section were (subsequent policies have since updated some of these items):

Agencies are authorized and encouraged to participate in programs to increase energy efficiency and for water conservation or the management of electricity demand conducted by gas, water, or electric utilities and generally available to customers of such utilities.

Each agency may accept any financial incentive, goods, or services generally available from any such utility, to increase energy efficiency or to conserve water or manage electricity demand.

Each agency is encouraged to enter into negotiations with electric, water, and gas utilities to design cost-effective demand management and conservation incentive programs to address the unique needs of facilities utilized by such agency.

If an agency satisfies the criteria which generally apply to other customers of a utility incentive program, such agency may not be denied collection of rebates or other incentives.

An amount equal to fifty percent of the energy and water cost savings realized by an agency, other than the Department of Defense, with respect to funds appropriated for any fiscal year beginning after fiscal year 1992 (including financial benefits resulting from energy savings performance contracts under title VIII and utility energy efficiency rebates) shall, subject to appropriation, remain available for expenditure by such agency for additional energy efficiency measures which may include related employee incentive programs, particularly at those facilities at which energy savings were achieved.

3. Financial Incentive Program

EPAct 1992 instructed the Secretary, in consultation with the Interagency Energy Management Task Force (IATF), to establish a financial bonus program to reward outstanding Federal agency facility energy managers. EPAct authorized appropriations to carry out these financial incentives at no more than $250,000 (cumulative) for fiscal years 1993, 1994, and 1995. These incentives were distributed in conjunction with the Department of Energy (DOE) awards program.

D. 2005 Energy Policy Act

1. Metering and Reporting

Section 103 includes the following requirements surrounding energy use measurement and accounting:

- Directs that all Federal buildings be metered "...for the purposes of efficient energy use and reduction in the cost of electricity used in such buildings..." by October 1, 2012. Advanced meters or metering devices must provide data at least daily and measure the consumption of electricity at least hourly. These devices must be used to the maximum extent practicable.

- Directs the Secretary of Energy to develop guidelines for implementation. The Guidance for Electric Metering in Federal Buildings was published on February 3, 2006.

- Requires Federal agencies to submit to the Department of Energy (DOE) an implementation plan identifying personnel responsible for achieving the requirements, and any determination by the agency that advanced meters or metering systems are not practicable in their specific situation.

2. Energy-Efficient Product Procurement

Section 104 requires that each agency incorporate energy efficiency criteria consistent with ENERGY STAR and FEMP - designated products for "...all procurements involving energy consuming products and systems, including guides specifications, project specifications, and construction, renovation, and services contracts that include provision of energy consuming products and systems, and into the factors for the evaluation of offers received for the procurement."

3. Voluntary Commitments to Reduce Industrial Energy Intensity

Section 106 requires the Secretary of Energy may enter into voluntary agreements with one or more persons in industrial sectors that consume significant quantities of primary energy for each unit of physical output to reduce the energy intensity of the production activities of the persons. The goal of this initiative is the reduction of energy intensity by not less than 2.5 percent each year during the period of calendar years 2007 through 2016. To accomplish this The Secretary, in cooperation with other appropriate Federal agencies, shall develop mechanisms to recognize and publicize the achievements of participants in voluntary agreements under this section. Who enters into this agreement shall be eligible to receive a grant or technical assistance.

E. 2007 Energy Independence and Security Act

The Energy Independence and Security Act of 2007 (52) established energy management goals and requirements while also amending portions of the National Energy Conservation Policy Act (NECPA). It was signed into law on December 19, 2007.

According to the US Energy Information Administration, the Annual Energy Outlook 2008 (1) addresses only those provisions in EISA2007 that establish specific tax credits, incentives, or standards, including the following:

- Appliance energy efficiency standards for boilers, dehumidifiers, dishwashers, clothes washers, external power supplies, and commercial walk-in coolers and freezers.

- Lighting energy efficiency standards for general service incandescent lighting in 2012 and sooner for general-service tubular fluorescent lighting and metal halide lamp fixtures.

- Standards for industrial electric motor efficiency, requiring industrial motors of various sizes to meet the National Electric Manufacturers Association (NEMA) premium motor efficiency standards.

- Standards for energy use in Federal buildings, requiring a 30-percent reduction by 2015.

F. 2008 Emergency Economic Stabilization Act

On October 3rd, 2008 the law H.R. 1424, the Emergency Economic Stabilization Act of 2008 was signed, which contains new and renewed tax incentives for consumers and businesses for energy-efficient homes and commercial buildings, equipment, and vehicles. The incentives originally enacted as part of the Energy Policy Act of 2005 encourage highly efficient commercial buildings, new homes, home improvements, heating and cooling equipment, appliances, and hybrid and diesel vehicles. The new law adds incentives for combined heat and power, electric and plug-in hybrid vehicles, truck idling

reduction, bicycling, and smart meters and smart grid. These incentives are designed to speed the introduction of energy-efficient technologies into the marketplace, to help niche products with new, efficient technologies to overcome steep market barriers and move into the mainstream, enabling them to better flourish in the market when the tax incentives end. (29)

1. Energy Tax Incentives: 303 Extension of Energy-Efficient Buildings Deduction

Current law allows taxpayers to deduct the cost of energy-efficient property installed in commercial buildings. The amount deductible is up to $1.80 per square foot of building floor area for buildings achieving a 50% energy savings target. The energy savings must be accomplished through energy and power cost reductions for the building's heating, cooling, ventilation, hot water, and interior lighting systems. This bill extends the energy efficient commercial buildings deduction through December 31, 2013 (5 Years) by amending Section 179D.

G. 2008 Energy Improvement and Extension Act

EIEA2008 reinstates and extends tax credits for renewable energy and for the purchase and production of certain energy-efficient appliances, many of which were originally enacted in EPACT2005. Some of the tax credits are extended to 2016.

H. Recovery and Reinvestment Act 2009

To make supplemental appropriations for job preservation and creation, infrastructure investment, energy efficiency and science, assistance to the unemployed, and State and local fiscal stabilization, for the fiscal year ending September 30, 2009, and for other purposes.

The American Recovery and Reinvestment Act of 2009 extended many consumer tax incentives originally introduced in the Energy Policy Act of 2005 (EPACT) and amended in the Emergency Economic Stabilization Act of 2008 (P.L. 110-343).

The American Recovery and Reinvestment Act of 2009, or "Recovery Act," awarded the Office of Energy Efficiency (EERE) $16.8 billion for its programs and initiatives.

1. Energy Efficiency and Renewable Energy

A $16,800,000,000 fund was issued for ‘‘Energy Efficiency and Renewable Energy’’ from ARRA initiative:

$3,200,000,000 shall be available for Energy Efficiency and Conservation Block Grants for implementation of programs authorized under subtitle E of title V of the Energy Independence and Security Act of 2007 (42 U.S.C. 17151 et seq.), of which $2,800,000,000 is available through the formula in subtitle E Provided further, That the Secretary may use the most recent and accurate population data available to satisfy the requirements of section

543(b) of the Energy Independence and Security Act of 2007: Provided further, That the remaining $400,000,000 shall be awarded on a competitive basis.

Provided further, That $5,000,000,000 shall be for the Weatherization Assistance Program under part A of title IV of the Energy Conservation and Production Act (42 U.S.C. 6861 et seq.)

Provided further, That $3,100,000,000 shall be for the State Energy Program authorized under part D of title III of the Energy Policy and Conservation Act (42 U.S.C. 6321): Provided further, That $2,000,000,000 shall be available for grants for the manufacturing of advanced batteries and components and the Secretary shall provide facility funding awards under this section to manufacturers of advanced battery systems and vehicle batteries that are produced in the United States, including advanced lithium ion batteries, hybrid electrical systems, component manufacturers, and software designers: Provided further, That notwithstanding section 3304 of title 5, United States Code, and without regard to the provisions of sections 3309 through 3318 of such title 5, the Secretary of Energy, upon a determination that there is a severe shortage of candidates or a critical hiring need for particular positions, may from within the funds provided, recruit and directly appoint highly qualified individuals into the competitive service: Provided further, that such authority shall not apply to positions in the Excepted Service or the Senior Executive Service: Provided further, that any action authorized herein shall be consistent with the merit principles of section 2301 of such title 5, and the Department shall comply with the public notice requirements of section 3327 of such title 5.

I. Energy Efficiency and Conservation Block Grant Program

The Energy Efficiency and Conservation Block Grant (EECBG) Program, funded for the first time by the American Recovery and Reinvestment Act (Recovery Act) of 2009, represents a Presidential priority to deploy the cheapest, cleanest, and most reliable energy technologies in the market (energy efficiency and conservation). The Program, authorized in Title V, Subtitle E of the Energy Independence and Security Act (EISA) and signed into law on December 19, 2007, is modeled after the Community Development Block Grant program administered by the Department of Housing and Urban Development (HUD).

J. State Energy Program (SEP)

The State Energy Program provides financial and technical assistance to states through formula and competitive grants. States use their formula grants to develop state strategies and goals to address their energy priorities. Competitive grant solicitations for the adoption of energy efficiency/renewable energy products and technologies are issued annually based on available funding. States provide a 20% match under SEP annual formula allocations. SEP emphasizes the state's role as the decision maker and administrator for the program activities within the state. The energy offices in each state and territory are a vital resource for delivering energy benefits, addressing federal energy goals, and coordinating energy-related emergency preparedness across the nation.

K. Weatherization Assistance Program

The Weatherization Assistance Program (WAP) enables low-income families to permanently reduce their energy bills by making their homes more energy efficient. Funds are used to improve the energy performance of dwellings of needy families using the most advanced technologies and testing protocols available in the housing industry. The U.S. Department of Energy (DOE) provides funding to states, U.S. overseas territories, and Indian tribal governments, which manage the day-to-day details of the program. These governments, in turn, fund a network of local community action agencies, nonprofit organizations, and local governments that provide these weatherization services in every state, the District of Columbia, U.S. territories, and among Native American tribes.

Families receiving weatherization services see their annual energy bills reduced by an average of about $437, depending on fuel prices. Because the energy improvements that make up weatherization services are long lived, the savings add up over time to substantial benefits for weatherization clients and their communities.

1. Goals

The overall goal of the Weatherization Assistance Program is to reduce the burden of energy prices on the disadvantaged. Weatherization is a priority for the U.S. Department of Energy (DOE), and it was recommended to Congress that it authorize budgets sufficient to weatherize 1.2 million homes between 2002 and 2010.

2. Metrics

The Weatherization Assistance Program's metrics consist of the amount of funding provided to the states and the number of homes weatherized. Since the states manage their respective programs, the funding and number – of - homes metric reflects what is accomplished in the states.

Funding has increased over the past two years reflecting the White House's support for this program. The total allocation for FY 2009 is $250 million.

The single most important metric is the number of homes weatherized, and reflects data collected from the states. Since many states operate on a different fiscal year and report at different times than DOE, these production data are reported on a "program year" that lags DOE's fiscal year ending September 30.

1.6 Puerto Rico Energy Policy Status

Latin American Energy Policies Institute of New Mexico University has in its database these energy policies issued in Puerto Rico:

- Law No. 128 - Establishes Puerto Rico's Public Policy on Energy, issued by Energy Affairs Administration, Puerto Rico, on June 29th, 1977. This law establishes an institution that integrates and coordinates all functions related to energy. Moreover,

this legislation states the need to investigate alternative sources of energy within the country.

- Law No. 325 – issued by Legislative Assembly of Puerto Rico, on September 16th, 2004. This law encourages the development and use of renewable energy sources. It ensures a tax exemption on accumulation, generation, distribution, and application of renewable energy for local use, whether commercial, industrial, or domestic. It promotes fiscal incentives such as deductions and/or credits for the development, manufacture and marketing of renewable energy equipment.

- Law No. 73 - Law of Economic Incentives for the Development of Puerto Rico, issued by Legislative Assembly of Puerto Rico, on May 28th, 2008. This law focuses on the need for the country to modernize its manufacturing sector in order to be competitive in the global economy. As part of this effort, this law states that the country needs to take action to reduce energy costs by using renewable sources of energy.

- P. del S. 1519 - Public Policy Law for Energy Diversification through Renewable, Sustainable and Alternative Energy in Puerto Rico, issued by Senate of Puerto Rico, on April 20th, 2010. This document contains the policy act put forth by the Puerto Rico Senate to create a law that promotes energy diversification through the use of renewable energy. By adopting a Renewable Energy Portfolio, Puerto Rico aims to reduce its dependence on energy sources from fossil fuels such as oil, reduce and stabilize its energy costs, control the price volatility of electricity in the country,

preserve and improve the environment, natural resources and quality of life, promote energy conservation and social welfare through various mechanisms, including the establishment and achievement of goals within a mandatory timetable and economic tax incentives to stimulate the generation of electricity through renewable energy and alternative energy sources.

- Law No. 83 - Law for Green Energy Incentives, issued by Legislative Assembly of Puerto Rico, on July 19th, 2010. This law promotes the generation of renewable energy in Puerto Rico. It consolidates and standardizes the existing economic benefits related with the development, production, and use of renewable energy; and creates new incentives.

  "The excessive reliance on fuels derived from oil poses a threat to the life, health, and safety of all Puerto Ricans. There is no doubt that Puerto Rico is undergoing an energy infrastructure crisis. We can no longer postpone the urgent renovation of our infrastructure if we are to generate environmentally-friendly energy and place Puerto Rico on the right track toward reducing its dependence on oil-derived fuels." (39)

Before fuel issues were brought into consideration, there was "Oficina Sobre Asuntos de Combustibles Derivados del Petróleo". As indicates its name, have the responsibility above any matter about the almost unique source of energy in Puerto Rico. In 1977, The Puerto Rico Senate issued the Law No 128, which created the Energy Administration Affairs (EAA) to establish the public policy foundation of the energy issue, the oil dependence.

In 1993 the “Comité de Cogeneración y Generación de Energía del Gobierno de Puerto Rico” delivered a inform with suggestions to implement public policy in Puerto Rico. In this inform incentives to purchase equipment and to take measures to implement energy efficiency are mentioned, however Law No 325 issued in 2004 by the Legislative Assembly of Puerto Rico, emphasizes incentives to adopt renewable energies technology. In August 2007 Puerto Rico enacted net-metering legislation, allowing customers of Puerto Rico Electric Power Authority (PREPA) to use electricity generated by solar, wind or other renewable-energy resources to offset their electricity usage. This law applies to residential systems with a generating capacity of up to 25 kW and non-residential systems up to one MW in capacity. (50)

On 2008, in Law No 73 it is mentioned that Puerto Rico has a history of more than 60 years of capital investment promoted by its industrial development program, which was one reason for the cost of electricity on the island is one of the higher and more volatile compared to other jurisdictions in US. So, this Law intent to “take forceful action to reduce energy costs, through the different renewable sources alternatives.”, but also in Section 5-d it granted tax exceptions of 50% to “Investment in Machinery and Equipment for the Generation and Efficient Use of Energy”. This tendency was continued in the other laws listed that emphasize incentives for renewable sources, and mention tax exceptions, but not a plan or policy pointed in this topic.

Considering Efficient Use of the Energy has a great potential to reduce considerably electricity expend in Puerto Rico, and therefore alleviate the problems that of dependence on imported fuels entails, besides the need for new generation power generation

infrastructure, it is imperative to develop clear initiatives to take Energy Efficiency into public knowledge through main programs in the Puerto Rico Energy Policy.

1.7 Section Conclusions

While any state in USA has a history developing energy efficiency public policy, Puerto Rico is recently adopting measures related to it. But the efforts are unnoticed for the general public while there are initiatives just for the industrial sector and those seems to be insufficient since there is no record about results or controls about those measures. It is necessary to redefine Puerto Rico public policy to really have results.

2. Selection of the Portfolio of Energy Efficiency Measures

Defining energy efficiency measure has to do with many factors: economy, finances, politics, society, willing, etc. But resources are very limited, so technically, these measures have to be chosen wisely and based on reliable information; those that will give the best return on the funds will be invested.

> "The question of how to define the cost - effectiveness of energy efficiency investments is a critical issue to address when advancing energy efficiency as a key resource in meeting future energy needs. How cost - effectiveness is defined substantially affects how much of our nation's efficiency potential will be accessed and whether consumers will benefit from the lower energy costs and environmental impacts that would result." (33)

2.1 Benefited Sector Selection

Before selecting any measure, it has to be determinate the group of clients that will be affected. The AEE has three major groups where to classify its clients:

- Residential: includes single family houses, multi familiar houses, apartment buildings, condominiums.

- Commercial (Business): includes restaurants, shops, offices (single and buildings), malls, accommodation buildings and others.

- Industrial: any projected consume above 50KVA need to contract a fixed KWH quantity.

There is also two other groups: Street Lightning and Agriculture, but the 2011 Energy Efficiency Potential Study for Puerto Rico took into account the first three mentioned.

Sometimes the Government could be considered as a separated sector. This is because when it is put together all its agencies, organisms, institutions. it becomes the biggest client in all USA: it has to be noticed that must be summed consume of federal, state, municipality, army and every organism which receives government funds. In this case we could not find any information to discern about government clients.

For the preparation of this document it has not been made any discrimination of consumption of government agencies. Presumably, the figures published by AEE include consumption of such institutions as there were figures of total electricity production in Puerto Rico and Total Energy Consumption in Puerto Rico, according to official information gathered from this institution.

In Puerto Rico, in 2012, AEE produced 23.47 million KWH and were consumed 19.49 million KWH, so 3.98 million KWH were lost (approximately 16.95% of the electricity

produced) well above of the 7% of USA (52) and over the average 10% in developed countries. The estimated loss for any electrical system should be between 3% and 6% (40).

The potential electricity saving for Puerto Rico is 26.7% (See Table 4). The residential sector is having the highest potential, 15%, which suggests that Energy Policy must consider programs for this sector (38).

The Potential Study gives guidelines for a portfolio of energy efficiency measures in the residential sector. Then this sector is chosen to take advantage from the work already begun.

Table 4: Energy Potential per Sector (38).

Consumer Sector	Energy Efficiency Potential
Residential	15.0%
Commercial	10.4%
Industrial	1.3%
TOTAL	**26.7%**

According to AEE, by March 2012 there were 1,335,783 residential clients in Puerto Rico. Notice that although the population of Puerto Rico has suffered a decline of 2.2% between 2000 and 2010, the number of residential customers continued to increase until July 2011 when reached the maximum of 1,343,804 clients (see Table 5 and Figure 4).

Table 5: Puerto Rico Historical Population (US Census Bureau - 2012).

Year	Pop.	±%
1910	1,118,012	-
1920	1,299,809	16.30%
1930	1,543,913	18.80%
1940	1,869,255	21.10%
1950	2,210,703	18.30%
1960	2,349,544	6.30%
1970	2,712,033	15.40%
1980	3,196,520	17.90%
1990	3,522,037	10.20%
2000	3,808,610	8.10%
2010	3,725,789	–2.2%

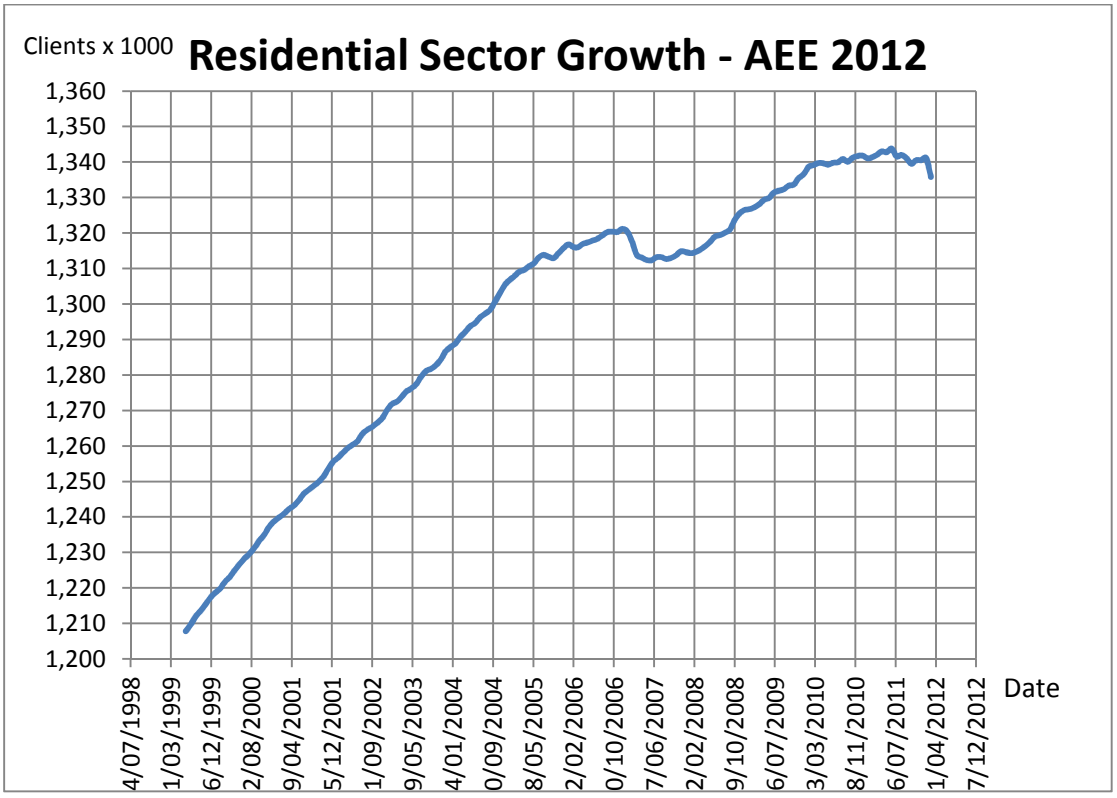

Figure 4: Residential Sector Historical Growing (AEE, 2012).

2.2 Potential Savings for Electricity Use

The Potential Study also shows how electricity is spend in Puerto Rico homes (See Figure 5), showing that lighting and other is the principal spend (42.5%). Air conditioning (A/C) is also an important subject with 36.8% of the home consume. Water heating is the next with 11.4% and at the end is the refrigeration with 9.3%.

