RE Flagship Projects
in the ECOWAS Region

Case Study
CABEÓLICA WIND PROJECT
Cabo Verde

BACKGROUND

The Cabeólica Wind Project comprises four small, separate wind parks on four of Cabo Verde's nine inhabited islands. The parks have a combined generation capacity of 25.5 MW and were commissioned between December 2011 and July 2012.[1] They are discussed as one single case, because (i) they have been planned, financed and built jointly and (ii) they are all owned and operated by the public-private company *Cabeólica* SA which is registered in Cabo Verde and was founded specifically for this project under a Public-Private Partnership (PPP) between *InfraCo Africa Limited*, the Government of Cabo Verde and *Electra* SARL (the national power and water utility). *Cabeólica* has a license to operate as an independent power producer (IPP) and sell its generation to *Electra* under a 20-year Power Purchase Agreement (PPA).

The project's claim to fame has been its demonstration effect as a flagship project for renewable energy (RE) in the region which led to a significant jump of the RE share in Cabo Verde's electricity mix that stood at 21.4% in 2016. It has received numerous prestigious awards precisely for this role, shortly after construction of *Cabeólica's* first two wind parks had finished in 2011. Half a decade into operation, we have revisited the project to identify lessons that might be learned from it.

KEY FACTS

Sites	Monte São Filipe — Praia (Santiago) Lajedo da Ribeira do Tarrafe (Sal) Selada do Flamengo (São Vicente) Morro da Vigia — Ponta do Sol (Boa Vista)
Technology	Wind power
Generation capacity	25.5 MW (9.35 MW, 7.65 MW, 5.95 MW, 2.55 MW)
Developer	Cabeólica SA
Equipment and Service Provider	Vestas
Commissioning	September 2011 to July 2012
Investment cost	Approx. EUR 60.9 million
Financing	Equity and loans

[1] Santiago (9.35 MW), São Vicente (5.95 MW), Sal (7.65 MW) and Boa Vista (2.55 MW).

PROJECT **DEVELOPMENT**

The initiative to develop the Cabeólica project came from the Government of Cabo Verde who approached *InfraCo Africa,* a privately managed, donor-funded infrastructure development company that undertook the first project development activities in 2006. This was at a time when Cabo Verde suffered from high generation costs and a severe supply deficit leading to frequent blackouts in its capital Praia and other parts of the country. In this context, the Government of Cabo Verde was also keen to increase wind energy capacity which was identified as a cost-effective source of generation for the country.

When *InfraCo* developed the project, they could benefit from the experiences with a series of smaller wind power projects developed on different islands, including wind parks developed at or near the future Cabeólica sites on Santiago and São Vicente. At that time the government had made attempts to procure additional wind generation capacity, but did not succeed because of the low level of interest from potential suppliers.

Project development activities included wind measurements, a demand forecast (which proved to be too optimistic, except for the island Santiago), a dynamic grid analysis as well as an Environmental and Social Impact Assessment (ESIA)[2] according to international standards and negotiations of land lease agreements. In this process, the originally planned capacity of 28 MW was reduced to 25.5 MW upon adjustment of demand forecasts prior to project implementation. A major milestone was the agreement on a bankable PPA and on a Support Agreement with the government of Cabo Verde, both of which were signed in February 2010 (see also Economic and Financial Analysis below).

One of the main steps in the project development phase was the structuring of the project company. *InfraCo* agreed with the government represented by the Ministry of Energy (formerly MECC) that the government and the state-owned *Electra* SARL would participate as minority shareholders of the special purpose vehicle (SPV) *Cabeólica* SA which was established with initially three shareholders in 2009. The *Africa Finance Corporation* (AFC) as the main shareholder as well as the *Finnish Fund for Industrial Cooperation Ltd. (Finnfund)* joined *InfraCo* as equity partners in 2010, and long-term loans were signed with EIB and AFDB.[3] This resulted in the project structure shown in graph 1 which was valid until AFC reinforced its role as lead investor in the project through the acquisition of *InfraCo Africa's* shares that was completed in February 2016. *Cabeólica* also obtained a pre-approval for a political risk insurance from the World Bank's *Multilateral Investment Guarantee Agency* (MIGA) in the same year, but eventually the insurance was not taken, because the investors and lenders felt comfortable with the assurances included in the government support agreement (IRENA 2016). This agreement includes the obligation to deposit funds in an escrow account for mitigating the off-taker's liquidity risk as well as a put option, i. e. the possibility for *Cabeólica* to sell the project to the government at an agreed price in case the latter breaches its obligations.

