Content

1. The National Program for Energy Sustainability;
2. Project Pipeline 2018-2030;
The National Program for Energy Sustainability (NPES)

The long-term strategy is to accomplish the transition to an energy sector that is:

• secure,
• efficient,
• sustainable, without reliance on fossil fuels and,
• capable to insure universal access and energy security.
The National Program for Energy Sustainability (NPES)

Main Axes
- Strengthening and Improvement in Business Environment
- Energy Market Reform
- Investment in Strategic Infrastructure
- Renewable Energy Development
- Promotion of Energy Efficiency

New Axes
- Promotion of Entrepreneurship and R&D
- Inclusion and Gender Equity
## Project Pipeline 2019 - 2030

<table>
<thead>
<tr>
<th>ID</th>
<th>Projects</th>
<th>Total (M €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENER01</td>
<td>Wind and Solar IPPs</td>
<td>248,9</td>
</tr>
<tr>
<td>ENER02</td>
<td>Santiago PSP</td>
<td>50,1</td>
</tr>
<tr>
<td>ENER03</td>
<td>Battery Storage</td>
<td>60</td>
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<tr>
<td>ENER04</td>
<td>Distributed Generation</td>
<td>7</td>
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<td>ENER05</td>
<td>Energy Efficiency Project</td>
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<td>ENER06</td>
<td>Brava Sustainable Island (Phase 1)</td>
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<tr>
<td>ENER07</td>
<td>E-mobility</td>
<td>19,8</td>
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<tr>
<td>ENER08</td>
<td>Grid Reinforcement</td>
<td>39</td>
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<tr>
<td>ENER09</td>
<td>Financing of Risk Mitigation Instruments (De-Risking)</td>
<td>15</td>
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<tr>
<td>ENER10</td>
<td>Institutional Strengthening and Reform of the Organizational Structure of Energy Market</td>
<td>5,5</td>
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</table>

**TOTAL (M€)** 476,8
**Renewable Energy Targets**

### Total Renewable Installed Capacity (MW)

<table>
<thead>
<tr>
<th>Year</th>
<th>Wind</th>
<th>Solar</th>
<th>Total</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>8.0</td>
<td>26.0</td>
<td>34.0</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>51.4</td>
<td>63.0</td>
<td>114.4</td>
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</tr>
<tr>
<td>2030</td>
<td>91.2</td>
<td>160.6</td>
<td>251.8</td>
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</tr>
</tbody>
</table>

### Percentage of Renewable Energy Generation

<table>
<thead>
<tr>
<th>Year</th>
<th>Wind</th>
<th>Solar</th>
<th>Storage*</th>
<th>PSP*</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>1%</td>
<td>16%</td>
<td>0%</td>
<td>1%</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>21%</td>
<td>9%</td>
<td>6%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>23%</td>
<td>14%</td>
<td>615%</td>
<td>7%</td>
<td></td>
</tr>
</tbody>
</table>

* Storage and PSP % represents part of renewable generation stored and discharged through inverters or turbine

**Fonte CV Master Plan 2018-2040**
2030 Renewables penetration per Island

<table>
<thead>
<tr>
<th>Island</th>
<th>Wind</th>
<th>Solar</th>
<th>Storage</th>
<th>PSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Santiago</td>
<td>18%</td>
<td>13%</td>
<td>25%</td>
<td>20%</td>
</tr>
<tr>
<td>Sal</td>
<td>19%</td>
<td>16%</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>São Vicente</td>
<td>20%</td>
<td>13%</td>
<td>25%</td>
<td>21%</td>
</tr>
<tr>
<td>Boavista</td>
<td>23%</td>
<td>10%</td>
<td>21%</td>
<td>15%</td>
</tr>
<tr>
<td>Santo Antão</td>
<td>23%</td>
<td>18%</td>
<td>15%</td>
<td>23%</td>
</tr>
<tr>
<td>Fogo</td>
<td>10%</td>
<td>6%</td>
<td>12%</td>
<td>34%</td>
</tr>
<tr>
<td>São Nicolau</td>
<td>8%</td>
<td>7%</td>
<td>36%</td>
<td>34%</td>
</tr>
<tr>
<td>Maio</td>
<td>51%</td>
<td>7%</td>
<td>8%</td>
<td>36%</td>
</tr>
<tr>
<td>Brava</td>
<td>21%</td>
<td>23%</td>
<td>51%</td>
<td>51%</td>
</tr>
<tr>
<td>Cabo Verde</td>
<td>7%</td>
<td>10%</td>
<td>14%</td>
<td>23%</td>
</tr>
</tbody>
</table>

* Only technically achievable 67% renewable penetration in Brava has been considered
Energy efficiency in buildings
Energy efficiency for appliances
Pilot demonstration projects
Replication and dissemination
Electric Mobility charter:

• Strategic vision for the adoption of electro-mobility in the country and the implementation of a public charging infrastructure.

• Key objectives:
  • Public Administration with 100% of electrical vehicles by 2030.
  • National public charging infrastructure by 2030.

