Cabo Verde: 100% RE Project

Build a safe, efficient and sustainable Energy Sector without dependence on fossil fuels

ECREEE
Praia, Cabo Verde
November 5, 2013

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100%+X% Concept

Capacity Building/Research

Energy Mix
- Wind / Solar/Waste

Storage
- Short/Long Term

Use Oversupply

Institutional Framework

Fossil Fuel: Business as usual
Fossil Fuel: Evolution of the Energy Cost

Cost of Energy

- Gasolea
- Fuel
- Energia

Increase rate:
- 10.9% per annum
- 10.3% per annum
- 6.3% per annum

Source: "Energia Nacional" tables
Fossil Fuel: Imports Evolution

Import of Fossil Fuel

ECV
14.000.000.000
12.000.000.000
10.000.000.000
8.000.000.000
6.000.000.000
4.000.000.000
2.000.000.000
0


Gasoleo Fuel

factor 12 in 11 year period

cost increase: 40.7 %/a

cost increase: 22.3 %/a

source: tables “Energia Nacional”
If the power demand and fossil fuel price increase would continue for the decade to come, the import expenditures would increase by a factor of 18 until the year 2022.

**assumptions**
- average increase rate for fuel: 10.3 %/a (from historic values 2002-2012)
- demand increase derived from Gesto’s figures for 2020
## Fossil Fuel: LCOE

### Assumptions
- Investment figures from Gesto study
- Efficiency figures by fuel consumption and power production (Sal)
- Fuel cost for 2012

<table>
<thead>
<tr>
<th>LCOE</th>
<th>Fuel 180</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>investment</strong></td>
<td>1.066 €/kW</td>
<td>1.066 €/kW</td>
</tr>
<tr>
<td>interest</td>
<td>5 %</td>
<td>5 %</td>
</tr>
<tr>
<td>duration</td>
<td>20 a</td>
<td>20 a</td>
</tr>
<tr>
<td><strong>annual capital cost</strong></td>
<td>86 €/a</td>
<td>86 €/a</td>
</tr>
<tr>
<td>operation &amp; maintenance</td>
<td>5 %</td>
<td>5 %</td>
</tr>
<tr>
<td><strong>annual operational cost</strong></td>
<td>53 €/a</td>
<td>53 €/a</td>
</tr>
<tr>
<td>service time</td>
<td>6.000 h/a</td>
<td>6.000 h/a</td>
</tr>
<tr>
<td>efficiency</td>
<td>38.6 %</td>
<td>33.3 %</td>
</tr>
<tr>
<td>fuel energy density</td>
<td>11.1 kWh/kg</td>
<td>9.7 kWh/l</td>
</tr>
<tr>
<td>fuel cost (actual)</td>
<td>0.73 €/kg</td>
<td>0.91 €/l</td>
</tr>
<tr>
<td><strong>annual fuel cost (actual)</strong></td>
<td>1.017 €/a</td>
<td>1.682 €/a</td>
</tr>
<tr>
<td>total annual cost (actual)</td>
<td>1.156 €/a</td>
<td>1.821 €/a</td>
</tr>
<tr>
<td><strong>levelized cost of energy</strong></td>
<td>0.1927 €/kWh</td>
<td>0.3035 €/kWh</td>
</tr>
</tbody>
</table>
assumptions
• fuel cost starting with fuel cost of 2012
• HFO 180 cost 0.73 €/kg
• Diesel cost 0.91 €/l
Fossil Fuel: Levelized Cost

assumptions
- fuel cost starting with fuel cost of 2012
  - HFO 180 cost 0.73 €/kg
  - Diesel cost 0.91 €/l

Levelized Cost of Energy
8 % Annual Fuel Price Increase

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### Assumptions

- **PV**: 3,400 €/kW
- **Wind**: 2,200 €/kW
- **Thermal Group**: 1,000 €/kW
- **Efficiency**: 30 %
- **Fuel Cost (act.)**: 0,71 €/l
- **Diesel Cost**: 1,09 €/l
- **Increase rate**: 15 %/a (8,5 %/a)