[2] The ESIA had to fulfil the requirements of the relevant domestic legislation as well as of the multilateral development banks involved in the project. A summary of the assessment is available at https://www.afdb.org/fileadmin/uploads/afdb/Documents/Environmental-and-Social-Assessments/ESIA%20-%20Cabeolica%20Wind%20Farm%20Projectt%20-%2018.03.2010%20EV.pdf

[3] According to IRENA (2016) and Brown (2017) the terms of both loans are as follows: 14 years tenure, 2 years grace period, interest rate approx. 7%.

PROJECT MILESTONES

2006
First project development activities undertaken by InfraCo Africa

2009
Establishment of the special purpose vehicle (SPV) Cabeólica SA

Signature of preliminary EPC contract with Vestas on 22.12.

2010
Signature of PPA and Support Agreement on 26.02.

Equity financial close reached in August

Loan documents with European Investment Bank (EIB) and African Development Bank (AFDB) signed in December

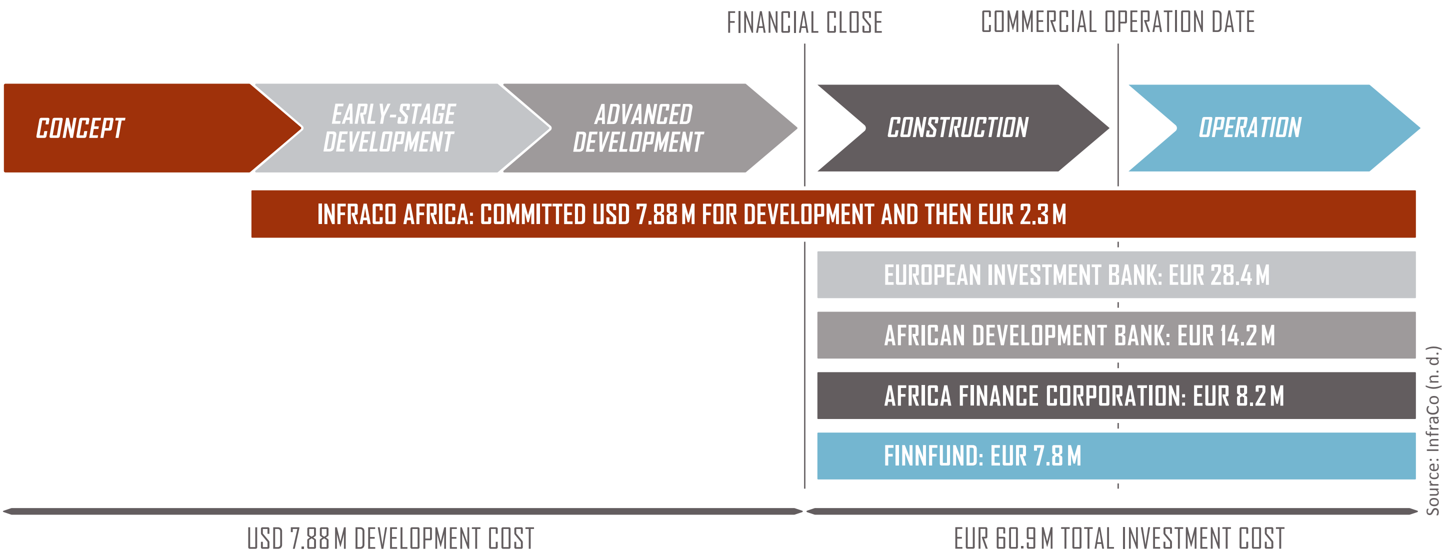
2011 2012
Start of construction at the beginning of 2011

