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Application of a Long-range Energy Alternatives Planning System to Assess Electricity Supply and Demand in Niger

1st Hamza Abarchi Halarou
University Abdou Moumouni
West African Science Service Centre on Climate Change and Adapted Land Use
Niamey, Niger.
hamza.h@edu.wascal.org

2nd Abdou Latif Bonkaney
University Abdou Moumouni
Ecole Normale Supérieure
Department of Physics
Niamey, Niger.
babdoulatif@yahoo.fr

3rd Daouda Abdourahimoun
University Abdou Moumouni
Faculty of Sciences and Technologies
Department of Physics,
Niamey, Niger
daoudaabdourahimoun@gmail.com

4th Yacouba Moumouni
Higher Colleges of Technology
Ras Al Khaimah Women's College
Electrical and Electronics Engineering
Ras Al Khaimah, United Arab Emirates
ymoumouni@hct.ac.ae

5th Saïdou Madougou
University Abdou Moumouni
Ecole Normale Supérieure
Department of Physics,
Niamey, Niger.
nassara01@yahoo.fr

***Abstract*— This study analyses Niger's current and future electricity supply and demand scenarios by exploring various resource potentials and their environmental impact. Based on the government of Niger's (GoN) plans, this study uses LEAP (Long-range Energy Alternatives Planning System) software to assess three policy scenarios, including 1) Reference (REF), 2) More Renewable Resources (MRR), and 3) More Renewable energy and Natural gas (MRN) from 2020 (base year) to 2050 (end year). The associated greenhouse gas (GHG) emissions (CO_2, CH_4, and N_2O) are assessed for each power generation scenario based on the IPCC Tier 1 database. The results reveal that electricity demand is projected to reach 13.2 and 16.6 TWh, respectively, in the REF and the high-demand scenarios (MRR and MRN). This demand will be met at around 84% in the REF scenario and 87% in both the MRR and MRN scenarios by 2050. As early as 2050, Nigeria's electricity imports will amount to only 12% of the total. Also, the CO_2, CH_4, and N_2O emissions will be drastically reduced, respectively, to 43.13%, 51.5%, and 80.7% in the MRN scenario compared to the REF scenario.**

***Keywords*— *electricity supply, electricity demand, LEAP, GHG emissions, scenarios, Niger*.**

I. Introduction

Over the past few decades, electricity demand in Niger has risen steadily as a result of population growth and rapid urbanisation. For example, since 2000, the country's electricity demand has increased by over 200%[1]. However, this demand has only been partially met due to insufficient supply and a lack of effective planning. As a result of the mismatch between supply and demand, the country's economic development is hampered during hot seasons. The current electricity supply is heavily dependent on electricity imports from Nigeria, which account for 71%[1].

In line with this, the Government of Niger (GoN) adopted in 2018 (SNAE, Décret No. 2018-743) a National Electricity Access Strategy (NEAS) intending to improve the electricity access rate to 80% by 2035, which is still at an undesirable state (low access, heavily dependent on electricity imported from Nigeria, and high discrepancies between urban and rural areas). As part of implementing this strategy, the GoN, with the support of its partners, is undertaking several electricity access projects.

Hence, a clear view of Niger's electricity supply and demand is essential for its long-term socio-economic development [2]. Therefore, long-term electricity supply and demand modelling are crucial for forecasting future electricity trends, thereby contributing to strong energy-policy strategies.

Many studies have addressed the long-term electricity supply and demand forecast in several countries across the world and showed its need and its importance for the socio-economic development and climate change mitigation. For instance, in Pakistan, Mirjat et al. [3] reported that the application of energy modelling both at the government and academic level for energy system analyses and policy formulation should be undertaken to test various hypotheses and policy perspectives. In India, Dash et al.[4] concluded that by forecasting the demand, the power generated using the available storage facilities can be accommodated, and this will help the power grid to maintain a balance between power sources. In Ethiopia, Gebremeskel et al.[5] showed that it is possible for countries to potentially reduce its biomass dependency and CO2 emission by focusing on long-term policies and implementing various strategies that can have a significant impact on the future electricity sector.

More specifically, some studies have been also conducted in the same direction in Niger. For example, Yacouba et al.[2], [6] concluded that even with the additional capacity of the diesel plant) and the solar PV plant system installed at Gorou Banda (2017-2023) and the full commissioning of the 130 MW Kandadji dam, Niger could only be energy self-sufficient between 2018 and 2030, and links with Nigeria need to be firmly strengthened for the country to meet future electricity challenges. Similarly, Pouye et al.[7]emphasised that the implementation of small solar and wind power plants on load centres, taking into account socio-economic and climatic parameters, would be a key factor in paving the way to energy independence in Niger.

