

Roadmap for the Transformation of the South Cameroon Interconnected Network (RIS) into Smart-Grid

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Abstract: This article comes as a contribution to the development of a specific roadmap with the intention to transform the RIS into a smart grid, based on examples experimented in other countries, surveys, interviews with resource people and the master plan of energy development in Cameroon. To set up this roadmap, an audit of the current network reveals many dysfunctions such as regular power outages, imbalances, losses power. The proposed roadmap is structured around three stages which can be summarized as follows: in the short term, the establishment of a reflection committee, his Functional organizational chart and its timeline of activities have been proposed; in the medium term, the deployment of certain equipment such as smart meters; finally, in the long term, the complete transformation of the current network into a smart grid. This will make it possible to integrate the renewable energies which are in development in African countries. It can serve as a guide for the deployment of smart grids in countries of the sub-region of Africa and in Cameroon in particular. The lack of related studies and the non-popularization of results by those who have already worked on those issues, make this paper a greater contribution for energy policy and development, mostly for sub-Saharan African countries.

Keywords: RIS, Smart Grid, Roadmap

1. Introduction

Faced with the exponential growth in energy demand in developing countries and particularly in Cameroon, the number of subscribers is estimated at 2,500,000 in 2035 compared to 1,250,000 presently [1] the current grid will not be able to provide energy in quality and quantity. This situation is justified by the multiple interruptions in energy supply recorded these last years; in 2019 we recorded 365 hours [2]. The smart grid seems to be the solution to this thorny problem because it is more reliable, allow an easy adaptation of production on demand by integrating various sources including new sources of renewable energy and can automatically recover a fortuitous peeling [3, 4] However, their implementation requires an in-depth study and a careful planning that will identify the different steps of the project, the stakeholders, the type of technology to be developed, the laws governing their operation and above all the socio-economic costs [5-8]. As a matter of fact, a study of the

characteristics of the current network is absolutely necessary. It is important to remind that former studies do not provide us with enough information on how to extend smart grids. This article is a contribution to the development of a roadmap for the transformation of the RIS into a smart grid. It comes as the interpretation, the treatment of interviews with academics, field engineers of SONATREL, ARSEL executives, members of the government and finally surveys applied on local populations.

This article is organized as follows: the second section is a presentation of the Cameroonian network, its strengths and limitations; the third records the benefits of smart grids in general; the obstacles related to its deployment in Cameroon are the the main issue discussed in the fourth part. The fifth part suggests different roadmaps, in a short, medium or long-term, as concerns the deployment of smart grids In Cameroon; the timeline for the implementation of the major stages of

these roadmaps are proposed in section six.

2. Methods

To develop this roadmap, it was necessary to audit the present network, analyze the roadmaps currently being executed in other countries, consult resource people and energy development strategy documents in Cameroon. This allowed us to adopt the following approach:

2.1. Presentation of the Cameroonian Network

The Cameroonian network is subdivided into three independent networks: the South Interconnected Network (RIS in French) which covers the Central, Coastal, West, North-West and South-West regions; the North Interconnected Network (RIN) covering the Adamawa, northern and Far North regions; the eastern interconnected network that covers only the eastern region (RIE) the RIS is positioned as the most important network, therefore our study is based on these different networks, given the fact that the problems are almost the same on the three networks.

2.1.1. Production Units

RIS's production is based on three hydroelectric power plants operating on a base: Song Loulou, Edéa and Menvele with an overall installed capacity of 746 MW [1]. These three plants are reinforced by a thermal plants consisting of several HFO, LFO and natural gas power plants; their installed capacity is 569 MW, bringing the total installed capacity to 1315 MW.

2.1.2. Power Transmission Lines

Two types of transmission lines are the sections of the RIS: the 90 KV lines with a total length of 1064 km (or 68% of the total linear of the network lines) and the lines of 225 KV over 480 km (or 32% of the total linear of the network lines).