Gradual commissioning between September 2011 (Santiago and São Vicente) and July 2012 (Boa Vista)

2013 2015
Registration as CDM project received in January 2013, sale of first certified emission reductions (CER) in 2015

2016
Sale of InfraCo Africa's shares to AFC completed in February

Graph 1: Project structure until February 2016



PROCUREMENT AND CONSTRUCTION

The Danish turbine manufacturer *Vestas* was chosen as the Engineering, Procurement and Construction (EPC) contractor through an international tender, and the respective contract was signed in December 2009. Logistical constraints in terms of road access and port facilities played a role in the selection of the turbines (Vestas V52-850kW at all sites) which are very small for today's industry standards.

Construction of the first two wind parks started in January 2011. The contractors had to import appropriate trucks and cranes to transport and erect the turbines, which have a hub height of 55 m, and bring in specialized work force.

Given the size and complexity of the project and the context within which it was realized, the project development process from the developer's first visits in Cabo Verde in 2006 to commissioning of the last wind park in July 2012 can be regarded as very short.

OPERATION

The contract with *Vestas* included a Service Agreement for the first five years in which they guaranteed an availability of 95%. The agreement was recently extended for the next seven years.

Electra and *Aguas e Energia da Boa Vista* (AEB)[4] have access to *Cabeólica's* remote SCADA system to control the output of the wind parks. This involves sometimes heavy curtailment to ensure grid stability by avoiding wind penetration levels above 50% which is practiced during periods of high wind speeds and low demand. However, in reality the penetration level goes often above that value without leading to technical problems in the grid. *Electra* and AEB make use of wind power generation forecasts provided by *Cabeólica* for dispatch planning and for the operation of the thermal power plants. This is done by adjusting the upper limit of the output of the respective wind farm (set point) on an hourly basis as well as in emergency situations. While the off-takers adopted initially a highly conservative approach, it was possible to increase the wind penetration rate through continued dialogue and information transfer between *Cabeólica* and *Electra*/AEB as well as training of the dispatchers. *Cabeólica* observed a human factor in the way that the wind power production is being dispatched, because of the important role of the thermal power plant operators[5] in regulating the output of the wind farms.

Graph 2 shows the actual generation as well as the amount of energy that could have been generated in the period 2012–2016. It can be seen that large amounts of energy are lost due to curtailment — up to 28% in certain years.[6] This is due to several factors that are discussed below. Despite the curtailment, all four have capacity factors that meet international standards, reflecting the excellent wind regimes in Santiago (39%), São Vicente (35%), Sal (26%) and Boa Vista (35%).[7] In the absence of curtailment, the wind farm in São Vicente could even reach a capacity factor of 56%.[8]

On average *Cabeólica* contributed approx. 22% to the electricity supply of Cabo Verde between 2012 and 2016, but depending on the island and the year, they were responsible for average annual wind penetration rates of up to 35% (see table 1). The highest monthly penetration rate experienced so far was registered in Sal (55%).[9]

Graph 3 shows the seasonality of the wind parks' output during the same period which is significantly lower between July and October.

