

# The Governance of Energy Transition: Lessons from the Nigerian Electricity Sector

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# Abstract

## *Background*

The rising need for energy transition towards more sustainable energy sources requires a rethink in the governance of energy systems. Arguably, policy makers have very important roles in governing transitions in any given society through established institutional frameworks. It has also been argued that energy infrastructure choices are determined by institutional dynamics and structures. However, what are the influences underlying changes in energy systems and what lessons can we draw from them for the governance of energy transition? This study focuses on understanding the dynamics of energy transition governance within the Nigerian electricity sector with the aim of drawing lessons that impact on energy transition and energy systems change.

## *Methods*

Using explorative research tools, this research explores the dynamics of energy transition governance within the Nigerian electricity sector with the aim of drawing lessons that impact on energy transition and energy systems change. Data from primary and secondary sources in documentary archives and other published sources that links to the Nigerian historical energy infrastructure provisions were used for analysis in order to draw lessons on energy transition dynamics in Nigeria.

## *Results*

The study revealed that there were three important factors that had a direct impact on energy transition and energy systems change within Nigeria's electricity sector. These are: (1) Changing perceptions and goals (during the period leading up to Nigeria's independence, 1890 – 1960s); (2) Direct government interventions in energy infrastructure provisions (1940s – 1970s); and (3) Major changes in market rules (from 2005 and beyond).

## *Conclusions*

The study concludes by highlighting that: (1) there is a need for government institutions to tackle energy access issues that addresses the needs of the poor; (2) it is imperative to explore technological options that are more sustainable; and (3) there is a need to address energy consumption patterns that are more energy intensive. Indeed, available energy resources, technological changes in electricity supply systems, and the 'geographies of energy' are major factors that influence energy production and consumption dynamics. All of these needs to be considered as energy decisions are primarily political choices.

## **1.0. Background**

Energy systems can be very complex, entangled with multiple interconnected issues that require both urgent and simultaneous solutions that may lead to unprecedented energy transition [1]. These changes necessitating a transition in energy use also has serious consequences for energy governance [2].

Providing modern energy access, improving security of energy supplies and reducing energy systems effect on climate are three important global energy challenges with implications on national and global energy governance [1]. Energy governance is aimed at addressing some of these challenges. However, the complexity of energy challenges requires the involvement of various actors and stakeholders in proffering solutions that addresses the diverse aspects of these challenges [3, 4]. Indeed, addressing these challenges requires a polycentric energy governance system as most energy related challenges cannot be easily addressed within a single agency or regime [5, 6].

Transitioning away from our current fossil intensive energy system is a necessity [7]. The current state of use of available fossil based resources is simply unsustainable due to increasing economic, social and environmental criteria. The current techno-institutional complex discriminates against other technologies and favour fossil fuels [8]. The future of energy is of great concern to both policy makers and end-users alike [9]. It is a central challenge confronting governments, industry players, end users and other stakeholders [10]. Understanding the motives and drivers of energy transitions is of utmost importance in effecting energy systems change. However, how is energy transition occurring? What lessons can we draw from energy transition dynamics in the global south, within developing country contexts? This paper explores the energy governance dynamics within the Nigerian electricity sector while drawing out lessons on some of the impacts of the various governance dynamics.

In Sect. 2, some background is presented that contextualizes the study. Section 3 presents some brief methodological considerations. In Sect. 4, the main findings detailing the important features of Nigeria's electricity system and their impact on energy transition are presented. The concluding thoughts are presented in Sect. 5.

## 2.0. Research Context

Energy transition is driven more by the quest to reduce environmental harm caused by continuous burning of fossil fuels [11–13]. A major consequence of this are the efforts directed towards limiting  $\text{CO}_2$  emissions [14]. Rojey argues that improving energy efficiency, increasing the share of low-carbon energy sources in our energy mix, and introducing Carbon Capture and Storage facilities can help reduce  $\text{CO}_2$  emissions in a considerable way [15]. Rojey further argues that ensuring technological progress to support new technologies that limit  $\text{CO}_2$  emissions, defining new energy governance rules that go beyond legislation, and the introduction of new lifestyle that are less energy intensive are examples of actions that are required for a successful energy transition.

