Galapagos San Cristóbal Island Wind Project 2003-2016

Performance summary and recommendations for enhancing Ecuador's longest-operating wind project

Global Sustainable Electricity Partnership

Project Highlights

The Global Sustainable Electricity Partnership Galapagos San Cristóbal Island Wind Project, operating since October 1, 2007 by EOLICSA, the Galapagos Wind Company is:

- The first large-scale wind project in Ecuador (three 800 kW turbines for a total installed capacity of 2,400 kW) that has cumulatively provided more than 26 million kWh of energy to San Cristóbal consumers.
- Ending its eighth year of operation, after a five year development and construction phase costing $10 million.
- Reliably generating electricity available 92% of the time with little downtime for repairs and maintenance.
- One of the world's largest wind-diesel hybrid systems, annually supplying approximately 30% of the Island's electric needs through wind power, reducing diesel consumption by a cumulative total of 2.3 million gallons and avoiding CO_2 emissions by a cumulative total of 21,000 tonnes and reducing risk of a fuel spill.
- Increasing the hatching and reproduction rates of the endangered indigenous Galapagos petrel through the Environmental Management Plan and zero mortalities and injuries from turbine operation according to very frequent monitoring of the wind farm area and bird nests.
- Registered under the Kyoto Protocol's Clean Development Mechanism yielding approximately 11,000 Certified and Verified Emission Reduction certificates worth approximately 110,000 US dollars purchased on the international market.
- Financially stable and sustainable with total revenue of $3.4 million for the eight years under a Power Purchase Agreement with ELECGALÁPAGOS S.A., the local utility company, to cover operation and maintenance costs, after innovative capital investments from UN agencies (UNF and UNDP), Ecuadorian taxpayer donations, the Government of Ecuador and Global Sustainable Electricity Partnership companies.
- A destination for tourists visiting this UNESCO World Heritage Site.
- The recipient of Power Engineering Magazine, World Energy Forum, and Energy Globe awards.
- Complemented by two, 6 kW solar PV systems that have produced 136,000 kWh of electricity.
- To be owned by ELECGALÁPAGOS S.A. beginning in 2016 in accordance with Trust Contract conditions, and for that purpose ELECGALÁPAGOS S.A. staff has been trained in order to take full responsibility of the administration, operation and maintenance of the wind farm and associated facilities.
- Being replicated while all stakeholders fully appreciate the benefits it is providing to the Galapagos Islands, Ecuador, South America and the world, the Global Sustainable Electricity Partnership members AEP, RWE and Enel believe that these benefits can be increased and have provided recommendations to the new owner in this report on how they could be achieved.
- This report and two earlier 2007 and 2013 reports and video of the project's development and construction phases are available in English and Spanish, posted at www.globalelectricity.org/galapagos.

Why this project was undertaken

Displacing all of the diesel electricity generation with renewable energy on all four of the inhabited Galapagos Islands was a plan developed by the United Nations and the Republic of Ecuador in the 1990s. The UN Development Programme had been seeking private sector partners to implement the plan and in 2001 asked the Global Sustainable Electricity Partnership (GSEP, formerly the "e8", a non-profit organization supported by 11 of the world's largest electric utilities from 10 countries: USA, Brazil, France, Italy, Canada, Russia, Japan, Germany, Spain and China) to lead it, after the Jessica Tanker Ship spilled approximately 150,000 gallons of fuel oil and diesel that it was delivering to the islands in January that year. GSEP, with its mission to promote sustainable energy development through building electricity sector projects hand in hand with local utility companies, pledged to meet the UN's goals to reduce the risk of diesel spills by displacing diesel fuel use, and reduce greenhouse gas emissions with renewable resources on San Cristóbal Island. GSEP transparently shared all of its work and solutions to engineering, environmental, financing, and other challenges throughout the project's development and construction phases to make it easy for other UN partners to replicate it on other islands, Ecuador and other places in the world. The UN has found other partners to continue the renewable electrification on the Islands.

Note to readers: This report is the Global Sustainable Electricity Partnership's (GSEP) summary of the performance of the Galapagos San Cristóbal Island Wind Project for the years 2003 to 2016 and summary optimization recommendations for enhancing the Project. It was prepared to assist the local electricity utility company ELECGALÁPAGOS S.A. as it becomes the new Project owner in 2016. Many more details about the Project since its inception in 2003, and its design, construction operation and maintenance and the economic and engineering analyses that support the optimization options are located on the GSEP website at www.globalelectricity.org/galapagos.

Persons who can be contacted about the Project and this report include:

- **EOLICSA:** Luis C. Vintimilla (luis.vintimilla@cablemodem.com.ec)
- **American Electric Power:** Paul Loeffelman (phloeffelman@aep.com)
- **RWE AG:** Dr. Peter Engelhard (Peter.Engelhard@rwe.com)
- **Enel:** Fabrizio Bonemazzi (fabrizio.bonemazzi@enel.com)

Message from the Minister of Electricty and Renewable Energy

The Ministry of Electricity and Renewable Energy is making sure that there is abundant, affordable, reliable, and clean electricity for Ecuador's homes, industries, and commercial power users today and well into the future on the basis of a methodical and orderly use of the abundant natural resources that our country has been blessed, within a framework of absolute respect for people and the environment. In this context, the San Cristóbal Island Wind Project has become an internationally known flagship project for its location within a natural heritage such as the Galapagos Islands and because after eight years of successful operation, it has managed to reduce in a high percentage the use of diesel fuel in electricity generation, with great benefits for the fragile island ecosystem. This project has been a national pioneer in the use of wind resources and has served as a reference for the development of similar projects both in the Galapagos Islands and in the mainland Ecuador.

More than a decade ago, the group Global Sustainable Electricity Partnership (GSEP) began its efforts in Ecuador to support the development of this project and after this period it has demonstrated that it is possible to successfully carry out joint actions between the government and private sectors and community. On this basis and with great enthusiasm, we are working to reach the goal of making the Galapagos a fossil fuels-free territory within a short term.

The Ecuadorian government, through the Ministry of Electricity and Renewable Energy, welcomes the first eight years of operation of the San Cristóbal Island Wind Project and commits its full support in continuing their achievements at the transfer of ownership and operation and management responsibility to ELECGALÁPAGOS S.A.

Dr. Esteban Albornoz Vintimilla
Minister of Electricity and Renewable Energy


Made
ELECGALAPAGOS S.A.
Solar-Eólico
e8

Message from American Electric Power

Although thousands of miles separate ELECGALÁPAGOS S.A. and AEP service territories, both of our companies are transforming to better meet our customers' needs. We are taking remarkably similar steps to spur innovation and integrate new technologies to ensure we can produce and deliver affordable, reliable and cleaner power that meets the expectations of our customers and regulators.

ELECGALÁPAGOS S.A.'s renewable generation portfolio is growing, and the company has incorporated innovative technologies like wind turbines that start generating power at very low wind speeds compared to conventional units. The company now has computerized interfaces between its diesel generators and the turbines to economically and reliably optimize the wind generation as it moves to achieve Ecuador's Zero Fossil Fuel use goal. We worked together to ensure that ELECGALÁPAGOS S.A.'s transmission grid is delivering this power as efficiently as possible. Under the leadership of the Ministry of Electricity and Renewable Energy, ELECGALÁPAGOS S.A. is improving its customers' end-use efficiency and the affordability of power by adding high efficiency refrigerators and induction stoves in the community.

AEP is following a parallel path, redefining our 110-year-old business model and developing the solutions and technologies our customers want. We are increasing our renewable generation fleet and have plans to more than triple AEP's renewable capacity by 2033. We'll build wind and solar projects ourselves or buy renewable energy through power purchase agreements like the one between ELECGALÁPAGOS S.A. and EOLICSA , the San Cristóbal, Galapagos Wind Company jointly owned by the Global Sustainable Electricity Partnership (GSEP) and ELECGALÁPAGOS S.A. We are increasing the efficiency of our distribution grid with Volt/Var optimization technology. Likewise, our new Breakthrough Overhead Line Design (BOLD™) transmission lines improve efficiency by delivering up to 60 percent more power in a smaller right of way. We also are helping our customers become more energy efficient with smart technologies that enable a two-way flow of both energy and data.

Both of our companies are transforming our cultures to continuously innovate, make smart informed decisions, take advantage of new tools and advanced technologies, and use resources in the most effective, efficient, safe and environmentally protective ways. By leveraging public-private partnerships and committing to continuous improvement, ELECGALÁPAGOS S.A. has become a role model for utilities in transition around the world. On behalf of AEP and the members of GSEP, please accept our congratulations for the transformation of ELECGALÁPAGOS S.A. We appreciate and applaud all of the public policy makers and other stakeholders that contributed to the success of the Galapagos Wind Project.

Nicholas K. Akins,
Chairman, President and CEO,
American Electric Power

Message from the Chairman of RWE

The energy industry is undergoing fundamental change all over the world. Climate action and decarbonization, renewables and more sustainability, the innovative powers of digital technology - these are megatrends thoroughly reshaping the entire energy business. Like with many big changes, the origins of such megatrends may be traced back to early beginnings and pioneering adopters. More than two decades ago, the Global Sustainable Electricity Partnership was among the pioneer organizations in taking concrete actions towards better access for people in many developing countries to clean and reliable electricity. This has been commensurate with the GSEP companies' track record for innovation leadership in the energy sector and corporate citizenship. RWE has been developing renewable technology since the 1970s, embarked on massive investment in clean energy of various sources since the early 2000s and is currently transforming itself into a leading green and digital utility of the future.

The San Cristóbal Island wind power project is among GSEP's flagship projects. Since it started back in 2003, the project has been an internationally recognized example for bringing sustainable power supplies to a community located in a particularly challenging environment. The Galapagos Islands are a highly sensible habitat for a vast number of unique endemic species and recognized as a World Natural Heritage.

