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Alternate energy strategies based on"clusters"

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CONTENIDO

EXECUTIVE SUMMARY

Report description

The main objective of the report is to lay the basis for the drafting of an energy policy based on the concept of "clusters." To that end, we initially present an exhaustive analysis of the performance of renewable energy investment and its characteristics at the global level; which renewable energy technologies have been developed; and which economies have gone farthest in the development of renewable energy sources.

Main Findings

- Renewable energy has increased in global importance, accounting for close to 6% of electric power generation in 2010 compared with 3.5% in 2004.
- There is a growing worldwide demand for renewable energy. It is estimated that by 2035 the net generation of renewable energy will grow by 3.1% yearly.
- In the United States, between 2001 and 2011, renewable (non hydroelectric) energy increased considerably as a proportion of total power generation, especially eolic energy.
- At the global level, investment increased to $211 billion in 2010, experiencing an annual compounded growth of 36% between 2004 and 2010, concentrated chiefly on eolic and solar energy. This pattern is expected to continue in coming years.
- Investment in China has contributed considerably to this expansion, earning the country the No. 1 spot worldwide.
- Governments have had a key role in accelerating expansion and development of renewable energy. The number of countries with some type of renewable energy policy or support increased from 55 in 2005 to 119 in 2011.
- Public support has been very important to the development of renewable energy. Non renewable energy sources still receive 86% of global energy subsidies. It is

estimated that these subsidies will increase, from $66 billion in 2010 to $250 billion by 2035.

- Funds from the American Recovery and Reinvestment Act (ARRA) have been key to the expansion of renewable energy in the United States. In federal Fiscal Year 2010, they represented 42% of total subsidies, direct expenditure, and support (tax relief and other kinds) allocated to renewable energy. These, in turn, represented 39.5% of total subsidies and supports earmarked for electric energy production, an increase compared with 29% in 2007.
- In 2009, $25 billion were committed to the development of renewable energy.
- In Puerto Rico, the adoption of a public policy to promote renewable energy as an alternate energy source has contributed, together with federal programs, to generating renewable energy projects. Already there are $498 million worth of investments planned or in the development stage.
- Based on the literature on "cluster" policies, induction government policies are preferable to direct intervention policies, save when the failings of the market or system are evident.
- Puerto Rico's so called "green economy" sector, which would encompass everything related to renewable energy, is still very small. The number of green jobs in Puerto Rico does not exceed 4,600 per year.
- This number can increase given at least two factors: (1) as the adoption of renewable energy technologies is expanded, the impact in terms of jobs will increase; and (2) the availability of government incentives for such projects.
- We developed a five-year economic impact exercise tied to investment in construction (a breakdown of individual investments is not available). The total amount of the investment ($498 million) was applied to our input-output model to get estimates of the direct and indirect impact on production, employment and payroll for that period.

- In terms of jobs, the construction phase would generate a total of 6,532 direct and indirect jobs for a total payroll of $164.4 million.
- The Caribbean region, is potentially the most relevant market for the development of renewable energy "clusters" for three reasons: (1) geographic proximity; (2) similar climate; (3) the need to explore energy alternatives due to dependence on fossil fuels.
- The two technologies with the most production potential in the Caribbean, primarily the Dominican Republic and Haiti, are photovoltaic panels and eolic. In terms of total resources, the Dominican Republic stands out with 61% of the total.
- The Irizarry, Colucci and Carrillo study (2008) recommends incorporating three renewable energy sources in the "Renewable Portfolio Standards": eolic, photovoltaic solar cells, and ocean energy. They consider that using a mere 10% of these sources would provide 115% of the electric power demand (as of 2006). Location potential factors identified in the study serve as the basis for the renewable energy strategy developed subsequently in the 2012 report (see Appendix A).
- An essential action for implementing the cluster based renewable energy policy in the creation of the appropriate institutional framework, including the designation of an entity to manage the process. The recommendation made is for the Council on Energy Autonomy to assume that responsibility.

1. INTRODUCTION

1.1. Definition of "clusters"

There are diverse definitions of the term "clusters." The Organization for Economic Cooperation and Development (OECD) defines it as "production networks of highly interdependent businesses (including specialized providers), united to each other in a production chain that adds value."

The common denominator in all "clusters" is the interrelation of participating actors.

There is an ever growing appreciation towards cluster based development initiatives as one of the most effective means of creating an environment thath stimulates innovation. This is the focus and justification for proposing a "cluster" strategy as an instrument for the implementation of a renewable energy policy in Puerto Rico.

What are "Clusters"

- An instrument to overcome obstacles, make it easier for businesses and government to unite efforts and resources with other entities, organizations of the private and public sector, and academia, to achieve a common vision or objective.
- One of the more effective means to stimulate an environment that will lead to innovation.
- At the heart of all "clusters" is the interrelation of the actors involved in the "clusters" and an interest in analyzing the same.

1.2. Purpose of the study

The main objective of the report is to develop a strategy that will serve as a guide or basis for the drafting of an energy strategy based on the concept of "clusters." To that end, we present, first of all, an exhaustive analysis of the performance and characteristics of global renewable energy investment and use, the renewable energy technologies, and the economies that stand out in developing renewable energy.

Second, show the importance of government support in the development of renewable energy policies, the types of policies in place and the magnitude of global government support for the production of electric power, especially using renewal energy sources.

Third, present an analysis of the energy "cluster" policy, the types of policies, and the role that energy plays in them. This chapter, together with the previous two chapters, serves as the basis for the strategies presented in Chapter 6.

Chapter 5 presents an analysis of the economic impact along with investment opportunities in technology, and Chapter 6 is a summary of the main findings and conclusions.

2. BACKGROUND: RENEWABLE ENERGY USE AND DEMAND AT THE GLOBAL LEVEL

The development of a public policy reflects, or should reflect, among other things, the external environment as well as the internal requirements and the domestic demand. Business opportunities are as much influenced by these aspects as by the public policy that is implemented.

The chief aim of this chapter is to examine what the recent external environment has been in terms of renewable energy. Specifically, it will focus on key aspects, such as investment, the demand for energy, and changes in the type of energy that is being used, allowing us to identify trends in the coming years.

For example, the International Energy Agency (IEA) estimated in 2011 that global renewable energy subsidies will increase from $60 billion in 2010 to $250 billion in 2035, a compounded yearly growth of 6%. On the other hand, it is unclear what is going to happen in the case of the United States when funding from the American Recovery and Reinvestment Act (ARRA), which has played a key role in expanding renewable energy since 2009, ends in 2014.[1]

The chapter also reviews the situation in Puerto Rico and what is foreseen in terms of investment over the coming years.

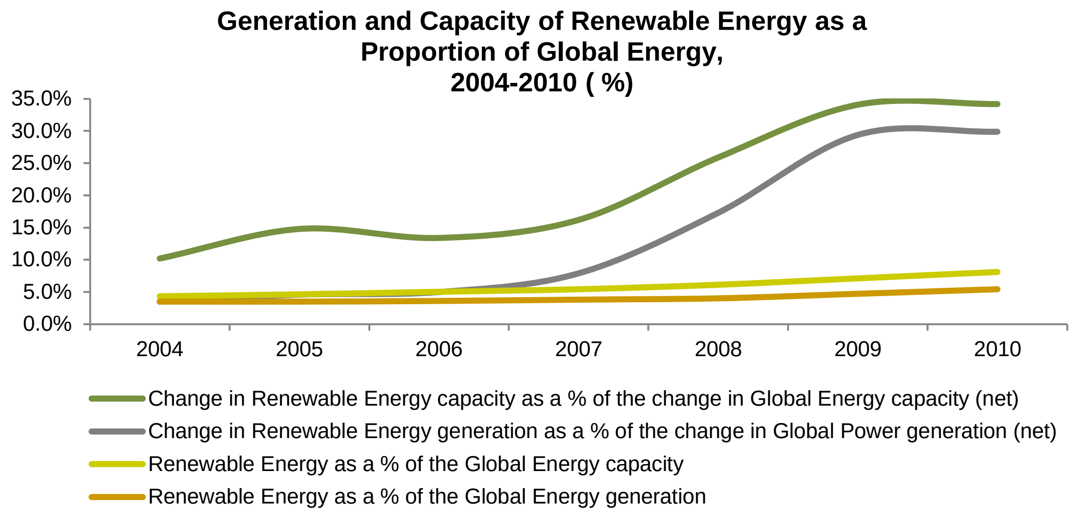
2.1 Production and generation of primary and renewable energy

The increase in renewable energy production capacity, as a proportion of global energy production in recent years, has been significant.

In 2004, renewable energy sources accounted for 3.5% of global energy production, increasing to 5.4 % by 2010; their share of global energy capacity increased from 4.3% to 8.1% during that same period.

[1] See Jesse Jenkins, Mark Munro et.al. (2012), and Adam Looney y Michael Greenstone (2012).

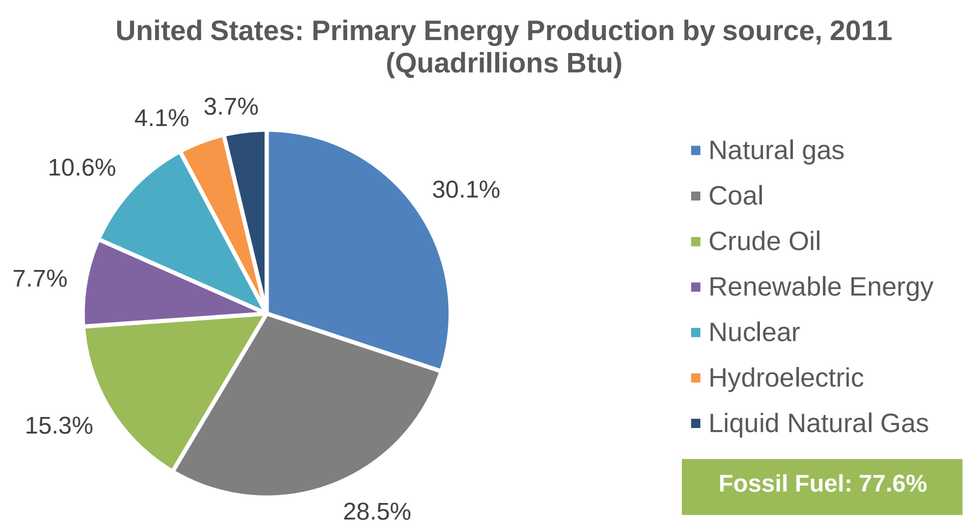
Chart 1



Source: United Nations (2012), *Global Trends in Renewable Energy Investment, 2011.*
Note: Facts about renewable capacity are based on the aggregate totals of Bloomberg New Energy Finance.

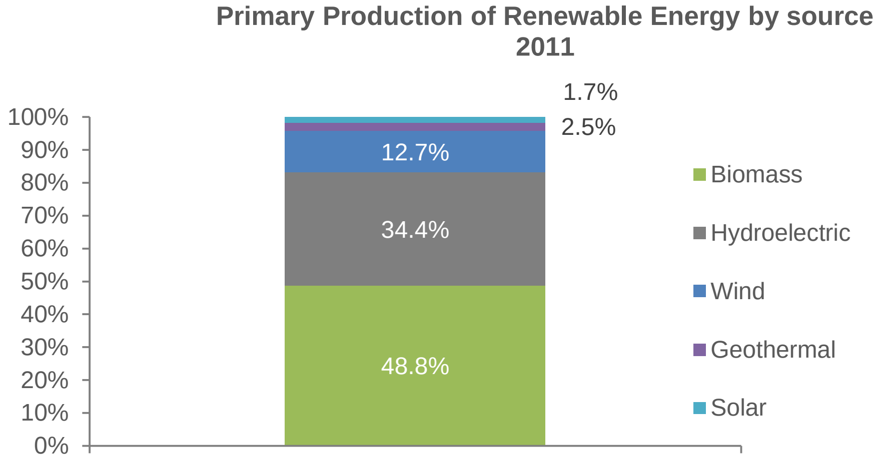
In the United States, most of the primary energy production is generated by fossil fuels, particularly natural gas and carbon (77.6%). Renewable energy accounts for 11.8 % (renewable plus hydroelectric), with biomass or biocombustibles as primary sources.

Chart 2



Source: U.S. Energy Information Administration. *Monthly Energy Review* (April 2012),

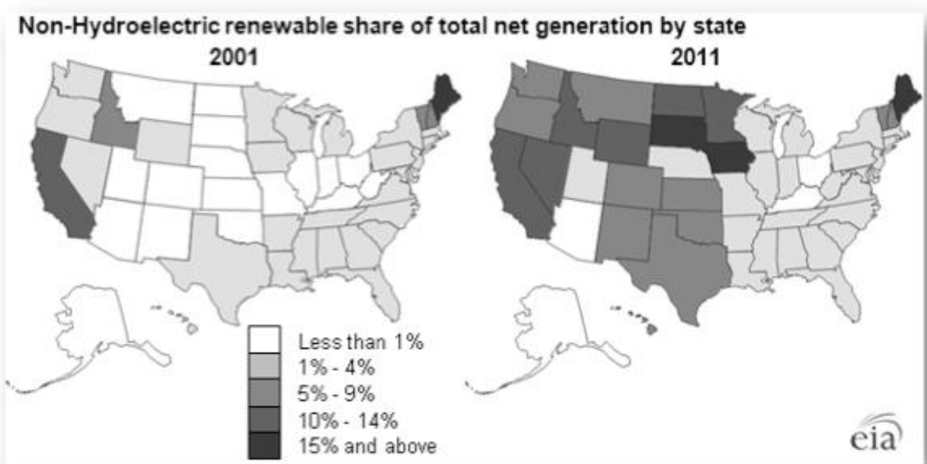
Chart 3



Source: U.S. Energy Information Administration. *Monthly Energy Review* (April 2012),

The production of non-hydroelectric, renewable energy has increased in many states during this decade. The state of Maine currently accounts for the highest percentage, 27%, up from 20% in 2001. It is followed by North and South Dakota, whose production of renewable energy, after starting out at a low level, now accounts for 21% and 17%, respectively, of total production.

Chart 4



Fuente: U.S. Energy Information Administration (2012). *Today in Energy* (Abril 9). En http://www.eia.gov/todayinenergy/detail.cfm?id=5750.

By 2035, it is estimated that solar energy will account for the highest growth in renewable energy production by source type, with an average yearly growth between 2008 and 2035 of 11% at the world level. By region, the highest increase will be in countries outside the OECD (22.8%), propelled by Asian countries, particularly China.

Eolic energy is in second place, with an average yearly growth of 7.5% at the world level, with non-OECD countries expected to account for the highest growth (11.6%). The following section will mention which specific countries are the most important in terms of the use and expansion of renewable energy.

