Summary
of
Cape Verde Renewable Energy Plan

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1. Introduction

The Republic of Cape Verde is an archipelago consisting of 10 islands and 13 islets approximately 400 km off the coast of Senegal in the Atlantic Ocean. The country has a total land area of 4033 square kilometers and a total population of 542.000 inhabitants, with a population growth rate of about 1.8% p.a.

Cape Verde has very limited natural resources and suffers from poor rainfall and limited fresh water. Only 4 of the 10 main islands (Santiago, Santo Antão, Fogo, and Brava) can support agricultural production, and over 90% of all food consumed in Cape Verde is imported while most of the water used in the country comes from desalination plants on the islands. Mineral resources include salt and pozzolana (a volcanic rock used in cement production).

The economy of Cape Verde is service-oriented, with commerce, transport, and public services accounting for more than 70% of GDP. Although nearly 70% of the population lives in rural areas, agriculture and fishing contribute to about 9% of GDP. Light manufacturing accounts for most of the remainder. An amount estimated at about 20% of GDP is contributed to the domestic economy through remittances from expatriate Cape Verdeans.

Since 1991, the government has pursued market-oriented economic policies, including an open welcome to foreign investors and a far-reaching privatization program. It established as top development priorities the promotion of market economy and of the private sector; the development of tourism, light manufacturing industries, and fisheries; and the development of transport, communications, and energy facilities. From 1994 to 2000 there was a total of about $407 million in foreign investments made or planned, of which 58% were in tourism, 17% in industry, 4% in infrastructure, and 21% in fisheries and services.

Fish and shellfish are plentiful, and small quantities are exported. Cape Verde has cold storage and freezing facilities and fish processing plants in Mindelo, Praia, and Sal.
Cape Verde's strategic location at the crossroads of mid-Atlantic air and sea lanes has been enhanced by significant improvements at Mindelo's harbour (Porto Grande) and Praia's harbour, and at Sal's and Praia's international airports. New international airports were opened in Boa Vista (December 2007) and Sao Vicente (December 2009). Ship repair facilities at Mindelo opened in 1983. The major ports are Mindelo and Praia, but all other islands have smaller port facilities. In addition to the international airport in Sal, airports have been built on all of the inhabited islands, although the airports in Brava and Santo Antão are now closed. All other airports enjoy scheduled air service.
The positive change in affluence amongst the population in parallel with the growth in the tourism sector have contributed to a corresponding increase in demand for petroleum

products, electricity and desalinated water. Therefore, Cape Verde is faced with increasing power deficit that is already hampering economic and social development. Although considerable investments have been made in the last few years, they have largely failed to address the ever widening power supply shortage. Beside this, the high electricity tariffs that the country experiences (about 0.25 euro per KWh) affects the development of the economy.
The Government of Cape Verde has launched an ambitious plan to reduce the country's dependence on imported fossil fuels through increased energy production from renewable resources. Through private-sector investment and government-supported projects, Cape Verde intends to generate at least 25% of its electricity from renewable sources by the year 2011 and 50% by the year 2020. To achieve these objectives, major projects in solar energy (5 MW for Santiago and 2.5 MW for Sal) and wind energy (28 MW for Santiago, S.Vicente, Sal and Boavista in total) are in process of implementation.

2. Review of Electricity Sector in Cape Verde

2.1. Overview

Cape Verde has no primary energy resources except wood, which is insufficient due to low rainfalls and poor soil quality. The country's energy supplies come from four main sources – petroleum products, butane gas, firewood and wind. Firewood meets 57% of household energy needs and the demand for wood fuel exceeds the regeneration capacity of the existing ecosystem. The use of firewood for cooking especially in the rural areas is therefore fuelling the evident deforestation in the country; the most affected being the islands that are traditionally more rural (S. Antão, S. Vicente, S. Nicolau, Santiago, Fogo and Brava).
As an archipelago, each island of Cape Verde has its own local power station running on petroleum products and its own electrical grid. Access to electricity has attained a rapid growth in the last years, achieving a national coverage of 95 % in 2010. An important Rural Electrification Programme, implemented since the 90's, has extended the electrical grid to the most remote rural areas. The coverage of the urban areas is almost 100%.

The National Electricity and Water Company (ELECTRA) is responsible for the supply of electricity and desalinated water in Cape Verde. ELECTRA is a company owned by the Cape Verdean Government (85%) and Cape Verde Municipalities (15%),

The largest power station is located in the country's capital (City of Praia) with an installed capacity of 31 MW, followed by Mindelo (18.3 MW) and Sal (9 MW).
Like many other countries Cape Verde is heavily dependent on imported petroleum products, including the HFO and diesel for power generation.
Despite the efforts by the government in recent years, the electricity production remains deficient in the country, affecting to a large-extend, its development. The situation should improve significantly in the near future, since several projects are under implementation.