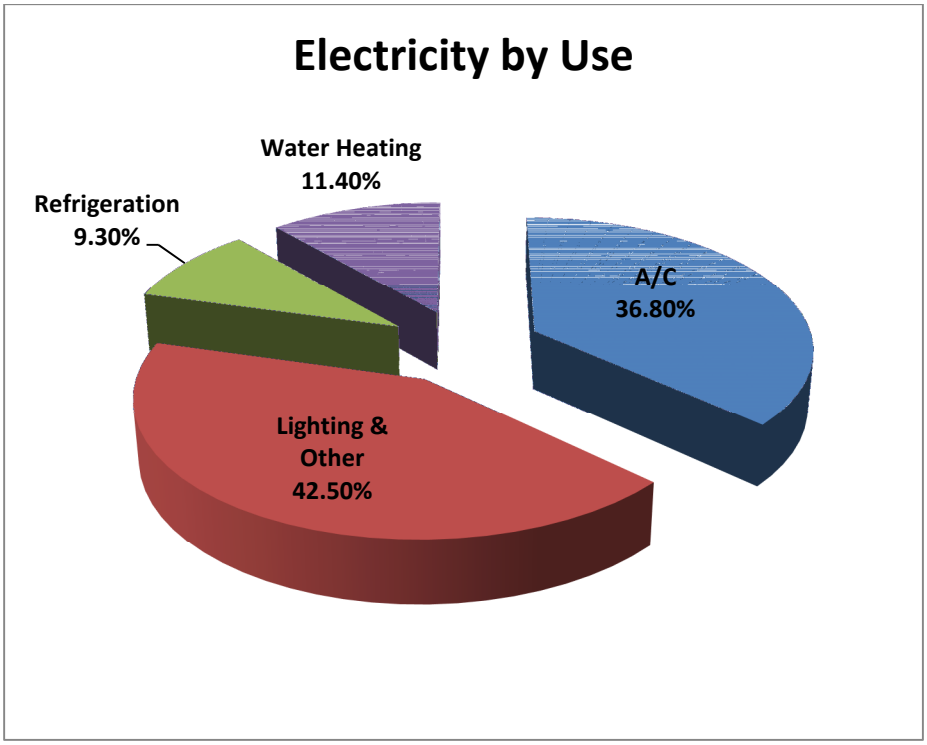

Figure 5: Use of Electricity in Puerto Rico homes (DOE, 2011).

According to the Potential Study (See Table 6), it is apparent that the highest potential exists in A/C 18.4%, followed by water heating 11.4% and lighting 8.3%. In water heating specifically, the potential of 11.4% is assuming 100% of the water heating load for the residential sector. This is an important measure because the average sun hour radiation equivalent in Puerto Rico is approximately five all the year. It has been showed that at least

80% of the water heating load can be supplied by the sun. Considering all sectors this measure alone may reduce the generation capacity by 300MW. Advances in domestic A/C technology (Inverter Technology) must also be applied since it has a very high EE potential for the residential sector (38).

Table 6: Residential Analysis Procedure (EE Potential Study - 2011).

End Use	A/C	Lighting & Other	Refrigeration	Water Heating
Percent of total (*EIA)	36.80%	42.50%	9.30%	11.40%
Potential per use	50.00%	19.60%	64.30%	100.00%
Potential of total	18.40%	8.30%	6.00%	11.40%

2.3 Chosen Measures

After then a portfolio of energy efficiency measures is defined in 6 initiatives:

- Changing A/C equipment
- Changing water heaters
- Changing indoor lights
- Changing refrigerators
- Changing Doors and Windows
- Installing Windows Awnings

NOTE: these two last initiatives will be explained in section 2.4.3. Both are related to increasing the energy efficiency of A/C.

These measures are aimed at reducing electricity consumption directly through changing the any home everyday devices, for more energy efficient ones. This is a direct approach focusing the use of new more efficient technology and not necessarily changing the uses of the users.

However, the parameters defining the energy efficiency contemplate an approach to housing as a whole, meaning that in addition to changing equipment measures for new more efficient ones, it should be considered the home environment, the building. This is to maximize the performance of the new equipment. And this can only be achieved in an environment with the right conditions.

These conditions are related to:

- Illumination
- Ventilation
- Keeping indoor temperatures
- Water heating.

2.4 Measures by the Code

2.4.1 Reviewing Puerto Rico Code

To constitute the Puerto Rico Construction Code, were used the International Code Council del 2009. There are 13 models, but just 9 applied for Puerto Rico: the International Building Code (IBC), International Residential Code (IRC), International Existing Building Code, International Fire Code, International Mechanical Code (IMC), International Energy Conservation Code (IECC), International Private Sewage Disposal Code, International Fuel Gas Code and the International Plumbing Code.

2009 International Building Code

The IBC in its section 1301.1.1 mentions: Criteria. Buildings shall be designed and constructed in accordance with the International Energy Conservation Code.

2009 International Energy Conservation Code

According to the IECC, Puerto Rico is classified in the 1A zone, Warm – Humid. This involves (See Figure 6):

Warm - humid Definition—Moist (A) locations where either of the following wet-bulb temperature conditions shall occur during the warmest six consecutive months of the year:

67°F (19.4°C) or higher for 3,000 or more hours; or 73°F (22.8°C) or higher for 1,500 or more hours

Zone 1: 9000 < CDD50°F

CDD = cooling degree days, is the number of degrees that a day's average temperature is above 65o Fahrenheit and people start to use air conditioning to cool their buildings.

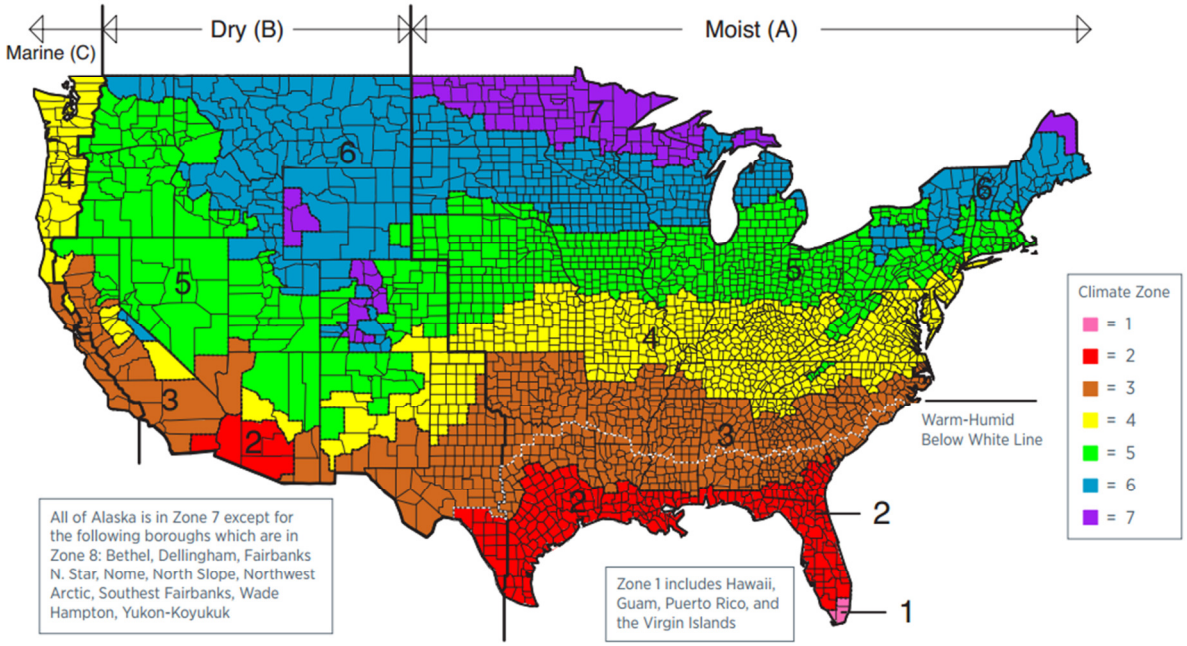

Figure 6: Climate Zones Map of USA

According to this classification, for an area of these features the design conditions are (302.1 section):

The interior design temperatures used for cooling load calculations shall be a minimum of 75°F (24°C) for cooling.

Table 7 and 8 shows the U - factors for windows and doors that are relevant for this research.

Table 7: 2009 IECC Table 303.1.3(1) Default Glazed Fenestration U - Factor (max.)

FRAME TYPE	SINGLE PANE	DOUBLE PANE	SKYLIGHT	
			Single	Double
Metal	1.20	0.80	2.00	1.30
Metal with Thermal Break	1.10	0.65	1.90	1.10
Nonmetal or Metal Clad	0.95	0.55	1.75	1.05
Glazed Block	0.60			

Table 8: 2009 IECC Table 303.1.3(2) Default Door U - Factors (max.)

DOOR TYPE	*U*-FACTOR
Uninsulated Metal	1.20
Insulated Metal	0.60
Wood	0.50
Insulated, nonmetal edge, max 45% glazing, any glazing double pane	0.35

The IECC has always required the building envelope to be caulked and sealed to prevent air leakage between conditioned and unconditioned spaces or the outdoors. The basic intent is to seal all potential sources of leaks.

Whole - house envelope air leakage has no a code defined baseline, nor does interior lighting. In all such cases, there is evidence (in the form of various independent studies) that shows a wide variation in the leakage rates and installed wattages achieved by builders who are not subject to mandatory testing or installed capacity limits (42).

In the 2009 IECC, it is mandatory to perform an air leakage test, using equipment commonly referred as a blower door (See Figure 7). This test requires air leakage rates of not more than 5 air changes per hour (ACH) when tested at a pressure of 50 Pascals (ACH50) in climate zones 1.

Figure 7: Blower Door Test

2.4.2 Overview of LEED for Homes

LEED for Homes is an initiative designed to promote the transformation of the mainstream homebuilding industry toward more sustainable practices. It's a collaborative initiative that works with all sectors of the homebuilding industry (61). It targets 25% of new homes with environmental features. It is based in a rating system which takes into special consideration energy efficiency and energy conservation measures, and also the use of renewable energy.

The LEED for Homes Rating System measures the overall performance of a home in eight categories (61):

1. Innovation & Design Process (ID): special design methods, unique regional credits measures not currently addressed in the Rating System and exemplary performance levels.

2. Location & Linkages (LL): the placement of homes in socially and environmentally responsible ways, in relation to the larger community.

3. Sustainable Sites (SS): the use of entire property so as to minimize the project's impact on the site.

4. Water Efficiency (WE): water – efficient practices, both indoor and outdoor.

5. Energy & Atmosphere (EA): energy efficiency, particularly in the building envelope and heating and cooling design.

6. Materials and Resources (MR): efficient utilization of material, selection of environmentally preferable material, and minimization of waste during construction.

7. Indoor Environmental Quality (EQ): improvement of indoor air quality by reducing the creation of and exposure of pollutants

8. Awareness & Education (AE): the education of homeowner, tenant and/or building manager about the operation and maintenance of the green features of a LEED home.

The LEED for Homes Rating System works by requiring a minimum level of performance through pre-requisites and rewarding improved performance in each of the categories listed on the Table 9. The level of performance is indicated by four performance tiers (Certified, Silver, Gold, Platinum), according to the number of points earned. The Rating System target is to guarantee minimum levels of sustainable practice through accomplish the requisites listed on the LEED manuals. At the same time, projects have some flexibility with a variety of credits available to achieve certification.

Table 9: LEED Certification Levels (US Green Building Council - 2012).

LEED for Homes - Certification Levels	Number of LEED for Homes Points Required
Certified	45-59
Silver	60-74
Gold	75-89
Platinum	90-136
Total Available Points	**136**

2.4.2.1 LEED Effectiveness

In determining the weighting scheme of the new LEED 2009 standard the USGBC has placed a relatively greater emphasis on "the reduction of energy consumption and greenhouse gas emissions associated with building systems…" (23)

Certified buildings are intended to use resources more efficiently when compared to conventional buildings built by the code. Often provide more healthy work and living environments, which contributes to higher productivity and improves employee health and comfort (25).

Depending on the certification level (on 2009, Version 2.0), USGBC estimates top electricity potential savings of 30% better performance (platinum level) in respect of the buildings constructed according code. No mention of different climate zones or regional code details. There are some third party researches which have evaluated LEED results in different scenarios:

- In 2003, Kats performed a research about green building costs and its financial benefits, there is an analysis of the savings from green building found from a review of 60 LEED buildings that the buildings were on average 25-30% more energy efficient and also attributed benefits to the increased productivity from better ventilation, temperature control, lighting control, and reduced indoor air pollution.

- Diamond in 2006 compared modeled and real building energy performance of a sample of 21 LEED certified new buildings (2009 Version 2.0 – 2.1). Results of this research indicate the effectiveness of the LEED energy model, which predicted average Energy Use Intensity (EUI) to be 73% of baseline building expected energy use (27% of savings). Actual energy use available information from 18 buildings was 72% of expected baseline demand, but with much higher variance (Standard Deviation = 46%). Despite accuracy of the mean, the authors also found wide

variation in individual buildings' energy use compared with modeled predictions. The study also found no correlation between either the number of energy efficiency specific LEED point totals and actual normalized building performance, or total LEED energy points and actual normalized building energy performance. The authors noted several limitations of the study, including the small sample size, partial resulting from sampling methodologies, uncertainties in actual floor area, and discrepancies between metered data.

- Baylon and Storm in 2008 studied 24 LEED commercial buildings constructed in Washington and Oregon between 2002 and 2005, comparing them to non LEED buildings built to relatively rigorous state codes. The research found that the LEED buildings only performed 12% better than buildings of the baseline in each building category in the research area, due in part to the more rigorous state codes in Oregon and Washington.

USGBC is expecting to release the 2012 LEED by the end of this year, 2009 Version 2.0 introduced in 2010 is the one in current use, replacing the 2006 version. Evaluating the relative strength of the 2009 reforms is difficult, in part because the energy implications of Version 2.0 are not comprehensively evaluated. The LEED standard is still new (the list of new house projects starts on 2006) and much of the energy use implications of buildings design decisions only become apparent over the course of the building's operational lifetime (9).

While the standard is well intentioned, it is also greatly misunderstood. Put simply, a building's LEED rating is more like a snapshot taken at its opening, not a promise of performance. Unless local, state and federal agencies do their part to ensure long-term compliance with the program's ideals, it could end up putting a shiny green stamp on a generation of unsustainable buildings (3).

2.4.2.2 LEED Initiatives in USA

Many federal, state, and local governments and school districts have adopted various types of LEED initiatives and incentives. A full listing of government and school LEED initiatives can be found online in DOE web page (49). Some areas have implemented or are considering incentives for LEED certified buildings.

The city of Cincinnati, Ohio adopted a measure providing an automatic 100% real property tax exemption of the assessed property value for newly constructed or rehabilitated commercial or residential properties that earn a minimum of LEED Certified (26).

In the state of Nevada construction materials for a qualifying LEED building are exempt from local taxes. Pieces of construction that are deemed "inseparable" parts, such as concrete or drywall, qualify (36)

The state of Michigan is considering tax-based incentives for LEED buildings (26).

Many local governments have adopted LEED incentive programs. Program incentives include tax credits, tax breaks, density bonus, reduced fees, priority or expedited permitting, free or reduced-cost technical assistance, grants and low-interest loans.

2.4.2.3 Status of LEED for Houses in Puerto Rico

Home construction in Puerto Rico was a very important industry until year 2004, there were 24,905 new homes approximately constructed per year (See Table 10), then it showed an important decrease, because according to US Census Bureau, since 2005 to 2010 in Puerto Rico were built 44,874 new homes, this is about 7,479 new homes per year (See Figure 8), but no project appears in the certified LEED project home list of 2012 that shows 2,670 projects since 2006. Also it is interesting to notice that in most states only 1 or 2 builders have built LEED homes built. Just California shows 3 builders who have built certified homes (its records begin in 2007). The residential sector in Puerto Rico is an attractive sector, as the potential to encourage LEED certification in the construction of houses could bring significant savings in electricity.

Table 10: New Homes in Puerto Rico – Historical Chart (US Census Bureau - 2012)

Time Lapse	No of New Homes
2005 - 1010	44,874
2000 - 2004	124,523
1990 - 1999	268,100
1980 - 1989	287,430
1970 - 1979	374,768
1960 - 1969	288,129
1950 - 1959	148,514
1940 - 1949	56,961

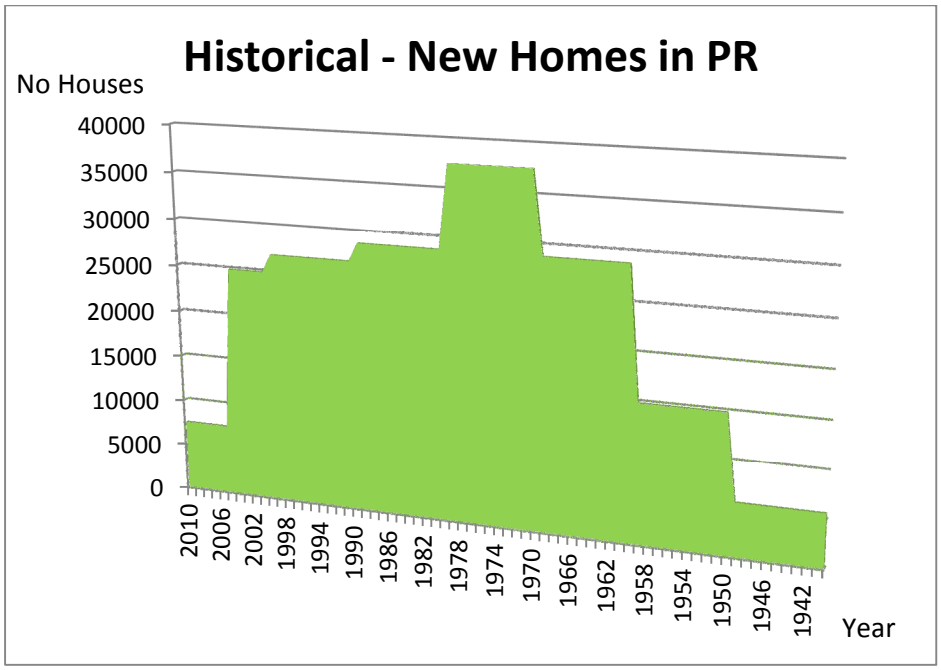

Figure 8: Puerto Rico New Homes – Historical Chart (US Census Bureau - 2010).

2.4.3 Passive Solar and Other Natural Measures

A study performed by the Intergovernmental Panel on Climate Change (IPCC) showed that by 2030 (See Figure 9) the building sector will have the biggest potential in economic savings in electricity in the world (5.3% – 6.7%), and this applying energy efficiency measures. This back up the role of the construction to reach the target of decreasing electricity consume (See Figure 9).

Coming back to the definition of energy efficiency mentioned earlier in this document, it should not just consider the application of energy efficient new technology initiatives (more efficient home appliances) but any technique to get the maximum benefit from the technology plus the use of any technique or methodology of construction to obtain energy savings.

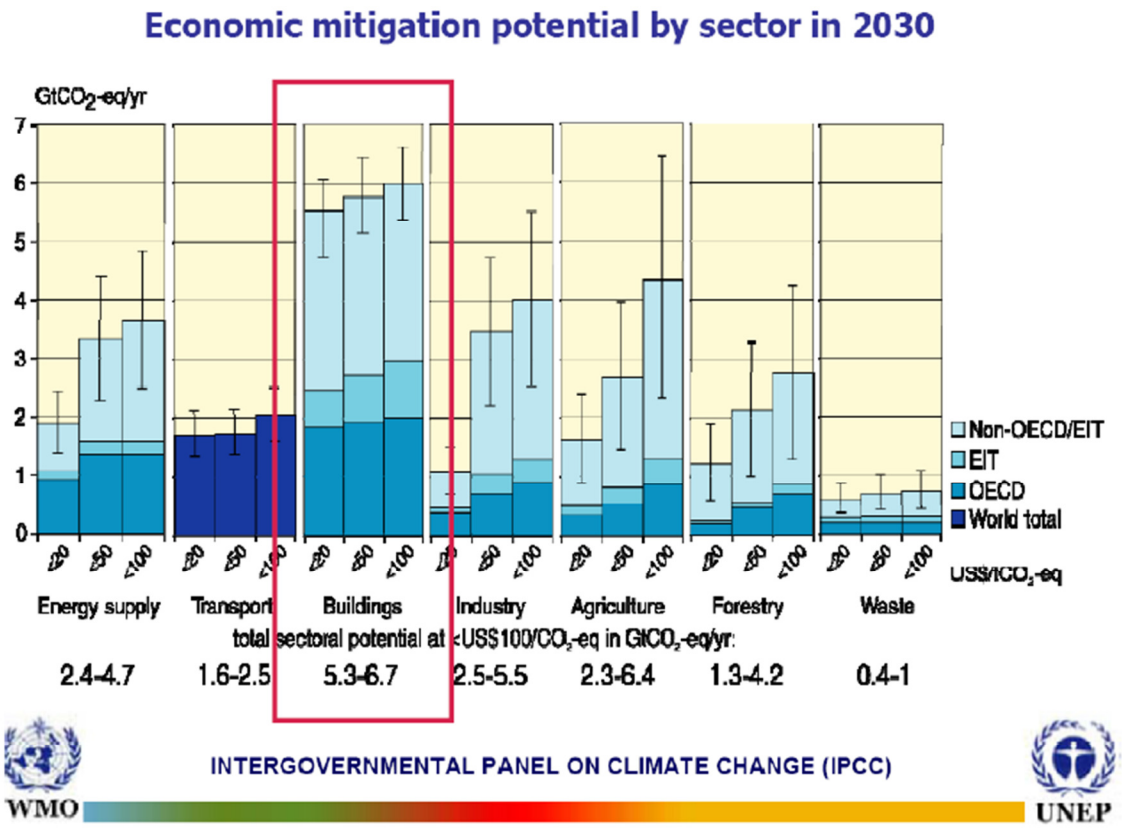

Figure 9: Electricity Economic Mitigation Potential (IPCC - 2012).

