Original Research Article

Study of the impact of grid parity on the integration of renewable energies in the Cameroon's electricity market

ABSTRACT

the integration of renewable energies becoming crucial in the electricity market. Cameroon has set the target of achieving 25% share of renewables in its energy mix by 2030. The aim of this study is to analyze the impact of grid parity on Cameroon's electricity market. The methodology involved conducting an assesment of Cameroon's electricy system , then, using a questionnaire and open-ended interviews with electrical engineering experts, identifying the factors that hindering grid parity, and carrying out an analysis using quality tools such as the Ishikawa diagram, SWOT, PESTEL and Pareto diagram, to finally develop a strategic action plan using the 3P framework. The results show that from 2019 to 2024, the integration rate ranges from 0.04% to 0.84% according to the 2011 law governing Cameroon's electricity sector on renewable energies, and under the same conditions, from 2024 to 2030, the rate would evolve according to three scenarios, the high scenario at 3%; the median scenario at 2% and the low scenario at 1%. Based on feedback from the experts, 59 causes have been identified, including 21 weaknesses and 12 threats. The predominant causes are technical or technological, social, economic and political factors, which account fort 80% of the factor influencing the system and, consequently, 20% of the barriers to grid parity. We have therefore proposed a strategic action plan comprising four priority actions; (i) popularising techniques and technologies, (ii) strengthening the participation of social stakeholders in the planning and management of renewable energies, (iii) promoting mechanisms for procurement of green installations, (iv) updating national policy.

Keywords: Grid parity, renewable energy, integration, Cameroon's electricity market.

I. INTRODUCTION

A balance between supply and demand is the best way to ensure that the electricity market competitive and attractive to investors. It lays the foundation for a strategic approach that enables energy policy and climate policy to be aligned in the context of the energy transition. Indeed, the concept of green growth has become indispensable today for any development policy, and encompasses several concepts that bring new challenges, such as the circular economy, sustainable development, and energy efficiency (Guergaziz, 2021).

In 2011, the European Commission, together whit its partners launched the "PV Parity" project to propose to national policy-makers in 11 European Union countries (Austria, Belgium, the Czech Republic, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain and the United Kingdom) with supporting measures to achieve grid parity and beyond . The project report concluded that photovoltaics sector is increasingly shifting from an investor-driven market towards a market of responsible consumers. This shift can be explained by the transition from a market based on feed-in tariffs (Feed In Tariff) to support mechanisms centred on self-consumption (Clastres & Rebenaque, 2020).

In 2015, the work of Hugo Lequertier, Ouassat Abderazak, Rogissart Lucile and Sandevoir Claire highlighted the threats posed to the electricity market by renewable energies and suggested some possible solutions. In the case of the European Union, these involve: (i) adapting the energy system with greenhouse gas (GHG) emission quotas; (ii) setting meaningful prices for carbon dioxide (CO2) emissions; (iii) building a network that allows renewable energy to be fully integrated int the common market; (iv) reducing the price of electricity in the event of overproduction due to renewable energy; (v) granting subsidies for renewable energy as necessary temporary support; (vi) achieving grid parity for photovoltaics. This would enable individuals and businesses who so wish to invest in renewable electricity generation without the need state aid (Lequertier et al., 2015). However, the massive injection of renewable electricity into the interconnected grid has crowding out effects and requires storage systems to avoid jeopardizing the balance of the interconnected grid. This is why it is desirable for the share of renewable energy in the electricity mix does not exceed 30%, to allow solar electricity to approach grid parity (Percebois & Pommeret, 2018).

Electricity generation from so-called new renewable sources is now a priority in international climate commitments. In the case of Cameroon, this is underpinned by the National Development Strategy to 2030 (SND 30), particularly the energy and waste component, which aims to develop energy production from renewable sources and whose objective is to increase the share of renewable energy (excluding large-sacle hydro) in the electricity mix to 25% by 2035.

II. MATERIALS AND METHOD

Our study is mixed-methods. On the one hand, it is qualitative, employing the chosen data analysis method-semantic and structural content analysis (N. LEFEVRE, 2013) which is suitable for research, the analysis of reports, and the identification of relationships between key concepts withing a dataset. of a dataset. and on the other hand, quantitative , using descriptive statistics to summarise and describe a dataset using tables, graphs and measures such as the mean, median or standard deviation. It also take a forward-looking view from 2025 to 2030.