• All vehicles to be electric by 2050
### Power System Objectives

1. **Increase electricity share from renewables**
   - To reduce energy dependency on fossil fuels

2. **Guarantee stability and security**
   - Power system enhancement in presence of higher renewable sources

3. **Reduce losses**
   - Losses have relevant values in the country

4. **Generation & operation cost reduction**
   - Leading to lower cost of electricity for customers

5. **Facilitate the integration of Distributed Energy Resources**
   - Customer empowerment and microgrids

6. **Increase the efficiency of the electricity consumption**
   - Demand increase management and consumption pattern collection

7. **Improve the quality of supply of customers**
   - To reduce outages

8. **ICT and Cyber Security Enhancing**
   - Guarantee the adequacy of communication infrastructure and its security

9. **E-Mobility and transport electrification**
   - Develop public infrastructure for charging management of electrical vehicles
Ongoing IPP Projects

• Development of 37 MW of RE as IPPs is underway
  • 5 MW solar PV IPP in Boa Vista Island (Gamma Solutions);
  • 13 MW wind farm IPP in Santiago (cabéolica exp. project);
  • 5 MW solar on São Vicente Island (APP/Impulso);
  • 5 MW solar on Sal Island (APP/Impulso);
  • 10 MW solar IPP in Santiago Island (on going tender);
  • Repowering existing 5MW solar in Santiago and 2.5 MW in Sal;
Ongoing Storage Projects

- BESS 1MW/1MWh in Sal (to be concluded in Dez2022).
- New BESS 5MW/5MWh in Sal (cabéolica exp. project)
- New BESS 5MW/5MWh in Santiago (cabéolica exp. project)
- BESS 5MW/5 MWh for Boavista;
- BESS 4MW/4 MWh for S. Vicente;
- **PSP 20MW/160MWh for Santiago**
2. WHY OF CHOSEN SAL ISLAND FOR PROJECT IMPLEMENTATION

<table>
<thead>
<tr>
<th>RENEWABLE PENETRATION RATE</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26.4%</td>
<td>27.6%</td>
<td>28.3%</td>
<td>29.3%</td>
</tr>
</tbody>
</table>

✓ Currently is the Island with the Highest Penetration Rate

✓ Curtailment of Wind Farm injection is being applied to Prevent System instability

✓ Ongoing projects to increase RE Installed Capacity

- Palmeira Thermal Power Station 13.5 MW (actual)
- CABEOLICA Wind Farm (IPP) 7,65 MW
- APP Independent Producer Thermal + PV
- PV FATIMA IPP 2,25 MWp

1 MWh OF BATTERY ENERGY STORAGE IN SAL ISLAND A PILOT PROJECT WITH CHALLENGES AND BENEFITS
5. FUNCTIONS & APPLICATIONS OF PILOT STORAGE SYSTEM

BESS Functions

Autonomous

BESS response is autonomous based on events and pre determined settings

On Demand

BESS response is based on setpoints introduced by Operator
4. PILOT BATTERY STORAGE SYSTEM DESIGN AND COMPONENTS

✓ 1 MW / 1MWh AT PCC
5. FUNCTIONS & APPLICATIONS OF PILOT STORAGE SYSTEM

**BESS Functions**

**AUTONOMOUS FUNCTIONS**

- Capacity Firming (RESF)
- Frequency Sensitive Mode (FSM)
- Voltage Control (Q (U) - REG)
- Power Factor Control - COSPHI-REG
5. FUNCTIONS & APPLICATIONS OF PILOT STORAGE SYSTEM

**BESS Functions**

**ON DEMAND FUNCTIONS**

- (P) – Active Power (kW)
- (Q) – Reactive Power (kVar)
- Dispatch program
6. CHALLENGES AND BENEFITS

**Challenges**
- Choose of Best Storage Technology
- First Storage Project
- Covid-19
- End of Life destination of Batteries
- Life Time of Batteries
- Best System Site and Location
- Projet Best Application For RE Increasing
- System Integration

**Benefits**
- Increase of RE Penetration
- Energy Transition Milestone
- Knowledge and Start of Experience
- Reactive Problem Mitigation
- Add Flexibility to Grid
- Improve Grid Stability
4. PILOT BATTERY STORAGE SYSTEM DESIGN AND COMPONENTS

1 MWh of Battery Energy Storage in Sal Island: A Pilot Project with Challenges and Benefits

- SHUNT REACTORS
- BESS CONTAINER
- BESS SWITCHING STATION
- ESPARGOS DISTRIBUTION STATION

Physical Components

Building 3D View
1 MWh of battery energy storage in Sal Island: a pilot project with challenges and benefits

4. PILOT BATTERY STORAGE SYSTEM DESIGN AND COMPONENTS

- Battery room
- Control room
- Power Converter Room
• The estimated project cost is US$16.5 million equivalent, which includes the following sources of financing:
  • (a) US$3.5 million IBRD loan;
  • (b) US$3.5 million equivalent IDA credit;
  • (c) US$7.0 million loan from the Canada Clean Energy and Forest Climate Facility (CCEFCF);
  • (d) US$0.5 million grant from the CCEFCF;
  • (e) US$2.0 million grant from Global Infrastructure Facility (GIF).
Figure 2. Theory of Change