Graph 2: Potential and actual power generation by Cabeólica 2012–2016

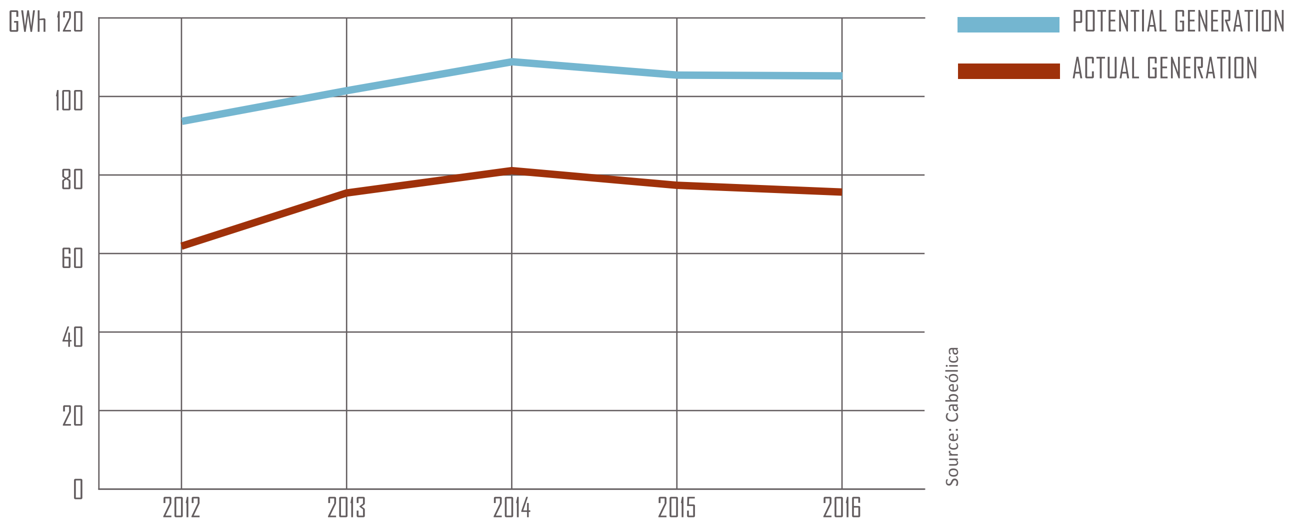


Table 1: Average annual wind penetration rates per island in %[10]

YEAR	SANTIAGO	SAL	S. VICENTE	BOA VISTA
2012	17	29	30	22
2013	17	31	32	23
2014	17	31	35	29
2015	16	33	28	27
2016	15	31	25	27

Source: Cabeólica annual reports

4 AEB is the subconcessionaire managing the electric grid in Boa Vista.

5 In the absence of a dispatch centre, the thermal power plant operators serve de facto as the dispatchers. This is expected to change in the near future.

6 This is the percentage registered in 2016 (own calculation based on data provided by Cabeólica).

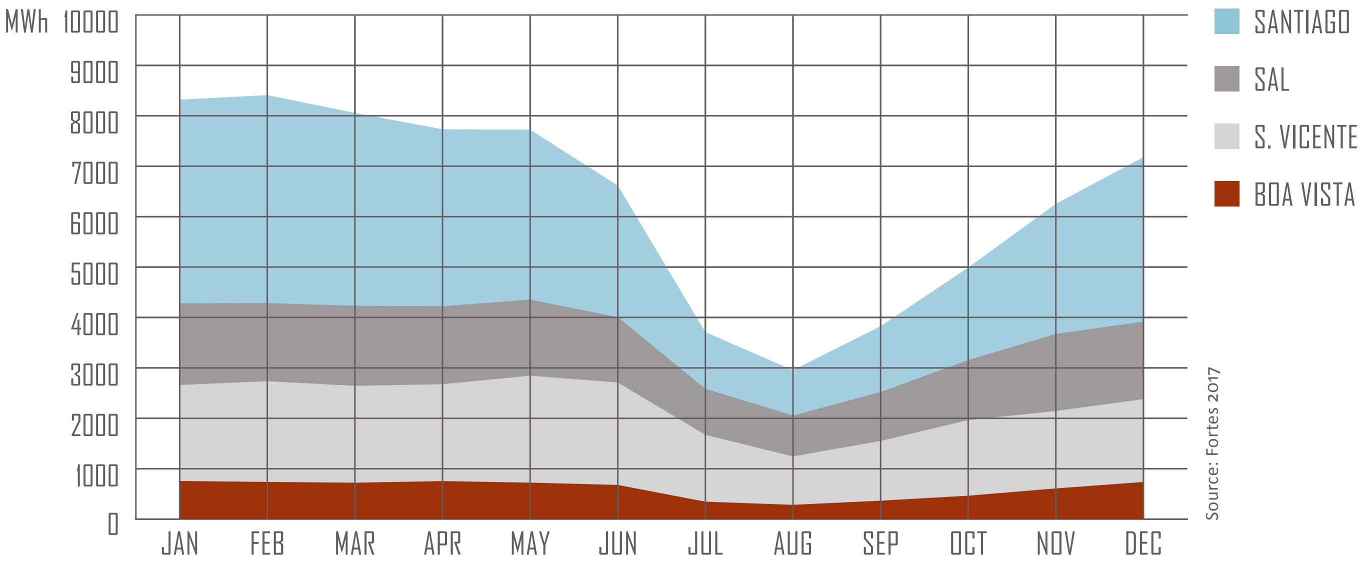
7 These were the capacity factors in 2016 (source: Evora 2017).

