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Integrated Energy Planning - high share of variable renewable energy sources for a Caribbean island

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Introduction

Actions are needed to mitigate global warming by well under 2ºC, such as a significant reduction in greenhouse gas (GHG) emissions following signing of the Paris agreement. Adapting the current grid to **renewable energy sources** can reduce GHG emissions, provide a more affordable energy system in the long term, and secure an energy supply, which are the three pillars of the European Union's plan for the energy transition.

Case study

The main objective of this paper is to reach a significant share of variable **renewable energy sources** in Aruba, a Caribbean island that does not have interconnections to nearby regions. In order to keep the curtailed energy as low as possible, an integrated approach between the power, cooling, transport, and water desalination sector is proposed. This typical Caribbean island has 100,000 inhabitants, consumed 676 GWh of electricity during the reference year of 2015. Moreover, almost all the energy demand for fossil fuel is from imported oil, and the island has very high wind and solar potential.

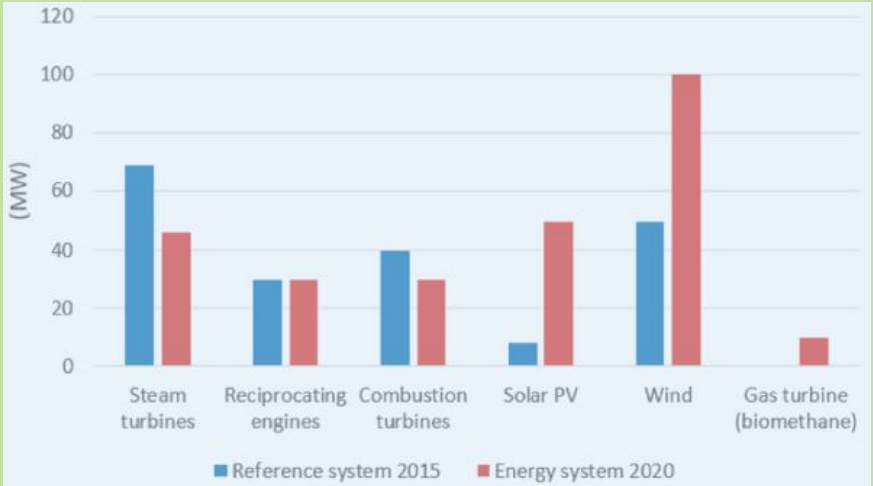
Indicators for the energy system:

.Economic: total socio-economic cost of the system.

.Technical: total primary energy supply, curtailed energy, fossil fuel consumption, and the need for dispatchable power sources in the system – when neither wind turbines nor photovoltaics are generating energy.

.Environmental: CO_2 emissions.

Installed capacities of different technologies



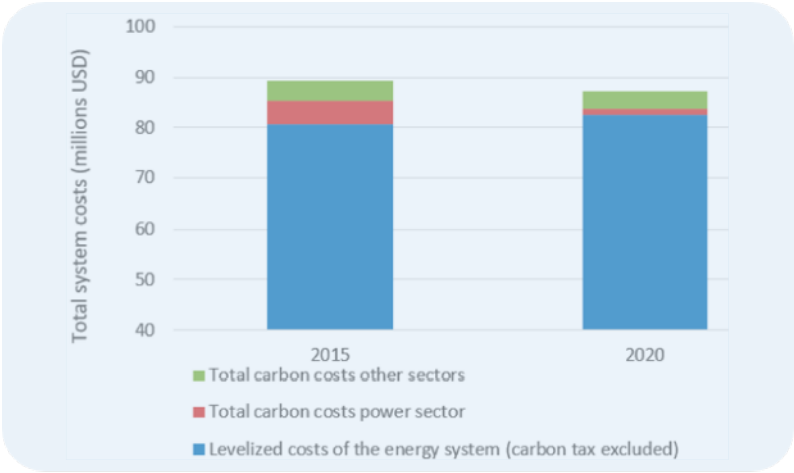
Results

The new energy system was simulated and the results for 2020 are encouraging, since it demonstrates that 84.6% of the electricity demand could be met by renewable energy sources. In addition, the levelized costs of the energy system (carbon costs excluded) were only 2.2% higher in the year 2020 than in the year 2015. On the other hand, the socio-economic costs of the energy system (carbon costs included) were 2.5% lower in the year 2020 than in the year 2015.

When looking the CO_2 emissions of the energy sector, industry, and transportation, the drop was significant. By comparing with the reference system in 2015, carbon emissions in the power sector were reduced by 76% in 2020, and the total carbon emissions were reduced by 46% in the year 2020.

The developed method of an energy system with a significant amount of variable renewable energy was simulated at a cost similar to the traditional, fossil fuel-based energy system in the Caribbean.

Total system costs of energy systems



CO_2 emissions in the energy system

Carbon Emissions	2015	2020	Unit
Carbon emissions power sector	317,000	76,000	$tonCO_2$
Total carbon emissions (including industry and transport)	578,000	311,000	$tonCO_2$

Furthermore, it was shown that the energy system could significantly change in the near future using existing technology solutions, where the electrified part of the transport sector successfully provides the flexibility needed for the integration of a substantial amount of renewable energy sources. Moreover, oil imports could be significantly reduced by adopting the proposed measures in the energy system.

Discussion

Globally more than 11,000 inhabited islands exists, with a population of 740 million people. The results of this study are therefore relevant for many different case studies, especially those of developed countries in tropical regions. Furthermore, the results of this study are relevant for any energy system with a large cooling demand, which is not connected to the surrounding regions via transmission cables.

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