Applying techniques of passive solar recommended by EERE can also be valid to maximize efficiency. In the time of design, applying mentioned techniques, significant electricity savings can be reached during the lifetime of the house. Techniques are varied, but among the best known, these can be mentioned as example:

NOTE: The measures to be mentioned are those recommended by the DOE in the web of EERE and those which correspond to climates corresponding to Type I (See Figure 7).

- Orientation of the house for cooling it using the wind. This technique consists in construct the building facing windows towards wind direction, so the hot air is

permanently removed from inside the house. Has to be mentioned that in this technique A/C cannot be used, so there is not electricity consumed.

- Construction of high ceilings to aid in the cooling of the house. Hot air always climbs to the top of a room, leaving space for cool air on the bottom. Can reduce consumption of electricity used in A / C between 5% and 10%.

- Awnings over the windows to prevent solar radiation in excess inside a house. In this case the awning project a shadow over the window, so it reduces the amount of solar radiation in consequence reduces the heating of the interior of the building. Can reduce consumption of electricity used in A / C between 20% and 30% (17)

- Installing solar water heaters. This measure aims to use solar radiation to heat water to reduce the use of electrical water heaters. Can reduce consumption of electricity used in heating water up to 80% (49).

The design process is the best opportunity to apply these techniques, but like most homes built in PR (and throughout USA) are constructed for a commercial purpose, builders seek to exploit the space available within the grounds, as well as possible to save on materials and time:

- Building homes based on wind direction, can avoid taking advantage of the space to build the maximum of housing units.

- Building houses with higher ceilings on what is customary in the market may lead to increased final price, which would be detrimental to the final sale price, what is a disadvantage for the seller.

- Awnings on the windows are not used massively and installation depends upon the owners.

- Solar water heaters increase the final sale price of a home in addition to the installation in apartment buildings is not feasible. Its installation depends on the decision of the owner.

For the reasons mentioned above (besides ignorance in many cases), the techniques are not applied during the construction phase, and the first two cannot be applied after the construction has finished.

However the other two measures are applicable in almost any home, including apartments located in many stories buildings, because they are items that can be attached to the building at any time of its service life.

Awnings in the market are prefabricated modular systems whose installation has been simplified to fit into almost any structure, requiring only that the place where you install them is in good condition.

The solar heater water system requires to be placed in a high place (the system usually works by gravity), usually the house roof (or building roof), so it is imperative the structure has to be in good conditions to support the system. Most of the constructions in Puerto Rico are made of reinforced concrete (columns, beans and roofs) so most of them are potentially suited to support the system. However there is always the need for a preliminary inspection of the structure by a qualified expert.

Within the traditional energy efficiency initiatives that are applied in the U.S. we can find the installation of the water heating systems. Most of these initiatives aim to provide subsidies, rebates and /or reduction of taxes for the purchase of such equipment (50). It should be noted that all measures are generally oriented towards the customer. Not found any measure that might suggest a market transformation by government agencies.

Puerto Rico receives high solar radiation found in the tropical zone near the Ecuador. It is therefore advisable to take extra care allowing radiation entry in houses, so the measures that can be applied are related to low the pace of solar radiation. In this case it is suggested install awnings. These work by projecting a shadow over the window so it reduces radiation heat generated inside the housing which would require a smaller quantity of electricity for cooling the building, allowing even can be illuminated within a naturally (without using artificial lighting systems) also allowing electricity savings.

Placing awnings is an energy efficiency measure suggested in this project and as the other presented in it, the cost-effectiveness is evaluated.

2.5 Weatherization Program in Puerto Rico

What is Weatherization?

Weatherization is the practice of protecting a building and its interior from the elements, particularly from sunlight, precipitation, and wind, and of modifying a building to reduce energy consumption and optimize energy efficiency.

Weatherization is distinct from building insulation, although building insulation requires weatherization for proper functioning. Many types of insulation can be thought as weatherization, because they block drafts or protect from cold winds. Whereas insulation primarily reduces conductive heat flow, weatherization primarily reduces convective heat flow (4).

In USA, DOE has modified the weatherization concept to accommodate the actions of replace and use of more energy efficient equipment to reduce electricity consume.

The main goal of these measures is to decrease the dependency of foreign fuels through a better use of the energy available. About this the EERE states:

> "The U.S. Department of Energy Weatherization and Intergovernmental Program provide grants, technical assistance, and information tools to states, local governments, community action agencies, utilities, Indian tribes, and overseas U.S. territories for their energy programs. These programs coordinate with national goals to reduce petroleum

consumption and increase the energy efficiency of the U.S. economy. They aim at market transformation to reduce market barriers to the cost effective adoption of renewable energy and energy efficiency technologies."

2.6 USA Weatherization Assistant Program

The Weatherization and Assistant Program (WAP) is a measure that aims to reduce energy expenditure for heating and/or cooling of the USA homes. This program emphasize on the economic most vulnerable sectors of the population, enables low income families to permanently reduce their energy bills by making their homes more energy efficient (2). This can be seen in the introduction that appears in most official documents relating to WAP:

> "The Weatherization Assistance Program helps low-income families to attain a reduction of household energy expenditures, while securing and enhancing the health and safety of the home. Of particular concern to the program is to provide assistance to the elderly, families with children, persons with disabilities, and those with a high energy burden in their household."

Every state in USA can request funds to finance initiatives to pursue the goals of decreasing the energy bills in low income homes. In order to achieve this, every state performs different researches to determine their necessities according to their needs and the solutions for them. For this they follow a planning process which also will determine the service providers who'll be in charge to apply the selected initiatives and also track the process and

present the results. These providers can be governmental agencies, foundations, utilities or utilities associations or any institution established for this purpose.

2.7 History of the Weatherization Assistance Program

The Weatherization Assistance Program (WAP) was created under Title IV of the Energy Conservation and Production Act of 1976, following the 1973 oil crisis (there was a period of staggering increases in energy prices). The program was designed to save imported oil and cut heating bills for low - income households, including senior citizens living on fixed incomes and Social Security, who were especially hard hit by rising energy bills (51).

At first, weatherization initiatives emphasized low - cost measures, such as covering windows with plastic sheets, caulking, and weather-stripping windows and doors. Many of these initiatives were emergency and temporary measures. As the planners and providers gained experience and understanding of the cost-effectiveness of different energy efficiency measures, they gradually included different types of weatherization measures (49).

By the early 1980s, the emphasis had turned to more permanent and more cost-effective measures, such as installing storm windows and doors and insulating attics.

In 1984, DOE began to allow states to fund energy efficiency improvements to existing space heating and water heating systems.

In 1985, replacement of defective furnaces and boilers was approved.

During the 1990s, advanced home energy audits were developed and widespread. It required every home to be comprehensively analyzed before work began in order to select the most cost-effective measures and the best approach. This custom analysis tries to ensure each client receives the most cost-effective treatment.

In 1994, it is allowed to use cooling efficiency measures, such as air conditioner replacement, ventilation equipment, screening, and shading devices in the weatherization programs. These measures were developed to help low-income households in warm climates, because cooling costs may be higher than heating costs. Work on heating systems and mechanical equipment was also allowed. Also, the early weatherization initiatives contemplated that 40% of Program funds were spent on materials. The states were allowed to waive this, when they adopt approved advanced audits, to ensure audit-driven cost-effectiveness tests of investments.

In 1999, the Millennium Weatherization Committee, the planning group, issued the strategy report, Weatherization Plus: Opportunities for the 21st Century. It outlines a plan for DOE to support weatherization agencies in flexibly adopting a whole-house approach and a whole-community initiatives approach.

With the American Recovery and Reinvestment Act of 2009 (ARRA), WAP received $5 billion. The idea is to "weatherize" nearly 600,000 homes while government's goal is to weatherize 1 million USA homes per year. In addition to the funding increase, a number of amendments were enacted to allow more cost-effective measures to be adopted in more

homes, including raising the maximum dollar limit per dwelling from $2,500 to $6,500 (17).

2.8 WAP in Puerto Rico

2.8.1 Background for the Implementation of the Program

The Energy Independence and Security Act of 2007 amended the WAP definition of "State" to include the Commonwealth of Puerto Rico and the other territories and possessions of the United States. Consistent with the statutory amendment, on December 29th, 2008 DOE issued a proposal to amend the regulatory definition of "State" and the allocation procedure relied on to calculate the amount of financial assistance received by each State so as to include Commonwealth of Puerto Rico, and the other territories.

On March 29th, 2009 the DOE expanded the definition of "State" under the WAP for Low-Income Persons and amended the financial assistance allocation procedure to reflect the expanded definition. Also, DOE amended WAP regulations consistent with the statutory amendments in the American Recovery and Reinvestment Act of 2009.

The 2009 American Recovery and Reinvestment Act (ARRA) assigned 5 billion dollars to the WAP. Through AAE, Puerto Rico could request $48,865,588 (raised to $65.2 million in 2010) for the implementation of this program in the island. AFI (Autoridad para el Financiamiento de la Infraestructura de Puerto Rico) through Ley Num. 8 – March 9th, 2009, was authorized to coordinate and assist the agencies and governmental institutions in Puerto Rico in the identification, programming, development and supervision of the

requested funds and the programs where the money is invested, and also to carry on the necessary tasks to accomplish the conditions imposed by the Federal Economic Stimulus Act. From 2011 the WAP Program is administered in Puerto Rico by the Energy Affairs Administration (EAA), acting as the Grantee under ARRA.

2.8.2 Characteristics of WAP in Puerto Rico

Due to the warm climate of the island, weatherization efforts are directed to improve the efficiency of cooling systems, reduction in electrical energy demand of light fixtures and selected household appliances, and mitigate energy-related health and safety concerns.

2.8.3 Program Work

Table 11 shows WAP measures that are priorities for Puerto Rico (17):

Table 11: Measures Applied in Puerto Rico WAP

WEATHERIZATION MEASURES	
1	Install low-flow showerheads and faucet aerators
2	Install ENERGY STAR qualified compact fluorescent light bulbs (CFLs)
3	Install window or through-the-wall room air conditioners
4	Replace old, inefficient refrigerators with top-freezer or side-by-side refrigerators
5	Install solar water heater (no pump) (1-7 person household)*
6	Install solar water heater with pump (2-7 person household)*
7	Install split ductless room air conditioners
8	Install electric tank water heater (4+ person household)
9	Install electric tank water heater (2-3 person household)
*Items 5 & 6 are pending a DOE standards decision (February 2010)	

Following the whole house approach WAP also considers:

- Roof and wall insulation
- Plugging leakage in air - conditioned areas
- Doors and windows; and others.

But these measures have not been considered to be implemented in Puerto Rico yet.

2.8.4 Eligibility

By 2009 eligible dwelling units were families whose income was below 150% of the poverty level (44). In the 2009 - 2012 State Plan this changed, now the eligible dwelling units are families whose income is at or below 200% of the poverty level with priority given to elderly, persons with disabilities and families with children (See Table 12). This is determined in accordance with criteria established by the Director of the Office of Management and Budget (OMB) or contains a member who has received cash assistance payments under Title IV or XVI of the Social Security Act or applicable State or local law at any time during the 12 - month period preceding the determination of eligibility for weatherization assistance (45).

Also to be eligible for weatherization in Puerto Rico, household income has to be less than $44,000 a year for a family of four (18).

The 2009 - 2012 ARRA income eligibility thresholds are the following:

Table 12: 2009 - 2012 ARRA income eligibility thresholds

Size of Family Unit	OMB Threshold	200%
1	$ 10,830.00	$ 21,660.00
2	$ 14,570.00	$ 29,140.00
3	$ 18,310.00	$ 36,620.00
4	$ 22,050.00	$ 44,100.00
5	$ 25,790.00	$ 51,580.00
6	$ 29,530.00	$ 59,060.00
7	$ 33,270.00	$ 66,540.00
8	$ 37,010.00	$ 74,020.00
Each additional member add	$ 3,740.00	$ 7,480.00

2.8.5 WAP Team of Puerto Rico

The Project Management Center (PMC) team at the National Energy Technology Laboratory (NETL) started to devise a game plan in spring 2009 to support Puerto Rico Weatherization Assistant Program, and then started assembling a National Weatherization Assistance Team, comprised of (17):

- DOE staff and contractors, to assist the Grantee.
- The Grantee, Energy Affairs Administration (EAA); and.
- The Subgrantee, la Autoridad para el Financiamiento de la Infraestructura (AFI).

The goal of this team was to help to develop and to get approval for 2009 State Plans and the requesting of ARRA funds.

In June and September 2009, DOE staff visited Puerto Rico to provide EAA and AFI with technical assistance on program regulations and guidance, program development, and operational logistics. Also made a number of site visits to understand the housing stock as well as various technical weatherization issues that are unique to the island. The Team identified the best measures to focus in providing the best energy savings potential for the climate and the local housing.

The WAP Team established the infrastructure needed to start the program during the last quarter of 2009. EAA and AFI where in charge of selecting personal: 50 Auditors and 50 Field Monitors were selected to be hired. AFI also issued a request for trainers to conduct comprehensive Weatherization training for the newly hired staff. After receiving their internal President of Boards of Awards' approval, AFI and EAA have secured Energy Coordinating Agency (ECA), based out of Philadelphia (PA), as their training company. ECA conducted the initial training during early February and then hold a contractor training in March 2010.

2.8.6 Puerto Rico WAP State Plan

The State Plan is intended as a general guide about the funding and operation of the Program. Specific information regarding the operation of the Program is contained in the Operations Procedure Manual, developed on 2009.

AEE has elaborated three plans:

2009 Puerto Rico Weatherization Program State Plan (July 2009)

2009 – 2012 Puerto Rico Weatherization Program State Plan (September 2010)

2011 Puerto Rico Weatherization State Plan (July 2011)

All three have two sections: Section Two and Section Three (48).

Section Two describes the initial allocation of funds for the program and the organizational structure for their administration and management. Also mentions the time in which the program activities will take place, the distribution between owned and rented households, training and monitoring activities, and the process followed to start the program.

Section Three is dedicated to discuss about the work related to the program. This includes the assessment of client eligibility, geographical location of dwellings to receive assistance, and establishing priorities for the program. The procedures used to determine the type of work to be performed are also covered, along with a description of weatherization measures, procedures followed to preserve the health and safety of occupants and work crews during the work, inspection of the dwelling after weatherization measures have been applied that assess improvements attained in energy usage and the health and safety of the occupants.

Luis Bernal, ex Energy Affairs Administration Executive Director declared that the first attempt to submit a State Plan to DOE was thought to access an initial 40% of the $48.8

million ($19.5 millions) granted to Puerto Rico to weatherize 4,700 homes ($4,150 per unit aprox.). A Plan of this magnitude needed more time to be developed, for this reason, to start WAP in Puerto Rico as soon as possible, another Plan was submitted: 2009 State Plan (See Table 13).

Table 13: PR State Plans Compendium

	Issued	Budget Period	Prog. Year	Allocation (Mill.)	Grantee	Funding	Units	Total Funds for Program Operation	Average Cost per Dwelling	Estim. Energy Savings MBTU
2009 S P	May, 2009	04/01/09 - 03/31/12	2009	$ 48.80	AFI	$ 44,762,646	4,700	$ 28,195,300	5,999	70,500
2009 S P	July, 2009	10/01/09 - 09/31/10	2009		AFI	$ 412,863	95	$ 274,345	2,887	1,475
2009 - 2012 S P	Septem ber, 2010		2009	$ 65.20	AFI	$ 15,957,653	2,300	$ 13,773,325	5,350	82,500
2011 S P	July, 2011				Sub-Grantee	$ 482,413	82	$ 370,346	4,500	2,500

The EAA elaborated the Puerto Rico Weatherization Assistance Program State Plan for Program Year 2009. This plan requested $425,558 (0.87% of the initial ARRA funds) to weatherize 95 homes, about $4,480 per unit.

The Plan elaborated for Program Years 2009-2012 was submitted on 2010, AEE requested $13'773,325 to weatherize 2,300 homes. The Average Program Operations Cost per Unit was $5,350. This Plan was planned as the main start for WAP in Puerto Rico. This Plan states:

> "Being the first year in the WAP, EAA will combine rigorous field monitoring by the grantee with an extensive training and a technical assistance program to identify areas for maintaining and improving work quality, efficiency, delivery of program services, and to correct Subgrantee administrative and management problems. Field monitoring also provides an opportunity for on-site training and technical assistance and the identification of areas where more extensive training and additional monitoring is needed." (45)

Additional to the $ 13.7 million requested, EAA would use $ 1'656,675 from DOE funding for the purpose of monitoring, training and technical assistance and the Subgrantee $6'533,782 for the same purposes. All the funds would come from the $48.8M first assigned.

On 2011 another State Plan was issued requesting $627,755. This one intended to benefit 82 households in Puerto Rico (approximately $7,655 per unit).

2.8.7 Estimates and Results

Until February, 2010, WAP has provided weatherization services to 6.4 million households across all USA. By 2009 DOE estimated that the program had saved 30.5 MBtu of energy per household each year. It estimates weatherization returns $2.69 for each dollar spent on the program (the average invest per home was $5,400), realized in energy and non-energy benefits. Families whose homes are weatherized are expected to save $358 on their first year's utility bills.

Since 2009 was the first year the Weatherization Assistance Program applied to Puerto Rico, there is no data from previous years about the energy savings per unit. According to WAP data and studies performed for other states, the average energy savings per unit is 30 MBTU and typically hot climates regions save much less energy than cold climate regions. Being Puerto Rico a hot climate territory it is assumed an average of 15MBTU/year per unit (45).

Until February 2010, through this program 15,000 households have been weatherized through the entire island. The theoretical average saving per family unit was 1,140 KWH in a single year. The total accumulate saving per year is 17.1 million KWH. This quantity of electricity is equivalent to $4.6 million per year in direct savings. Also WAP has avoided 9.5 million metric tons of CO2 to spread in the atmosphere.

WAP Achievements in Puerto Rico

- Assigned Funds: $65.2 millions
- Beneficiated Households: 15,000 (aprox.)

Installed Equipment

1. Refrigerators: 12,122
2. A/C Equipment: 5,642
3. Solar Water Heaters: 11,156

4. Saving Lights: 150,000

Some enquires have been done to the Weatherization Assistant Program in USA and Puerto Rico, about the controls to measure savings and protocols and procedures, but there has not be response until the completion of this document.

2.8.8 Accomplishing VISION 2025 with WAP

The management structure, which is in operation, can be used as a start to improve and making grow WAP, however, the conception of WAP has to be adapted from a social program to a saving energy. Also, to reach Vision 2025 targets in Puerto Rico, WAP in order to adapt to the reality should affect all levels of the residential sector and not just those with low incomes. Also, funds for WAP depend on USA government. Their distribution calendar not necessarily meets the needs to reach 1% savings per year. Another source of funding will have to be implemented.

2.9 SECTION CONCLUSIONS

The Residential Sector has the highest potential to save energy (15%) while using energy efficiency measures; the second is the commercial sector, and the last one is the industrial. These two last sectors have to be considered in future projects to ensure reaching the goal of 1% of savings of consumed electricity in Puerto Rico.

Most of the measures are evaluated with their theoretical estimates, but to really accomplish a thirteen years goal; more accurate control has to be performed as long as the initiative is

running. Then there has to be a control program that runs parallel to the energy efficiency initiatives. This program would collect information about initiatives performance and then would retrofit information to the initiative developers to assure the best resource distribution to improve measures performance.

3. Evaluating Energy Efficiency

3.1 Objective to Reach

The Action Plan of the Integrated Process to stimulate Energy Efficiency action in Puerto Rico contemplates the goal of this initiative as to achieve an annual minimum target electricity savings of 1 % of the consumed electricity in Puerto Rico. This target was settled by the DOE in the request for proposal of the project mentioned.

To reach this target, utilities, administrators and investors need to be financially interested in saving energy. To achieve that, all the involved parties have to engage their multiple interests, to create a long term mechanism (see Table 14) to integrate them (the stakeholders) into the decision making process for the development of feasible and cost energy efficiency policy for Puerto Rico.

> "The goal is to create a sustainable, aggressive national commitment to energy efficiency through gas and electric utilities, utility regulators, and partner organizations. Improving energy efficiency in our homes, businesses, schools, governments, and industries (which consume more than 70 percent of the natural gas and electricity used in the country) is one of the most constructive, cost - effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and global climate change (35)."

Table 14: National Action Plan for Energy Efficiency Recommendations (National Action Plan for Energy Efficiency - 2008)

1. Recognize energy efficiency as a high-priority energy resource.
2. Make a strong, long-term commitment to implement cost - effective energy efficiency as a resource.
3. Broadly communicate the benefits of and opportunities for energy efficiency.
4. Promote sufficient, timely, and stable program funding to deliver energy efficiency where cost-effective.
5. Modify policies to align utility incentives with the delivery of cost-effective energy efficiency and modify ratemaking practices to promote energy efficiency investments.

As mentioned before, the main target of this project is to decrease 1% per year of the consumed electricity in Puerto Rico. This could be achieved through different energy efficiency initiatives according to a sector: residential, commercial, industrial. It has been mentioned that this document will assess energy efficiency measures for the residential sector, and these are: Changing luminaries, Changing air condition equipment, Changing Refrigerators, Installation of sealing doors and windows, Installation of windows awnings.

Because the evaluation of energy – efficiency initiatives is focused in the residential sector, in this document, the baseline electricity consumption is considered as the 2011 Residential Consume, 2012 year has just measured until March.