This transportation network serves about 20 source stations that supply the distribution network. The peak load has evolved from 2012 to 2019 from 670 Mw to 880 Mw, which corresponds to an annual growth of 5.4%. Peak network demand was most *often met between weeks 50 and 52 of the year (second fortnight of December)* [2]

2.1.3. The Network Functioning

An analysis after simulation in the NEPLAN software package for a 934 MW load peak distributed among all RIS source stations, in consideration of the Kribi plant in operation, reveals the different productions grouped in the following table:

Table 1. Existing RIS thermal power plants. [2]

Central	Started power (MW)
Ahala	17.2
Bafousam	17.1
Bamenda	6
Bassa	6
Dibamba	4.5
Edea	3.3

Central	Started power (MW)
Kribi	4.5
Limbé	1.5
Logbaba	1.6
Oyomaban	1.2
Songloulou	1.2
Ebolowa -Mbalmayo	1.2

These simulation results reveal that, under normal regime, all thermal power plants must be in service and the operation of the network becomes difficult. There are also the following constraints

Table 2. Overloads of works.[2]

Works	Type	Overloads (%)
Oyomaban-ngouso	Line	139.21
TR logbaba	Transformer	146.36
Logbaba-Bassa II	Line	135.9
Logbaba Koumassi	Line	120.33
Logbaba-Bassa I	Line	123.46
Dibamba Ngodi	Line	111.8

Table 3. Tension drops.[2]

Node	(U%)
Bafousam	93.53
Bamenda	94.91

The results of the above tables show unacceptable overloads in the Yaounde and Douala regions and very severe voltage reductions in the western and north-west regions. In the case of the loss of a transport structure, the situation is even more serious.

The protective devices used are MICOM P442, P443 and SIPROTEC circuit breakers. This is under the supervision of SCADA.

2.1.4. Distribution Network

Distribution is done through the HTB/HTA source stations under voltages of 30 KV in inter-urban and 15 KV in urban the most important positions in terms of peak power are the Bassa and Koumassi stations. This region alone accounts for more than 46% of the total peak of riS.

Energy sales are in HTB, a percentage of 40%, HTA or a percentage of 23.9% and in BT or a percentage of 36.1% overall, sales have an annual growth rate of 2.1%.

The rate of increase in HTA subscribers remained stagnant 2.3% while that of BT subscribers increased to 6.1% [1]

2.1.5. Losses

A review of ENEO's annual business reports establishes the evolution of technical and non-technical losses for transport and for the public sector it appears that the average loss rate for the transport network is 6.3% and that of the distribution is 27% or a total of 33.3%, so the overall network output is estimated at 66.3%. Overall losses relative to production are estimated at 20.2% or a yield of 79.8%. Non-technical losses are estimated at 10%. [1]

2.2. Benefits of Smart Grids

The smart grid is characterized by several advantages [9, 10, 11]

2.2.1. Technical Benefits

- 1) Easy demand and supply management
- 2) Actively engaging consumers
- 3) Integrating decentralized production (renewable energy)
- 4) Self-healing of the network
- 5) Reducing technical and non-technical losses
- 6) Improving RIS reliability
- 7) Store electrical energy
- 8) Promotes the use of electric vehicles
- 9) Optimizing network protection

2.2.2. Socio-economic Benefits

- 1) Creating new jobs
- 2) Controlling consumerism
- 3) The consumer can also supply energy to the grid
- 4) Reducing the price of a kilowatt over the long term
- 5) Reducing greenhouse gases

2.3. Obstacles to the Deployment of Smart Grids in Cameroon

Despite all the benefits listed in Section III, it is important to mention that several obstacles limit the deployment of smart grids in Cameroon. They are grouped into several categories as presented below:

2.3.1. From a Legal Point of View

The current law on the production and distribution of electricity in Cameroon does not fully liberalize these two sectors of activity, which is a major obstacle for the deployment of small producers. New draft laws are to be put on the agenda of the Cameroon's parliament

2.3.2. From a Technological Point of View

The absence of a digital map of the distribution network does not facilitate the identification of subscribers, the current meters are one-way, which does not allow consumers to become a player in the network, the absence of a communication and data processing network at the distribution level and the absence of intelligent devices such as PMU, Smart relays and sensors do not quickly identify incidents when they occur in the network, let alone self-healing; The lack of automatic demand/supply control devices makes it difficult to integrate decentralized production.

2.3.3. As concerns Economy

The lack of capital does not encourage the deployment of smart grids because they are very expensive. France has paid a sum of... only for the deployment of smart meters, which is well in the value of Cameroon's budget.