RWE is proud of partnering in a project of unquestioned success, not least due to the dedicated leadership of AEP as well as prudent management of EOLISCA, the local operator. There are promising prospects for further development under the ELECGALÁPAGOS's aegis. Hence, RWE is particularly happy to contribute respective analytic insights to this final report highlighting – apart from wind power – solar PV and advanced storage technology. In any case, the San Cristóbal Island project has briskly demonstrated that public-private partnerships based on mutual trust and cooperation among all stakeholders are a key factor for enabling universal access to sustainable energy. RWE is proud to be part of the San Cristóbal Island success story.

Peter Terium,
CEO, RWE AG

Message from ELECGALÁPAGOS S.A. Executive President

We, the staff of ELECGALÁPAGOS S.A. are aware of the responsibility from now owning, operating and maintaining the San Cristóbal Island Wind Project, one of most important wind-diesel hybrid electricity generating systems at local, national and international level, which has more than eight years of successful operation for the benefit of the Galapagos Islands community and in particular San Cristóbal Island. From the beginning of the project, our technical staff has been working and training in joint management with EOLICSA, and has been imbued with a culture of teamwork, with innovation and enthusiasm, and particularly with a deep commitment to respect and protect the environment, which allows us to say with certainty that we will face this new challenge with absolute solvency, as has been usual in ELECGALÁPAGOS S.A.

Our team shall continue working in the implementation of current and future renewable energy projects in the Galapagos Islands, within the frame of the government initiative to convert the Galapagos into a "Zero Fossils Fuel" territory, taking advantage of the optimal experience that has been accumulated during the operation of the San Cristóbal Island Wind Project, as the basis to generate a synergic process in the development of similar projects in and out Ecuador.

In assuming this responsibility, ELECGALÁPAGOS S.A. takes this opportunity to thank and congratulate the Global Sustainable Electricity Partnership (GSEP), as well as the General Manager and staff of EOLICSA for the important contribution they have given to the Galapagos Islands through this project, and we are confident that it will be a replicable experience oriented to build a more sustainable world to the future generations.

Ing. Marco Salao Bravo
ELECGALÁPAGOS S.A. Executive President

Message from EOLICSA General Manager

The General Manager and staff of Eólica San Cristóbal S.A. - EOLICSA are very pleased for achieving the proposed goals during more than eight years of operation of the San Cristóbal Island Wind Project. The project objectives have been fulfilled, mainly by reducing the fossil fuel consumption in the Galapagos Islands. Since the project started its operation in October 2007, until December 2015, more than 26 million kWh of clean energy have been produced, equivalent to 30% of the San Cristóbal Island demand. This equates to 2.3 million gallons of diesel that have not been transported and burned and the equivalent of 21,000 tons of CO_2 was not emitted into the atmosphere. Those are very important achievements in favor of the fragile ecosystem of the Galapagos Islands, a UNESCO World Heritage Centre.

One of our priorities is the strict compliance of the Environmental Management Plan approved by the Ministry of Environment and CONELEC (currently ARCONEL). This plan focuses on the preservation of the endangered bird, the Galapagos petrel, for which EOLICSA received the permanent support of the Galapagos National Park. The results are outstanding, since after more than eight years of operation no petrels have been injured because of the wind turbines.

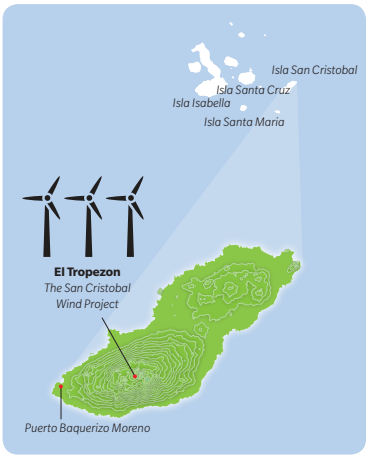
The staff of ELECGALÁPAGOS S.A. are closely involved with EOLICSA staff and are trained in the operation and maintenance of the project facilities. It ensures the existence of a highly qualified professional team to take over the operation of this project and other renewable energy facilities on the Galapagos Islands.

At the transfer of EOLICSA ownership to ELECGALÁPAGOS S.A., we wish great success to the new owner and at the end of this important period facing the leadership of the project, we take this opportunity to thank the public and private agencies and companies and, in particular, the community of San Cristóbal Island for the permanent and unconditional support received from them.

Ing. Luis C. Vintimilla C.
General Manager
Eólica San Cristobal S.A. – EOLICSA

INTRODUCTION

The main objective of the San Cristóbal Island Wind Project is to replace the electricity generation system, based on burning diesel, with a clean energy source. The project was developed within the framework of the cooperation agreement signed between the Government of the Republic of Ecuador and Global Sustainable Electricity Partnership (GSEP , formerly "e8"), as a part of the overall re-electrification of the Galapagos Islands with renewable energy led by the Ministry of Electricity and Renewable Energy (MEER). In addition, the project is a component of the "Regional Plan for the Conservation and Sustainable Development of Galapagos" approved by the Governing Council of Galapagos (Consejo de Gobierno de Galapagos – previously known as INGALA).



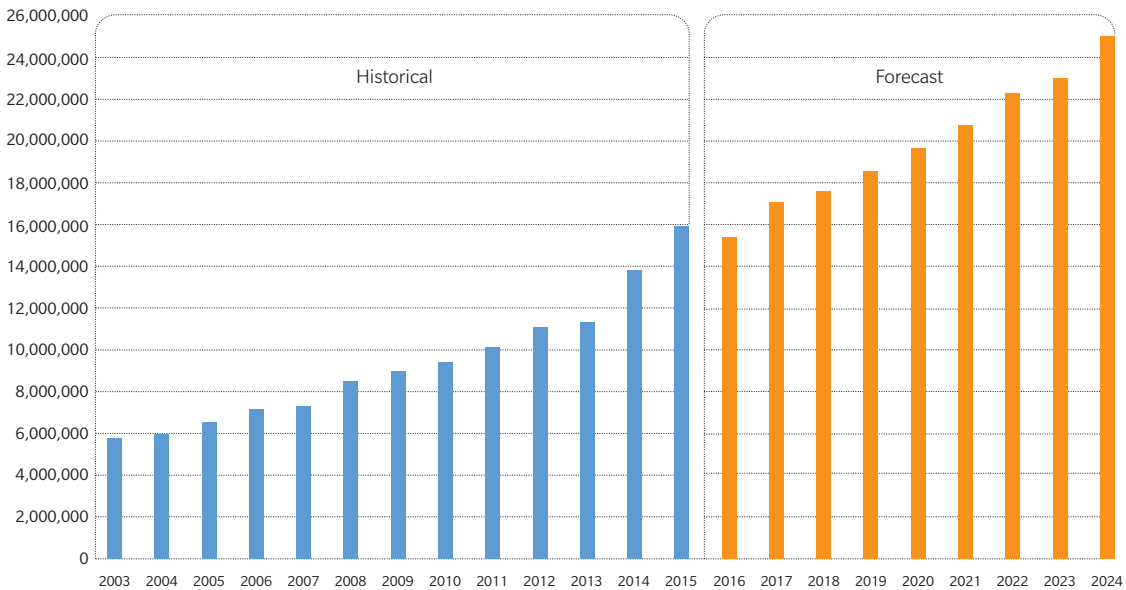
The project, with an estimated cost of 10 million USD, was funded primarily through a grant of funds from member companies of GSEP and additional contributions from the United Nations Foundation (UNF), voluntary donations from income tax, and FERUM funds (Rural and Urban Marginal Electrification Fund) through ELECGALÁPAGOS S.A. (the local public utility). To address these contributions, the San Cristóbal Wind Project Commercial Trust was created, with the companies AEP and RWE (GSEP members), as "settlors" and ELECGALÁPAGOS S.A. as adherent and sole beneficiary of the Trust. The Trustee is FIDEVAL (formerly Fondos Pichincha).

As required by the Electric Law, the Independent Power Producer company Eólica San Cristóbal S.A. – EOLICSA was created, owned by the Trust and ELECGALÁPAGOS S.A. EOLICSA is the owner and operator of the Project.

From 2003, the initial year when the Memorandum of Understanding (MOU) for the development of the San Cristóbal Island Wind Project was signed between the Government of Ecuador and the GSEP (formerly "e8") until 2015, the electricity demand on San Cristóbal Island has increased 275%, as shown in the next chart and graph. ELECGALÁPAGOS S.A. forecasts this increase to continue as shown for the years 2016 to 2024

Year	Demand (kWh)
2003	5,763,414
2004	5,970,261
2005	6,546,056
2006	7,170,788
2007	7,322,207
2008	8,513,512
2009	8,966,488
2010	9,388,824
2011	10,129,466
2012	11,085,208
2013	11,300,060
2014	13,807,990
2015	15,822,180
2016	15,533,524
2017	16,626,943
2018	17,456,528
2019	18,539,405
2020	19,688,244
2021	20,906,964
2022	22,199,712
2023	23,570,871
2024	25,025,074

San Cristóbal Demand (kWh)



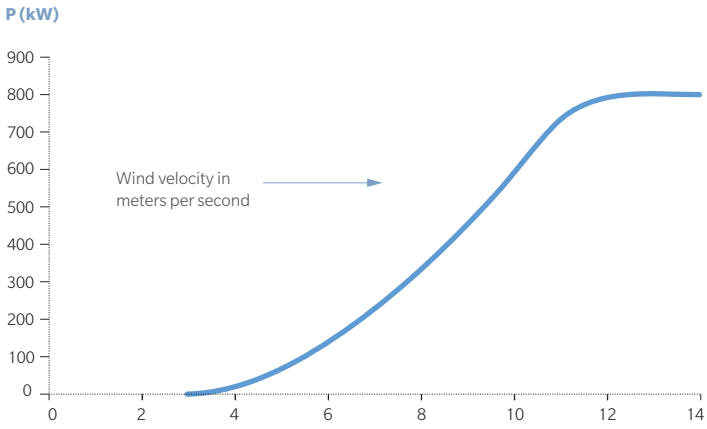
DESCRIPTION OF FACILITIES

Wind Park

The wind park is located on El Tropezón hill, San Cristóbal Island. It is composed of three wind turbines, 800 kW each, AE-59 model, manufactured by the Spanish company MADE, TECNOLOGÍAS RENOVABLES S.A. (currently GAMESA group). The total capacity is 2,400 kW. The towers are 51.5 meters high and the blades have a diameter of 59 meters. Each unit is equipped with a step up transformer, inverter, cables, auxiliary equipment and supplementary materials. The turbines and surrounding area are visible in satellite images at. https://goo.gl/maps/g3VLzoSWSHB2.