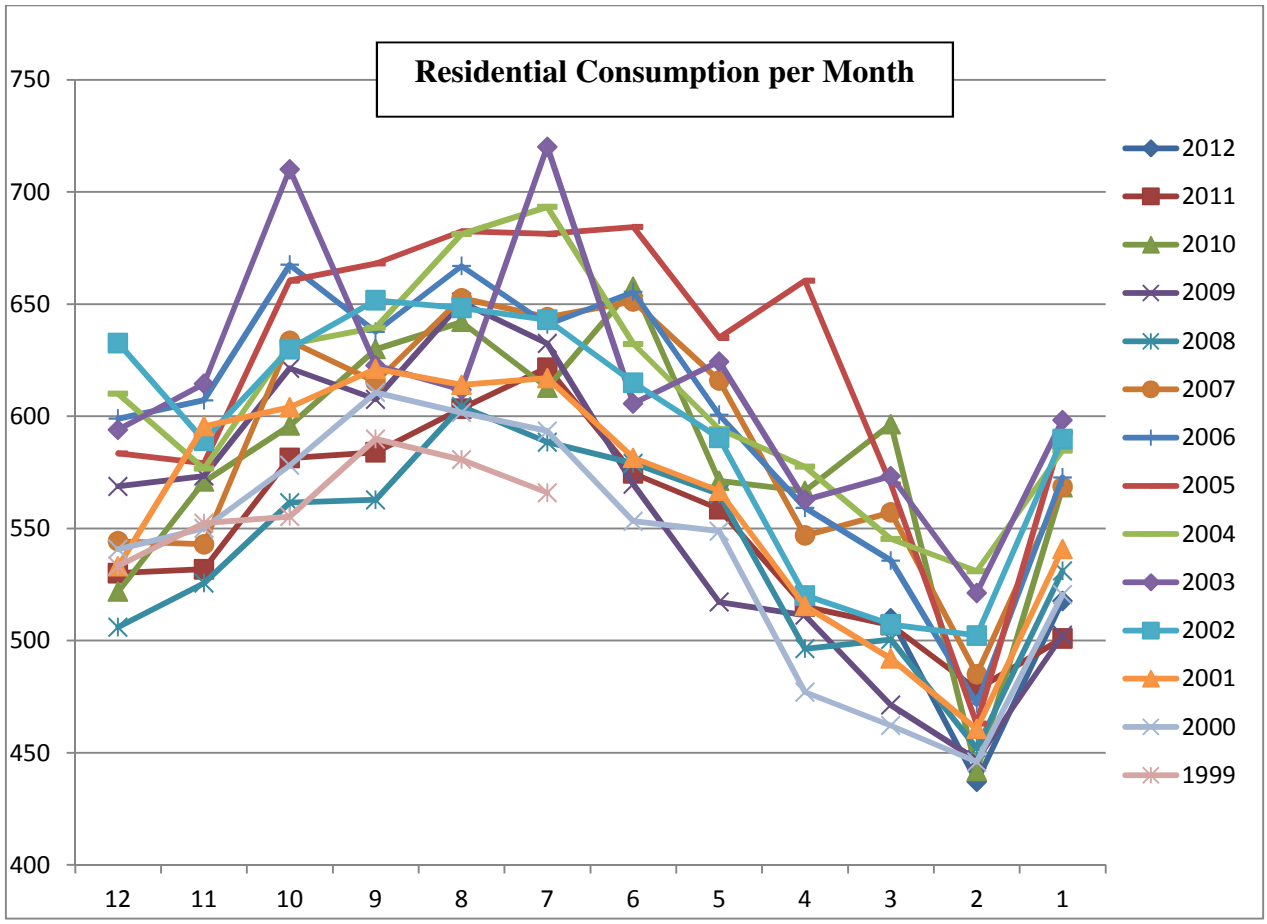

Figure 10: Puerto Rico's Residential Consumption per Month from July 1999 to March 2012 (PREPA. 2012)

This year measure (2012) covers until March, but February shows the lowest measure (437.10 million KWH) since 1999. The 2011 consumption average (548.91 million KWH) is the third lower in the last 13 years. The highest consume was registered in 2005 with an average of 621.65 million KWH (See Figure 10 and Figure 11). This decrease in consumption may be due to the economic problems that USA has been presenting first in 2008 and then in 2010 and that directly affect Puerto Rico.

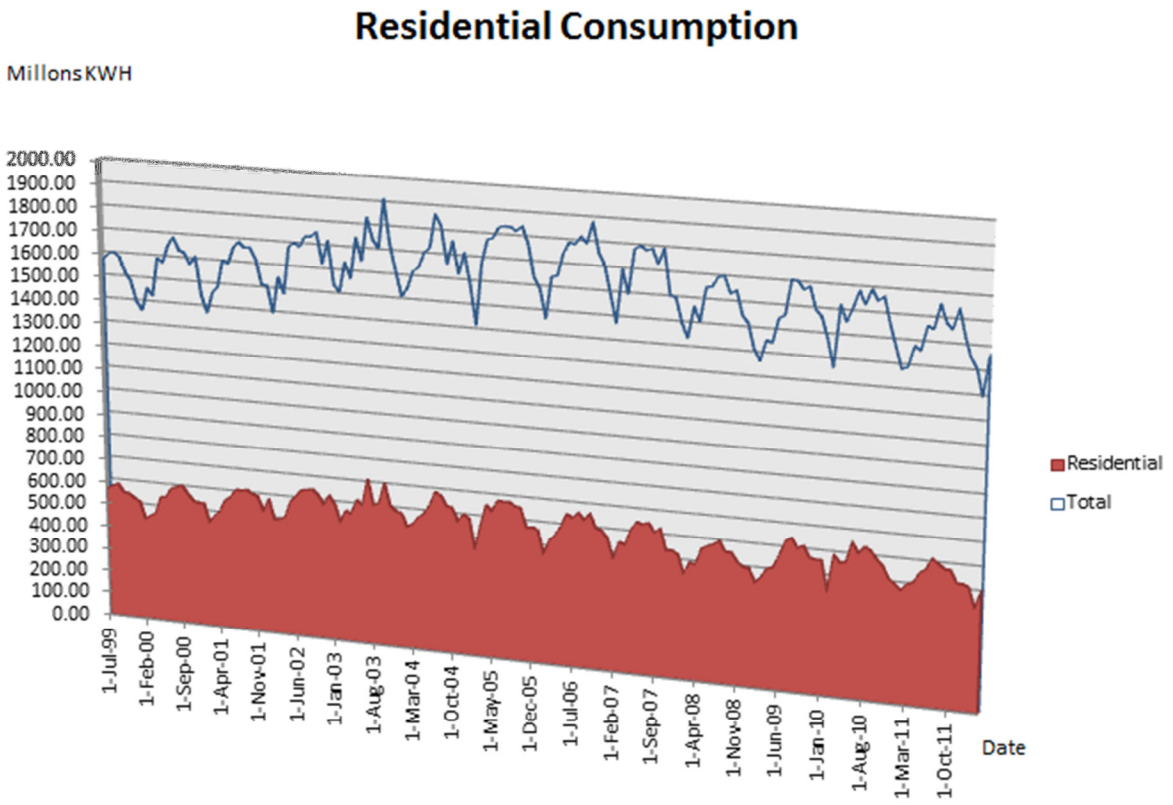

Figure 11: Historical Residential Consume from July 1999 to March 2012

3.2 Tests to Evaluate Energy Efficiency

In its simplest form, the evaluation of cost - effectiveness is measured by comparing the costs of implementing the energy efficiency measure against the benefits it will produce.

For over 20 years, a set of test effectiveness tests have been used as the principal approach for energy efficiency program evaluation. First developed and applied by California (four tests) and then adapted, with minor modifications and the adoption of a new test, by VISION 2025, to make it possible its application by any state or territory of USA. These five cost-effectiveness tests are the Participant Cost Test (PCT), the Utility Program

Administrator Cost Test (PACT), the Ratepayer Impact Measure test (RIM), the total resource cost test (TRC), and the societal cost test (SCT).

The key points from the methodology include (33):

- There is no single best test for evaluating the cost - effectiveness of energy efficiency

- Each of the cost-effectiveness tests provides different information about the impacts of energy efficiency programs from distinct vantage points in the energy system. Together, multiple tests provide a comprehensive approach.

- Jurisdictions seeking to increase efficiency implementation may choose to emphasize the PACT, which compares energy efficiency as a utility investment on a par with other resources.

- The most common primary measurement of energy efficiency cost-effectiveness is the TRC, followed closely by the SCT. A positive TRC result indicates that the program will produce a net reduction in energy costs in the utility service territory over the lifetime of the program. The distributional tests (PCT, PACT, and RIM) are then used to indicate how different stakeholders are affected. Historically, reliance on the RIM test has limited energy efficiency investment, as it is the most restrictive of the five cost - effectiveness tests.

There are a number of choices in developing the costs and benefits of energy efficiency that can significantly affect the cost - effectiveness results. Several major choices available to utilities, analysts, and policy - makers are described below.

- Where in the process to apply the cost - effectiveness tests: The choice of where to apply each cost - effectiveness test has a significant impact on the ultimate set of measures offered to customers. In general, there are three places to evaluate the cost - effectiveness test: at the “measure” level, the “program” level, and the “portfolio” level.

- Applying cost - effectiveness tests at the program or portfolio levels allows some non cost - effective measures or programs to be offered as long as their shortfall is more than offset by cost - effective measures and programs.

- Which benefits to include: There are two main categories of avoided costs: energy related and capacity - related. Energy - related avoided costs refer to market prices of energy, fuel costs, natural gas commodity prices, and other variable costs. Capacity related avoided costs refer to infrastructure investments such as power plants, transmission and distribution lines, and pipelines. From an environmental point of view, saving energy reduces air emissions, including greenhouse gases (GHGs). Within each of these categories, policy-makers must decide which specific benefits are sufficiently known and quantifiable to be included in the cost-effectiveness evaluation.

- Net present value and discount rates: A significant driver of overall cost-effectiveness of energy efficiency is the discount rate assumption used to calculate the net present value (NPV) of the annual costs and benefits. Since costs typically occur upfront and savings occur over time, the lower the discount rate the more likely the cost - effectiveness result is to be positive. As each cost - effectiveness test portrays a specific stakeholder's view, each cost - effectiveness test should use the discount rate associated with its perspective. For a household, the consumer lending rate is used, since this is the debt cost that a private individual would pay to finance an energy efficiency investment. For a business firm, the discount rate is the firm's weighted average cost of capital, typically in the 10 to 12 percent range. However, commercial and industrial customers often demand payback periods of two years or less, implying a discount rate well in excess of 20 percent. The PACT, RIM, and TRC should reflect the utility weighted average cost of capital. The social discount rate (typically the lowest rate) should be used for the SCT to reflect the benefit to society over the long term.

- Net – to - gross ratio (NTG): The NTG can be a significant driver in the results of TRC, PACT, RIM, and SCT. The NTG adjusts the impacts of the programs so that they only reflect those energy efficiency gains that are the result of the energy efficiency program.

- Therefore, the NTG deducts energy savings that would have been achieved without the efficiency program (e.g., "free - riders") and increases savings for any "spillover" effect that occurs as an indirect result of the program. Since the NTG

attempts to measure what customers would have done in the absence of the energy efficiency program, it can be difficult to determine precisely.

- Non - energy benefits (NEBs): Energy efficiency measures often have additional benefits (and costs) beyond energy savings, such as improved comfort, productivity, health, convenience and aesthetics. However, these benefits can be difficult to quantify. Some jurisdictions choose to include NEBs and costs in some of the cost-effectiveness tests, often focusing on specific issues emphasized in state policy.

- GHG emissions: There is increasing interest in valuing the energy efficiency's effect on reducing GHG emissions in the cost-effectiveness tests. The first step is to determine the quantity of avoided carbon dioxide (CO2) emissions from the efficiency program. Once the amount of CO2 reductions has been determined, its economic value can be calculated and added to the net benefits of the energy efficiency measures used to achieve the reductions. Currently, some jurisdictions use an explicit monetary CO2 value in cost - benefit calculations and some do not.

- Renewable portfolio standards (RPS): The interdependence between energy efficiency and RPS goals is an emerging issue in energy efficiency. Unlike supply-side investments, energy efficiency, by reducing load, can reduce the amount of renewable energy that must be procured pursuant to RPS targets. This reduces RPS compliance cost, which is a benefit that should be considered in energy efficiency cost - effectiveness evaluation.

3.2.1 Structure of the Cost – Effective Tests

The basic structure of each cost - effectiveness test involves a calculation of the total benefits and the total costs in dollar terms from a certain stand point to determine whether or not the overall benefits exceed the costs (35).

The result of a test is favorable if the benefit - cost ratio exceeds one, and unfavorable if it is lower than one. Results are reported either in net present value (NPV) dollars or as a ratio (benefits/costs). The formulas are shown in the Figure 12.

$$\boldsymbol{Net\ Benetfits} = \sum \boldsymbol{NPV\ Benefits} - \sum \boldsymbol{NPV\ Costs} \ldots (\boldsymbol{i})$$

$$\boldsymbol{Cost - Benetfit\ Ratio}\ \frac{\sum \boldsymbol{NPV\ Benefits}}{\sum \boldsymbol{NPV\ Costs}} \ldots (\boldsymbol{ii})$$

Figure 12: Cost - Benefit Tests Formulas

The cost - effectiveness test results compare the costs and the benefits from different perspectives, those are relative depending of the applied test. A benefit/cost ratio over 1 means the program has positive net benefits. A benefit/cost ratio less than 1 means that the costs exceed the benefits, or they are favorable and the program is unfavorable. The first

step in analyzing energy efficiency initiatives is to see which cost - effectiveness tests produce results over or less 1, in other words, which initiatives are favorable and which are not.

3.2.2 Net Present Value

The Net Present value (NPV) is the value on a given date of a payment or series of payments made at other times. It is also known as present discounted value.

If the payments are in the future, they are discounted to reflect the time value of money and other factors such as investment risk. If they are in the past, their value is correspondingly enhanced to reflect that those payments have been (or could have been) earning interest in the intervening time. Present value calculations are widely used in business and economics to provide a means to compare cash flows at different times.

Most of the people think in terms of present value of a dollar (nominal values), not some future value. Some analysts prefer to use nominal discount rates that include inflation, with the result that the cost of saved energy is the same in 2012 dollars as in 2025 dollars, since the inflation has already accounted them for. The Figure 13 shows the relationship between the nominal and discounted rates values in a graph, where there can be seen that the nominal values form an straight line, the same values affected by a discount rate, curved lines are diminishing. This was what was expected, as the value of an investment recovery is affected by different factors, the main is economic inflation, which makes their real value in the future, lower than the nominal value. That is, for example, that if in the future we

expect to recover 100, with a 1% monthly inflation, the first month will recover nominally 100, but really the return will be 99, in the second month, nominally the return will be 100 again, but it will really be 98.01 and so on. This is important to mention and analyze when developing public policy, because it is important to determine not only the real time payback, which is affected by a discount rate, but also the common public perception because a little portion of the common public have the information or the necessary knowledge to understand what has been described above.

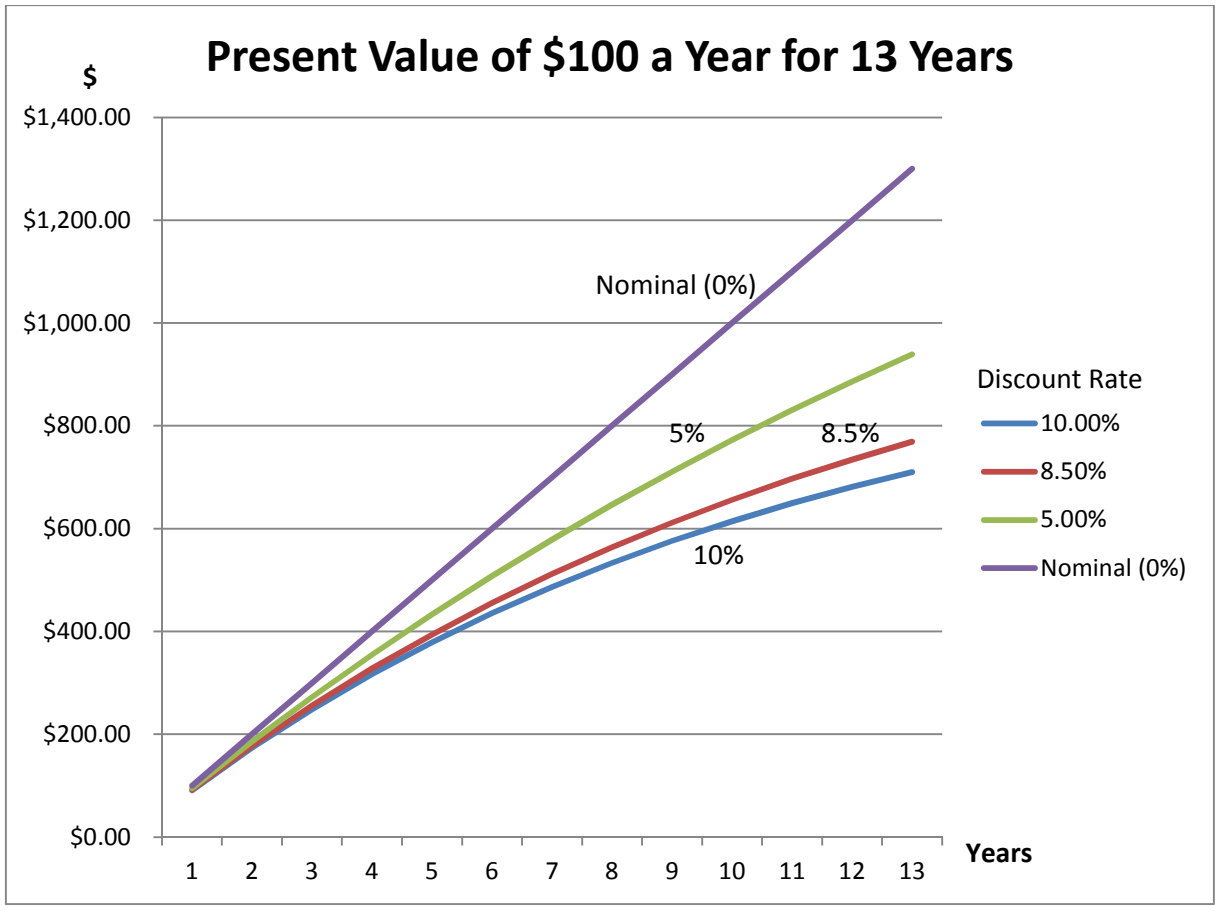

Figure 13: Comparison between Nominal and Discount Rates

Each cost - effectiveness test compares the Net Present Value of the annual costs and benefits over the life of an efficiency measure or program. Energy efficiency initiatives require an investment in the beginning, while the energy savings and maintenance costs accrue over several years. The calculation of the Net Present Value requires a discount rate assumption, which can be different for the stakeholder perspective of each cost - effectiveness test. A significant driver of overall cost - effectiveness of energy efficiency is the discount rate assumption.

3.2.3 Choosing Discounting Rate

A significant driver of overall cost - effectiveness of energy efficiency is the discount rate assumption used to calculate the net present value of the annual costs and benefits. Since costs typically occur upfront and savings occur over time, the lower the discount rate the more likely the cost - effectiveness result is to be positive.

Each test is like a different perspective which portrays a specific stakeholder's point of view; each perspective comes with its own discount rate. The five cost - effectiveness tests are listed in the Table 15, along with the discount rate that are both suggested by Vision 2025 documents (33). Using the appropriate discount rate is essential for correctly calculating the net benefits of an investment in energy efficiency.

The mentioned discount rates are not mandatory. Vision 2025 methodology allows the evaluator to choose the discount rate to use based on the characteristics of the market.

Table 15: Vision 2025 Discount Rates (NAPEE, 2008)

Tests and Perspective	Discount Rate Used	Illustrative Value	Present Value of $1 a Year for 20 Years
PCT	Participant's discount rate	10%	$8.51
RIM	Utility WACC	8.50%	$9.46
PACT	Utility WACC	8.50%	$9.46
TRC	Utility WACC	8.50%	$9.46
SCT	Social discount rate	5%	$12.46

For a household, the consumer lending rate is used, since this is the debt cost that a private individual would pay to finance an energy efficiency investment. Two financial institutions, with their respective lending rates, as of June 2012, are shown in Table 16.

Table 16: Rates from some Financial Institutions in Puerto Rico

FINANCIAL INSTITUTE (June 2012)	NOMINAL RATES
Banco Popular	7.49% in publicity, 7.70% min., 9.95% base
Doral Bank	7.45% min., 17.95% max.

These rates do not include insurances, loan closure fees or other loan mandatory payments. The exact amounts including these items could not be obtained. The financial institutions

presented in the table were consulted, and unfortunately were unwilling to provide the requested information unless an individual applied for a loan. Even tough, the discount rate with all the fees was not found for the purpose of the study presented in this document, it is expected that the final rate of a personal loan should be around 10% to 13%.

In Vision 2025 documents (33) a discount rate of 10% was suggested for the purpose of using the cost – effectiveness tests because a value of a discount rate of 10% is considered conservative with respect to the local values this is the one chosen for the calculations where the cost affect directly the individual clients.

In the case of the TRC, RIM, or PACT tests, This discount rate is typically called the weighted average cost of capital (WACC) and takes into account the debt and equity costs and the proportion of financing obtained from each test. The WACC is typically between the participant discount rate and the social discount rate (33). The utility's loan rate is often used as the discount rate.

In the case of using cost – effectiveness test for initiatives in PR, the evaluator can use the Puerto Rico bonus payment rate in the international market. This rate is 5.75% as of March 2011 rate. The reason for using this rate is the fact that funds by the government, and it is also an accepted rate by DOE.

However for the calculations of the cost – effectiveness test presented in this document, where the utility administration and institutional costs need to be considered a higher value of 8.5% is more appropriate. This value is suggested by the National Action Plan for

Energy Efficiency – Understanding Cost Effectiveness (35). This value was finally chosen to conduct the study because it represents a less favorable scenario, in other words a higher discount rate between the options.