Sampling was carried out using the judgemental or purposive sampling method, as it only selects only

those individuals who meet the research criteria and final objectives, whilst others are excluded, with as overall population comprising experts from the Order of Electrical Engineering Engineers. The formula for the sample size (N).

$$\text{Sample size} = \frac{Z^2 \text{ x } (p) \text{ x } (1-p)}{c^2}$$

Where:

Z2 = confidence level (95% or 99%);

P = 0.5;

C2 = Margin of error (0.04 = 4%).

N greater than 91 **(N**>91). Data entry, processing and analysis were carried out using Excel sofware , Power BI, and online tool *https://www.questionpro.com/sample-size-calculator/.* In order to identify the causes that affecting grid parity, the experts were interviewed using semi-structured and open-ended, after which a cause tree was developed, the impact of the causes was analysed using SWOT, they were grouped by factor using PESTEL, prioritise them using Pareto (80/20) method, and finally structure the strategic action plan around the 3Ps (implementation, monitoring of effectiveness and tracking of efficiency).

III. RESULTS AND DISCUSSION

1. RESULTS 1: CURRENT SITUATION

1.1. ELECTRIC MIX OF ACTIVITIES

The electricity mix of activities takes into account all power stations operated by electricity sector operators that are subject to regulatory principles, as well as those built by third parties. The figures below indicate the rates of primary sources that make up the electricity mix.

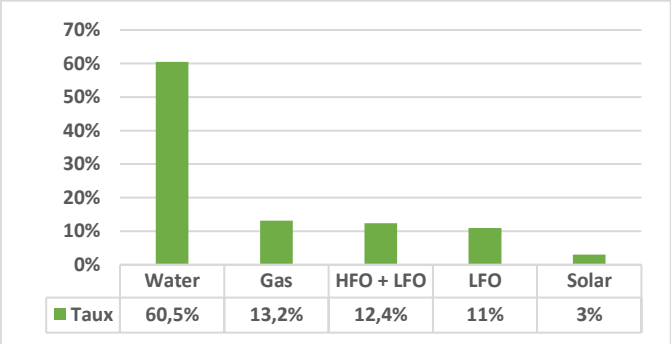


Figure 1: Electrical mix of regulated activities (Source, SI/ARSEL)

For activities of the electricity sector including those of third parties, in 2025 hydro and thermal sources will account for 97% of the total installed capacity, with solar photovoltaic accounting for 3%.

1.2. CHANGES IN THE AVERAGE TARIFF WHITHIN THE ELECTRICITY SYSTEM

The analysis of data collected regarding energy sold from 2019 to 2023 allowed us to highlight the evolution of energy and average price. The figure below illustrates the evolution of the tariff based on the energies sold from 2019 to 2023.

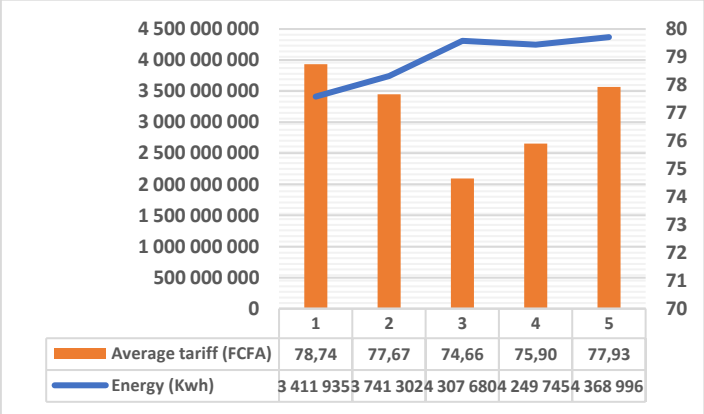


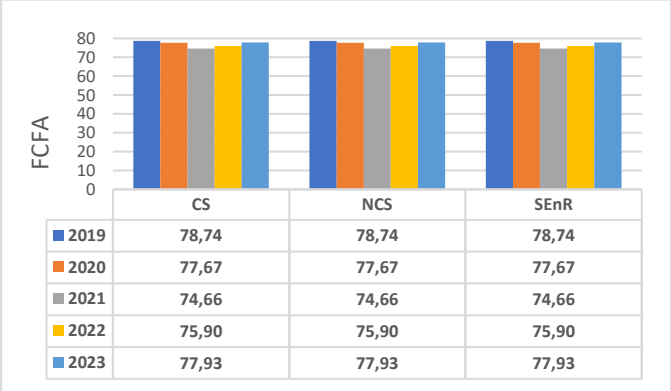
Figure 2: Evolution of the average tariff and energy sold.