The machine design is appropriate to take advantage of the best wind conditions in the area. The units are variable speed, with synchronous generator and power inverters.

Wind Generator Power Curve



The wind turbines were selected to best fit the modeled and actual wind conditions on San Cristóbal and to use as much of the wind energy as practical to produce electricity at a reasonable cost. As the performance curve shows, the turbines start to generate power at about 3.5 meters/second wind speed – very low for this type of turbine – and peak at about 12 meters/second. During commercial operation, maximum output is rarely attained due to operational restrictions such as electricity demand limitations and minimum on-line diesel requirements.

Transmission Line

The 13.2 kV transmission line connects the wind park with the substation located at the diesel plant owned by ELECGALÁPAGOS S.A.: from here, the energy is distributed to the users on San Cristóbal Island.

The transmission line consists of an initial underground section, 3km long, as a protection for the birds in that area and especially for the Galapagos petrel, an endangered bird. The overhead section, 9 km long, is connected to the underground cable and ends at the substation located at the ELECGALÁPAGOS S.A. diesel plant. It is a conventional line on concrete poles, with aluminum conductor.

Interconnection Substation

At the substation located at the ELECGALÁPAGOS S.A. diesel plant site, the overhead line is connected to the bus bar through a vacuum circuit breaker, and associated disconnecting switches and lightning arresters.

Automation of diesel units

As a component of the Wind Project, the diesel units owned by ELECGÁLAPAGOS S.A. were automated in order to have a full automatic hybrid wind-diesel system in the Island. The diesel generation component is owned by ELECGALÁPAGOS S.A. More recently, ELECGALÁPAGOS S.A. has installed some additional new diesel units whose inclusion in the automated system is pending.

Control Room

Within the premises of the ELECGALAPÁGOS S.A. diesel plant, the control room for the wind-diesel hybrid system was installed. In the control room the following equipment and services are located:

- Control and protection panel for the 13.2 kV circuit breaker of the transmission line;
- SCADA (Supervisory Control and Data Acquisition) system for automatic control of wind-diesel hybrid generation. Using this computerized system, an automatic optimal dispatch of generation units at all times is achieved, to optimize the use of the wind resource and consequently to minimize the use of diesel.

For technical requirements, it is necessary to maintain at least one diesel unit operating at 25% of its rated capacity. In the SCADA system operation, the same ELECGALÁPAGOS operators working in the diesel plant are able to operate the new hybrid system, after adequate training on these new technologies. Supervision is under responsibility of the EOLICSA Operations Manager, Fernando Naranjo.

Photovoltaic system

Through a GSEP complementary grant, two photovoltaic systems were installed and interconnected at low voltage to the distribution grid of ELECGALÁPAGOS S.A. A set of 5.1 kWp solar panels is installed in the Pedro Pablo Andrade School and two sets of 5.1 kWp and 2.5 kWp respectively, are on the roof of the control room. Each system has its own energy measuring equipment.

Start of Operation

The execution of the project works demanded a high degree of coordination, due to the logistical difficulties of the San Cristóbal Island. These activities were carried out by MADE, TECNOLOGÍAS RENOVABLES S.A. from Spain, as the equipment supplier, SANTOS CMI from Ecuador in charge of transport, civil works and erection, Ecuadorian ELECDOR responsible for the transmission line, and several local firms and consultants who provided support for specialized tasks. The Project Management was under responsibility of the U.S. company IEA, with Jim Tolan as Project Manager and Luis C. Vintimilla as Local Manager. Paul Loeffelman, from AEP (GSEP member) was the Project Leader. See the GSEP website www.globalelectricity.org/galapagos for details on the development and construction of the project.

Once all the acceptance tests stipulated in the contracts were satisfactorily completed, the San Cristóbal Island Wind Project began commercial operation on October 1, 2007. The official dedication ceremony was on March 18, 2008.

Eight years of operation

On September 30, 2015, the San Cristóbal Wind Project completed eight years of operation, fulfilling its main objectives. This success is due to the following factors.

Operation and maintenance

The operation and maintenance tasks are performed under the supervision and coordination of EOLICSA Operations Management (Operations Manager and Assistant) in addition to the ELECGALÁPAGOS S.A. staff after an adequate training process about these new technologies. The manufacturer, GAMESA, provides permanent remote assistance from Spain, as needed.

The operation of the wind-diesel hybrid system, automatically monitored by a SCADA system, provides dispatching preference to the wind generation in order to reduce fuel consumption as much as possible. Because of the addition of two new diesel units by ELECGALÁPAGOS S.A. and in order to update and optimize the system after eight years of operation, a modernization of the SCADA and other functions needs to be conducted with coordinated participation of GAMESA, EOLICSA and ELECGALÁPAGOS S.A.

Preventive and predictive maintenance programs are strictly completed by local staff, in accordance with the manufacturer's recommendations and in line with best practices and standards for this type of activity.

The corrective maintenance activities have always been successfully implemented by local staff to minimize the time of unavailability of wind turbines. Only two notable events during the eight years of operation occurred: the first one in May 2012, which resulted in the unavailability of 80 days of one wind turbine and required two specialists from the manufacturer to be on site, and the second one in May 2015 with 23 days unavailability of one wind unit. The problem was resolved by EOLICSA staff.

The global availability of the wind park for the eight years of operation is 92%, which is considered a high value compared with other similar projects, especially taking into account its remote location, away from technology centers and with little infrastructure to support local logistics.

One of the activities that deserves special attention on an annual basis is the external cleaning of towers, blades and nacelles, and blade repair due to the blades being continuously subjected to low cloud cover. This was originally performed with the assistance of a group of high altitude specialists from the Ecuadorian mainland. They have since trained local staff from ELECGALÁPAGOS S.A. and EOLICSA to perform these activities.

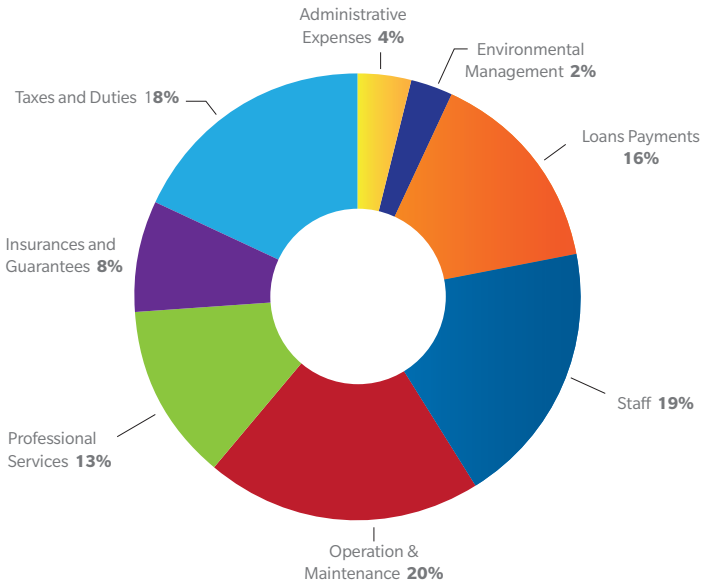
EOLICSA Operations Management maintains a continuous training program for the staff of operators and maintenance technicians from ELECGALÁPAGOS S.A.

Economic and financial issues

EOLICSA accounting reports are recording accumulated losses since the start of the operation, mainly because of the high annual depreciation value of the project facilities and other operation and maintenance costs, and the limited energy prices set by CONELEC (currently ARCONEL) for such projects in Galapagos. In spite of this, a positive cash flow has been available at all times for covering the costs of operation and maintenance and other related duties. Due to the characteristics of the project financing through non-refundable grants, it was not necessary to provide resources to recover the capital investment; this project would not have been financially feasible under a strictly private financing scheme. Unfortunately, this situation has been seriously affected by a decision of the Internal Revenue Service (SRI) office obligating EOLICSA to make income tax payments based on sales, assets and other parameters, although no profit has been registered. Such a decision is against the exemption provisions established in the Electric Law ruling at the time of the implementation of the Project, which was the law on which the financial scheme of the project was grounded.

The project's revenues and expenses have been carefully managed through monthly cash flow analyses updated every 30 days and an annual budget that includes anticipated periodic and one-time expenditures. This has allowed the project to continue functioning properly and smoothly, as outlined in the following chart and graph for 2015.

EOLICSA: 2015 EXPENSES



EOLICSA 2015 BUDGET EXECUTION (US$)

Description	Est. Execution until Dec. 31, 2015
Energy Sales	
Unit price (US$ / kWh)	0.1282
Energy sold to ELECGALÁPAGOS S.A. (kWh)	3,396,364
Incomes	
Energy Sales	435,414
Others	11,158
Total Incomes	**446,572**
Expenses	
Staff	87,298
Operation & Maintenance	91,239
Professional Services	58,311
Insurances and Guarantees	37,349
Taxes and Duties	78,483
Administrative Expenses	15,719
Environmental Management Plan	10,405
Loans Payments	70,000
Total Expenses	**448,805**

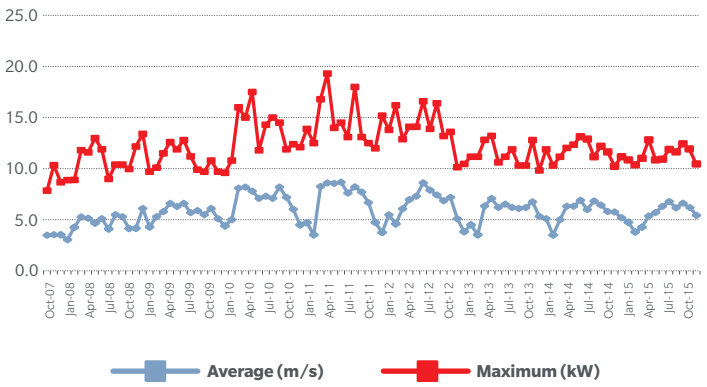
When EOLICSA will be transferred to ELECGALÁPAGOS S.A. in 2016, the project shall face a better economic situation since publicly owned companies adhere to more benign taxation rules. The financial sustainability of the project will no longer be at risk.

