

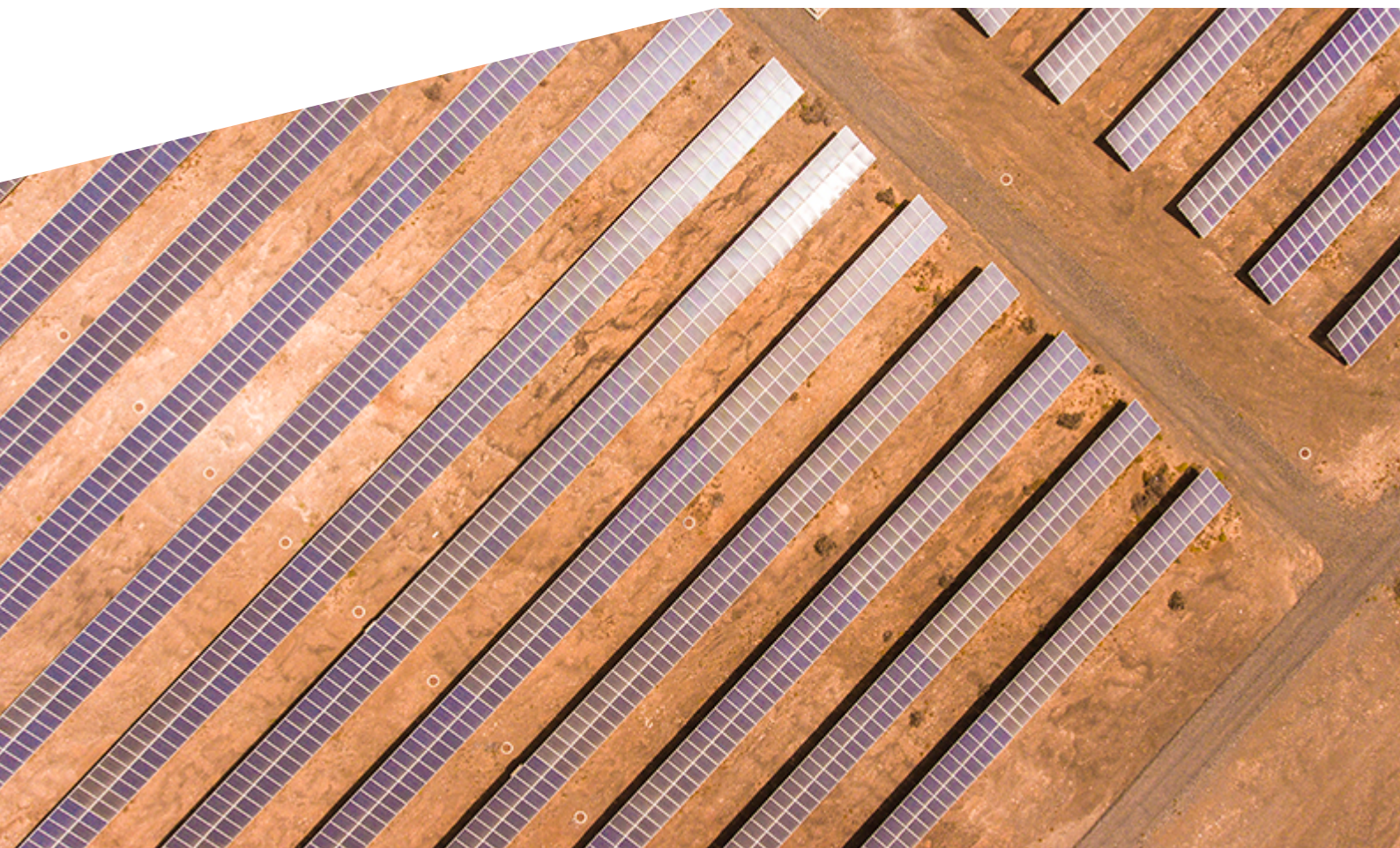
Case Study: Sal Solar PV Project *Cabo Verde*

BACKGROUND

The Government of Cabo Verde (GoCV) with support from various partners took first steps to develop its vast renewable energy (RE) potential in the 1980s, but it was only in the period 2008 to 2011 that the government decided to adopt ambitious plans for RE development, to create an enabling environment for private sector investment in RE power generation, and to develop the first utility-scale solar PV projects in the country. This process was supported by a soft loan from the Government of Portugal that was used to finance technical assistance for assessing the country's RE potential, assistance in RE planning as well as the development of the Sal Solar PV Project and its sister project on the island Santiago (see separate case study). The *ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)* in cooperation with *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)* and Cabo Verde's *Directorate General of Energy (DGE)* agreed to conduct an in-depth analysis of these two projects, which were among the first utility-scale solar PV projects in West Africa, with a view of disseminating the experiences and lessons learned to other stakeholders in the region. In addition, the assessment served as a basis for the development of options for improving the operation and maintenance of the two power plants.