2.2. Sector objectives

The Cape Verde Government's primary objective for the sector is the provision of reliable efficient, affordable energy services in a sustainable and environmentally friendly manner.
To achieve this objective, the government has defined a strategic plan (Cape Verde Energy Policy) for the sector to be implemented in the next 10 years with the following overall objectives:

- Improve and expand in an efficient manner, the existing energy supply systems to:
    - Meet growing demand induced by increased economic activity, population growth and desalination of water for domestic and commercial uses. This is expected to be achieved by increasing the generation capacity from 85 MW in 2009 to 100 MW in 2010 and 140 MW in 2012 . This production is expected to come from a combination of fossil fuel thermal plants and renewable energy sources.
    - Centralize the power generation on each island (one power station for each island), by installing higher capacity machines and consequently improving the efficiency of the system;
    - Reinforce the electric grid and cut technical and non-technical losses from 30% in 2008 to 24% in 2010 and 20% in 2012;
    - Promote private sector participation in electricity generation;
    - Restructure the National Electricity and Water Company (ELECTRA) to become financially viable and capable of meeting shareholder obligations.
- Create a Fuel Logistics Company in order to reduce the internal logistic costs of petroleum products;
- Promote the development of renewable energy projects in Cape Verde, to achieve 25% renewable energy penetration in 2012 and 50% in 2020, and on one island (Brava) attain 100% penetration of renewables;
- Promote a domestic fuel sub-sector, which will clearly focus on sustainable management of wood fuel resources;
- Widen the population's access to modern forms of energy so as to stimulate development and reduce poverty;
- Strengthen institutional and human resource capacity and enhance Research and Development (R&D) in energy development; and
- Provide adequate security of supply.

In summary, the national strategy for the energy sector in Cape Verde is based on the development of more efficient electricity generation and distribution systems, where the renewable energy should have an important role, and also a more efficient management of internal logistic costs of petroleum products.

2.3. Generation Capacity

The electricity production in Cape Verde is based on thermal power stations running on heavy fuel or diesel (97%); and a small percentage of wind energy (3%). ELECTRA operates all over the country, 18 diesel power stations of different capacities (with a total capacity of 85.08 MW), 3 wind farms (with a total capacity of 2.4 MW) and two Solar Parks (5 MW at Santiago and 2,5 MW at Sal – inaugurated in November 2010).

Table 1: Cape Verde Generation Capacity 2010 (ELECTRA)

Island	Power Plant	P.P. Installed Capacity (MW)	Total Installed Capacity (MW)	Wind Firm Installed Capacity (MW)	Solar Photovoltaic Installed Capacity (MW)
S. Antao	Ribeira Grande	4,33			
	Porto Novo	2,88			
	Porto Novo		7,21		
S. Vicente	Matiota	10,90			
	Lazareto	7,44			
			18,34	0,90	
S. Nicolau	Ribeira Brava	0,58			
	Tarrafal SN	2,22			
			2,80		
Sal	Palmeira	10,34			
			10,34	0,60	2,50
Boavista	Sal-Rei	2,14	2,14		
Maio	Porto Ingles	1,38	1,38		
Santiago	Gamboa (Praia)	5,03			
	Palamrejo (Praia)	26,04			
	Assomada	3,92			
	Tarrafal ST	2,80			
	S. Cruz	4,05			
			41,84	0,90	5,00
Fogo	S.Filipe	3,00			
	Joao Pinto	2,08			
	Mosteiros	0,80			
			5,88		
Brava	Favetal	1,06	1,06		
TOTAL ELECTRA			90,99	2,40	7,50

The power plants at S.Vicente, Sal and Praia (Gamboa and Palmarejo) run on heavy fuel. For the rest of the country the power plants run on diesel, with a very high production cost. According to data provided by ELECTRA, the peak load at each power station is lower than the installed capacity, as shown in Figure 1.