8 Analysis conducted by Evora (2017) based on data for 2016.

9 The monthly average generation in Sal reached 55% in January 2015 (Cabeólica Annual Report 2015).

10 The wind parks in Sal and Boa Vista only started operations in February and July 2012, respectively.

Graph 3: Seasonality of power generation



ECONOMIC AND FINANCIAL ANALYSIS

According to *Cabeólica* and its shareholders, the CAPEX for the project was approx. EUR 60.9 million.[11] In addition to that, *InfraCo* has reportedly spent USD 7.88 million on project development, part of which was sponsored by grants.[12]

The PPA includes three tariff levels nominated in the local currency which is pegged to the Euro. The first level (base price) applies to the amounts of energy per wind park and month that *Electra* is obliged to buy, whether they are generated and dispatched or not *(take or pay)*. These amounts in kWh are specified in the PPA. The other two tiers, which are significantly lower, are only used for any additional amount of energy that is produced and fed into the grid. Since the amount of energy procured by *Electra* varies over the years, the effective average tariff also varies depending on the extent to which they exceed the amount of energy that is charged at the take-or-pay tariff in the respective year.

The amount of energy that is actually produced and consumed is lower than it was expected to be due to the lower-than-expected demand growth and the decline of the oil price which makes it financially more attractive for *Electra* to generate its own electricity when the oil price is very low. However, *Cabeólica's* average tariff was always below *Electra's* variable generation costs until January 2015.[13] This means that *Electra* and the general public benefitted from lower generation costs during most of the first five years of operation. Even at times when the *Cabeólica* tariff is higher than *Electra's* cost of production, Cabo Verde benefitted from FOREX savings because of avoided fuel imports and the reduced need to have FOREX reserves for those imports.

JOB CREATION — The Cabeólica project generated 15 permanent jobs (ten at *Cabeólica* SA and five at *Vestas* CV Lda.), all of which are held by Cabo Verdeans. This includes one site manager for each of the wind parks on the *Cabeólica* side as well as five working for *Vestas*. During the construction phase, approx. 80 people were employed by the various contractors.

[11] Some other sources mention different amounts.

[12] InfraCo (n. d.). This includes among others a USD 170,000 grant from the PIDG Technical Assistance Facility for wind resource assessment and technical engineering studies (PIDG, n. d.).

[13] Electra also reduced its thermal generation costs by investing in new power plants and increased use of fuel oil 180 and 380 in recent years.

ENVIRONMENTAL **BENEFITS** AND CARBON **CREDITS**

The avoided thermal power generation helped to save about 15 million liters of fuel and curb roughly an average of 55,000 tons of CO_2 annually.[14] Since April 2013 *Cabeólica* SA is earning Certified Emission Reductions (CER) for the avoided greenhouse gas emissions, but it took them approx. four years to register the project as a Clean Development Mechanism (CDM) project. The respective documentation incl. the annual monitoring reports are available on the website of the secretariat of the UN Framework Convention on Climate Change (UNFCCC).[15] The initial crediting period is seven years, but *Cabeólica* has the possibility to re-register the project for up to two additional crediting periods of the same duration based on updated documentation.

