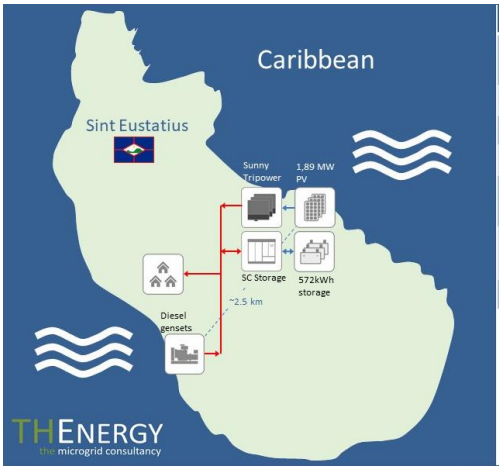
THEnergy Analysis

Evaluation of first 12 months of operational data for a PV-battery diesel hybrid plant on the island of Sint Eustatius



Key operation data for first year	
Solar energy produced	3126 MWh
Diesel savings	812 887 l
CO2 reduction	2146 tons
PV Performance ratio	>82%
Battery energy throughput	148 MWh
Battery state of health	99%
High forecasting accuracy!	

Excellent operational results: Island utility Stuco has decided to expand solar power plant and battery energy storage system to switch off diesel generators

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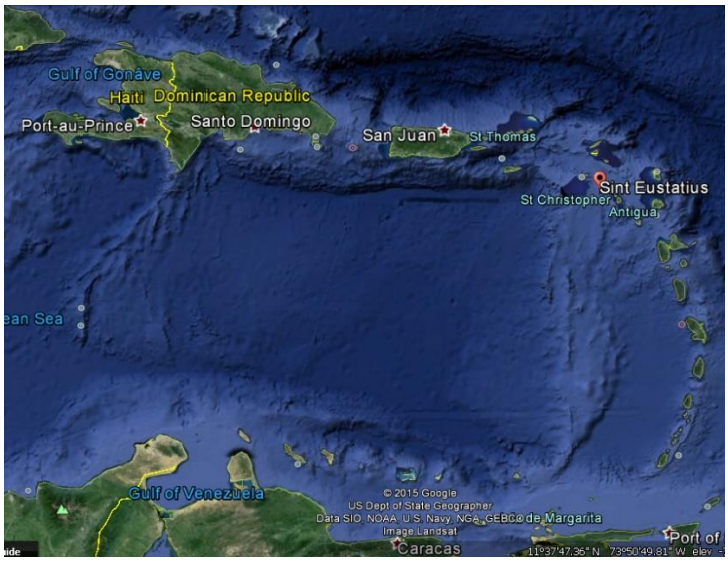
SMA

THENERGY
the microgrid consultancy

A Caribbean island has changed its power generation paradigms by reducing diesel consumption with solar plus energy storage in March 2016. The result is a leading-edge PV-battery diesel hybrid power plant. This paper analyses the data of the first year of operations for this milestone microgrid, which also serves as an example for electrifying islands in the future. A special focus is put on assessing battery degradation.

Sint Eustatius

The Dutch Caribbean Island of Sint Eustatius is located north of Venezuela and east of the Dominican Republic. It is one of three Dutch islands in the Caribbean and has approximately 4,000 inhabitants. It covers an area of 21 km².



Island of Sint Eustatius in the Caribbean - © Google

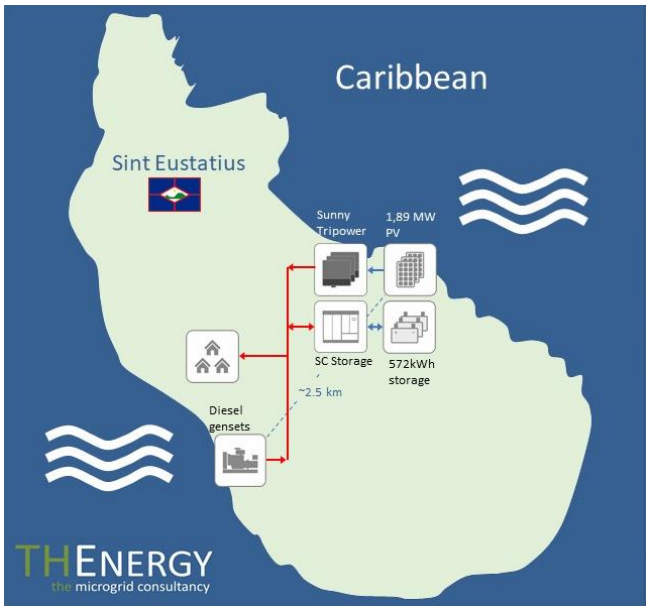
Stuco is the utility on St. Eustatius and is responsible for power generation, distribution, and retail. Small scale commercial and domestic appliances such as air conditioning units are the main electrical loads on the island.