- **Electr, Prod.:** 300 → 700 GWh/a
- **RE**: 20 → 50 %
- **Timeframe**: 2012 → 2020

### Results:

- **Pressure on Balance of Payment**
- **High domestic electricity and water prices**
Renewable Potentials: Wind / Solar

Potential by Island

<table>
<thead>
<tr>
<th>Island</th>
<th>Potentials [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>São Vicente</td>
<td>50</td>
</tr>
<tr>
<td>São Nicolau</td>
<td>10</td>
</tr>
<tr>
<td>Santo Antão</td>
<td>200</td>
</tr>
<tr>
<td>Santiago</td>
<td>713</td>
</tr>
<tr>
<td>Sal</td>
<td>100</td>
</tr>
<tr>
<td>Maio</td>
<td>10</td>
</tr>
<tr>
<td>Fogo</td>
<td>929</td>
</tr>
<tr>
<td>Brava</td>
<td>10</td>
</tr>
<tr>
<td>Boavista</td>
<td>50</td>
</tr>
</tbody>
</table>

source: Gesto
Cost Decrease for Photovoltaic Systems

- since 2000: - 75 %
- since 2008: - 50%
- until 2016: - 50% - on top on 2012 level

Source: Agentur für Erneuerbare Energien, BMU

Decrease in Photovoltaic Price

Since 2000:
- 75 %
Since 2008:
- 50%
Until 2016:
- 50% - on top on 2012 level

Quellen: Deutsche Gesellschaft für Sonnenenergie, Bundesverband Solarwirtschaft; Stand: 06/10

Source: Agentur für Erneuerbare Energien, BMU
100% + X% Concept

- **Fossil Fuel:** Business as usual
- **100%+X% Concept**
- **Institutional Framework**
  - Energy Mix: Wind / Solar/Waste
  - **Capacity Building/Research**
    - Storage: Short/Long Term
    - Use Oversupply

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Through the implementation of 100% renewable energy strategy Cabo Verde will reduce the reliance on imported food. Cabo Verde will be able to offer cost efficient harbor and terminal services creating an additional attraction for international investment in logistics and storage facilities.

Due to the nature of renewable energy technologies Cabo Verde will need to generate surplus energy ranging from 241GWh (Scenario of Synthetic Methane Storage) up to 553GWh (Scenario of Pumped Hydro Storage) — much more than needed for the coverage of the energy demand in 2020.

This tremendous overcapacity of cheap electrical work offers a unique opportunity for other, much needed developments on the Cabo Verde islands. Energy can be turned into:
- some 140 million cubic meter of cheap desalinated water re-vitalizing local agricultural structure,
- or 2.2 billion passenger kilometer of electric mobility,
- or into 1.4 million bottles of cooking gas.

Converting additional electricity into water and agriculture, into methane and fuel for cars or into international competitive cold storage service gives Cabo Verde a unique chance for sustainable economic and industrial development.
100% + X% Concept: the VISION

VISIONARY, AMBITIOUS but FEASIBLE

- Saving 100% on imported fuel, Building an high efficiency agriculture,
- Building a modern cooling logistics for fishery and vegetables,
- Building a modern engineering and training society based on Renewable Energy,
- Exporting Know-how to other African State and
- Building a green tourism economy
Storage: Short and Long Term

- Fossil Fuel: Business as usual
- 100%+X% Concept
- Institutional Framework

Capacity Building/Research

Energy Mix
- Wind / Solar/Waste

Storage
- Short/Long Term

Use Oversupply
Although often stated, compressed air is not a renewable option, since it requires fossil fuel to run a gas turbine as integral part.

**Need for Storage Systems**

*Supply from Fluctuating Resources*

**Long term** fluctuations, induced by seasonal variations of solar irradiation and appearance of wind.

**Short term** fluctuations, induced by single events not to be addressed by weather reports like single clouds or turbulences resulting from single gusts.
Short Term Storage

- Large battery systems covering some megawatts of power and some megawatt-hours of storage capacity are foreseen to balance short term fluctuations and provide some reserve energy before backup from seasonal storage has to be considered.