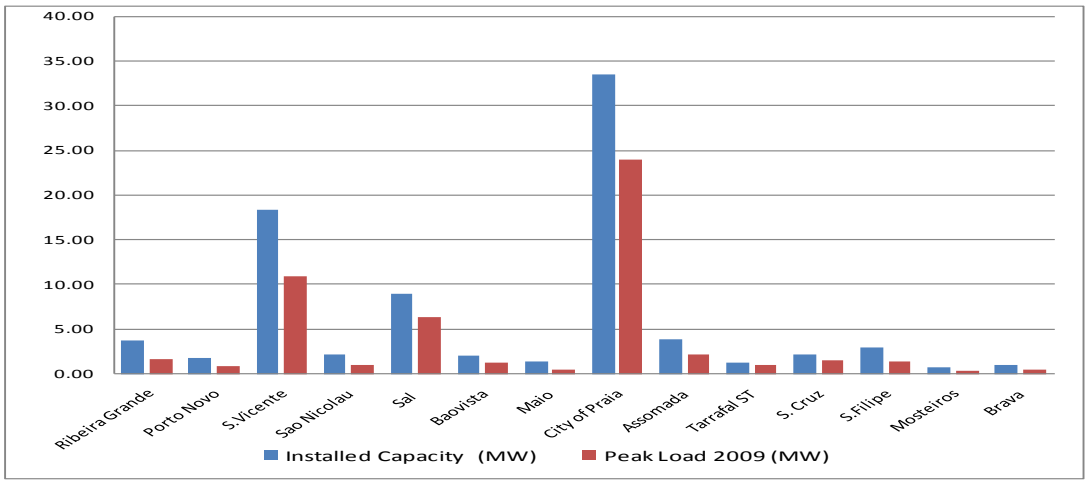

Figure 1: Peak Load vs. Installed Capacity at Cape Verde Power Stations

During 2009 ELECTRA registered a consumption of 8,838,142 litres of heavy fuel type 380, 41,280,339 litres of heavy fuel type180 and 19,306,960 litters of diesel for electricity generation. Figure 2 shows the evolution of fuel consumption in the last five years.

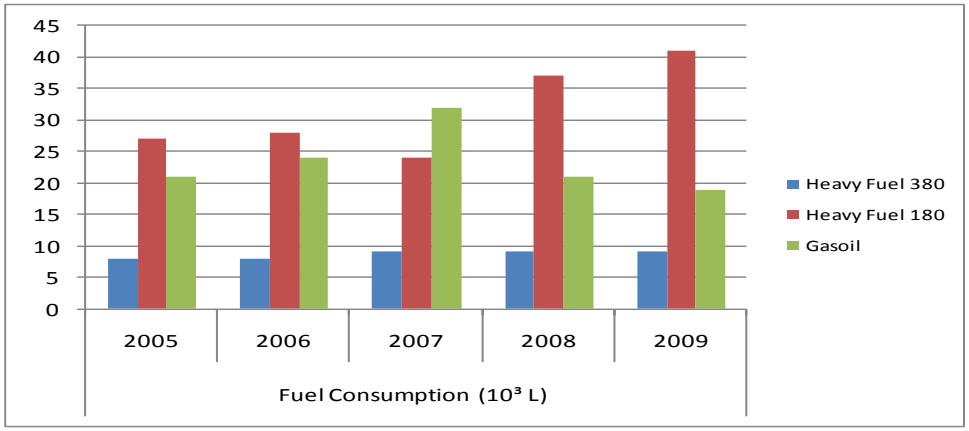

Figure 2: Fuel Consumption 2005 – 2009 (ELECTRA)

As it can be seen since 2007 there has been a reduction in the consumption of diesel, resulting from a greater utilization of generator sets that use heavy fuel oil.
Apart from the main power plants of ELECTRA, there are several small diesel electrical systems that provide electricity to remote rural communities under the responsibility of the municipalities.

2.4. Energy balance – demand and supply

The Renewable Energy Plan for Cape Verde (REPCV) recently elaborated by the Government indicate that the electricity consumption in Cape Verde has registered in the last ten years (2000 – 2009) **an annual growth rate of 8%, having reached 295 MWh in 2009**. The three main islands of Cape Verde (Santiago, Sao Vicente and Sal) represented about 90% of the total demand of the country in 2009. The island of Santiago alone contributes to about 60% for the national demand.

Almost 50% of the electricity demand is from the domestic sector, while the commercial, industrial and agricultural sectors are responsible for about 38% of the demand. ELECTRA internal energy consumption which includes energy consumption for the desalination plants (Praia, Mindelo, Sal and Boavista), represents about 18% of the total demand.

The electrical system registered an increase in losses (technical and non-technical losses) from an average of 17% in 2005 to 26% in 2008, with a very small reduction in 2009. The system in Praia (Santiago island), which is the largest electrical system, registered extremely high losses from 24% in 2005 to 36% in 2008. In 2009, total energy generated in Praia was 143,676 MWh out of which only 88,666 MWh was consumed, corresponding to over 51,000 MWh in technical and non-technical losses during the year. Fraud and electricity theft is one of the problems on Santiago Island. **Loss reduction is therefore one of the main objectives for the near future**.

2.5. Future demand projections

The Renewable Energy Plan for Cape Verde has developed three scenarios for the future electricity demand in Cape Verde:

- A Base scenario – Based on the demographic and macroeconomic projections;
- An Energy Efficiency scenario – based on the implementation of a National Energy Efficiency Program corresponding to a moderate demand growth;
- An Aggressive Scenario – based on the growth rates of the last 10 years representing a very ambitious scenario.