The discount rate to consider when there are costs that affect the whole society is called social discount rate, and it reflects the benefit to society over the long term, and takes into account the reduced risk of an investment that is spread across all of society, such as the entire state or region. This is typically the lowest discount rate (34). Vision 2025 documents suggest 5% as the social discount rate. The California Public Utilities Commission points a discount rate of 3% for that State, considering a larger distribution of the risk and a better fund administration.

The US Federal Reserve considers 3.25% as the right discount rate for social investments and it can be considered for public and private funds used to finance social initiatives.

For this project the social discount ratio chosen is 5% (Vision 2025) because it represents a more conservative scenario.

3.2.4 Factors to Consider when Evaluating EE

3.2.4.1 Stakeholders

- **Clients**

PREPA has defined the clients as every individual who asked for an electrical connection with an electric meter (not a fixed KWH quantity). This definition apply to all participants,

those who are beneficiated with energy efficiency programs, and no – participants of energy efficiency initiatives. The first one participates of an energy efficiency initiative; the second is a client with the same rights and duties as the first, but doesn't participate in the mentioned initiative

- **Utility**

In this case, the utility for Puerto Rico is the Puerto Rico Power Authority (PREPA), the entity providing such good called energy.

- **Initiatives Administrator**

In USA most of the time, a group a utilities based in the same region, county or state, organize an institution who plan, controls, develop, administrates the energy efficiency initiatives required by DOE or the government. PREPA is the indicated entity who takes such a role in Puerto Rico.

3.2.5 Benefits and Costs

The Table 17 below shows the factors involved in the cost – effectiveness tests calculations in general.

Depending on the cost effectiveness test the factors to be considered can be either benefits or costs. For example, in the PCT bill savings can be considered a benefit for the clients, but in RIM the same item is a cost for the utility.

Table 17: Summary of Benefits and Costs Included in Each Cost - Effectiveness Test (California Standard Practice Manual - 2001)

Component	PCT	PACT	RIM	TRC	SCT
Energy - and capacity - related avoided costs		Benefit	Benefit	Benefit	Benefit
Additional resource savings				Benefit	Benefit
Non - monetized benefits					Benefit
Incremental equipment and installation costs	Cost			Cost	
Program overhead costs		Cost	Cost	Cost	Cost
Incentive payments	Benefit	Cost	Cost		
Bill savings	Benefit		Cost		

The following section contains an explanation of these five factors in more detail:

3.2.5.1 Program Overhead

The necessary expenses needed to maintain the activities to administer the energy efficiency programs, but not directly related to the products or services offered. This includes:

- Program Administration: Expenses related to research, develop, administrate and evaluate the activities concerned to the initiative.

- Marketing and Outreach: Expenses related to the processes of creating, communicating, delivering, and exchanging what the initiative has to offer to the beneficiaries involved.

- Subvention Processing: Expenses related to processing information concerning the delivered subsidies. This includes management and selection of participants and the respective customer delivery grants process, including, delivery of funds, rebates, coupons or any other form of customer grant.

3.2.5.2 Program Incentives

- Program incentives are grants that are delivered by the initiative including rebates and other different ways to deliver these funds like tax exceptions, refunds, coupons, rebates, etc.

- For some cost effectiveness tests they are direct installation costs that correspond directly to every client.

- Finally, program incentives can have a form of upstream payments in advance of the necessary acquisitions related to the program

3.2.5.3 Measure Costs

This item includes those costs incurred in preparing for the implementation of the initiatives, like measuring equipment, installation and maintenance.

3.2.5.4 Energy Savings (net)

This item accounts the savings from the generation of electricity, due to the decrease in electricity consumption, decrease in fuel consumption and less maintenance of infrastructure.

3.2.5.5 Bill Savings

This item accounts for client electricity savings or bill savings. The savings must be applied using the billing system as a reference, including those savings that correspond to different rates based on the customer consumption.

3.2.5.6 Monetized Emissions

Decreased emissions mean savings corresponding to less social costs. These savings should be measured in a baseline before the measures are applied and depend on the kind of fuel or the efficiency of the equipment.

3.2.5.7 Non Energy Benefits

These are the benefits not related directly with electricity generation or consumption and have been monetized like improved comfort, health, convenience, and aesthetics and are often referred to as non - energy effects they include costs as well as benefits. Examples of this can be the avoided costs of reducing absence in working places or the reduction of funding costs invested in lung diseases due to reduced emissions.

3.3 Methodology to Conduct Benefit – Cost Test for Energy Efficiency Programs

The template shown below (Table 18) shows the factors described before that are involved in calculating cost - benefit test in energy efficiency. This table allows the opportunity to easily change or know each factor. As mentioned before, the use of each factor may vary, sometimes it is considered a cost or a benefit and vice versa, depending on the test being applied.

Table 18: Energy Efficiency Test Calculations Template

	TEST	
	Benefits	Costs
Program overhead	$ -	$ -
Program incentives	$ 100	$ -
Measure costs	$ -	$ 200
Energy savings (net)	$ 1,000	$ -
Bill savings	$ -	$ -
Monetized emissions (net)	$ -	$ -
Non-energy benefits	$ -	$ -
Total	$ -	$ -
Net benefit	$ 900	
Benefit - Cost Ratio	5.5	

It is worth to remember that the values of the factors involved must be brought to Present Value, meaning that you must apply the respective discount rate and consider the time that will take to recover the investment. For residential clients or individuals, the rate may vary

between 10% and 12%, for benefits and costs of the utility and / or the administration of the initiatives a rate of 8.5% is suggested, and; for the social costs and benefits the discount rate suggested is 5%.

The steps for using this template are: the selection of the Benefit - Cost test to apply; then to consider the factors based on Table 15; then calculate the PV for the cost or the benefit that apply; the figures are arranged in columns according Benefits and Costs as shown in the template; then the total cost and the total benefit is calculated with those values the Net Benefit and the Benefit – Cost Ratio can be obtain (See Figure 14)

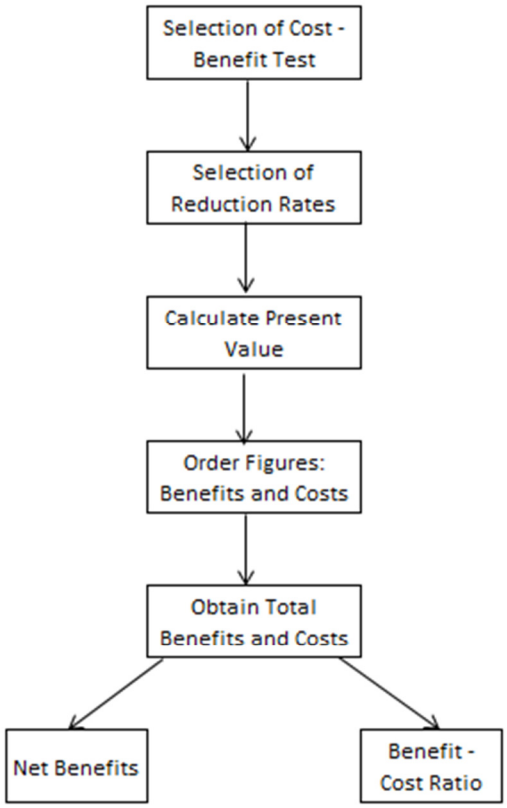

Figure 14: Steps to use Energy Efficiency Test Template

In the Net Benefits box in the template, the formula shown below must be applied.

$$\boldsymbol{Net\ Benetfits} = \sum \boldsymbol{NPV\ Benefits} - \sum \boldsymbol{NPV\ Costs} \ldots (\boldsymbol{i})$$

The Net Benefit is a simple subtraction to denote the monetary gain or loss experienced by the entity that the test is focusing on, that may be participants, customers, utility, initiative administrator, or society.

In the Cost - Benefit Ratio box, in the template the Cost – Benefit Ratio Formula consists of dividing the PV of all the Benefits between the PV of all the Costs, as shown in the formula below.

$$\boldsymbol{Cost - Benefit\ Ratio} = \frac{\sum \boldsymbol{NPV\ Benefits}}{\sum \boldsymbol{NPV\ Costs}} \ldots (\boldsymbol{ii})$$

The purpose of this ratio is to present a quick relationship between monetary benefits and costs associated with the energy efficiency initiative. If the ratio is greater than 1, the initiative is favorable, if the ratio is less than 1, then the initiative is unfavorable. However this result will apply to the test under consideration and the entity directly related with that test, because this ratio depends on the selection of the factors involved in the tests.

3.4 Cost- Effectiveness Tests

Currently, five key tests are used to compare the costs and benefits of energy efficiency and demand response programs. These tests were all originated in California (11), with the exception of the Societal Cost Test. In 1974, the Warren Alquist Act established the California Energy Commission (CEC) and specified cost - effectiveness as a leading resource planning principle. In 1983, California's Standard Practice for Cost - Benefit Analysis of Conservation and Load Management Programs manual, later known as the California Standard Practice Manual, developed four costs - effectiveness tests for evaluating energy efficiency programs.

Vision 2025 based on the use of Cost Efficiency Tests on the California Standard Practice Manual protocol in the version of 2001, suggests a methodology to evaluate cost - effectiveness of an energy measure using 5 tests, which, with minor updates, continue to be used today and are the principal approach used for evaluating energy efficiency programs across the United States. The tests are:

- Participant cost test (PCT)
- Program administrator cost test (PACT)
- Ratepayer impact measure test (RIM)
- Total resource cost test (TRC)
- Societal cost test (SCT)

Each test is designed to evaluate the performance of a measure in certain isolated sector or entities: the TRC and SCT cost tests help to answer whether energy efficiency is cost – effective for the society in general; while PCT, PACT, and RIM help to answer whether the selection of measures and design of the program are balanced for participant, utility, and the non - participant sectors respectively.

The factors of costs and benefits included in each cost - effectiveness test should be consistent across all regions and markets as described in the template before. However, the specific components that add up to each factor included in each test can vary across different regions, market structures, and the different kinds of utilities. For example deferring transmission and distribution investment may be considered through energy efficiency in some places and not in others. Likewise, the TRC and SCT may consider just natural gas or electricity resource savings in some cases, but also include benefits of other savings streams, such as water and fuel oil, among others. In this document only electricity has been considered in the development of the evaluation methodology to apply the tests (49).

The results of all five cost - effectiveness tests provide a more comprehensive picture than the use of any one test alone (33). Looking at the cost - effectiveness tests together helps to characterize the attributes of a program or measure to enable decision making, to determine whether some measures or programs are too costly, whether some costs or incentives are too high or too low, and what adjustments need to be made to improve distribution of costs and benefits among stakeholders. For that reason, the study conducted and presented in this document includes the use of the five test presented in Vision 2025.

3.5 Participant Cost Test (PCT)

The PCT assesses the costs and benefits from the perspective of the customer installing the measure. It compares the benefits of participating in an efficiency program (incentives plus savings on energy bills) with the cost of implementing energy efficiency (incremental or capital cost, installation, O&M, etc.) for either a typical client or for all the clients participating as a group.

3.5.1 PCT Benefits & Costs

Table 19 shows benefits and costs from the perspective of the participant customer.

Table 19: PCT Benefits and Costs (National Action Plan for Energy Efficiency - 2008)

Benefits	**Costs**
- Incentive payments - Bill savings - Applicable tax credits or incentives	- Incremental installation costs - Incremental equipment costs

3.5.2 PCT Strengths

The PCT gives a good first impression of the desirability of the program to customers. This information is especially useful for voluntary programs as an indication of potential participation rates.

For programs that involve a utility incentive, this test can be used for program design considerations such as the minimum incentive level or time span of the program. Incentives are really needed to induce participation and whether changes in incentive levels will induce the desired amount of participation (CPUC, 2001).

These test results can be useful for program penetration analyses and developing program participation goals, which will minimize adverse ratepayer impacts and maximize benefits.

3.5.3 PCT Weaknesses

This test ignores impact on utility, non - participants and the society even if they do or they do not make the investment. Since many customers do not base their decisions to participate in a program entirely on quantifiable variables, this test cannot be a complete measure of the benefits and costs of a program to a customer. Until more is known about customer attitudes and behavior, interpretations of PCT results continue to require considerable judgment. Results of this test play only a supportive role in any assessment of conservation and load management programs as alternatives to supply projects (CPUC, 2001).

3.6 Program Administrator Cost Test (PACT)

The PACT measures the net costs of a demand - side management program as a resource option based on the costs incurred by the program administrator and excluding any net costs incurred by the participant. In other words PACT calculates the costs and benefits of the program from the perspective of the program administrator based on how the utility is

implementing the program. This test evaluates the impacts of energy efficiency initiatives on the objectives of the program administrator.

This test is sometimes referred to as the utility cost test, because it compares the utility's avoided costs with energy efficiency program expenditures where the two items to consider are incentives plus administrative costs.

Along with the TRC test, the PACT is one of the most commonly used tests for energy efficiency program planning purposes. The benefits are similar to the TRC benefits, but costs are defined more narrowly. It is also used in a resource planning context to evaluate energy efficiency investments against supply - side alternatives (ECW, 2009).

3.6.1 PACT Benefits & Costs

Table 20, shows the benefits and cost from the perspective of the utility, the government agency, or a third party that would likely implement the program.

Table 20: PACT Benefits and Costs (National Action Plan for Energy Efficiency - 2008)

Benefits	**Costs**
- Energy-related costs avoided by the utility - Capacity-related costs avoided by the utility, including generation, transmission, incentive costs and distribution	- Program overhead costs - Utility/program administrator installation costs - Utility/program administrator incentive costs

The benefits for the (PACT) are the avoided supply costs of energy and demand, the reduction in transmission, distribution, generation, and capacity valued at marginal costs for the periods when there is a load reduction. These avoided costs should be calculated using net program savings. The calculations have to avoid those savings that would have happened in the absence of the program. For fuel substitution programs benefits include avoiding supply costs for the energy - using equipment not chosen by the program participant only in the case of a combination utility where the utility provides both fuels (35).

The costs for the Program Administrator Cost Test are those incurred by the administrator, the incentives paid to the customers, and the increased supply costs for the periods in which load is increased. Administrator program costs include initial and annual costs, such as the cost of utility equipment, operation and maintenance, installation, program administration, customer dropout, and removal of equipment, except for the salvage value. For fuel substitution programs, costs include the increased supply costs for the energy - using equipment chosen by the program participant only in the case of a combination utility, who uses more than one fuel to generate electricity (11).

In this test revenue shifts are viewed as a transfer payment between participants and all ratepayers. Though a shift in revenue affects rates, it does not affect revenue requirements, which are defined as the difference between the net marginal energy, capacity costs avoided, and program costs.

3.6.2 PACT Strengths

As with the TRC, the PACT treats revenue shifts as transfer payments, so they are not considered in this test, and meaning that test results are not complicated by the uncertainties associated with long - term rate projections and associated rate design assumptions. In contrast to the TRC, the PACT includes only the portion of the equipment of participant costs that is paid for by the administrator in the form of an incentive. For purposes of comparison, costs in the PACT are defined similarly to those supply - side projects which also do not include direct customer costs (11).

3.6.3 PACT Weaknesses

By defining device costs exclusively in terms of costs incurred by the administrator, the PACT results reflect only a portion of the full costs of the resource.

The PACT has two limitations noted (49), by treating revenue shifts as transfer payments, the rate impacts are not captured; and; by the test cannot be used to evaluate load building programs.

3.7 Ratepayer Impact Measure Test (RIM)

The RIM examines the potential impact the energy efficiency program has on rates overall. The net benefits are the avoided cost of energy (same as PACT). The net costs include the overhead and incentive costs, but also include utility lost revenues from customer bill savings.

Demand - side management (DSM) programs cause a direct shift in revenues, because of the decrease in the incoming revenues. The revenue lost from demand - side management programs have to be made up by ratepayers (this under many conditions). The RIM test is the only test that reflects this revenue shift along with the other costs and benefits associated with the program.

3.7.1 RIM Benefits & Costs

Table 21 shows the benefits and costs from a perspective of the impact of efficiency measure on non - participating ratepayers overall.

Table 21: RIM Benefits and Costs (National Action Plan for Energy Efficiency - 2008)

Benefits	**Costs**
- Energy-related costs avoided by the utility - Capacity-related costs avoided by the utility, including generation, transmission and distribution	- Program overhead costs - Utility/program administrator incentive costs - Utility/program administrator installation costs - Lost revenue due to reduced energy bills

3.7.2 RIM Strengths

Strength of RIM test is that the test can be used for all demand - side management programs including conservation, load management, fuel substitution, and load building. This makes the RIM test particularly useful for comparing impacts among demand - side management options.

3.7.3 RIM Weaknesses

Long term projections of marginal costs and long term projection rates are two cost streams that are difficult to quantify with certainty, because of this results of the RIM test are probably less certain than those of other tests. RIM results are also sensitive to assumptions regarding the financing of program costs.

Sensitivity analyses and interactive analyses that capture feedback effects between system changes, rate design options, and alternative means of financing generation and non - generation options can help overcome these limitations. However, these types of analyses may be difficult to implement.

Though the results of the RIM test accurately reflect rate impacts, the implications for long term conservation efforts need to be considered.

3.8 Total Resource Cost Test (TRC)

The TRC measures the net costs of a demand - side management program as a resource option based on the total costs of the program, including both the participants and the utility's costs. It reflects the total benefits and costs to all customers (participants and non - participants) in the service territory. The key difference between the TRC and the PACT is that the former does not include program incentives, which are considered non net transfers in a regional perspective (example: costs to the utility and benefits to the customers).

In California, the TRC includes a mechanism that internalizes the benefits of avoiding the emission of NOx, CO2, sulfur oxides (SOx), and volatile organic compounds (VOCs). The mechanism is incorporated into energy savings, and not broken out as a separate category.

In many jurisdictions, the avoided costs are based on a market price that is presumed to implicitly include emissions permit costs and an explicit calculation of permit costs for regulated emissions is not made.

3.8.1 TRC Costs & Benefits

Table 22 shows benefits and costs from the perspective of all utility customers, participants and non – participants, in the utility service territory.

Table 22: TRC Benefits and Costs (National Action Plan for Energy Efficiency - 2008)

Benefits	**Costs**
- Energy-related costs avoided by the utility - Applicable tax credits - Capacity-related costs avoided by the utility, including generation, transmission and distribution - Monetized environmental and non-energy benefits - Additional resource savings (i.e. gas and water if utility is electric)	- Program overhead costs - Program installation costs - Incremental measure costs and distribution (whether paid by the customer or utility)

3.8.2 TRC Strengths

The primary strength of the TRC test is its scope. This test includes total costs (participant and program administrator) and also has the potential for capturing total benefits. In the case of California, the avoided supply costs plus externalities for the societal test variation. To the extent supply - side project evaluations also include total costs of generation and/or transmission, the TRC provides a useful basis for comparing demanded supply - side options.

Since this test treats incentives paid to participants and revenue shifts as transfer payments (from all ratepayers to participants through increased revenue requirements), the test results are unaffected by the uncertainties of projected average rates, thus reducing the uncertainty of the test results. Average rates and assumptions associated with how other options are financed (similar to the issue of incentives for DSM programs) are also excluded from most supply - side cost determinations, again making the TRC useful for comparing DSM and supply - side options.

3.8.3 TRC Weakness

The treatment of revenue shifts and incentive payments as transfer payments can be considered a weakness of the TRC. While it is true that most supply - side cost analyses do not include such financial issues, it can be argued that demand - side management programs should include these effects since, in contrast to most supply options, demand - side management programs do result in loss of revenues.

In addition, the costs of the demand - side management "resource" in the TRC test are based on the total costs of the program, including costs incurred by the participant. Supply-side resource options are typically based only on the costs incurred by the power suppliers.

Finally, the TRC test cannot be applied meaningfully to load building programs, thereby limiting the ability to use this test to compare the full range of demand-side management options.

3.9 Societal Cost Test (SCT)

This test was not developed in the California's Standard Practice Manual. The DOE describes it as a variation of the TRC that includes monetized effects of externalities benefits and may use a "social" discount rate that is lower than that used in the TRC. It considers every aspect as the TRC plus non – monetized benefits and costs.

The Societal Test is an attempt to measure the net cost/benefit to society of a program or portfolio of programs. Simply put this is the Total Resource Cost Test with the cost and benefits to society added. The benefits to society are called "externalities." The externalities include benefits such as environment and health improvement. They also include participant benefits such as improved comfort and health.

Similar to other tests, the results of the Societal Test are expressed as a net present value, life cycle impact, or benefit - cost ratio. The results may be expressed in terms of life cycle impact or net present value per unit of energy saved.

This test is usually used in the political or regulatory environment to evaluate the impact of programs and whether these programs are beneficial to society as a whole.

3.9.1 SCT Benefits & Costs

Table 23 shows benefits and costs to all in the utility service territory, state, or nation as a whole. Note that in this case there are benefits taken in account that normally are not considered because of the difficulty of giving them a monetary value.

Table 23: SCT Benefits and Costs (National Action Plan for Energy Efficiency - 2008)

Benefits	**Costs**
- Energy-related costs avoided by the utility - Additional resource savings (i.e., gas and water if utility is electric) - Capacity-related costs avoided by the utility, including generation, transmission and distribution - Non - monetized benefits (and costs) such as cleaner air or health impacts	- Program overhead costs - Incremental measure costs and distribution (whether paid by the customer or utility) - Program installation costs

3.9.2 SCT Strength

The strength of the Societal Test is its ability to view costs and benefits from a much broader perspective and to include issues that society wants to address. Thus, it provides a framework with which to determine whether a program is desirable and should be implemented or continued.

3.9.3 SCT Weakness

The weakness of the Societal Test is in monetizing the externalities. Many of these are difficult, if not impossible, to represent accurately. Any arbitrary or misapplied monetization can significantly impact the test results providing an incorrect picture of the true environment in which the program will be delivered.

3.10 Section Conclusions

To assure the most accurate analysis from the energy effectiveness tests, their factors have to be correctly chosen. Although the Vision 2025 allows the evaluator to choose the components of the factors, this person must choose carefully the criteria for selection of components and they should be applied equally to all the tests that will be performed.