Thus, the aforementioned studies on Niger's long-term electricity supply and demand planning considered the river zone (Western zone), which represents only one of the four zones of the Nigerien power grid, while in the remaining three zones, some additional power plants are fully operational. Although approx. 68% of the electrical load is concentrated in the Western zone; it is worth investigating the remaining percentage to shed more light on the national power grid.

Hence, this study aims to fill in the knowledge gap on long-term energy forecasting by focusing on the new energy policies in the country. The general objective of this study is to assess the future electricity supply and demand,

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considering socioeconomic and climate change parameters. In the scope of this work, we develop a LEAP model based on the historical relationship between electricity, demographic parameters, and various power generation plans to analyze: 1) the future electricity demand in Niger by 2050 considering the fast-changing socioeconomic variables, 2) the supply-demand balance in the medium to long-term, 3) the future electricity supply pathways impact on the social (people), economy (profit), and environment (planet). The rest of the paper is organised as follows: Section 2 describes the data and methods used in the study; Section 3 presents the results and discusses; and Section 4 concludes the paper.

II. Methodolgy

A. *Study area*

In this work, the study area is Niger (12°N-24°N; 0°E-16°E), a West African country with a land area of 1,267,000 km^2 and nearly 25 million of the total population[8]. Niger has an electrical grid which is managed by the Socité Nigérienne d'Electricité(NIGELEC) and divided into four electrical zones (Fig. 1): 1) the river zone, including the main towns of Tillaberi, Dosso and Niamey, accounts for 68% of consumption and is served by power supplies from Nigeria, the Gorou Banda power plant and the Istithmar power plant of Goudel, 2) the North Centre-East zone, comprising the Tahoua, Maradi and Zinder regions. This zone is also served by electricity imports from Nigeria and local NIGELEC production facilities, 3) the East zone, located around the city of Diffa and currently supplied by local production facilities owned by NIGELEC, and 4) the North zone, which covers electricity demand in Agadez, Arlit and Tchirozerine. In this zone, electricity is supplied by the coal company's Anou Araren power plant and local generation facilities[9].

In addition to the four network zones, NIGELEC also manages mini-grids supplying isolated areas, which account for 2.68% of total electricity consumption[1].

The end users of electricity are broadly classified into four sectors: household, industrial, administration and agriculture. The main sector of electricity consumption is household and accounts for 53.8%, followed by administration (26.5%), industrial (19.1%) and agricultural sector (0.6%) in 2020[10].

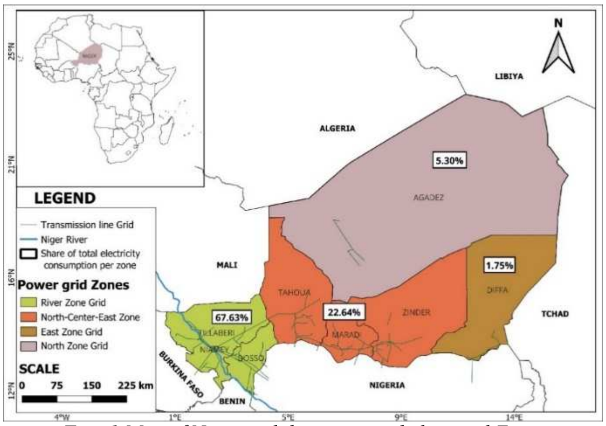

Fig. 1.Map of Niger and the associated electrical Zones

B. *Historical electricity generation and demand data*

The historical electricity generation and demand data are yearly that span from 2000 to 2022 as represented in Fig.1. It can be observed a significant increase of electricity demand over the last two decades, with an average growth rate of 8%/year. The gap between electricity supply and demand is significant and has reached 720 GWh in 2022.

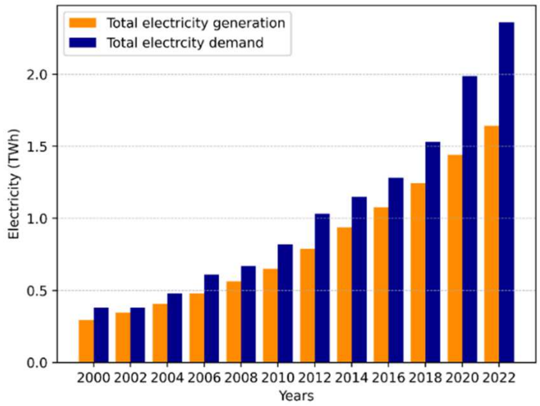

Fig. 2. Historical Electricity generation and demand in Niger[10]

Fig.2 shows the electricity consumption by sector from 2010 to 2020. It can be seen that the structure of electricity consumption is dominated by the household sector, with a share ranging between 56% and 54%, and an average growth rate of 6.6%/year. After a slight increase from 2010 to 2012, the industrial sector's share of electricity consumption decreased from 32% in 2012 to 19% in 2020. The share of the administration sector has varied between 15% in 2011 and 26% in 2020, while the agriculture sector's share remains around 1%.

