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NEEDS FOR RENEWABLE ENERGY IN NIGER'S ELECTRICITY SUPPLY BY 2030

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ABSTRACT

In Niger, the majority of population today does not have access to electricity. This study analyzes how the electricity consumption could increase, and whether Niger's supply plans are sufficient to meet the growing demand. With the current efforts of electrification, Niger will have supply capacity of 1,361 GWh by 2020 and 1,444 GWh by 2024. This accounts only for the national capacity expansion plans. If this proves true, the increase in generation capacity will be unable to maintain the country's current electrification rate. This means, by 2021 there will be a supply deficit of 145 GWh, and it will reach to 783 GWh in 2030. In order to supply this deficit, e.g. with solar PV system, new installations ranging from 512 MW to 682 MW would be required by 2030.

Keywords: Electricity access, scenarios, solar photovoltaics, Niger, rural electrification

NONMENCLATURE

GHG	Greenhouse Gas
IEA	International Energy Agency
NIGELEC	National Electricity Company of Niger
OECD	Organization for Economic Co-operation and Development
PV	Photovoltaics
SDG	Sustainable Development Goal
SONICHAR	Anou Aren Coal Company of Niger

1. INTRODUCTION

Widespread lack of electricity access in Niger is a major problem. In 2014, according to NIGELEC, only 25% of the country's population had access to electricity [1], [2], [3]. In the same year, the capital city of Niger, Niamey, had a percentage of population with access to electricity of about 93.95%; while Tillabery, the region which surrounds the capital city, had only 17.02%. In 2016, according to the World Bank, the percentage of people with access to electricity nationwide was only 16.22% (for urban areas 65.37% and for rural areas 4.68%) [4]. The access to electricity is not distributed throughout the country evenly.

This low access numbers stem from the lack of sufficient generation capacity to be able to reliably supply its current grid connected users. The local electricity production in the country only constitutes about 25% of the supplied electricity (includes NIGELEC and SONICHAR [5]), the rest is imported, mostly from Nigeria as shown in Figure 1.

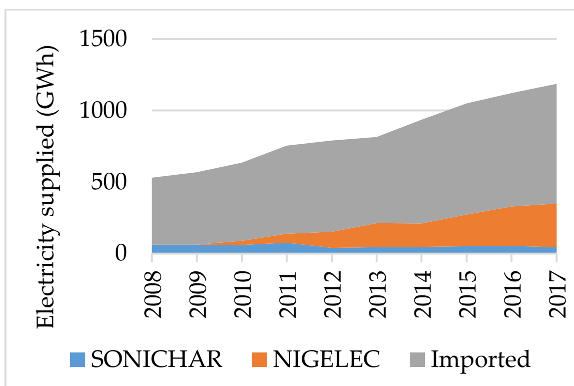

Fig 1 Source of the electricity supplied in Niger [5]

In its efforts of increasing local generation and expanding national electricity grid, Niger has applied for international funds for two projects [6], [7] one at the World Bank (WB) and the other at the African Development Bank (ADB).

The aim of this paper is to identify the future electricity demand, expected to increase with the projected economic and population growth in the country, and to assess its supply possibility with renewable energy technologies, mainly solar PV. This paper does not examine the economic analysis of electrification projects, nor does it compare the feasibility of renewable projects with grid expansion projects. Furthermore, it does not provide any specific environmental assessment of the "to be implemented" renewable energy projects.

2. MATERIAL AND METHODS

This study analyzes how the electricity consumption could increase under the influence of different factors, and whether Niger's plans are sufficient to supply the growing demand. The effects of three factors are considered: population, sector employment and economy.

These factors are subdivided into indicators with which scenarios of demand were built and compared to the electricity expansion plans of the country. The expansion plans are limited to local increase of generation capacity and assume that the amount of electricity imported from Nigeria will stay constant throughout the calculation period. The overall methodology followed can be seen in Figure 2.

2.1 Future supply

The yearly available amount of electricity per year to supply its population can be obtained by adding the generation capacities of planned projects to the current electricity supply values (Figure 1), while keeping the amount of electricity imported from Nigeria at constant to the level of 2017. Figure 3 presents this supply scenario under the assumptions that the planed generation plants are finished within the proposed timeframe and they operate at their rated capacities at least until 2030.