- An energy management system made by an electrical grid that uses information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity

- A sophisticated inverter technology and control software, will respond automatically to changes in grid frequency in millisecond range – faster than any rotating mass, which introduces inertia, only.

Battery and energy management system to ensure a stable operation of the grid without the need of a running diesel generator
Long Term Storage

Pumped hydro storage

Sterner, 2009 Fraunhofer
Long Term Storage

Production and Use of Synthetic Methane

Wind gas
Efficiency

Hydrolyzer (3.5 MW)

→ RE-power becomes primary energy

60-65% SNG (today: 40% due to electrolysis)
35-40% Power
50-60% CHP
Vs. 0% due to power cut off
Vs. More efficient but capacity limited storage alternatives
Pumped Hydro: Energy Mix

seasonal storage
• pumped hydro

assumptions
• storage power \( \geq \) peak demand
• storage capacity > 1 day reserve
• battery power 50 % peak demand
• installed power least installed power to meet given storage reserve

Energy Mix
Pumped Hydro

- wind
- photovoltaic

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### Pumped Hydro: Investment by Island

<table>
<thead>
<tr>
<th>Island</th>
<th>photovoltaic</th>
<th>wind</th>
<th>battery</th>
<th>seasonal storage</th>
<th>total per island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boavista</td>
<td>50.4 Mio. €</td>
<td>47.6 Mio. €</td>
<td>16.2 Mio.</td>
<td>50.0 Mio. €</td>
<td>164 Mio. €</td>
</tr>
<tr>
<td>Brava</td>
<td>2.9 Mio. €</td>
<td>1.0 Mio. €</td>
<td>1.8 Mio.</td>
<td>2.0 Mio. €</td>
<td>8 Mio. €</td>
</tr>
<tr>
<td>Fogo</td>
<td>12.2 Mio. €</td>
<td>11.6 Mio. €</td>
<td>3.6 Mio.</td>
<td>15.0 Mio. €</td>
<td>42 Mio. €</td>
</tr>
<tr>
<td>Maio</td>
<td>12.5 Mio. €</td>
<td>4.4 Mio. €</td>
<td>1.8 Mio.</td>
<td>8.6 Mio. €</td>
<td>27 Mio. €</td>
</tr>
<tr>
<td>Sal</td>
<td>43.2 Mio. €</td>
<td>40.8 Mio. €</td>
<td>16.2 Mio.</td>
<td>62.0 Mio. €</td>
<td>162 Mio. €</td>
</tr>
<tr>
<td>Santiago</td>
<td>201.6 Mio. €</td>
<td>190.4 Mio. €</td>
<td>54.0 Mio.</td>
<td>214.0 Mio. €</td>
<td>660 Mio. €</td>
</tr>
<tr>
<td>Santo Antão</td>
<td>14.4 Mio. €</td>
<td>5.1 Mio. €</td>
<td>5.4 Mio.</td>
<td>11.0 Mio. €</td>
<td>36 Mio. €</td>
</tr>
<tr>
<td>São Nicolau</td>
<td>3.6 Mio. €</td>
<td>3.4 Mio. €</td>
<td>1.8 Mio.</td>
<td>3.4 Mio. €</td>
<td>12 Mio. €</td>
</tr>
<tr>
<td>São Vicente</td>
<td>76.8 Mio. €</td>
<td>27.2 Mio. €</td>
<td>18.0 Mio.</td>
<td>38.0 Mio. €</td>
<td>160 Mio. €</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>418 Mio. €</strong></td>
<td><strong>332 Mio. €</strong></td>
<td><strong>119 Mio. €</strong></td>
<td><strong>404 Mio. €</strong></td>
<td><strong>1,272 Mio. €</strong></td>
</tr>
</tbody>
</table>

**Assumptions:**
- **Pumped hydro**
- Operating cycle: 40 yrs
- Storage power \(\geq\) peak demand
- Storage capacity > 1 day reserve
- Battery power 50% peak demand
- Installed power least installed power to meet given storage reserve