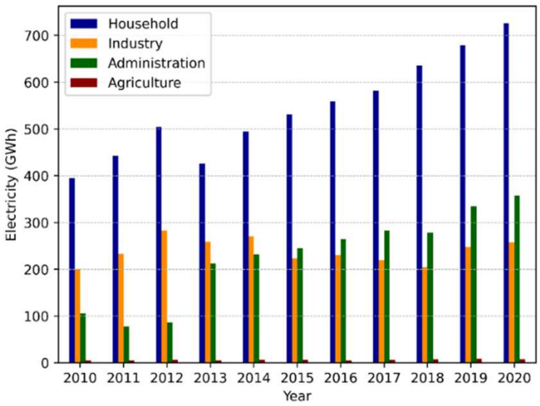

Fig. 3. Historical electricity consumption by sector in Niger[10]

C. *Methods*

This study proposes LEAP to forecast three policy scenarios, viz., 1) Reference scenario (REF), 2) More Renewable Resources (MRR) scenario, and 3) More Renewable Energy and Natural gas scenario (MRN)from 2020 to 2050. The reference year used for the model was 2020 because of the availability of electricity demand data for each sector. The end year of the model was 2050, in line with the IRENA roadmap, that the share of renewable energies in the electricity sector would rise from 25% in 2017 to 85% in 2050, mainly through growth in solar and wind power generation[11].The LEAP model framework developed for this study is shown in Fig.3.

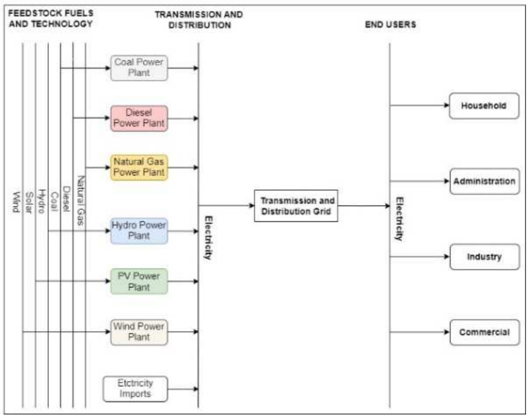

Fig. 4. LEAP modelling framework for electricity generation and demand

1) Calculation in the LEAP model

When evaluating electricity demand on LEAP, the model calculates the final energy demand by multiplying the overall activity level and the overall energy intensity of each branch or sector, as shown in Equation (1) [12].

$$ED_{b,s,t} = AL_{i,s,t} \times EL_{i,s,t} \quad (1)$$

Where, ED is final energy demand, AL refers to activity level, EI stands for energy intensity, i represents the sector, s shows scenario, and t is the time in years.

For the electricity generation assessment, the energy transformation and the net energy consumption are calculated into LEAP model by means of Equation (2) [12]:

$$ET_p = ETP_{sec,tec} \times \left(\frac{1}{f_{p,sec,tec}} - 1\right) \quad (2)$$

Where, ET is net consumption for transformation, ETP indicates the product obtained from the transformation process, $\frac{1}{f_{p,sec,tec}}$ represents the energy transformation efficiency, tec refers to technology, p is the type of primary energy, and sec refers to the type of secondary energy.

The total GHG emissions from electricity generation are calculated, as indicated in Equation (3) [12].

$$GHG_T = \sum_s \sum_m \sum_{sec} ETP_{sec,m} \times \frac{1}{f_{sec,m,s}} \times EF_{sec,m,s} \quad (3)$$

here, GHG_T is Greenhouse Gas Emissions of the energy transformation process, ETP stands for transformation product, $\frac{1}{f_{sec,m,s}}$ shows energy transformation efficiency, and EF refers to Emission Factor from a unit for a primary energy source type $\boldsymbol{s}$ secondary energy type sec with equipment m.

2) Scenarios

a) Reference Scenarios (REF)

For electricity demand assessment, the scenario is developed according to the historical trend of electricity consumption by sector. Furthermore, demographic parameters such as population growth rate, urbanization rate, urban and rural electrification rate and national electrification rate etc., are also taken into account, as presented in Table 1.