The average tariff is generally the ratio of the amount of sales in FCFA to the quantity of energy sold in kWh. The evolution of the average tariff is not linear, so other specific parameters are involved in the intermediate calculations. We can mention technical and non-technical or commercial losses, frauds, non-payment of electricity bills, estimates,

etc. Overall, there is a clear increase in the quantity of energy sold from 2019 to 2023.

1.3. CHANGES IN THE THE AVERAGE TARIFF BY SOURCE OF GENERATION

From the analysis of the data collected from 2019 to 2023, we have categorized by type of production source and highlighted the evolution of the average tariff. Figure 3 summarises the results obtained.



	CS	NCS	SEnR
2019	78,74	78,74	78,74
2020	77,67	77,67	77,67
2021	74,66	74,66	74,66
2022	75,90	75,90	75,90
2023	77,93	77,93	77,93

Figure 3: Evolution of the average tariff by production source.

The evolution of the average electricity system tariff in Cameroon from 2019 to 2023 is identical for all production sources. the annual average rates are in slope, the highest average rate was observed in 2019 and the lowest average rate in 2021. The causes can be related to investments, to the evolution of demand, to population growth. With the usual pricing model in Cameroon, 'the service cost' and a billing structure designed to have a single kWh rate throughout the national territory for each type of consumer, to be competitive in this case the average renewable energy tariff must be less than 74 FCFA.

1.4. CHANGES IN THE SHARE OF RENEWABLE ENERGIES IN THE ELECTRICITY MIX

The energy transition is at the heart of the electricity sector and the integration of renewable energies is taking place at a very slow pace. It is enough to observe the curve of the evolution of the integration of renewable energies into the energy mix on the basis of sold energies, which corresponds to an affine function written in the form:

$f(x) = ax+b$. with two conditions, , a et b □ R et, and et b ≠ 0, where: a is the director coefficient, and b the intercept;

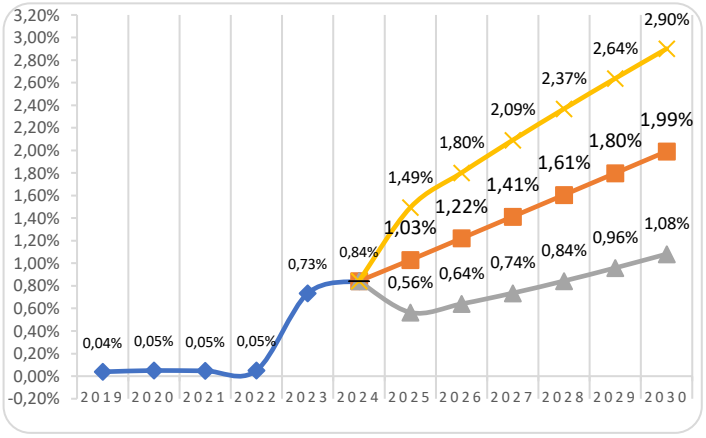


Figure 4: ENR weights and projection to 2030.

An analysis of data on energy sale volumes from the distribution operator ENEO shows that, from 2020 onwards, the generation of electricy from so-called renewable energy sources will becomes a reality to helping to reduce fuel costs which are projectd to reach 42 billion in 2023 and 65 billion, to be accounted for to the Regulator for the 2024 financial year and gradually phase out thermal energy production using fuel oil, whic is harmful to our environment. To date, in the present case, the share of renewable energy does not even reach 1%. This figure does not take into account hydroelectric production of less than 5MW, in accordance with the 2011 Law governing the electricity sector, nor does it account for all error in data colection and processing. If the pace of implementing renewable energy integration is not accelerated, three final scenarios are projected for the period 2025 to 2030. In the high end scenario, the figure is expected to reach 3%; the medium end scenario, 2% ; and in the low end scenario, it will remain around 1%.

2. RESULT 2: ANALYSIS OF FACTORS HINDERING THE ACHIEVEMENT OF GRID PARITY IN CAMEROON

The following table seta out the main factors identified based on the questionnaire and interview protocol. The majority of the experts consulted for our study are menbers of the National Order of Electrical Engineers.

Table 1: Results of the identified causes.

