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GREEN ENERGY FOR ISLANDS:

Case of La Gomera

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SUMMARY

The island of La Gomera is the focus of a case study for analyzing the potential of renewable energy integration into the power grid of an island considering current cost trends. The aim of the study is to investigate how beneficial full renewable energy systems are from a cost perspective, compared to diesel-based power systems, which are currently used in many islands. La Gomera has been selected for this study as it is primarily powered by diesel generators. Moreover, La Gomera belongs to the Canary Islands, which are located in a region with favorable conditions for solar and wind energy. This white paper presents the results of a complete renewable energy system. This system consists of photovoltaic (PV) panels, wind turbines and electric battery storage for power generation during night time. With the renewable system, the average cost of electricity could be reduced by around 1 euro cent per kilowatt hour compared to a diesel-only-case during a project lifetime of 25 years, meaning savings of up to 6 Million EUR and 1.202.500 tons of CO_2.

WHY ISLANDS ARE SO RELEVANT IN THE CONTEXT OF CLIMATE CHANGE

As the temperature in the planet continues to rise, the consequences can be observed in numerous ways. In around 25 years, Greenland has lost 286 billion tons of ice, whereas in the Antarctica 127 billion tons of ice have melted within the same time period. Snow is melting earlier and the sea levels are rising. Extreme events are now the new normal: record high temperatures, record low temperatures, increased number of intense rainfall. Moreover, salinity levels are highly important to the world's climate. The different levels of water salinity and density in the oceans control the circulation of ocean currents from the tropics to the poles. These currents control the heat transport within the oceans and thus the world's climate as well. Small islands are considered to be very vulnerable to the effects of climate change, due to their highly specialized and localized ecosystems, as well as their physical, socio-political and economic characteristics.

Even though the most industrialized and highly populated countries of the Earth are responsible for the majority of emissions worldwide, solutions for decarbonizing energy systems can begin within the islands, since more than 730 Million people live on islands. This represents around 11% of the total world's population. Many islands are highly dependent on diesel or natural gas systems for generating electricity. The Canary Islands, for example, rely primarily on fossil-based generators to produce electricity.

Renewable energies a vital part of the transformation of the islands energy systems, not only from an environmental perspective, but also from an economic point of view. The price of fossil fuels are volatile and depend on many geopolitical factors. The cost of renewable energies drops every year, which means they are becoming an increasingly cost-effective solution for gaining energy independence. In total there are 2056 islands around the world with a population between 1000 and 100,000 inhabitants (Howe, 2013). The largest archipelago in the world, Indonesia has over 17,000 islands of which roughly 6,000 are inhabited.

THE ELECTRICITY SECTOR OF THE CANARY ISLANDS

The Canary Islands are a Spanish archipelago in the Atlantic Ocean, just 100 km west of Morocco. Around 2.1 Million people live on this archipelago. The contribution of various power sources in the Canary Islands is shown in Table 1. It can be seen that the renewable energy sources account for only 12% of the total energy requirements in the Canary Islands. In particular, wind turbines and photovoltaics (PV) contribute with 5.2 % and 5.9 %, respectively. Local energy sources such as wind and solar, can help to reduce the island's vulnerability by minimizing fuel imports (and thus emissions).

Table 1: Installed capacity in the electricity sector of the Canary Islands. All values are given in MW, except percentage values (Uche-Soria, 2018)

Primary Energy Sources	Gran Canaria	Tenerife	Lanza-rote	Fuerte-ventura	La Palma	La Gomera	El Hierro	Canary Islands	% of Total
Petroleum Derivatives									
Thermal Power stations	999.2	1046.5	232.3	187	105.3	21.2	14.9	2606.4	85.1
Refinery	-	25.9	-	-	-	-	-	25.9	0.80
Cogeneration	24.9	39.2	-	-	-	-	-	64.1	2.10
Total oil derivatives	1024.1	1111.6	232.3	187.0	105.3	21.2	14.9	2696.4	88.0
Renewable Sources									
Wind	88.1	36.7	13.4	13.1	7.0	0.4	-	158.6	5.18
PV	40.0	115.0	7.8	13.1	4.6	0.04	0.03	180.5	5.90
Small-scale Hydro	-	1.2	-	-	0.8	-	-	2.0	0.07
Hydro-wind	-	-	-	-	-	-	22.8	22.8	0.75
Biogas(landfill)	-	1.6	2.1	-	-	-	-	3.7	0.10
Total renewable sources	128.1	154.5	23.3	26.2	12.4	0.4	22.9	367.7	12.0
Total	1152.2	1266.1	255.6	213.2	117.7	21.6	37.8	3064.0	100

POTENTIAL OF RENEWABLE ENERGIES IN LA GOMERA

In the present case study, the goal is to find the optimum configuration of a full renewable energy system comprising photovoltaic (PV) installations, electric storage (lithium-ion batteries) and wind turbines for supplying electricity to La Gomera Island. An optimization is made in order to find the most cost-effective system configuration to cover the current power demand of La Gomera. This island is located at a latitude of 28.1° N and a longitude of 17.2° W.