For the base scenario, REPCV predicts a slight slowdown in demand growth, resulting from a more moderate growth in different sectors, as summarized in the table below:

Table 2: Average Annual Increase Tax (REPCV)

Sector	Average Annual Increase Tax	
	2000 - 2009	2009 - 2020
Domestic	10%	6%
Commerce/Industry/Agriculture	8%	7%
Tourism	14%	8%
Institutions	11%	6%
Dessanilation	0%	6%
Internal Consumption	12%	5%
Technical losses	7%	7%

Taking in consideration the historic demand evolution (2000 – 2009) and all the assumptions referred above, the REPCV established the following demand predictions for 2012, 2015 and 2020 (CEE – scenario EE; CI – base scenario; CA – aggressive scenario.):

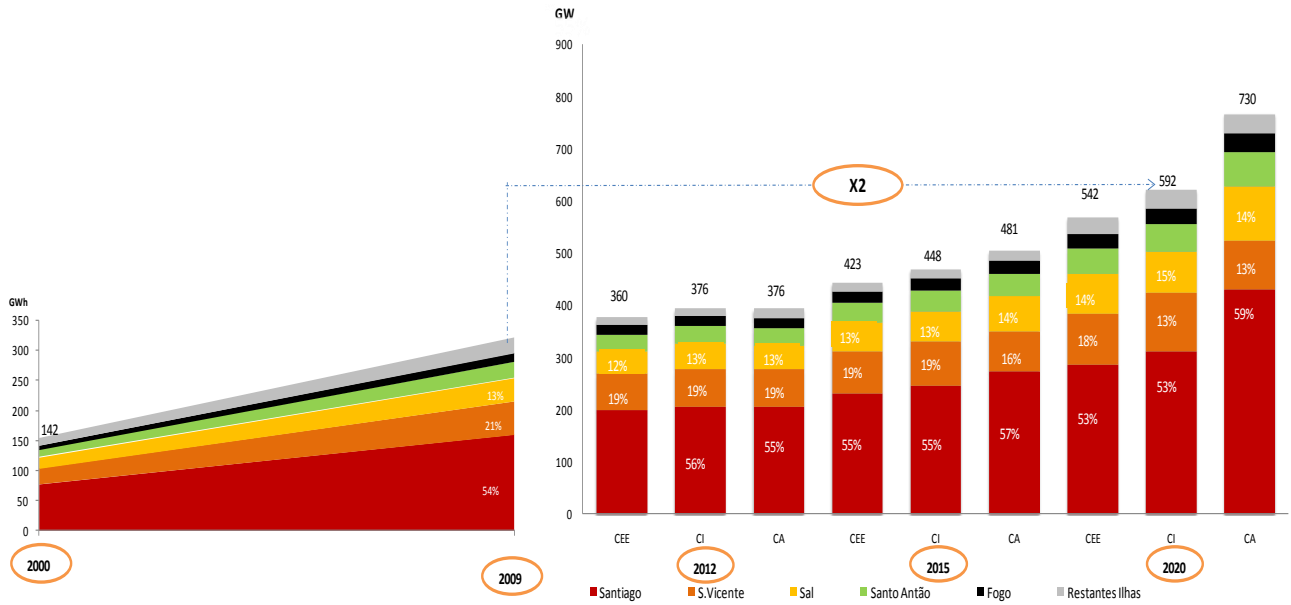

Figure 3: Demand Prediction 2012/2015/2020 (REPCV)

For the base scenario (an average annual growth rate of 6,5%), the REPCV foresees **a two fold increase in electricity demand in Cape Verde in the next 10 years**. The three main islands (Santiago, Sao Vicente and Sal) will continue to represent about 90% of the total electricity consumption of the country, especially Santiago island, which represent about 50% of the national consumption.

3. Ongoing Renewable Energy Projects

There are some ongoing renewable energy projects in different islands, namely wind, solar and hybrid projects:

- **Wind Power Project for Santiago, Sao Vicente, Sal and Boavista** – CABEOLICA - Installation of 25,5 MW wind energy in four main electrical greed (Santiago - 9,35 MW ; Sao Vicente – 5,95 MW; Sal - 7,65 MW; Boavista – 2,55 MW). The project is the result of a Public-Private Partnership (PPP) between the Government of Cape Verde, InfraCo and Electra. The estimated annual generation is 80 - 110 GWh/year, representing about 25% of the electricity production from 2011 - 2015, resulting in 20,000 ton/year of imported fuel saved and more than 20,000 tons/year of CO2 emission avoided.
- **Wind Power Project for Santo Antao** – ELECTRIC – Installation of 1MW wind energy by a private company.
- **Solar Photovoltaic Project for Santiago and Sal** – Government of Cape Verde, financed by a credit loan from Portugal. – Installation of 5 MWp at Santiago and 2,5 MWp at Sal, including the installation of a diesel backup of about 5 MW in each island. The expected annual production is 8.120 MWh and 3.960 MWh respectively for Santiago and Sal.
- **Micro-generation at public buildings** - Government of Cape Verde, financed by a credit loan from Portugal – installation of about 150 KWp of grid connected solar photovoltaic systems on different public buildings.
- **Off-grid systems for electrification of remote areas** – Municipality of Porto Novo – Santo Antao and Government of Cape Verde.