[14] Source: Cabeólica.

[15] https://cdm.unfccc.int/Projects/DB/RWTUV1359635253.96/view

DISCUSSION

The main strength of the project lies in its demonstration effects which in turn rest on an impressive number of firsts it has achieved in a single stroke: it was at once (i) the first utility-scale wind project in the region, (ii) the first public-private partnership (PPP) for non-hydro RE in sub-Saharan Africa, (iii) the first emerging market project which dared push a country without significant hydropower generation (and without cross-border export options) to a high level of RE penetration in the electricity mix and (iv) the first registered CDM project in Cabo Verde.

TECHNOLOGY — While wind power was mature well before 2010, not many wind farms had been installed in developing countries by then — let alone in Africa. Therefore, the »classic« technology demonstration effect of the project was relevant by itself: it has helped to convince policy makers, investors and utilities across the region that wind generation (i) works at utility scale, (ii) can be installed in relatively short time spans (compared to large thermal power plants), and — most notably — (iii) can be dispatched without compromising system stability even at high penetration rates.

The latter is of paramount importance regarding the technology demonstration effect: Before 2010, most developing countries considered renewable energy shares above 5% a major technology risk on system level. While pioneer countries such as Denmark, Germany and Spain had reached higher rates by then (but still less than the daring island-level wind shares of 30–35% reached by two of the four islands), the argument against variable RE in emerging markets was unanimous: their weaker grids and dispatch strategies did not allow similar levels. Only five years later, many developing countries have followed suit — formally enacting national RE targets of 20% or more by 2030. Some — including Cabo Verde — are even going further and targeting up to 100% RE-based power generation. While this is due to various reasons that cannot be laid out in this present report, the beacon example of Cabeólica — along with a few other island states — has undoubtedly contributed to the development of a more optimistic attitude towards high shares of renewables in the electricity mix.

ECONOMICS — On the downside, the wind parks generate much less than they could due to significant curtailment — especially on Sal island, where the actual output of the wind park was 47% below its potential output in 2016 (source: Evora 2017). As discussed earlier, this is mainly an effect of the tariff structure of the PPA, which makes that *Electra* often only buys the amounts it is obliged to buy, when the oil price is low. However, the curtailment is also due to the fact that the wind farm in Sal was dimensioned for a system with a significantly higher demand (in view of the growth of the tourism industry which did not develop as fast as expected) and due to a lack of demand side management (DSM) strategies in the island's power system. There seems to be a good potential for DSM in the desalination of water, because at least one of the two desalination plants on the island could be used as a flexible load.[16]

Another option would be to install storage systems which is under discussion since some time and is becoming financially more viable with the reduction of the price for Li-ion batteries. Furthermore, electricity demand is expected to rise significantly with the continuing increase of tourist numbers and the commissioning of new larger hotels on Sal and Boa Vista.

FINANCE — The project's financial aspects are its stronger side, especially when its timing, technology, emerging market aspects and the project environment are considered. Indeed, when the project was developed, it was one of the first RE projects in Subsaharan Africa financed with non-recourse loans (mature project financing based on expected free cash flow) despite the fact that the country had a fairly high risk rating at that time. The project, with its 70:30 debt to equity ratio, was structured in a way that it attracted commercial investors with moderate return on equity expectations. The fact that all project agreements were signed and that the project reached financial close within a year is a strong indication that the conditions agreed upon successfully addressed all the concerns of the lenders and investors and were also acceptable to their Cabo Verdean partners. However, the risks of the project seem to be distributed in a way that is favourable for the investors, because important risks such as the off-taker risk and the currency risks were mitigated.