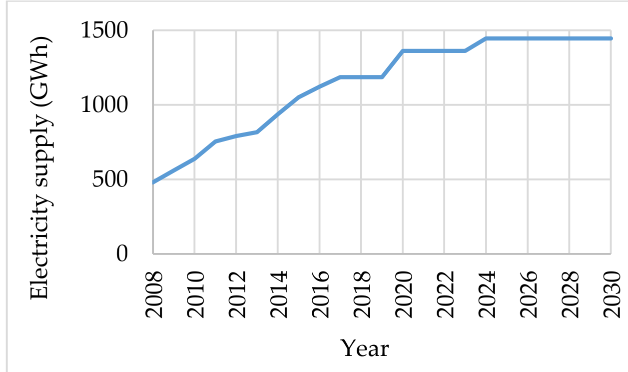

Fig 3 Available electricity supply in Niger [6], [7]

2.2 Demand scenarios

An indicator based approach was followed to model how different scenarios would affect the electricity demand until 2030. A total of 9 scenarios were built: one keeping the electricity demand growth from 2008 to 2017 at constant until 2030 (to be referred as base scenario), and 8 others that account for variations in population growth (scenarios 1-4) and employment and economic changes (scenarios 5-8).

2.3 Renewable share

In order to integrate the role renewable energy in the future electricity mix of Niger, the difference

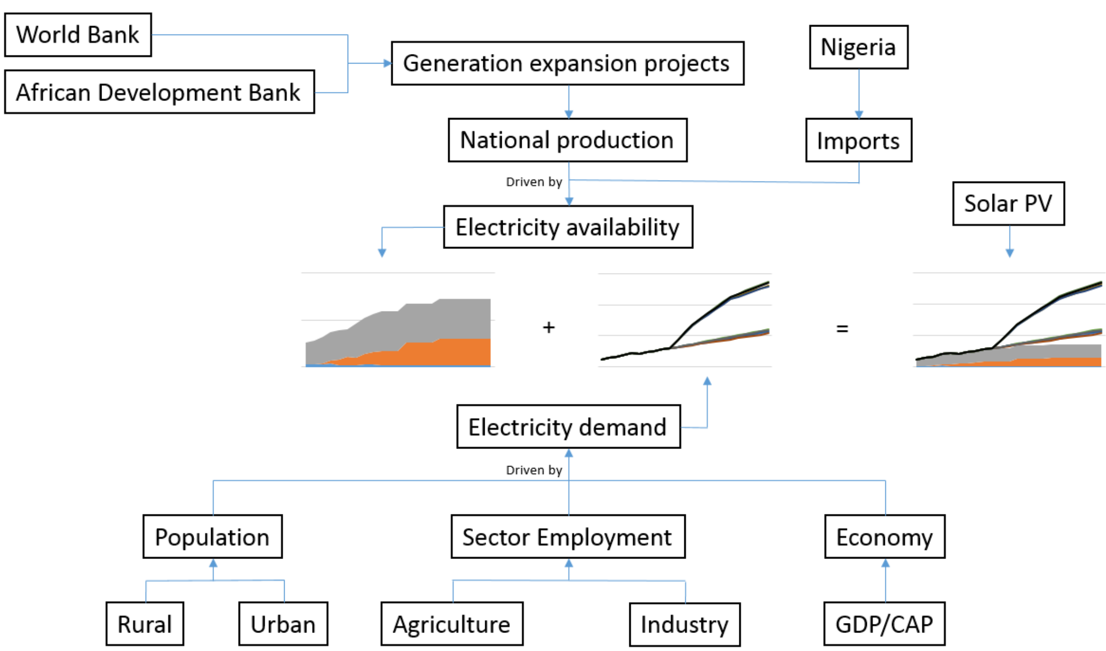

Fig 2 Schematic flow chart of the methodology followed

between the planned supply and the projected demand is supposed to be met with solar PV generation.

3. RESULTS AND DISCUSSION

3.1 Planned supply vs. projected demand

While comparing the planned supply with the base scenario for demand growth, which follows the demand growth trend between 2008 and 2017, it was found that there will be already a supply deficit, as shown in Figure 4. Out of other 8 demand scenarios, only one would result in a decreased demand growth than the base scenario. Even in this case, the demand for electricity would still exceed the planned supply by a big margin.