It is important to understand energy transition from a geographical and political perspective [16–18]. Rocher and Verdeil, in examining the socio-technical collectives involved in the Tunisian energy transition argues that there are four major elements that can be used as a basis to analyze the role of distributed agencies. These elements, which are crucial in understanding the dynamics at play on-the-ground, can help in providing useful guidance on effecting energy transition to low carbon energy sources. They include [16]:

- The actors involved in energy issues, including those involved in proffering solutions to energy challenges at local, regional and national levels.
- The (shared or unique) visions of the various actors and the goals that they pursue or the interests they defend.
- The current available technologies in the energy production and consumption systems.
- The conditions and policy instruments under which the current technologies at play are rolled out.

Indeed, at the heart of all the ongoing changes in energy systems are the drivers of electricity demand and supply. It is argued that there are some major drivers of electricity demand and supply necessitating changes in energy systems [19]. These include:

- i. **Prices:** End user energy prices and fuel cost play a vital role in energy systems change. It is generally believed that the higher the energy price, the lower the consumption due to energy efficiency measures, energy savings and/or switch to other cheaper alternative energy sources. Arguably, the life cycle cost of renewables is much cheaper than fossil based energy source due to additional fuel cost [20, 21].
- ii. **Economic factors:** Factors such as GDP growth rate and increased income levels have a strong correlation with electricity demand growth. Increased income levels of households directly impacts on comfort levels through increased energy expenditure for cooling and heating requirements [22, 23].
- iii. **Subsidies:** Subsidies for certain types of technologies such as solar PV (and other renewable technologies) play a vital role in ensuring the adoption of such technologies. Subsidy for certain energy resources (such as crude oil and natural gas) also determines to a large extent the kind of energy infrastructure we end up with [24, 25].
- iv. **Structure of electricity demand:** This includes demand level, peak load and demand variation, energy intensity, etc. Since electricity cannot be stored, it has to be produced and consumed simultaneously. This means seasonal and instantaneous variations in energy demand has to be met. Indeed, systems need to be matched with demand in such a way that long term energy demand (over a long time period) and peak load (short term) demand are met [26].
- v. **Industry structure and other policy factors:** Industry structure plays a vital role in energy infrastructure choices. A country/region with intensive industrialization drive will necessarily need to make energy decisions that support industrial growth. Other policy factors such as reaching certain emissions and energy efficiency targets could have significant impact on energy demand and supply [27].
- vi. **Potential for energy savings and demand side management (DSM):** As many countries in Europe are gradually becoming less industrialized and moving towards a more service intensive economy, the need for greater energy savings and demand-side management becomes paramount. The offshoring of manufacturing processes necessitates a rethink in energy systems and use, particularly in embracing energy efficiency measures. Technologies that help save and optimize energy consumption can also have significant impact on energy demand [28, 29].

## 2.1. Energy transition dynamics in Nigeria

Energy transition in Nigeria is a necessity, not only because it provides environmental gains but because Nigeria's current electricity infrastructure is mainly characterized by an unstable grid, obsolete systems infrastructure, and demanding logistics to get the lights on [30–32]. Addressing the challenge of energy infrastructure deficit and replacing obsolete infrastructure provides an opportunity for an energy transition that ensure the provision of more electrical power from cleaner energy sources in a sustainable way without detrimental impact on the environment [33, 34]. Indeed, if energy transition is a necessity, in what ways have Nigeria tried to effect these changes in energy systems? What changes have occurred over time? Fig. 1 provides a panoramic overview of the various stages of the Nigerian energy transition.

In Fig. 1, the various eras of energy use is defined following different time periods. Starting from the pre-industrial (agricultural) era from the 1800s, we notice a gradual change in technology-in-use and social practices that became more energy intensive, thus requiring more energy dense sources which explain the changes in energy resource use [35, 36]. Energy (re)sources have been a major (but not the only) driver and mediator in effecting energy transitions in Nigeria [37]. Changes in energy sources based on available energy resources have also impacted on technology shifts over time [38]. In this study, we further explore the factors that necessitated energy transition and energy systems change within the Nigerian context while particularly focusing on the role of resources and available technologies as later presented in Sect. 4.