POLICY — We have already discussed the successful demonstration of record-high national RE shares on global level. However, regarding national level, it should be noted that no significant additional wind projects have been implemented in Cabo Verde following the Cabeólica example. This is mainly due to the very success of the project. *Cabeólica* has led to significant shares of wind generation in the four islands with the highest demand in one large leap, so that — under current conditions — no additional large variable renewable energy (VRE) generation projects can be implemented. This situation is only expected to change with growing demand and once the country has started implementing a strategy for reaching higher shares of VRE in the electricity mix. On the one hand, this suggests that the size of future RE projects with a strong demonstration or market development impetus should be limited to levels well below the total national market potential, in order to allow replication by the private sector. On the other hand, small countries and islands may need to »think big« in order to achieve (i) project sizes that can attract the interest of private investors and development banks and (ii) a visible effect on local markets. Furthermore, the replication benefits (which limit project market share) have to be weighed against economies of scale (which increase optimal project size) and the immediate project benefits such as saved fuel. Overall, the Cabeólica project can be considered as a mutually beneficial project for the investors and Cabo Verde which had a strong demonstration effect in the country and beyond.

[16] This is discussed for the island of Sal in IRENA (2017).

SOURCES

Borba, Fabio (2011): Wind Power Comes to Cape Verde. In: International Sustainable Energy Review, Volume 5, Issue 4. http://eleqtra.com/wordpress/wp-content/uploads/2013/03/ISER_4_2011.pdf

Brown, Philippe (2017): EIB presentation held at Cabeólica's 5th anniversary in Praia, Cabo Verde on 31.03.2017.

Cabeólica (2014): Factbook 2013. http://cabeolica.com/site1/docs/Factbook201321Out.pdf

Cabeólica (2015): Annual Report 2014. http://cabeolica.com/site1/docs/Cabeolica-AnnualReport2014-ENG-site.pdf

Cabeólica (2016): Annual Report 2015. http://cabeolica.com/site1/docs/Annual%20Report%202015%20-%20website.pdf

Evora, Rito (2017): Smart grids in Cabo Verde: Potential, Opportunities and Challenges. Presentation held at CERMI in Praia, Cabo Verde on 09.05.2017 (in Portuguese).

Fortes (2017): PPP Model — Cabeólica's Contribution to Cabo Verde's Renewable Energy Targets. Presentation held at Cabeólica's 5th anniversary in Praia, Cabo Verde on 31.03.2017 (in Portuguese).

InfraCo Africa (n. d.): Cabeólica — Powering a sustainable future for Cape Verde. http://www.infracoafrica.com/project/cabeolica/

IRENA (2016): Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance. https://www.irena.org/DocumentDownloads/Publications/IRENA_Risk_Mitigation_and_Structured_Finance_2016.pdf

IRENA (2017): Technology Options for Renewable Desalination in Cabo Verde. Draft report written by Fraunhofer Institute for Solar Energy systems (ISE).

Monteiro, Ana (2012): The Cabeólica Project. In: Vilar (ed.), Renewable Energy in West Africa: Status, Experiences and Trends. http://www.ecreee.org/sites/default/files/renewable_energy_in_west_africa_0.pdf

PIDG — Private Infrastructure Development Group (n. d.): Green Energy Generates a Brighter Future — Cabeólica Wind Farms, Cape Verde. http://www.pidg.org/resource-library/case-studies/pidg-case-study-cabeolica.pdf

ECREEE would like to thank the staff of Cabeólica SA as well as all other interview partners for their time and efforts that made this publication possible.

IMPRINT

Published in November 2017 by
ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)
Achada Santo Antonio
C. P. 288
Praia, Cabo Verde
www.ecreee.org

With support from

cooperation germany – ecowas
ZUSAMMENARBEIT DEUTSCHLAND – ECOWAS

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Authors:
Kilian Reiche (iiDevelopment), Georg Hille (iiDevelopment), Lucius Mayer-Tasch (GIZ), Mohamed Youba Sokona (GIZ) and Eder Semedo (ECREEE).

Photos:
Cabeólica SA.

Graphic design: Anne Mayer-Tasch / amt tipografia design gráfico