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seasonal storage
- synth. methane

assumptions
- storage power ≥ peak demand
- storage capacity > 1 day reserve
- battery power 50 % peak demand
- installed power least installed power to meet given storage reserve
## Synthetic Methane: Investment per Island

<table>
<thead>
<tr>
<th>investment</th>
<th>power generation and storage infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>photovoltaic</td>
</tr>
<tr>
<td>Boavista</td>
<td>28.8 Mio. €</td>
</tr>
<tr>
<td>Brava</td>
<td>1.5 Mio. €</td>
</tr>
<tr>
<td>Fogo</td>
<td>7.2 Mio. €</td>
</tr>
<tr>
<td>Maio</td>
<td>4.8 Mio. €</td>
</tr>
<tr>
<td>Sal</td>
<td>4.2 Mio. €</td>
</tr>
<tr>
<td>Santiago</td>
<td>72.0 Mio. €</td>
</tr>
<tr>
<td>Santo Antão</td>
<td>1.2 Mio. €</td>
</tr>
<tr>
<td>São Nicolau</td>
<td>1.1 Mio. €</td>
</tr>
<tr>
<td>São Vicente</td>
<td>16.2 Mio. €</td>
</tr>
</tbody>
</table>

seasonal storage
• synth. Methane
• operating cycle: 20 yrs

assumptions
• storage power ≥ peak demand
• storage capacity > 1 day reserve
• battery power 50 % peak demand
• installed power least installed power to meet given storage reserve
Necessary renewable energy capacities to be installed [including short-term storages (vital for grid stability) and seasonal storages]

<table>
<thead>
<tr>
<th>installed power</th>
<th>power generation and storage infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>photovoltaic</td>
</tr>
<tr>
<td>Boavista</td>
<td>35 MW</td>
</tr>
<tr>
<td>Brava</td>
<td>2 MW</td>
</tr>
<tr>
<td>Fogo</td>
<td>10 MW</td>
</tr>
<tr>
<td>Maio</td>
<td>10 MW</td>
</tr>
<tr>
<td>Sal</td>
<td>39 MW</td>
</tr>
<tr>
<td>Santiago</td>
<td>168 MW</td>
</tr>
<tr>
<td>Santo Antão</td>
<td>12 MW</td>
</tr>
<tr>
<td>São Nicolau</td>
<td>3 MW</td>
</tr>
<tr>
<td>São Vicente</td>
<td>64 MW</td>
</tr>
<tr>
<td>total</td>
<td>343 MW</td>
</tr>
</tbody>
</table>

A combination of battery and new inverter were defined as short term storage facility as the combination of both are delivering vital grid stability function and are commercially available.

For seasonal storage (up to 7 days of full load) the two technical options of pumped hydro storage (PHS) and power-to-gas were evaluated. While PHS is a mature technology (but requiring certain topographical conditions) the power-to-gas technology is currently undergoing the commercialisation (in particular in Germany) and yet has to prove its applicability on the magnitude foreseen on Cape Verde.
Total Investment per Island

- **Total investment**
  - pumped hydro: ca. 1.3 billion €
  - synth. methane: 1 billion €

**Investment**

<table>
<thead>
<tr>
<th>Island</th>
<th>Pumped Hydro</th>
<th>Synth. Methane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boavista</td>
<td>168</td>
<td>149</td>
</tr>
<tr>
<td>Brava</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Fogo</td>
<td>42</td>
<td>36</td>
</tr>
<tr>
<td>Maio</td>
<td>27</td>
<td>25</td>
</tr>
<tr>
<td>Sal</td>
<td>135</td>
<td>132</td>
</tr>
<tr>
<td>Santiago</td>
<td>660</td>
<td>451</td>
</tr>
<tr>
<td>Santo Antão</td>
<td>36</td>
<td>35</td>
</tr>
<tr>
<td>São Nicolau</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>São Vicente</td>
<td>160</td>
<td>148</td>
</tr>
</tbody>
</table>
Levelized Cost of Energy: Average for all Islands