N°	Identified causes
1	Fraudes
2	Public subsidies
3	Tariff compensations
4	Recovery problem
5	Structural reforms
6	Aging infrastructure
7	Poor quality of service
8	Liberalization of the sector
9	Consumer mentality
10	Electricity price
11	Insufficient ENR-specific standards
12	Legal provisions relating to renewable energies
13	Regulatory framework specific to ENR
14	Regulation not adapted to the promotion of ENR
15	Unsuitable ENR energy policy
16	International agreements
17	Low purchasing power
18	Reduced tax policy for renewable energies
19	vulnerability to climate change
20	Dependence on hydroelectric dams
21	Dependence on thermal energies based on fuel
22	no access to electricity in rural areas
23	Ambitious Governmental Strategic Goal
24	Bad hydrology
25	Untapped ENR potential
26	Increase in energy demand
27	Favourable political framework
28	Support for international funding
29	Diversification of the energy mix
30	Energy security
31	Dependency on hydraulics
32	Population growth
33	Large hydroelectric projects costly and long to implement
34	Import of petroleum products for thermal production
35	Low electrification rate
36	Electricity Act 2011
37	Program and initials of the funders
38	Public Private Partnerships
39	Local industry
40	Green jobs
41	Global decline in solar costs
42	Fossil fuel subsidies
43	Complex tariff structure
44	Use of fossil thermal power plants
45	Price differentiation
46	Limit of use of energy-consuming devices
47	Limited knowledge of technology
48	Extension of the limited network
49	Distance from consumers to the network
50	Untimely power outages
51	Possibility of installation on the roofs of buildings to avoid land or land use conflicts
52	Corruption
53	Energy poverty
54	Local opposition due to concerns about the landscape
55	Helping the most vulnerable households
56	Training and requalification needs for workers in the fossil fuel sectors
57	Insufficient skilled labor
58	Pollution from heating and cooking
59	Lack of solidarity and collective actions.

It appears that 59 causes are responsible for the low integration of renewable energy into the energy mix.

Based on the results of the cause tree, the following table presents the results of the analysis carried out that out to identify the external and internal influences of each cause.

Table 2: FFOM analysis of the causes.

Forces	Weaknesses
1. Public subsidies 2. Structural reforms 3. Electricity price 4. Legal provisions relating to renewable energies 5. Regulatory framework specific to ENR 6. Reduced tax policy for renewable energies 7. Diversification of the energy mix 8. Energy security 9. Electricity Act 2011 10. Local industry 11. Favourable political framework	1.Fraudes 2.Tariff compensations 3.Business loss 4.Aging infrastructure 5.Poor quality of service 6.Insufficient ENR-specific standards 7.Dependence on hydroelectric dams 8.Dependence on thermal energies based on fuel 9.No access to electricity in rural areas 10. Untapped ENR potential 11. Low electrification rate 12. Fossil fuel subsidies 13. Complex tariff structure 14. Use of fossil thermal power plants 15. Price differentiation 11. energy guzzlers 21.Local opposition due to concerns about the landscape
Opportunities	**Threats**
1. Liberization of the sector 2. Energy policy 3. International agreements 4. Ambitious Governmental Strategic Goal 5. Support for international funding 6. Donor program and initiatives 7. Public Private Partnerships 8. Green jobs 9. Global decline in solar costs	1.Consumer mentality 2.Bad hydrology 3.Increase in energy demand 4.Dependency on hydraulics 5.Population growth 6.Grands projets hydroélectrique couteux et long à mettre en œuvre 7.Importation of petroleum products for thermal power generation 8.Limited knowledge of technology

Forces	Weaknesses
10. Possibility of installation on the roofs of buildings to avoid land or land use conflicts	9.Corruptions 10. Lack of solidarity and collective action 11. Vulnerability to climate change 12. Low purchasing power

This SWOT analysis highlights 21 weaknesses and 12 threats. The following table present table presents the various causes by PESTEL factors, along with their respective weights :

Table 3: Causes Identified by PESTEL Factor

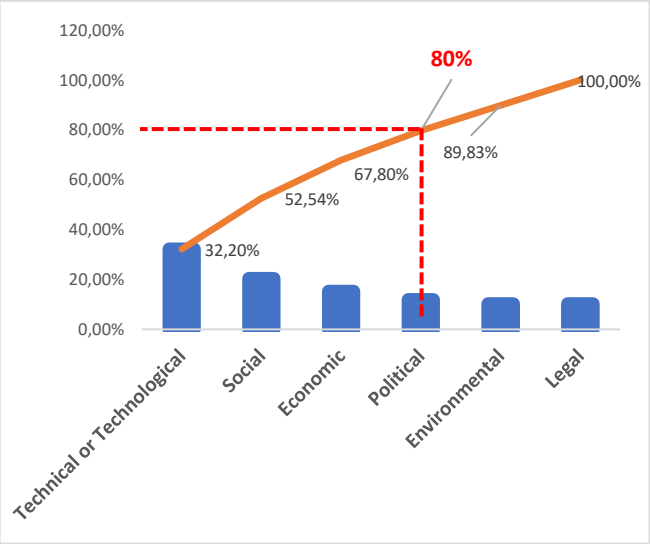
	Politique	
	Cause	**Poids**
	7	12%
	Economique	
	Cause	**Poids**
	9	15%
	Social	
	Cause	**Poids**
	12	20%
	Technique ou Technologique	
	Cause	**Poids**
	19	32%
	Environnement	
	Cause	**Poids**
	6	10%
	Legal	
	Cause	**Poids**
	6	10%
Total	**59**	**100%**