The implementation of the ongoing projects will ensure the attainment of the first target set by the Government of Cape Verde (25% renewable energy penetration in 2012).
To achieve the second target (50% renewable energy penetration by 2020) it is fundamental to pursue the implementation of new Renewable Energy Projects, as well as new basic electricity infrastructure, in order to ensure the stability and security of the electrical system.

4. Renewable Energy Assessment

The Renewable Energy Plan for Cape Verde (REPCV) has developed the renewable energy assessment for wind, solar, hydro and geothermal for the five main islands of Cape Verde (Santiago, Sao Vicente, Sal, Sao Antao and Fogo). The plan identifies and defines on a map the best location for each renewable resource. These areas will be reserved by law as a Renewable Energy Development Zone (ZDER). For each zone the plan estimates the total installed capacity, the expected annual production and the investment cost.
The REPCV identifies an enormous potential of RE in Cape Verde, distributed by wind energy (220 MW), solar energy (2.600 MW - estimate annual energy production of 4,7 GWh/year), geothermal (3 MW - estimate annual energy production of 22,3 Ghh/year – Fogo island), waves and tides energy (11 MW - estimate annual energy production of 14,2 Ghh/year), as described at the tables bellow:

Table 3: Wind Energy Projects (REPCV)

RANKING	ZDER	PROJECT INDENTIFICATION	INSTALLED CAPACITY (MW)	ANNUAL ENERGY PRODUCTION (GHh/y)	INVESTMENT COST (M€)	ANNUAL O&M COST (M€)
SANTIAGO						
1	ZDER.ST.2 - ST W4	PE Monte Leao	3,40	16,60	8,30	0,18
2	ZDER.ST.2 - ST W6	PE Achada Mostarda	18,70	60,80	36,60	0,79
3	ZDER.ST.2 - ST W8	PE Montes Redondos	12,80	41,50	26,80	0,54
4	ZDER.ST.2 - ST W3	PE Rui Vaz	3,40	12,20	8,10	0,16
5	ZDER.ST.2 - ST W5	PE Pedra Branca	6,80	22,90	15,10	0,30
6	ZDER.ST.2 - ST W7	PE Achada Descanso	5,10	15,50	11,00	0,20
7	ZDER.ST.2 - ST W9	PE Forno	4,30	12,20	9,10	0,16
8	ZDER.ST.1 - ST W2	PE Monte Chamine	6,00	17,40	14,20	0,23
9	ZDER.ST.1 - ST W1	PE Praia Baixo	6,80	17,90	16,00	0,23
SAL						
1	ZDER. SL.1 - SL W2	PE Cascanhal	15,30	41,50	31,30	0,54
2	ZDER. SL.1 - SL W4	PE Serra Negro	6,00	18,00	13,60	0,23
3	ZDER. SL.1 - SL W1	PE Curralona	11,10	30,00	22,80	0,39
4	ZDER. SL.1 - SL W1	PE Socorro	6,00	15,70	13,00	0,20
FOGO						
1	ZDER. FG.1 - FG.W1	PE Cova Figueira	17,90	58,10	38,60	0,76
2	ZDER. FG.1 - FG.W2	PE Monte Ledo	1,70	3,80	3,90	0,05
S. ANTAO						
1	ZDER. SA.1. - SA.W1	PE Lombo Torre	11,10	27,60	25,60	0,36
2	ZDER. SA.1. - SA.W2	PE Joao Daninha	11,10	25,00	23,80	0,33
3	ZDER. SA.2. - SA.W3	PE Galheteiro	12,80	25,90	27,00	0,34
S. VICENTE						
1	ZDER.SV.1 - SV.W2	PE Areia Branca	7,70	33,80	15,70	0,44
2	ZDER.SV.1 - SV.W3	PE Pe de Verde	2,60	11,20	5,20	0,15
3	ZDER.SV.1 - SV.W2	PE Joao D'Evora	10,20	46,50	22,10	0,60
	TOTAL		**180,80**	**554,10**	**387,80**	**7,18**

Project Live Time – 20 years

Table 4: Solar Photovoltaic Projects (REPCV)