Table 1

Renewable energy net generation by source of energy: 2008-2035 (billions of kilowatt-hours)

	Historic	Projections					
Region	**2008**	**2015**	**2020**	**2025**	**2030**	**2035**	**Average annual percent change**
OECD Countries							
Hydroelectric	1,329	1,418	1,520	1,600	1,668	1,717	1.0
Wind	181	492	689	806	852	898	6.0
Geothermal	38	56	67	79	93	104	3.8
Solar	12	68	86	95	105	120	8.8
Other	217	268	309	362	381	398	2.3
Total	**1,778**	**2,302**	**2,670**	**2,941**	**3,099**	**3,236**	**2.2**
No - OECD Countries							
Hydroelectric	1,791	2,363	2,946	3,224	3,536	3,903	2.9
Wind	29	219	347	426	499	564	11.6
Geothermal	22	56	58	61	70	81	5.0
Solar	-	19	48	60	65	71	22.8
Other	41	132	186	252	321	375	8.5
Total	**1,884**	**2,788**	**3,585**	**4,023**	**4,491**	**4,995**	**3.7**
World							
Hydroelectric	3,121	3,781	4,465	4,823	5,204	5,620	2.2
Wind	210	710	1,035	1,232	1,350	1,462	7.5
Geothermal	60	112	125	139	163	186	4.2
Solar	13	87	134	155	170	191	10.6
Other	258	400	496	614	702	772	4.1
Total	**3,662**	**5,091**	**6,256**	**6,964**	**7,590**	**8,232**	**3.1**

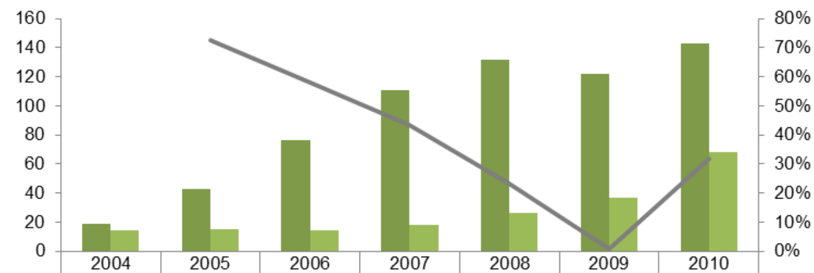
Note: Totals do not add due to rounding.
Source: U.S. Energy Information Administration, *International Energy Outlook 2011 (September 2011). In:http://www.eia.gov/forecasts/ieo/pdf/0484(2011).pdf*

2.2 Global investment in renewable energy

Investment in renewable energy has been increasing in a significant way since 2004, reaching $211 billion in 2010, a compounded yearly growth of 32% and an absolute growth of $178 million since 2004. The bulk corresponds to financial investment, followed by public and private R&D and investments in small projects, many of them at the residential level.

Chart 5

New global investment in Renewable Energy, 2004-2010 (in $bb)



	2004	2005	2006	2007	2008	2009	2010
New financial investment	19	43	76	111	132	122	143
SDC, R&D private and public	14	15	14	18	26	37	68
Growth		72.7%	57.9%	43.3%	23.3%	0.6%	31.9%

Source: United Nations, *Global Trends in renewable Energy Investment, 2011.* Note: SDC = small distribution capacity.

Most of the new investment is financial investment, comprising 68% of the total, and mostly consisting of asset financing, followed by internal capital, debt issuance or capital financing for the development of technology and equipment manufacturing. The rest includes investment in public and private R&D and small projects (see Table 2).

Table 2

Global Trends in Renewable Energy Investment (in $bb)

Category	2004	2005	2006	2007	2008	2009	2010	CAC 2004-2010
1.0 Total Investment								
1.1 New Investment	33.0	57.0	90.0	129.0	159.0	160.0	211.0	36%
1.2 Total transactions	41.0	83.0	125.0	187.0	224.0	225.0	268.0	37%
2.0 New investment by value chain								
2.1 Technology development								
2.1a Venture Capital	0.4	0.6	1.3	1.9	2.9	1.5	2.4	36%
2.1b R & D public	1.1	1.2	1.3	1.5	1.6	2.4	5.3	29%
2.1c R & D private	3.8	2.9	3.1	3.3	3.7	3.7	3.3	-2%
3.0 Equipment Manufacturing								
3.1 Capital expansion of private assets	0.3	0.8	3.1	3.2	6.6	3.1	3.1	45%
3.2 Public Markets	0.4	4.0	11.0	22.0	12.8	12.5	15.4	87%
4.0 Projects								
4.1 Asset Financing*	18.3	37.2	62.1	90.1	114.7	107.5	127.8	38%
4.2 Reinvestment in assets	0.0	0.0	1.1	5.7	4.5	2.4	-6.0	
4.3 Capacity of distribution in small-scale**	8.6	10.7	9.4	13.2	21.1	31.2	59.6	38%
Total financial investment (2.1a + 3.1 + 3.2 +4.1 +4.2)	19.0	43.0	76.0	111.0	132.0	122.0	143.0	40%
R & D public and private, small projects (2.1b + 2.1c + 4.3)	14.0	15.0	14.0	18.0	26.0	37.0	68.0	31%
New total investment	**32.9**	**57.4**	**92.4**	**140.9**	**167.9**	**164.3**	**210.9**	**36%**
Mergers and acquisitions	8.5	25.9	35.0	57.4	65.2	65.7	57.7	
Total transactions	**41.4**	**83.3**	**127.4**	**198.3**	**233.1**	**230.0**	**268.6**	
New financial investment by technology								
Wind	11.3	21.9	29.7	51.1	62.7	72.7	94.7	43%
Solar	0.5	3.2	10.4	21.8	33.3	25.3	26.1	91%
Biofuel	1.6	6.0	20.4	20.0	18.7	6.9	5.5	23%
Biomass & w-t-e	3.7	6.7	10.0	11.4	10.1	11.5	11.0	20%
Hydroelectric	1.1	4.4	4.2	5.0	5.8	4.1	3.2	19%
Geothermal	1.0	0.4	1.3	1.9	1.6	1.4	2.0	12%
Marine	0.0	0.0	0.5	0.4	0.1	0.2	0.1	33%
Total	19.0	43.0	76.0	111.0	132.0	122.0	143.0	40%

Source: United Nations, *Global Trends in renewable Energy Investment, 2011*

Nota: The volume of new investment is adjusted for the assets invested. Total values include estimates for undisclosed transactions.

* Includes all the money invested in projects of renewable energy generation, either with domestic capital, debt or financing capital.

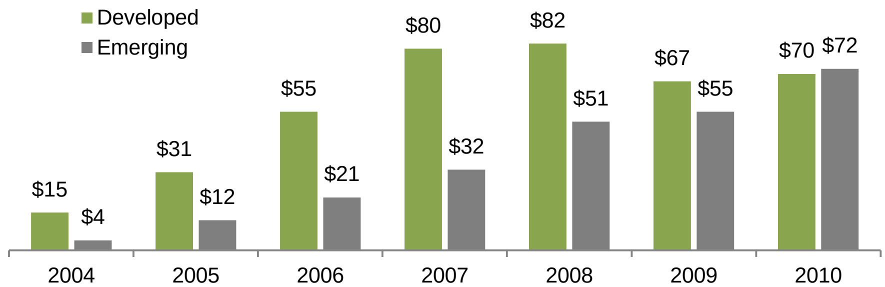
** This category includes investment in residential solar projects of less than 1 MW.

By type of technology, the two main ones also happen to be the most commonly developed in Puerto Rico, namely eolic and solar. The total financial investment in these two renewable energy sources reached $120.8 million in 2010, representing 84% of the total financial investment. Investment in these two technologies registered a compounded yearly growth of 43% and 91%, respectively. Still, the highest investment growth has been in solar energy technology.

By 2010, new investment in emerging economies (propelled by China) surpassed developed countries. Graph 6 shows that while new financial investment in developed countries decreased between 2007 and 2010, investment in emerging economies more than doubled during that same period.

Chart 6

New financial investment in Renewable energy: Developed and Emerging Countries



Source: United Nations, *Global Trends in renewable Energy Investment, 2011*
Note: The volume of new investment is adjusted for the assets invested. Total values include estimates for undisclosed transactions.

By region, the bulk of new renewable energy investment has taken place in Asia and Europe, specifically in China and Germany. The United States were in third place in 2010.

Table 3

Top 10 countries investing in Renewable energy

2010 Rank	Country	Investment 2009 ($bb)	Investment 2010 ($bb)	2009 Rank
1	China	39.1	54.4	1
2	Germany	20.6	41.2	3
3	United States	22.5	34.0	2
4	Italy	6.2	13.9	8
5	Rest of EU-27	13.3	13.4	4
6	Brazil	7.7	7.6	7
7	Canada	3.5	5.6	9
8	Spain	10.5	4.9	6
9	France	3.2	4.0	12
10	India	3.2	4.0	11

Source: The Pew Charitable Trust (2011), *"Who's Winning the Clean Energy Race?"* (p.11)

In the last five years, the annual growth in renewable energy investment has centered in Asian countries (China and South Korea) and Latin America; based on the investment value, China stands out.

Table 4

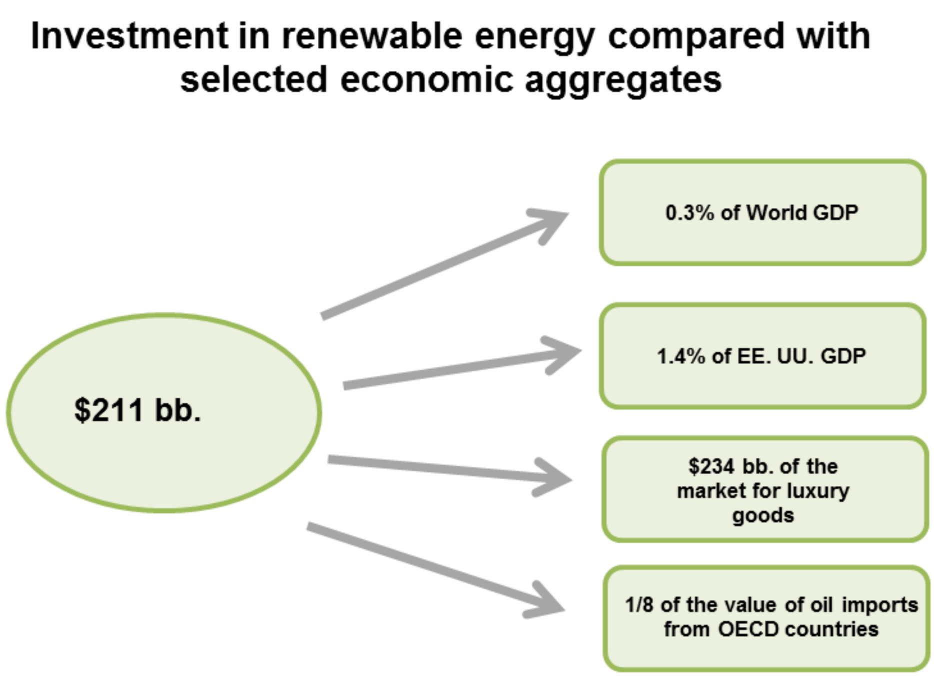
Investment Growth:
Top 10 economies (2005-10)

Rank	Country	Growth rate (5 years)
1	Turkey	190%
2	Argentina	115%
3	South Africa	94%
4	Indonesia	89%
5	China	88%
6	Brazil	81%
7	Mexico	74%
8	Italy	71%
9	South Korea	62%
10	Rest EU-27	62%

Source: The Pew Charitable Trust (2011), "Who's Winning the Clean Energy Race?", (p.12)

Although investment has increased significantly, it still remains small when compared with some global economic and consumption indicators, as illustrated in Diagram 1.

Diagram 1



2.3 Renewable energy investment and capacity

The previous data shows, as corroborated by the Pew Report (2011), that the center of gravity for renewable energy investment is moving from Europe and the United States to China, India and other Asian countries, while the competitive position of the United States is eroding, though it maintains a considerable edge in the area of risk capital investment and capital investment.[2]

This situation is reflected in the relation between installed capacity and investment strength (investment per GDP dollar), as shown in Table 5. The United States is in 9th place in terms of investment strength, but places second in terms of installed capacity. Nevertheless, the divide with China is considerable, and taking into account the rapid growth of investment in China, it is probable that this gap will widen more in coming years. For example, China accounts for 47% of total global investment in eolic energy and in 2010 reached a capacity of 17 GW in this type of energy.[3]

Table 5

Installed Capacity: investment and intensity

Rank	Country	Intensity (%)	Rank	Country	Capacity (GW)
1	Germany	1.40%	1	China	103.36
2	Italy	0.79%	2	United States	57.99
3	China	0.55%	3	Germany	48.86
4	Canada	0.42%	4	Rest EU-27	39.8
5	Australia	0.37%	5	Spain	27.78
6	Spain	0.36%	6	Japan	25.96
7	Brazil	0.35%	7	India	18.65
8	Rest EU-27	0.30%	8	Italy	16.66
9	United States	0.23%	9	Brazil	13.84
10	France	0.15%	10	France	9.57

Source: The Pew Charitable Trust (2011), *"Who's Winning the Clean Energy Race?", (p.12)*

2 The Pew Charitable Trusts (2011), pp. 10, y 14-15.

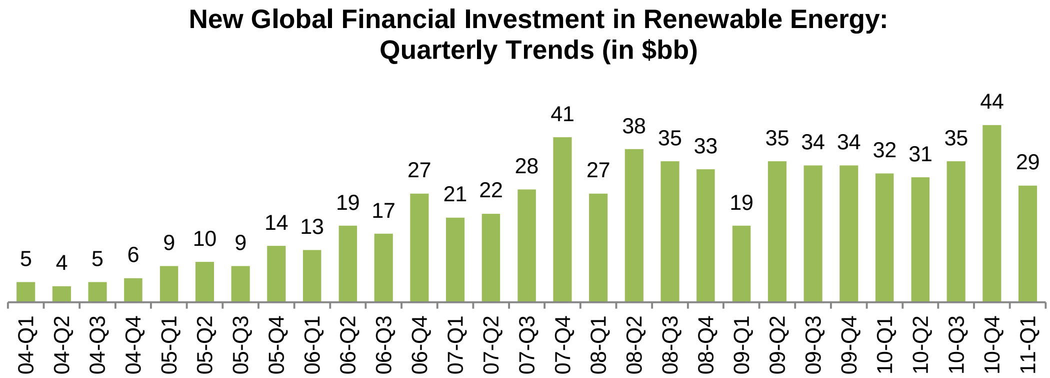
3 Ibid., p. 13.

2.4 Recent trends in global investment

Global investment in renewable energy reached a record level of $263 billion in 2011. The previous year it had been $211 billion.[4] Recent data shows that by the beginning of 2012 investment had slowed down, dropping from $35 billion in the last quarter of 2011 to $27 billion in the first quarter of 2012, the lowest level since the first quarter of 2009.[5]

This change is due, in part, to uncertainty over whether governments are going to continue supporting renewable energy growth given the financial crisis and the end of stimulus programs in the United States which, as we have seen, have held the key to this sector's expansion. In view of the fact the financial crisis in the Euro zone is worsening and that the United States is not expected to continue its support (at least, not at the same level), global investment in this sector for the rest of 2012 is not favorable, although it is anticipated that investment in China will continue to increase.

Chart 7



Source: United Nations, *Global Trends in renewable Energy Investment, 2011.* Note: The volume of new investment is adjusted for the assets invested. Total values include estimates for undisclosed transactions.

4 *The Guardian Environtmental Network (2012), p. 2. No details available for 2011 of the total investment as presented in Table 2.*

5 *The Guardian Environtmental Network* (2012), p. 1.

3. PUBLIC SUPPORT FOR RENEWABLE ENERGY

Government support for the development of renewable energy has been and is fundamental. In all the economies where there has been an increase in investment, energy subsidies (direct, contributions, loans) have played an important role.

3.1 Public policy

According to *Bloomberg New Energy Finance* (2011), governments have played a key role in accelerating the expansion and development of renewable energy, and the number of countries with some type of support or renewable energy policy have more than doubled, from 55 in 2005 to 119 in 2011.[6] There are no less than 95 countries that have some kind of policy to support the production of renewable energy, according to the report, with the most common being "feed-in" tariffs or FITs.[7]

There are two types of renewable energy policies: those that have a specific policy based on goals or objectives and those that offer some kind of support, the first being the most common. By 2011, there were no less than 98 countries with specific goal-oriented policies, half of which were being adopted by emerging economies, while a combination of both types of energy policies is prevalent in the European Union.[8]

In the case of the United States, there isn't a renewable energy policy based on goals or objectives, although there are specific goals for the development and use of biocombustibles through the *Renewable Fuel Standard* (RFS). In turn, many of the states (and Puerto Rico) have adopted the *Renewable Portfolio Standards* (RPS),

6 *Bloomberg New Energy Finance* (2011), p. 27.

7 FITs is paid to people who generate their own "green" electricity using a removable power source (usually up to 5 MGW). The goal is to increase renewable energy generation nationwide. The person receives payment for all renewable energy produced, an additional payment if exported to the electricity transmission network, or a reduction in your electric bill, corresponding to renewable energy used. Every user is eligible (property owner): residential, commercial, institutional, schools and ordinary users of electricity.