The portfolio will be applied along thirteen years, so it will be important to think, in the planning stage, about the mechanisms that will cope with the changes and additions that will occur over the time, in the components of the test factors, for proper evaluation and comparison of planned periodic goals.

4. Research Methodology

In this section it is described the research methodology. Figure 14 shows the steps that were considered and the sequence followed.

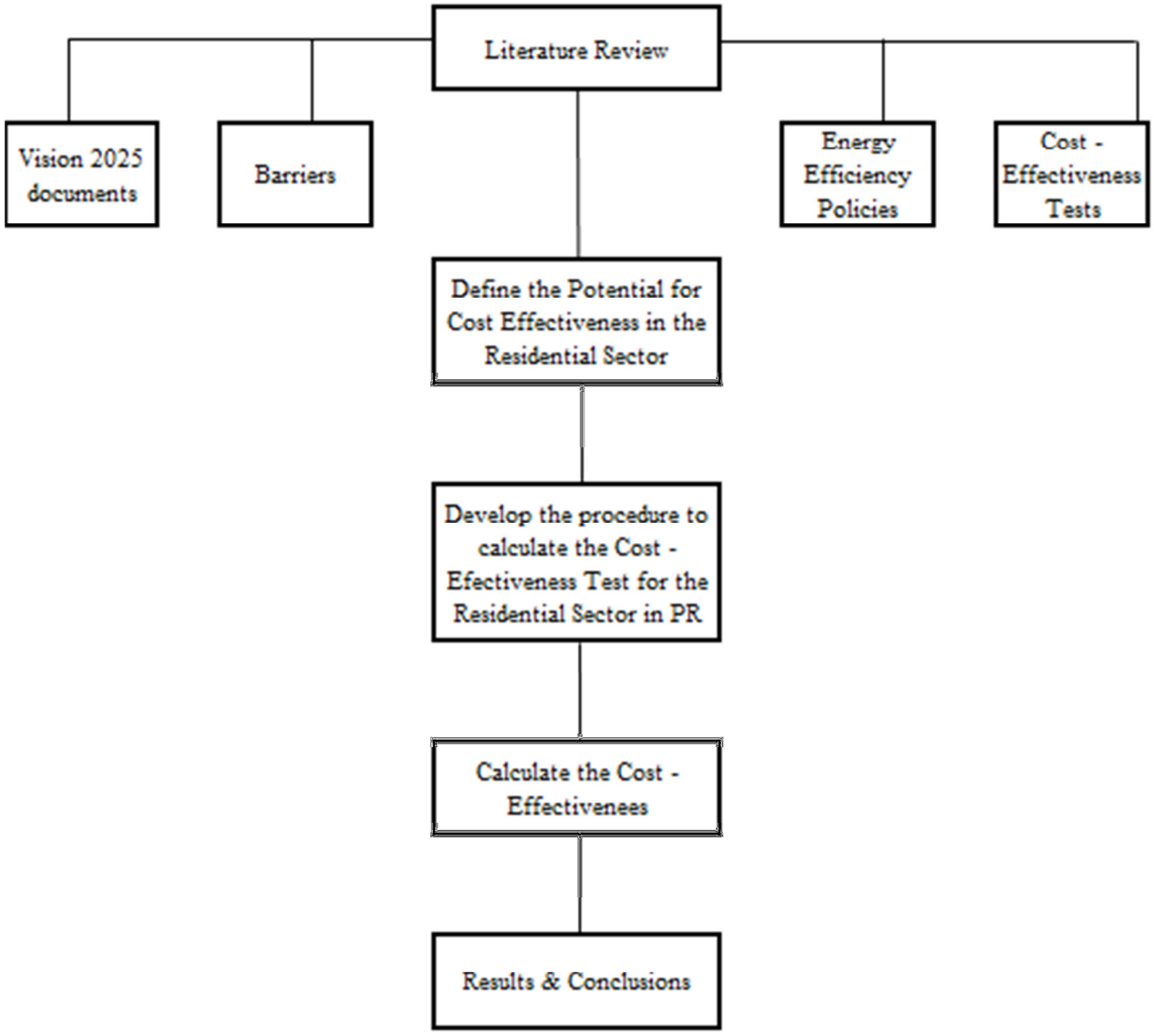

Figure 15: Energy Efficiency Research Methodology Flow Chart

This research is originated from the need to reduce dependence on imported fuel for electricity generation in Puerto Rico. As electricity generation depends on demand, what is important is decreasing electricity consumption, and it has been determinate that energy efficiency is the resource with most potential to reduce consumption and then reduce the need for imported fuels.

Figure 15 depicts a flow chart of the methodology used in performing this research, which is described below:

It was performed a literature review of documentation associated with the implementation of energy efficiency measures focused on the DOE program, Vision 2025, a revision of public policy development in the field of energy efficiency, barriers for the implementation of such policies and ultimately manuals and guidelines for evaluating cost effectiveness of energy efficiency initiatives were revised.

From the Potential Study of 2011, the residential electricity consumption sector was selected for its highest potential for electricity savings. Then a group of energy efficiency initiatives were selected to be part of the Portfolio of energy efficiency initiatives. Based on the suggestions mentioned in documents of Vision 2025, there was developed the methodology for assessing the energy efficiency measures selected. Then they were evaluated using the five cost effectiveness tests implemented for programs related to Vision 2025.

According to the results obtained necessary conclusions and suggestions for implementing the portfolio of energy efficiency measures.

4.1 Applying Cost Efficiency Tests - Procedure Description

1. Defining target: savings equivalent to 1% of electricity residential consumption (KWH)

2. Defining costs per initiative, per client. &. Defining savings per initiative, per client (KWH and $)

3. Finding the optimal subsidy for each initiative ($): searching for the optimal time to recover the investment (PV and nominal)

4. Optimize the distribution of efforts to achieve the most cost effective way for saving targets

5. Perform the Cost – Effectiveness Tests and evaluate them.

4.2 Expected Savings

The target of this project is to reach 1% annually savings of consumed electricity in the residential sector in Puerto Rico from 2013 to 2025 (13 years).

It is important to notice that until 2007 a stable growth in energy consumption (without major changes) in residential electricity was observed. Between 2008 and 2009 shows fluctuations in consumption happened. Since 2010, there has been a decrease in the consumption of electricity in Puerto Rico (probably by economic problems that have

plagued the island). For this reason it is difficult to choose the prediction of consumption bench mark. However, this research has been based on year 2011.

The energy spent in the residential sector in 2011 was 6,950 million KWH. Table 24 shows the expected savings per year from 2013 to 2025.

Table 24: Residential Sector Electricity Savings Expected Goal

	Consume	**Savings**	**Goal Expected**
Year	**millions of KWH**		
2013	6,953.39	69.53	6,883.86
2014	6,883.86	68.84	6,815.02
2015	6,815.02	68.15	6,746.87
2016	6,746.87	67.47	6,679.40
2017	6,679.40	66.79	6,612.61
2018	6,612.61	66.13	6,546.48
2019	6,546.48	65.46	6,481.02
2020	6,481.02	64.81	6,416.21
2021	6,416.21	64.16	6,352.04
2022	6,352.04	63.52	6,288.52
2023	6,288.52	62.89	6,225.64
2024	6,225.64	62.26	6,163.38
2025	6,163.38	61.63	6,101.75
	TOTAL =	**851.64**	**Million KWH**

One can see that the expected electricity savings do not follow a linear pattern, this is due to being posted savings of 1% on the expected consumption (affected by previous savings), this means that this subtracting 1% saving, over 99% of the previous year, and so on (See Figure 16).

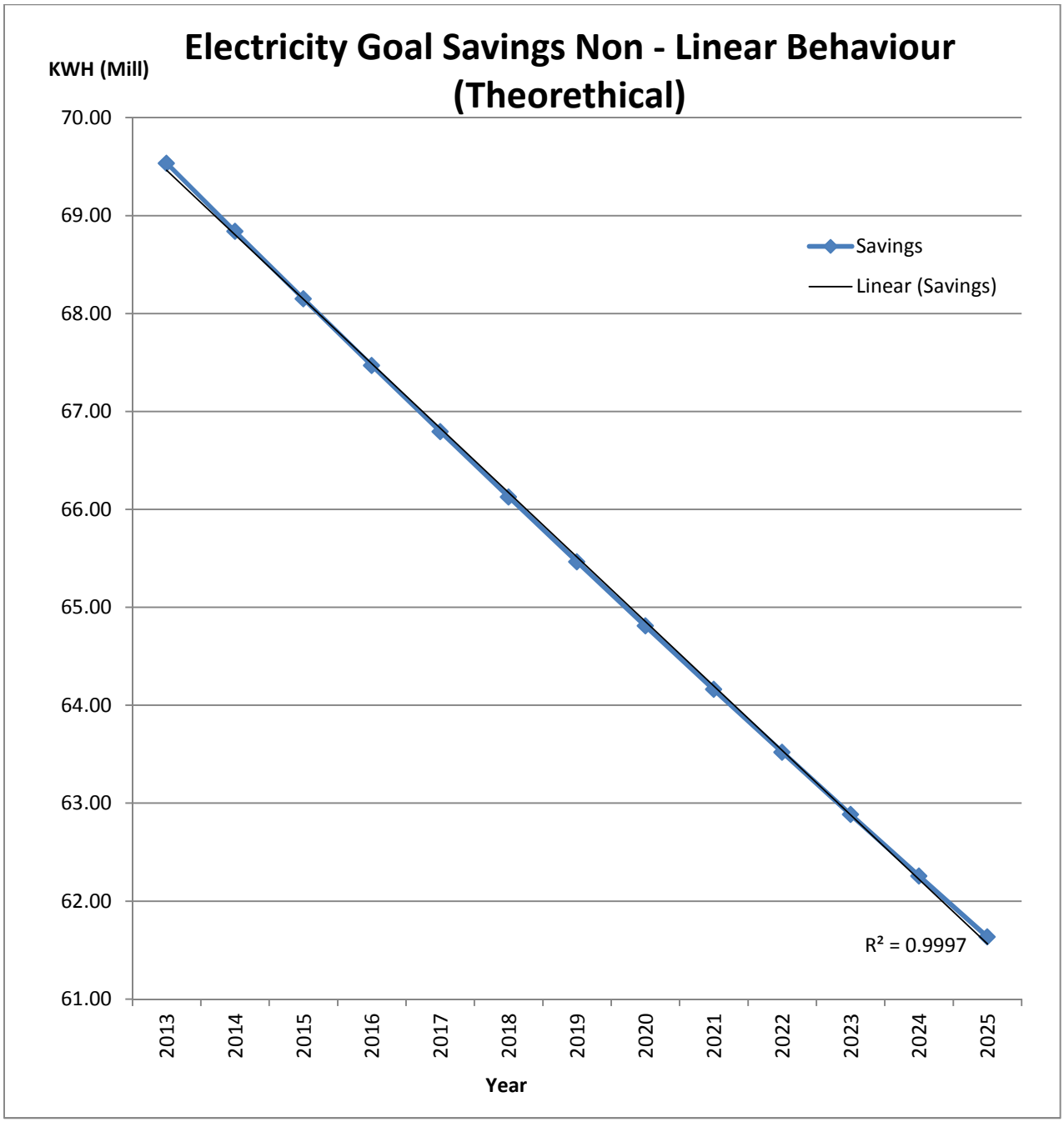

Figure 16: Theoretical Electricity Goal Savings Chart

4.3 Optimal Subsidy - Investment Return Time: Government and Client

Defining energy efficiency measure has to do with many factors: economy, finances, politics, society, willing, etc. But resources are very limited, so technically, these measures have to be chosen wisely, taking special care on the monetary issue of these initiatives.

Each initiative to be applied has an initial cost or investment. Depending on how much of this investment is provided by the government as subsidies; the client could decide to complete the remaining amount. In this case much is related to how long will take the client to recover the investment. This time can be defined when the accumulated savings are equivalent to the investment, so the savings turn to be earnings for the client (See Figure 17).

The payback is given by the electricity savings caused by the selected initiative. This saving has a face value that will be repeated in as time goes on, but whose real value over time, will be affected by the rate of decrease; if the rate is cero, then the value will not be affected.

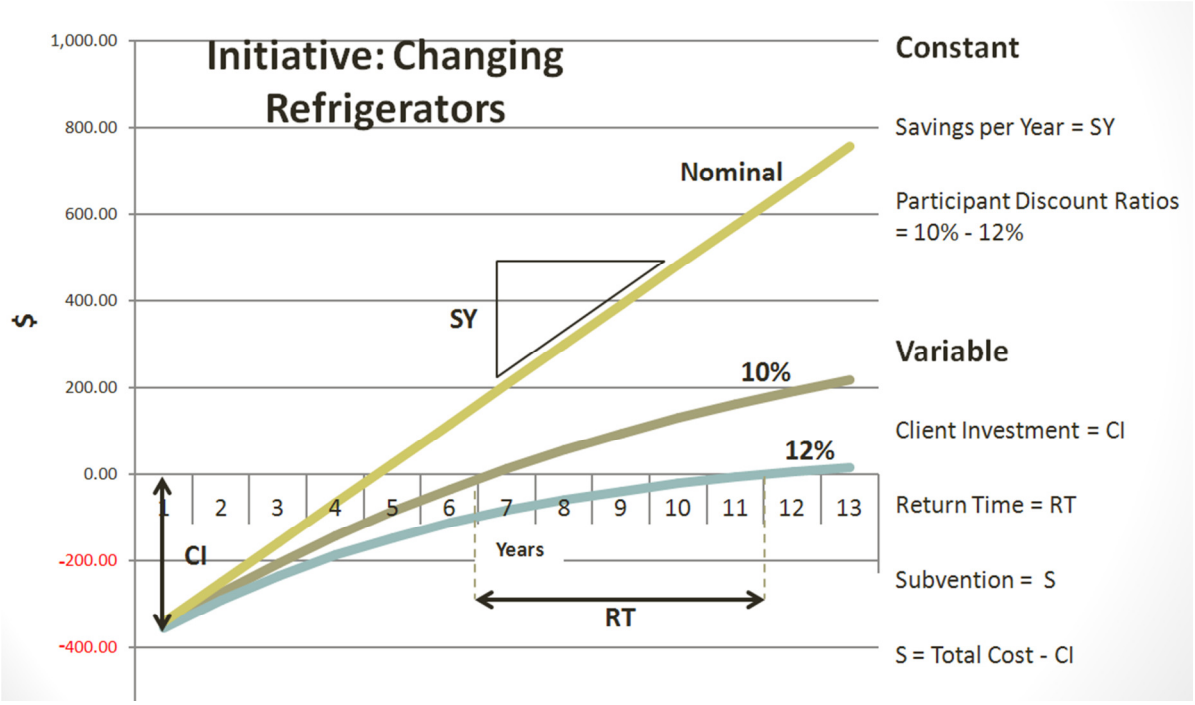

Figure 17: Investment Recovery Time Example Chart

4.4 Assumptions for the Initiatives

As mentioned before, the analysis will be made on the residential sector of the PREPA clients. There are 1,298,695 residential active clients in Puerto Rico (2012). The last whole year report (2011) shows a total consumption of 6,586.86 millions of KWH. The average residential consume per year (since 2000 to 2011) is 6,953.39 millions of KWH. The average consumption per client is 5174.4 KWH per year. These quantities have been accounted without the losses in transmission and distribution.

For the calculations in this document, the following assumptions were considered:

- **Changing sealing door and windows (living room and main bedroom)**

There is a maximum of 8% of houses with less than 15 years in Puerto Rico, the sealing properties of their doors and windows should be adequate yet to keep the conditioned air inside the mentioned rooms, so for the rest 92%, the sealing properties of their doors and windows are questionable.

To improve the performance of the A/C equipment, in other words to decrease A/C electricity use, this measure contemplates changing old doors and windows for new ones with sealing properties. This initiative contemplates to save an average rate of 30% of the A/C electricity (52).

House with two A/C equipment have been considered: one in the living room and one in the main bedroom. To seal these environments the following changes have been considered:

- In the living room: a house main entrance door (living room main door), an internal door and three windows

- In the main bedroom: the entrance door and two windows.

In total per client (per house) the items to change would be: 1 entrance door, 2 single doors, 5 windows.

A search was performed on the Puerto Rico market to locate the most affordable sealing doors and windows for a house.

The total cost to apply the mentioned changing is: $2,264.00 per client.

- **Installing Awnings Over Windows**

The Northwestern Alliance for Energy Efficiency considers 245 sqf as the average windows surface for a common house. Consulting Home Depot sellers (June, 2011) the best seller window measured 3.5' x 4' (about 14 sqf of surface). This is about 18 windows in a single house.

For this initiative, the considerations points again to increase the performance of the two A/C equipment mentioned in the last initiative. In this case the idea is decreasing the entry of solar radiation using the projection of shadow on the windows of the rooms equipped with A/C equipment. This could be achieved by installing awnings over the windows of the mentioned rooms (living room and bedroom). The savings of this initiative could reach 27% of the A/C electricity (49).

The windows where the awnings would be installed are localized on the living room (3 units) and on the main bedroom (2 units). According to hardware store sellers, the best seller window is 4' x 3.5' standard model. So in total 5 x 3.5' every benefit house will need 17.5' of lineal awnings (they are sold per lineal feet)

The cost per benefit client is: $1,200.00

- **Changing A/C Equipment**

The 2011 Potential Study considers two A/C equipment per house (client) to be replaced for Energy Star qualified equipment. Also indicates a potential of 50% of A/C electricity reduction.

Total cost per client: $989.00

- **Changing Indoor Lights**

According to EIA a high efficiency lamp can reduce the electricity consumption by 25%, although some manufacturers claim that savings could reach 75%. The Potential Study considers changing 10 fluorescent 13W saving lamps per client that would decrease electricity consumption in 19.6%. The mentioned energy efficient lamp has been assessed as Energy Star.

a Energy Star qualified

The research in the market brought this lamp as the most affordable one which would replace 60W – 100W traditional incandescent lamps. The total cost per client is: $105.1

- **Changing Refrigerators**

According to EIA, Energy Star refrigerators can save 35% of the electricity bill and the Potential Study indicates a potential of 64.3% to reduce the electricity in this concept. This initiative considers replacing the refrigeration unit for an Energy Star qualified unit.

In the Puerto Rico market, the most affordable equipment is: $539.99

- **Installing Solar Water Heaters**

The Potential Study of 2011 pointed a potential of 100% of the hot water used in the Puerto Rico homes, can be warmed up using solar shinning.

The cost of the equipment to be installed is: $1,495.00

4.5 Section Conclusions

Although the information obtained for assessments raised in this paper are from official sources and therefore reliable, it is necessary to conduct studies and investigations to obtain more precise results. It is important to note, however, that the main purpose of this project is the process itself, the methodology, and the results are the logical consequence of it.

5. Calculations

This section shows the cost - effectiveness calculation process performed in this work. The tables that will be mentioned along the explanation have some figures on a yellow background, those are input data, and those which don't have a background are working results.

5.1 Input General Data

Puerto Rico Electric Power Authority periodically publishes new data about number of clients, consumption per sector and residential KWH rate. This data is fundamental and the basis for calculations to start energy – efficiency initiatives evaluation, because it conforms the savings potential, the distribution of the initiatives and the distributed groups of clients along the time, who will be benefited with the initiatives (See Table 25).

Also it is important to notice the KWH price for residential clients; historically it has changed from $0.22 to $0.29 in the last 4 years and has been highly variable. The selected value to do the calculations is the April 2012 because was the last publicized by PREPA.

Table 25: Input PREPA data

Total Housing (units)	1,636,946.00
Total Population (people)	3,725,389.00
Total Residential Clients	1,298,695.14
Total Gross Production of Energy (10^9 KWH)	23.47
Total Consumption of Energy (10^9 KWH)	19.49
Total Residential Consumption of Energy (10^9 KWH)	6.95
Loss Energy in Transmission and Distribution (10^9 KWH)	3.98
% Used Energy	83.05%
% Lost Energy	16.95%
Consumption per Residential Client (KWh / RC)	5,354.14
Consumption per Capita (KWh / person)	1,866.49
Electricity Cost $/KWH - April 2012	$ 0.2858
Total Time (Years) =	13

5.2 Number of Clients per Use of Electricity Consumption and Electricity Spent (KWH - $)

The Tables 26, 27, 28, 29 showed in this section are used to determinate the number of clients who could be benefit from energy efficiency initiatives of the four main electricity consumption groups: A/C, lightning, water heating, and refrigeration; and also the KWH consumed and costs related.

These figures were obtained from estimated percentages from Potential Study and DOE and the total number of clients.

Table 26: Total number of clients with A/C and A/C electricity consume per client per year (KWH - $)

Clients with A/C %	50.00%
Clients with A/C	649,348
Electricity Spent in A/C	36.80%
KWH spent in A/C	1,970.32
$ spent in A/C	563.12

Table 27: Total number of clients with Indoor lightning and lightning electricity consume per client per year (KWH - $)

Clients with Lights %	100.00%
Clients with Lights	1,298,695
Electricity Spent in Lights	42.50%
KWH spent in Lights	2,275.51
$ spent in Lights	650.34

Table 28: Total number of clients with water heating and water heating electricity consume per client per year (KWH - $)

Clients with Water Heating %	80.00%
Clients with Water Heating	1,038,956
Electricity Spent in Water Heating	11.40%
KWH spent in Water Heating	610.37
$ spent in Water Heating	174.44

Table 29: Total number of clients with refrigeration equipment and refrigeration electricity consume per client per year (KWH - $)

Clients with Refrigerator %	100.00%
Clients with Refrigerator	1,298,695
Electricity Spent in Refrigeration	9.30%
KWH spent in Refrigeration	497.93
$ spent in Refrigeration	142.31

5.3 Initiatives Savings and Investment Return Period

This section presents the six energy efficiency initiatives and the results of applying the method proposed in Chapter 4. The initiatives are presented in subsections. Every initiative savings subsection has two tables and a chart. There is an exception in the first subsection; there are 3 Tables instead of 2, because this initiative has two savings element that has to be considered. The explanation of these is showed as follows:

- The Tables shows the following: savings in KWH and dollars, and the cost of implementing the initiative per client, and per year (See Tables 30, 33, 35,37,39, 41)

- In the second Table is showed the details of how are calculated costs and savings. There is a third table In the first initiative section: Sealing House – Decreasing Solar Radiation, it shows a second source of savings: changing windows is part of sealing the internal environment, also called envelope, but

also helps to decrease the solar radiation inside a room, which it helps to decrease the temperature of a room (See Tables 31, 32, 34, 36, 38, 40, 42).

