IRENA Project Navigator Workshop in Cape Verde
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Praia, Cape Verde

The Current Situation of RE – Status and Challenges

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Ministério do Turismo, Indústria e Energia

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CAPE VERDE PRESENTATION

- Cape Verde is composed by 9 inhabited islands
- ELECTRA operates 9 independent and isolated electric systems
- Boa Vista Island is managed through a sub-concession to the company AEB
- In Sal Island, besides ELECTRA, exists APP, an independent producer.
- Electricity production by ELECTRA is based on:
  - 3 Diesel Power Plants (LFO e HFO)
  - 6 Diesel Power Plants (GO)
  - 5 Wind Farms
  - 2 Solar Power Plants
- Water production by ELECTRA is based on:
  - 3 Desalination Plants (RO) in São Vicente and Sal islands and in Praia

COMPANY PRESENTATION

COMPANY HISTORY
MAIN MILESTONES

1982 — **Launch**

- ELECTRA was launched in April **17th 1982**

2000 — **Privatization**

- Sale of 51% of the share capital. Private management on January **18th 2000**.

2006 — **Corporate Restructuring**

- EDP/AdP transfered all its shares to the State of Cape Verde, which started to hold full control of the company with 85% stake, and the remaining 15% kept being held by the municipalities of Cape Verde - **August 31st 2006**,

2013 — **3 Companies separation**

- Entry into operation of 3 companies from **July 1st, 2013:**
  ELECTRA SARL
  ELECTRA Sul
  ELECTRA Norte
- ELECTRA SARL owns all assets
- **ELECTRA Sul** (Maio, Santiago, Fogo e Brava) and **ELECTRA Norte** (Sto. Antão, S. Vicente, S. Nicolau e Sal) are operating companies.

COMPANY PRESENTATION
ACTIVITY AREAS

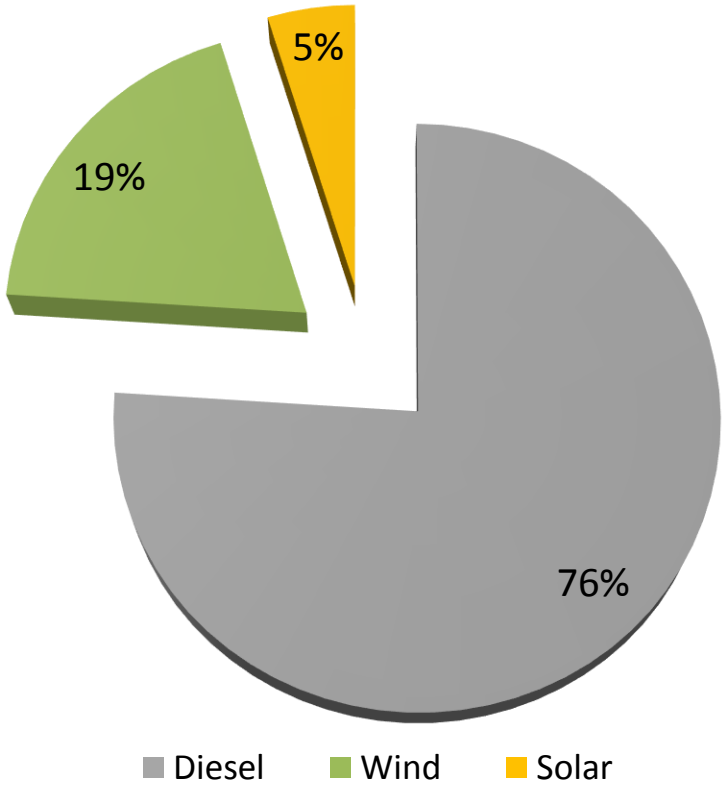
ELECTRA ACTIVITY AREAS:

- Electricity transmission and distribution across the country, on an exclusive basis (except Boa Vista island)
- Water transport and distribution in S. Vicente, Sal and Praia, on an exclusive basis
- Electricity Production nationwide
- Desalinated water production in S. Vicente, Sal and Praia
- Wastewater collection and treatment for reuse in Praia, on an exclusive basis

COMPANY PRESENTATION

CONVENTIONAL AND RENEWABLE PRODUCTION MANAGEMENT

Installed Capacity



In recent years, Cape Verde has invested in renewable energy making use of its endogenous resources, mainly wind and solar resources.

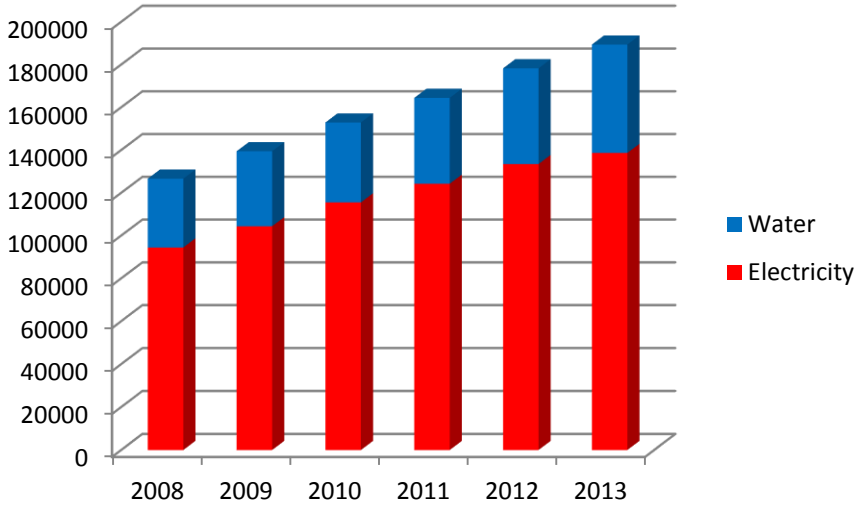
Presently ELECTRA manages **26,9 MW** of renewable capacity

(independent power producers and state owned renewable power plants represents **24%** of the total installed capacity of **140 MW**)

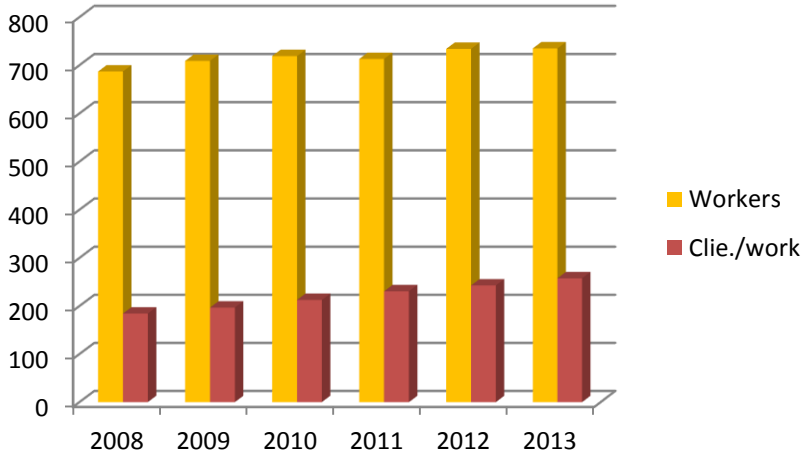
COMPANY PRESENTATION
RELEVANT NUMBERS…

In **2013** ELECTRA has about **189 000 clients (138 000 electricity and 51 000 water)** and employs **735 workers**

Nº Clients



Clients/worker

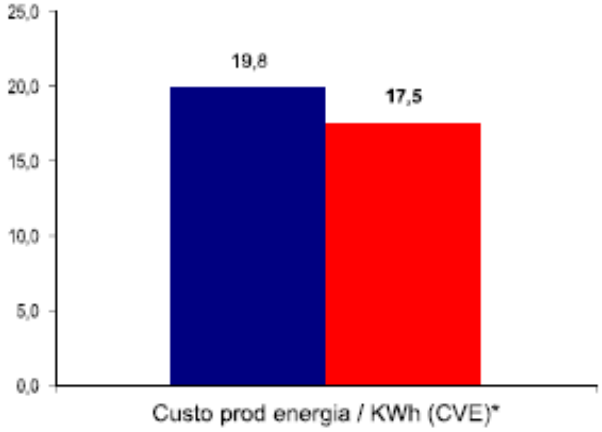


COMPANY PRESENTATION
RELEVANT NUMBERS…

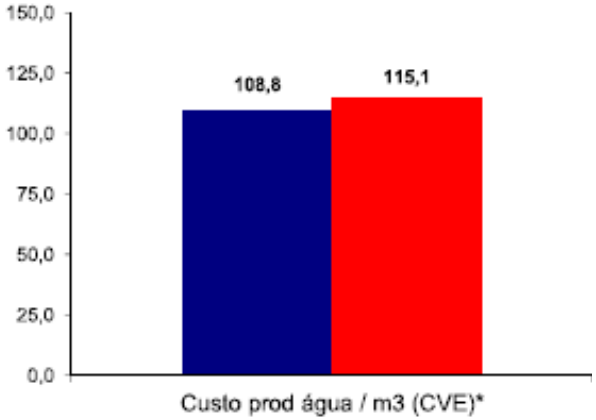
Energy and Water is **strongly dependent** on fuel and diesel power plants.