8 *Bloomberg New Energy Finance* (2011), p. 28.

which requires energy providers to increase their sources of renewable energy until they can reach a specific percentage of production by a given year.[9]

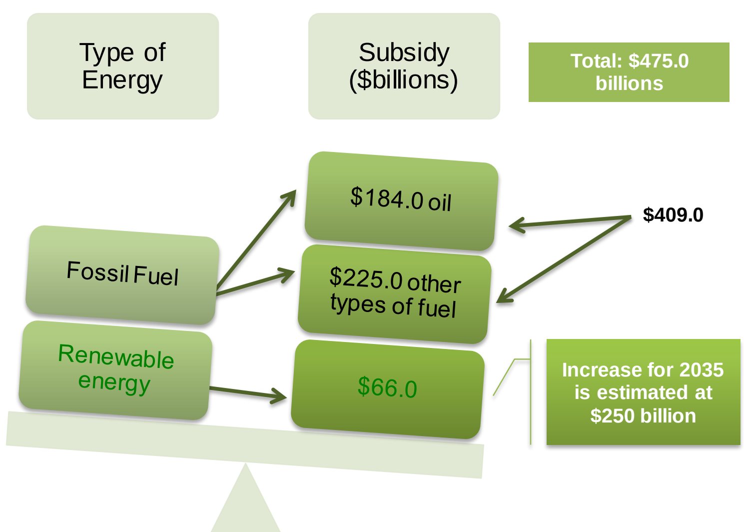
3.2 Financial support

Despite an increase in subsidies for renewable energy, most of these subsidies target nuclear and combustion fuels. The support instruments most used by government, as for example the United States, are direct government expenditures, tax subsidies, R&D funding, loan guarantees and other backing for electric power transmission networks.[10]

This aspect is illustrated in Diagram 1. According to information from the International Energy Agency (IEA), a total of $475 billion in different kinds of energy subsidies were granted globally in 2010. Most (86.2%) were granted to fossil fuel sources and other combustible types, and 13.8% to sources of renewable energy. Nevertheless, it is estimated that renewable energy subsidies will increase to $250 billion by 2035.

Diagram 1

How big are energy subsidies worldwide? -2010



Source: IEA (2011). *World Energy Outlook 2011 Factsheet.*

[9] Ibid. p. 28.

[10] See U.S. EIA (2011). In the case of Puerto Rico is 15%

In the case of the United States, the government's energy subsidies also have centered on combustible fuels and nuclear energy. Still, in light of the new federal energy policy which uses ARRA funding as its financial tool, subsidies for renewable energy sources have increased considerably.

In federal fiscal year 2007, a total of $17.9 billion were granted in subsidies and assistance to the energy sector, 29% of which went to renewable energy sources. In federal fiscal year 2009, subsidies and assistance grew to $37.2 billion, of which $14.7 billion went to renewable energy sources, corresponding to a 39.5% share of the total.

Table 1

Beneficiary	Direct Ex-penditures	Tax Ex-penditures	Research & Develop-ment	DOE Loan Guarantee Program	Federal & RUS Electricity[1]	Total	ARRA Related
2010							
Coal	42	561	663	0	91	1,358	97
Refined Coal	0	0	0	0	0	0	0
Natural Gas and Petroleum Liquids	4	2,690	70	0	56	2,820	0
Nuclear	0	908	1,169	265	157	2,499	147
Renewables	4,696	8,168	1,409	269	133	14,674	6,193
Biomass	57	523	537	0	0	1,117	10
Geothermal	160	1	100	12	0	273	228
Hydro	17	17	52	0	130	216	16
Solar	496	120	348	173	0	1,134	788
Wind	3,556	1,178	166	85	1	4,986	4,852
Other	95	0	205	0	1	302	130
Biofuels	314	6,330	0	0	0	6,644	169
Electricity -Smart Grid & Transmission	461	58	222	20	211	971	495
Conservation	3,387	3,206	0	4	0	6,597	6,305
End-Use	5,705	693	832	1,011	0	8,241	1,549
LIHEAP	5,000	0	0	0	0	5,000	0
Other	705	693	832	1,011	0	3,241	1,549
Total	**14,295**	**16,284**	**4,365**	**1,570**	**648**	**37,160**	**14,786**

Federal government subsidies for energy

=3.7%

=7.6%

=6.7%

Renewables: 39.5%

Fossil Fuel: 11.3%

The participation of renewable energy sources (in all their variety) in the total amount of subsidies assigned to electric power production rose between 2007 and 2010, even when the bulk of production came from nuclear and combustible fuels. This increase is attributable in good measure to ARRA funding which, in federal Fiscal Year 2010, accounted for 42% of all subsidies and assistance received by the renewable energy sector, which was not the case in 2007 and even when the sources of renewable energy are responsible for 12% of energy production in the United States.

Table 2

Distribution of Energy Production and Subsidy Amounts by Energy Sector, 2007-2010

	Production	% of Total Federal Subsidies	
Energy Sector	**2007**	**2007**	**2010**
Petroleum & Natural Gas	49.2%	15.7%	13.2%
Carbon	28.5%	31.0%	6.4%
Nuclear	10.6%	13.4%	11.7%
Renewable Energy	**11.8%**	**39.9%**	**68.7%**
	100.0%	100.0%	100.0%

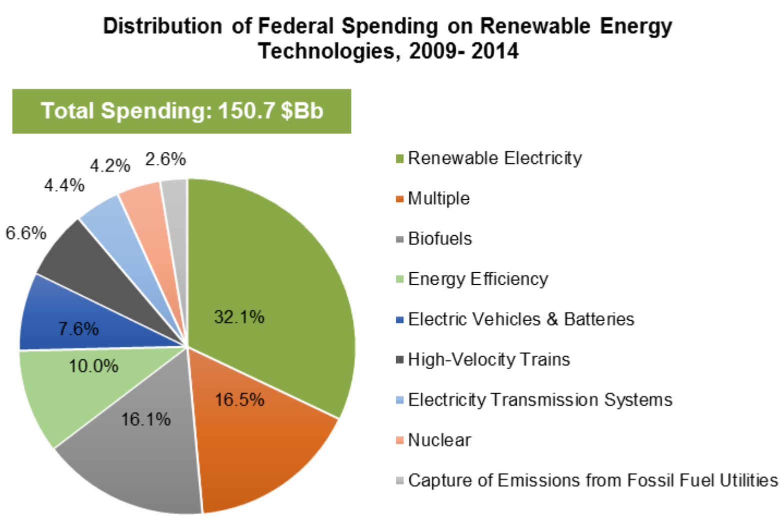
Sources: Adam Looney y Michael Greenstone (2012). *Paying Too Much for Energy? The True Costs of Energy Choices. The Hamilton Project (April), p. 25.* U.S. Energy Information Administration (2011) *Direct Federal Financial Intervention and Subsidies in Energy in Fiscal Year 2010,* pp. xiii & xiv.

* These percentages correspond to the total subsidies and aids for the respective energy sources, from the total grants and subsidies available.

** Federal subsidy amounts for 2007 were converted to 2010 prices before calculating these shares.

By type of technology, the bulk of federal spending incurred and estimated for the period 2009-2014 went to sources of renewable energy and biocombustibles.

Chart 1

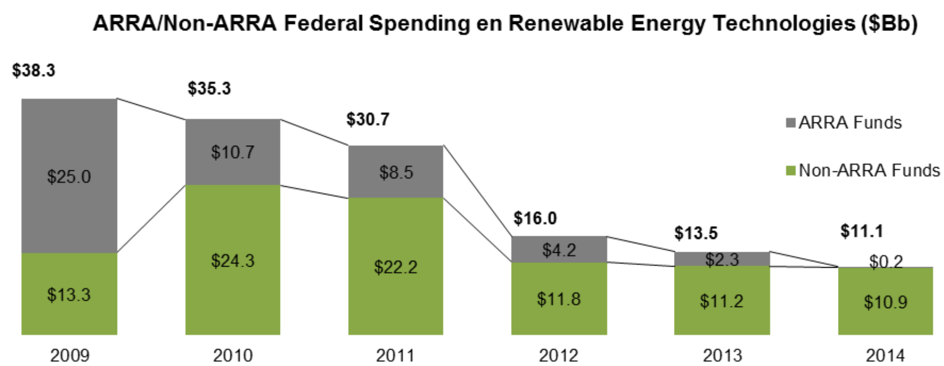


Source: J. Jenkins, Mark Munro et.al. (2012). *Beyond Boom & Bust* (April), p. 18.

ARRA funding has played a key role in the development of renewable energy in the United States during the last four years. Therefore, the eventual loss of these funds in 2014 poses a challenge for the renewable energy sector. Public support is declining and in the face of the economic environment foreseeable over the medium term, it remains to be seen if private investment will be able to compensate for the absence of public funding and investment.

In 2009, $25 billion in ARRA funds were assigned to the development of renewable energy; by 2014, this funding will drop to $200 million, a reduction in public and private expenditure for renewable energy at a time when the trend worldwide is for it to grow in importance. This will require, as advanced by Jenkins and Muro (2012), a new approach in public policy designed to make the renewable energy sector less dependent on subsidies.[11]

Chart 2



Source: J. Jenkins, Mark Munro et.al. (2012). *Beyond Boom & Bust* (April), p. 19.

3.3 Puerto Rico

The government of Puerto Rico has adopted in the last three years public policy initiatives for the development of renewable energy, a response not only to federal government efforts but also to local needs, with the main goal being to reduce energy costs, for which the use of fossil fuels is mostly to blame. This has been done by using ARRA funds set aside for renewable energy and through local tax incentives programs.

[11] Jesse Jenkins, Mark Muro, et.al. (2012), p.5, and Part 3.

In essence, Puerto Rico's renewable energy policy is shaped by Laws No. 82 and No. 83, of July 19, 2010, which establish the main legal framework for sustainable energy on the island. Their outstanding features are the following (see Diagram 2):

- ✓ Act for a Public Policy for Energy Diversification Through Sustainable and Alternative Renewable Energy, Law No. 82 of July 19, 2010.
- ✓ Creates the Renewable Energy Portfolio in Puerto Rico, establishing the requirements and criteria for the integration of renewable energy sources in electricity supply in the next twenty five years. The goal is to achieve in that period that 20% of electric energy be produced from renewable sources.
- ✓ Also enacted was the Puerto Rico Green Energy Incentives Act, which amends Law 70 of 1978; the Solid Waste Act and Law 120 of 1994; the Internal Revenue Code, Law 83 of July 19, 2010. This law created the "**Puerto Rico Green Energy Fund**" which provides economic incentives for the development of renewable energy projects in Puerto Rico.

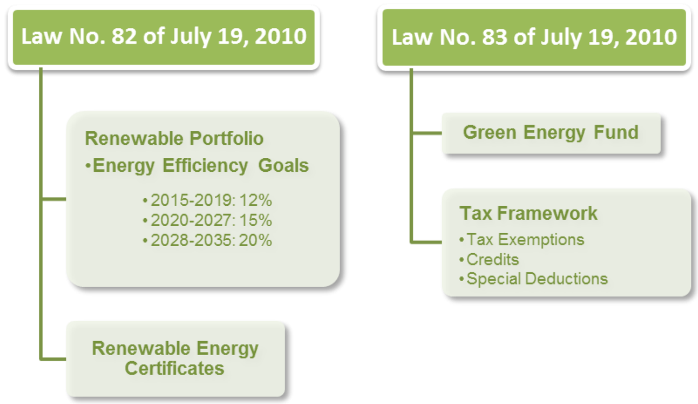
Energy Policy

- Reduce the cost of energy and guarantee affordable, viable, and sustainable electricity.
- Make renewable energy projects viable.
- Set up a program for the reduction of energy costs through investment in energy efficient public buildings.
- The declaration of an energy emergency in 2010-2012 provided a mechanism for the development of a new power infrastructure, through eligible projects for solar, eolic, biomass, and ocean energy.

Article 2.3 of Law 82 sets a 12% level of sustainable production as an energy efficiency goal for the 2015 - 2019 period, 15% for 2020-2027 and 20% to be reached in or before 2035. The law also creates a Renewable Energy Commission, an organism charged with reporting on, supervising, regulating and developing the island's renewable energy policies.[12] Its principal mission is to ensure compliance with the policy, but also includes other responsibilities related to economic activity.

12 §2.5. Law No. 82 of July 19, 2010.

Diagram 2



Law 83, on the other hand, creates two important structures for the development of economic activity in the area of sustainable energy: (1)the Green Energy Fund (created under article 2.2. of this law), which serves as a financial platform to negotiate incentives, loans, credit lines, trainings, research and other projects aimed at establishing a renewable energy industry on the island; (2) a tax framework for the production of renewable energy, that includes: a) tax exemptions for assets and income from the production of renewable energy; b) special deductions for capital, property and infrastructure investment; and c) credits geared to industrializing low-income areas, the purchase of products manufactured in Puerto Rico, and requests for municipal business licenses (patentes municipales).[13] As stated in the preamble, the law seeks to bring together and institutionalize the incentives policies in previous laws.

The most notable initiative is the introduction of Renewable Energy Certificates (RECs), designed to commercialize and quantify the production of renewable energy in Puerto Rico. Established by Law 82, the RECs initiative seeks to introduce renewable energy itself as a commercial commodity and to create a free market for renewable energy suppliers and investors.[14] It also seeks to promote productive investment and increase the availability of capital for this type of

[13] §2.8 – 2.14. Law No.. 83 of July 19, 2010.

[14] A REC is equivalent to one kilowatt / hour produced by renewable energy, the price set by the market. Source: Energy Affairs Adminsitration (2010). *Resumen de Nuevas Legislaciones de Energía en P.R.* In: http://www.aae.gobierno.pr/pdf/Resumen%20Leyes%20de%20Reforma%20Energetica.pdf.

investment, which should lead to compliance with the Renewable Portfolio Standard through the establishment of a renewable energy market on the island.

These measures complement the federal public policy fostered by the *American Recovery and Reinvestment Act* (ARRA), under which Puerto Rico receives funds through the Puerto Rico Infrastructure Financing Authority (PRIFA).

Governor Alejandro García Padilla in May of 2013 issued theree Executive Orders related to alternative energy sources (OE-2013-037, OE-2013-038 and OE-2013-040). One of these stipulates that renewable energy projects are to receive priority in the permitting process. The other two create a Council for Energy Autonomy and a Council on Energy Quality. Although there is an Energy Affairs Administration, it is clear from these Executive Orders that the Governor wants to introduce additional impetus in the transition to renewable sources.

4. AN ANALYSIS OF "CLUSTERS"

As previously explained, the "cluster" concept, networks or groupings, has been in use with growing frequency in the past two decades as an instrument to overcome obstacles and to make it easier for businesses and governments to unite efforts and resources with other private and public sector entities or academic organizations in order to achieve a common goal or objective. The common denominator found in all analyses of "clusters" is the interrelations and complementarities of participating entities.

4.1 Bases for "cluster" policies

It is possible to have different economic benefits in the development of networks or groupings (referred to as "clusters"). Keeping in mind the changing nature of innovation, technology, demand for resources and the characteristics of participants themselves, "clusters" serve to support market dynamics and the interchange of knowledge between companies and other actors, whether at the regional or international level.

The analysis of "clusters" proves the need to take into account a series of factors:

- The importance of location and external factors that generate the geographic concentration of activities.

- The importance of interactions and cooperation, which transcend traditional territorial limits and frequently are not based on market relations.

- The idea that businesses and sectors cannot be seen in isolation but are part of a system, which conditions their operational ways and results.

- The fact that a wide gamut of organizations and institutions play a significant role in the sector's performance.

4.2 Types of "cluster" policies - characteristics

OECD (2010) notes the following elements or characteristics:

- The purpose of the "cluster" policies may be to strengthen a particular regional economy but it may vary, depending on the type of "cluster" that is designed or set up.