2.3.4. From the Social Point of View

The acceptance of new technologies brought by the deployment of smart grids in Cameroon will not be easy due to some social behaviors. As it will give room to the reduction of fraud, the reevaluation of the cost of a kilowatt in the short term as well as the required time for the implementation of new technologies acquainted after a free training.

3. Results and Discussion

In this section, we propose a roadmap for transforming RIS into a smart-grid and a deployment schedule for equipment for this transformation.

3.1. Roadmap for Transformation in Smart Network

This roadmap provides short, medium and long term guidance for the deployment of smart grids in Cameroon. It proposes the different actors and their missions. To set it up, we have collected information from resource people (academics, ministry of mines, network operators), and also the roadmaps of some countries in the process of deploying smart grids [12-15].

3.1.1. Short-term Roadmap (1 to 5 Years)

This first roadmap shows that the think tank whose functional chart is given in Figure 1, it assumes the current RIS transfer to smart Grid. Its setting up must be functional as from the first few months after the project, so that the main orientations be known long before. The other steps will follow and proceed as the process will go on in a medium and long term.

Figure 1 above presents the organizational chart of the think tank and the way it must be set up in the first months of the project. This committee is charged with monitoring the complete transfer from the RIS into a smart grid. It consists of two large commissions.

The one in charge of all the technical aspects consists of three sub-committees that eventually interact with each other to coordinate their activities: The subcommittee responsible for evaluating the network produces evaluation reports for all stages of each phase (short, medium and long term). A first report in the first year of the project should serve as the basis for the start of the work; it will highlight the inadequacies of the current RIS, the need for its gradual transformation into a smart grid and the challenges to be met in this transformation. This information could then be gradually transmitted to the subcommittees on intelligence integration and the subcommittee in charge of research and training, the first of which could be defined the equipment to be gradually integrated to overcome the limits of the current RIS; the second will perform all necessary checks, tests and pre-training before any deployment of a type of equipment begins.

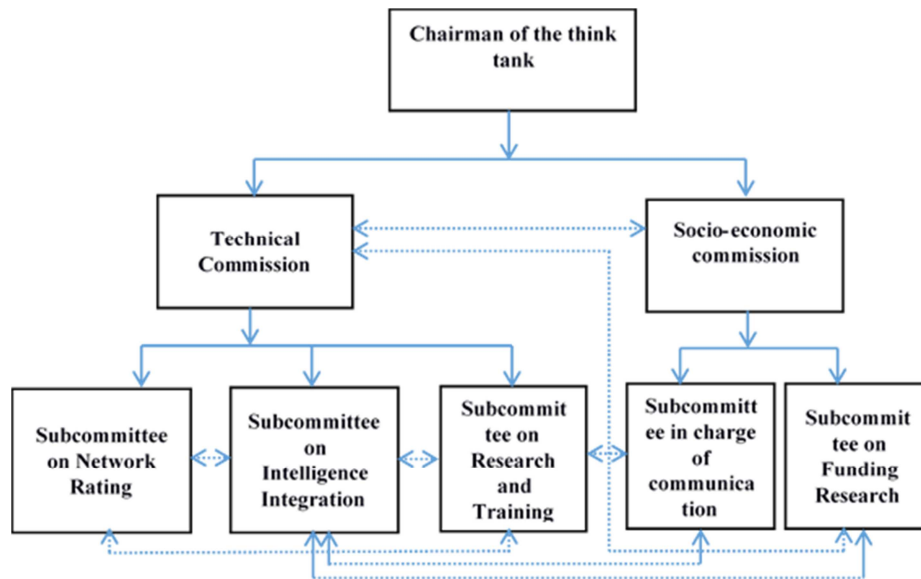


Figure 1. Functional organizational of the think tank.

Table 4. Short-term roadmap.