**Activities**
- Component 1: Small-scale variable renewable energy integration
  - Efficient electricity services to public buildings
- Component 2: Advisory Services for Electricity Sector Reform Implementation
  - Incorporation of a new electricity generation company
  - Incorporation of a new electricity distribution company
  - Establishment of a new state-owned single buyer/system operator
- Component 3: Project preparation and implementation support
  - Electricity sector development

**Outputs**
- Construction of four small scale solar projects and grid infrastructure, including storage
- Installation of distributed PV systems and EE equipment in public buildings
- Females trained and employment for solar PV O&M
- Incorporation of a new electricity generation company
- Incorporation of a new electricity distribution company
- Establishment of a new state-owned single buyer/system operator
- Implementation and supervision of activities under Component 1 and 2
- Technical Assistance and Capacity Building for key sector stakeholders

**Outcomes**
- Additional renewable energy generation capacity constructed
- Improved efficiency and resilience of public health buildings
- Reduction in CO2 emissions
- Reduction of the education and employment gender gap in Cabo Verde
- Mobilization of private capital
- Sustainable restructuring of power sector
- Reduction of power system losses

**PDO**
- Increase renewable energy generation and improve the performance of the electricity utility in Cabo Verde by leveraging private finance.

**Critical Assumptions:**
1: Resilient infrastructures (built infra resist to disaster and climate risks)
2: Continued commitment for electricity sector reform & private sector participation (ELECTRA privatization moving forward with private sector interest)
WB Supported

- Four small-scale solar PV projects:
  - 1.3 MW for Fogo Island;
  - 1.2 MW for Santo Antão Island;
  - 0.4 MW for Maio Island;
  - 0.4 MW for São Nicolau
- Battery storage investments for this systems are also been considered.
Presentation of main results from the BESS analysis in 5 islands in Cabo Verde
Objetives

• To conduct the analysis until 2040 and in order to determine how much new renewable capacities, taking into account the evolution of the load on 5 islands of Cabo Verde: Sal, Maio, Fogo, Santo Antão and São Nicolau;

• To determine the optimal amount of battery energy storage systems to install on those islands in order to comply with the ambitious renewable penetration goals set by the national Master Plan issued in 2018-2040, as well as to minimize the cost of electricity generation on those islands;

• To see if the addition of a battery can optimize the dispatch of existing plants to minimize the cost of electricity production;

• The 100% renewable target by 2040 would require further analysis which goes beyond the scope of our study.
Table 2: Total electricity demand in the business as usual scenario for each island.

<table>
<thead>
<tr>
<th>Yearly demand for each island</th>
<th>2020</th>
<th>2025 (Interpolated by consultant)</th>
<th>2030</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sal</td>
<td>114.4 GWh</td>
<td>147.40 GWh</td>
<td>180.4 GWh</td>
<td>201.6 GWh</td>
</tr>
<tr>
<td>Santo Antão</td>
<td>18.9 GWh</td>
<td>20.1 GWh</td>
<td>21.4 GWh</td>
<td>22 GWh</td>
</tr>
<tr>
<td>Fogo</td>
<td>14.7 GWh</td>
<td>15.8 GWh</td>
<td>16.9 GWh</td>
<td>18.2 GWh</td>
</tr>
<tr>
<td>São Nicolau</td>
<td>6.96 GWh</td>
<td>7.42 GWh</td>
<td>7.87 GWh</td>
<td>8.41 GWh</td>
</tr>
<tr>
<td>Maio</td>
<td>6.29 GWh</td>
<td>7.43 GWh</td>
<td>8.56 GWh</td>
<td>12.2 GWh</td>
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</tbody>
</table>
Evolution of the load per island from 2022 to 2030

In kW
<table>
<thead>
<tr>
<th>Project implementation options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of the storage system considered for the project implementation</td>
</tr>
<tr>
<td>Sal</td>
</tr>
<tr>
<td>Maio</td>
</tr>
<tr>
<td>Fogo</td>
</tr>
<tr>
<td>Santo Antão</td>
</tr>
<tr>
<td>São Nicolau</td>
</tr>
</tbody>
</table>
Storage is used in two main ways to minimize the total cost associated with electricity generation over the period 2025 - 2040:

- **Reserve supply**: Thermal power plants have reserve obligations, which prevent them from generating electricity at their maximum capacity. Thus, generation plants with low SRMCs cannot be operated at their maximum, and the system must resort to using plants with higher SRMCs, which increases the overall cost of electricity generation.

- Thus, storage can provide the reserve obligation of thermal entities with low short-term marginal cost, so that they can be used to their maximum capacity and the use of power plants with higher SRMC can overall be reduced.

- **Load Shifting**: When thermal power plants have technical constraints such as minimum generation, when demand is low, the production of renewables must be capped. Storage can intervene to charge the otherwise capped energy during periods of low demand and discharge it in the evening when demand is higher, to avoid the use of peak power plants which are usually expensive.
Thank you!

rito.evora@mice.gov.cv