TABLE I. SUMMARY OF DEMOGRAPHIC DATA

Variables	Values	References
Total population in 2020 (Million)	22.75	(INS, Niger)
Urban population	16%	(INS, Niger)
Rural population	84%	(INS, Niger)
Population having electricity in 2020	15.72%	(INS, Niger), (NIGELEC, Niger)
Urban population having electricity in 2020	74.39%	(INS, Niger), (NIGELEC, Niger)
Rural population having electricity in 2020	1.55%	(INS, Niger), (NIGELEC, Niger)

To assess the electricity supply, the GoN and NIGELEC's current plans and policies were considered in this scenario. It involves increasing the national electricity access to 80% by 2035. The technical electrification options aim to achieve by 2035 1) 85% through the national power grid, 2) 5% by various mini-grids, and 3) 10% through distributed solutions. Under the NEAS, a minimum target of 30% of Renewable Energy Sources (RES) integration in the Nigerien energy mix has been considered, which is set to come up by 2030 [13].

b) More Renewable Ressources Scenarios (MRRS)

This scenario inherits all variables from the REF for electricity demand, except in the industrial and agriculture sectors. Therefore, to describe an essential development of industries in Niger, it is assumed that about 30% of total electricity demand will come from the industrial sector by 2050 compared to 19% in the base year (2020). Despite the fact that agriculture in Niger is too dependent on rainfall and, so far, traditional, the sector accounts for about 40% of the country's GDP [14]. To reflect a development towards modern agriculture, a minimum of 5% of the sector's electricity consumption is assumed by 2050, compared with 1% in 2020.

According to this scenario, RES (PV, wind, and hydro) will increase in supply compared to the 30% integration targeted in the NEAS. Seeing the enormous RES potential, it will be an option to enhance the country's electricity supply and a way to mitigate greenhouse gas emissions.

c) More Renewable and Natural gas

Knowing the intermittent nature of RES and their expected high share in Niger's electricity mix, the natural gas-fired power plant is identified as an optimistic option to enhance the country's electricity supply and improve flexibility. Indeed, Natural gas is a potential complement to RES, as it can cover the intermittency of electricity generated, for example, when the wind isn't blowing, or the sun isn't shining. Also, natural gas (NG) has the ability to provide a relatively low-carbon backup solution during peak times. Hence, this ability could be accounted as NG's major contribution to the energy transition [15]. For a more reliable electricity supply, this scenario considers that the most suitable option for Niger will be more hybrid (RES and Natural Gas).

III. RESULTS AND DISCUSIONS

A. Electricity Demand Forecast

Fig.4 presents the total estimated electricity demand considering the historical trends in the blue line and the high demand (industrial and agricultural sectors with a hypothetical 30% and 5% of electricity demand by 2050) in orange.

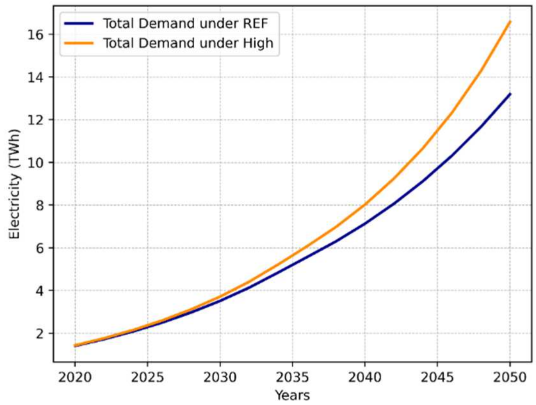

Fig. 5. Total electricity demand forecasted, 2020 – 2050

As represented in the blue line, the LEAP model estimated that electricity demand will likely increase from 1.4 TWh in 2020 (base year) to 13.4 TWh in 2050 (end year). The average yearly growth rate of the forecasted electricity is 8%. A similar increase in growth rate was found in the study of [16] in Ghana. As shown in Table 2, the main sector that consumes more electricity remains household, with about 75.9% of electricity demand at the end year. This energy consumption pattern is in line with the status quo [2]. The latter sector is followed by administration, industrial and agricultural sectors, respectively, with 15.3%, 8.3%, and 1.1%. The high share in household electricity demand could be directly due to population growth, rapid urbanization, and/or other social well-being. Further, these results are in accordance with the study conducted by [17]. A significant decrease in electricity demand share can be observed from 2020 to 2050 in the industrial and administration sectors, while a slight increase in the agricultural sector. This drop shows that based on the historical electricity consumption trends, the industrial sector of the country would remain at an undeveloped state even by 2050. In the same case, the agricultural sector remains still unmodernized in the end year.