- Public intervention generally takes place to correct deficiencies in markets or systems, aspects which "cluster" policies take into account.

- For OECD, the concept of "cluster" is not applicable when businesses are involved in the same activity, despite cooperative links for some activities.

Additional characteristics shaping the development of a public policy are:

- In the majority of cases, "clusters" are trans-sectorial networks (vertical and lateral) that include businesses that complement each other and are specialized in a specific link or knowledge base.

- “Clusters” also include strategic alliances with universities, research institutes, knowledge-intensive business services, consultants and clients.

- The relation between the entities in the "cluster" may be based on a commercial link, that is to say, on an interchange of products or a technology/knowledge/innovation link.

- The “cluster” analysis would provide the basis for initiating and promoting projects that increase cooperation among the principal firms, their providers or suppliers, R & D centers, as well as other public and private institutions..

4.3 Evaluation of components

The existing links in the "clusters" may be based locally, nationally or internationally, resulting in three geographic "cluster" levels. Still, most analysts concur that in view of the requirements for the transmission of knowledge and the functioning of a network, it is best for the components in the network or conglomerate to be in close proximity.

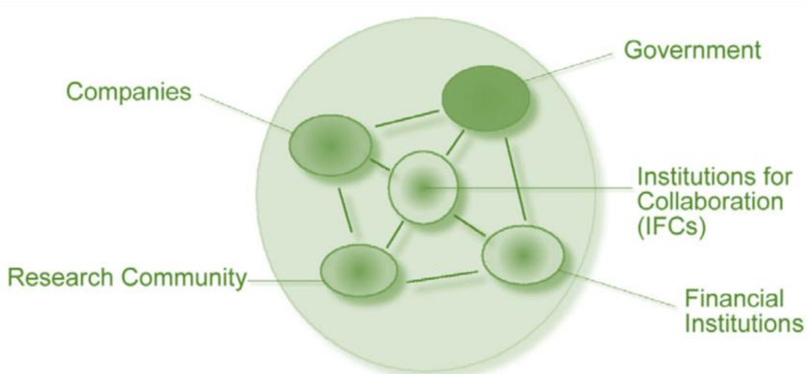
The cluster concept goes beyond simple agglomeration of similar activities, a frequently mad mistake in classifying clusters. In order for the term cluster to be used it is essential that there be complementarities between the components that leads to increased efficiency at the cluster level above that possible by individual firms.

The term "cluster" spotlights, above all, the links and cooperation among participants.

The diagram below illustrates the types of actors making up a "cluster".[15] Notice how businesses are not the only potential actors. "Clusters" can involve strong alliances and links between various institutions, such as universities, research institutes, public entities, and community level organizations, among others.

Diagram 1

Categories of cluster actors



Source: Adapted from Sölvell et al. (2003)

15 From The Cluster Policies Handbook (2004), p. 25.

4.4 Current "cluster" policies: Reviews and experiences

"Cluster" policies are becoming an instrument increasingly in use internationally. The number of initiatives is rather extensive and diverse, making it difficult to categorize them. Nevertheless, Table 1 provides a list of specific initiatives that were adopted in response to systemic and market failures, which gives an idea of the types of "cluster" policies that are being adopted.[16]

Table 1

Table 1: Cluster-based response to systemic and market failures

Systemic and market failures	Policy response	Countries' focus in cluster-based policy making
Inefficient functioning of markets	- Competition policy and regulatory reform.	- Most countries.
Informational failures	- Technology foresight.	- Netherlands, Sweden.
	- Strategic market information and strategic cluster studies.	- Canada, Denmark, Finland, Netherlands, United States.
Limited Interaction between actors in innovation systems	- Broker and networking agencies and schemes.	- Australia, Denmark, Netherlands.
	- Provision of platforms for constructive dialogue.	- Austria, Denmark, Finland, Germany, Netherlands, Sweden, United Kingdom, United States.
	- Facilitating cooperation in networks (cluster development schemes).	- Belgium, Finland, Netherlands, United Kingdom, United States.
Institutional mismatches between (public) knowledge infrastructure and market needs	- Joint industry-research centres of excellence.	- Belgium, Denmark, Finland, Netherlands, Spain, Sweden, Switzerland.
	- Facilitating joint industry-research cooperation.	- Finland, Spain, Sweden.
	- Human capital development.	- Denmark, Sweden.
	-Technology transfer programmes.	- Spain, Switzerland.
Missing demanding customer	- Public procurement policy.	- Austria, Netherlands, Sweden, Denmark
Government failure	- Privatisation.	- Most countries.
	- Rationalise business.	- Canada.
	- Horizontal policy making.	- Canada, Denmark, Finland.
	- Public consultancy.	- Canada, Netherlands.
	- Reduce government interference.	- Canada, United Kingdom, United States.

In general, the literature on "cluster" policies leans toward government policies of indirect induction rather than direct intervention, except when the failures of the market or the system are evident. There are reasons to think that government intervention can improve the situation (as happens, for example, with the financing of basic research) without this involvement necessarily entailing hidden measures for subsidy policies and competition protection.

Salient points:

16 Ibid., p. 62.

- Seeks to favor cooperation and interaction without harming the competitive environment.

- It is thought that the government can act as a catalyst agent and intermediary, as well as a coordinator in the "clusters," helping to surmount obstacles and organizational and institutional imbalances and conflicts that prevent the optimal functioning of a "cluster"' however, it cannot create or stimulate clusters out of thin air.

- Greater emphasis is placed on favoring the optimal functioning of the system rather than promoting businesses, industries or particular technological solutions.

- It is recognized that each "cluster" raises specific requirements for the government policy.

Jörg Meyer-Stamer and Tilman Altenburg analyze the types of "clusters" that exist in Latin American countries.[17] They highlight three major failings these clusters have over those in advanced countries:

1) in contrast with developed countries, where small and medium enterprises (PYMES) play an important role as providers of specialized services and supplies, the large majority of PYMES in Latin America do not play such a role;

2) if "clusters" in advanced countries often take place in design intensive or high-technology sectors with substantial product and process innovations, "clusters" in Latin America are confined to the standardized production of consumer goods or assembly operations without substantial innovations;

3) in comparison with the innovative “clusters” of advanced countries, those in Latin America generally include only some stages in the value chain, incorporate few complementary services, and lack the social capital required to achieve cooperative agreements.

[17] Jörg Meyer-Stamer and Tilman Altenburg Meyer-Stamer (1998), pp. 1708-1709.

Concerning developed economies, Rui Baptista highlights the following:[18]

1) Although there are different hybrid types within a same country, there are different national patterns in the development of "clusters" associated with the different innovation systems of each country.

2) The French model is more interventionist and is based on the government's orientation and financing, following Perroux' growth poles theory in which groupings take place between universities, research centers, small and medium-size businesses and some branches of large multinationals; from the point of view of entrepreneurial innovation.

3) The Italian model springs from the concerted efforts of local municipal and private organizations, with strong associations of producers and merchants and close provider-client relations but without large foreign companies and with few public resources for research, development, and innovation.

4) The German model is based on a definite institutional hierarchy, encompassing large private and government institutions to institutions of multiple technology transfers that provide business services to PYMES; it is also based on provider-client relations that lead to new innovations. Moreover, the model appears relatively balanced in so far as relations between large and small businesses and public and private research institutions, with a higher degree of association than the average.

5) The United States model is characterized as being the result of a more spontaneous and less planned process, with a high level of technological competition, research that is basically internal and private, and a large presence of global corporations.

In their 2011 comparative analysis on the recent experience in Latin America and the Caribbean, Pietrobelli and Stevenson highlight the following findings:[19]

1. National as well as local governments and international institutions have been using "clusters" more frequently to promote economic development.

[18] Rui Baptista (1998), p. 41.

[19] Pietrobelli and Stevenson (2011), p. 1.

2. Development programs have been diverse but share the common characteristic of being successful in creating public and private institutional spaces to negotiate, design and implement projects with benefits and shared externalities.

3. "Cluster" programs are a priority for governments and the country's productive sectors.

4. Two essential elements have ensured their success: citizens and the private sector have participated in their design right from the beginning.

5. Occasionally, the intervention of institutional intermediaries between the government and the actors has helped resolve problems with apathy and gaps in information.

6. Established programs have helped add to these economies new capabilities to handle complex projects that require government transparency, group level decisions, and coordination. These experiences have contributed to establishing new intra-government and public-private processes that are relevant to production and competitiveness.

4.5 The role of energy - a renewable energy "cluster"

Taking as a point of departure the synergies and advantages that a "cluster" offers, this would be a very useful tool to take advantage of the strengths and opportunities of renewable energy. One could say there is already an incipient renewable energy "cluster" in Puerto Rico, as evinced by efforts and initiatives adopted, implemented, or in process.

The recent experience of the state of Hawaii can be illuminating. [20] As with Puerto Rico, that state economy faces a high cost of living, dependency on food and fuel imports, power costs above the average of all other mainland states, and the need to adopt a renewable energy policy to substitute fuel imports.[21] Already there is a "cluster" of renewable energy technologies, and it has been proposed that the state

[20] See Nina Brown, R. Finn, R. Robinson, et.al. (2008).

[21] Compared to Puerto Rico, however, Hawaii has an advantage: by 2011, 12% of electricity sold by utilities come from renewable sources, mostly geothermal, with a capacity of 1,000 MWs of renewable energy in service or construction. This places Hawaii very close to meeting the goal of a 15% RPS in 2015..

should contribute to strengthening it for the development and implementation of new renewable energy technologies that will significantly reduce dependency on fossil fuel imports. In other words, it's all about trying to expand an incipient renewable energy "cluster."[22]

Unlike Puerto Rico, Hawaii has an advantage in terms of renewable energy sources. The creation of geothermal energy is an already established industry compared with other states, having started out in the 1970s and currently providing 20% of total electric power demand in Hawaii, the largest island.[23]

The strategy proposed for the state is based on the geographical location of the islands and the potential of a wide gamut of energy sources besides geothermal, such as ocean thermal energy and eolic energy. The current state policy of diversifying energy sources is carried out through initiatives funded with federal and state funds, the University of Hawaii, and the private sector.

Diagram 2 below presents, according to Brown, Finn, Robinson et al, what should be the structure for a renewable energy "cluster" and which one should be adopted in Hawaii. This plan encompasses all the key actors or participants, combining industrial sectors and entities related directly to renewable energy, as well as those industrial sectors on the periphery of the action. Importance also is given to the factor of education, a key component of a renewable energy “cluster” based on its implications on educating the work force and luring businesses.

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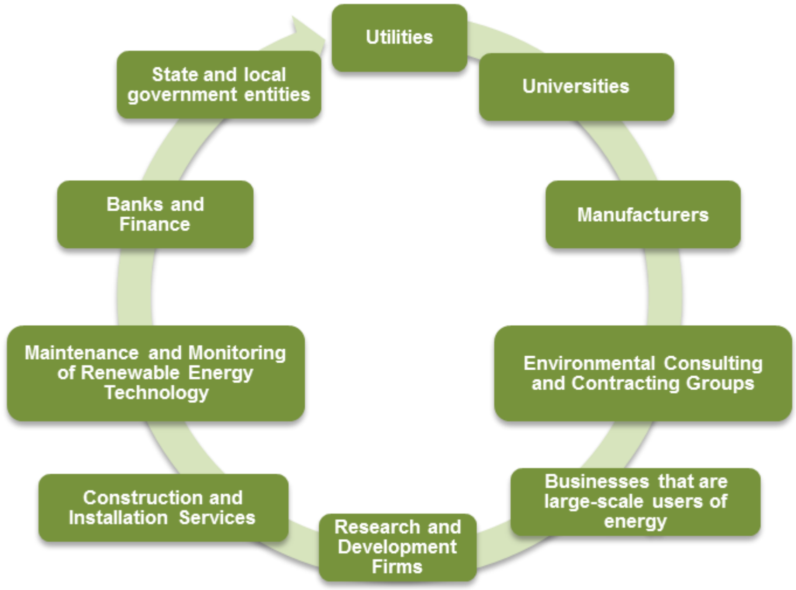
22 In October 2008, the State of Hawaii adopted the Initiative for Renewable Energy through an agreement with the electricity companies, which sets a goal for 2030 to 70% renewable energy. Law 155 of 2009 establishes a goal of increasing to 40% the Renewable Portfolio Standard, and an energy efficiency standard of 30% by 2030. See the Hawaiian Electric Company (2012) webpage at http://www.heco.com/portal.

23 Brown, Finn, Robinson, et.al. (2008), p. 12.

Diagram 2



Next, we show a comparison between activities in Hawaii and those in other states. Table 2 presents a comparison of energy renewal incentives offered in California and Minnesota, and also shows areas of opportunities.[24] In general terms, Hawaii's efforts are considered competitive with respect to those of these other two states, with possible areas of expansion for Hawaii.[25]

24 Brown, Finn, Robinson, et.al. (2008), pp. 33-34.

25 Ibid., p. 34.

Table 2

Table 4: Renewable Energy Incentives Comparison

ACTIVITY	HAWAII	MINNESOTA	CALIFORNIA
Tax Credits	Income tax credit for a percentage RE equipment and installation costs		Tax deduction for interest on loans for energy efficiency
Property Tax Exemption		Wind and Solar-Electric Exemptions	Property tax exemption for solar systems
Industry Recruitment/Support	High Technology Business Investment Tax Credit		
Solar and Wind Sales Tax Exemption		✔	
Green Building Incentives	Priority Permit Processing for Green Buildings		Fee waiver and or expedited permitting for green building
Local Loan and Grant Programs			✔
Zoning, Codes and Solar Access Guidelines			✔
Utility Loan Programs	✔	✔	✔
Utility Rebate Programs	✔	✔	✔
Utility Grant Programs		✔	✔
State Production Incentives	Net Metering Rules	Net Metering Rules State pays .0¢ to 1.5¢ p/kWh for electricity generated by hydro, manure methane digesters, and new wind projects Local utility pays customers who install PV solar arrays and connect them to the grid based on the system's production on a $/kWh basis.	Net Metering Rules California Feed-In Tariff; Solar Credit Purchase Program; Biomass Standard Contract; and Supplemental Energy Payments
State Loan Programs	Solar Roofs Loan Programs	✔	✔
State Rebate Program		Solar-electric (PV) rebates, funded by Xcel Energy, to buy down up-front costs of grid-connected systems	✔
Green Power Option	Sun Power for Schools and Kauai Co-op Green Rate	Mandatory Utility Green Power Option	Green Power Purchasing Programs
Leasing/Lease Purchase Programs			✔

Data source: Database of State Incentives for Renewables and Efficiency

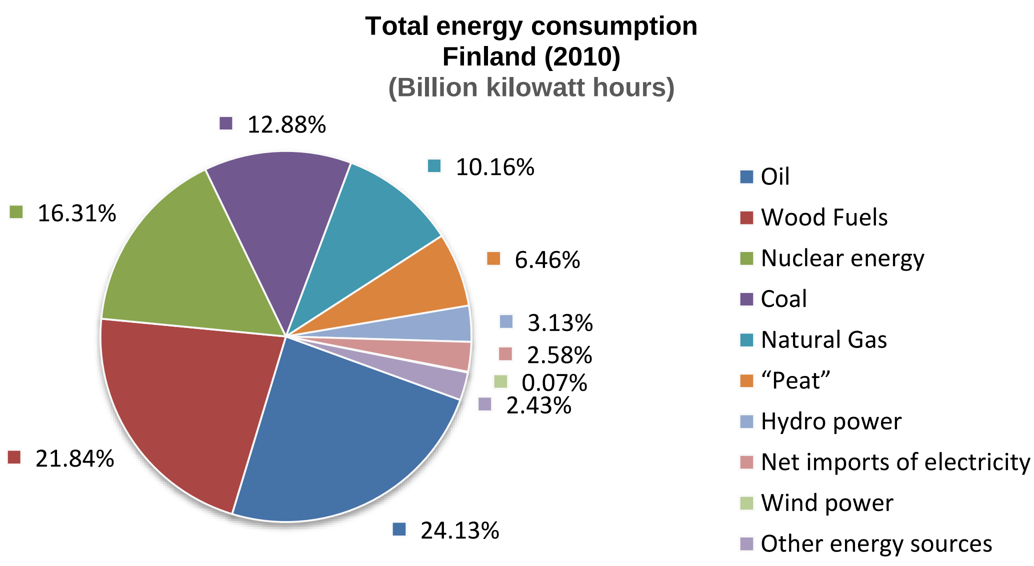
4.5.1 The experience of renewable energy "clusters" – Finland and Massachusetts

The experiences of Finland and the state of Massachusetts with already established renewable energy "clusters" provides an experience that can be useful for Puerto Rico. Finland's "cluster" focuses on the development of renewable energy technology and manufacture, and the one in Massachusetts is a technology and production conglomerate.