Levelized Cost of Energy

- pumped hydro
- synth. methane
- HFO180
- Diesel

in 2012

€/kWh

0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

0.1861
0.1731
0.1041
0.1269

related to energy demand
related to total production
Levelized Cost of Energy
Related to Energy Demand

- Pumped hydro
- Synth. methane
- HFO180
- Diesel

in 2012

€/kWh

assumptions
- demand according to Gesto Study, "business as usual" scenario for 2020
Levelized Cost of Energy
Related to Total Production

- pumped hydro
- synth. methane
- HFO180
- Diesel

€/kWh

Boavista | Brava | Fogo | Maio | Sal | Santiago | Santo Antão | São Nicolau | São Vicente | average

assumptions
• production according to energy mix, assuming flexible additional demand
assumptions
• demand of 2020 (constant)
• fuel cost starting with fuel cost of 2012

• HFO 180 cost 0,73 €/kg
increase 10,3 %/a
(period 2002-2012)
• Diesel cost 0,91 €/l
increase 10,9 %/a
(period 2002-2012)
Macro-Economic Effects

assumptions
- demand demand of 2020 (constant)
- fuel cost starting with fuel cost of 2012
- HFO 180 cost 0,73 €/kg
- Diesel cost 0,91 €/l

Cumulated Macro-Economic Savings
4 % Annual Fuel Price Increase

- Fuel 180
- Diesel

million €

years

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- 100% RE electricity supply equals to min. up to 6.0 Mio. tons of CO2e / 21 years (Fossil Fuel Switch)
  - Assumption 0.9 kg CO2e/kWh (in 2012) declining to 0.1 CO2e / kWh in 2020
- 100% RE Water Supply (25.000m3/day/21years) equals up to 1.2 Mio. tons CO2e / 21 years (Fossil Fuel Switch)
- 100% Waste-to-Energy Recovery equals to min. 1.0 Mio. tons CO2e / 21 years (Avoided LFG)
assumptions
• demand of 2020 from Gesto study, “business-as-usual”-scenario
• estimated figures, only
• further increase of emissions by enhancement of installed power will be reduced by additional shares of renewable supply of up to 80% in 2050
Excess Energy Use

Fossil Fuel: Business as usual

100%+X% Concept

Institutional Framework

Energy Mix
Wind / Solar/Waste

Capacity Building/ Research

Storage
Short/Long Term

Use Oversupply
Use of oversupply

Oversupply represents a valuable resource by itself; new businesses with temporal switchable load may be developed. In addition, making use of this resource may lead to different models for electricity market itself:

- temporal switchable loads may be subject to special low tariffs, enabling agricultural cultivation by desalinated sea water (actually energy cost for desalinization are prohibitive for irrigation purposes)
- additional revenues from switchable loads may be used for cross-subsidization and thus lead to lower electricity production cost
- a mixture of these proposals

Total Production:
100% + X% Load
Excess Energy Use

- Surplus Energy could be utilized as:
  - Water and electricity (Cooling) for an agricultural production
    - 1,000ha of irrigation
    - 100GWh of energy
    - 300.00 Mio Investment
    - 200,000t food production (export) and 5,400 jobs
    - Annual Profit of 38 Mio EUR (at 0,15 EUR/kWh)
  - Lower domestic water and electricity price
  - Production of synthesized methane ($36.5 \text{ GWh}_{\text{therm}}$ can produce $3,650,000m^3$ of methane)
    - Substitution for cooking gas
    - Substitution of diesel (transportation)
    - Used as diesel substitute in tri-generation processes at tourism facilities for hot water, decentralized electricity and cooling energy
  - Grey water Re-use (Industry, Tourism, Municipality)
  - Brownfield and Greenfield Applications (100% Tourism)
  - Fishing and Fish Processing
    - Cooling for Ice and Refrigeration
    - Thermal for Canning
Excess Energy Use: Cost Structure – RO based Desalination

- Current Freshwater Production Costs per m³ are around **3,00 EUR**
- Current Average Sales Prices vary between **2,98 EUR to 4,98 EUR per m³**
- Current Energy Costs vary between **1,00 to 1,50 EUR/m³**
- Yield per ha is only about **50% of (European) standard**
- Domestic selling prices are above import prices

- Renewable Energy Costs (for excess energy) of averaged **0,10 EUR/kWh** could decrease the water production costs up to **30%**
Agriculture is an interesting option to utilise excess energy

The 100+X% strategy will re-vitalize agricultural structures which had been abandoned due to high water prices.