Thus,according to this table, the factor with the highest number of causes is the Technical or Technological factor, with 19 occurrences representing 32% of the factors influencing the national energy mix, followed by the Social factor with 12 occurrences, representing 20%, followed by the economic factor with 9 occurrences,or 15%,followed by the political factor with 7

occurrences or 12%, and finally the last two factors,Environmental and Legal, with 6 occurrences,or 10%. The resulting PARETO curve identifies the factors with the greatest impact.

Thus, according to this figure, the Technical or Technological, Social, Economic and finally Political factirs represent the factors with the greatest impact on the system, as they account for 80% of the

Figure 5: Prioritization of Impact Factorsof Renewable Energy Integration into the Energy Mix



factors influencing the system and, to this end, represent 20% of the factors according to the Pareto principle. This means that if one we wish to improve the integration of renewable energy into the energy mix, we must address the causes associated with these factors. It therefore follows that the central problem of integrating renewable energy into the energy mix stems from technical or technological, social, economic and political factors, which manifest as : (1) technology that is very stagnant and techniques that are still rudimentary; (2) a glaring lack of involvement from civil society; (3) low purchasing power and inadequate subsidies; (4) an insuitable national policy on renawable energy. The problems linked to these factors form the basis for strategic planning.

RÉSULT 3 : STRATEGIC ACTION PLAN FOR THE INTEGRATION OF RENAWABLE ENERGY INTO COMEROON'S ELECTRICITY MIX

The strategic action plan is structured around Priority Action Areas (PAAs). The table below highlights four colour coded zone for each priority.

Table 4: Priority rating of actions

	Priority Action Area 1 Requiring a short-term response. Disseminate techniques and technologies related to the integration of renewable energy into the energy mix (PAA 1)
	Priority Action Area 2 Requiring a short- or medium-term response. Strengthen the involvement of social stakeholders in the planning and management of renewable energy at national level (PAA 2)
	Priority Action Area 3 Which requires a medium-and long-term response. Promoting mechanism for the procurement of renewable energy facilities (PAA 3)
	Priority Action Area 4 Which requires a response in the medium to long term. Update the national policy framework for renewable energy management (PAA 4).

The following tables present the results obtained.

Table5: implementation plan for the Priority Action Areas

PAA	Areas of intervention	Operational Objectives	Activities relating to the implementation of the area of intervention	Period	Actors of implementation	Cost (KF CFA)
PAA 1	Establish moderm training centres specialising in renewable energy trades.	Construction of a trainin centre per municipality,i.e 360 training centres across the country.	1. Identification of academic institution capable of establishing moderm training centre for renewable nergy professions. 2. Establishment of practical laboratories for renewable energy professions.	2 years	MINEE, MINFOP, MINJEC, MINESUP, et their constituent bodies, Higher education, universities, reseachers, etc.	43,000,000
	Construction of production and/or assembly plants for renewable energy equipment.	Estalishment of at least two factories per province, i,e. 20 factories	1. Identification of renewable energy equipment for our industries. 2. Incorporate projets for the construction of production and/or assembly plants for renewable energy equipment into the Regional Council's plans	2 years	MINEE, MINMID, MINRESI, MINTP MINDUH,MINCAF,MINDDEVEL. Experts, etc.	78,000,000
					Coût Global	**121,000,000**
PAA 2	Compile a list of civil society expert in renewable energy and promote their work .	Compilation of list of civil society representatives with a good understanding of issues relating to renewwable energy,covering the whole country.	1. Identify civil society experts in renewable energy and allocate them to cover all regions, departements and municipalities. 2. Publish the list of these Experts.	2 ans	MINDDEVEL,MINEE, MINEPDED, MINPMEESA	1,225,500
					Coût Global	**1,225,500**
PAA 3	Introduce the green energy voucher and make tax and customs exemptions more acessible.	Identification of all authorised credit institution in Cameroon and lendersthat can issue green voucher.	1. Definition of the sector of activity eligible for green voucher. 2. Formulation of energy packages tailored to the needs of consumers by sector of activity.	3 ans	Cmercial banks, Micro – finance, FEICOM, MAETUR, CFC,SNI	6 1700 000
	Intégrating slora installation as a civic contribution.	Adopting a pilot programme to create energy « prosumers ».	1. Incorporate solar installation as an option with the distribution concessionaire. 2. Incorporate « prosumer » into certain construction projects .	5 ans	ENEO, AER, MINEE, MINEPAT, ARSEL.	12 000 000