Wind resource

Actual wind conditions during the period 2008-2015 can be seen in the tables and graphs below, from which it shall be highlighted that:

- as predicted by wind measurements and modeling during the project's development phase, the period from January to May is the one with the lowest presence of wind;
- the year 2008 had an extremely low presence of wind;
- wind conditions are progressively improving and increasing from 2008 onwards, and show a cyclic characteristic to be verified over the coming years.

WIND SPEED m / s



WIND SPEED: m / s

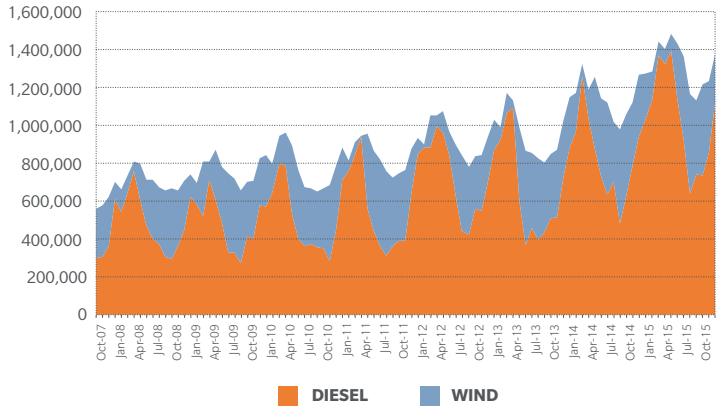
	2008		2009		2010		2011		2012		2013		2014		2015	
	Avg. (2)	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Jan	3.5	7.9	4.2	10.0	6.1	10.8	6.0	12.4	4.7	12.0	5.1	10.2	5.3	9.8	5.2	11.2
Feb	3.5	10.3	4.2	12.2	5.1	9.7	4.5	12.1	3.8	15.2	3.8	10.5	5.1	11.9	4.8	10.9
Mar	3.5	8.7	6.1	13.4	4.4	9.6	4.7	13.9	5.5	13.8	4.5	11.2	3.5	10.3	3.8	10.4
Apr	3.0	8.9	4.3	9.7	5.0	10.8	3.5	12.5	4.6	16.2	3.5	11.2	5.0	11.2	4.3	11.0
May	4.3	8.9	5.3	10.1	8.1	16.0	8.3	16.8	6.1	12.9	6.4	12.8	6.3	12.0	5.4	12.8
Jun	5.3	11.8	5.8	11.5	8.2	15.0	8.6	19.3	7.0	14.1	7.1	13.2	6.3	12.4	5.7	10.9
Jul	5.2	11.6	6.6	12.6	7.8	17.5	8.6	14.0	7.3	14.1	6.2	10.6	6.9	13.1	6.3	10.9
Aug	4.7	13.0	6.3	11.9	7.1	11.8	8.7	14.5	8.6	16.6	6.5	11.2	6.0	12.9	6.8	11.9
Sep	5.1	11.9	6.6	12.8	7.3	14.3	7.6	13.1	7.9	13.9	6.2	11.9	6.8	11.2	6.2	11.6
Oct	4.1	9.0	5.7	11.2	7.1	15.0	8.2	18.0	7.4	16.4	6.1	10.3	6.4	12.2	6.6	12.4
Nov	5.5	10.4	5.9	9.9	8.2	14.5	7.7	13.1	6.9	13.2	6.2	10.3	5.8	11.6	6.3	12.0
Dec	5.3	10.4	5.5	9.7	7.2	11.9	6.7	12.5	7.2	13.6	6.8	12.8	5.8	10.2	5.5	10.5
Avg. (1)	4.4		5.5		6.8		6.9		6.4		5.7		5.8		5.6	

(1) Annual average values are the average of the monthly averages (2) 2008 was an unusual low wind year

Energy production and penetration factor

The amount of energy generated by the wind park in each month depends on the availability of wind and its distribution throughout the day, as well as its correspondence with the Island's demand. The table and graph below for each month and year (2008-2015) show the values of produced wind energy, compared with that from diesel generation. The accumulated information on wind will provide valuable support for optimizing the project's operation in the future and shall also provide a benchmark for other important projects in the Galapagos.

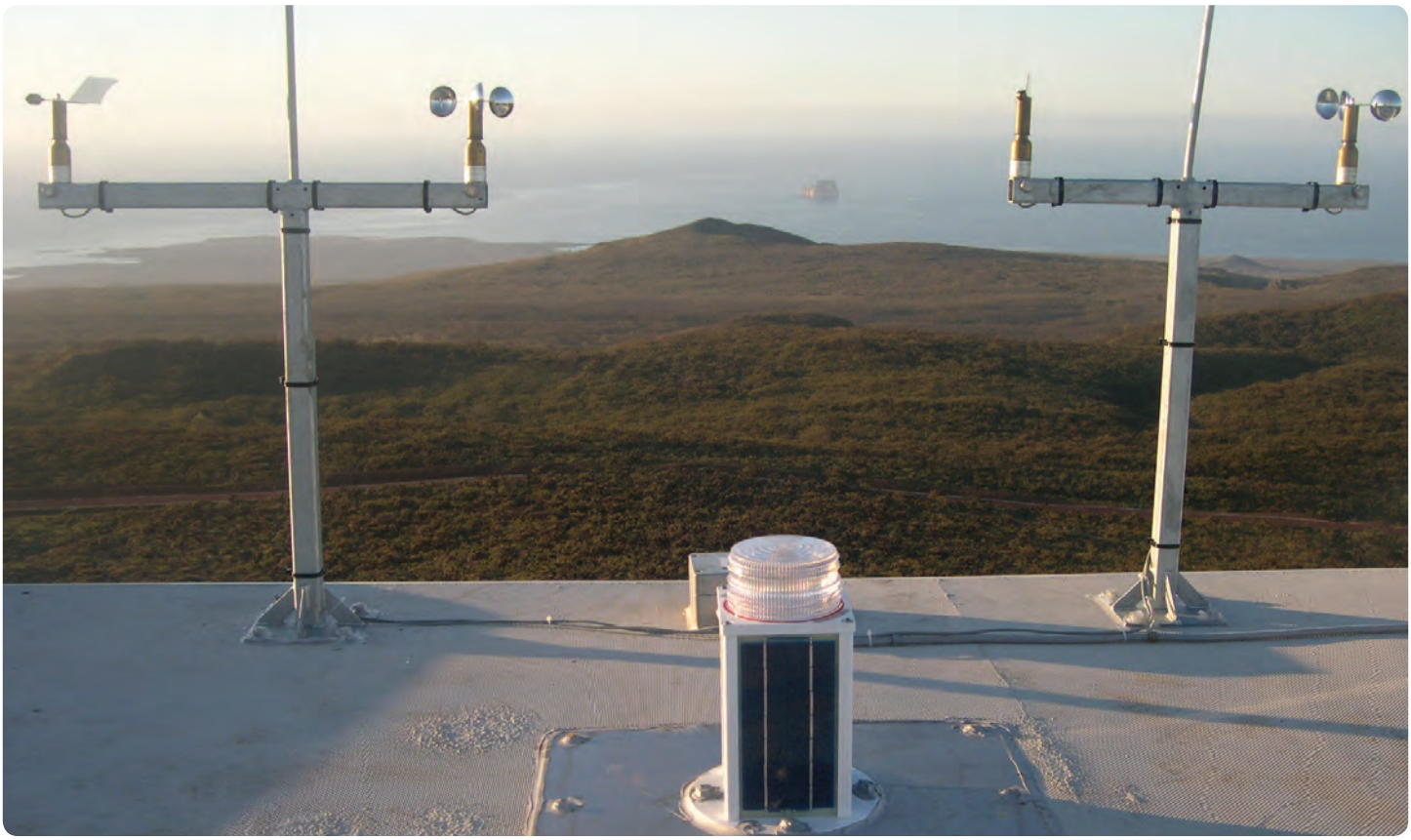
WIND - DIESEL GENERATION - kWh (2007 - 2015)



WIND - DIESEL GENERATION SUMMARY: 2007-2015

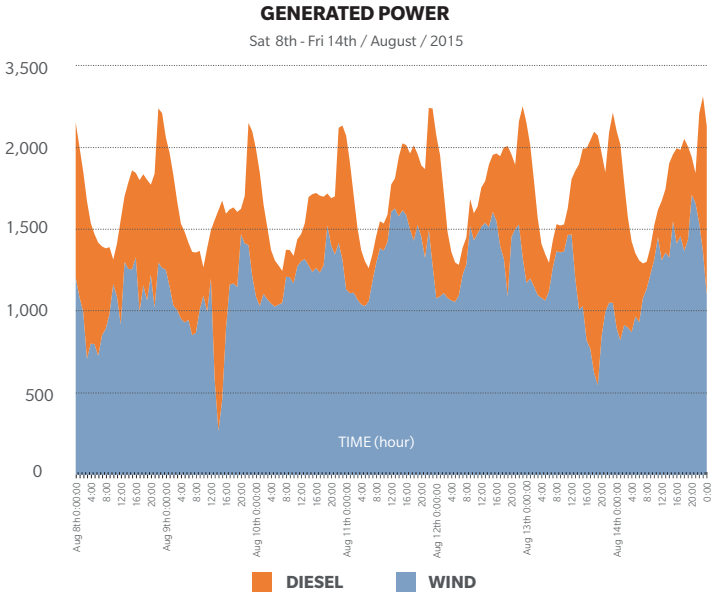
Year	Diesel (kWh)	Wind (kWh)	Total (kWh)	Diesel (%)	Wind (%)	TON CO_2 Avoided	Diesel Saved (Gallons)	Invoicing (USD)
2007	975,858	790,398	1,766,256	55.3%	44.7%	632	68,730	101,329
2008	5,834,693	2,682,461	8,517,153	68.5%	31.5%	2,146	233,257	343,891
2009	5,882,731	3,204,436	9,087,167	64.7%	35.3%	2,564	278,647	410,809
2010	5,919,000	3,434,854	9,353,853	63.3%	36.7%	2,748	298,683	440,348
2011	6,745,046	3,344,625	10,089,672	66.9%	33.1%	2,676	290,837	428,781
2012	8,752,958	2,398,372	11,151,330	78.5%	21.5%	1,919	208,554	307,471
2013	7,984,046	3,451,451	11,435,497	69.8%	30.2%	2,761	300,126	442,476
2014	9,956,002	3,864,396	13,820,396	72.0%	28.0%	3,092	336,034	495,415
2015	12,425,816	3,396,364	15,822,180	78.5%	21.5%	2,717	295,336	435,414
Total	**64,476,150**	**26,567,355**	**91,043,504**	**70.8%**	**29.2%**	**21,254**	**2,310,205**	**3,405,935**