The local electricity demand data for the year 2020 is retrieved from the Red Eléctrica de España - the Spanish power grid operator. The annual peak load is 11.3 MW and primary electric load is 193.95 MWh/d.

The load demand profile, solar radiation and wind speed data as well as the costs of the system components are provided into a simulation model. The model simulates the operation of a system by making hourly energy balance calculations per each of the 8,760 hours of the year. For systems including batteries or fuel-powered generators, the model decides for each hour how to operate the generators and whether to charge or discharge the batteries. After simulating a large number of possible system configurations, the model finds out which option has the least net present value (NPV).

THE FUTURE ENERGY MIX IN THE ELECTRICITY SECTOR

Table 2 presents some of the cost assumptions associated with various components of the full renewable energy system.

Table 2: System components costs assumptions

System component	Investment Costs
Photovoltaic system	830 EUR/kWp
Wind turbines	990 EUR/kW
Battery storage system	260 EUR/kWh

The project life span has been considered to be 25 years. The discount rate and inflation rate are 8%, 2% respectively. Fuel costs are taken as 0.30 EUR/liter (49 EUR per barrel), which are realistic prices in the year 2021. The cost of crude oil has fluctuated globally in the last decade, from over 110 EUR per barrel to below 35 EUR. Within the energy modeling sector, there is less disagreement when discussing assumptions of PV and wind power plant costs, as these are two technologies which have been massively deployed in the past decade and therefore, enough robust data is available regarding the specific costs. Battery costs however, are often a source of disagreement and different sources show occasionally large differences. For this study a low battery cost scenario has been taken into account regarding the data from the National Renewable Energy Laboratory (NREL).

The optimized energy mix comprises 36.42 MW_p PV capacity, 8 wind turbines of 3.5 MW capacity each and a battery pack with a capacity of 231.9 MWh.

In this system, the larger share of electricity generation in one year is that of the wind turbines with a share of 60,4%, whereas solar PV generates 39,6%.

The optimized case has an average cost of electricity of 0.192 EUR/kWh and NPV of 175 Million EUR. An only-diesel-based system is compared to the optimized renewable energy system. In this case, the O&M and fuel costs as well as the replacement costs of the components are taken into account. No initial investment costs are considered here, since La Gomera already possesses generators of this type, as shown in Figure 1.

The NPV of the only-diesel case is 181 Million EUR, of which the fuel costs account for the majority. The proposed full renewable energy system has an average cost of electricity nearly 1 euro cent per kilowatt-hour lower compared to this case, as it can be observed in Figure 2. Over 25 years this leads to savings of 6 Million EUR. The results from the simulation of the diesel-only case in this study show good agreement with the documented electricity generation costs from La Gomera, which fluctuated between 0.21 EUR/kWh and 0.22 EUR/kWh in the last decade (Suárez Garcia, 2019).

Figure 1: Thermal power plant El Palmar in La Gomera © HATECHNO

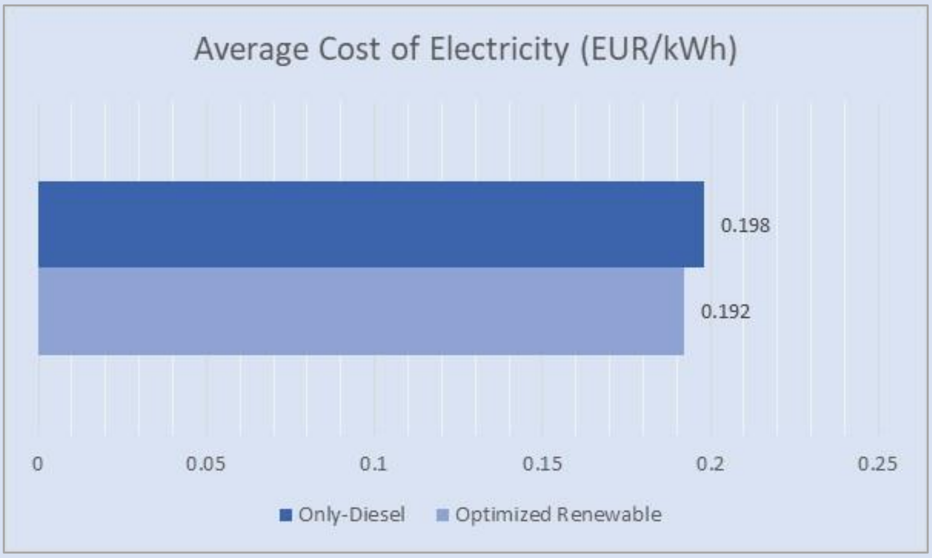

Figure 2: Average cost of electricity generation for both configurations

The other important concern is the amount of emissions associated with the only-diesel system. A representation of the pollutant quantities of the only-diesel case are presented in Figure 3 and 4. As much as 48,100 tons CO_2 are emitted each year in the only-diesel case. It would take roughly 2 Million trees to absorb this amount of CO_2 from the atmosphere. With the renewable energy system, it can be prevented that this massive amount of CO_2 enters the atmosphere.