PAA	Areas of intervention	Operational Objectives	Activities relating to the implementation of the area of intervention	Period	Actors of implementation	Cost (KF CFA)
					Coût Global	**18 620 000**
PAA 4	Accelerating reform in the electricity sector.	Drafting of implementing regulations covering all technicla aspects of revewable energy.	Proposing draft implementing decrees for renewable energy	5 ans	All stakeholders in the electricity sector	10 213 000
					Coût Global	**10 213 000**

Table 6: Plan formonitoring the effectiveness of the implementation of the Priority Action Areas

DAP	Areas of intervention	Activities relating to the implementation of the area of intervention	Effectiveness monitoring period	Effectiveness monitoring indicator	Means of verification	Costs (KF CFA)	Those responsible for or involved in monitoring effectiveness
PAA 1	Establish moderm training centres specialising in renewable energy trades.	Construction of training centre per municipality, i .e 360 training centres across the conutry.	01 year	Number of training centres..	Reports	20,000	MINEE, MINFOP, MINJEC, MINESUP, MINCAF,MINTP,MINDDEVEL, MINPMEESA, FEICOM and partners
	Construction of production and/or assembly plants for renewable energy equipment.	Estalishment of at least two factories per province, i,e. 20 factories .	01 year	Numbe of factories opened	Reports	15,000	MINDDEVEL,MINTP, MINDUH,MINCAF,MINDDEVEL.
					Coût Global	**35 000**	
PAA 2	Compile a list of civil society expert in renewable energy and promote their work .	Compilation of list of civil society representatives with a good understanding of issues relating to renewwable energy,covering the whole country.	06 months	Number of expert by region, department and municipality.	Publication of the list of experts	30,000	MINDDEVEL,MINEE,MINEPDED, MINPMEESA
					Coût Global	**30 000**	
PAA 3	Introduce the green energy voucher and make tax and customs exemptions more acessible.	Identification of all authorised credit institution in Cameroon and lenders that can issue green voucher.	06 months	Number of credit institution identified	Reports	15,000	Banques commerciale, Micro – finance, ,MINFI,MINEPAT,MINEE,MINNDEVEL,MINHDU.

DAP	Areas of intervention	Activities relating to the implementation of the area of intervention	Effectiveness monitoring period	Effectiveness monitoring indicator	Means of verification	Costs (KF CFA)	Those responsible for or involved in monitoring effectiveness
	Intégrating slora installation as a civic contribution.	Adopting a pilot programme to establish energy « prosumer »..	01 year	Number of energy package	Guide	20,000	MINFI,MINEPAT,MINEE ,MINNDEVEL,MINHDU.
					Coût Global	**35 000**	
PAA 4	Accelerating reform in the electricity sector.	Drafting of implementing regulations covering all technicla aspects of revewable energy.	03 months	Nombre textes Number of implementing regulations available	Reports	100,000	ARSEL, MINEE, Electricity Sector Operators, Industrial Customers, Consumer Associations.
					Coût Global	**100,000**	

Table 7: Plan for monitoring the efficiency of priority Action Areas

DAP	Areas of intervention	Expected Results	Baseline	Efficiency indicators	Method of verifying the indicator	Indicator verification period	Cost (KF CFA)	Stakeholders involved in monitoring the effectiveness of implementation
PAA 1.	Establish moderm training centres specialising in renewable energy trades.	Establishment of modern training centres specialising in renewable energy professions.	01 centre opened at the Faculty of Science in Yaoundé 1.	Number of training centres per year.	Report	5 years	5,000	MINEE, MINFOP, MINJEC, MINESUP, et leurs démembrements