Finland

EnergyVaasa is the most important "cluster" in the region of Ostrobothnia. It consists of 100 companies dedicated to eco-friendly technology innovation and more than 120 PYMES in the region that subcontract renewable energy technology services.[26] The companies that make up the "cluster" maintain a network of diversified exports, China being its largest client in recent years, and a long tradition of international relations.

Chart 1



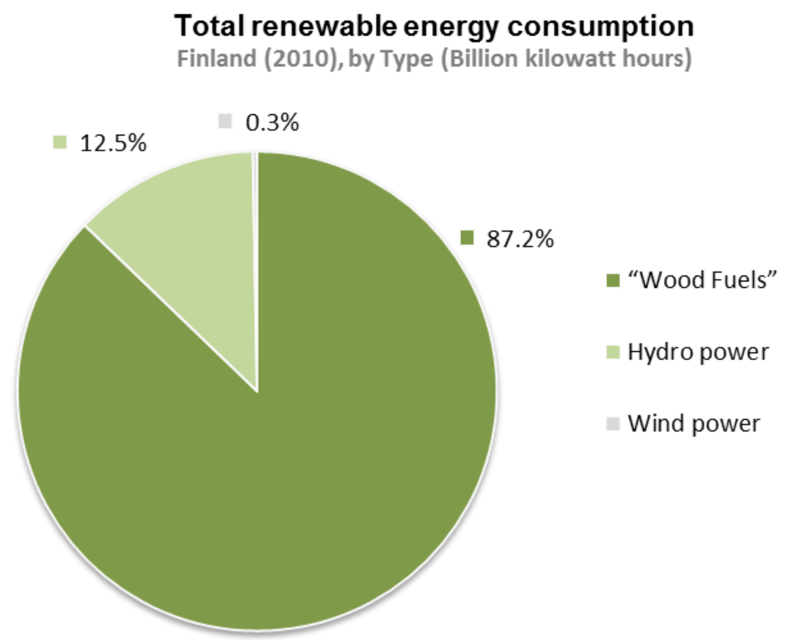
Source: Official Statistics of Finland (2011). Note: Does not include imports.

Its main integration resource is extensive technological knowledge and the strong educational component available in the region, with 7 universities, 3 vocational

[26] EnergyVaasa (2012).

schools, and approximately 13,000 students - 20% of the area's population.[27] *EnergyVaasa* currently accounts for 30 % of Finland's total renewable energy exports of technology and renewable energy equipment, with 75% of its production exported worldwide.

Chart 2



Source:Official Statistics of Finland (2011). Note: Does not include imports.

Companies belonging to the "cluster" count with a highly development infrastructure for exporting, with ships, airports, land transport companies and trains, and alliance networks with close to 7,000 other businesses.[28] According to *Meeting of European Energy and Environmental Technology Clusters* (see page 35), 70% of *Energy Vaasa* funds come from the government, which implies that the public policy is focused on supporting the conglomerate. The conglomerate also relies on consulting services and private financial support, which eases participants' handling of risk.

27 Vaasa Region Development Company.

28 Ibid.

Massachusetts

The institution under which a renewable energy"cluster" was formed is the *Massachusetts Clean Energy Center*.[29] According to Levy and Terkla (2006), “Massachusetts is well positioned to participate in the growing market for renewable energy technologies, since it houses a 'cluster' of specialized businesses, skilled manpower, universities, capital sources, and an enthusiastic community of entrepreneurs and environmental activists."[30]

29 See the *Massachusetts Clean Energy Industry Report 2011*.

30 D. Levy, and D. Terkla. (2006), p. 4.

Cluster Fact Sheet

Meeting of European Energy and Environmental Technology Clusters, Brussels, 10 Feb 2009

		Cluster de Energia	Cluster Eco-Construction	Cluster Energietechnik (Bavaria)	Copenhagen Cleantech Cluster	ECO WORLD STYRIA	Energy Cluster Fionia	Energy Cluster in Vaasa	EnviroCluster Peterborough	Kompetenznetz-werk Dezentrale Energietechnol.	Oekoenergie-Cluster Upper Austria	
1 Cluster Contact												
1.1 Cluster Name		Cluster de Energia	Cluster Eco-Construction	Cluster Energietechnik (Bavaria)	Copenhagen Cleantech Cluster	ECO WORLD STYRIA	Energy Cluster Fionia	Energy Cluster in Vaasa	EnviroCluster Peterborough	Kompetenznetz-werk Dezentrale Energietechnol.	Oekoenergie-Cluster Upper Austria	
1.2 Country		Spain	Belgium	Germany	Denmark	Austria	Denmark	Finland	United Kingdom	Germany	Austria	
1.3 Cluster Manager / Contact Person		Juan Jose Alonso / Iñaki Gorriño	Eddy Bauraing/ Jean-Pierre Binamé	Constanin Schirmer	Nicolai Sederberg Rottbøll	Bernhard Puttinger	Erling Sörensen	Johan Wasberg	Gareth Jones	Daniel A. Gottschald	Christiane Egger	
1.4 E-Mail		igorri@clusterenergia.com	info@ecoconstruction.be/ jpbiname@ecoconstruction.be	Schirmer@bayern-innovativ.de	nro@copcap.com	puttinger@eco.at	es@odense.dk	johan.wasberg@merinova.fi	g.jones@ukceed.org	d.gottschald@deenet.org	oec@esv.or.at	
1.5 Telephone		+34 944240211	32 81 71 41 00	+49 911-20671-156	+45 33 26 87 13	+43 316 407744-17	0045 70211850	+358 6 2828 261	(+44) 1733 311644	+49-561-78809613	0043-732-7720-14386	
1.6 Postal Adress		C. San Vicente. Edificio ALBIA I. Bilbao 48001 Spain	Rue H. Lecocq, 47, bte 7 5000 NAMUR	Gewerbemuseumsplatz 2, D-90403 Nürnberg, Germany	Copenhagen Capacity, Gammel Kongevej 1, 1610 Copenhagen V, Denmark	Reininghausstraße 13, A-8020 Graz, Austria	Forskerparken 10, DK-5230 Odense M, Denmark	P.O. Box 810, 65101 Vaasa - Finland	UK CEED, Eco Innovation Centre, Peterscourt, City Road, Peterborough, PE1 1SA, UK	Ständeplatz 15, 34117 Kassel, Germany	Landstrasse 45, A-4020 Linz	
1.7 Web		www.clusterenergia.com	http://clusters.wallonie.be/ ecoconstruction/fr	www.cluster-energietechnik.de	www.copcap.com	www.eco.at	www.energycluster-fionia.dk	www.merinova.fi	www.envirocluster.net	www.deenet.org	www.oec.at	
2. Cluster Statistics												
2.1 Number of Member Companies in 2008		84	98	1300		140	41	100	372	110	148	
2.2 Membership fee (range from to)	€/a	300 - 1.000	75 to 150	0		200 - 4.900	0	0	0 - 6.700	50 - 10.000	dep.	€/a
2.3 Turnover: Total of all Member Companies (2007 or latest available year)	Mio. €		50			5.050		7.500	48		1.600	Mio. €
2.4 Turnover: "Green" (Ren.En., En.Effic., Clean Techn.) turnover of members	Mio. €	15%	45			2.260		3.750	36		1.600	Mio. €
2.5 Employees: Total in all Member Companies (2007 or latest available year)	pax		400			20.696	2.000	12.000	5.000		4.500	pax
2.6 Employees: in "Green" Areas (Ren.En., En.Effic., Clean Techn.)	pax	10%	360			11.406	1.100	6.000	4.000		4.500	pax
2.7 Geographic Extension of Cluster		Basque Country	Wallonia (+ Brussels)	Bavaria	Copenhagen	Styria	FYN / DK	Ostrobothnia	Greater Peterbor.	Northern Hessen	Upper Austria	
3. Profile of Members												
3.1 Type of members: specialised enterprises	%	95	75	70		80	75	90	98	50	80	%
research institutions	%	0	10	10		10	5	5	1	30	8	%
administration	%	2,5	0	10		5	5	3	1	10	7	%
other	%	2,5	15	5		5	15	2	0	10	5	%
3.2 MAIN Areas of activity: **Conventional Energy (nuclear, fossil, utilities, ...)**		Yes	No	Yes	No	No	Yes	Yes	Partly	No	No	
Renewable Energies and Energy Efficiency		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Sustainable Transport		No	No	No	Partly	Partly	Partly	No	Yes	Partly	No	
Construction (sustainable constr., materials)		No	Yes	No	Partly	Partly	No	Partly	Yes	Yes	Yes	
Air and Noise (pollution control)		No	No	No	No	Partly	Partly	No	Yes	Partly	No	
Soil Remediation		Partly	No	No	No	Partly	No	No	Partly	No	No	
Waste (collection, recycling, ecodesign)		Partly	No	No	Yes	Yes	Yes	Partly	Yes	No	No	
Water (treatmant, waste water)		Partly	Partly	No	Partly	Yes	Partly	Partly	Yes	No	No	
OTHER		Eco Consultancy								Adapting to Climate Change		
4. Profile of Cluster Organisation												
4.1 Year of Foundation of Cluster		1996	2002	2006	2008	1998	2006	2000	2001	2003	2000	
4.2 Number of Employees in Cluster Organisation (Full-Time-Equivalent)	pax	4	2,25	3		5	2	6	2	17	3	pax
4.3 Funding Sources: Public Administration	%	40	80			65	100	70	15	80	80	%
Companies	%	45	20			25	0	20	70	20	10	%
Other	%	15	0			10	0	10	15	0	10	%
4.4 Services offered: **R&D Services**		Partly	Partly	No		Yes	Partly	Yes	Partly	Yes	Yes	
Access to Finance		Partly	No	Partly		Partly	Partly	Yes	No	Yes	Yes	
Specialist Advice		Yes	No	Partly		Yes	No	Yes	Yes	Yes	Yes	
Education and Training		No	Yes	No		Yes	No	Yes	Yes	Yes	Yes	
Knowledge and Information Transfer		Yes	Yes	Yes		Yes	Partly	Yes	Yes	Yes	Yes	
Technology Transfer		Partly	No	Yes		Partly	Partly	Yes	Partly	Yes	Yes	
Market Analysis		Partly	No	Partly		Yes	No	No	Yes	Yes	Yes	
Marketing Activities		Partly	Yes	Partly		Yes	No	No	Yes	Yes	Yes	
Export Support		Yes	Partly	No		Yes	No	Yes	Partly	Yes	Yes	
Access to incubation space		No	No	No		No	Partly	Yes	Yes	Partly	No	
Job/Partner exchange		No	No	No		No	No	No	Yes	Partly	No	
OTHER							Yes					
4.5 Remarks												

The Massachusetts conglomerate spans four main sectors: renewable energy production; "green electronics" or the production of the equipment and software that controls, stores and monitors renewable technology; the energy efficiency industry, or the mix of economic activities aimed at optimizing the use of energy in buildings, electronics or others; and a renewable energy research sector.

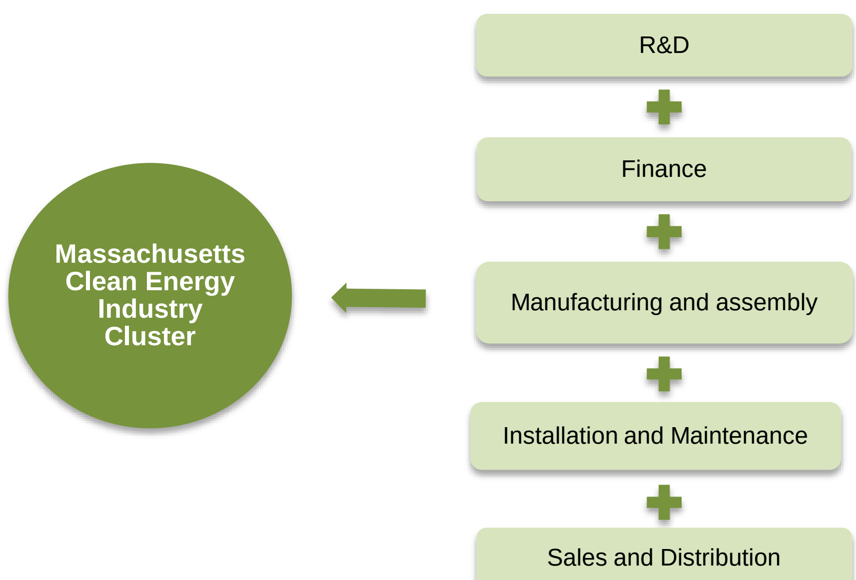
This "cluster" employs approximately 10,000 people in 400 businesses and institutions, with high rates of growth due to the promotion of renewable energy at the regional, national and international level. Its main attributes are:

- strong collaborative links with universities.
- a network of businesses and nonprofit institutions that cater to dedicated segments of the market.
- and a strong participation in the national marketplace.

Diagram 3

Segments of the Renewable Energy Cluster - Massachusetts

Added Value Chain



Source: Massachussets Clean Energy Center (2011). P. 12.

According to the *Massachusetts Renewable Energy Industrial Census* (2007), "renewable energy is poised to grow three times as fast as the growth of any other industrial sector last year, with an estimated average growth in employment of 20%." [31]

In terms of the value chain, and based on the results of a survey conducted in 2011 by the Massachusetts Clean Energy Center, 9.4% of "cluster" companies are in assembly and manufacturing; 17.7% are in research and development; and 18% are in sales and distribution. The majority of the businesses (41.8%) are involved in the installation and maintenance of renewable energy systems sector. Another 13.14% are classified as "Others," which include finance and other specialized sectors within the value chain. (Check table 3).)[32]

Table 3

Table 1: Clean Energy Firms and Employment By Value Chain Activity[8]

Primary Value Chain Activity	Number of Clean Energy Employers	Number of Clean Energy Workers
Manufacturing and assembly	462	8,173
Research and development	868	11,019
Sales and distribution	881	18,686
Installation	2,052	20,709
Other	645	5,722

8. Note that the total in each category is rounded to the nearest worker, which explains the difference with the totals reported previously.