High cost of energy (fuel and electricity) leads to high cost of electricity and water production .

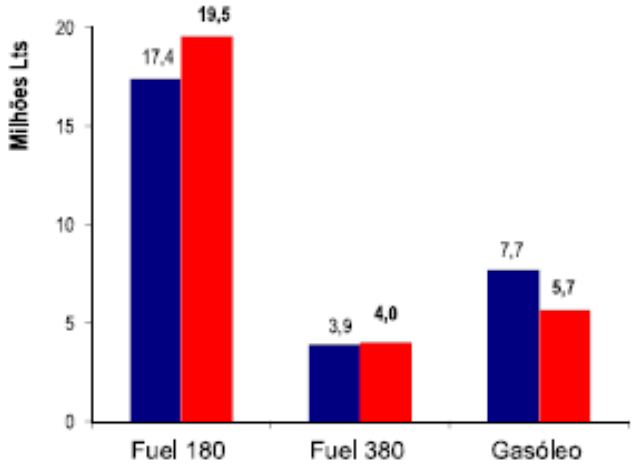
Fuel Cost per kWh



Energy Cost per m3 of Water Production



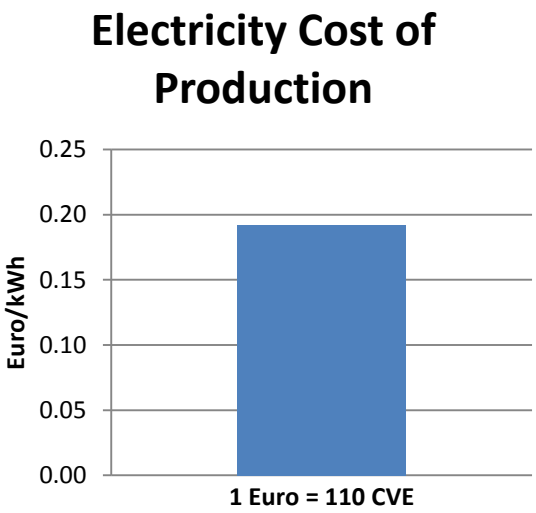
Fuel and Diesel Consumption

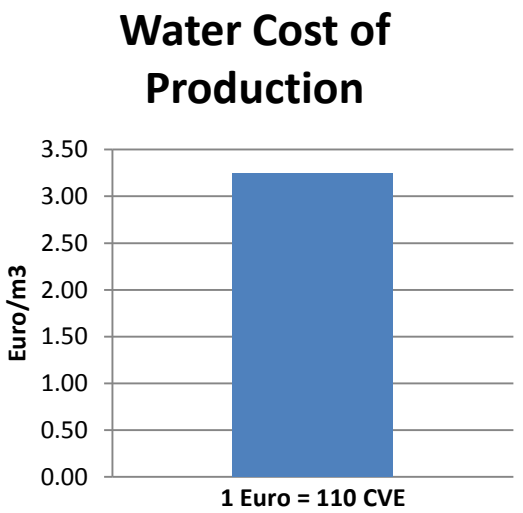


Source: Management Control Report – Production (June'13)

COMPANY PRESENTATION
RELEVANT NUMBERS…

High cost of electricity and water production leads to the need of more renewable power in Cape Verde

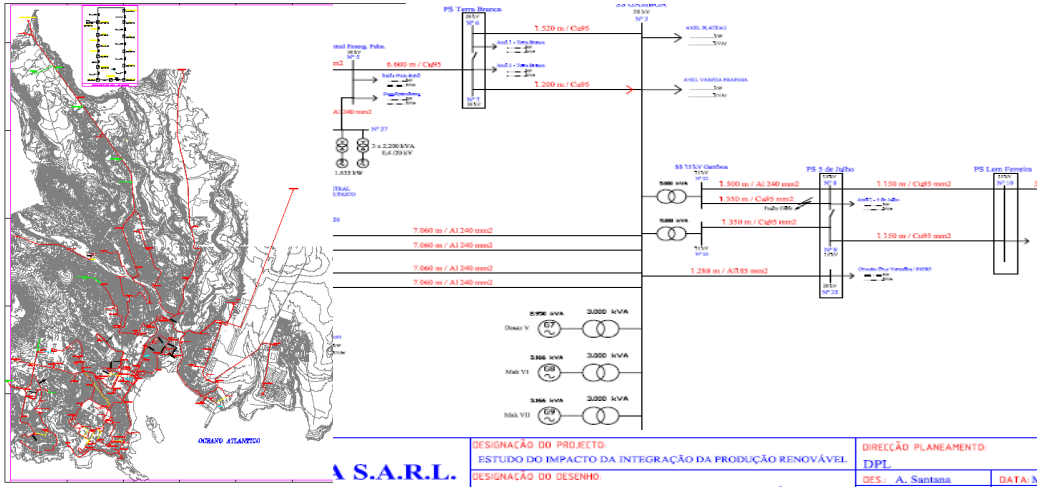


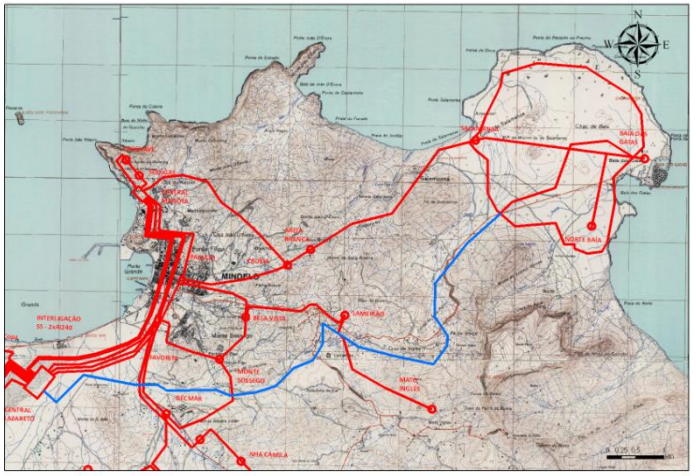


Source: Management Control Report – Production (June'13)

ENERGY DISTRIBUCTION CURRENT GRID (2010)

Island	HV Overhead	MV Overhaed	MV Underground	LV Overhead	LV Underground
Santiago	70	135	145	352	39
S. Vicente	-	29	102	214	17
Sal	-	-	119	36	32
Other islands	-	125	172	574	24
Total (km)	**70**	**289**	**538**	**1176**	**112**