Steps	Organizations in charge	Missions	Proposals for solutions
Step 1: Creation a think-tank	Government (Ministry in charge of energy)	Set up A Functional organization chart Committee.	See Figure 1
		Identify members	Government, academics, network operators (ENEO, SONATREL, ARSEL), consumers. Improving access to electricity in three phases: - Phase 1 (1 to 5 years): 35-50% - Phase 2 (6 to 15 years) from 50 to 80% - Phase 3 (16 to 30 years) at the end of 80 to 100%.
		Set broad directions	Achieving a high level of energy supply quality, in terms of interruption and disturbances such as harmonics, voltage troughs, voltage drops. Achieving a high level of security of electrical systems in Cameroon through supply-demand balance, and cybercrime. Take social issues into account by transforming the consumer into a consumer, and reducing the price of a kilowatt. Optimize the economic gains achievable by the state, and the companies in charge of electric power management.
Step 2: Creating a research center	Government and Reflection Committee	Propose new laws to the National Assembly	New laws to fully liberalize the energy sector must be adopted to enable the deployment of decentralized production.
	Reflection Committee	Identify members	Academics, network operators, ministry executives in charge of energy
Step 3: Analysis of the current network	Reflection Committee	Setup a test lab	The think tank, through its laboratory, needs to be reassured of the operation and impact of any new equipment to be gradually integrated into the network for its transformation. In the short term, the tests will be done on the AMI meters, on the installation of LAN and SCADA in the transport and distribution network.
	Network operators and Think tank	Developing a digital map of the current network Create a database of all subscribers	
Step 4: Education and Awareness	Reflection Committee	Training of the players of the future smart grid	Internships and training of staff and network operators on the takeover of smart grid and their operation with advanced countries in this field such as China, the United States, Germany, France and Canada..., must be organized and programmed in depending on the needs and evolution of the project.
	Network operators and Reflection Committee	Consumer awareness campaigns in major urban centers	Show the consumer's interest in accepting new kilowatt costs that will be quite high at first, but much lower in the long run, controlling its consumption and the possibility of decentralized production through batteries and electric vehicles.
	Government	Integrating smart grid training modules into the education system	The teaching requirements will apply to the secondary and university levels; smart grid research laboratories should be set up in universities.

Steps	Organizations in charge	Missions	Proposals for solutions
Step 5: Infrastructure Deployment	Reflection Committee	Choose the devices to deploy in the short to medium term	For the transport network: PMU, sensors, smart meter. For distribution networks: AMI smart meters, decentralized production control and management devices For LAN communication networks, SCADA
	Network operators	Start deploying certain equipment in certain areas of major metropolises	150,000 AMI smart meters will be installed over 5 years; for the same period, the LAN network and SCADA also distributed in major metropolises.

The Committee on Socio-Economics Affairs has two sub-committees: one in charge of communication and the other committed to the search for funding. The first will inform the general public about future changes and new behaviours; an exchange and information. By the way a website can be created for that this purpose; this subcommittee must exchange with two subcommittees of the major technical committee in order to soak up the gradual evolution for possible updates. The subcommittee on funding research must work in line with the technical commission, in collaboration with the government, to contact national or international organizations that can provide financial solutions for the smooth running of the project.

The order of the steps in this roadmap is justified by the fact that the think tank must first be created, then it will contribute to the creation of the research center where all of the network analysis and deployment checks equipment will be carried out.

3.1.2. Medium-term Roadmap (6 to 15 Years)

This second roadmap shows activities such as the installation of AMI meters, the expansion of the LAN and SCADA will continue not only in urban centers but also in rural communities, so that the entire current network is fully covered; decentralized production and NAN can be tested in urban canter first.

Table 5. Medium-term roadmap.

Steps	Organizations in charge	Missions	Proposals for solutions
Step 1: Evaluation of short-term roadmap deployment	Reflection Committee	Establish a fact sheet of activities defined by the short-term roadmap	Systematic updates and medium-term roadmap adjustments
Step 2: Education and awareness	Reflection Committee	Continue to animate the website for the exchange of information on smart grids, awareness and modus operandi of the use of certain equipment; continue to organize the necessary seminars and training in and out of the country	With the expansion of the smart grid, new training, seminars and awareness are imperative for the staff of network operators and also and customers.
	Network operators	Expand awareness campaigns among consumers in rural areas covered by the current network.	Continue to show the consumer's interest in the implementation of smart grids, start to interest all urban populations in decentralized productions
	Government	Ensure monitoring and intensifying educational programs on smart grids	Teaching requirements on short-term smart grids need to be evaluated and intensified if necessary
	Think tank and network operators	Choose the devices to be extended in rural communities; design software to secure the telecommunications and information network.	PMU, sensors; AMI smart meters in all urban and rural areas over 15 years. extension of the LAN and NAN networks and SCADA to rural areas
Step 3: Infrastructure Deployment	Network operators	Expand the deployment of equipment in rural areas covered by the current network	PMU, sensors; 1000,000 AMI smart meters over 15 years. Decentralized production control and management devices. LAN, NAN and SCADA across the current network
Step 4: Research	Reflection Committee	Check and test new equipment to be integrated into the network	The NAN and decentralized productions must be pre-verified and tested before they are integrated into the network.