TABLE II. SHARE OF ELECTRICITY DEMAND BY SECTOR (REF)

Year	Characteristic	Households	Industry	Administration	Agriculture
2020	Sector share (%)	53.9	19	26.4	0.6
2050		75.9	8.3	15.3	1.1

To avoid an ongoing industrial underdevelopment situation in Niger, and also to reflect a development towards modern agriculture, it is assumed that by 2050, about 30% and 5% of electricity demand will come from industries and agriculture sectors. After configuring this assumption in the LEAP model, Fig.4 (in orange) presents the estimated electricity demand. Under this scenario, electrical power demand will increase from 1.4 TWh in the base year to 16.7 TWh in 2050. It is worth pointing out that the main end user of electricity is still the household sector, with a share of 48.6% at the end year. This sector is followed by Industry (30.1%), Administration (16.3%), and Agriculture (5%), as shown in Table 3. Between 2020 and 2050, the share of electricity demand originating from the industrial sector increased by 11.1%, while in the agriculture sector, it rises by 4.4%. This increase implies a relatively reasonable development of the industrial sector in the country by 2050 and also a step towards modern agriculture. These results align with the status quo found in [18].

TABLE III. SHARE OF ELECTRICITY DEMAND IN THE HDS

Year	Characteristic	Households	Industry	Administration	Agriculture
2020	Sector share (%)	53.9	19	26.4	0.6
2050		48.6	30.1	16.3	5

B. *Electrcity Supply Forecast*

1) *Reference Scenario(REF)*

Fig.5 presents the simulation results of the model under the REF scenario for existing and planned electricity generation. According to NEAS targets, the installed capacity is expected to increase significantly by 2030. These results show that about 1830 MW of installed capacity is required to meet the growing electricity demand by 2050. The maximum share is from a low-cost electricity generation source of Coal with 637 MW of the installed capacity. In its new electricity access policy, the government has set a target of 30% renewable energy [19]. Hence, the simulated results show that 660 MW are from renewable sources (*viz.*, photovoltaic, wind, and hydro), and account for 36% of the total installed capacity share. These results align with the national government policy mentioned above and remain consistent with the notion that by harnessing the vast potential of renewable energies, sub-Saharan countries could achieve the goal of universal access to electricity more rapidly[20].

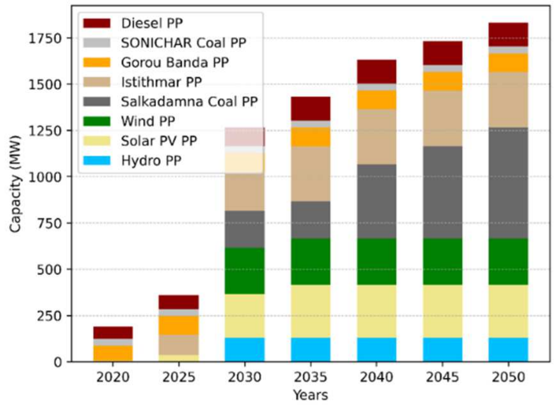

Fig. 6. Total installed capacity under the REF

Similarly, the total electricity generation will increase from 1.5 to 10.3 TWh between 2020 and 2050, as shown in Fig.6. In 2050, coal and diesel will account for 37.2% and 24.3% of electricity generation, respectively. Renewable sources (PV, Wind, and Hydro) represent 23.1% of total electricity generation at the end year. Electricity imports will account for 14.6% of total electricity generation by 2050. Between 2020 and 2050, coal and diesel-based electricity generation increased by 33.1% and 5.4%, respectively. However, a significant decrease in electricity imports of 61.4% is observed in the total electricity generation. This reduction in the share of electricity imports shows that the reliance on electricity imports (76% in 2020) of Niger could be drastically reduced (14.6%) by 2050, which aligns with the existing government policies to reduce the heavy reliance on electricity imports. The increase in the share of electricity generation from renewable energy (1% to 24.3% between 2020 and 2050) is consistent with the GoN's renewable energy integration policy. To meet the growing electricity demand, imports from Nigeria should be maintained, whereas its share will significantly decrease by the end year. As has been the case for many decades, these results show that

Niger's electricity generation sector will be self-sufficient, and also RES will play a significant role in the electricity mix.