Even though diesel is locally available and prices are relatively low in comparison to other islands, Stuco decided to reduce diesel fuel consumption for power generation by integrating solar energy. The Dutch Ministry of Economic Affairs supported and financed the project.

Due to its location in the middle of the sea, the island traditionally experiences quickly changing weather conditions caused by passing clouds. This is a special challenge for hybridizing existing diesel gensets, i.e. for integrating solar and storage systems.

The PV-battery diesel hybrid power plant

The existing 5 MVA diesel power plant is located in the port area in the southern outskirts of the island's capital. As the area is rather densely inhabited, the solar power plant was built 2.5 km from the diesel generators, close to the East Coast.



Location of new PV-battery power plant on the island

The power plant upgrade consists of a 1.89 MWp PV power plant and a 1 MW/ 572 kWh Li-Ion energy storage system. Favorable solar irradiation results in an estimated average annual energy yield of 3,200 MWh, annual diesel savings of more than 850,000 liters and CO2 reductions of 2,240 t.

Under the contractual scope, SMA Sunbelt Energy, a leading supplier of turnkey solar-diesel hybrid power solutions, also provided the hybrid system design, a project specific monitoring system, and a containerized Li-Ion storage facility with cells from Samsung SDI. Eco Energy, Curacao, was responsible for the installation.

Planning and construction

Stuco contracted the companies in July 2015 after an international tendering process to add a solar plus energy storage power plant to the existing diesel generators. Construction started in September 2015 and finished in February 2016.

Though the plant was ready on time, commissioning did not begin until two weeks after schedule due to the wishes of the client. After being commissioned for 10 days, the plant was fully operational and completely accepted by the customer on 24 March 2016.

Operational data

After one year of operations, the first extensive data analysis of the flagship solar-diesel hybrid plant on Sint Eustatius could be conducted. For plant owners and operators, analyzing deviations between forecasted performance indicators and actual performance allows a thorough evaluation of the plant for the first time. The following table summarizes the key parameters:

Parameter	Forecast (21.09.2015)	Measurement (28.03.2016-27.03.2017)	Relative values
Total load [MWh]	13 697	13 087	4.5% less
Fuel savings [liter]	822 733	812 887	1.2% less
Rel. fuel savings [l/MWh]	60.1	62.1	3.4% more
Renewable energy fraction [%]	23%	23.89%	3.8% more
Performance ratio of the PV system [%]	82%	>82%	0%
Irradiation [kWh/m²]	2124	2021	4.9% less
Energy produced by PV system [MWh]	3200	3126	2,3% less
Curtailed PV energy [MWh] / [%]		216 / 6.45%	
Battery energy throughput [MWh]	149	148	0.7% less
Diesel generator [MWh]	10 467	10 007	4.4% less
Battery capacity /state of health [kWh] / [%]	547/ 95.6	565 / 98.7	3.2% more

Forecasts vs. measurements for first 12 months of operational data

The diesel consumption was reduced even more than forecasted, so that it contributed less than expected to the overall power generation. This happened for several reasons. An external factor was that the overall load was significantly lower than in previous years. In this context, it makes sense to point out that the solar irradiation in the analyzed year was also lower than expected. There might be a direct correlation between relatively "bad weather" conditions and lower electricity demand, e.g. due to less use of air conditioning units. A consequence of the lower than expected solar irradiation for the particular year is that the absolute solar generation is slightly lower than forecasted. While the irradiation is 4.9% less, the solar generation is only 2.3% less than forecasted, resulting in diesel savings of 1.2% less than predicted.