There is also a chart in every initiative section. They show the percentage from the initiative cost that will be subsidized to impulse the program adoption. In every chart, the straight line represents the recovery of the investment in time, where the recovery ratio is cero; this is also called the nominal value, a value that is not been affected by any rate in the time. When the value Y = 0, X is the time of the investment return, without inflation or devaluation of the economy or no other factor that could not affect the investment value in the future: the value will be the same in the future as it is today. In this case the value X can be used with marketing purpose. However is not a right approach of the investment return time. The other two lines show the return of the investment when the return ratios are those found in the market, as mentioned in chapter 3, for residential clients in this case. When these lines cross the X axis, that mark the sensitive time of the client investment return (See Figures 18, 18, 19, 20, 21, 23)

The Initiative Changing Indoor Lights is a special case, because while there is a fast investment return time of 1 year, there is a chance of a little public response. To avoid this, the idea is to deliver a monetary incentive to promote the adoption of the measure.

5.3.1 Sealing House – Decreasing Solar Radiation

Table 30: Savings and Costs of Sealing House and Decrease Solar Radiation

A/C Savings	$	140.78	per client, per year
		492.58	KWH / Year
Total investment	$	4,229.00	per client
Clients with A/C %		50.00%	
Clients with A/C		649,347.57	
Electricity Spent in A/C		36.80%	
KWH spent in A/C		1,970.32	KWH
$ spent in A/C	$	563.12	
Electricity Cost $/KWH - April 2012	$	0.29	

Table 31: Detail of Savings and Costs Calculations - Sealing House - Decreasing Solar Radiation

	Initiative:	**Sealing House**			
	Potential Clients	50%	of clients with A/C		
		649,347.57			
	Principal Door	1	$ 159.00	$	159.00
	Indoor Door	2	$ 70.00	$	140.00
	Windows 4'x 4' (3 living room / 2 bedroom)	5	$ 393.00	$	1,965.00
			Cost per Client	$	2,264.00
	Savings with the measure				
per Client	% (energy spent in A/C)	12%			
	KWH	236.44	/ Year		
		$ 67.57	/ Year		

Table 32: Changing Windows to Decrease Solar Radiation

	Initiative:	**Change Windows to Decrease Solar Radiation**		
	Windows 4'x 4'	5	$ 393.00	$ 1,965.00
			Cost per Client	$ 1,965.00
	Savings with the measure			
per Client	%	13%	(7 - 15 %)	
	KWH	256.14		
	$	73.21		

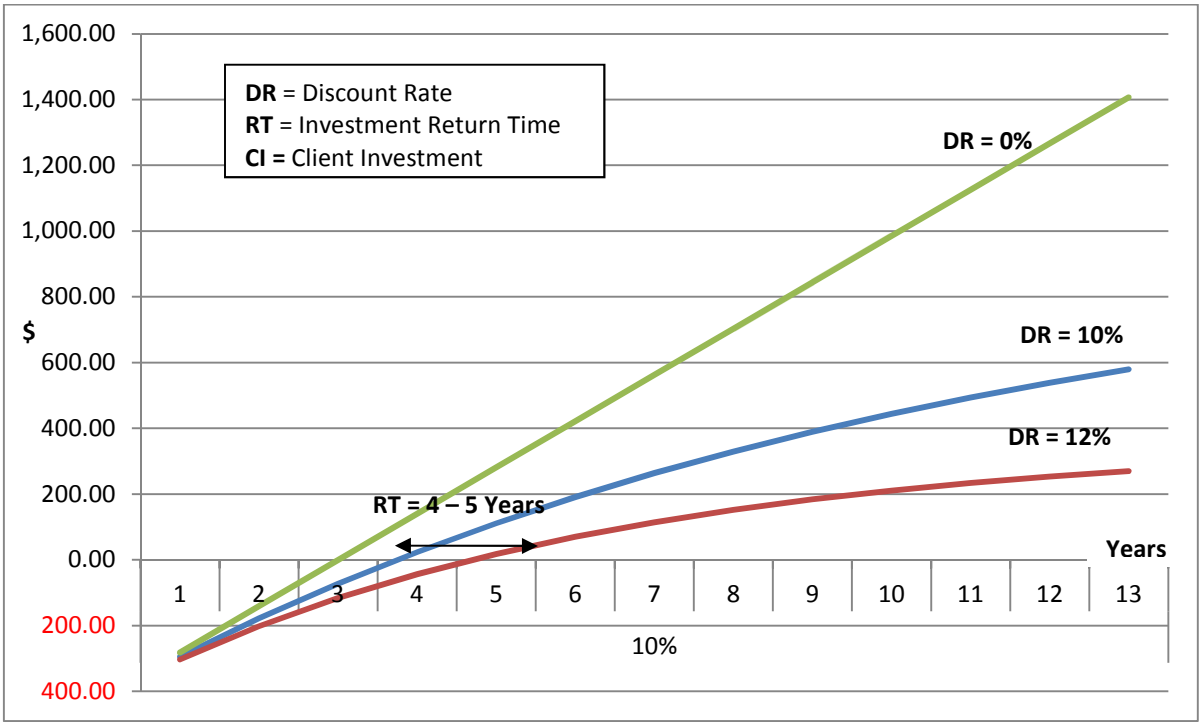

Figure 18: Sealing House – Clients Return Time

Period of Return 3 to 5 Years

5.3.2 Installing Windows Awnings

Table 33: Costs and Savings of Installing Windows Awnings

A/C Savings	$ 130.08	per client, per year
	455.14	KWH / Year
Total investment	$ 1,200.00	per client
Clients with A/C %	50.00%	
Clients with A/C	649,347.57	
Electricity Spent in A/C	36.80%	
KWH spent in A/C	1,970.32	KWH
$ spent in A/C	$ 563.12	
Electricity Cost $/KWH - April 2012	$ 0.29	

Table 34: Details of Costs and Savings - Installation of Windows Awnings

		Initiative:	**Windows Awnings**	
	Windows 4'x 4' Awnings			
	Total Windows 4'x 4'		5	Units
	Total Length		20	Foot
	Price per linear foot		$ 60.00	
	Cost per Client		$ 1,200.00	
	Savings with the measure			
	Windows Sun Light Heating		30%	all expenses in A/C
	Shade over windows can reduce		77%	of the sunlight heating
	Awnings can reduce		23%	all expenses in A/C
per Client		%	23%	
		KWH	455.14	
			$ 130.08	

Figure 19: Installing Windows Awnings - Return Time

Period of Return 3 to 5 Years

5.3.3 Changing A/C Equipment

Table 35: Costs and Savings Changing A/C Equipment

A/C Savings	$	281.56	per client, per year
		985.16	KWH / Year
Total investment	$	1,978.00	per client
Clients with A/C %		50.00%	
Clients with A/C		649,347.57	
Electricity Spent in A/C		36.80%	
KWH spent in A/C		1,970.32	KWH
$ spent in A/C	$	563.12	
Electricity Cost $/KWH - April 2012	$	0.29	

Table 36: Details of Costs and Savings - Changing A/C Equipment

	Initiative:	**Changing Air Conditioning Equipment**	
	Price per Unit	$ 989.00	LG Electronics 8,000 BTU 115v Window
	Units per Client	2	
	Cost per Client	$ 1,978.00	
	SEER 20 - 12000 Btu	50.00%	
	Savings with the measure		
per Client	%	50.00%	
	KWH	985.16	
		$ 281.56	

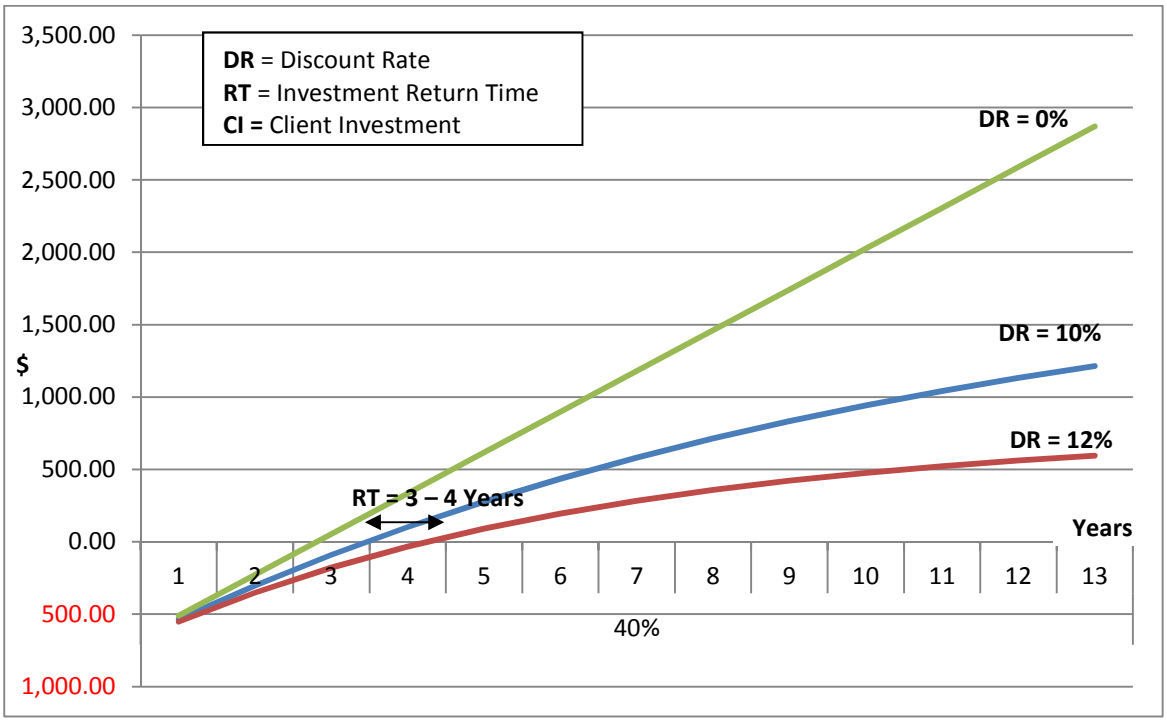

Figure 20: Changing A/C Equipment - Return Time

Period of Return 3 to 4 Years

5.3.4 Installing Solar Water Heaters

Table 37: Costs and Savings of Installing Solar Water Heaters

Water Heating Savings	$	174.44	per client, per year
		610.37	KWH / Year
Total investment	$	1,495.00	per client
Clients with Water Heaters %		50.00%	
Clients with Water Heaters		649,347.57	
Electricity Spent in heating water		11.40%	
KWH spent in heating water		610.37	KWH
$ spent in heating water	$	174.44	
Electricity Cost $/KWH - April 2012	$	0.29	

Table 38: Details of Costs and Savings - Installing Water Heaters

	Initiative:	**Solar Water Heaters**	
	Solar Water (installed)	$ 1,495.00	Clasificados de Puerto Rico
	Cost per Client	$ 1,495.00	
	Solar Water Heater can reduce	100.00%	of WH Electricity
	Savings with the measure		
per Client	%	80.00%	
	KWH	610.37	
		$ 174.44	

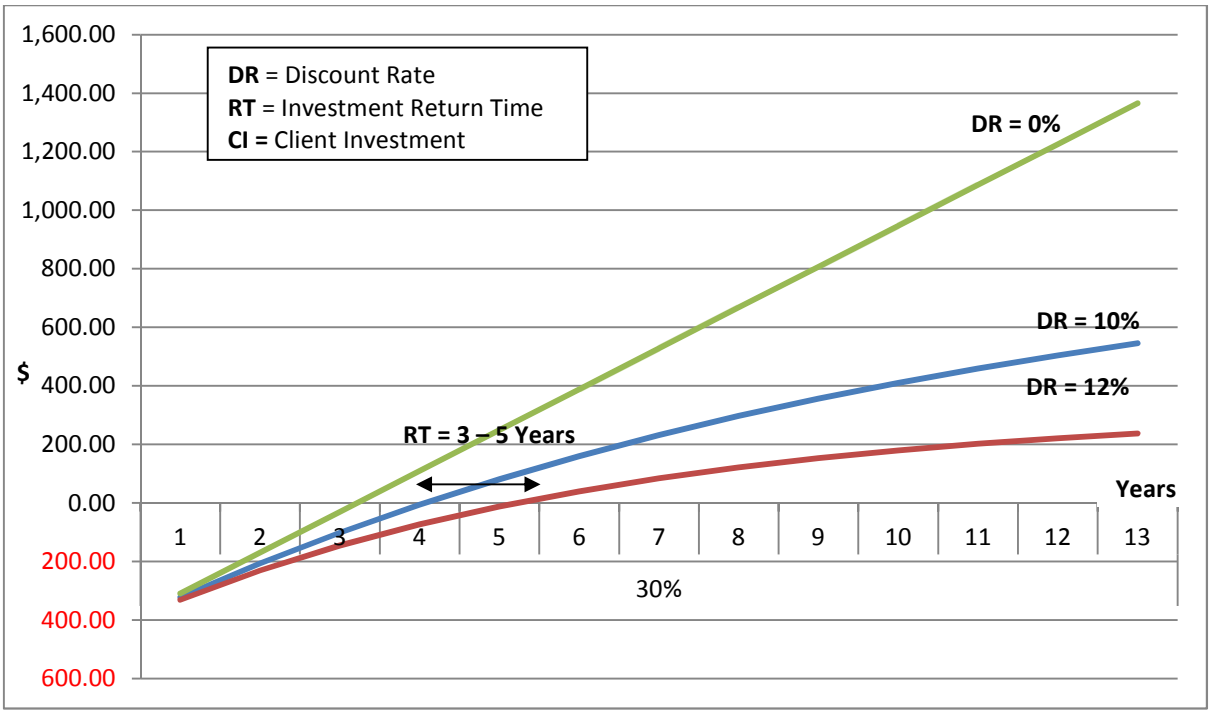

Figure 21: Installing Solar Water Heaters – Investment Return Time Period of Return 3 to 5 Years

5.3.5 Changing Indoor Lights

Table 39: Costs and Savings of Changing Indoor Lights

Lights Savings	*$*	*127.47*	*per client, per year*
		446.00	KWH/Year
Total investment	$	105.10	per client
Clients with Lights %		50.00%	
Clients with Lights		649,347.57	
Electricity Spent in Lights		42.50%	
KWH spent in Lights		2,275.51	KWH
$ spent in Lights	$	650.34	
Electricity Cost $/KWH - April 2012	$	0.29	

Table 40: Details of Costs and Savings - Changing Indoor Lights

Initiative:	**Changing Indoor Lights**		
No Lamps		10	Units
Cost per Energy Saving Lamp	$	10.51	(Home Depot 800 lumens: Eco Smart 14W)
Cost per Client	$	105.10	
Energy Star Lamps savings		19.6%	of Light Electricity
Savings with the measure			
per Client	%	19.60%	
	KWH	446.00	
	$	127.47	

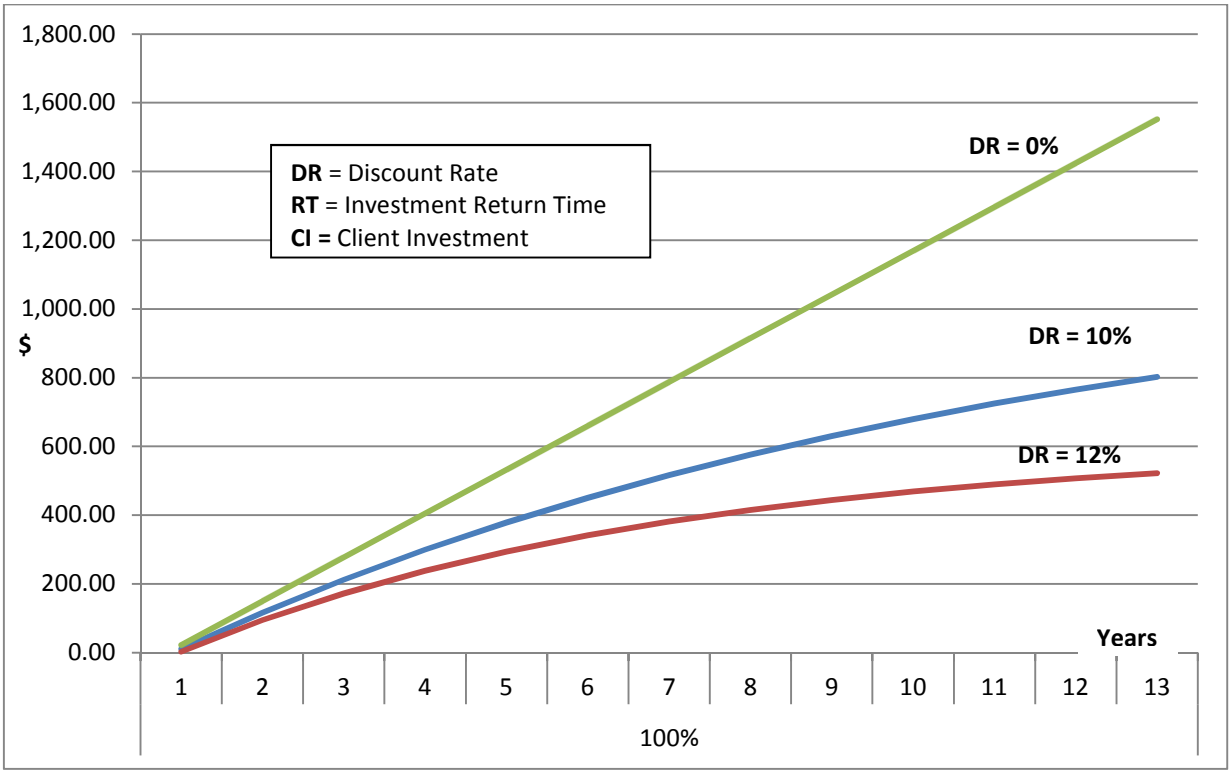

Figure 22: Changing Indoor Lights - Investment Return Time
Notice there is no need of an incentive for this measure

5.3.6 Changing Refrigerators

Table 41: Costs and Savings of Changing Refrigerators

Refrigeration Savings	$	91.51	per client, per year
		320.17	KWH / Year
Total investment	$	539.99	per client
Clients with Refrigerator %		50.00%	
Clients with Refrigerator		649,347.57	
Electricity Spent in Refrigerator		9.30%	
KWH spent in Refrigerator		497.93	KWH
$ spent in Refrigerator	$	142.31	
Electricity Cost $/KWH - April 2012	$	0.29	

Table 42: Changing Refrigerators - Details of Cost and Savings

	Initiative:	**Changing Refrigerators**		
	Price per Unit	$ 539.99		Frigidaire 18.2 cu. ft. Top Freezer Refrigerator
	Units per Client		1	
	Cost per Client	$ 539.99		
	Energy Star Equipment savings (20% Elec. Per Equipment)		64.30%	of Refrigeration Electricity
	Savings with the measure			
per Client	%		64.30%	
	KWH		320.17	
		$ 91.51		

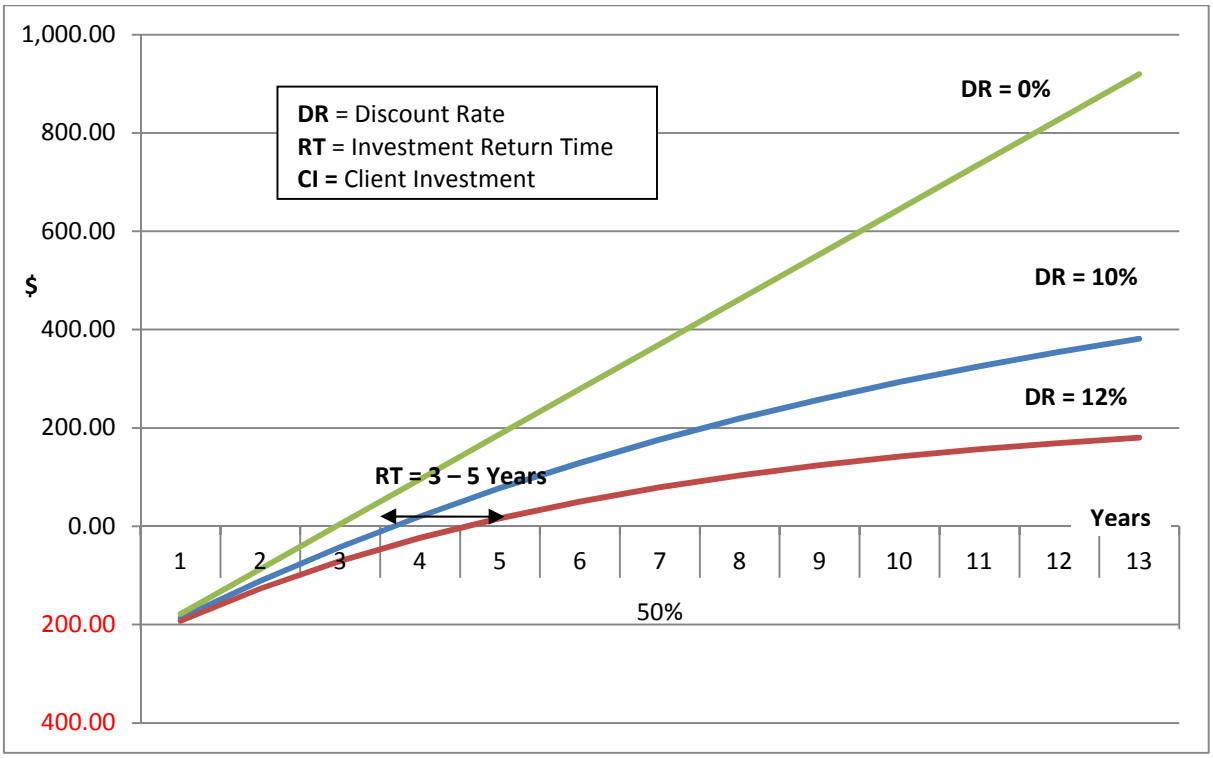

Figure 23: Investment Return of Changing Refrigerators

Period of Return: 3 to 5 Years

5.4 Totalized Incentives and Costs and Investment Return Period per Client

In this section Totalized Incentives and Costs in Present Value are presented, calculated per client. The obtained values were used in the calculations for the evaluation of the Portfolio of Energy Efficiency Initiatives (Section 2), the selected initiatives presented with their targets and period of application. For this reason the used rate in these calculations is the mandatory rate for administration entities, 8.5% in this case and the period of time is the highest (Table 43 column “Return Years”).