- The underlying 100% renewable energy supply is not only ensuring energy security; it also has the potential to ensure the water and food security, too!

- The tremendous overcapacity of cheap electrical work offers unique opportunities to transform the excess electricity into water via desalination processes (as a kind of secondary storage and dispatchable consumer option) since it will be technically and economically easy to establish a water storage facilities for 15 days of irrigation.
Investing in RE is an highly lucrative investment option since is:

- creating more investment in agriculture
- Enhancing food security and creating new export options
- maintaining local jobs and creating significantly new employment options
- Creating in the mid-and long term development perspectives, new industrial clusters and agricultural production processes and products
Excess Energy:
Green Agriculture and New Added Value Process

- Zero Discharge Seawater Desalination: Integrating the Production of Freshwater, Salt, Magnesium, and Bromine
- Domestic production of fertilizer based on renewable energies.
- Ecological Agriculture
  - Storage of excess energy in nitrogen, phosphorous and potassium + trace elements by:
    - Haber-Bosch Synthesis Option (12,5kWh/kgN)
    - Ammonium-Magnesium-Phosphat Precipitation from sewage sludge and waste water
    - Potassium extraction from brine of reverse osmosis (desalination processes)
100%+X% Concept

Energy Mix
- Wind / Solar/Waste
- Storage
- Short/Long Term
- Use Oversupply

Fossil Fuel: Business as usual

Institutional Framework

Capacity Building/Research
Knowledge and soft skills are necessary:

- **On craftsmen level**
  - In the initial phase it is necessary to identify and evaluate the existing craftsman educative programs in both, structure and content.
  - In the mid and long term it is suggested that at Cabo Verde the structure of dual practical and theoretical apprenticeship is in close cooperation with the companies and state owned vocational training schools.

- **On academic level**
  - Capacity building strategy will be the establishment of a Zero-Emission University network entitled as “Collaborative Tertiary Education and Applied Research Center in 100% Renewables and Zero Emission System Design in the long-term. The Zero-Emission University network will be located at Cape Verde associated to a Cape Verdenian University.”
Education and Research: Network

Cluster das Energias Renováles

Non-Academic Training

Academic Training

Vocational Training

ECREEE

Political Support

IfaS

Jean Piaget

CAMPO
Institutional Framework

- Fossil Fuel: Business as usual
- 100%+X% Concept
- Capacity Building/Research
  - Energy Mix
    - Wind / Solar/Waste
  - Storage
    - Short/Long Term
  - Use Oversupply

Institutional Framework
The major obstacle for a quick implementation of the 100% renewable energy master plan lies in the organization of the investment. Just exchanging the import of fossil energy by the import of external technology and money will not be the solution to Cabo Verde’s structural problems.

- The master plan proposes a mixture of local and international funding in strong proximity with a change in the organization of the public utility ELECTRA.

- Key concern in the area of money allocation must be the creation and protection of regional and national added value. The first interest should be to create capital values for Cape Verde before offering the investment opportunity to external lenders. And in all cases ownership of the energy system must be in the realm of stakeholders from Cape Verde.
IFI & Sovereign Wealth Funds
(Capital Costs < 5%)

Related Government Entities INPS

Guarantee

Long-Term Concessional Loans

Climate Funds

NAMA Credits
Discounted Carbon Finance

Government of Cabo Verde

Due Diligence and Asset Assessment

Direct Investment (Share Exchange)

100% RE Holding Cabo Verde

Direct Investment (e.g. Pension Fund)

ELECTRA Holding (existing)

Donor & Foundations

“Lost Grants”
Government of Cape Verde

100% RE Holding Cabo Verde

100% RE Investment Company

Circular Economy Foundation

Donors & International Foundation

CV Circular Economy Research & Education

Social, Community and Efficiency Projects

Corporate Tax

100% State Owned Holding

Equity Interest & Annuity

“Dividend Capital”