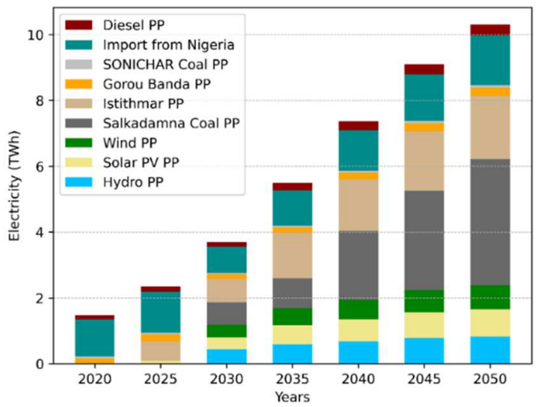

Fig. 7. Total electricity generation in the REF Scenario

2) More Renewable Resources Scenario (MRRS)

To counter climate change and address sustainability issues, renewable energy sources (RESs) like solar, wind, and hydro are expected to play a key role in mitigating greenhouse gas emissions. Fig.7 shows the total installed capacity with an increase from 190 MW to 2269 MW between 2020 and 2050. By 2050, the installed capacity of RES will be 1402 MW, up from 7 MW in 2020. Coal and diesel capacity have also increased, reaching 437 MW and 429 MW, respectively.

Indeed, the share of RES has risen considerably from 1% to 60% in 2050, compared to the 36% of the REF scenarios. Therefore, these results show that RES, if harnessed, can contribute considerably to meeting Niger's growing electricity demand. These findings are consistent with the notion that diversification of the electricity generation mix with renewables would reduce the country's vulnerability to fossil fuel price shocks and reduce global warming potential [21].

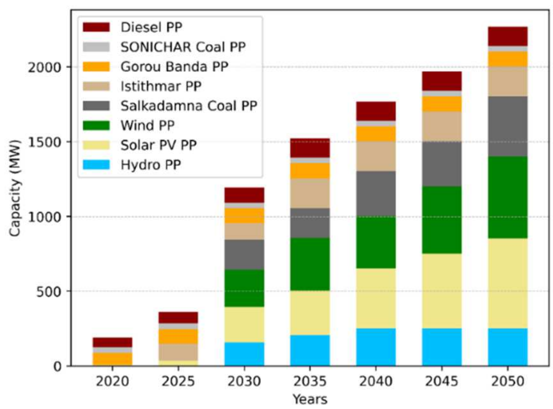

Fig. 8. Total Installed capacity in the MRRS

At the same time, the total electricity generation output increased from 1.5 to 12 TWh between the base and end year, as shown in Fig.8. 41.9% of total electricity generation is from RES, while 22.4% and 22.9% are, in that order, from diesel and coal-based generation in 2050. Therefore, electricity imports represent only 12.7% of the total electricity generation. Compared to the REF scenario, the share of coal and diesel-based generation decreased, respectively, to 14.3% and 1.9% in 2050. A reduction of 1.9% in electricity imports is observed compared to the REF scenarios. On the one hand, the high penetration of RES and the slight reduction in the share of coal and diesel in the electricity generation mix should result in a better environmental impact. On the other hand, the decrease in electricity imports will avoid Niger's heavy reliance on imports from Nigeria. However, to harness more RES due to their intermittent nature and to reduce considerably the share of diesel and coal (main GHG emitter), flexible power plants, such as NG-based plants, are needed.

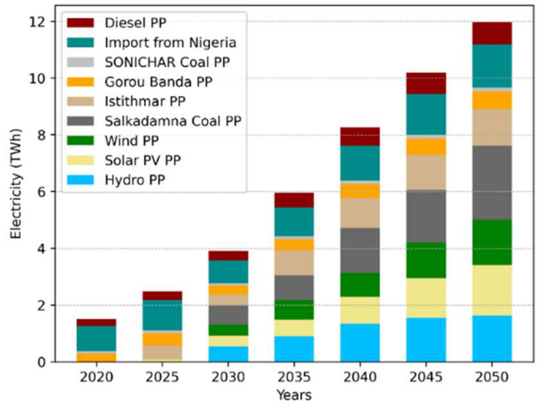

Fig. 9. Total electricity generation in the MRRS

3) More Renewable Energy and Natural Gas (MRN)

At this point, it is worth pointing out that an increase in the share of RES reduces the country's dependence on oil and coal. These two resources constitute the main GHG emitters. As a result, there is a need for flexible energy sources, such as natural gas to offset electricity demand due to the present lower capacity factors of RES-based plants.

Fig.9 presents the simulated results of the total installed capacity under the MRN scenario. The total installed capacity is slightly the same as in the MRR scenario. Also, RES's installed capacity exhibits the same share (about 63%), as in the previous scenario. In contrast, the shares of coal and diesel are considerably reduced to 4.6% and 2.3%, respectively, in 2050. The reduction in the share of installed capacity of coal and diesel resulted in the increase of Natural gas capacity to 30% of the total installed capacity. Therefore, the new installed capacity from natural gas-based plants should enhance the overall installed capacity from all sources to meet the electricity demand and shall impact on the mitigation of greenhouse gases from coal and oil-based electricity generation.