DAP	Areas of intervention	Expected Results	Baseline	Efficiency indicators	Method of verifying the indicator	Indicator verification period	Cost (KF CFA)	Stakeholders involved in monitoring the effectiveness of implementation
	Construction of production and/or assembly plants for renewable energy equipment.	Construction of factories for the production and /or assembly of equipement for renewable energy..	No factories.	Number of production and/or assembly plants opened.	Report	5 years	5,000	MINSUP, MINESEC, MINRESI, Universités, Grandes écoles, Chercheurs, etc.
						Coût Global	**10,000**	
PAA 2.	Compile a list of civil society expert in renewable energy and promote their work	Compilation of list of civil society representatives in the field of renewwable energy.	No list.	Number of expert by region,department and municipality.	Report	2 years	10,000	MINEE, MINFOP, MINJEC, MINESUP, MINPMEESA, FEICOM et partenaires.
						Coût Global	**10,000**	
PAA 3.	Introduce the green energy voucher and make tax and customs exemptions more acessible.	Identification of all authorised credit institution in Cameroon and lenders that can issue green voucher.	No Green voucher	Number of credit institution identified	Report	3 years	5,000	MINEE, MINMID, MINRESI, Experts, etc.
	Intégrating slora installation as a civic contribution.	Adopting a pilot programme to establish energy « prosumer »..	No pilot porjects	Number of energy packages	Report	1 year	10,000	MINDUH,MINCAF, MINDDEVEL.
						Coût Global	**15,000**	
PAA 4.	Accelerating reform in the electricity sector.	Drafting of implementing regulations covering all technicla aspects of revewable energy.	The reform began in 2011.	Numbers of implementing regulation available	Report	5 years	15,000	MINDDEVEL,MINEE,MINEPDED, MINPMEESA
						Coût Global	**15,000**	

The estimated total cost of the strategic action plan is summarised in table 8 below.

Table 8: Total cost of the Priority Action Areas of the Strategic Plan

Area of Action	Estimated Cost			
	Implement	Effectiveness	Efficiency	Total
Priority 1	121 000 000	35 000	10 000	121 045 000
Priority 2	1 225 500	30 000	10 000	1 265 000
Priority 3	18 620 000	35 000	15 000	18 670 000
Priority 4	10 213 000	100 000	15 000	10 328 000
Total Cost (KFCFA)	151 058 500	200 000	50 000	151 308 500

The cost of implementing priority actions to achieve grid parity is estimated at 151,308 K FCFA for the period from 2025 to 2030.

IV. DISCUSSION

The analysis of the impact of grid parity on the integration of renewable energy into the electricity market involved assessing and understanding the strategiy implemented by the Government of Cameroon to promote renewable energy.

The share of renewable energy will be less than 1% in 2024. Analysis of the data indicates thress possible scenarios for 2025 to 2030, namely : lthe high scenario,where 3% could be achieved; the medium scenario,where 2% could be achieved ; andthe low scenario,where the figure could remain around 1%. This reflects the fact that investment in electricity generation from renewable energy sources is low.In the work by (EL Moummy et al., 2021) on the impact of renewable energy on economic growth in the case of Morocco, the key recommendation in terms of energy policy concern fiscal measures for renewable energy. Indeed, just as in Morocco in 2021, the situation in Cameroon in 2025 appears to us to be almost identical. The Cameroonian government, as the Moraccan government has done since 2021, must encourage the use of renewable energy sources over conventional ones by introducing tax incentives to stimulate investment and consumption, and by facilitatting the transition from thermal energy to green technologies. On the other hand, it is necessary to create a climate conducive to investment, enabling the country to attract potential investors. The training of a skilled workforce and the development of human capital are also necessary condition for the deployment of the renewable energy sector,notably the renewable energy sector. Which has been included in the finance act since 2012, with the list deemed approved upon publication by the Minister of Finance. In practice, however, it must be noted that the customs administration require, in order to benefit from this exemption, that a request be submitted to the Director General of Customs. The administration is therefore creating a condition not provided for by law, which suggest that the General Directorate of Custom is acting contrary to the mechanisms established by the State to ensure the exemption (Zang & Ozoto, 2024).We understand that, in view of the incentives adopted by the Government of Cameroon to promote renewable energy, this is a quantity-based innovation (Bourgeois et al., 2017), as the low-voltage electricity tariff in cameroon ha not changed since 2012, thereby confirming the 1% intégration rate for renewable energy and justifying the view that grid parity cannot be achieved over the next five years. renewable energies, and justifies parity.