KEY FACTS

Site	Murdeira, Sal Island
Technology	Grid-connected solar PV power plant
Generation capacity	2.2 MWp
Developer	Government of Cabo Verde
Operator	Electra Norte (state-owned utility)
Commissioning	October 2010
Investment cost	EUR 8,403,243
Financing	Concessional loan



PROJECT DEVELOPMENT

The project development process for the Sal Solar PV Project and its sister project in Santiago took approx. one year which is shorter than the time that is usually required for developing similar projects in developing countries. Due to rising electricity demand and the generation shortage that prevailed at the time, the Cabo Verdean government decided in early 2009 to develop the two plants as public projects within a short period of time. This was in a situation when the government was already in discussion with the Government of Portugal on the establishment of a EUR 100 million credit line for renewable energy, environmental and water projects. The idea of developing solar power plants had been discussed in this context. At the same time it was decided to launch a comprehensive technical assistance project for supporting DGE in analysing Cabo Verde's RE potential, developing an RE investment plan and developing the legal and regulatory framework for RE promotion. The consulting firm that was chosen to

implement this project participated in the development process of the solar PV plants by assisting DGE in activities like site identification and the coordination with *Electra* SARL, the future off-taker and operator of the plants. The approach to project development taken by DGE was very results-oriented and pragmatic. No feasibility study was undertaken, and the sizing was done based on the need for additional generation capacity at the time. DGE obtained a waiver for conducting an environmental impact assessment. The fact that the government itself was the developer of the project facilitated the process of obtaining land and all necessary permits for the project. The selection of the site was complicated by the fact that in Sal, which is Cabo Verde's prime tourist destination, many areas are classified as zones for integrated tourism development (ZDTI). However, DGE finally obtained suitable land near an existing substation in Murdeira, approx. 11 km from the island's tourism centre Santa Maria.

PROJECT MILESTONES



29. 06.
Signing of agreement on credit line between the governments of Cabo Verde and Portugal

28. 12.
Cabinet authorization for direct procurement of the solar PV plants in Santiago and Sal



January:
EPC contract signed between Martifer Solar and the Ministry of Economy, Growth and Competitiveness (MECC)

01. 10.
Inauguration of Sal plant

22. 11.
Adoption of Decreto-Lei nº 53/2010 which provides the legal basis for the concession agreement between DGE and Electra



January:
Signature of the concession contract with Electra and handing over of the plant



September:
Aguas de Ponta Preta (APP) started providing operation and maintenance services to Electra

PROCUREMENT AND CONSTRUCTION

One of the requirements of the loan agreement with Portugal was that all goods and services for projects financed under the credit line would be procured from Portuguese firms. It is against this background that the government opted for a direct award of the Engineering, Procurement and Construction (EPC) contracts for both plants to *Martifer Solar* (MTS), a company that is also a manufacturing PV modules and now part of the French *Voltaia group*.

The decision to develop the Sal solar PV plant and its sister project in Santiago with public funds and to award the contract directly to MTS was heavily criticized by the opposition who accused the government among others of corruption and of choosing a technology that is significantly more expensive than windpower and would increase the cost of electricity generation in Cabo Verde. The government reacted with a declaration stating that all these claims were wrong and highlighting the various expected benefits of the projects.¹

The contract with MTS foresaw initially that the contractor would install a 2.5 MW plant for a total price of EUR 9.34 million (3.75 EUR/kWp). In parallel, the government invested in grid reinforcements and in a 4.9 MW thermal »backup« power plant under separate contracts. However, the government and the contractor agreed during the construction phase to reduce the plant's capacity to 2.2 MWp and the contract price to EUR 8.4 million, because the government was not in a position to mobilize the share of the CAPEX that would

have had to be paid directly to the contractor by them (the other payments were made by the Portuguese bank managing the credit line).

The plant consists of 9,912 polycrystalline 225 Wp modules from *Martifer Solar*, four central inverters from SMA and a fixed steel mounting structure with concrete foundations.

