ANALYSIS OF THE AFRICAN ELECTRICITY INFRASTRUCTURE WITH FOCUS FOR THE USE OF WIND AND SOLAR POTENTIALS

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Introduction

The mitigation of climate change is a topic of global interest as movements like Fridays for Future and intense discussions at the 2019 United Nations Climate change conference in Paris (COP25) show. With a few exemptions, the majority of countries have agreed that it is necessary to cut down carbon dioxide (CO_2) emissions in order to reduce the impacts of climate change. Currently Africa globally is the region with the least amount of CO_2 emissions, with about 1 235.5 Mt in 2018 [1]. The predicted growth of the African population from about 1 305 million people in mid-2019 to about 2 515 million people in 2050 [2], in combination with the desire to get a higher standard of living could lead to a sharp rise of CO_2 emissions of the continent if the development is not done in a sustainable way.

Africa has large potentials for Solar/Photovoltaic and wind power plants, especially if the prices for these technologies get more and more competitive. The contribution of this paper is to get an overview of the locations with great wind and solar potentials and how these potentials could be used with the existing electricity infrastructure of Africa.

Methodology

In order to perform the analysis of the African electricity infrastructure with a focus on the utilization of wind and solar potentials, the areas with high potentials of the renewable energies are determined. Figure 1 on the left shows the mean surface incoming shortwave (SIS) radiation between 1983 and 2017 calculated from the monthly data of the Climate Monitoring Satellite Application Facility (CMSAF) [3]. On the right, the mean wind speed at a height of 100 m as obtained from the Global Wind Atlas 3.0 [4] can be seen.

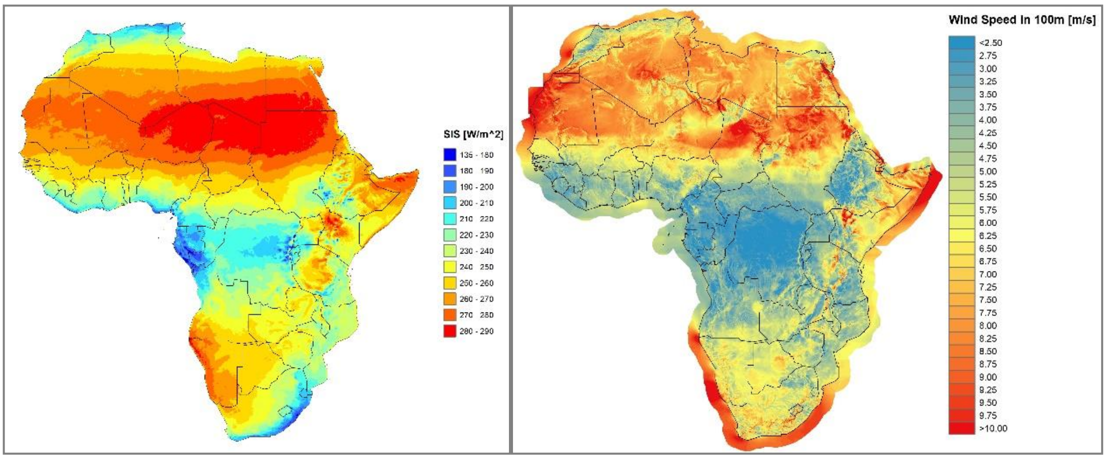

Figure 1: Mean Surface Incoming Shortwave (SIS) radiation 1983-2017 in W/m² (left) and Mean Wind Speed at 100 m in m/s (right). Based on SIS data from [3] *and wind data from* [4]*.*

As a second step, information about the African electricity infrastructure with a focus on the high voltage power grid is overlaid on the renewable potential maps (found in the long version of the paper). Contrary to Europe, where the information about the high voltage grid is readily available from the Transmission System Operators (TSOs) or from the European Network of Transmission System Operators for Electricity (ENTSO-E), information for African countries are scarce. Therefore, a tool [5] was developed to obtain the information from the open source community of Open Street Maps and implemented in the electricity economics model ATLANTIS of the Institute of Electricity Economics and Energy Innovation.

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Figure 2 shows the available grid data from Open Street Map with transmission lines of 100 kV and above. A more detailed description of the conversion process to get the grid data from Open Street Map into ATLANTIS will be found in the long version of the paper.

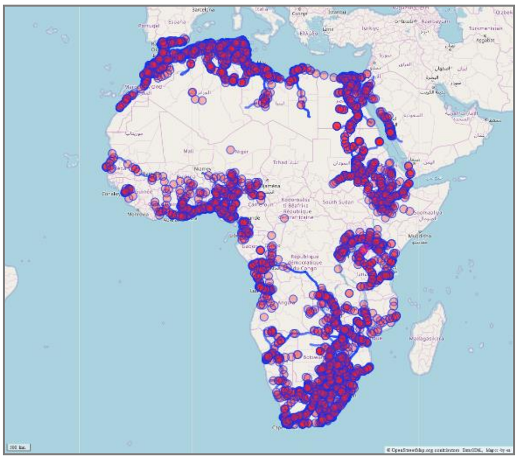

Figure 2: Grid data from Open Street Map [6] *with all lines of 110 kV and above.*

Conclusions

The African electricity system is divided into five major power pools: Northern African Power Pool (NAPP), Eastern African Power Pool (EAPP), Southern African Power Pool (SAPP), Western African Power Pool (WAPP) and Central African Power Pool (CAPP). The first four power pools can also roughly be seen in Figure 2.

The areas with the highest SIS radiation are located in the Saharan desert. This area is sparsely populated and therefore there is little existing electricity infrastructure. In order to utilize the solar potential in the Saharan desert, new HVDC lines would be needed to transport the electricity from the production site to the demand centres. Other drawbacks are the high temperatures in the desert, which reduce the efficiency of PV panels, and the water needed to clean the PV panels and the mirrors from concentrated solar plants (CSP) from sand [7].

Wind potential is mainly available in the northern part of Africa and also around the eastern and southern coast. These off-shore wind potentials could be interesting to use especially for South Africa, but the higher costs of off-shore wind parks are still a burden compared to on-shore wind parks.

References

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