RANKING	PROJECT CODE	PROJECT INDENTIFICATION	INSTALLED CAPACITY (MWp)	ANNUAL ENERGY PRODUCTION (GHh/y)	INVESTMENT COST (M€)	ANNUAL O&M COST (M€)
SANTIAGO						
1	ST.S1	PS Achada Ponta Bomba (I)	5,00	8,63	16,30	0,19
		PS Achada Ponta Bomba (II)	10,00	17,26	32,50	0,39
2	ST.S2	PS Achada Ribeira Pedro (I)	5,00	8,63	16,30	0,19
		PS Achada Ribeira Pedro (II)	15,00	25,89	48,80	0,58
3	ST.S3	PS Achada Bela Costa (I)	10,00	17,26	32,50	0,39
		PS Achada Bela Costa (II)	20,00	34,52	65,00	0,78
4	ST.S4	PS Achada Tambarina (I)	10,00	17,26	32,50	0,39
		PS Achada Tambarina (II)	30,00	51,78	97,50	1,17
5	ST.S5	PS Ponta Lombo (I)	10,00	17,26	32,50	0,39
		PS Ponta Lombo (II)	25,00	43,15	81,30	0,98
6	ST.S6	PS Achada Cidade Velha	17,00	29,34	55,30	0,68
7	ST.S7	PS Achada Salineiro (I)	10,00	17,26	32,50	0,39
		PS Achada Salineiro (II)	15,00	25,89	48,80	0,59
8	ST.S8	PS Achada Barnel (I)	10,00	17,26	32,50	0,39
		PS Achada Barnel (II)	15,00	25,89	48,80	0,59
9	ST.S9	PS Ponta Inglesa (I)	10,00	17,26	32,50	0,39
		PS Ponta Inglesa (II)	20,00	34,52	65,00	0,78
SAL						
	SL.S1	PS Parda	20,00	34,52	65,00	0,78
	SL.S2	PS Sal (II)	2,50	4,32	8,10	0,10
		PS Sal (III)	5,00	8,63	16,30	0,19
		PS Sal (IV)	10,00	17,26	32,50	0,39
	SL.S3	PS Constancia (I)	10,00	17,26	32,50	0,39
		PS Constancia (II)	20,00	34,52	65,00	0,78
	SL.S4	PS Terra Boa	10,00	17,26	32,50	0,39
	SL.S5	PS Baleia	5,00	8,63	16,30	0,19
FOGO						
1	FG.S1	PS Fogo (I)	1,50	2,59	4,90	0,06
2		PS Fogo (II)	2,50	4,32	8,10	0,10
S. ANTAO						
1	SA.S1	PS Porto Novo (I)	1,00	1,73	3,30	0,04
2		PS Porto Novo (II)	3,00	5,18	9,80	0,11
3		PS Porto Novo (III)	6,00	10,36	19,50	0,22
S. VICENTE						
1	SV.S1	PS Salamansa (I)	2,50	4,32	8,10	0,10
2		PS Salamansa (II)	5,00	8,63	16,30	0,19
	TOTAL		**341,00**	**588,57**	**1.108,80**	**13,29**

Project Live Time – 30 years

Table 5: Waves Energy Projects (REPCV)

	PROJECT CODE	PROJECT INDENTIFICATION	INSTALLED CAPACITY (MW)	ANNUAL ENERGY PRODUCTION (GHh/y)	INVESTMENT COST (M€)	ANNUAL O&M COST (M€)
		Wave S. Vicente	3,50	4,60	12,60	0,34
		Wave S. Antao	3,50	4,80	12,60	0,34
		Wave Sal	3,50	4,80	12,60	0,34
	TOTAL		**10,50**	**14,20**	**37,80**	**1,02**

Project Live Time – 15 years

Table 6: Municipal Solid Waste (MSW) Projects (REPCV)

	PROJECT CODE	PROJECT INDENTIFICATION	INSTALLED CAPACITY (MW)	ANNUAL ENERGY PRODUCTION (GHh/y)	INVESTMENT COST (M€)	ANNUAL O&M COST (M€)
		RSU Mindelo	2,50	15,30	11,30	0,13
		RSU Praia (I)	2,50	15,30	11,30	0,14
		RSU Praia (II)	2,50	15,30	11,30	0,14
	TOTAL		**7,50**	**45,90**	**33,90**	**0,41**

Project Live Time – 25 years

Table 6: Pumping Projects (REPCV)

	PROJECT CODE	PROJECT INDENTIFICATION	INSTALLED CAPACITY (MW)	INVESTMENT COST (M€)	RETROFIT COST (25 YEARS) (M€)	ANNUAL O&M COST (M€)
		Bombagem Mato Sancho - ST	20,00	41,00	6,30	0,37
		BombagemMonte Goa - SV - see Water	10,00	28,00	7,70	0,42
		Bombagem Ribeira Picos	20,00	39,00	6,20	0,35
		Bombagem Cha Goncalves	20,00	39,50	6,70	0,37
	TOTAL		**50,00**	**108,00**	**20,20**	**1,14**

Project Live Time – 50 years

5. Electricity Production Costs

The cost of electricity production in Cape Verde is strongly linked to fluctuation in the international oil market. Data's from Electra indicates an average production cost of electricity during 2010 130 € / MWh for the heavy fuel based production, and 250 € / MWh for the power stations running on gasoil.