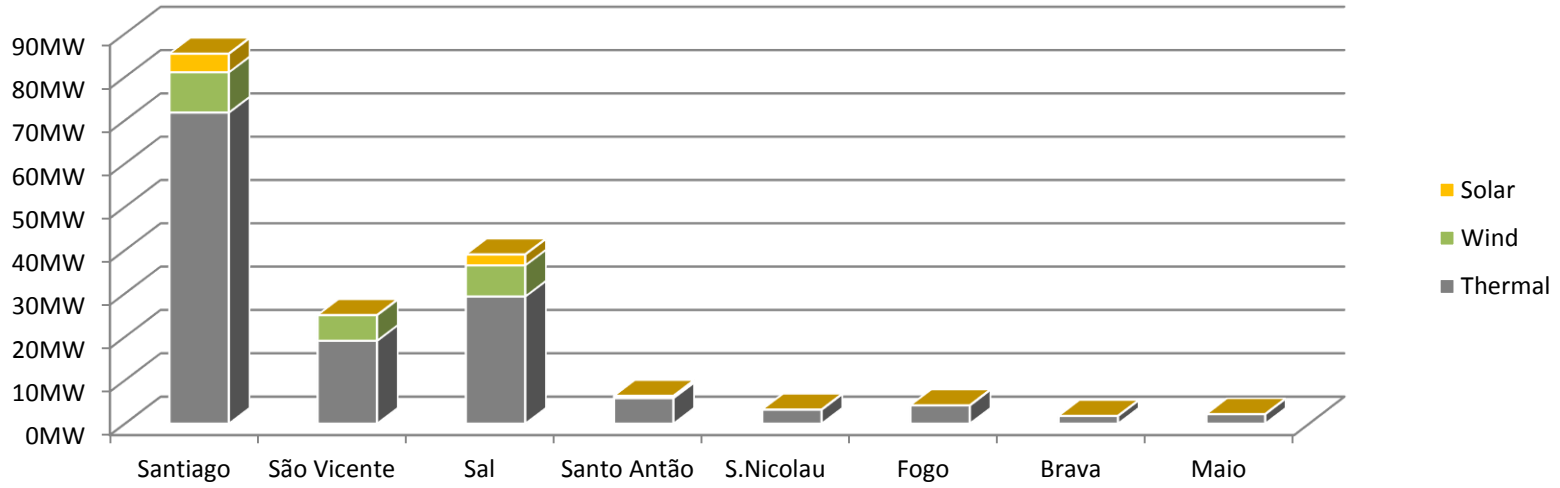


RENEWABLES IN CAPE VERDE

ENERGY PRODUCTION
INSTALLED CAPACITY

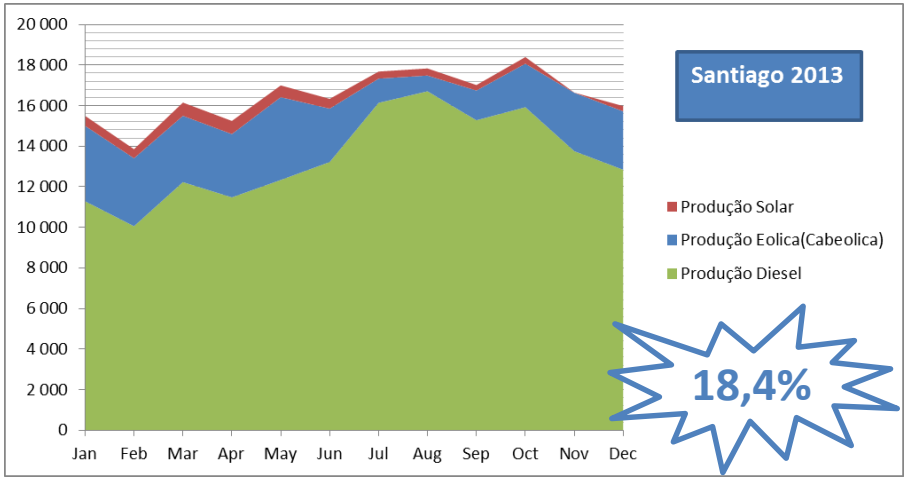
Presently ELECTRA manages **29,68MW** of renewable capacity (independent power producers and state owned) in Santiago, São Vicente, Sal and Santo Antão.

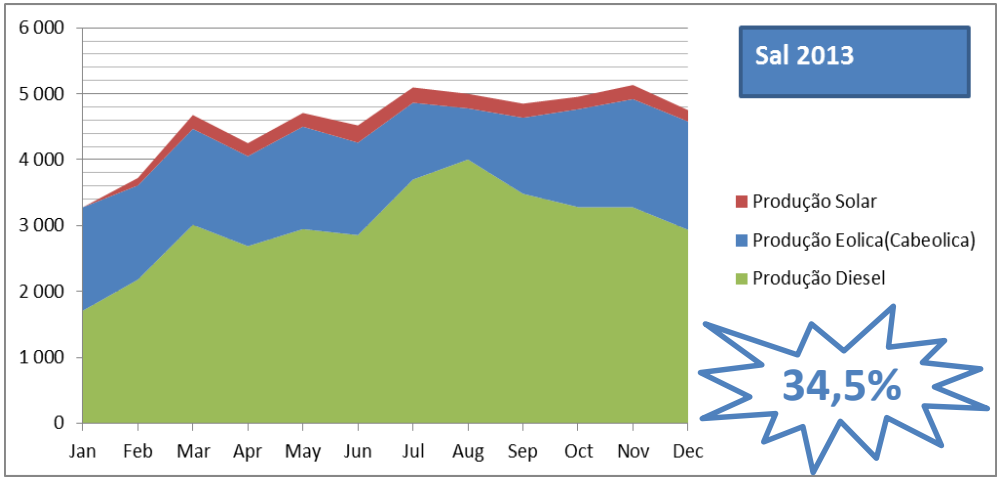
Installed Capacity [MW]	Santiago	São Vicente	Sal	Santo Antão	S.Nicolau	Fogo	Brava	Maio	TOTAL
Thermal	58,21MW	13,20MW	19,60MW	5,37MW	3,22MW	4,20MW	1,77MW	2,18MW	**137,43MW**
	13,58MW	5,90MW	9,70MW	0,50MW					
Wind	9,30MW	5,90MW	7,20MW	0,50MW					**22,90MW**
Solar	4,28MW		2,50MW						**6,78MW**
TOTAL	**85,37MW**	**25,00MW**	**39,00MW**	**6,37MW**	**3,22MW**	**4,20MW**	**1,77MW**	**2,18MW**	**167,11MW**
RE/TE Ratio	**16%**	**24%**	**25%**	**8%**	**0%**	**0%**	**0%**	**0%**	**18%**

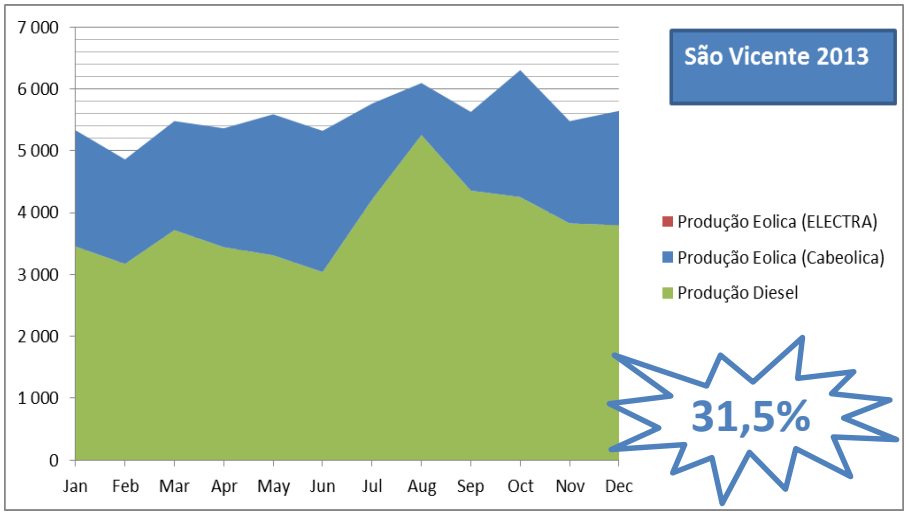


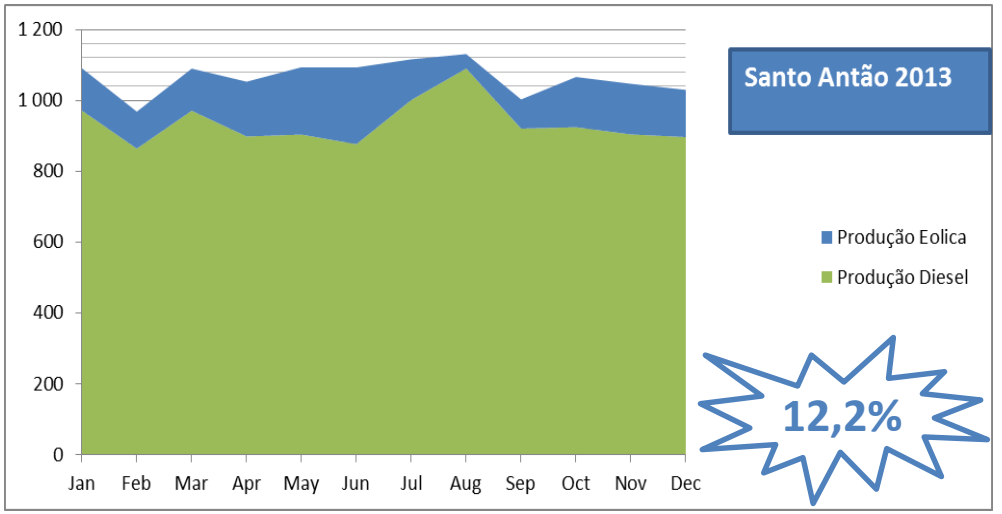
ENERGY PRODUCTION
2013 ENERGY MIX

In 2013 **Santiago, São Vicente, Sal and Santo Antão** islands registered relevant renewable energy penetration levels…