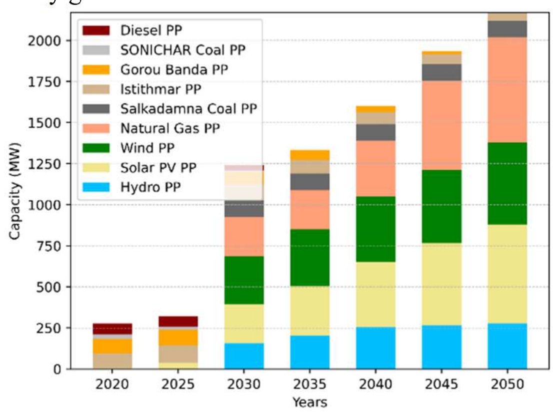

Fig. 10. Total installed capacity in the MRN

The electricity generation, under the MRN scenario, is presented in Fig.10. Coal and diesel-based electricity generation represent only 4.6% and 2.6%, in that order, of the total share of electricity generation in 2050. The RES and NG generation are the main sources of electricity generation, accounting for 40.9% and 40%, respectively, of the total share of generation by 2050. A significant decrease of 12.7% in the share of electricity generation from imports is observed at the end of the model. This decrease, in the shares of coal and diesel, is an optimistic scenario. This situation will contribute to lessen the effects of GHG emissions in Niger. Hence, these results are consistent with the study conducted by [22]. The decrease in the share of electricity generation from imports shall reduce the reliance of Niger on electricity imports. It can be inferred from all the above-mentioned scenarios that the MRN is most environmentally friendly.

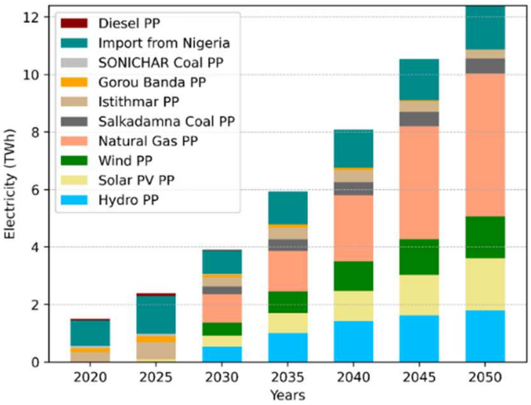

Fig. 11. Total electricity Generation in the MRN

C. Environmental Impacts

In the LEAP model, emissions from diesel, NG, and coal power plants are estimated using the Technology Database (TED). The estimated emissions factors were based on the IPCC Tier 1 database. The simulated results of the three major GHG sources in the first and end year for the three scenarios are presented in Table 4.

TABLE IV. GHG EMISSIONS IN THE DIFFERENT SCENARIOS

Emission	Units	2020	2050		
			REF	MRR	MRN
CO_2	Million Tons	0.4	5.1	4.2	2.9
CH_4	Thousand Tons	0.5	3.3	3.2	1.6
N_2O	Thousand Tons	1.1	17.1	13.4	3.3

1) Carbone dioxide (CO_2)

Fig.11 shows the estimated CO_2 emissions for the three scenarios. The simulated results show that Carbone dioxide emissions will increase from 0.4 million tons to 5.1 million tons in the REF scenario between 2020 (base year) and 2050 (end year). This increase is due to the fact that most upcoming power plants are mainly fossil fuel-based (i.e., Diesel and Coal). Similarly, an increase is also observed to 4.2 and 2.9 million tons, respectively, in the MRR and MRN scenarios by the end year. However, these emissions are less by 43.14% and 18% in MRR and MRN compared to the REF scenario. The step down in Carbone dioxide emissions in the MRN scenario is due, on the one hand, to the high integration of renewable energy sources on the other hand, this reduction may be attributable to the replacement of aging oil and coal power plants with NG-based power plants. The latter plant emits fewer GHGs than diesel and coal-based plants. These results align with the view that reductions in GHG emission levels can be achieved if renewable energies play a major role in the country's energy plan [23].