Taking in consideration the data in tables above and the different funding resources (private or public - subsidized interest rates) the REPCV document indicates the following conclusions:

- The Wind Projects are the most competitive compared to other technologies, with an average levelized production cost (LPC) of about 100 €/MWh.
- The majority of Wind Projects and all MSW projects are economically competitive compared to the production cost based on heavy fuel.
- The Solar Photovoltaic Projects with an average LPC of € 238/MWh, are still competitive, compared to the production cost based on diesel
- .
  The Waves Projects have a LPC of 378 to 394 € / MWh, are not competitive compared to too high compared to the production cost based on diesel.

6. Investment Plan

The implementation of the ongoing projects will permit to achieve 25% renewable energy penetration by 2012.

To achieve the second main objective (50% renewable energy penetration in 2020) it is fundamental to pursue implementation of new Renewable Energy Projects, as well as new basic electrical infrastructure, in order to ensure the stability and security of the electrical system.

System stability study is very important for an informed decision on the quantity of renewable energy that the system can support. To define the optimal renewable energy penetration for each island, the REPCV performed steady state and transient stability analysis of the electrical system, taking in consideration actual operational conditions.

Based on the results of these studies, combined with economic considerations, the REPCV defined the investment requirement for the period 2012 to 20015 and 2015 to 2020, to ensure the attainment of 50% renewable energy penetration by 2020, as indicated in the tables below:

Table 7: Scenario 2011 - 2015 towards 50% penetration on 2020

	SOLAR		WIND		MSW		WATER PUMPING		RE Penetration
	Inst. Capacity (MW)	Annual Production (MWh)	Inst. Capacity (MW)	Annual Production (MWh)	Inst. Capacity (MW)	Annual Production (MWh)	Inst. Capacity (MW)	Annual Production (MWh)	
Santiago	9	9.182	30,6	86.176	2,5	16313	0	0	45,16%
Sao Vicente	3	3.152	8,5	31.824	0		0	0	41,61%
Sal	2,5	2.910	7,65	20.463	0		0	0	40,65%
Santo Antao	1	1.728	1	1.761	0		0	0	20,35%
Fogo	1	1.799	0,85	2.471	0		0	0	28,28%

Table 8: Scenario 2015 - 2020 towards 50% penetration

	SOLAR		WIND		MSW		WATER PUMPING		RE Penetration
	Inst. Capacity (MW)	Annual Production (MWh)	Inst. Capacity (MW)	Annual Production (MWh)	Inst. Capacity (MW)	Annual Production (MWh)	Inst. Capacity (MW)	Annual Production (MWh)	
Santiago	16,5	14.954	48,45	134.257	5	30.751	20	-5.604	57,27%
Sao Vicente	3	2.475	13,6	47.426	2,5	14.609	0	0	59,92%
Sal	5	6.468	9,35	24.317	0		0	0	35,66%
Santo Antao	2	3.599	1	2.554	0		0	0	27,09%
Fogo	1	1.799	1,7	4.782	0		0	0	32,71%

6.1. Different scenarios for Renewable Energy Penetration

The REPCV has defined three scenarios of renewable energy penetration:

- **Market scenario –** based on the maximum RE penetration about 5% reduction in production cost - RE penetration of 43%;
- **Economic scenario –** based on the minimum electricity generation cost, considering the technical and security limits for the system operation – RE penetration of 47%;
- **Scenario 50% RE Penetration –** a more ambitious scenario, based on a high penetration of solar photovoltaic and the installation of storage systems (flywheels and water pumping systems) – RE penetration of 52,3%.