4.6 Relations of the supply chain

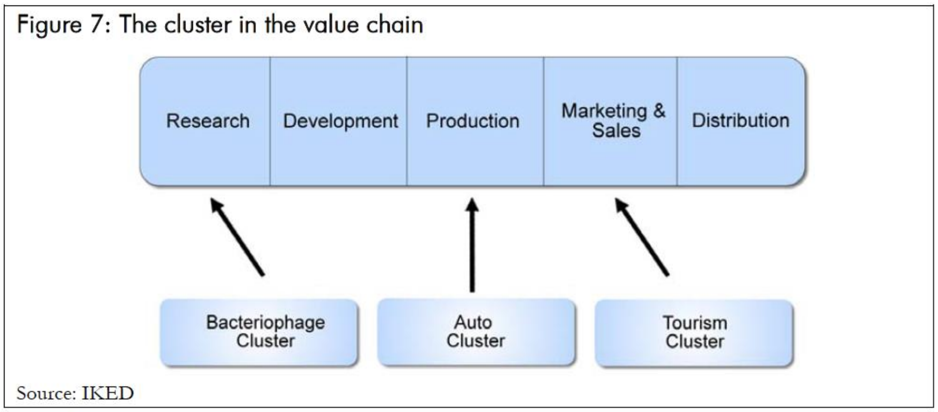
Renewable energy has turned in recent years into a sector with international distribution, just like any other major industry. Countries import turbines made by manufacturers in Germany or China, or financing is offered by a country's local or foreign banking institutions. Also, there may be local projects aiming to export abroad. Similarly, a "cluster" may focus on different activities and central aspects of

31 Massachusetts Technology Collaborative Renewable Energy Trust (2007, p. 3.

32 Massachusetts Clean Energy Center (2011), p. 12.

a value chain, as illustrated in diagram 4.[33] Participating actors can cover the complete value chain or certain segments.

Diagram 4



4.7 Aspects to consider in implementing a "cluster" action plan

In their **Cluster Policies Handbook**, Thomas Andersson, Sylvia Schwaag Serger, Jens Sörvik, y Emily Wise Hansson suggest carrying out various actions. Table 4 presents a list of actions that may be useful in designing a renewable energy "cluster" strategy.[34]

33 **The Cluster Policies Handbook** (2004), p. 33.

34 Ibid., p. 81.

Table 4

Table 2: Possible cluster actions

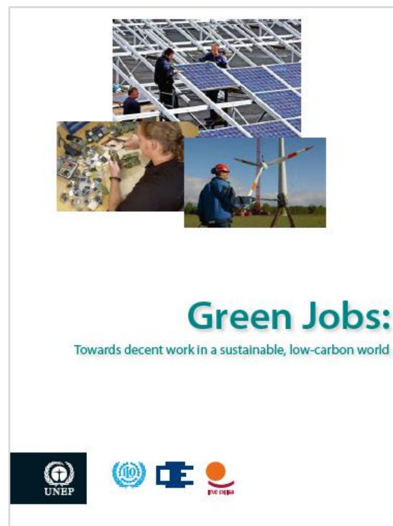
Improve Cluster Dynamics			Improve Cluster Environment	
New Technology & Firm Growth	Inter-Actor Network Creation	Cluster Formation	Factor Markets	Cluster Basis
New Technology. - Organise seminars, meetings, workshops to facilitate the diffusion of technology within the cluster - Establish centres to develop and test new production technologies and processses - Create an observatory of technical trends - Establish hubs for technology transfer *Firm Growth* - Support cluster-based incubators - Encourage entrepreneur networks - Provide business assistance - Launch marketing and image campaigns to attract new firms - Improve FDI incentives - Improve financing conditions for spin-offs through regulatory changes or the set-up of special financeing mechanisms or investment funds	*Networking* - Form cross-agency cluster teams - Foster firm networks - Foster the sharing of personal networks - Facilitate external connections *Commercial Cooperation* - Form export networks - Compile market intelligence - Coordinate purchasing - Establish technical standards *Joint R&D Projects*	*Cluster Analysis* - Conduct a competence audit - Undertake a strategic study & analysis - Model and amplify systematic relationships - Conduct benchmarking analysis - Organise and disseminate information in the cluster *Actions for Engagement and Service Delivery* - Create or formalise IFC and communication channels - Improve firms' cluster awareness - Facilitate interaction between different areas of government and cluster actors *Cluster Marketing* - Create brand for region - Actively promote cluster - Target inward investment	*Specialised Labour Supply* - Provide management & technical training - Use clusters as context for learning - Establish cluster skill centres - Support regional skills alliances - Attract talent to region *Specialised Capital Markets* - Prioritise investments in cluster projects - Give incentives or set aside funds for multi-firm projects. - Promote joint financing, the creation of special investment funds, or the provision of credit guarantees - Encouage mutualisation of risk across cluster actors - Improve access to and usage of natural resources	*Legal Framework* - Improve framework conditions - Evaluate competition policy *Infrastructure* - Develop new or existing infrastructure through joint actions and new financing models - Conduct private infrastructure projects *Social Capital* - Foster the expansion of personal networks - Foster inter-firm communications and networks *S&T, R&D Framework* - Mutualise the realisation or financing of research and development projects

5. GROWTH POTENTIAL AND ECONOMIC IMPACT

The worldwide expansion of renewable energy occurs within a twofold economic context: the need to reduce dependency on fossil fuels to generate electricity so as to lessen environmental contamination and reduce energy costs; and the need to reactivate the world economy, creating new and better jobs, and eliminate persistent world poverty.

A study by the United Nations found the following:[35]

- At the global level, there was an increase of 2.3 million in people working in the area of renewable energy; en 2030, there could be 20 million jobs.
- Retrofitting buildings in Europe and the U.S. for energy efficiency could create 2 million jobs.
- In China, there are 10 million jobs in the recycling area.



In other words, renewable energy is an important instigator of economic growth through the creation of jobs and the reduction of energy costs.

5.1 Implications for Puerto Rico: advantages

We can identify the following advantages in a policy expansion of renewable energy sources:

1. With the development of new pro-environment energy technologies, the labor market and environmental conservation will diversity, leading to possible job expansion.
2. The creation of new opportunities for businesses that are starting out and require a retraining of the work force to be able to see the picture from a completely innovative point of view.

---

[35] United Nations Environment Program (2009).

3. A positive direction in terms of preservation of the environment that will result in greater economic wellbeing.

4. Contribution to sustained economic growth.

5. The benefit of jobs created as a result of the investment in renewable energy can be quantified not just in purely economic terms. In addition to generating direct jobs, it also creates environmental benefits that, in turn, lead to other positive effects.

6. Reducing dependency on oil for the production of electric energy, using methods such as solar and eolic energy, can produce significant savings in monetary terms as well as reduce the production of gases harmful to the atmosphere. The people's financial savings can be transformed, in turn, into consumption or long-term investment.

In terms of renewable energy sources, the analysis in Chapter 2 on global investment trends identifies the sources within renewable energy production and which, among these, will experience the highest growth in the coming years and represent areas of opportunities for investment in Puerto Rico. This relation and the trends are illustrated in Diagram 1.

Diagram 1

areas of investment opportunities

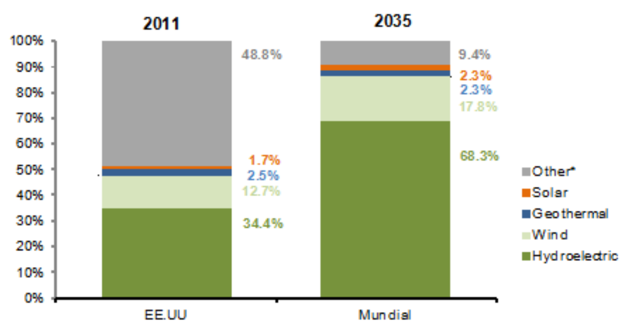
based on global trends

Increased participation of renewable energy in the global energy.

New Investment Annual Growth by Technology Type, 2004-2010	
Solar	91.0%
Wind	43.0%
Marine	33.0%
Biofuel	23.0%
Biomass	20.0%
Hydroelectric	19.0%
Geothermal	12.0%

Source: Table 2, Chapter 2.

Renewable Energy Production by Source

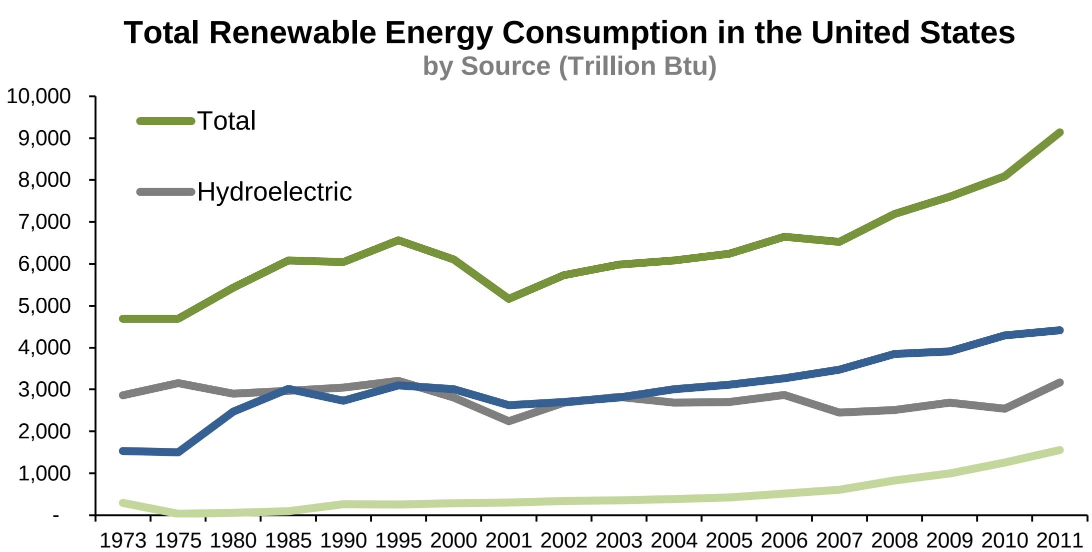


Source: U.S. Energy Administration (2011 y 2012). * For U.S. percent is the biomass or biofuel.

The graph in the previous Diagram 1 shows a comparison between the production of renewable energy, by source or technology, in the United States in 2011 and the world growth of those same sources by 2035.We can see that although the source of hydroelectric energy represents the bulk of the renewable energy production in the United States and worldwide; the highest investment growth has been in solar and eolic technologies.

In fact, during the 2001-2011 period, total consumption of renewable energy grew at an annual compounded rate of 5.9% and consumption of hydroelectric energy increased 3.5% , biomass grew 5.3%, and geothermic, solar and eolic energy sources grew 18% (see graph 1). Based on previously mentioned reasons, growth was highest during the 2007-2011 period when consumption of the latter energy sources (solar, eolic, geothermic) increased 27%..

Chart 1



Source: U.S. Energy Information Administration (2012). *Renewable Energy Production and Consumption by Source* (May). Table10.1. * Geothermal, wind and solar.

On that basis, and keeping in mind the endowment of Puerto Rico's energy resources, we can see that the areas of opportunities are solar and eolic energy sources.

5.2 Opportunities in renewable energy resources

The analysis from the previous section makes reference to the endowment of Puerto Rico's renewable energy sources. There are two related aspects to be considered: the contribution potential of electric energy and the costs behind each source. The Irizarry, Colucci, and Carrillo report (2008) presents an examination of the diverse renewable energy sources in Puerto Rico and the cost estimates.[36] The results are presented in table 1.

Table 1

Table 1-1 Summary of required surface area, capital costs and potential electric energy contribution from each resource/technology.

Renewable resource/technology	Footprint estimate Installed capacity per unit area [MW/km^2]	Capital costs estimate Millions of US dollars per MW electric [M$/MW]	Electric energy production estimate MWh per year if 10% of the resource is used to produce electricity [MWh/year@10%]	Comments
Wind (total)	-	-	2,977,052	14.4% of the 2006 electric energy demand [a]
• small	0.3 [b]	2.01	35,842 [c]	
• large inland	5 [d]	1.20	323,760 [e]	
• large offshore	5 [d]	2.00	2,617,450 [f]	
Ocean (total)			16,935,360	82.2% of the 2006 electric energy demand [a]
• OTEC	A 5 MW prototype, platform occupies 3660 m^2. See [t]	Unknown [g]	Unknown	
• waves/offshore attenuator (Pelamis)	37.5 [h]	8.3	16,394,560 [i]	
• waves/shore Oscillating Water Column (LIMPET)	25 MW/km [j]	3.5	540,800 [k]	LIMPET´s facilities are about 7.5 m wide.
Fuel cells	3,000 [s]	5.0 – 7.0	Unknown	Highly dependent on availability of Liquefied Natural Gas (LNG)
Micro hydro	240	4.0	2,628	0.01% of the 2006 electric energy demand [a]
Annual cumulative energy production, if 10% of wind, ocean waves and solar photovoltaic is used to produce electricity.	---	---	23,812,412	115.5% of the 2006 electric energy demand [a]
Annual energy production, if 10% of agricultural biomass, from microalgae, is used to produce electricity.	---	---	24,000,000	116.5% of the 2006 electric energy demand [a]
Annual energy production, if 10% of wind, ocean waves, solar photovoltaic and agricultural biomass, from microalgae, is used to produce electricity.	---	---	47,812,412	232% of the 2006 electric energy demand [a]

a. According to the "Banco de Desarrollo Económico de Puerto Rico" in 2006 Puerto Rico demanded 20,600,000 MWh of electricity.

b. For small wind turbines we use a very conservative estimate that each wind turbine will occupy approximately 20,000 m² (5 cuerdas/turbine) or 0.02 km^2 per turbine. Bornay Inclin 6000 turbines are chosen for the estimate.

c. Energy production assumes Bornay Inclin 6000 wind turbines, or similar, at 25 m height and wind regime as measured in the southeast coast of Puerto Rico.

d. Corresponds to a conservative separation of 10 rotor diameters in the direction of prevailing wind for large turbines. It is most important to note that at least 90 to 95% of the land use in a wind farm is available for agriculture or other uses.

maximum number of adjacent OTEC platforms even further.

e. Energy production assumes Gamesa G58 wind turbines, or similar, at 50 m height and wind regime as measured in the southeast coast of Puerto Rico.

f. Energy production assumes Fuhrlander FL2500 wind turbines, or similar, at 100 m height and wind regime as measured in the east coast of Puerto Rico.

g. No reliable cost data is available to judge the economic feasibility of OTEC technology. Although the concept is well understood and the resource is available in Puerto Rico no one in the World has built a commercial OTEC plant.

h. A 37.5 MW Pelamis array contains 50 devices in two kilometers long and half kilometer wide arrangement.

i. Total north-west sea area is approximately 862 mi² (2241 km²), thus 10% is about 224 km². A single Pelamis device is estimated to produce about 1,463.8 MWh per year in the north-west sea of Puerto Rico.

j. LIMPET facilities are about 7.5 m wide, thus we specify their footprint using MW per kilometer of length.

k. Puerto Rico´s north shore length is estimated at a length of 160 km, thus 10% is about 16 km. A 1 MW OWC plant is estimated to produce about 1,352 MWh per year assuming a 15% attenuation in wave power as it arrives to the shore.

l. Assuming grid-connected, net metering systems without batteries. The lower estimate corresponds to systems where the owner is knowledgeable of electric systems and can do some of the design, purchase, installation and maintenance by him/herself. The economic analysis in Chapter 5 is done using the more conservative cost figure of 9.1 $/W.

m. Estimated for agricultural productivity of biofuels from ground soil crops (1,000 gallons/yr-ha) to microalgae (20,000 gallons/yr-ha). 12 kW/gal/hr was assumed for electricity generation.

n. Only includes the agricultural and biofuel production investment. Power generation investment not included. Based on lignocellulose and microalgae biofuel production preliminary estimates at large capacity (> 10MGPY).

[36] Colucci, and Carrillo (2008), pp. 1-5 a 1-10.

Their analysis highlights that the examined renewable energy sources have notable physical differences, thus the technology for the production of electric energy also changes, affecting whether or not it is commercially available. The comparison considers three parameters: the location required, capital costs and the electrical energy production potential. On this basis, the authors recommend three renewable sources of energy to be incorporated in the RPS ("Renewable Portfolio Standards"): eolic, photovoltaic solar cells, and the ocean.[37] They consider that the mere utilization of 10% of these sources could provide 115% of the electric power demand (on the basis of 2006).[38]

5.3 Economic impact

The most recent renewable energy investment data for Puerto Rico shows that it is expanding. At the beginning of this year, the private investment underway was $498 million, the bulk of it concentrated in eolic energy. A total of $34.7 million in federal funds is financing several state projects. Table 2.