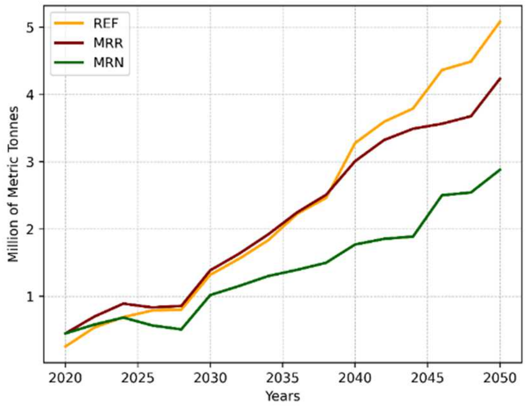

Fig. 12. Total CO2 emission in the REF, MRRS and MRN

2) Methane (CH_4) emission

As one of the major components of GHGs, methane emissions are projected to increase considerably under the REF and MRR electricity generation scenarios. Table 4 shows that methane emissions would increase from 500 tons in the base year to 3300 tons (REF), 3200 tons (MRR), and 1600 tons (MRN) in 2050. Fig.12 shows that methane emissions are more important in the REF and MRR scenarios compared to the MRN scenario. The steep rise in emissions in the REF and MRR is due to a high share of oil and coal-based power plants, which improve the flexibility of intermittent renewable electricity generation. After all, the MRN scenario would be more environmentally friendly as methane emissions are less compared to the REF and MRR scenarios.

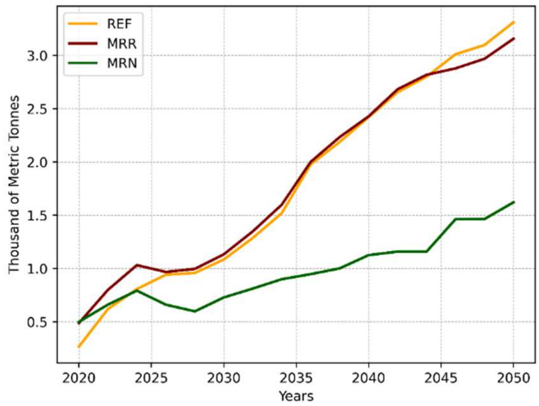

Fig. 13. Total CH4 emission in the REF, MRRS and MRN

3) Nitrous oxide (N_2O) emission

Nitrous dioxide is the third GHG considered in this study. It is mainly emitted by coal-based generation and a certain amount from oil and natural gas power plants. As presented in Table 4 nitrous dioxide emissions are estimated to increase from 1100 tons in the base year to 17.1, 13.4, and 3.3 thousand tons, respectively, under the REF, MRR, and MRN scenarios. These emissions are the lowest in MRN due to the high share of renewable energy and the lowest share of coal and oil-based electricity generation. The results in Fig.13 show and confirm that the MRN scenario has the lowest emissions of greenhouse gases among the three scenarios, therefore more environmentally friendly.

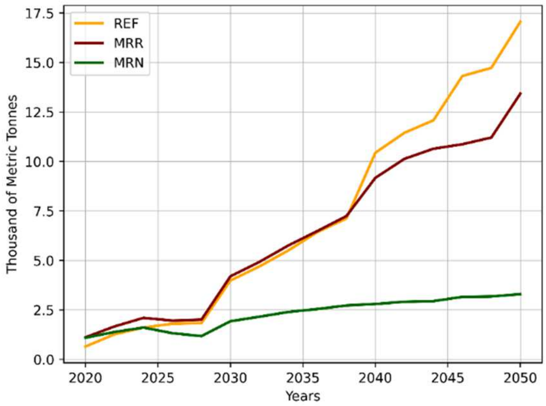

Fig. 14. Total N2O emission in the REF, MRRS and MRN

IV. CONCLUSIONS AND RECOMMENDATIONS

The analysis of simulated results shows that, electricity demand at the base year is 1.4 TWh and is projected to reach 13.2 TWh and 16.6 TWh, respectively, in the REF and the high-demand scenarios. In both scenarios, the largest consumer of electricity is the household sector. The results revealed that by 2035, Niger's electricity supply under the REF scenario will meet approximately 84% of electricity demand, which will decrease by 2050 due to rapid population growth, with only 78% of demand met.

Similarly, in the MRR and MRN scenarios, around 87% of electricity demand (high-demand scenario) will be met by 2035, but this proportion is expected to fall by 2050 due to the high demand for electricity from the industrial sector, which is estimated to be around 75%. To significantly reduce the heavy dependence on electricity imports from neighboring countries, Niger's electricity demand in all three scenarios will be met by an average of over 70% by 2050.

The MRR and MRN scenarios showed the high share of renewable energy sources and their good integration into the electricity generation mix. As a result, the decrease in fossil fuel-based electricity generation certainly leads to a reduction in greenhouse gas emissions. Accordingly, GHG emissions are slightly the same in the REF and MRR scenarios, while an important drop is observed in the MRN scenario about 2 times compared to the REF and MRR scenarios. These reductions are due to the high share of RES and the decrease in the share of major sources of GHGs emitters, namely coal and diesel-based electricity generation. Consequently, the MRN scenario is more environmentally friendly than the REF and MRR scenarios.

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