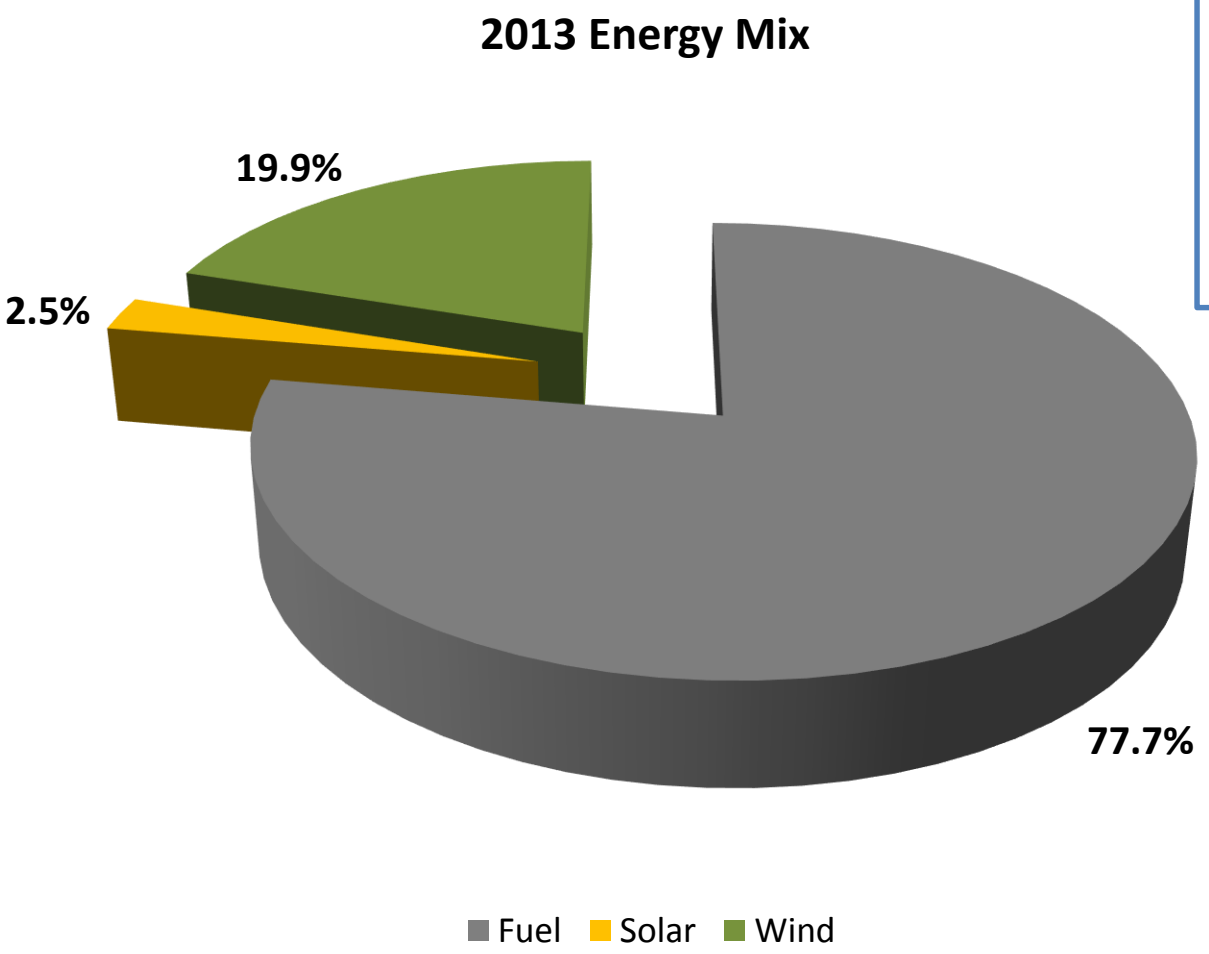








ENERGY PRODUCTION
2013 ENERGY MIX

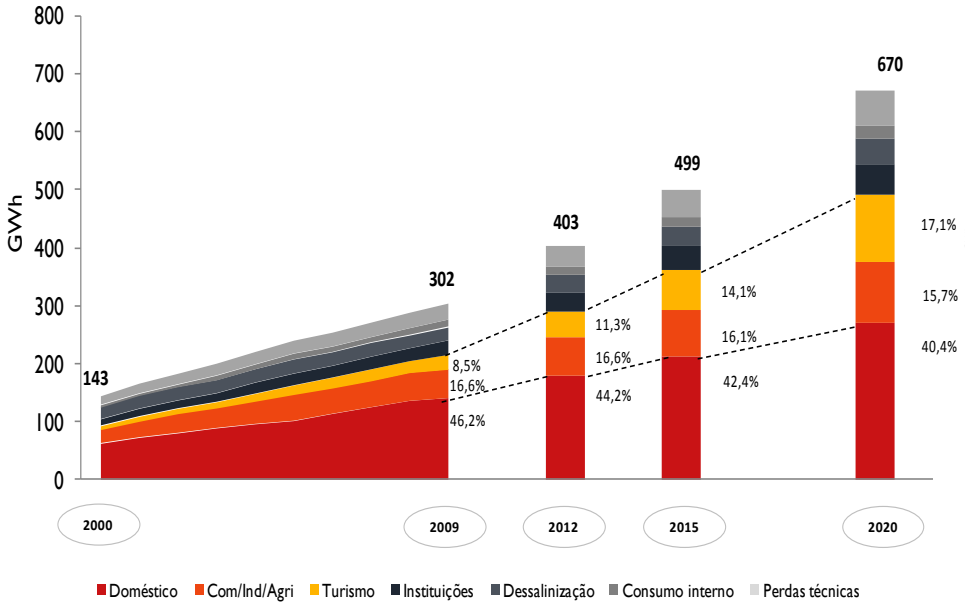


Currently, **22,35%** of the energy produced in Cape Verde comes from renewable resources!!!

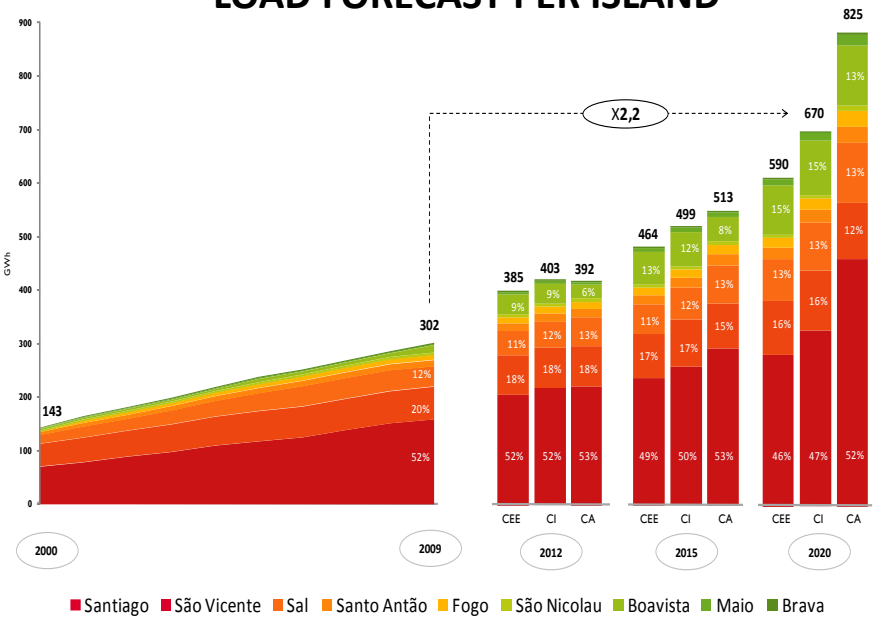
ELECTRA
LOAD FORECAST

In a moderate load growth scenario, it is expected that consumption in Cape Verde reaches **670 GWh** in 2020 with a total installed capacity of approximately **300 MW**

LOAD FORECAST PER SECTOR



LOAD FORECAST PER ISLAND



Source: Cape Verde 50%Renewable - Energy Master Plan 2010-2020 – Load Forecast Study (GESTO Energy 2010)

THE GOAL
RENEWABLE ENERGY HIGH PENETRATION

Given the dependence on petroleum products, ELECTRA intends to:

- Increase substantially the penetration of renewable energy
- Reduce the diesel portion in the production mix
- Reduce the pollution emission gases

THE GOAL
RENEWABLE ENERGY HIGH PENETRATION

Cape Verde Renewable Energy Masterplan establishes a target of **50% Renewables penetration until 2020!!**