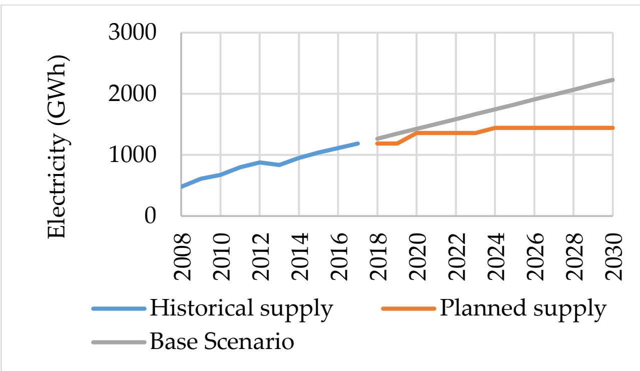

Fig 4 Electricity demand and supply: past and future

3.2 Demand scenarios

The influence of each indicator in the future electricity consumption was simulated by finding the change in electricity consumption between 2008 and 2017 in relation with each individual indicator. The study analyzed the effects of multiple indicators and their individual influence was compared and a weight was assigned to each. The weight assigned [8] to each indicator can be seen in Table 1. Because the study did not directly mention any social indicator and its influence, the indicator "total population" is assumed to represent any social or behavioral influence in the electricity demand of the population.

Table 1 Indicator weights

Indicator	Weight %
GDP/cap $2010	0.602%
Total population	5.213%
Rural population	6.840%
Employment in agriculture %	15.148%
Urban population	21.926%
Employment in industry %	50.270%

Beside the base scenario, the further scenarios considered are: described here: S1-Increased urban population growth; S2-Increased rural population growth; S3-Decreased rural population growth; S4-Increased urban population growth and decreased rural population growth; S5-Employment shift from agricultural to industrial sector and increased GDP/cap; S6-Employment shift from agricultural to industrial sector, increased GDP/cap and decreased rural growth rate; S7- Employment shift from agricultural to industrial sector, increased GDP/cap and increased urban growth rate; and S8-Employment shift from agricultural to industrial sector, increased GDP/cap, decreased rural growth rate and increased urban growth rate. The electricity demand under each of these scenario can be seen in Figure 5. In scenarios 1 to 4, the demand ranges between 2145 GWh and 2360 GWh in 2030, while the demand of scenarios' 5 to 8 ranges between 5150 GWh and 5400 GWh. This dramatic change is due to the weightage values assigned to each indicator.

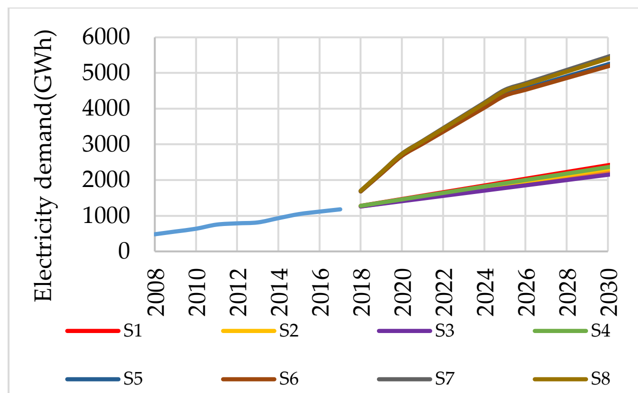

Fig 5 Electricity demand under different scenarios

From these results two points can be highlighted. Firstly, they reflect the agriculture's dominance in the country as well as only a very small role of industrial sector. Secondly, the electricity availability would need to increase dramatically if Niger would want to develop its industrial sector to the levels considered in this study (From 7.57% of the total employment as industrial employment in 2017 to 11.17% as industrial employment by 2025, and 11.89% by 2030).

3.3 Role of renewable energy in electricity supply

From Figure 5, it is apparent that supplying the demand under scenarios 5 to 8 with renewable energy alone would be unrealistic within the timeframe considered in this study. However, the base scenario demand could be supplied with renewables given that the heavy influx of renewables would only be needed after 2025 (with increasing demand between planned project completion dates), as can be seen in Figure 6.

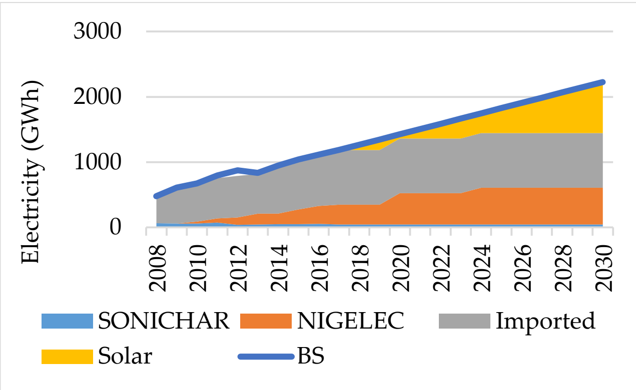

Fig 6 Electricity demand under base scenario and supply

The extra capacity needed for scenarios S1 to S8, if it were to be supplied solely with solar PV, would be between 0.5 and 1 GW solar installations for scenarios S1 to S4 and between 2.5 and 3 GW for scenarios S5 to S8. Figure 7 presents the ranges for each of these scenario. The uncertainty values were calculated by using quality factor (performance ratio) values between 0.6 and 0.8.