Construction started in April 2010 and was completed in September of the same year. The plant was officially inaugurated on 01.10.2010. At the time, it was one of the biggest solar PV plants in Africa.

OPERATION

Upon completion of construction, the plant was handed over to the state-owned utility *Electra* S.A.R.L. which was split in subsidiary companies for managing the electricity systems of the northern islands (*Electra Norte*) and of the southern islands (*Electra Sul*) in 2013. Since then the Sal plant is managed by *Electra Norte*. In the first years of operation, all operation and maintenance tasks were performed by *Electra*. Two *Electra* technicians were looking after the plant, and the company used external service providers for cleaning the plant from time to time. Since June 2017, the private company *Aguas de Ponta Preta* (APP) is providing certain operation and maintenance services to *Electra*.

¹ Source: MTIE, no date.



In January 2010 the government signed a concession agreement with *Electra* which specifies that the company will operate the Sal plant as well as the plant in Santiago for 20 years renewable. The contract foresees that the utility will only have to pay a symbolic concession fee of 1% of the »value« of the electricity delivered to the distribution system from the sixth year of operation onwards, and that it has to make payments into a maintenance fund which would be used to finance any necessary repairs and reinvestments. The payments into this fund should be 2.5% of the sales volume (*volumen de negócios*) during the first 10 years and 5% from year eleven onwards.

The amount of solar energy that was fed into the island grid varied over the years. 2013, the third year of operation was the

The extremely low production in 2012 is due to the fact that the plant was completely switched off for at least seven months during that year.³ This has to do with the commissioning of the *Cabeólica* wind farm in Sal in February 2012 (commercial operation date).

The weak performance of the plant may be explained by the fact that the plant was not handed over in an optimal condition, and that some of the technical problems that occurred early on were never resolved despite the fact that *Electra* and DGE had repeatedly requested the contractor to solve them. A representative of MTS was in the country during the first six months after commissioning of the Sal and Santiago solar PV plants, and MTS did address some but not all of the defects put forward by DGE and *Electra* during the 2-year warranty period. This included the

GENERATION OF THE SAL SOLAR PV PLANT

YEAR	GENERATION IN kWh	DIFFERENCE WITH REFERENCE YIELD IN %	MEASURED PERFORMANCE RATIO IN %	CAPACITY FACTOR IN %	SHARE IN SAL'S ELECTRICITY MIX IN %
2011	2,062,099	-43.6	39.5	10.6	6
2012	1,640,227	-51.8	32.4	8.4	6
2013	2,388,333	-31.8	46.4	12.2	6
2014	1,279,529	-62.9	24.9	6.5	2
2015	2,173,475	-28.7	44.9	11.1	4
2016	2,099,308	-30.9	43.3	10.7	4
TOTAL	11,642,971				

Source: Agência de Regulação Económica/own calculations

one with the highest generation. In that year the plant generated approx. 2.4 GWh and contributed 6% of the island's electricity mix. The table above shows how the generation, the capacity factor as well as the share of solar in the islands energy mix evolved between 2011 and 2016. It also compares the generation with the reference yield which was calculated for a plant with the same characteristics based on satellite irradiation data for the same site and years. The data shows that the plant's output was significantly below the reference yield since its commissioning, with 2014 being the year with the lowest generation (-63%). The capacity factor, which varied between 7% and 12%, was significantly below the average for solar PV systems in Africa of 22%.²

In 2016 *Electra* signed an agreement with the private company *Aguas de Ponta Preta* (APP) that operates among others a thermal power plant and a PV system on Sal. The agreement foresees that APP executes certain operation and maintenance tasks at the power plant (cleaning, provision of security guards etc.). The involvement of APP since September 2016 led to a significant increase of the plant's output in the last four months of 2016 which was 47% higher than in the same period during 2015.

occurrence of Potential Induced Degradation (PID)⁴ in a number of modules which was confirmed by an independent inspection conducted by *Instituto Tecnológico de Canarias* (ITC) on behalf of DGE in 2011. A re-inspection by the same institute two years later confirmed that the implementation of the measures undertaken by MTS to address the problem had been effective, so that the majority of affected modules had recovered.

Another explanation for the low performance of the plant is the strong effect of soiling which is related to the fact that Cabo Verde is an arid country and that there are strong concentrations of dust in the air, especially during the Harmattan period (October to June). The ITC study found that soiling accounted for a 17% reduction of the plant's output at the time of inspection in 2013. Frequent cleaning with water would increase the operation and maintenance (O&M) costs significantly, because desalinated water is the only freshwater available near the site.