Table 2

Private Investment in Renewable Energy Projects

Project	Investment (US$)
AES Ilumina	$98 m [a]
Gestamp Renewables	$90m
Pattern energy	$250m
Windmar Renewables	$60m [b]
Total	**$498 m**

Source: sincomillas.com (a) $98 m initial investment; $1000 m committed investment
(b) Already there are other projects in Ponce and Dorado.

[37] The study by Salasovich and Mosey (2011) analyzes the economic viability of solar photovoltaic (PV) on land (landfills) under control of the U.S. Environmental Protection Agency. The study considers the participation of AEE under the scheme of "Power Purchase Agreement". There are already two PV projects in operation in Guayama and Salinas under this scheme. The study concludes that it would be feasible in this type of terrain, under certain conditions. See James Salasovich and Gail Mosey (2011)

[38] Ibid., p. 1-17.

Table 3

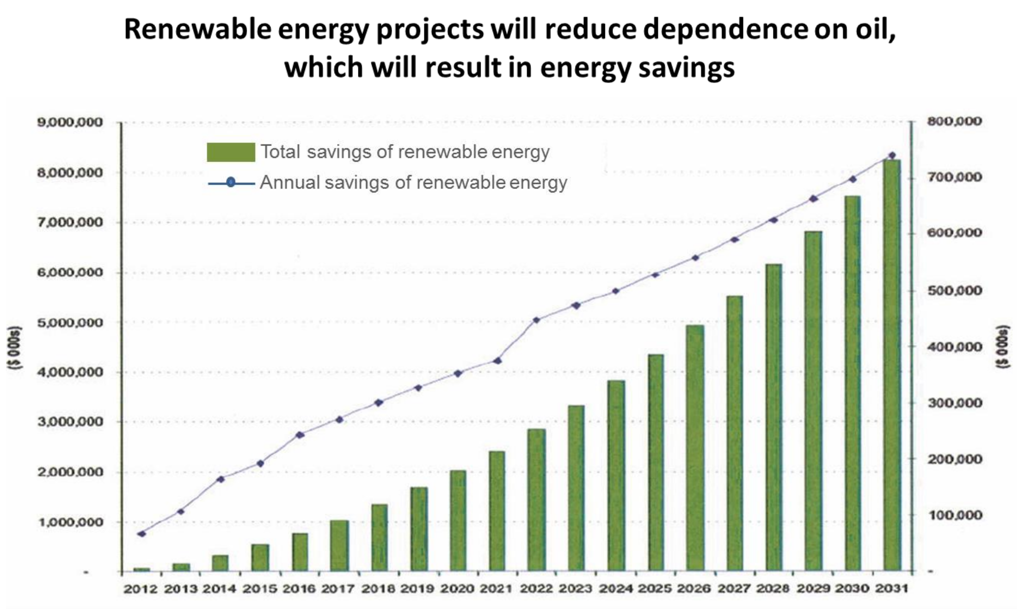
Federal Programs for Renewable Energy Investment

Program	Investment (US$)	Program	Investment (US$)
Agriculture Renewable Energy Program	$ 1 m	Street Lightning Retrofit Program (street lights)	$1.8 m
Building Energy Efficiency Retrofit Program	$7.5 m	Government Energy Program	$12 m
Sun Energy Program	$4.8 m	Energy Codes	$1.1 m
Solar Water Heater Rebate Program	$280,000	Mass Media & Outreach Program	$2 m
Wind Energy Program	$156,588.50	State Energy Efficent Appliance Rebate Program	$3.6 m
Street Ligthning Retrofit Program (traffic light)	$513,633.81		
Total			**$34,750,222.3**

Source: Energy Affairs Administration, (Department of Economic Development and Commerce of Puerto Rico).

According to an estimate by the Department of Economic Development and Commerce (2010), renewable energy projects to reduce dependence from petroleum will result in annual savings of $2.4 billion by 2020 (see Appendix A).[39] The government's Energy Plan assumes that more than 10,000 jobs will be created by 2015, with an investment of $4 billion during 10 years.[40]

Chart 2



Source: Department of Economic Development and Commerce of Puerto Rico.

39 Lower costs reflect the shift to natural gas.

40 Carlos Márquez and Gina M. Hernández (2010). "¿Qué tendrá Puerto Rico en común con la Casa Blanca, el Pentágono y el Capitolio de los EE.UU.?," *Caribbean Business* (Thursday, April 22, 2012).

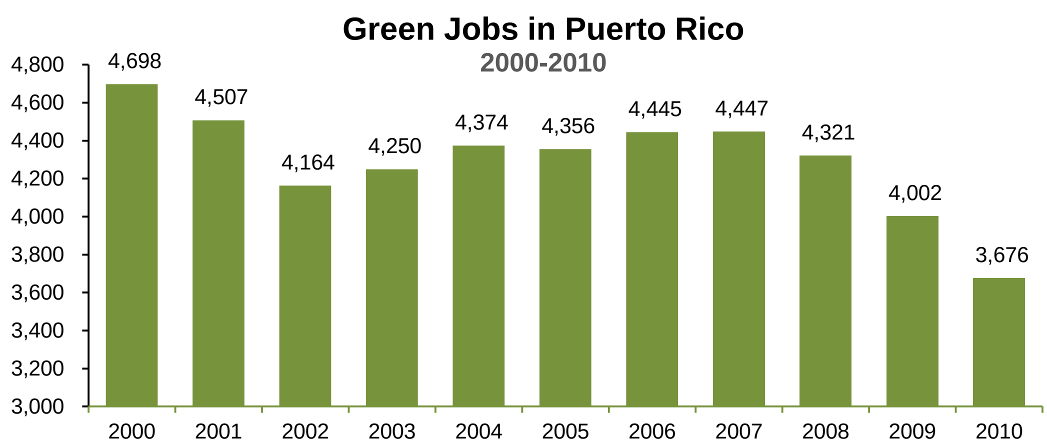
The total amount of private investment in progress and programmed as of 2012 is substantial, considering that the emphasis on renewable energy in Puerto Rico is recent.

5.3.1 Employment in the green economy

Puerto Rico's so called "green economy" sector, which includes everything related to renewable energy, is still very small. Limits in the availability of information do not permit carrying out a more detailed evaluation in terms of employment and investment trends.

A recent study, prepared by Estudios Técnicos, Inc. for the Department of Labor and Human Resources (DLHR), included an analysis of Puerto Rico's green economy jobs.[41] Using disaggregated data submitted by DLHR and the *U.S. Bureau of Labor Statistics*, a time series on employment in industrial sectors with "green jobs" was generated for the 2001-2010 period.[42]

Chart 3



Source: Estudios Técnicos, Inc.

As can be observed in graph 3, the number of green jobs in Puerto Rico has not exceeded 4,600 jobs per year, with a declining trend in recent years. This trend, nevertheless, must be seen as a reflection of the economic recession, during which

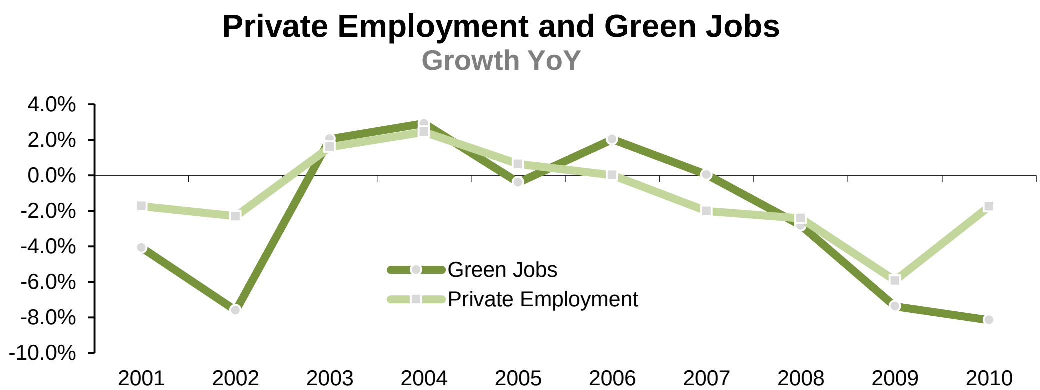
41 Estudios Técnicos, Inc. (2011). Green Jobs projections. San Juan (May 17).

42 The classification of "green jobs" used in the study is according to the definition of the U.S. BLS, September 2010. This classification includes industrial sectors beyond those in the renewable energy sector. It also includes other sectors, such as construction, where jobs can be registered in the construction of renewable energy projects.

private employment has decreased along with investment in construction (sea graph 4).

During the 2001-2010 period, when private employment dropped to an annual average rate of 1.1%, the so-called green jobs decreased at a rate of 2.3%. It is understood that this trend may vary depending on at least two factors: 1) as the adoption of renewable energy technologies is expanded, its impact on employment will increase; and 2) the existence of government incentives for projects in this area.

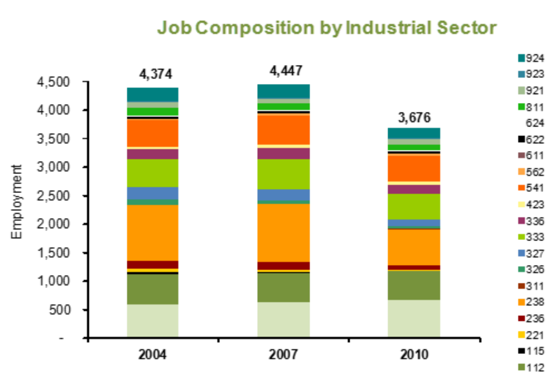
Chart 4



Source: Estudios Técnicos, Inc. (May 17),p. 2.

The job composition by industrial sector is diverse, although the bulk (22%) was concentrated in agriculture (NAICS 111-112) and 17% in the sub-sector of special construction contractors (NAICS 238) (see graph 5).

Chart 5



NAICS Sector	Industry
111	Crop Production
112	Animal Production
115	Support Activities for Agriculture and Forestry
221	Utilities
236	Construction of Buildings
238	Specialty Trade Contractors
311	Food Manufacturing
326	Plastics and Rubber Products Manufacturing
327	Nonmetallic Mineral Product Manufacturing
333	Machinery Manufacturing
336	Transportation Equipment Manufacturing
423	Merchant Wholesalers, Durable Goods
541	Professional, Scientific, and Technical Services
562	Waste Managmenet and Remediation Services
611	Educational Services
622	Hospitals
624	Social Assitance
811	Repair and Maintenance
921	Executive, Legislative, and Other General Government Sup
923	Administration and Human Resource Programs
924	Administration of Environmental Quality Programs

5.3.2 Multiplier Effect of Investment

According to data on renewable energy investment recently made public (see table 2 above), the preliminary estimate for private investment in renewable energy projects over the next few years is $498 million.[43] For the purpose of estimating the impact of an investment in terms of jobs, one uses what is known as multipliers (and coefficients) for jobs and payroll by industrial sector, obtainable through an input output model.[44]

Table 4

Employment Multipliers, Selected Sectors, 2002

Sectors*	Employment Multiplier Type 1	Employment Multiplier Type 2
Building Maintenance and Repair	**3.033**	**4.303**
New Construction	**1.774**	**2.274**
Engineering and Architectural Services	**1.412**	**2.045**

Source: P.R. Planning Board (2007).
* The industrial classification system used in the I-O matrix of Puerto Rico is that of the old Standard Industrial Classification System (SIC), and not that of the NAICS, which does not provide a more detailed breakdown of sectors comparable to that of the nonfarm employment data.

Interpretation:
Type 1: For every one direct job an x number of indirect jobs are generated. Thus, in the case of the first sector, 2.03 direct and indirect jobs are generated, in the second sector, .77 indirect jobs.

Type 2: Consist of the direct and indirect employment (Type 1) plus the induced ones. Following the example above, about 3.3 direct, indirect, and induced jobs would be generated in the sector and the rest of the economy.

Table 4 presents the (Type 1 and 2) multipliers for three selected sectors related to renewable energy, though it is understood that activity in the area of renewable energy may extend to other sectors.[45] One can see that the biggest impact in terms of jobs (direct, indirect, and induced) is in the sector of maintenance and building repairs, a sector that spans activities and tasks related to the energy efficiency of structures. Jobs connected with designing renewable energy projects are included in

43 The Green Energy Fund provides $290.0 millons for comercial and residential proyects.

44 The most recent I-O matrix is for 2002.

45 The industrial classification used in the I-O matrix is limited to 92 sectors.

the third industrial sector which covers engineering and architecture, with a Type 1 multiplier effect of 1.412.

Using this conceptual basis, an economic impact exercise was drawn up. It starts from the assumption that part of this investment began already in 2011 and will extend for a period of five years to reach its highest level by 2015, coinciding with investment in construction (a project by project breakdown of investment is not available). The total amount of investment ($498 million) was applied to the input-output model to obtain estimates of the direct and indirect impact on production, employment, and payroll for the 2012-2015 period. The results are shown in table 5.

Table 5

Impacts of Planned Investment in Renewable Energy Projects

	2012	2013	2014	2015	2016
Investment					
Total ($000)	**$20,000**	**$48,783**	**$118,988**	**$290,229**	**$20,000**
Direct and indirect impact:					
Production ($000)	$39,573	$96,524	$235,436	$574,262	$39,573
Employment (number)	282	668	1,582	3,749	251
Payroll ($000)	$6,603	$16,104	$39,281	$95,812	$6,603

Source: Estudios Técnicos, Inc. estimates.

In terms of employment during that period, a total of 6,532 direct and indirect jobs would be generated during the construction phase, for a total payroll of $164.4 million.

5.4 Export potential - markets

The Caribbean region, specifically the Caribbean islands, has the potential to become the most relevant market for the development of a renewable energy "cluster" for three reasons: first, its geographical proximity; second, sharing a similar climate; and third, the need to explore energy alternatives because of its dependence on fossil fuels. [46]

[46] The exception would be Trinidad and Tobago, both producer and exporter of natural gas and petroleum. For Puerto Rico and Dominican Republic it is the main supplier of natural gas.

One additional reason is that already, for the past several years, there have been initiatives for the development of a network to promote the use of renewable energy among Caribbean islands (although with mixed results).[47] According to a study by Nexant, it is estimated that the peak demand for electric energy in the Caribbean will increase between 2011 and 2028 at an annual compounded rate of 3.8%, with the Dominican Republic and Jamaica the biggest consumers, with an estimated annual growth in demand of 3.5% and 4.5%, respectively (see Table 6).[48] For practically all these economies, with the exception of Trinidad and Tobago, which depend on natural gas, and the Dominican Republic with 20% hydroelectric energy, 100% of the energy they produce derives from petroleum or distilled combustibles.[49]

Table 6
Net Peak Demand Load Forecast (MW)

Year	Antigua and Barbuda	Barbados	Dominica	Dominican Republic	Grenada	Haiti	Jamaica	St. Kitts	Nevis	St. Lucia	St. Vincent and Grenadines	Martinique	Guadeloupe	Total
2009	54	170	15	2,353	31	226	680	29	10	56	27	242	250	4,142
2010	57	176	15	2,447	33	237	707	30	10	58	28	247	256	4,302
2011	60	182	16	2,544	34	249	736	31	11	61	30	255	263	4,472
2012	63	188	16	2,640	36	261	767	32	11	63	32	263	269	4,643
2013	65	195	17	2,727	38	274	799	33	12	65	35	272	276	4,808
2014	67	201	17	2,803	40	288	832	35	13	68	37	281	284	4,965
2015	69	208	18	2,896	42	303	867	36	13	70	40	290	291	5,143
2016	71	216	18	2,992	45	318	904	37	14	73	42	297	298	5,324
2017	73	223	19	3,091	47	334	943	38	15	76	45	303	305	5,512
2018	75	231	19	3,194	50	350	983	40	16	79	48	310	313	5,708
2019	77	239	20	3,300	52	368	1,026	41	17	82	52	317	321	5,911
2020	80	247	20	3,409	55	386	1,071	43	18	85	55	324	329	6,121
2021	82	256	21	3,522	58	405	1,116	44	19	88	59	331	337	6,339
2022	85	265	21	3,638	61	426	1,165	46	20	91	63	339	346	6,565
2023	87	274	22	3,758	64	447	1,214	47	21	95	68	346	354	6,798
2024	90	284	22	3,882	68	469	1,267	49	23	98	72	354	363	7,041
2025	92	294	23	4,010	72	493	1,322	51	24	102	77	362	372	7,293
2026	95	304	24	4,143	75	517	1,379	52	25	106	83	370	381	7,555
2027	98	314	24	4,280	80	543	1,439	54	27	110	88	378	391	7,827
2028	101	325	25	4,421	84	570	1,502	56	29	114	94	387	400	8,109
Growth Rate	3.3%	3.5%	2.7%	3.4%	5.4%	5.0%	4.3%	3.5%	5.9%	3.8%	6.9%	2.5%	2.5%	3.6%

Another alternative that has been proposed to reduce the cost of power is to expand distribution networks and establish an electric grid between the islands.[50] Currently,

[47] See the ECLAC report (1999).