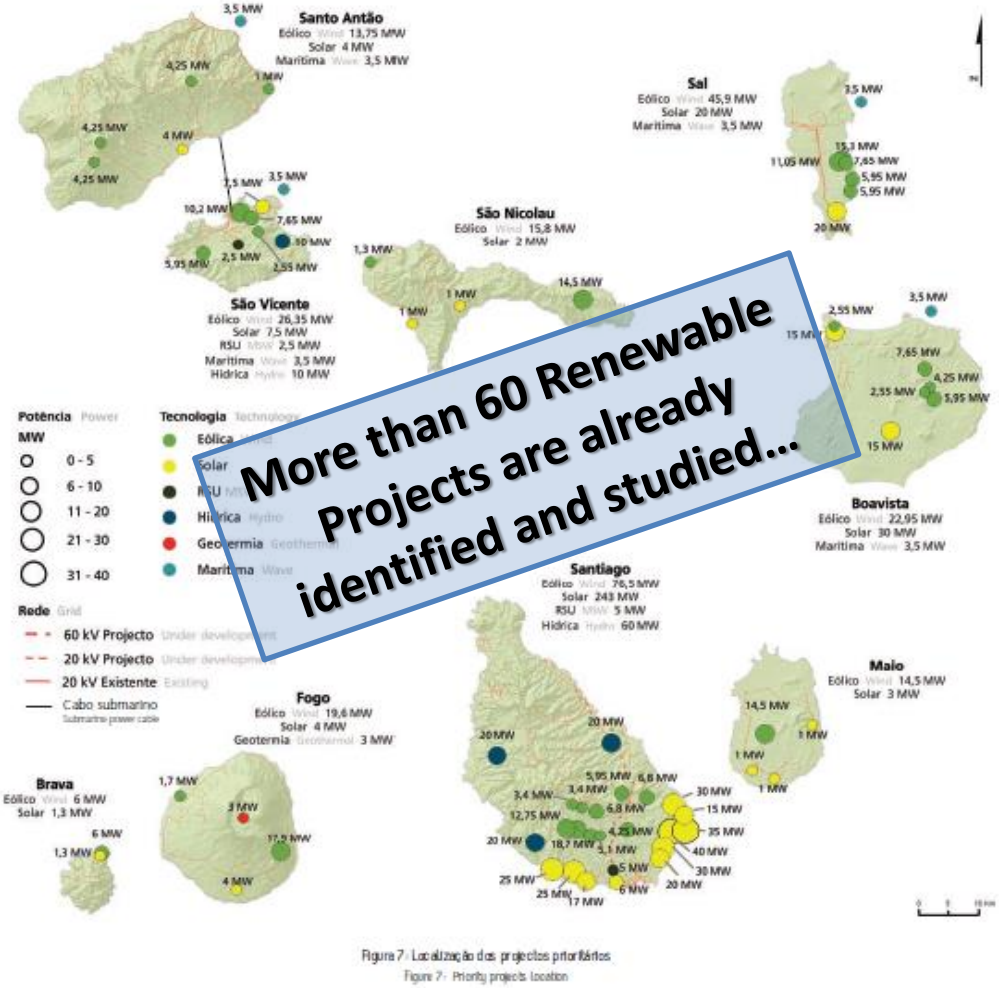
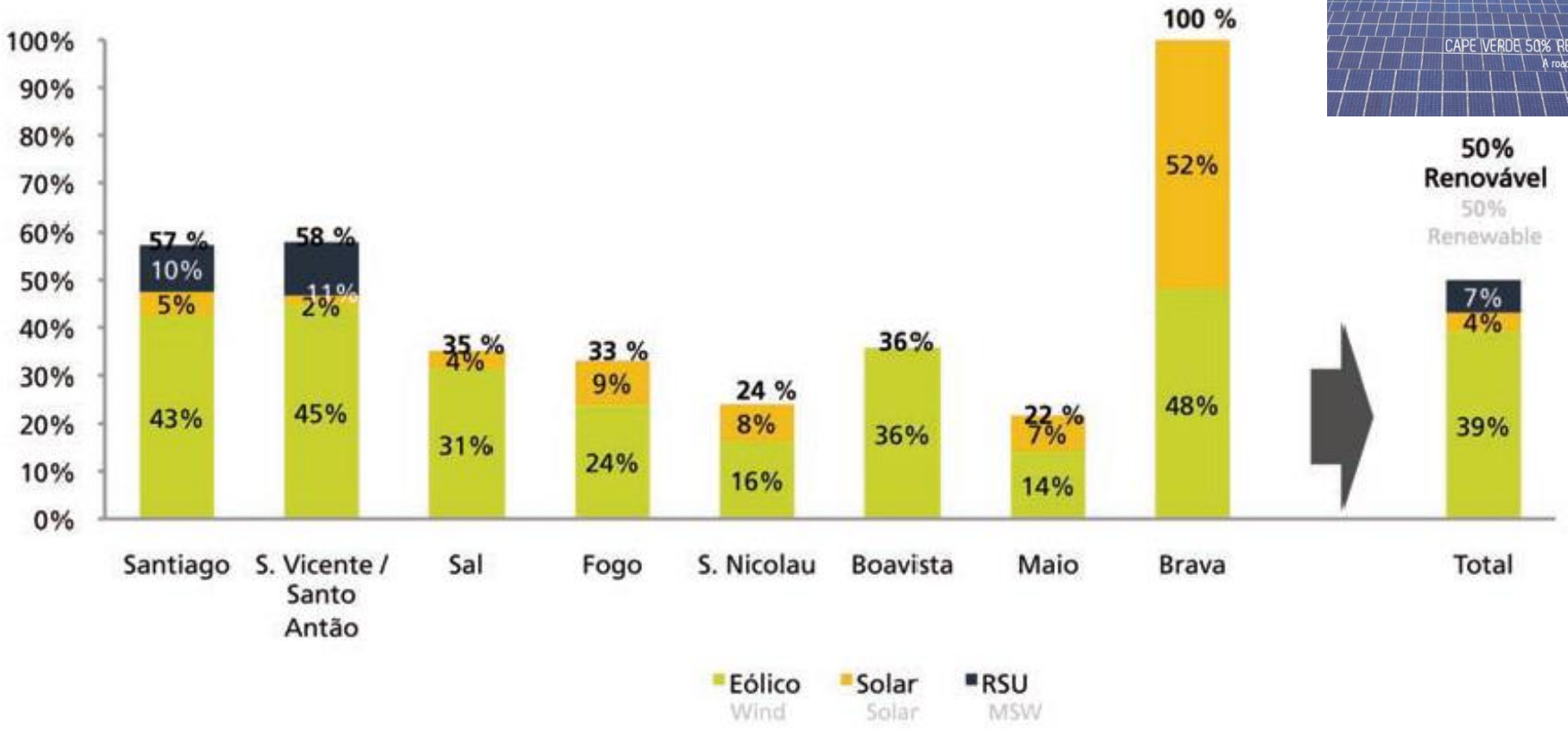


Figura 7: Localização dos projectos prioritários
Figure 7: Priority projects location

Source: Cape Verde 50%Renewable - Energy Master Plan 2010-2020 (GESTO Energy 2010)

THE GOAL
RENEWABLE ENERGY HIGH PENETRATION

Cape Verde Renewable Energy Masterplan establishes different targets for each island in order to reach the 50% Renewables scenario until 2020



Source: Cape Verde 50%Renewable - Energy Master Plan 2010-2020 (GESTO Energy 2010)

Proposed Implementation Plan 2017-2022 Renewable Energy

Island	Total Installed Capacity (MW)
Total Santiago	**74,1**
Total S.Vicente	**13,2**
Total Sal	**4,2**
Total Santo Antão	**2,0**
Total Fogo	**2,7**
Total 5 Ilhas	**96,2**

	2014	2017	2020	2022
Diesel Generation (MWh)	290.727	269.159	291.062	303.206
Renewable Generation (MWh)	75.525	139.391	209.397	277.757
Total Generation (MWh)	**366.252**	**408.550**	**500.459**	**580.964**

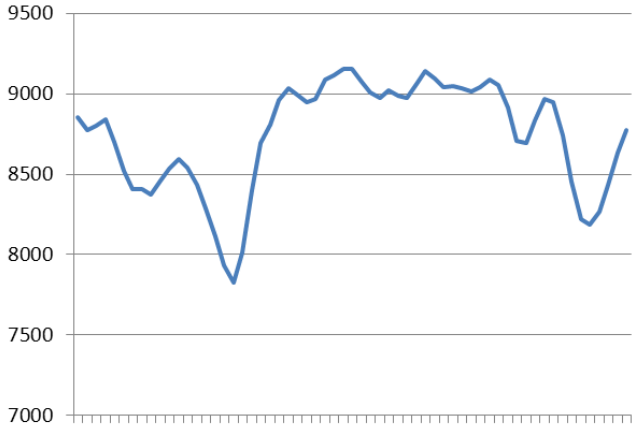
RENEWABLE ENERGY HIGH PENETRATION CHALLENGES…

GOAL

maximize the penetration of renewables ensuring the system stability

CHALLENGE

Instability caused by a high penetration of renewable energy in isolated systems, small and weak



Large power variations in seconds

THE GOAL
RENEWABLE ENERGY HIGH PENETRATION

CONCLUSION

- ELECTRA is focused on the objective of maximizing the penetration of renewables.