² According to IRENA, the capacity factor of fixed tilt systems are typically between 10 and 25%, and the weighted average capacity factor for utility-scale PV projects in Africa is around 22% (IRENA 2015).

³ The production value for May 2012 is lower than the May value for other years, and no generation was recorded for the period June to December 2012.

⁴ PID is a reversible form of degradation of crystalline PV modules which is caused by so-called stray currents that can occur if the voltage of the individual PV modules to the ground is negative.

ECONOMIC AND FINANCIAL ANALYSIS

The plant was financed by the Government of Cabo Verde with funds from a soft loan provided by the Government of Portugal with a 20-year tenure, a 10-year grace period and an interest rate of 1.71%. The total investment cost excl. complementary investments in the thermal back-up generators and grid reinforcement was EUR 16,839,900.

The plant constituted a cheap source of generation for *Electra* and allowed them to save approx. EUR 3.96 million on fuel and wind power procured from *Cabeólica* during the period 2011 to 2015.⁵ This had a dampening effect on electricity prices, and — due to the reduced need for fossil fuel imports — on Cabo Verde's balance of payments (the country is suffering from a large trade deficit).

An analysis of the estimated cost of generation conducted during project preparation showed that the Levelized Cost of Electricity (LCOE) was just below the utility's cost of generation which was very high at the time. A new calculation of the LCOE based on the original CAPEX and an estimate of the reinvestment that would be required for restoring the full generation capacity resulted in a cost of EUR 0.14 per kWh. This compares favourably with the utility's cost of generation which stood at approx. EUR 0.20 per kWh in 2016.⁶

During the first six years of operation the utility only had to pay the cost of operation, there was no tariff for the generation of the power plant. If this situation continues, the general public will pay for the bulk of the costs associated with the project, and these will not be passed on to the consumers. The study conducted by ECREEE and GIZ recommends to refurbish the plant and change the concession agreement in a way that the government's revenue from the concession fee will be sufficient for covering at least a significant share of the debt service for repaying the loan. This would also be an occasion for integrating clear performance indicators and incentives in the contract which are currently lacking.

ENVIRONMENTAL BENEFITS

During the first five years of operation, the plant helped to avoid approx. 15,788 t CO₂ (3,736 t in the first year). This figure was calculated based on the UNFCCC-approved grid emission factor for Cabo Verde.⁷ The initial idea to register the two projects as Clean Development Mechanism (CDM) projects in order to generate revenue from the sale of Certified Emission Reductions (CER) was not pursued.⁸ Furthermore, the project also helped to avoid local emissions of nitrogen oxides (NO_x) and other pollutants that would have occurred if the utility had had to replace the plant's generation partly with generation from its thermal power plants.

CONCLUSIONS

The Sal Solar PV Project was one of the very first utility-scale solar PV projects in West Africa that demonstrated the feasibility of the technology in Cabo Verde and the region. The project, together with its sister project in Santiago and more importantly the *Cabeólica* wind parks, also contributed to an increase of the share of renewable energy in Cabo Verde's electricity mix from 1.3% in 2010 to 22% in 2013. This, in turn, strengthened the government's will to embark on an energy transition and set the target of 50% RE in the electricity mix by 2020 which was adopted in early 2012.⁹

The project has obvious benefits, but in order to maximize them, there is a need to refurbish the plant and improve its operation and maintenance. The planned unbundling of *Electra* into a generation company and a transmission and distribution company presents a window of opportunity for the government to discuss some of the provisions of the current concession contract for both PV plants and agree on a solution that is favourable for the government, the electricity companies and consumers.

⁵ The wind penetration rate in São Vicente in 2015 stood at 28% (Source: Cabeólica 2016). For further information on the Cabeólica project see the ECREEE Case Study »Cabeólica Wind Project, Cabo Verde« that is available at <http://www.ecreee.org/page/grid-connected-renewable-energy-flagship-projects>.

⁶ Source: Fonseca 2016.

⁷ Source: UNFCCC 2016.

⁸ At the time, the government estimated to be able to generate a total annual revenue of EUR 140,000 with the CERs of both plants which was based on a CER price of EUR 10 per ton of CO₂ emissions (MTIE, no date).

⁹ Source: GoCV 2010. This target was increased to 100% in 2015.



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