15-20% EQUITY

Dividends

Sovereign Wealth Funds & RE Funds

IFI & FDI

Debt Capital (Concessional & Market-based Interest)

Application of CE Technology Research Results

Social Capital & Funding

Project Development and Equity

100% RE Project(s)

Equity Mezzanine (Preferential Interest)

Equity Capital (Limited Interest (>5% < 10%))
ROAD MAP to 2020

Short Term Objective until End of 2014:
Detail Engineering Concepts and implement first

Mid Term Objective until End of 2017:
Installation of new renewable energy production and short-term storages at all islands.

Long Term Objective until End of 2020:
Installation of seasonal storages and additional renewable energy production sites
ROAD MAP to 2020

Short Term

- Objective: create immediate solutions enhancing current renewable energy production (penetration) and grid stability.
- Detailed engineering studies for new renewable energy production sites and their grid integration as well short term storage and grid stability measures (battery packs and inverters) will be initiated based on the 100% study (and partly the site pre-evaluations done in the GESTO study). The detail engineering studies - if done cost effectively parallel for all islands and predefined sites – require an initial investment of approximately 10.0 Mio. EURO.

Mid-Term

- On all islands new renewable energy installations as well as short-term storage (up to 12 hours of full load) and grid stability measures are implemented maximising the renewable energy penetration to an economic interesting point possible without seasonal storage concepts.
- In parallel, different seasonal storage (for up to 7 days of full load) technologies are evaluated in detailed engineering studies.

Long Term

- The energy transition towards 100% Renewable shall be completed until 2020 with the construction of seasonal storage technologies based on the expected mature technology and international experiences.
- The detailed engineering concepts are an important pre-requisite for the tendering process and business planning.
ROAD MAP to 2020: necessary conditions

- Careful considerations have to be performed for each of the islands. Strategies shall cover the utilization of oversupply by dispatchable loads.

- Implementation phase requires strong governance to follow a systemic approach covering supply and grid related issues jointly.

- Step-by-step implementation has to be developed making use of existing fuel driven generators which can play a vital role as long term (seasonal) storage device in a transition phase while related constructions are on the way. Even as backup they are valuable assets.

- Grid stabilizing by the introduction of battery storages has to be highlighted as one of the first steps for implementation at short term. As a matter of course the design of storage hardware and control shall consider future enhancements to 100 % regenerative supply. Thus renewable production from existing photovoltaic systems and wind turbines may be enhanced to their capabilities without the need for today’s power reductions.
The project aims to develop the technical engineering design as a pre-requisite for a designated tender process for:

1. Wind Park with 7.65-8.5MW nominal power capacity with suitable inverter;
2. PC Park with 2.5MW nominal power capacity with suitable inverter;
3. Battery with 9MW/9MWh and Grid Management System (SCADA System):

The detailed engineering concept for the positions 1) and 2) include:
- all relevant measurements,
- planning and permitting assessment,
- grid connection design,
- geological survey and environmental impact assessment
- logistics planning.

The detailed engineering concept for position 3) includes:
- Power flow analysis for estimation of grid extension and cross section
- Adoption grid safety concept/selectivity study
- Design concept energy management system/SCADA
- Design of interface to wind park(s) / Design of interface PV plant(s) / Design of control system for existing thermal plant and grid
- Planning/permitting for battery plant
- Infrastructure Specification of the battery inverters
- Preparation of climatisation concept & analysis of fire protection requirements

**Requested Funding**
The requested funding for the detailed engineering concepts sum up to 1.05 Mio EUR (3% of the designated project value of 35.0 Mio EUR).
ROAD MAP to 2020: Conclusions

- 100 % are by far achievable by existing potentials
- 100 % will cause challenges:
  - grid capacity
  - grid Management
  - storage capacity
  - high investments for power plants, grid, storage and grid management
  - high prices for regulating energy

BUT

100 % are feasible and cost-effective
OBRIGADO