These under-proportional decreases are indicators of the excellent performance of the new system. Relative diesel savings were 3.4% higher than forecasted: diesel consumption was reduced by 62.1 l/MWh instead of 60.1 l/MWh. These additional savings are particularly remarkable as solar irradiation during the year was below average. Solar irradiation forecasts are only valid for longer time periods. Deviations on an annual basis are normal. A more detailed analysis allows for a final assessment of the plant performance. For evaluating the PV-diesel hybrid system, it is important to use an indicator that measures the performance without taking into consideration these annual irradiation deviations. The performance ratio is a measure of the plant performance at a specific irradiation. The performance ratio of the PV system on Sint Eustatius exceeded expectations. Altogether, this results in a higher than expected renewable energy share and higher irradiation specific diesel savings.

The operational data also allows for an analysis of the battery energy storage. Battery degradation was assessed and batteries were found to degrade less than predicted. Although the battery was used almost as intensively as expected, it did not degrade significantly (degradation of 1% (565 kWh after 1 year vs. 572 kWh initially)). The capacity was conservatively estimated to decrease to 547 kWh, which would have corresponded to a degradation of 4% for the first year of intense usage.

Evaluation

Many island utilities have started to consider hybridizing existing diesel power plants with renewable energy and storage solutions. Large-scale solar-diesel hybrid solutions are still relatively new. Operational

experience is not broadly available. Island utilities and commercial or industrial off-takers must rely largely on manufacturers for assessing how additional solar generation translates into diesel savings. Having said this, it is obvious that the project example at hand will further improve the trust in PV-battery diesel hybrid solutions and, in particular, in the design accuracy. Being aware of the hybrid system's relevance as a flagship project, both Stuco and the Dutch Ministry of Financial Affairs are pleased to share their experience and are generally willing to welcome interested utilities for site visits.

Solar-PV plant on the island of Sint Eustatius - ©SMA Sunbelt Energy GmbH

Even with significantly below average solar irradiation during its first year of operations, the solar-diesel hybrid plant almost met its overall diesel saving projections. It is highly probable that in years with average irradiation, the forecasted diesel savings will be exceeded. This assessment is also confirmed by the higher than expected performance ratio of the PV system.

Generally, the long-term performance of energy storage systems is still uncertain. For large-scale Li-Ion batteries in stationary power generation solutions, only limited operational experience is available. The fact that the capacity degradation of the battery is better than predicted will further increase the trust in the technology in general and in SMA's storage solutions in particular.

Outlook

The excellent operational results of SMA Sunbelt's milestone island project will have a positive influence on future island hybridization projects. The results were achieved under the specific challenge of rapidly changing weather conditions, which are typical for island locations.

Island utilities will value operational experience from an island PV-battery diesel hybrid plant. It is likely that this successful power plant will trigger many additional projects in the near future. The economic hybridization of existing diesel generators makes sense for the majority of islands.

It is no surprise that on Sint Eustatius, Stuco has decided to expand the solar power plant and battery energy storage solution in a way that in future the diesel generators can be switched off during the day. This will result in a much higher renewable energy share in the generation mix. CO2 emissions will be further reduced. Sint Eustatius will cement its role at the vanguard of integrating solar energy, thereby improving its environmental footprint.

About SMA Sunbelt

SMA Sunbelt Energy GmbH is a 100% affiliated company of SMA Solar Technology AG. It was founded in 2014 and focuses on Off-Grid, PV-Diesel-Hybrid and battery-based solar projects. SMA Sunbelt Energy GmbH concentrates its business on the world's Sunbelt regions (Africa, Central America and Caribbean, Middle East, South-East Asia and Pacific). Customers profit from more than 30 years of SMA know-how in Off-Grid and PV-Hybrid system solutions. http://www.sma.de/sunbelt.html

About Dr. Thomas Hillig Energy Consulting ("THEnergy")

THEnergy assists companies in dealing with energy-related challenges. Renewable energy companies are offered strategy, marketing and sales consulting services. For industrial companies, THEnergy develops energy concepts and shows how they can become more sustainable – combining experience from conventional and renewable energy with industry knowledge in consulting. In addition to business consulting, THEnergy advises investors regarding renewable energy investments in changing markets. www.th-energy.net