### 3.0. Materials And Methods

This study explores dynamics of energy transition governance within the Nigerian electricity sector with the aim of drawing lessons that have impacted on energy transition and energy systems change. It is an explorative study of Nigeria's electricity sector, focusing on historical electricity policy and infrastructure decisions, the governance of those changes, and how they necessitated a transition in energy use.

In this study, archival documents of various institutions and other relevant literature were used for data collection using documentary literature research tools. Scott argues that documents are texts produced by an individual or group with the exclusive aim of addressing immediate practical needs [39]. They are written based on particular assumptions and with a clear purpose. In this study, data from primary and secondary sources in documentary archives and other published sources that links to the Nigerian historical energy infrastructure provisions were used for analysis in order to have a better understanding of the Nigerian energy (infrastructure) history.

The following steps were followed in analyzing archival documents/records used in this study [40, 41].

1. *Meeting the documents*: this process involves checking to ascertain if there are any special markings or figures on the documents which could tell us something in connection with the subject under study. Circle or highlight those markings
2. *Observing the parts*: this entails finding out who wrote the documents and for what purpose. When was the record produced and archived? Are those dates useful in analyzing times of energy transition and how society develops over time?

3. *Trying to make sense of the documents*: this stage entails trying to obtain the main ideas of the documents. Why was the document written? Are there useful aspects that support my research and can be used as evidence?
4. *Use the documents as historical evidence*: this stage helps in asking questions that can help provide answers to validate the use of those documents as evidence. For example, where can I find more information about a particular event referenced in the document? Where can I find more information about the person who wrote the document? Are there empirical evidences that are aftermaths of the things observed in the documents?

Indeed, the aforementioned process guided the data analysis that addressed the first sub-question.

## 4.0. Results

Following collection and analysis of data, the study reveals that three major factors characterized Nigeria's electricity sector that had a direct impact on Nigeria's energy transition and energy systems change. These are:

- Changing perceptions and goals (during the period leading up to Nigeria's independence, 1890–1960s)
- Direct government interventions (1940s – 1970s)
- Major changes in market rules (from 2005 and beyond)

The following sub-sections now delve into further details around the aforementioned themes.

### 4.1 Changing perception and goals on Nigeria's electricity system (1890–1960s)

The study revealed that changing perception and goals of Nigeria's electricity systems were manifested in three main ways:

- Changing motives for energy infrastructure provision
- Intermittent switch in energy fuels
- Changes in energy technology in use

With respect to changing motives for energy infrastructure provisions, the study revealed that initial provision of electricity infrastructure were motivated by the need to light up settlements and government offices mostly occupied by Europeans. Lighting was the primary motive for the provision of the first power plant in Nigeria, the Lagos Marina station as shown in Table 1. The increased demand for electricity beyond lighting application led to the expansion of existing plants and the provision of new ones as shown in Table 1. The need to power the workshops of the Nigerian Railway Corporation (NRC) for the maintenance of locomotives triggered the next wave of power plant expansion. In the Plateau region of Nigeria, the need to provide electricity to support mining activities for Tin was another motivation for

provision of electricity infrastructure in that region. The topography of the region (being a high plateau) supported the provision of the first hydropower plant in Nigeria. Indeed, lighting, powering of NRC workshops, supporting the Tin mines and powering government offices and government settlements were key motives for the provision of electricity infrastructure in pre-independent Nigeria.

Table 1  
Summary of electricity infrastructure provision in colonial Nigeria

(Source: Author compilation)