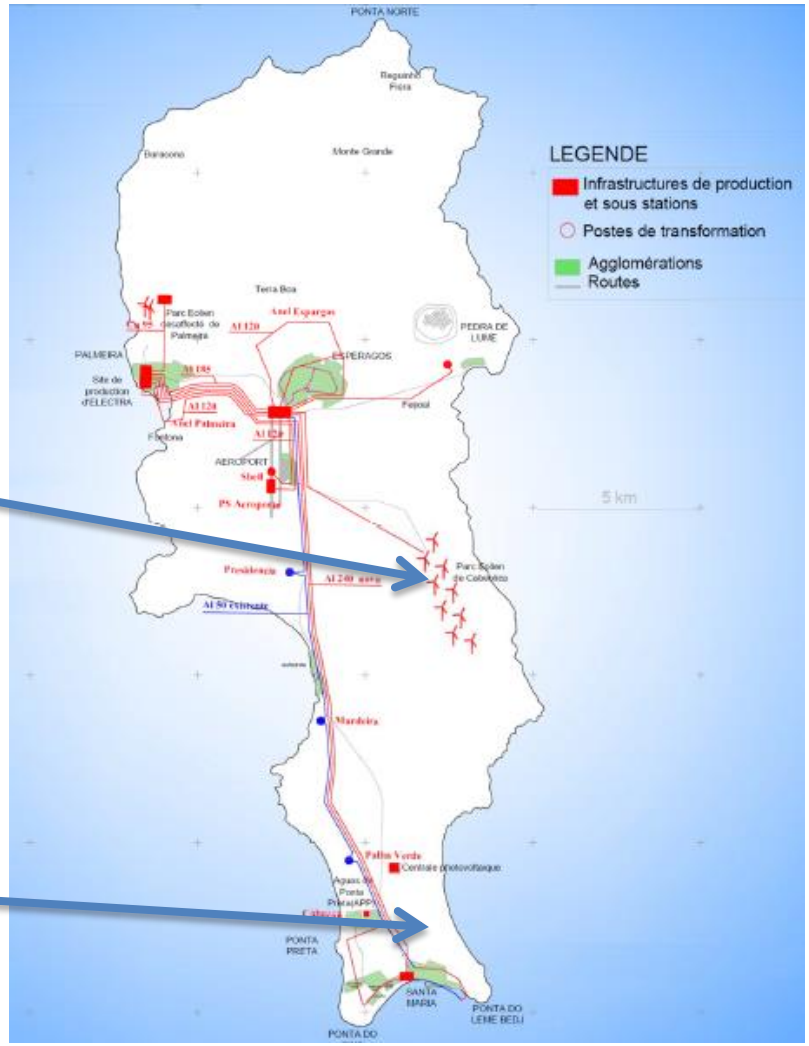
- ELECTRA is conducting various technical and economical studies in order to achieve this objective, while maintaining system stability and quality of power supply:

  - Use of energy storage in some islands:
    - Flywheels
    - Batteries
  - Brava Island 100% Renewable;
  - …

SAL ISLAND CASE STUDY

SAL ISLAND
RENEWABLE ENERGY HIGH PENETRATION ISLAND

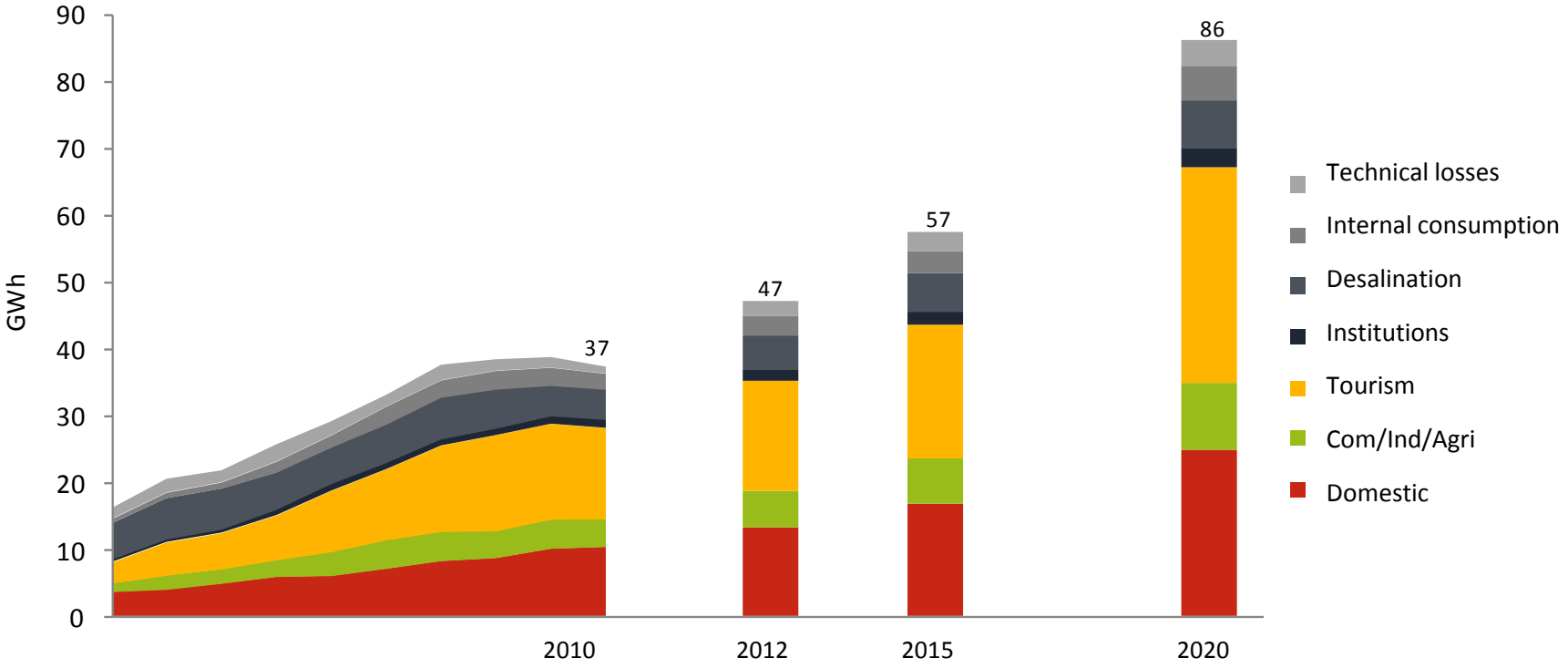
ELECTRA intends to substantially increase the penetration of renewable energy in Sal island



Source: Report «Projet de renforcement et d'optimisation du système d'énergie électrique de l'île de Sal»

SAL ISLAND
LOAD FORECAST 2020

It is expected that the consumption on the island of Sal reaches **86 GWh** in 2020, strongly driven by the Tourism sector

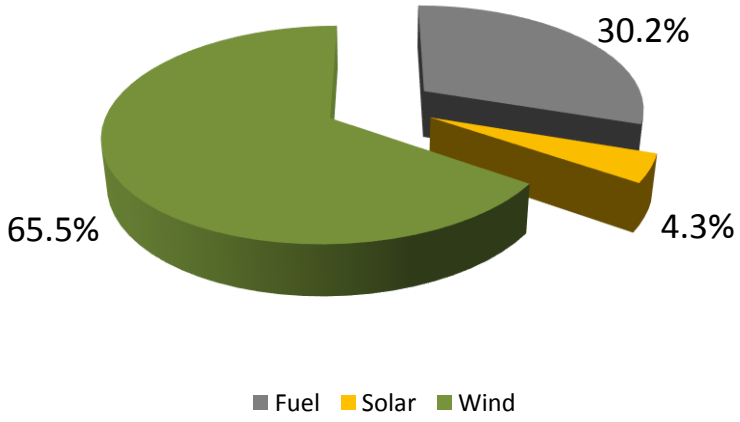


Source: Cape Verde 50%Renewable - Energy Master Plan 2010-2020 – Load Forecast Study (GESTO Energy 2010)