The identification, analysis, classification and prioritisation of cause using quality tools has enabled the identification of the 20% of factors responsible for 80% of the problems related to the failure to achieve grid parity in cameroon’s energy

mix. These include technical or technological,social, economic and political factors. By addressing these factors,Cameroon's electricity system can achieve grid parity. Renewable energy can become a threat to the electricity market once they account 30% of the electricity mix ; solutions include : (i) aligning the energy system with the European Union's greenhouse gas (GHG) emission quotas; (ii) setting meaningful prices for carbon dioxide (CO_2); (iii) building a grid that allows renewable energy to be fully integrated into the common energy market; (iv) reducing the price of electricity in the event of overproduction due to renewable energy; (v) granting subsidies to renewable energy as necessary temporary support to allow thes technologies to mature (Lequertier et al., 2015), are among the factors responsible for grid parity not being achieved.

In the scenario, the strategic plan sets out the action to be taken to achieve grid parity, based on the key factors identified in the PESTEL analysis. For the period from 2025 to 2030, four (04) priority actions have been proposed to achieve grid parity. The case of Ageria's renewable energy strategy, which has established a two-satge renewable energy development programme. From 2015 to 2020 : a capacity of 4,010 MW will be achieve through photovoltaic and wind powerser, as well as 515 MW through biomass, combined heat and power, and geothermal energy ; and from 2021 to 2030 : the installation of large-scale renewable energy power stations in the regions of in salah, Adrar, Timimoune et Bechar ans their integration into the national energy system in oder to develop the electricity interconnection between the North and the Sahara. These two phases were preceded by a pilot phase from 2011 to 2014, during which several projects were carried out, and in 2016, a new strategy was introduced by the Ministry of Energy for the development of renewable energy. Implementation is governed by Executive Decree N°17-98 du 26 February 2017 . thus, the five (05) years implementation period set out in our strtagic plan linked to this study correponds to that of Algeria's pilot phase, during which the country invested in the devlopment of approximately 162 MW (Guergaziz, 2021). Consequently, within the same timeframe, it will not be possible to achieve the results envisaged by the strategic priorities set out in the plan.

Overall, it is clear that, to provide an effective response to the challenges of integrating renewable energy in Cameroon, solutions must be combined in propotions that respect the context and the enviornment. For example, the addendum to annex 3 of ENEO's framework concession contract defines the following zones : metropolitan areas, defines the following zonesdu ENEO concession framework contract defines the zones: metropolitan areas, notably Douala and Yaoundé, urban areas; all towns with more than 50,000 inhabitants, and rural areas,comprising all parts of the territory not included in metropolitan or urban areas. Taking this classification into account,it is possible to combine solution in ways that will have a significant impact on achieving grid parity. It is understood that grid parity. It is understood that grid parity can be broken down by the production cost of each electricity grid. In any case,based on the findings of this study ,we emphasise that grid parity in Cameroon's electricity market will not be achieved between 2025 and 2030 ; however,there will be a slight increase in the share of renewable energy in the electricity mix due to third-party installation.

V. CONCLUSION

Electricity generation in Cameroon from renewable energy sources is not optimised. This means they

account for a negligible share of the electricity market. Achieving grid parity remains one of the major challenges for the integration of renewable energy in Cameroon, given its impacts. The overall objective of the article was to conduct a study of the impact of grid parity on the integration of renewable energy into Cameroon's electricity market. It is essential to note that gris parity is the situation in which the cost of renewable energy sources becomes as competitive as that of other energy sources within a given electricity system is the primary target to be achieved for the promotion of renewable energy. This study was conducted over a period of six (06) months, from February to august 2025. Interviews conducted with members of the National Order of Electrical Engineers reveal a multitude of factors hindering the achievement of gris parity in Cameroon.

The result show that, to date, renewable energy is developing according to three possible scenarios for 2025 to 2030: the hugh-end scenario 3%; the medium-end scenario at 2% ; and the low-end scenario at around 1%. Based on the feedback, 59 causes have been identified, 21 of wich are weaknesses and 12 threats to achieving grid parity. The analysis highlights that the major causes stem from technical or technological,social,economic and political factors which account 80 % of the factors influencing the system and ,consequently, 20 % of the barriers to be overcome . based on these results, a strategic action plan has been proposed, implementing four priority actions: (i) popularising technique and technologies related to the integration of renewable energy, (ii) strengthening the involvement of social stakeholders in the planning and management of renewable energy, (iii) promoting mechanisms for the procurement of renewable energy installation, (iv) updating the national policy for renewable energy management with estimated cost of 151,308,000,000 CFA franc.

This study confirms the importance of grid parity as a key factor for the successful promotion of renewable energy. By identifying challenges, capitalising on opportunities and mobilising key stakeholders in the electricity sector to take sustainable measures within the competitive environment of the electricity market

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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