3.1.3. Long-term Roadmap (16 to 30 Years)

At the end of the roll-out of this latest roadmap, the RIS will be fully transformed into a smart grid. It will incorporate smart meters; sensors for the communications network LAN, NAN, WAN and SCADA; relays for protection; batteries and

vehicles in addition to other decentralized productions. The network will be fully protected from natural incidents and cybercrimes, with a great peculiarity that it will cover the entire national territory.

Table 6. Long-term roadmap.

Steps	Organizations in charge	Missions	Proposals for solutions
Step 1: Evaluation medium-term roadmap deployment	Reflection Committee	Establish a fact sheet to assess activities defined by the medium-term roadmap	Systematic updates and long long-term roadmap adjustments

Steps	Organizations in charge	Missions	Proposals for solutions
Step 2: Education and awareness	Reflection Committee	Continue to animate the website for the exchange of information on smart grids, awareness and modus operandi of old and new equipment to be integrated into the network; develop advertising pages to promote the expansion of decentralized productions; continue to organize the necessary seminars and training in and out of the country	Initiate new training, seminars and new awareness of new products to be integrated into the network for its final transformation into a smart grid.
	Network operators	Expand consumer awareness campaigns throughout the country.	Awareness campaigns are no longer limited to areas covered by the network but rather throughout the national territory.
	Government	Create smart grid research labs at all state universities	Research on smart grids needs to be popularized and re-extended throughout the national scientific community and focused on the creation of Cameroonian products.
Step 3: Infrastructure Deployment	Think tank and network operators	Choose the devices to be extended throughout the country; design software to secure the telecommunications and information network.	PMU, sensors; AMI smart meters, decentralized production control and management devices, LAN, NAN, WAN and SCADA throughout the country, rechargeable batteries, and electric vehicles.
	Network operator	Expand the deployment of equipment throughout the country	Expansion of PMU Sensors; 5,000,000 AMI intelligent meters over 30 years; the control and management of decentralized production of the LAN, NAN and SCADA throughout the country; the gradual integration of the WAN for the communication network, rechargeable batteries and electric vehicles in decentralized production first in urban centers and then in rural areas..
Step 4: Research	Reflection Committee	Check and test the latest equipment to integrate into the network, the Contact with the research laboratories of the various universities of the country.	The WAN rechargeable batteries and electric vehicles must test before the liberalization of their integration into the network their integration into the final network.

3.2. Equipment Deployment Planning

The deployment of certain equipment will take place in several phases and during the three main periods of the roadmap. Figures 1, 2 and 3 below describe the way activities are carried out as concerns AMI smart meters, IT and decentralized productions respectively.

3.2.1. Timeline of AMI meter Deployment Activities

The AMI counts will be deployed in six extended phases in the short, medium and long term following the scan in Figure 2:

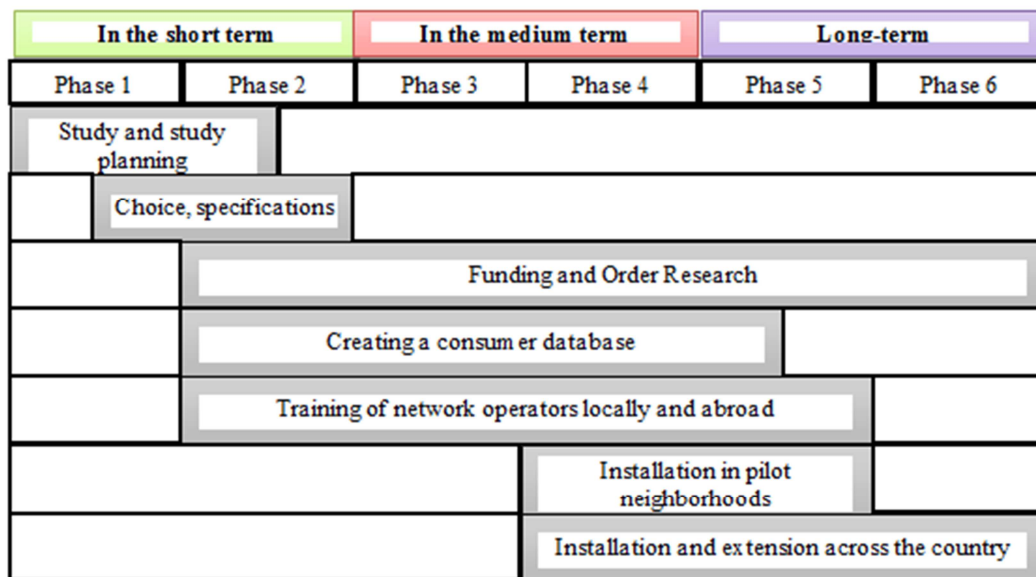


Figure 2. Timeline of AMI meters' installation.

The deployment of AMI smart meters will take place in seven stages, spread over the six phases and during the major periods of the roadmap, as shown in Figure 2. The project will begin with a study and will be completed when the entire national territory is covered. But the large cities such as Douala and Yaoundé will be the pilot cities in which any experimentation will take effect, given their density in terms of the number of subscribers. It will be hard work on the part of the think tank, network operators and the government for about thirty years; it will require very large financial resources,

which is why the research stage of funding and ordering will be crucial in the uninterrupted operation of the project.

3.2.2. Deployment Timeline of IT Activities

IT must take into account the billions of data to be processed and, above all, their security. We are talking about implementing the various telecommunications and information networks that would facilitate the intervention and management of the new RIS. These include LAN, NAN, WAN and SCADA with all their respective accessories.

In the short term		In the medium term		Long-term	
Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Study and study planning					
	Specifications				
		Proposal of network type and creation of a Database			
		Funding research and command Equipment			
		Training of network operators locally and abroad			
		Integration of telecommunications equipment into the electricity grid			
		LAN and SCADA in major metropolises			
		LAN, NAN and SCADA throughout the country			
		LAN, NAN, WAN and SCADA throughout the country			

Figure 3. IT Deployment Acher.

IT will be deployed in nine phases over six phases and over the three major periods of the short, medium and long-term roadmap as shown in Figure 3. The telecommunications and information networks LAN, NAN, WAN and SCADA will be the main facilities to be set up; IT will then be necessary to install the smart sensors, wifi, and CPL and internet connection necessary for this purpose. Just like smart meters everything will start in some pilot districts of the big cities and will spread throughout the national territory in thirty years.

3.2.3. Aerating of Activities to Deploy Decentralized Productions

The decentralized products here concern solar production, wind, rechargeable batteries, electric vehicles and small-scale power plant microphones. But it is important to remember that this important step in the transformation of RIS should begin with the liberalization of Cameroon's energy production and distribution sector.

In the short term		In the medium term		Long-term	
Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Study and planning					
	Loads				
		Integration of renewable energy in rural areas			
		Renewable energy throughout the territory batteries			
		Renewable energy Batteries throughout the territory in addition to electric vehicles			

Figure 4. Aching of deployment activities decentralized productions.

The decentralized productions will be deployed in five stages, spread over the six phases and during the three main periods of the roadmap, as shown in Figure 3. Unlike smart meters and IT, the project will be able to start in rural areas before expanding into major cities. After the thirty years of the project, decentralized production is expected to be operational throughout the country.

4. Conclusion

This article is a roadmap proposal for the deployment of smart grids in Cameroon. Which roadmap gives short, medium and long-term orientation in order to improve the quality of energy supply. This is the first step of a great deal of studies that will focus on the integration of renewable energy into the current grid, the security of consumer data, energy storage, the cost of this mutation, communication and data transmission. This roadmap could serve as a guide to the deployment of smart grids in other countries in the sub-region.

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