Note: 2007 includes October - December period only

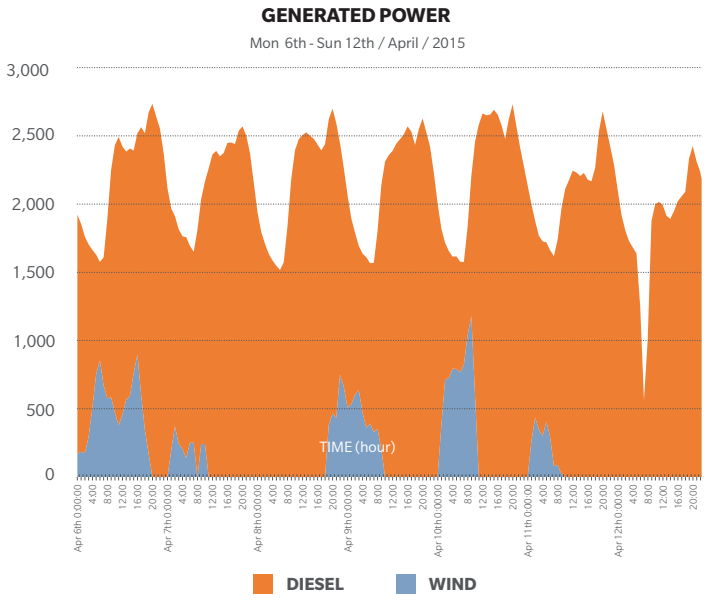


It is worth emphasizing that during high wind season, the wind energy production is considerably high, as seen in the next graph showing wind power production in comparison with diesel production for a typical complete high wind week (August 8 - 14, 2015).

On the contrary, during low wind season, the wind energy production is modest, as seen in the following graph showing wind power production in comparison with diesel production for a typical complete low wind week (April 6 -12, 2015).



If the project will be optimized according to the recommendations provided by RWE and Enel (pages 18-22), future electricity demand on San Cristóbal Island will be adequately and timely addressed by ELECGALÁPAGOS S.A. after they receive the full ownership of the wind facilities in 2016.



Clean Development Mechanism

The Clean Development Mechanism (CDM) is one of the flexibility mechanisms defined in the Kyoto Protocol, which allows emission-reduction projects in developing countries to earn Certified Emission Reduction (CER) credits, each equivalent to one tonne of CO_2. These CERs can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets.

EOLICSA received support from RWE in the development of the project under the CDM. On May 13, 2008, the San Cristóbal Island Wind Project was approved as a CDM project by the United Nations Framework Convention on Climate Change (UNFCCC). In its first eight years of operation, the project has avoided more than 21,000 tonnes of CO_2 emissions and more than 2.3 million gallons of diesel have been displaced by wind power. Eleven thousand certified and verified emission reduction certificates were sold on the international market for approximately 110,000 US dollars. Emissions reductions and diesel consumption were monitored locally by the plant staff and were verified by an independent entity. Because of low CER prices on the international carbon market during the last three years, the verification and registration of additional CERs is pending.

Photovoltaic Production

The two photovoltaic (PV) systems donated by GSEP companies help to train local staff in this type of technology. They have a total output of 12.7 kW and are permanently connected at low voltage to the ELECGALÁPAGOS S.A. grid. Photovoltaic generation for the period 2007 - 2015 was as follows:

Period	Control Room (kWh)	School P.P. Andrade (kWh)	Total (kWh)
Oct-Dec, 07	1,572	1,208	2,780
Jan-Dec, 08	7,600	7,157	14,757
Jan-Dec, 09	9,387	6,776	16,163
Jan-Dec, 10	10,373	7,604	17,977
Jan-Dec, 11	10,333	7,522	17,855
Jan-Dec, 12	9,742	7,002	16,744
Jan-Dec, 13	9,525	7,316	16,841
Jan-Dec, 14	9,756	7,494	17,250
Jan-Dec, 15	8,999	6,860	15,860
Total (kWh)	**77,287**	**58,939**	**136,227**
Capacity (kW)	**7.64**	**5.1**	**12.7**

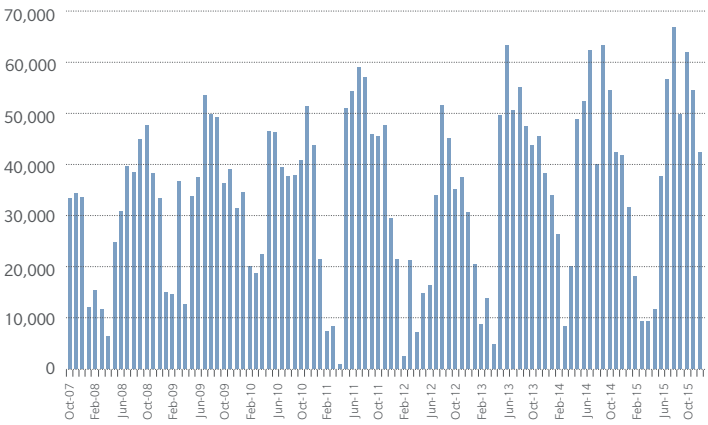
The total amount of 136,227 kWh produced by the PV system was delivered free of charge to ELECGALÁPAGOS S.A.

Invoicing

The power purchase agreement (PPA) signed between ELECGALÁPAGOS S.A. and EOLICSA establishes the selling price of electricity at 0.1282 USD/ kWh, in accordance with the provisions of CONELEC (currently ARCONEL) regulations. Therefore, the total energy of 26,567,355 kWh billed during the period represents a total turnover for the period of eight years of 3,405,935 USD.

ELECGALÁPAGOS S.A. honored the payments to EOLICSA in a timely manner for eight years within the terms established in the PPA, which is a positive signal that should build confidence in potential private investors who are interested in developing new renewable energy projects, both in the Galapagos and Ecuador mainland.

INVOICING (USD)



Environmental Management Plan (EMP)

The EMP is a component of the Definitive Environmental Impact Assessment (EIAD) which was approved by the Ministry of Environment and CONELEC (currently ARCONEL) as a prerequisite for granting of the Ambient License. The Plan considers the execution of several programs that are strictly conducted by EOLICSA administration.

From these programs, the most outstanding is the Petrels Conservation Program, which reflects the serious commitment made by the San Cristóbal Island Wind Project to promote the preservation of this species which nests in the highlands of San Cristóbal Island. The Galapagos petrel *(Pterodroma phaeopygia)* is an endemic bird. According to the IUCN Red List (International Union for the Conservation of Nature), it is classified as "critically endangered", mainly because of introduced species, such as blackberry *(Rubus niveus)* and guava *(Psidium guajava)*, which impair the nesting habitat and clog flight routes and access to the nests for breeding, as well as the rat *(Rattus rattus)* and the wild cat *(Felis catus)*, which devour the eggs, birds and chicks of this species, resulting in low levels of reproductive success.

In order to minimize the risk of injury to petrels because of the wind park operation, an intensive two-year study about flight patterns, flight elevation and nesting behavior was carried out by GSEP together with local agencies in order to select the most suitable site for the wind park. El Tropezón hill, located in an area of the San Cristóbal highlands, was finally selected with the acceptance of Galapagos National Park and the Charles Darwin Foundation. The following flight pattern map shows how the three turbines were located on the hill, away from the birds' normal flight direction. The turbines were spaced for optimal wind flow onto their blades and to allow a fourth, future turbine to be sited on the hill without risk to the birds. Studies also showed that the birds mostly fly at elevations lower than 20 meters, below the tips of the turbine blades.

To carry out a preservation program for petrels as determined under the Environmental Management Plan, EOLICSA maintains a cooperation agreement with the Galapagos National Park (GNP) which is supervised by a specialized high-level committee. The main activities under this program include monitoring any injuries to petrels and other species at the site of the wind farm and the implementation of measures aimed to increase the population of petrels (nest monitoring, control of rats and wild cats, control of introduced plants), as summarized below.

Monitoring of affected species in the wind farm area

A detailed inspection in areas adjacent to each wind turbine is carried out bimonthly using a standardized procedure in order to determine the possible presence of corpses of species that could have been affected by the operation of the wind farm.

As a result of the conducted monitoring, it has been determined that during the whole period of operation of the wind farm no petrels have been affected. The finding of four frigate birds and 27 bats (not included in the list of critically endangered species) was reported and the specimens have been sent to the Directorate of the Galapagos National Park (DGNP) for analysis and corresponding actions.

Petrels nests monitoring

Every 15 days, monitoring at each individual nest is conducted which allows information to be collected about the petrel's breeding cycle at the six pre-selected nesting areas in the upper part of San Cristóbal Island. A total of 78 nests from 294 existing nests are monitored. The monitored nests are registered with the following data: date, sector, number of the nest, how it is occupied and the condition of the nest. A chronological file of data collected at each visit is being kept.