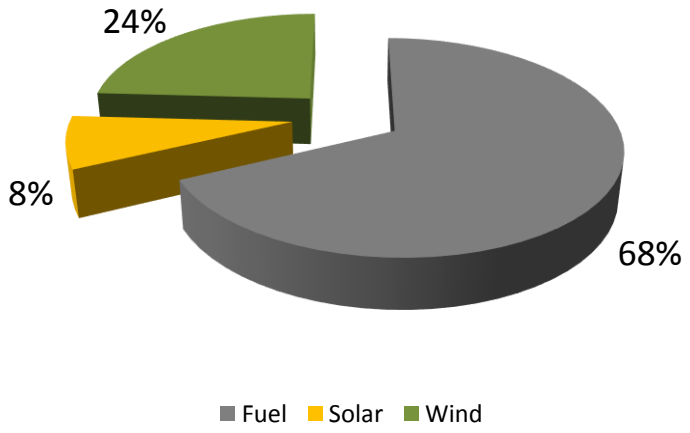
SAL ISLAND
ENERGY MIX AND INSTALLED CAPACITY

Sal Island currently has a renewable installed capacity of **10.1 MW** (7.6 MW wind and 2.5 MWp Solar) and reached a penetration of renewable energy of approximately **34.5%** in 2013

Energy Mix



Installed Capacity



Sal 2013		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Wind	MWh	1.568	1.429	1.455	1.364	1.554	1.403	1.165	777	1.154	1.485	1.642	1.644	16.640
Solar	MWh	113	211	198	207	261	232	220	215	189	215	172	155	2.388
Fuel/Diesel	MWh	1.709	2.180	3.012	2.687	2.947	2.855	3.699	4.002	3.482	3.280	3.276	2.935	36.064
Total	MWh	3.390	3.820	4.665	4.259	4.762	4.490	5.084	4.993	4.825	4.980	5.090	4.734	55.092
Wind penetration ratio	%	46,3%	37,4%	31,2%	32,0%	32,6%	31,2%	22,9%	15,6%	23,9%	29,8%	32,3%	34,7%	30,2%
Solar penetration ratio	%	3,3%	5,5%	4,2%	4,9%	5,5%	5,2%	4,3%	4,3%	3,9%	4,3%	3,4%	3,3%	4,3%
Total penetration ratio	%	49,6%	42,9%	35,4%	36,9%	38,1%	36,4%	27,2%	19,9%	27,8%	34,1%	35,6%	38,0%	34,5%

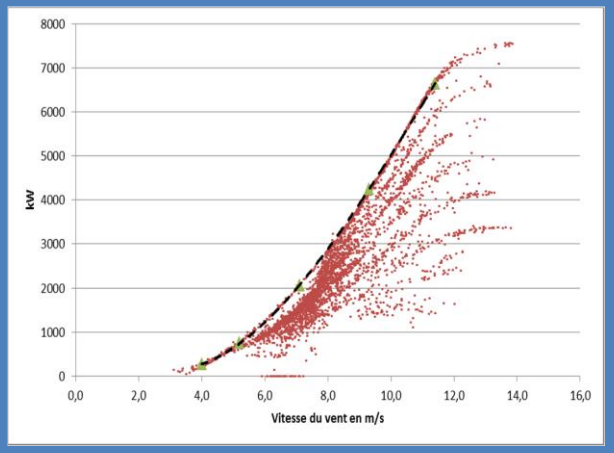
SAL ISLAND
RENEWABLE ENERGY MANAGEMENT STRATEGY

Spinning Reserve 50%
(50% of the renewable power supplied)

Currently the spinning reserve is managed manually by imposing **remote limitation set points** to the Windfarm turbines.

Remote limitation setpoints

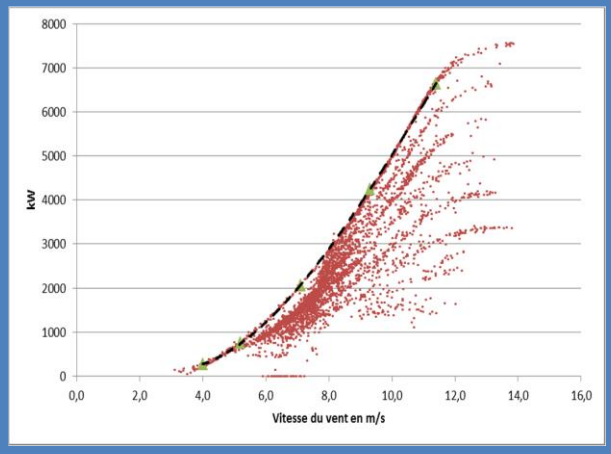
Wind Turbine derating



SAL ISLAND
RENEWABLE ENERGY MANAGEMENT STRATEGY

Unit Commitment

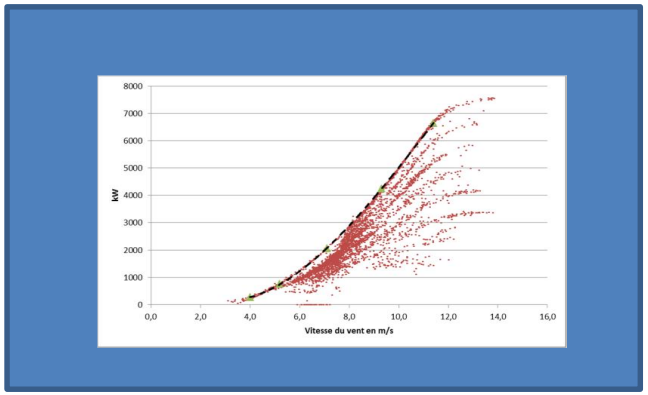
- Unit commitment solves the problem of determining wich generation units should be running in each period so as to satisfy a predictably varying demand for electricity
- Period of optimization is variable (up to 10 days)



SAL ISLAND
RENEWABLE ENERGY MANAGEMENT STRATEGY

Load Forecast
And
Renewables Forecast

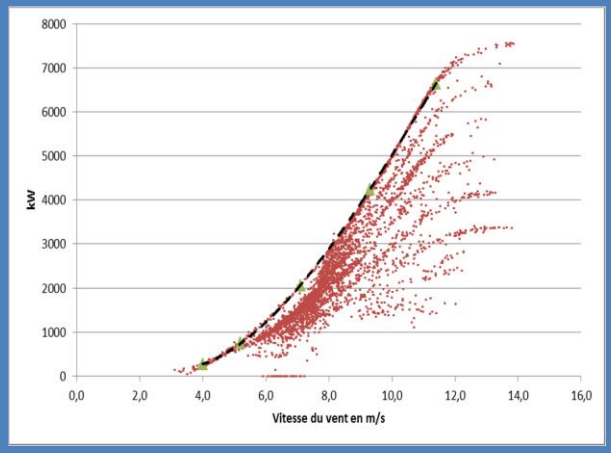
- Forecast based on history, day type, weather and current system sate
- Short-term forecast – 7 days with one hour granularity
- Bottom-up approach
- Support for solar and wind generation forecast
- Forecast based on history, weather (current and forecasted) and current system state
- Near – term forecast – 24h with one hour granularity
- Short – term forecast – 7 days with one hour granularity