s/n	Power station/supply	Year	Capacity	Fuel type	Technology type	Main application	End-user group
1	Lagos Marina Station	1896–1920	30KW which grew to 420KW	Diesel	Steam engines	Lighting application	Mainly Europeans
2	Iddo Power Station	1923	3.6MW which grew to 13.75MW	Coal	Coal-fired steam engines	Lighting and Railway workshops	Mainly Europeans
3	Plateau Electricity Supply (owned by the Nigeria Electricity Supply Company – NESCO – a British company)	1922–1945	2MW which grew to 12MW (with peak load at installed capacity of 18.4MW)	Hydro	Hydro-electric plant	Lighting applications and mining industry	European settlements and Tin mines
4	Enugu Electricity Supply	1922–1953	3 X 350KW plant which grew to 3000KW by 1953	Diesel	Steam engine plants	Lighting and industry	Nigerian Eastern Railway (NER) workshops, European settlements, Church, and Barack
5	Nigerian Railway Plant Port-Harcourt	1928	2250KW that grew up to 8530KW	Diesel	Steam engines	Industry application (transport)	Nigerian Railway Corporation (NRC) workshops
6	Kaduna Northern Province Head Quarters	1929	8.28MW installed capacity	Diesel	Steam engines	Lighting, residential and administrative uses	Government offices and residential areas

Fuel source for the power plants also constituted a vital part of electricity infrastructure decisions. The study revealed that during colonial Nigeria, most power plants built depended on diesel as its fuel source which at the time was imported from the United Kingdom. However, the discovery of coal in Nigeria in 1909 triggered the use of coal for the Iddo power station that was commissioned in 1923. Indeed, the study further revealed that the discovery of coal did not really change the energy fuel trajectory from diesel to coal. However, it was observed that more diesel power plants were installed up to 1940 as shown in Table 2.

Energy technology also played a dominant role in the provision of electricity infrastructure in Nigeria. The study revealed that the dominant technology for most power plants that were deployed in Nigeria between 1890 and 1940 were steam engine technologies that were either diesel-fired or coal-fired power plants. The only exception was the hydropower plant built in the plateau region due to the advantages presented by the topography of the region. Indeed, the study revealed that there was a case of technological lock-in to the use of steam engine technologies which was interrupted (and completely halted) by the Second World War since it now became impossible to get maintenance spares for the plants owing to the war.

Some other power stations that came on stream are listed in Table 2, together with their capacity, location and institution responsible for its provision.

Table 2  
Other electrical infrastructure provision in Nigeria (1933–1940)

(Source: Author compilation)

s/n	Location	Institution Responsible	Year	Capacity (KW)
1	Katsina	Native Authority	1933	100
2	Maiduguri	Public Works Department (PWD)	1934	210
3	Abeokuta	Native Authority	1935	600
4	Yola	Public Works Department (PWD)	1937	75
5	Zaria	Public Works Department (PWD)	1938	1436
6	Calabar	Public Works Department (PWD)	1939	570
7	Warri	Public Works Department (PWD)	1939	530
8	Ibadan	Native Authority	1940	4515

## 4.2. Direct government interventions (1940s – 1970s)

The study reveals that government intervention in the provision of electricity infrastructure was evident through the establishment of institutions that were given the mandate to address a specific challenge that served as a barrier to the diffusion, spread and expansion of new and existing electricity infrastructure to cater for the growing energy needs. Table 3 provides a summary of various government interventions in electricity infrastructure, institutions responsible and their central focus.

Table 3  
Direct government interventions in Nigeria's electricity infrastructure provision

(Source: Author compilation)

s/n	Year	Institution	Main mandate/focus
1	1940s	Nigerian Government Electricity Undertaking (NGEU)	Design a plan to increase electricity generation capacity by at least 200% to support industrialization
2	1950s	Electricity Corporation of Nigeria (ECN)	Provide the cheapest form of energy consistent with continuity of supply
3	1960s	Electricity Corporation of Nigeria (ECN)	Address issues and concerns about electrical standards due to repeated fires in Lagos caused by electrical faults
4	1960s	Niger Dams Authority (NDA)	Develop Nigeria's hydropower potential
5	1970s	National Electric Power Authority (NEPA)	Take charge of provision, operation and maintenance of electricity infrastructure nationwide

In the 1940s, the Nigerian Government Electricity Undertaking (NGEU) was established by the British colonial government out of the Public Works Department (PWD) to design a plan to increase electricity infrastructure provision by at least 200% to pave the way for industrialization in Nigeria. This intervention led to the establishment of several industries in different parts of the country starting from the early 1950s. Indeed, by 1970, there were more than 2000 industries scattered around different industrial estates in Nigeria. The NGEU, which was set up as a holding company, eventually morphed into a new corporation in the 1950s called the Electricity Corporation of Nigeria.