The Investment Return Periods were selected from the charts presented in the last section. In the single case of the lighting retrofit, the selection was based on the appreciation that return period was very short because of the little investment and the strong savings in electricity: If the client invest in 100% (PV = $96.86) in purchasing the efficient lamps, the return time will be less than a year. To encourage the clients to adopt this initiative, the proposed incentive should reach 50% of the total cost (PV = $48.43).

Table 43: Totalized Incentives and Costs & Investment Return Period

	Savings / Year		COST			COSTS		
INITIATIVE	**KWH**	**$**	**$ Total**	**Subvention**	**Return Invest Period**	**$ Incentives**	**TOTAL INCENTIVE**	**TOTAL COST**
Change Windows: Sealing House - Decrease Solar Radiation	492.58	$ 140.78	$ 4,229.00	90%	4-5	$ 3,806.10	$ 14,998.48	$ 16,664.98
Windows Awnings	455.14	$ 130.08	$ 1,200.00	70%	3-5	$ 840.00	$ 3,310.14	$ 4,728.77
Changing A/C Equipment	985.16	$ 281.56	$ 1,978.00	60%	3-4	$ 1,186.80	$ 6,074.65	$ 10,124.42
Change Water Heater to Solar Heater	488.30	$ 139.56	$ 1,495.00	70%	3-5	$ 1,046.50	$ 5,356.52	$ 7,652.18
Changing Indoor Lights	446.00	$ 127.47	$ 105.10	50%	0-1	$ 52.55	$ 48.43	$ 96.87
Changing Refrigerators	320.17	$ 91.51	$ 539.99	50%	4-5	$ 270.00	$ 1,063.95	$ 2,127.91

Total Clients = 1,298,695.14

Clients / Year = 99899.6

NOTE: Return Rate 8.5%

5.5 Totalized Participants per Initiative per Year & Total Costs, Incentives and Savings

Table 44 presents the expected Total Number of Participants per Initiative.

The Row No 1 of the Table 44 represents the percent of the total of residential clients that should participate in the initiative. The percent are selected using the difference between the calculated savings and the goal savings showed in the Table 45.

The participants per year results from dividing the total number of participants between the 13 years period. The Total Costs and Total Incentives per year are the costs and incentives multiplied by the number of participants per year.

The savings showed in rows 6 and 7 (participant rates of return 12% and 10% respectively) are also the savings present value per client multiplied by the number of clients benefit by the initiative per year.

Table 44: Totalized Participants per Initiative per Year & Total Costs, Incentives and Savings (12% and 10% Participants Investment Return Rates) per Year

		CH-W	I-WA	CH-AC	I-WH	CH-IL	CH-R			
1	**% of Total Clients (Participants)**	0.25%	2.00%	30.0%	7.8%	52.0%	25.0%			
2	**Total Participants**	3,247	25,974	389,609	101,298	675,321	324,674			
3	**Participants / Year**	250	1,998	29,970	7,792	51,948	24,975			
4	**Total Cost / Year**	$ 4.16	$ 9.45	$ 303.43	$ 59.63	$ 5.03	$ 53.14	**$ 434.84**	**Mill $**	
5	**Incentives / Year**	$ 3.75	$ 6.61	$ 182.06	$ 41.74	$ 2.52	$ 26.57	**$ 263.24**	**Mill $**	
6	**Savings per Year - Rate 12.00%**	$ 2.94	$ 21.70	$ 704.65	$ 90.81	$ 552.95	$ 293.97	**$ 1,667.02**	**Mill $**	Savings (i)
7	**Savings per Year - Rate 10.00%**	$ 3.25	$ 24.00	$ 779.22	$ 93.60	$ 611.46	$ 211.04	**$ 1,722.57**	**Mill $**	Savings (ii)

Table 45: Calculated Savings VS Goal Savings

Year	Year Start	Goal Savings	Year Finish	CH-W	I-WA	CH-AC	I-WH	CH-IL	CH-R	Calc. Sav.	Goal Savings	Total Savings
	millions of KWH											
2013	6,953.39	69.53	6,883.86	0.12	0.91	29.53	3.80	23.17	8.00	65.53	69.53	65.53
2014	6,883.86	68.84	6,815.02	0.12	0.91	29.53	3.80	23.17	8.00	65.53	68.84	131.05
2015	6,815.02	68.15	6,746.87	0.12	0.91	29.53	3.80	23.17	8.00	65.53	68.15	196.58
2016	6,746.87	67.47	6,679.40	0.12	0.91	29.53	3.80	23.17	8.00	65.53	67.47	262.11
2017	6,679.40	66.79	6,612.61	0.12	0.91	29.53	3.80	23.17	8.00	65.53	66.79	327.64
2018	6,612.61	66.13	6,546.48	0.12	0.91	29.53	3.80	23.17	8.00	65.53	66.13	393.16
2019	6,546.48	65.46	6,481.02	0.12	0.91	29.53	3.80	23.17	8.00	65.53	65.46	458.69
2020	6,481.02	64.81	6,416.21	0.12	0.91	29.53	3.80	23.17	8.00	65.53	64.81	524.22
2021	6,416.21	64.16	6,352.04	0.12	0.91	29.53	3.80	23.17	8.00	65.53	64.16	589.75
2022	6,352.04	63.52	6,288.52	0.12	0.91	29.53	3.80	23.17	8.00	65.53	63.52	655.27
2023	6,288.52	62.89	6,225.64	0.12	0.91	29.53	3.80	23.17	8.00	65.53	62.89	720.80
2024	6,225.64	62.26	6,163.38	0.12	0.91	29.53	3.80	23.17	8.00	65.53	62.26	786.33
2025	6,163.38	61.63	6,101.75	0.12	0.91	29.53	3.80	23.17	8.00	65.53	61.63	851.86

TOTAL S =	851.64
	65.51 / Year

	Saving. Calc.	Total Goal Savings	Sav. until 2025
Mill KWH	851.86	851.64	5963.00
Δ =		0.22	Mill KWH
		0.025%	

5.6 Savings on Fuel

The Table 46 shows how PREPA spend the incomings from its client's bills.

The Table 47 shows the used funds to buy the different fuels PREPA uses in electricity generation. This number includes the private companies that sell electricity to PREPA. The main fuel used to generate electricity in Puerto Rico is oil, which accounts for 69% of the total.

With the mentioned data, in addition to the electricity saved, a calculation can be performed that results in an estimated monetary savings in fuel. The main savings, as expected, is in oil: $ 0.00697 / kWh (generated)

Table 46: Distribution of PREPA Incomings (DATA Source PREPA, 2011)

	2008-2009			2009-2010			PROM	
	$ Mill		$ / KWH	$ Mill		$ / KWH		
Obligations and Contributions	$ 622.00	15.54%	$ 0.0336	$ 746.00	18.64%	$ 0.0404	$ 684.00	17.09%
Fuel	$ 1,919.00	47.95%	$ 0.1037	$ 2,007.00	50.15%	$ 0.1088	$ 1,963.00	49.05%
Purchased Energy	$ 672.00	16.79%	$ 0.0363	$ 694.00	17.34%	$ 0.0376	$ 683.00	17.07%
Salaries	$ 534.00	13.34%	$ 0.0289	$ 510.00	12.74%	$ 0.0276	$ 522.00	13.04%
Operational Spends	$ 255.00	6.37%	$ 0.0138	$ 216.00	5.40%	$ 0.0117	$ 235.50	5.88%
Total	$ 4,002.00		$ 0.2163	$ 4,173.00		0.2169		

Table 47: Electricity Generation Fuel Costs Distribution in Puerto Rico & Fuel Expected Savings EIA 2009

		SAVINGS / FUEL		
$ FUEL DISTRIBUTION - PR (EIA 2009)		**Mill KWH**	**MILL $**	**$/KWH**
Petrol	69.0%	4114.47	$ 576.79	$ 0.0967
Coal	15.0%	894.45	$ 125.39	$ 0.0210
Natural Gas	15.0%	894.45	$ 125.39	$ 0.0210
Renewables	1.0%	59.63	$ 8.36	$ 0.0014

TOTAL	$ 835.93
Fuel Cost / KWH	$ 0.140

5.7 Tests Results

This section presents the Energy Efficiency Tests. TABLE 48 shows the benefits and costs to perform the tests.

The calculations were performed following the directions of the Section 4.5 (See Table 18) of this document, as a compilation of the Vision 2025 documents and California Standard Practice Manual. For the calculations it has been considered the two participant ratios suggested by Vision 2025 documents, to observe how these differences might affect that may be great for individual public but there are small at first.

Calculations are performed in Tables 49, 50, 51, 52, 53, 54.

Table 48: Benefits and Costs of the Suggested Initiatives (Participants Rates)

	Factor Description	$ Factor
1	Administrative and Marketing	$ 59.44
2	Incentives, Direct Installation, Upstream Payments	$ 263.24
3	Installation Costs for Customers (before incentives)	$ 434.84
4	Avoided Cost Savings to the Utility (Saved Fuel)	$ 835.93
5	Bill Savings to the Customers (Discount Ratio 10%)	$ 1,495.42
	(Discount Ratio 12%)	$ 1,550.97
6	Reduced Carbon Dioxide Emissions (CO2)	$ 47.718

Table 49: PCT Test (values in $ millions)

	PCT 12.0% Benefits	PCT 12.0% Costs	PCT 10.0% Benefits	PCT 10.0% Costs
Program overhead				
Program incentives	$ 263.24		$ 263.24	
Measure costs		$ 434.84		$ 434.84
Energy savings (net)				
Bill savings	$ 1,495.42		$ 1,550.97	
Monetized emissions (net)				
Non-energy benefits				
Total	$ 1,930.26	$ 434.84	$ 1,985.81	$ 434.84
Net benefit	$ 1,495.42		$ 1,550.97	
Benefit-cost ratio	4.44		4.57	

Table 50: PACT Test (values in $ millions)

	PACT 12.0% Benefits	PACT 12.0% Costs	PACT 10.0% Benefits	PACT 10.0% Costs
Program overhead		$ 59.44		$ 59.44
Program incentives		$ 263.24		$ 263.24
Measure costs				
Energy savings (net)	$ 835.93		$ 835.93	
Bill savings				
Monetized emissions (net)				
Non-energy benefits				
Total	$ 835.93	$ 322.68	$ 835.93	$ 322.68
Net benefit	$ 513.25		$ 513.25	
Benefit-cost ratio	2.59		2.59	

Table 51: RIM Test (values in $ millions)

RIM	12.0%		10.0%	
	Benefits	Costs	Benefits	Costs
Program overhead		$ 59.44		$ 59.44
Program incentives		$ 263.24		$ 263.24
Measure costs				
Energy savings (net)	$ 835.93		$ 835.93	
Bill savings		$ 1,667.02		$ 1,722.57
Monetized emissions (net)				
Non-energy benefits				
Total	$ 835.93	$ 1989.7	$ 831.73	$ 2,174.55
Net benefit	$	-1,153.77	$	-1209.32
Benefit-cost ratio	0.42		0.41	

Table 52: TRC Test (values in $ millions)

TRC	12.0%		10.0%	
	Benefits	Costs	Benefits	Costs
Program overhead		$ 59.44		$ 59.44
Program incentives				
Measure costs		$ 434.84		$ 434.84
Energy savings (net)	$ 835.93		$ 835.93	
Bill savings				
Monetized emissions (net)	$ 47.72		$ 47.72	
Non-energy benefits				
Total	$ 883.65	$ 494.28	$ 883.65	$ 494.28
Net benefit	$	389.37	$	389.37
Benefit-cost ratio	1.79		1.79	

Table 53: SCT Test (values in $ millions)

	SCT 12.0%		10.0%	
	Benefits	Costs	Benefits	Costs
Program overhead		$ 59.44		$ 59.44
Program incentives				
Measure costs		$ 434.84		$ 434.84
Energy savings (net)	$ 835.93		$ 835.93	
Bill savings				
Monetized emissions (net)	$ 47.72		$ 47.72	
Non-energy benefits				
Total	$ 883.65	$ 429.28	$ 883.65	$ 429.28
Net benefit	$ 389.37		$ 389.37	
Benefit-cost ratio	1.79		1.79	

Table 54: Savings Percentages and Totalized Costs, Incentives and Costs after Scope Time

Initiatives	CH-W	I-WA	CH-AC	CH-WH	CH-IL	CH-R
% Savings	0.19%	1.39%	45.06%	5.81%	35.36%	12.20%
Total Costs	$ 0.03	$ 0.12	$ 3.94	$ 0.78	$ 0.07	$ 0.69
Total Incentives	$ 0.03	$ 0.09	$ 2.37	$ 0.54	$ 0.03	$ 0.35
Total Savings 12%	$ 0.04	$ 0.28	$ 9.16	$ 1.18	$ 7.19	$ 3.82
Total Savings 10%	$ 0.04	$ 0.31	$ 10.13	$ 1.22	$ 7.95	$ 2.74

Note: These values are accumulated along the 13 years project period.

6. Conclusions and Recommendations

6.1 Discussion of the Tests Results

Energy Efficiency tests were performed to evaluate a portfolio of energy efficiency initiatives that are suggested with the goal to decrease 1% of electricity consume per year in the residential sector in Puerto Rico. These initiatives are defined in Chapter 2 and go along with what was defined in the Energy Efficiency Potential Study of 2011.

This section presents a brief discussion of the results of each cost – efficiency test. They were performed using two different discount ratios 12% and 10% suggested in Vision 2025 documents.

The Table 55 shows the results of all the Energy Efficiency Cost Effectiveness Test performed for the study presented on this document.

Table 55: Benefit - Cost Tests Results

	NET BENEFITS (NB) $ Millions		BENEFIT - COST RATIO (BCR)	
	12%	10%	12%	10%
PCT	$ 1,495.42	$ 1,550.97	4.44	4.57
PACT	$ 513.25	$ 513.25	2.59	2.59
RIM	$ - 1,153.77	$ - 1,209.32	0.42	0.41
TRC	$ 389.37	$ 389.37	1.79	1.79
SCT	$ 389.37	$ 389.37	1.79	1.79

Four of the five cost effectiveness test results present positive Net Benefits (NB) and Benefits Cost Ratios (BCR) over 1, except the RIM test that presented a negative NB value. At first sight this means that the suggested initiatives have potential to reach the target of 1% of savings per year based on the electricity consumed by the residential sector in Puerto Rico, since the energy efficiency portfolio presented here is expected to meet the needs to fulfill the objective.

The Participant Cost Test presents the highest positive Net Benefits ($1495.42 and $1550.97 million for discount rates of 12% and 10% respectively). This is because the bill savings are significantly higher than the costs involved in the adoption of the suggested initiatives. These figures represent a strong economic incentive for the clients to participate, because they will get high benefit and a low payback period. This can be verified by checking the values of Benefit - Cost ratio: 4.44 for 12% discount rate and 4.57 for 10% discount ratio, with an average of 4.5. It means that for every $1 invested in the energy efficiency portfolio, in a period of 13 years to reach the goal of 1% energy efficiency per year, there will be $4.5 in gross benefits for the participant. But these results are also a warning for the utility, because greater savings mean less income from the electricity bills of each client every year. Due to that fact, the utility must decide what resources they will allocate and how they might be impacted by the possible reduction in incomes.

In the case of the PACT test the administrator of energy efficiency programs is seen as a different institution from the entity in charge of selling electricity, therefore bills reduction are not considered in the calculations. In this case the Net Benefits calculated was $513.25 million; this positive value indicates that the total costs to save energy are less than the

costs of the utility delivering the same power. The benefits of the measures, mostly based on fuel not purchased, will exceed the costs. These results also show that customer average bills will eventually go down if efficiency is implemented. The Benefit - Cost Ratio reach 2.59 for both discount rates studied and that means that the benefits will be more than two and a half times the related direct costs of implementing the measure.

Ratepayer impact measure test (RIM) is the only one with negative NB and BCR below 1. By looking at the input data the reader can find that the bill savings are the highest value to consider, 50.39% and 51.21% for 12% and 10% respectively (See Table 56). In this case the avoided costs of savings in fuel are not enough to cover the drainage of income from the reduction in the bills. Remember that PREPA covers its expenses from the collection of payments from electricity sales concepts. At first sight this can be considered as a problem for the utility and / or the programs administrator, but it is really a warning that may incentive the utility to consider that instead of rising the KWH price, they must separate the payment of fixed expenses, salaries, programmed maintenance, or others, in a fixed quantity equally distributed in the bills of all the residential clients; from the total electricity consume. This has been called decoupling. It is also important to mention that in this case, non - participants might feel affected with extra fees to cover losses due to the participants lower electricity consumption based on energy efficiency initiatives adopted. Participants have the opportunity to be less affected, as the billing from consumption will be less. It is important to note that if there is not any palliative measure like compensation funds or different base rates or the creation of a separate special rate of base rates, there could appear resistances to the initiatives from customers who have not yet adopt the measures. It has to be mentioned that the positive PACT result shows that there are saving funds from fuel

savings that can be used to compensate the reduction of incomes. More accurate analysis has to be performed to determinate how much can be used from the mentioned funds.

Table 56: % of Participation of Benefits and Costs of the Suggested Initiatives

	Rate 12%	Rate 10%
Administrative and Marketing	1.80%	1.77%
Incentives, Direct Installation, Upstream Payments	7.96%	7.83%
Installation Costs for Customers (before incentives)	13.14%	12.93%
Avoided Cost Savings to the Utility (Saved Fuel)	25.27%	24.85%
Bill Savings to the Customers	50.39%	51.21%
Reduced Carbon Dioxide Emissions (CO2)	1.44%	1.42%

The primary purpose of the TRC is to evaluate the net benefits of energy efficiency measures to the region as a whole, it do not take care of the individual stakeholder. This positive test result, $389.37 million, indicates that the program will produce a net reduction in energy costs in the utility service territory over the lifetime of the program. But the Administrator Program has to take special care to palliate the rejection from the no participants. Bill savings are not considered because inside the society the resources in movement are not necessarily considered, benefits to clients and costs to the utility cancel each other on a regional level.

The SCT includes costs and benefits beyond the immediate region and those that are not monetized in the TRC, but it also includes environmental and other non - energy benefits that are not currently valued by the market. The SCT may also include non - energy costs such is the wellbeing feeling of the participants but also the reduction of the non

participants comfort levels, and the reaction change, monetarily speaking. For this evaluation no information or theories could be found about these topics. The SCT NBV is $389.37 million, and the CBR 1.79 which means implementing the evaluated portfolio will be beneficial for the target region.

6.2 Conclusions

- After performing an overall analysis of the energy efficiency measures it can be mentioned that it is possible to achieve the goal of reducing 1% of electricity consumption per year in the residential sector.

- The positive Net Benefit results in PCT, PACT, TRC and SCT and their benefit – cost ratios over 1, demonstrate that the energy efficiency initiatives portfolio is a resource that can expect greater benefits than the costs involved and should be considered for reducing the consumption of electricity, in the effort to reduce Puerto Rico dependence on imported fuels.

- According to the review of the legislation in Puerto Rico in energy efficiency measures, it can be determined that to meet the target of 1% annual reduction on electricity consumption for the residential sector, it is necessary to develop legislation in energy efficiency for this sector because there is none. Current law only covers industry, tax incentives for to be taken in capital investments and research.

- In the theoretical review there is an issue that has to be taken in account when determining the costs of the energy efficiency portfolio measures, to implement a program to inform and to educate consumers on the consistency of the measures that will benefit them must be implemented. This is necessary for consumers to continue with the measures once the subsidies run out.

- Construction related measures are the most expensive of the portfolio, but should not be discarded until it is demonstrated that the other measures can reach the target of 1% savings on electricity per year.

6.3 Recommendations

- During the course of this research, the main problem for developing calculations performed here was the collection of data because certain reticence and reluctance from institutions those own such data. It is necessary to mention that this kind of effort requires a closer and more permanent collaboration from the agencies and institutions that handle the technical and economic information on the factors mentioned in this research, costs, users, consumption to determine more accurately the results listed here.

- According to the evaluation of the measures suggested, changing interior lights is the best initiative because of the low investment and the short recovery time. However, it should be noted that this measure involves a change in the habits of the people, for the light cast by an efficient lamp is sometimes less intense than

an incandescent, there is possible rejection of a beneficiaries percentage for accepting this measure in addition to the continued use of such lamps. It requires the implementation of a program of education to minimize this possibility, along with a pre - selection of beneficiaries of this program.

- Changing A/C equipment and refrigeration equipment came in second place in the initiatives evaluation. There has to be special care with this initiative because there should have to be created control measures for removal and disposal of the changed equipment because some initiatives beneficiaries who have the new and the old equipment could use both. This would increase the electricity consumption. There has to be considered the cost of a recall system for the old equipment and the implementation of centers to process it.

- Apply an energy efficiency test requires a great amount of resources, collecting, synthesizing and developing data, and a great consumption of human resources. Most of the Program Administrators do not use all of the tests but about three. The selection of the tests has to be done meticulously. Public policy developers have to consider the stakeholders main interests before starting planning the evaluation of any initiative.

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