Control of rats and feral cats

Rat control is performed using PVC tubes 35 cm long, in which a specific dose of poison is inserted. The tubes are installed in close proximity to each nest in the six pre-selected nesting sites. For control of wild cats, another specific poison is placed at regular intervals along the trails leading to the petrel nests.

Control of introduced plants

The clearing of introduced plants (mainly blackberry and guava) is done by manual means (machetes) during the months of January and August, so that the nesting sites are clean before the petrel breeding season starts.

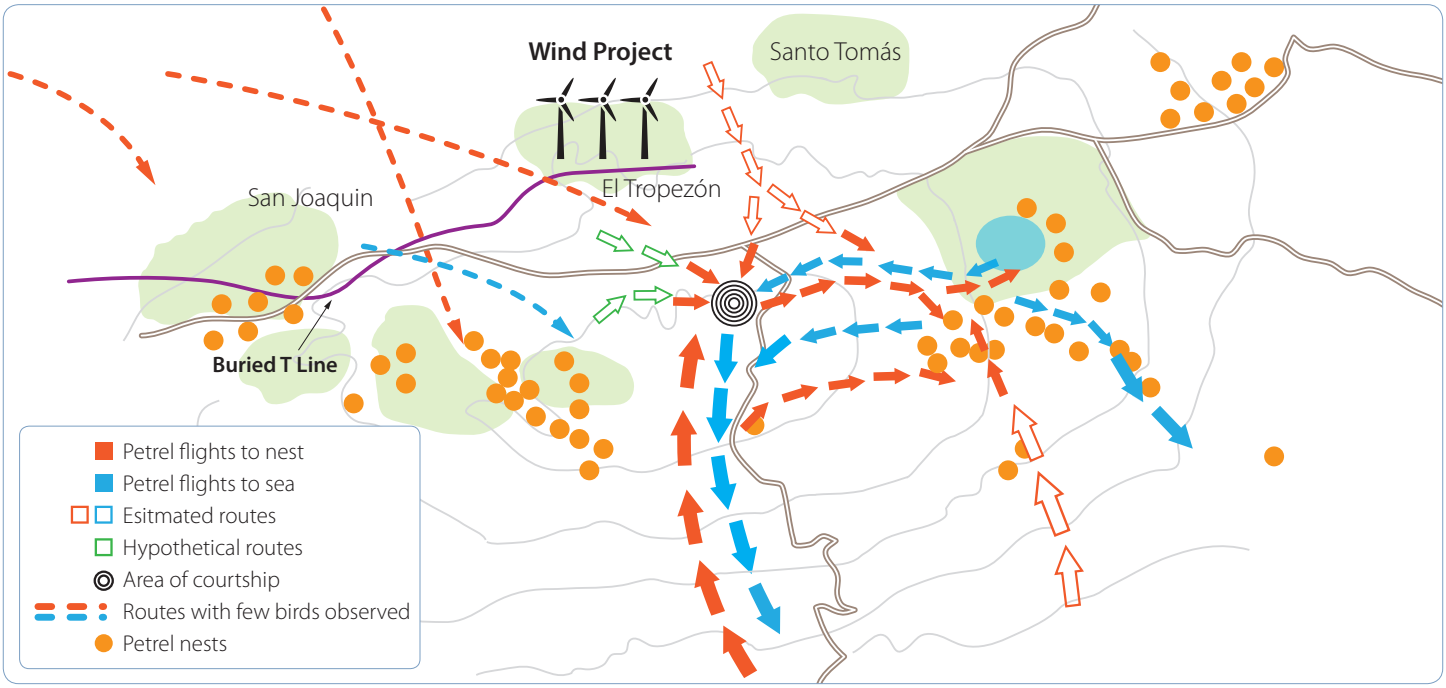
Reproductive success

The effectiveness of the above-listed petrel conservation measures is determined by the percentage success of hatching and reproduction in the monitored nests. With great satisfaction, we can say that these two indicators have shown a progressive increase throughout the period of implementation of the program. The results for recent years are indicated as a reference.

Success	2012	2013	2014
Hatching	85.4%	94.0%	96.3%
Reproductive	81.3%	95.7%	100%

These data confirm that after eight years of continuous operation, no petrel specimen has been affected because of the wind park. On the contrary, as a result of the intensive campaign of pest control and control of invasive species carried out jointly with the Galapagos National Park, there are encouraging signals showing the increase of this bird population. It is recommended to ELECGALÁPAGOS S.A. to continue this initiative after taking over the total ownership of the San Cristóbal Island Wind Project facilities.

The Internal Environmental Audit is submitted to CONELEC and the Ministry of Environment on an annual basis, receiving positive approval every time.



Analyses and optimization recommendations to improve the performance and value of wind and solar generation, distribution grid efficiency and a summary of end-use efficiency programs.

GSEP's San Cristóbal Island Wind Project has been a very successful initiative to improve the sustainability track record of the island's power supply. To date, almost 30% of the near 7,500 inhabitants' power demand is covered by renewables, mainly onshore wind. San Cristóbal has the highest renewable penetration within the Galapagos archipelago. Nevertheless, approximately 70% of San Cristóbal's power demand and approximately 85% of the entire archipelago's power demand is still covered by diesel generators. Furthermore, electricity demand is expected to increase, according to government forecasts (see graph on page 8)

This fact encourages us to reflect on future ways to achieve even higher renewable penetration rates in the Galapagos Archipelago, particularly on the island of San Cristóbal. Today, Latin America is a region of rapid growth for renewable energy, with an even faster-growing interest in developing those resources. Investment in more renewables and higher penetration rates are in line with the Government of Ecuador's target to cover 90% of the country's power demand with renewable energy by the year 2017.

As indicated previously, electricity demand on San Cristóbal continues to experience significant growth due to increased population and economic activity. The Ministry of Electricity and Renewable Energy (MEER) and ELECGALÁPAGOS S.A. are helping to moderate this increased demand in the Galapagos Islands through the use of demand-side energy efficiency programs. Further, AEP, with the assistance of EOLICSA and ELECGALÁPAGOS S.A., assessed the potential of implementing Volt/VAR optimization (VVO) to help achieve energy efficiency objectives. A summary of the AEP findings and ELECGALÁPAGOS S.A. end-use efficiency efforts are described later in this report and details are on the GSEP website at www.globalelectricity.org/galapagos.

Options to optimize generation potential

It is against this backdrop that further optimization of the power system and expansion in renewable generation may be evaluated once the project is handed over to the local utility and GSEP's aegis has ended. Experts from GSEP member companies RWE and Enel have evaluated the possible technologies that could be optimized to increase the supply and penetration of renewable electricity on San Cristóbal Island. They independently concluded that four actions should be taken in a step-wise program as follows.

The optimization options which are technically and economically feasible and should be sequentially implemented are:

1. Fully automating control of diesel electricity production with the operation of wind turbines and overhauling the SCADA system; then
2. Adding more solar photovoltaic capacity; then
3. Adding a fourth wind turbine unit at the existing wind park at El Tropezón hill; and finally
4. Adding significant battery storage which currently is not part of the project.

Results from RWE's power system analysis and Enel's project-level modeling reinforce each other. A summary of their findings are described here. RWE's and Enel's detailed reports are accessible on the GSEP website www.globalelectricity.org/galapagos.

RWE's power system analysis results

For all of the Galapagos Islands, experts – e.g. from UNDP - have identified pre-existing potential for significant amounts of additional renewables due to the fact that the archipelago enjoys a very good solar regime and favorable wind conditions at different locations.

Looking more closely at the specific circumstances of San Cristóbal, GSEP's project partners have undertaken a power system analysis. Based on the analysis, prospective optimization paths towards higher renewable penetration rates can be derived, which may serve as suggestions to the new owner for further development.

Power generation mix on San Cristóbal, current situaiton		
Diesel	GWh/a	11.5
Wind		4
Total		15.5
Maximum load	MW	2.9
Consumers		3,134

The analysis finds that wind generation and power demand are negatively correlated in San Cristóbal, resulting in very high seasonal variations of the diesel power generation. Obviously, dispatch of wind and diesel units is a key issue for the efficient operation of the island's entire power system. Under current conditions there is headroom for improving the efficiency of the wind-diesel-dispatch. Existing diesel units are currently operated at unnecessary high levels. This corresponds with relatively high switch-off times for wind units and an increased fuel demand.

Optimized dispatch would allow for minimization of the operating time of diesel units and maximization of the power output of wind units. Model-based analysis shows that renewable penetration may be increased from today's 25% to approximately 35% by optimized dispatch alone, and without any additional capacities added to the grid. Fuel demand would decrease by up to approximately 160,000 gallons/year.

As a consequence, optimizing the dispatch of existing generation assets is a no-regret measure which could be implemented on short notice. Moving beyond this finding, we further evaluated options for expanding and diversifying installed renewables on San Cristóbal.

For this purpose, optimized portfolios of wind, solar PV and battery storage have been analyzed using a model-based systems approach.

Background on wind energy considerations

These modeling results support more renewable development on San Cristóbal, tempered by environmental protections that must be made for the local flora and fauna. For example, during the feasibility study for the current San Cristóbal Island Wind Project, it was determined that El Tropezón hill (the current wind park location) was the most suitable site for the wind turbines' installation. It has good wind conditions. and is away from the petrels' normal flight pattern and nest area. At this site, a fourth 800 kW wind unit, also away from the petrels' normal flight pattern and nest area, could be installed. San Joaquin hill, although the best site in regards to wind conditions, was eliminated as a potential site for the wind park after environmental evaluation because it is a highly intensive petrel nesting area and a site for the endangered Galapagos miconia *(Miconia robinsoniana)*. The feasibility report also establishes that Santo Tomas hill near the existing Wind Park could be a supplemental site if additional wind turbines were considered at a later date to address system load growth.