The Electricity Corporation of Nigeria (ECN) was the second major institutional intervention set up by the Nigerian government with a mandate of seeking ways of providing the cheapest form of energy that is consistent with continuity of supply. The ECN was established on 6th July 1950 but only took over from the NGEU on 1st April 1951. The ECN continued with their established mandate. However, frequent cases of fire outbreaks owing to electrical faults necessitated an intervention by the Nigerian government to further extend the mandate given to the ECN (in the 1960s) to include developing standards for electrical equipment and devices to help curtail the frequent fire incidences.

The study further revealed that in the 1960s, government interventions on electricity infrastructure provision led to the establishment of the Niger Dams Authority (NDA) with a clear mandate of developing Nigeria's hydropower potential. This intervention led to the planning and provision of several large dams in Nigeria, particularly Kainji, Jebba and Shiroro dams.

The need to have a coordinated system where one central institution of government can take charge and responsibility for everything that has to do with electricity infrastructure in Nigeria led to the establishment of the National Electric Power Authority (NEPA) in the 1970s. NEPA came about as the result of a merger of the Niger Dams Authority and the Electricity Corporation of Nigeria.

Indeed, the study further revealed that there were other interventions that were mainly private interests. The Nigerian Electricity Supply Company (NESCO), a British company, and the African Timber and Plywood Company (AT&P) are examples of such. Table 4 shows the number of power stations in Nigeria as of 1952 and the institutions responsible for its provision.

Table 4  
Number of Power station in Nigeria, Institutions responsible and their capacity  
as of 1952

(Source: Author compilation)

s/n	Responsible institutions	Number of power plants
1	ECN	17
2	NESCO	1
3	AT&P	1
4	Planned and under construction	17
s/n	Responsible institutions	Power generated (in million KW)
1	ECN	89.1
2	NESCO	66.6
3	Industrial undertakings	9.5
<b>TOTAL</b>		<b>165.2</b>

The study also revealed that several government interventions led to widespread diffusion and provision of several electricity infrastructure. As of 1953/54, there were a total of 43,659 electricity consumers in Nigeria. With respect to electricity consumption patterns in the 1953/54 fiscal year, about 50.3% of electricity produced was consumed through various forms of domestic applications, closely followed by power requirements which took about 33.1%. Commercial applications was responsible for 12.7% of total electricity consumption while public lighting and other miscellaneous uses took 1.7% and 2.2% respectively of total electricity consumption as shown in Fig. 3.

### 5.3. Major changes in market rules (from 2005 and beyond)

The study revealed that major changes in market rules played an important role in the governance of energy transition in Nigeria. Some key events leading to changes in market rules in Nigeria's electricity sector that had some impact on Nigeria's energy transition are highlighted in Table 5.

The liberalization of the Nigerian electricity sector was a major reason for changes in market rules. This process started in 2001 with the introduction of the National Electric Power Policy (NEPP) which paved the way for the production of the National Energy Policy (NEP) framework in 2003. The NEP framework provided a basis for the preparation and enactment of the Electrical Power Sector Reforms Act (EPSRA) in 2005. The EPSRA act provided the legal/regulatory backing that aided the liberalization process of the

Nigerian electricity sector. This act paved the way for the establishment of the Power Holding Company of Nigeria (PHCN), a holding company that was eventually unbundled to eighteen companies comprising six generation companies, one transmission company and eleven distribution companies.

The study revealed that the liberalization of the Nigerian electricity market also opened up other opportunities for Nigeria by providing a platform for the establishment of some important agencies of government or some regulations to address specific challenges within the Nigerian power sector. An example is the formation of the Nigerian Electricity Regulatory Commission (NERC) saddled with the responsibility of regulating the activities of various players within the Nigerian electricity sector. The Renewable Energy Policy Guideline (REPG) and the Renewable Action Program (REAP) were instrumental in paving the way for large scale deployment of solar home systems and off-grid solutions. National biofuels policy formulated in 2007 paved the way for the production of a national guideline of the use of biofuels. Indeed, these various changes in market rules were instrumental in the liberalization of the Nigerian electricity market which paved the way for the inclusion of cleaner on-grid and off-grid energy sources to Nigeria's energy mix.

