ECREEE
Towards Sustainable Energy

RE Flagship Projects in the ECOWAS Region

Case Study:
Santiago 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 Santiago Solar PV Project and its sister project on the island of Sal (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 two of 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	Praia, Santiago Island
Technology	Grid-connected solar PV power plant
Generation capacity	4.4 MWp
Developer	Government of Cabo Verde
Operator	Electra Sul (state-owned utility)
Commissioning	November 2010
Investment cost	EUR 16,839,900
Financing	Concessional loan

PROJECT **DEVELOPMENT**

The project development process for the Santiago Solar PV Project and its sister project in Sal 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 these projects 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 resident advisors working for 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. It was decided to locate the Santiago plant on public land close to *Electra's* main power station in Palmarejo at the outskirts of Praia.

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)

15. 04.
Laying of the foundation stone

02. 11.
Inauguration of Santiago 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 and handover of the plant

July:
CERMI took over operation and maintenance on behalf of 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 manufacturing PV modules and now part of the *French Voltalia group.*

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

The contract with MTS foresaw initially that the contractor would install a 5 MW plant for a total price of EUR 18.71 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 capacity to 4.4 MWp and the contract price to EUR 16.84 million, because the government was not in a position to mobilize its 10% share of the CAPEX that would have had to be paid directly by them to the contractor (the other payments were made by the Portuguese bank managing the credit line).

The plant consists of 19,512 polycrystalline modules (8,568 with a capacity of 225 Wp and 10,944 with a capacity of 230 Wp each) from *Martifer Solar*, seven central inverters from SMA and a fixed steel mounting structure with concrete foundations.

Construction started in April 2010 and was completed in October of the same year. The plant was officially inaugurated on 02.11.2010. At the time, it was the biggest solar PV plant in Africa.

[1] Source: MTIE, no date.

OPERATION

Upon completion of construction, the plant was handed over to the state-owned utility *Electra* SARL which in 2013 was split in two subsidiary companies for managing the electricity systems of the northern islands *(Electra Norte)* and of the southern islands *(Electra Sul).* Since then the Santiago plant has been managed by *Electra Sul.* Until mid-2015 there was one dedicated *Electra Sul* employee looking after the plant, and the company used external service providers for cleaning the plant from time to time.

In January 2010 the government signed a concession agreement with *Electra* which specifies that the company will operate the Santiago plant as well as the plant in Sal for 20 years with option for further extension. 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 *(volume de negócios)* during the first 10 years and 5% from year eleven onwards.

2011, the first full year of operation was the one with the highest generation. In that year the plant generated approx. 6.9 GWh and contributed almost 7% of the island's electricity mix. The capacity factor of 17.7% registered in 2011, which is fairly high for international standards, reflected the high solar irradiation in Cabo Verde.[2] The generation during the following five years was between 16% and 49% lower. The table above shows how the generation as well as the share of solar PV in the island's electricity mix evolved in the period 2011 to 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 acceptable in the first year but deteriorated continuously in the following years.

In 2017 *Electra* signed an agreement with the *Centre for Renewable Energy and Industrial Maintenance* (CERMI), that is located right next to the power plant, which foresees that CERMI will execute certain operation and maintenance tasks at the power plant. The agreement came into effect in July 2017.

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 Santiago and Sal 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 occurrence of Potential Induced Degradation (PID)[3] 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 for addressing 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 when the wind carries Saharan dust to Cabo Verde. 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, but the benefits in terms of additional generation would by far outweigh the additional cost.

GENERATION OF THE SANTIAGO SOLAR PV PLANT

YEAR	GENERATION IN kWh	DIFFERENCE WITH REFERENCE YIELD IN %	MEASURED PERFORMANCE RATIO IN %	CAPACITY FACTOR IN %	SHARE IN SANTIAGO'S ELECTRICITY MIX IN %
2011	6,893,418	–2.8	66.4	17.7	6.9
2012	5,823,494	–12.3	57.7	15.0	5.8
2013	4,864,504	–28.9	47.4	12.5	4.9
2014	5,366,988	–24.0	51.2	13.8	4.0
2015	4,033,699	–29.8	42.5	10.4	2.0
2016	3,496,244	–43.0	35.6	9.0	1.6
TOTAL	30,478,347				

Source: Agência de Regulação Económica/own calculations

[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). The capacity factor of the Santiago solar PV plant registered in 2015 was only 10.4%.

[3] 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.[4] 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.[5]

During the first six years of operation the utility only had to pay the cost of operation, it did not have to pay anything to the government in exchange for using the power plant. If this situation continues, the government will have to rely on the State budget to pay back the loan (principal and interest) and have no revenue from the concession fee to recover these costs. 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. 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 CO_2 (3,736 t in the first year). This figure was calculated based on the UNFCCC-approved grid emission factor for Cabo Verde.[6] 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.[7] Furthermore, the project also helped to avoid local emissions of nitrogen oxides (NOx) 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 Santiago 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 Sal 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.[8] In addition, the two solar PV projects in Santiago and Sal helped the government, the utility and other stakeholders to gain experience with the technology and build capacity that is proving to be valuable for the further deployment of renewables in the country.

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. Another option that is currently under discussion is to hand the Santiago solar PV plant over to CERMI who would operate it as an Independent Power Producer (IPP) and no longer as a subcontractor of *Electra.*

[4] 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 »Cabeolica Wind Project, Cabo Verde« that is available at http://www.ecreee.org/page/grid-connected-renewable-energy-flagship-projects.

[5] Source: Fonseca 2016. The source does not specify the exact period during which the generation costs were at this level.

[6] Source: UNFCCC 2016.

[7] At the time, the government estimated to be able to generate an annual revenue of EUR 140,000 which was based on a CER price of EUR 10 per ton of CO_2 emissions (MTIE, no date).

[8] Source: GoCV 2010. This target was increased to 100% in 2015.

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