[48] Nexant (2010), p. 10.

[49] Barbados produces a small amount of oil sent to Trinidad and Tobago for processing.

[50] Nexant (2010), p. 1.

none of these economies is interconnected in such an electric power transmission network.

Nevertheless, such a grid scheme is advantageous when one of the islands has a low cost source of energy and a neighboring island does not. This is not the case of these economics, since all of them, save Trinidad and Tobago, depend on petroleum and gas imports, but it would have a greater benefit if the participation of renewable energy sources increases,which eventually will spell out lower production costs.

As in the case of Puerto Rico, technologies identified as having generation potential and less costly than energy production from distilled combustibles are eolic, solar and ocean thermal energy conversion. The three least expensive sources to operate (with a capacity factor of more than 30%) are geothermal, eolic and, on a lesser scale, hydroelectric; those with the least potential, compared with the cost per kWH of combustible fossils, are solar and photovoltaic panels.[51] Several of these economies (Nevis, Dominica, and Saint Lucia) also count with geothermal energy.

In general terms, there has been very little development of these sources in the islands, with the exception of the Dominican Republic. The potential for the generation of renewable energy in the Caribbean varies depending on the country, its geographical characteristics, and the magnitude of its demand for electrical energy.

Table 7 presents, according to the previously mentioned Nexant study (2010), the potential generation by type of source or technology for a group of economies in the Caribbean.[52] It provides an understanding of which technologies have the most potential. In terms of production (MW), photovoltaic solar panels and eolic predominate with three countries in the lead: the Dominican Republic, Haiti, and Jamaica. In terms of total resources, however, the Dominican Republic stands out with 61% of the total.

[51] Ibid., p. 1-23.

[52] Franz Gerner (2010), p. 19.

Table 7
Resources of Renewable Energy in the Caribbean (MW)

	Wind	Geothermal	Hydro	Solar PV	Biomass	Total
Antigua and Barbuda	400			**27**		427
Barbados	**10**			**26**		36
Dominica		100	8	**45**		153
Dominican Republic	3,200		210	**2,900**		6,309
Guadeloupe	15	30		**98**		143
Haiti	10		50	**1,600**	**40**	1,754
Jamaica	70		22	**650**	**20**	761
St. Kitts and Nevis	5	300		**16**		321
St. Lucia		25		**36**		61
St. Vincent/Grenadines	2		5	**23**		30
Trinidad and Tobago	**50**			**308**		363
Total	**3,750**	**455**	**294**	**5,700**	**65**	**10,400**

The U.S. Virgin Islands (USVI) also have adopted a strategy to reduce dependency on combustible fossils by 60% by 2025. This will allow developing an electric energy transmission grid, combining renewable energy and combustible fossils, between USVI and Puerto Rico, as has been proposed.[53] The potential for opportunities is important, since the use of similar renewable energy technologies will lead to demand for equipment as well as technology counseling services.

[53] Kari Burman, Dan Olis, Vahan Gevorgian, Adam Warren, and Robert Butt (2011), pp. vi-vii; 6-7.

6. STRATEGIES

Laws 82 and 83 of 2010, together with Law 73 of 2008, reflect what Puerto Rico's current energy policy is. In this section, additional details are added that should be considered in the strategies to foster the development of alternate renewal energy sources, using the concept of "clusters" as the core element. In addition to the Executive Orders mentioned previously, the President of the Senate has also put forth a number of measures aimed at reducing the cost of energy in Puerto Rico. His proposal calls for placing caps on private sector profits from energy generation, which could be an obstacle for investment in renewable sources. Senator Bhatia also proposes the establishment of an independent energy regulatory board.

6.1 Energy strategies and risk management

During uncertain conditions such as those that characterize the current global economy, the subject of risk assumes a central importance in everything dealing with the management of economies. For economies as open as Puerto Rico, risk management is even more important because such a condition generates the most risks.

The risk may stem from various sources: technological change, geo-political events, natural events, changes in financial, food and oil markets. There are others that result from the very nature of a globalized economy and the volatility associated with it. There is always the risk of a "black swan" event that can disrupt the entire system, as occurred with the oil embargo three decades ago[54].

It's within this perspective, in which risk management assumes a central role, that one should conceive the process of formulating an economic policy and specifically, an energy policy. What is decided with respect to it has the potential to significantly reduce or increase the level of risk facing an economy. For that reason, and not just because of considerations tied to costs or system efficiencies, energy policy, development policy and risk management are closely interconnected.

54 Nassim Nicholas Taleb, *The Black Swan: The Impact of the Highly Improbable*, Random House, New York, 2007.

Obviously, to the extent that energy sources are limited to one or very few, the risk level increases considerably for an economy. In so far as the dependency on fossil fuels, there are three aspects that are important. On the one hand, the probability is very high that situations with a negative impact on the economy will occur. This applies not only to price increases, but also availability. Second, the impact of these events is significant on all the society and economic sectors. And third, the fact remains that risk sources are completely outside of our control.

The aforementioned suggests the need to regard energy policy not just as an issue to make an essential infrastructure more efficient but as a mechanism to reduce an economy's external risk.

Diversifying energy sources is paramount, especially in view of the isolation of our electric energy system. But it is also essential for Puerto Rico to place an emphasis on the management of demand and this means that the decisions regarding the future productive structure should take into account the power consumption vector of the production functions of diverse productive structures. This implies considering --within the framework of a process to formulate economic policies based on risk management -- that both issues are linked: that is, productive structure and energy.

If it is true that an energy policy should be formulated on the previously mentioned bases, it is no less certain that, in the end, it will depend on how we visualize the social and economic future of Puerto Rico. The effectiveness of an energy policy is linked to the model for socio-economic development.

To the extent that the concept of "clusters" is used in an energy policy, the policy's capacity as an instrument to reduce economic risk is strengthened. There are successful examples of such policies in places like Hawaii, Michigan, Holland, and other countries.

6.2 Requirements for strategies based on "clusters”

The essential part of an energy strategy based on clusters is described as follows.

1. It is essential to identify the components of the cluster that span production, distribution, consumption and that incorporate production entities, equipment manufacturers, universities, important energy users, government institutions, financial entities, and community-based organizations. The key to keep in mind, as noted in this report, is that a "cluster" is not an assemblage of businesses that carry out similar activities based in one location. At the heart of the concept is the complementariness between components.

2. It is vital to set in motion a process to achieve a consensus regarding the strategy based on "clusters" since this involves important changes in the way that companies and government entities operate.

3. Ensure that the legal elements necessary for the development of an energy policy based on "clusters" exist and are in tune with other laws and regulations; for example, those dealing with the market structure, permitting, and other. In Puerto Rico, the aforementioned laws provide very positive incentives which, however, would have to be examined in light of a "cluster" based strategy.

4. Establish a public/private structure to manage the creation and operation of the "cluster." The importance of relying on a management structure is that it facilitates the continuity of efforts and the coordination of the various participants. A mechanism of this type is considered in the current law.

5. The promotional strategies must shift from an emphasis on specific enterprises to the promotion of "clusters." This means that such policies must be conceived based on the external savings resulting from the creation of the "clusters." The promotional strategies must be pro-active in contributing to the formation of the "cluster," contrary to the current emphasis on promoting particular businesses by giving them incentives.

6. A key component in "cluster" development is the integration of universities and various research centers dedicated to the issue of energy at the University of

Puerto Rico in Mayaguëz and the University of Turabo, where the Puerto Rico Energy Center is based, among others.

6.3 "Cluster" strategies in Puerto Rico

It should be added that an energy strategy can be an important instrument in strengthening local businesses and regional initiatives that have emerged in the past years. That's why an energy policy should be conceived to create opportunities for these initiatives to play a more important role in the development of alternate sources and to consolidate the economic activity stemming from them. This dimension acquires particular importance in view of the fact that Governor García Padilla recently created a bipartisan Decentralization Commission with the task of decentralizing government programs and providing regions and municipalities with the wherewithal to be self sufficient.

One element in the strategy is to take advantage of the experience and the capacity of the construction sector within the energy "cluster." In view of projections that investment in construction will not increase significantly, organizations within the industry together with the government must set in motion a program aimed at strengthening the capacity of the industry in areas related to the development of the infrastructure needed for alternate energy.

For that reason, we suggest that energy strategies in Puerto Rico incorporate the participation of regional initiatives (INTECO, INTENOR, INTENE, PR-TECH and DISUR) as well as measures aimed at making it possible for community-based organizations to assume a role in the development of "cluster" activities. What should be avoided is a repeat of industrialization strategies from the past decades in which the emphasis was almost exclusively on promoting businesses from abroad. This might be the fastest way to obtain investment in energy infrastructure as part of developing alternate sources but, if the strategy is conceived on the basis of "clusters" and as an instrument to reduce external risk and promote a strengthened local economic, this course would be wrong. In so far as the potential to generate economic activity based on the development of alternate energy sources, there are opportunities that Puerto Rico can take advantage of. The island's research infrastructure in the field of energy is such that it allows Puerto Rico to turn into a knowledge center. On the other hand, Puerto Rico can assume leadership in strategies based on "clusters" and transform itself into a model for the Caribbean region. Again, this will require a concerted effort by government agencies responsible for economic development and exports as well as changes in the way export promotion has been planned. Recently approved legislation to promote the exporting of advanced services is an important step that can provide the basis for transforming Puerto Rio into a center for exporting alternative energy related services.

The above requires a concerted effort by Government to coordinate efforts aimed at stimulating the development of an energy system base don renewable sources. The best practices identified all provide ample justification for the Government to assume a key role for this purpose.

The existing legislation and the Governor's recent Executive Orders provide for such concerted action. Creating a successful cluster based energy policy will requiere the integration of at least the following entities:

The PR Energy Affairs Administration
The PR Energy Power Authority
The Department of Natural Resources
The PR Industrial Development Company
The University of Puerto Rico
The PR Manufacturers' Association
The Association of Renewable Energy Producers
The PR Planning Board

The recently created Council foe Energy Autonomy could be the appropriate entity to channel efforts towards creating a renewable energy cluster that brings together R&D, production capacity, engineering services and promotional efforts.

7. SUMMARY

- The global importance of renewable energy sources has increased and their share of electric power generation has grown from 3.5% in 2004 to close to 6% in 2010.
- There is a growing world demand for renewable energy. It is estimated that by 2035, the net generation of renewable energy will experience an annual growth of 3.1%.
- In the United States, (non hydroelectric) renewable energy's share of total production went up considerably between 2001 and 2011, propelled by eolic energy.
- Globally, investment centered on eolic and solar energy increased to $211 billion in 2010, experiencing a compounded annual growth of 36% between 2004 and 2010. This pattern of rapid growth is expected to continue in the next years.
- The investment in China has contributed considerably to this expansion, and now this country is number one worldwide. It manufactures half of all solar panels and wind turbines, and each year creates 100,000 new jobs in renewal energy.
- Governments have played a key role in accelerating expansion and development of renewable energy, and the number of countries with some type of renewable energy policy or support has more than doubled, from 55 in 2005 to 119 in 2011.
- There are two types of renewable energy policies: those that have a specific policy based on goals or objectives, and those that offer some type of support, with the former being the most common.
- Public support has been key to the development of renewable energy, both in terms of subsidies and rates. None the less, all sources of renewable energy receive 86% of global energy subsidies. It is estimated that renewal energy subsidies will increase, from $66 billion in 2010 to $250 billion by 2035.
- Funds and subsidies made available through ARRA have been essential to the expansion of renewable energy in the United States. In federal Fiscal year 2010, ARRA funds represented 42% of all subsidies, direct expenditures and supports (tax breaks and others) earmarked for renewable energy. In turn, these funds represented

39.5% of all subsidies and supports committed to the generation of electric energy, an increase compared with 2007 (29%).

- The importance of renewable energy has raised a concern: what will happen after ARRA funding ends in 2014? In 2009, $25 billion were allocated to the development of renewable energy; by 2014, funding will drop to $200 million which is expected to reduce public and private spending on renewable energy, at a time when the trend at the global level is for this type of energy to grow in importance.
- The bulk of federal spending (2009-2014) in renewable energy technology has been for renewable electricity (32%), followed by biocombustibles (16.1%).
- In Puerto Rico, adopting a public policy to promote renewable energy as an alternative energy source has contributed, together with federal programs, to help generate renewable energy projects. Already there are projects underway representing an investment of $498 million.
- According to the literature on "cluster" policies, government policies based on direct indiction are preferable to those of direct intervention, save when the failures of the market or the system are evident.
- The Caribbean region, specifically the Caribbean islands, is potentially the most relevant market for the development of a renewable energy "cluster" for three reasons: one, its geographical proximity; two, sharing a similar climate; and third, the need to explore energy alternatives because of its dependency on combustible fuel.
- Just like in Puerto Rico, the technologies identified as holding a production potential and being less costly than energy production from distilled combustibles are eolic, solar, and, to a less degree, ocean thermal energy conversion.
- The Irizarry, Colucci and Carrillo study (2008), for example, recommends incorporating three sources of renewable energy within the RPS (Renewable Portfolio Standards): eolic, photovoltaic solar cells, and ocean energy.

- The generation technologies with the most potential in the Caribbean (MW) are photovoltaic solar panels and eolic, led by the Dominican Republic and Haiti, followed by Jamaica. Still, at the level of total resources, the Dominican Republic stands out with 61% of total resources.
- Puerto Rico's so-called "green economy", which would comprise everything related to renewable energy, is still very small. The number of green jobs in Puerto Rico does not exceed 4,600 jobs per year, with a trend towards lower employment in the last few years.
- It is understood that this trend can vary depending on at least two factors:(1) as the adoption of renewable energy technology expands, the impact in terms of jobs will increase; (2) government incentives for projects in this area.
- A five-year economic impact exercise was developed based on investment in construction (a breakdown of each investment is not available). Applying the total amount of investment ($498 million) to our input-output model produced estimates of the direct and indirect impact on production, employment and payroll for that period.
- In terms of employment, a total of 6,532 direct and indirect jobs would be created during the period for a total payroll of $164.4 million.
- Puerto Rico's strategy on alternate energy sources should be conceived as a policy that not only aims to improve the energy infrastructure but also to minimize the risks the economy faces.
- The energy policy presents an important opportunity to strengthen the local economy but it must focus on ensuring that the supply chains are completed locally. Also, it requires an approach that will permit the transformation of sectors like construction so they will be able to take advantage of the opportunities offered by the power transformation.
- Puerto Rico has the capability to become a regional knowledge center for alternate energy sources. Its university infrastructure and research capacity in this area

support this prospect. At the same time, recently approved legislation to stimulate the exporting of advanced services provides the basis for initiatives in this regard.

- An essential action for implementing the cluster based renewable energy policy is the creation of the appropriate institutional framework, including the designation of an entity to manage the process. The recommendation made is for the Council on Energy Autonomy, created by OE-2013-039, to assume that responsibility.

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