The table bellow summarize the economic, social and environmental impact of each scenario, considering the heavy fuel and diesel price of 0,5 €/Kg and 0,8 €/Kg, respectively, and a tariff of 10 € per ton of avoided CO_2 emission:

	Market Scenario	Economic Scenario	50% RE Penetration
Renewable Energy Penetration	43% RE Penetration at 2020 72 MW RE Installed (incl. InfraCo) - 54 MW Wind - 9,5 MW Solar - 7,5 MW MSW	47% RE Penetration at 2020 86 MW RE Installed (incl. InfraCo) - 69 MW Wind - 9,5 MW Solar - 7,5 MW MSW	52% RE Penetration at 2020 108 MW RE Installed (incl. InfraCo) - 76 MW Wind - 25 MW Solar - 7,5 MW MSW
New Investments	€M 126 (39 MW of new projects)	€M 142 (55 MW of new projects)	€M 247 (97 MW of new projects) 2011 - 2015: €M 144 2016 - 2020: €M 104
Aditional Jobs Creation	Construction (total period) - 244 direct jobs Operation & Maintenance (annual) - 87 direct jobs	Construction (total period) - 320 direct jobs Operation & Maintenance (annual) - 92 direct jobs	Construction (total period) - 1.110 direct jobs Operation & Maintenance (annual) - 130 direct jobs - Possibility of installation of Solar Panel factory: + 20 to 30 jobs
Reduction in import oil	Production cost: €131/MWh (-19%) Reduction of: - 51 M liters/year of Heavy Fuel - €26M/year of import oil	Production cost: €121/MWh (-25%) Reduction of: - 56 M liters/year of Heavy Fuel - €28M/year of import oil	Production cost: €124/MWh (-24%) Reduction of: - 63 M liters/year of Heavy Fuel - €32M/year of import oil
Reduction on CO_2 Emission	179.600 ton ≈ €1,8M/year of CDM	195.500 ton ≈ €2,0M/year of CDM	222.800 ton ≈ €2,2M/year of CDM

Figure 4: Summary of economic, social and environmental impact (REPCV)

6.2. Investment Plan 2011 -2020

Taking in consideration different economic, social and environmental aspects, the study recommended the implementation of 50% RE penetration scenario. Despite the large volume of investment required, this scenario will have a significant impact on economic growth and job creation.

The implementation of a renewable energy program will require an important investment in the electric grid to ensure the security and operationality of the system.

The table bellow summarizes the investment plan for 2011 – 2020, indicating the projects, the installed capacities, the investment costs and the implementation periods:

Table 9: Investment Plan 2011 - 2020

Island	New Projects	Type	Capacity (MW)	Cost (€M)	Construction	Investment (€M)			Installed Capacity (MW)		
						2010 -2012	2013-2015	2016-2020	2010 -2012	2013-2015	2016-2020
Santiago	PS Palmarejo - extension	Solar	1	3,25	2013		3,25			1	
	PS Achada Cidade Velha	Solar	9	29,25	2014/2018		9,75	19,5		3	6
	PE Monte Leao	Wind	3,4	7,48	2013/2015		7,48			3,4	
	PE Rui Vaz	Wind	3,4	7,48	2013/2015		7,48			3,4	
	PE Achada Mostarda	Wind	18,7	41,14	2014/2018		28,16	12,48		12,8	5,9
	PE Pedra Branca	Wind	6,8	14,96	2013/2015		14,96			6,8	
	MSW Praia	MSW	5	22,5	2013/2014		22,5			5	
	PE Montes Redondos	Wind	6,8	14,96	2016/2018			14,96			6,8
	Pumping Cha Goncalves	Water Pumpi	20	42,6	2014/2018		8,25	34,08			20
TOTAL SANTIAGO			**74,1**	**183,62**		**0**	**101,83**	**81,02**	**0**	**35,4**	**38,7**
S.Vicente	PS Salamansa	Solar	3	9,75	2013	4,875	4,875		1,5	1,5	
	PE Areia Branca	Wind	7,65	16,83	2014/2018		5,61	11,22		2,55	5,1
	MSW Mindelo	MSW	2,5	11,25	1016/2018			11,25			2,5
TOTAL SAO VICENTE			**13,15**	**37,83**		**4,875**	**10,485**	**22,47**	**1,5**	**4,05**	**7,6**
Sal	PS Sal (extension)	Solar	2,5	8,125	2016/2018			8,13			2,5
	PE Serra Negro	Wind	1,7	3,74	2016/2018			3,74			1,7
TOTAL SAL			**4,2**	**11,865**		**0**	**0**	**11,87**	**0**	**0**	**4,2**
Santo Antao	PS Porto Novo	Solar	2	6,5	2011 & 2018	1,65	1,65	3,25	0,5	0,5	1
TOTAL SANTO ANTAO			**2**	**6,5**		**1,65**	**1,65**	**3,25**	**0,5**	**0,5**	**1**
Fogo	PS Fogo	Solar	1	3,25	2012/2014	1,625	1,625		0,5	0,5	
	PE Cova Figueira	Wind	1,7	3,74	2014/2018		1,87	1,87		0,85	0,85
TOTAL SAL			2,7	6,99		1,625	3,495	1,87	0,5	1,35	0,85
TOTAL 5 ISLANDS			**96,2**	**246,81**		**8,15**	**117,46**	**120,48**	**2,5**	**41,3**	**52,35**