Due to the documented seasonal fluctuation of wind speeds compared to relatively stable solar radiationthroughout the year, it is more beneficial to add more PV capacity in optimization step 2 according to RWE and Enel analyses. Furthermore, given the urgent need to address the forecasted electricity demand, PV can be installed very quickly relative to the time needed to install wind turbines. More wind capacity would then be added in step 3.

Background on energy storage considerations

Energy storage options were considered at the feasibility stage of the project, both for transient situations as well as for long duration reserve, opening the doors to several recognized technologies at that time. However, after an open bidding process, the supply contract was signed with the Spanish manufacturer MADE (GAMESA Group) with AE-59 wind turbines. These types of units are highly recommendable for the San Cristóbal system, since they are able to generate power across a wide range of wind velocities. In addition, these machines do not need a separate storage system for controlling transients due to the random nature of the wind, since in case that in any moment a surplus of energy is needed in the system, the wind turbines will take it from their rotor kinetic inertia. Once past the transient, the wind turbines will go back to their optimal working point.

Based on that technology, no separate energy storage system for transient control purposes was included in the supply. On the other hand, because of budget limitations, an additional storage system for long duration reserve was also not included in the contract. However, the system is perfectly adequate for the future installation of such a storage arrangement, in order to improve the overall system performance.

Assuming world market price levels for diesel fuels, distinct portfolios of wind, solar PV and battery storage are economically feasible and were to correspond to renewable penetration rates of 50% to 60%.

Economic cases for more renewables		
		Additional capacity
Wind	MW	1.0 – 1.5
Solar PV	MW	1.5 – 3.0
Battery Storage	MWh	0.4 – 2.4
Renewable penetration rate	%	>50% - >60%

However, much higher penetration rates of renewables are feasible provided that portfolios of different technologies are carefully optimized. Ecuador's overall nation-wide 90% renewable target is predominantly based on hydro power, which is not available on San Cristóbal. Given the specific locational circumstances of San Cristóbal Island, the analysis finds that a renewable penetration rate of at least 70% may be achieved within a reasonable investment range.

70% - case for more renewables		
		Additional capacity
Wind	MW	1.7
Solar PV	MW	4.5
Battery Storage	MWh	6.5
Renewable penetration rate	%	70%

Enel's power system analysis results

Objective

The purpose of this modeling effort is to briefly analyze all possible solutions to reduce the fossil fuel dependency for San Cristóbal Island's electricity production and the current curtailment of wind power.

Introduction

Preliminary analysis was done to verify the consistency of information and possibilities to store excess energy from wind turbines. As a result of this analysis, it was found that a complete integration of diesel units on the power control is necessary to avoid excessive wind power curtailment (33% today) and thus diesel consumption. There are three main months during which a lot of wind energy now is lost.

Model

Assuming the first step of fully automating control of diesel electricity production with the operation of wind turbines is taken, a technical economical model was developed in order to define the suggested steps of adding additional PV and wind generation energy storage upgrades.

The proposed model consists of three blocks. One block is used to calculate the wind power based on wind speeds, another is used for the Battery Energy Storage System (BESS) representation (including the batteries model and the charger model) and the last one is used to calculate the diesel generation based on the existing solar PV, wind and stored energy on batteries.

The necessary data to run the model are the wind speeds, the PV profile and the load profile. For San Cristóbal, these data were provided for an entire year, with a sampling of 10 minutes. The model for calculating the wind power is the simplest one and only calculates the wind power based on the wind speed data.

The model for the BESS, as already mentioned, consists of two blocks. The model of batteries is based on information from Enel Green Power projects and basically estimates the state of charge of one battery by integration of the current, which is calculated with consideration of the internal resistance and voltage reduction because of the variation of the state of charge.

Sodium nickel batteries of 38 Ah, about 620 V and 24 kWh were chosen for the simulation. This choice of technology is only for modeling purposes. A detailed analysis of the best technology for the case should be performed before detailed design begins.

The charger control is very simple and only identifies the time window to load or unload the batteries. This decision is based on the state of charge and the desired moment of the day to perform the discharge.

For this work, it has been assumed that the state of charge is varying between 20% and 95% to ensure the lifetime of the batteries.

The same block considers an efficiency for load/unload of 80% (entire cycle).

Finally, the block to estimate the diesel consumption assumes a minimum diesel generation (in this case, 200 kW), and calculates the necessary diesel generation to ensure a good frequency control. The inertia of each diesel generation unit was assumed the same. The inertia of PV, wind and BESS was considered null. for modeling simplicity.

In this study, the hypothesis is to operate only one diesel generator, at minimum 30% of nominal power Pn (200 kW) in order to reduce fuel consumption and to not have engine mechanical problems due to low power (<30% Pn). The grid voltage and frequency reference can be operated also from BESS inverters, but it was decided to always maintain working one diesel generator to be a back-up for grid voltage and frequency reference.

The same block estimates the necessary number of diesel generator units and varies the inertia accordingly.

Results

A complete analysis month by month was performed, considering the number of batteries varying between 0 and 20,000. The case with 20,000 (480 MWh) batteries is only theoretical and illustrates what happens if infinite storage capacity is present.

For example, the results of the analysis for September, which is the month with higher wind power exceedance, clearly show that for infinite storage capacity the curtailment is null because all the energy is stored for the following months. Thus, the diesel consumption remains the same than without BESS. To minimize the diesel consumption, a total of 5,000 batteries is enough (about 120 MWh). This value is still clearly unacceptable from an economical point of view.

It appears more convenient to generate about 250 MWh with diesel and only between 1 and 2 MWh of batteries would be necessary.. In contrast, the situation in April, with low wind power generation, shows that the storage would be practically useless.

The overall results show that a very limited amount of energy could be stored, and that even in this case, between 50 and 100 batteries would be the best solution (1 to 2 MWh in total), even if the use of these batteries would be limited to a short period of the year.

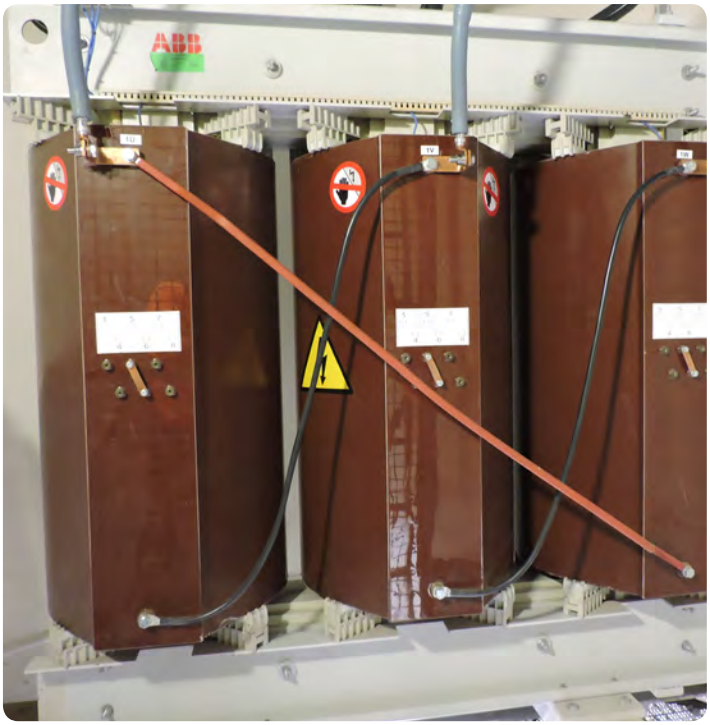
After the sizing of the BESS nominal power, in order to maximize the storage usage during the year, new PV capacity was modeled.

The following cases were analyzed:

- PV of 1.0 MW of ac nominal power;
- PV of 1.0 MW of ac nominal power, plus daily BESS with discharge during night;
- PV of 1.5 MW of ac nominal power, plus daily BESS with discharge during night;
- PV of 2.0 MW of ac nominal power, plus daily BESS with discharge during night;
- PV of 2.5 MW of ac nominal power, plus daily BESS with discharge during night.

The results are summarized considering different BESS energy installations (0 and 1 MWh):
As a Base case, only diesel generation was considered, without BESS and without additional PV plant.

No substantial advantages could be expected due to BESS or due to its strategy of discharge, in the sense that with current fuel cost and CAPEX assumptions the installation of the BESS is beneficial but still not economically convenient.



On the other hand, bigger energy savings could be expected when adding a PV plant.. This option seems economically justified and in particular the 1 MW option without BESS seems the optimal one to be implemented as for today.

A further cost reduction of future storage systems, that is just around the corner, could make it convenient in the medium term (2-3 years from now) to additionally install of 1-2 MWh of BESS.

The analysis has been performed considering an initial period of 10 years, the expected lifetime for BESS batteries. In the case of PV plant without BESS, the optimization was done considering the lifetime of 25 years as commonly used for this technology.

Next steps

The next step to improve this analysis would be to consider different BESS models, the indirect costs/year for maintenance (ordinary and extraordinary) of diesel unit, for pollution, for noise, etc. and a better estimation of the wind and solar resources.

Options for optimizing the grid operation to improve electrical efficiency

Besides regular operation and maintenance, the project has continued to develop and improve in response to changing technologies, environmental policies, and customer demands. In 2015 AEP, a GSEP member company, with the assistance of EOLICSA and ELECGALÁPAGOS S.A., commissioned a pre-feasibility and a feasibility study to assess the potential of implementing Volt/VAR optimization (VVO) on the San Cristóbal grid. The objective of the initiative was to optimize the grid's operating characteristics, while also ensuring that customers were not negatively impacted.

Recent improvements in sensors, equipment and software have made advanced Volt/VAR optimization (VVO) a reality for many distribution systems. Using real-time information from sensors and other equipment, VVO helps reduce the amount of electricity wasted along the distribution grid while still maintaining an acceptable output voltage for customers.

Following the studies, it was concluded that the San Cristóbal grid is already providing voltages close to those required by customers and it cannot be further optimized without the risk of voltage drops below the authorized minimum level. However, VVO still holds considerable potential for other electricity distribution grids for the Galapagos Islands. The results of AEP's study will be shared with other local utilities by EOLICSA and will be an important reference for future implementation of VVO on other grid systems.