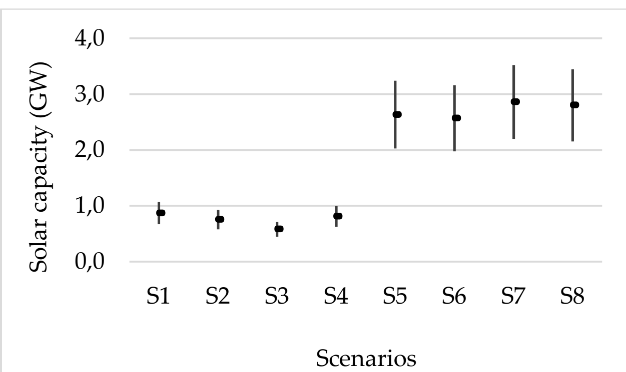

Fig 7 Solar installations required to meet scenarios' demand

If the capacity required to meet the demand of the base scenario were to be installed, and the amount of electricity imported from Nigeria were to stay at the value of 2017, the electricity mix in Niger in 2030 would be as shown in Figure 8.

Niger is one of the countries in the world with the lowest rate of electricity access. Solar PV is an appropriate technology to meet the future electricity supply. Standalone and mini-grids can be used to reach remote locations without incurring on substantial and sometimes uneconomical grid expansion projects. However, to meet the sustainable development goals (SDGs) of the United Nations, one of them being the

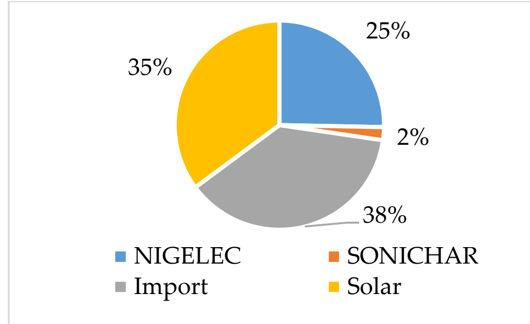

Fig 8 Electricity mix in 2030 with solar PV for base scenario

energy access to all (SDG 7), these installations need to be much higher.

3.4 Significance of the study in international context

According to the Center for Global Development, 63% of the annual greenhouse gas (GHG) emissions are produced by developing countries [9]. And this figure is expected to grow and outpace the emissions from the OECD (Organization for Economic Co-operation and Development) countries over the coming decades due to their higher rate of economic growth and continued use of fossil fuels [10]. The amount of GHG released between 1751 and 2016 by the developed world ranged between 50 and 400 billion tons in comparison to the amount released during the same period by West Africa barely 500 million tons (excluding Nigeria, where the emissions are in 5 billion tons range) [11]. Percentage wise, Sub-Saharan Africa (where 14% of the world's population live) only has an emission share of 2% [12].

By using solar PV to supply for the electricity needs of (not only) rural villages in developing countries, the increase in the expected emissions could be tapered into a more gentle growth line.

Solar PV is undoubtedly a solution to electricity access deficiencies. It already paves a way to effectively decarbonize the European electricity supply [13]. It has also been identified as a major player in a cost competitive energy supply system [14]. Studies have also identified its importance for rural electrification in developing countries [15]. There are many benefits of solar PV use to supply electricity to remote regions and its cost competitiveness over grid extension [16]. All these reasons highlight that solar PV must represent a major resource for electricity supply in a solar radiation rich country like Niger.

According to IEA (International Energy Agency) figures, the final energy consumption on a global scale can be divided into residential (22%), industry (29%), transport (29%), other energy uses (12%), and non-energy uses (9%) [17]. It is clear that replacing the source of energy from all those sectors with renewables is not an easy target. Replacing the energy consumed in the residential sector alone could, however, represent an easier first step, where solar PV can find directly its use.

The methodology employed in this work is of an interest to the scientific community working in the field of energy scenario modelling and renewable energy integration to the grid, especially solar PV.

4. CONCLUSIONS

The study showed that there is a big deficit in electricity supply to the people in Niger. With its growing population and expected economic growth the demand will increase in near future further. One of the most convincing solutions to supply this electricity, both in grid connected and off-grid locations, is from solar PV. In order to achieve this goal, solar PV installations in the range of 0.5 to 3 GW will be needed under different demand scenario by 2030. Although these numbers are high looking at the current solar PV use in the country, they are less than annual installations if looked at other countries' PV installation in the recent years (China, Japan, Germany, etc.). With the proper planning and investment/energy policies, this could be achieved in the country by 2030.

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