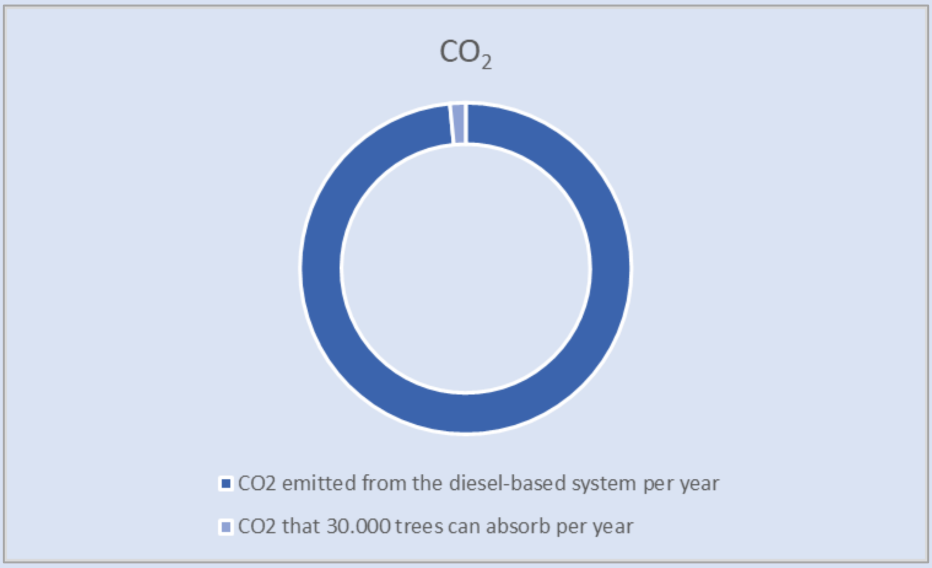

Figure 3: Comparison between CO_2 emitted from the fossil fuel system and CO_2 that can be absorbed from 30.000 trees, which would fit in a field of the size of 100 football stadiums

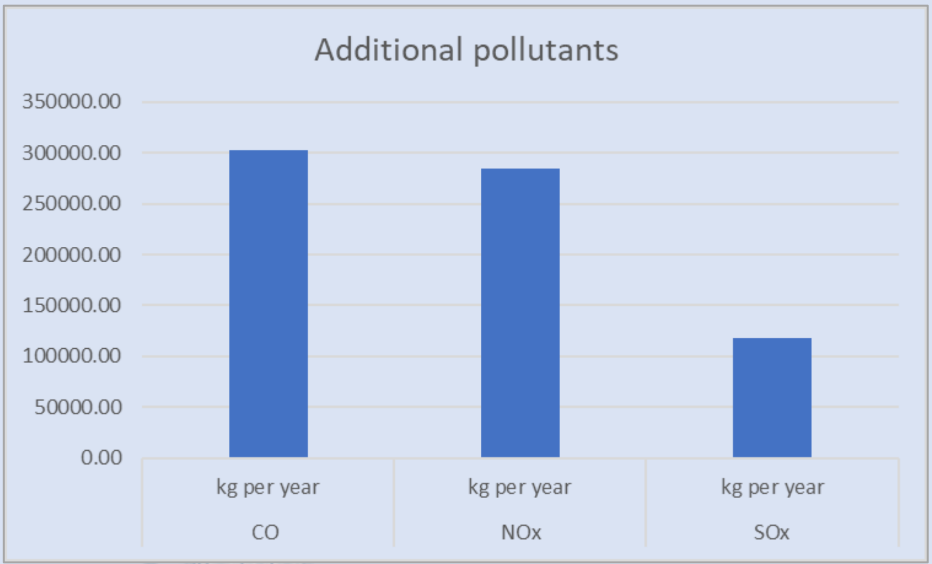

Figure 4: Other pollutants emitted from the diesel-based system

FAVORABLE OUTLOOK

Renewable energies for islands are an attractive option for investors. An intelligent combination of green generation technologies and storage could cover the current electricity demand of La Gomera, offering cheaper prices for electricity than a diesel-based system.

The aim of this white paper was to show how a set of commercially available renewable energy technologies can already be deployed to supply 100% of the power demand of islands in a cost-effective way. The results of the case study show one of the possible scenarios to reach this goal. CO_2 taxes and incentives play an important role in the current international market. These factors as well as uncertain future oil prices would have a significant effect on the simulation outcomes. In addition, the use of bio- or synthetic gas and fuels could be another option of energy storage technology. The global effort on the topic of renewable fuels, including green hydrogen is gaining momentum, so that it is not unrealistic to think that in the near future the prices of synthetic fuels could sink drastically and make them a feasible alternative.

Moreover, additional flexibility and sector coupling mechanisms shall be implemented in order to further improve the dispatchability, cost-effectiveness and security of supply of the total energy demand of the island, including other energy intensive sectors. Spatial, regulatory and technical (grid) issues must be taken into consideration before planning the electrical system installation. These issues can be planned in the short to medium term if the long-term economic perspectives are favorable.

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