AEP's full report is available at www.globalelectricity.org/galapagos.

End-use energy efficiency

GSEP recognizes the initiatives by the Ministry of Electricity and Renewable Energy (MEER) and ELECGALÁPAGOS S.A. which are helping to moderate the demand for electricity and to promote the efficient use of energy in the Galapagos Islands, as a component of a national program implemented on the Ecuadorian mainland.

The most important initiative within this frame is the substitution of old-fashioned and low-efficiency refrigerators with modern high-efficiency units. The program started in 2012 and the scope is to replace a total of 3,000 refrigerators in the Galapagos Islands until 2016. The last available report in September 2015 reflects a total of 1,109 old refrigerators replaced by modern, efficient units in the Galapagos Islands (376 on San Cristóbal Island alone). The program slowed down in 2015 because of transport and logistical problems which occurred in the Islands, since several private, commercial ships transporting goods from the mainland to the Galapagos were out of service for a long period of time. It is expected that in 2016, activities will resume.

Another important program being carried out by the Ministry of Electricity and Renewable Energy in the Ecuadorian mainland and in the Galapagos Islands is the replacement of ovens currently using LPG (liquefied petroleum gas) for modern induction ovens. The goal is to use electricity for cooking purposes in order to minimize (or eliminate) the use of highly subsided LPG, considering that after 2016 on the mainland, almost 90% of the electricity shall be generated by cheap hydroelectric sources. Although that is not the situation in the Galapagos, the program has also been extended to this region, aligning with the "zero fossil fuels" goal declared by the government for the Islands. For San Cristóbal Island, a total of 2,500 LPG ovens shall be replaced by induction ovens (3 million units for the whole country). The government facilitates the purchase of new ovens by means of extended payments at 36 monthly installments paid through electricity bills. For San Cristóbal, it represents a demand increase of 1.08 MW at peak time. In order to cover that new demand and other regular demand increase, ELECGALÁPAGOS S.A. is planning the installation of a new 1.7 MW diesel unit and they have also researched the option of installing a 2 x 1 MW photovoltaic facility in the coming years.

Details for each activity are contained in supporting documents at www.globalelectricity.org/galapagos.

Recommended principles to support future electricty development

From the beginning of the project to the current date, GSEP and EOLICSA have permanently shared the experiences from the San Cristóbal Island Wind Project with local partners, mainly with ELECGALÁPAGOS S.A., in order to get well-trained staff in new technologies and to smooth the path toward the objective of "zero fossil fuels" in the Galapagos Islands. To achieve this objective, the Ecuadorian Government and ELECGALÁPAGOS S.A. have already completed some additional renewable energy projects in the Archipelago, such as the Baltra Wind Park and a photovoltaic facility in San Cruz Island.

GSEP strongly believes that it can most effectively assist local electricity providers and national governments by working with them through hands-on replicable projects like the Galapagos San Cristóbal Island Wind Project and workshop programs in host countries. GSEP is a very credible partner and program convener because its 11 members generate and deliver 33% of the electricity used in the world with a capacity mix of which 60% has no direct carbon emissions. Representatives from over 150 countries have participated in GSEP's Public-Private Partnerships (PPP) for Sustainable Electricity Development Program which empowers these decision makers in regional developing and transition economies to define the best practices and strategies for the successful implementation of PPPs in the sustainable electricity sector. By creating a strong network of experts with lessons learned from implemented projects, this program is having a real impact creating a bottom-up approach to sustainable electricity development. GSEP's program and projects are aligned in support of the United Nation's Sustainable Energy for All initiative and its Sustainable Development Goals for energy.

The Galapagos San Cristóbal Island Wind Project and the conclusions from each GSEP PPP workshop reinforce the importance of four principles for public policymakers, electricity providers and civil society to follow:

1. Electricity systems need to be developed using a system approach, taking into account the interrelations and synergies between the various elements of the electricity value chain, in order to enable electricity providers to plan, design, construct, and operate the most advanced electricity systems with the goal of providing cleaner, reliable, sustainable, secure, flexible and resilient electricity infrastructures.

2. The development and operation of electricity systems must be enabled by secure, stable, clear, consistent and long-term policies that address critically important energy, legal/regulatory, economic development, financial and environmental issues with the goal of ensuring an adequate supply of cleaner, secure, reliable, accessible and affordable electricity.

3. Public-private partnerships are needed to facilitate decision – making among electricity providers, government, representatives and private stakeholders to foster the development and deployment of new commercially available technologies.

4. Innovative research, development and demonstrations of advanced economically viable technologies that increase environmental performance and accelerate the efficient generation, delivery and end-use of electricity need to continue.

GSEP's 2015 Powering Innovation for a Sustainable Future report at www.globalelectricity.org provides support for these principles and successful projects like the Galapagos San Cristobal Island Wind Project.

Concluding Message from Project Leader

The Galapagos San Cristóbal Island Wind Project will be in good hands as the new owners are well-prepared for the transition. The excellent environmental, engineering, and financial status of the project is a credit to all who collaborated on the vision for the project years ago, designed it to avoid problems and enhance benefits where practical, and who have so well-operated and maintained this relatively new technology to the Islands and Ecuador.

As the nations of the world begin to ratify and implement the agreement reached in the Conference of the Parties meeting in 2015 to reduce CO_2 emissions, they will find great value in studying and following the disciplined, comprehensive approach the partners took and GSEP documented in the Project's development, construction, operation and maintenance phases. Although the Project is an outstanding example of teamwork that yields effective solutions to great challenges, the Project is capable of performing better and that is the reason AEP, RWE and Enel experts have shared their enhancement ideas in this report. From my experience working with ELECGALÁPAGOS S.A. and the national ministries, I know that there is a strong desire for the Project to continue to be world class.

Paul Loeffelman,
American Electric Power

Profiles

Eólica San Cristóbal S.A. – EOLICSA is the Independent Power Producer company owned by the Trust and ELECGALÁPAGOS S.A. EOLICSA is the owner and operator of the Project. EOLICSA General Manager, **Luis C. Vintimilla C.** is an Ecuadorian electrical engineer, with a wide experience in the planning, engineering and operation of power systems. At the former Ecuadorian Electrification National Institute (INECEL) he was the Electrical Engineering Manager and the Operations Director of the National Interconnected System. When the Ecuadorian electricity sector was restructured, Luis C. Vintimilla was nominated as the first Executive Director of the National Electricity Regulatory Council (CONELEC). In 2001 he joined the GSEP team as the Local Manager in Ecuador for the development and construction of the Galapagos San Cristóbal Island Wind Power Project. Currently he is the General Manager of the Galapagos Wind Company, EOLICSA, an independent power producer with a power purchase agreement with the local utility company ELECGALÁPAGOS S.A. Luis is in charge of the administration and operation of the Project. He has been involved in all the phases of the Project such as site selection, environmental issues, planning, studies, financing, engineering, construction, erection, operation and administration, and thanks to his experience, facilitating the relationship with local and national stakeholders for the success of Ecuador's first and longest running wind project.

American Electric Power is one of the largest electric utilities in the United States, delivering electricity to nearly 5.4 million customers through 223,000 miles of distribution lines in 11 states. AEP owns the nation's largest electricity transmission system, a more than 40,000-mile network that includes more 765-kilovolt extra-high voltage transmission lines than all other U.S. transmission systems combined. AEP also ranks among the nation's largest generators of electricity, owning approximately 32,000 megawatts of generating capacity in the U.S. AEP's utility units operate as AEP Ohio, AEP Texas, Appalachian Power (in Virginia and West Virginia), AEP Appalachian Power (in Tennessee), Indiana Michigan Power, Kentucky Power, Public Service Company of Oklahoma, and Southwestern Electric Power Company (in Arkansas, Louisiana and east Texas). AEP's headquarters are in Columbus, Ohio. Paul Loeffelman served as the Project Leader and led the team preparing this report.

RWE is one of Europe's five leading electricity and gas companies. Through its expertise in oil, gas and lignite production; electricity generation from gas, coal, nuclear and renewables; energy trading as well as electricity and gas distribution and sales; the company is active at all stages of the energy value chain. Around 59,000 employees supply over 16 million electricity customers and nearly eight million gas customers with energy, both reliably and at fair prices. In fiscal 2014, RWE recorded €48.5 billion in revenue. Europe is its market: in terms of sales, RWE is No. 3 in electricity and No. 5 in gas. In Germany, the Netherlands and the United Kingdom, the company is among the largest suppliers of both fuels. In the Czech Republic, RWE is No. 1 in the gas business. RWE maintains leading positions in other markets in Central Eastern Europe. Dr. Peter Engelhard currently leads RWE's long-term support for the Project and RWE's contributions to the optimization recommendations in this report.

Enel is a multinational power company and a leading integrated player in the world's power and gas markets, with a particular focus on Europe and Latin America. Enel Group operates in over 30 countries across four continents, producing energy through a net installed capacity of more than 89 GW and distributes electricity and gas through a network of approximately 1.9 million kilometers. With over 61 million users worldwide, Enel has the largest customer base among European competitors and figures among Europe's leading power companies in terms of installed capacity and reported EBITDA. Fabrizio Bonemazzi leads Enel's team which analyzed and recommended optimization measures in this report.

About the Global Sustainable Electricity Partnership

The Global Sustainable Electricity Partnership is a non-profit international organization, composed of the world's leading electricity companies, whose mission is to play an active role in global electricity issues within the international framework and to promote sustainable energy development through electricity sector projects and human capacity building activities in developing and emerging nations worldwide. The organization, in partnership with UN agencies, key international organizations and local partners, contributes to enhancing access to energy for some of the 1.4 billion people around the world still without access to this essential resource.

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This report is posted in English and Spanish with previous 2007 and 2013 reports at www.globalelectricity.org/galapagos

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EOLICSA
ELECGALAPAGOS S.A.
Energías Renovables Nueva Generación