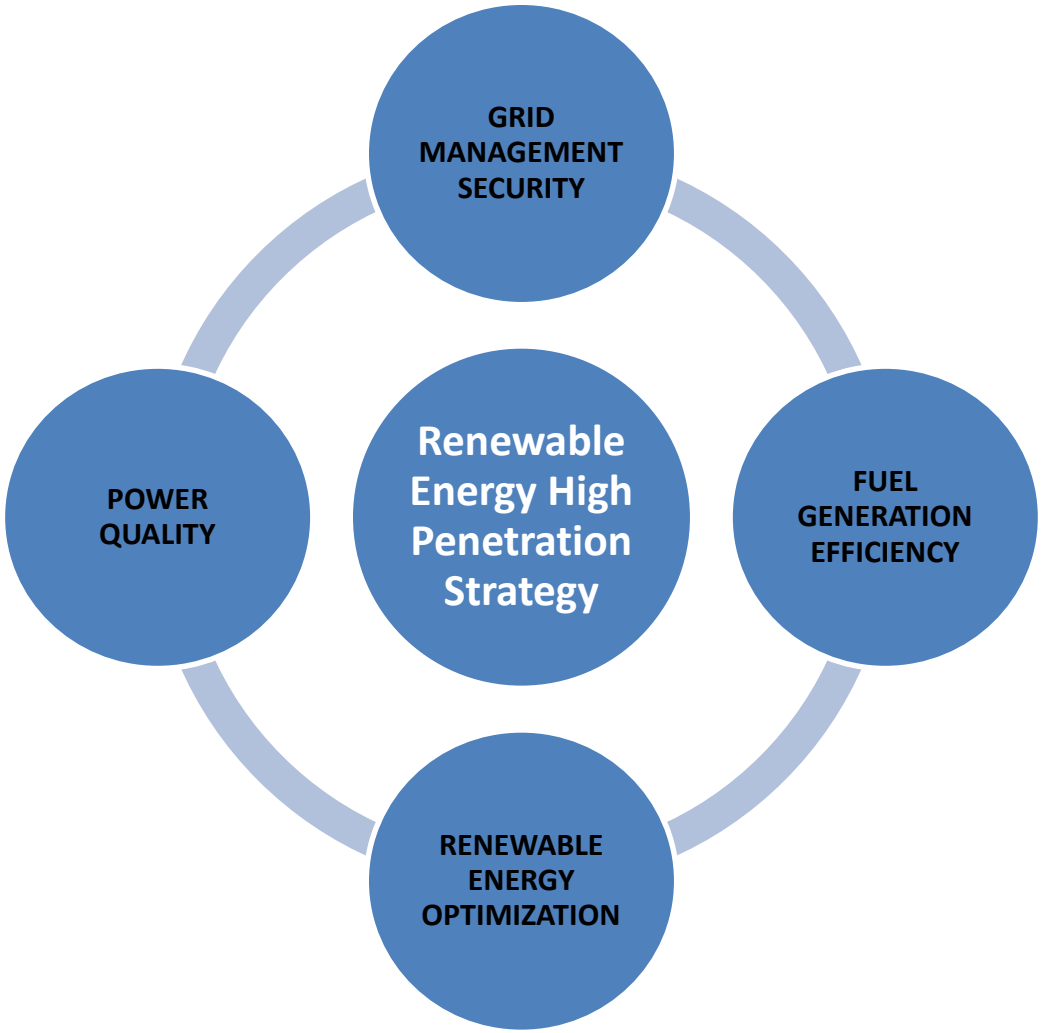
SAL ISLAND
RENEWABLE ENERGY MANAGEMENT STRATEGY

Load Sheding

- 10 levels of consumer priorities
- Fast response time



SAL ISLAND
RENEWABLE ENERGY INCREASE STRATEGY



ELECTRA has a Renewable Energy High Penetration Strategy for Sal Island based on 4 drivers

SAL ISLAND
RENEWABLE ENERGY INCREASE STRATEGY

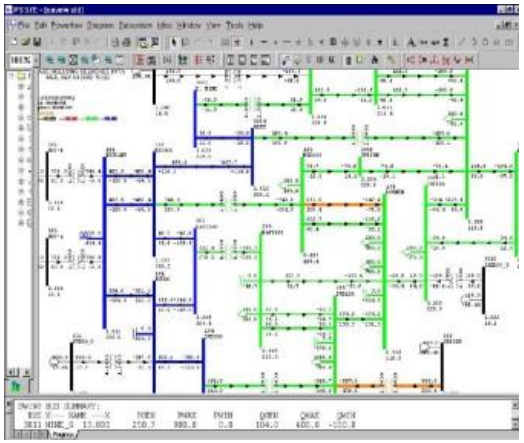
1st STAGE

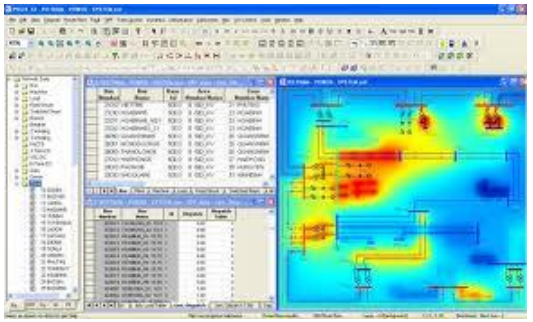
...

Grid Studies

Selectivity and protections coordination studies, complemented with steady state and dynamic grid studies, in order to ensure the stability of the grid in different contingency scenarios:

- Building the static model of each network.
- Building of dynamic models and preparation of the scenarios for dynamic stability simulations.
- Load Flow and Short Circuit studies.



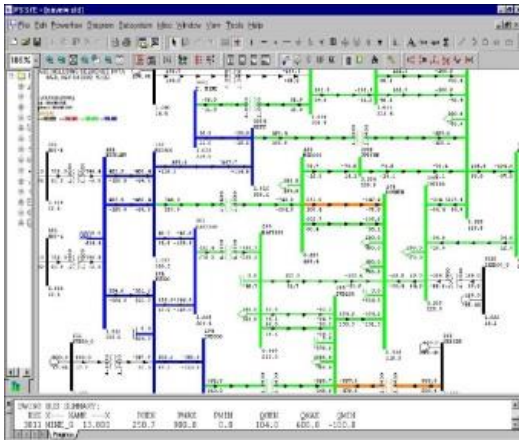


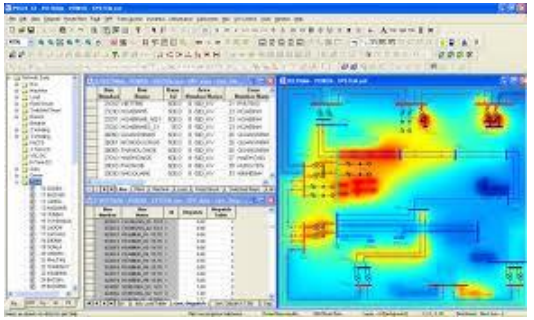
SAL ISLAND
RENEWABLE ENERGY INCREASE STRATEGY

... 1st STAGE ...

Grid Studies

- Dynamic stability simulations: calculation of critical clearing times and Frequency response at Loss of largest diesel generator, largest wind farm/aero generators, Loss of major load, up to 10 contingency scenarios, e.g. three-phase short circuit followed by outage of line or bus bar.
- Identification of limitation and actual problems that can affect the system stability.
- Analysis of weaknesses in the protection system and recommendations to its improvement.





SAL ISLAND
RENEWABLE ENERGY INCREASE STRATEGY

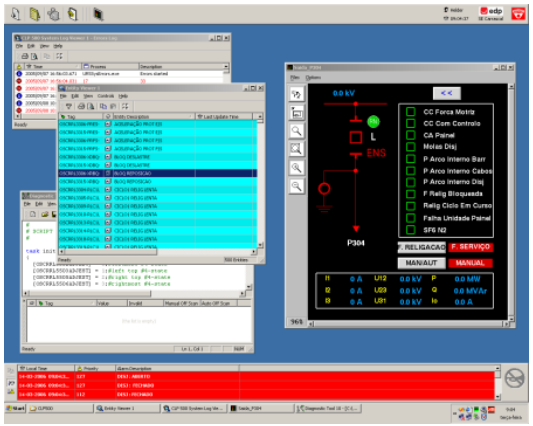
...

2nd STAGE

...

Standard Dispatch System

installation of a standard dispatch system in Sal island to efficiently manage the existing power plants in safety conditions



SAL ISLAND
RENEWABLE ENERGY INCREASE STRATEGY

... 3rd STAGE ...

Advanced Dispatch System and Energy Storage Systems

- To integrate the simulation software and grid models developed in Stage 1 with the Dispatch System, in order to ensure the stability of the grid on contingency scenarios with relevant fluctuation of renewable power;

- Study the use of complementary systems with the purpose of creating conditions to safely integrate more renewable energy power into the grid (Flywheels systems, Battery Systems, Energy Storage Control Systems, etc.);

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... 3rd STAGE ...

Advanced Dispatch System and Energy Storage Systems

- Upgrade the Standard Dispatch System with advanced and specific modules to manage massive amounts of Renewable Power, based on algorithms specially dedicated to the management of high renewables penetration grids, optimizing the use of Renewable Energy, ensuring grid stability and safety conditions including, namely:
  - Master control system configuration to control the renewable's power output smoothing and grid operation stability;
  - Monitoring system configuration to meet monitoring and management needs of network operation;

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... 3rd STAGE

Advanced Dispatch System and Energy Storage Systems

- Refurbishment of the protection systems based on the recommendations of the result of the selectivity and coordination of protection systems studies, accomplished in Stage 1;

- Development of the terms of reference for a pilot-project in Sal island containing:
  - Overall Design of Energy Storage (Energy storage system should include at least three dimensions: energy storage stack design, battery management systems and energy storage inverter).
  - Energy storage system configuration

Thanks!

Merci!

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ECOWAS Regional Centre for Renewable Energy and Energy Efficiency
Centre Régional pour les Energies Renouvelables et l'Efficacité Energétique de la CEDEAO
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