Table 5  
Key events leading to changes in market rules in Nigeria's electricity sector (2000–2015)

(Source: Adapted from [42])

s/n	Year	Events impacting market rules
1	2001	National Electric Power Policy (NEPP) initiated
2	2003	National Energy Policy (NEP) framework produced
3	2004	National Economic Empowerment and Development Strategies (NEEDS) issues to address development challenges (including energy)
4	2005	Electric Power Sector Reform Act (EPSRA) enacted
5	2005–07	Formation of the Nigerian Electricity Regulatory Commission (NERC); The formation of the Power Holding Company of Nigeria (PHCN); and the eventual unbundling of the PHCN into 18 companies
6	2006	Renewable Energy Policy Guideline (REPG) released, together with the Renewable Energy Action Program (REAP)
7	2007	National Biofuels Policy and incentives were formulated
8	2008–09	Multi-Year Tariff Order (MYTO) was established while the Power Sector Reforms Committee was formed
9	2010	The Presidential Task Force on Power (PTFP) and the Presidential Action Committee on Power (PACP) were established.  The Power Sector Roadmap was released
10	2012	MYTO 2 was approved and released
11	2013	Privatization of generation and distribution companies was effected. Transmission was retained by the government but managed under a management contract agreement (by Manitoba Hydro International – MHI)
12	2015	Commencement of the Transitional Electricity Market (YEM) regime.  Tenure of the NERC Commissioner ended (Dec)  MYTO 2.1 approved and released but faced opposition from consumer groups (with proposed 80% price increase which was later reduced by 25%)  Draft Rural Electrification Strategy & Plan (RESP) released. The National Renewable Energy & Energy Efficiency Policy (NREEEP) was also released

## 5.0. Discussion And Conclusion

Following the findings, it is evident that policy and institutional interventions manifests itself in various ways, particularly through government institutions and other multilateral organizations that come together to seek ways of addressing some common societal and global challenges such as energy access [43, 44], energy security [45, 46], de-carbonization [47, 48] and climate change issues [49, 50]. The World Bank

Group argues that to achieve a sustainable energy future for all, there is a need to ensure universal energy access that focus on the poor which can be achieved more quickly through the rapid expansion of renewable energy [51].

Various technological interventions over time have impacted on energy systems change and energy transition. Electricity systems in many countries started off with the use of steam engines from the late 1800s to the early 1900s [37]. Further technological changes that saw the shift from one technology to another also occurred. The shift from steam engines [52] to diesel engines [53], thermal power plants [54], hydroelectric power [55] and the various forms of renewable technologies, including solar photovoltaic cells [56], concentrated solar plants [57], wind technology [58], etc., are evident of the role of various energy technology pathways in ensuring energy transition and energy systems change within the Nigerian context.

Social and societal (everyday) practices, which essentially consist of the way people habitually do things, have evolved over time [59]. Some everyday practices such as cooking, commuting, trading, entertainment, etc., have evolved over time such that they now require more energy than ever before for the actualization of those practices [60–62]. The fact that energy infrastructure provision has enabled some everyday practices to be performed in a manner that helps in satisfying the need for greater levels of comfort, cleanliness and convenience has increased the public value for energy [23, 63]. Indeed, energy is that net currency that enables the actualization and entrenchment of new and existing practices that are becoming more energy intensive.

Available energy resource options have played (and will continue to play) a dominant role in energy choices and energy systems change. Most countries started off with electricity systems that depended on coal as the major fuel source. The discovery of other fuels such as crude oil and natural gas changed the energy landscape by enabling the introduction and provision of new power plants that depended on those fuel sources [64].

## List Of Abbreviations

AT&P African Timber and Plywood Company

ECN Electricity Corporation of Nigeria

NRC Nigerian Railway Corporation

NGEU Nigerian Government Electricity Undertaking

NDA Niger Dams Authority

NEPA National Electric Power Authority

NESCO Nigerian Electricity Supply Company

NERC Nigerian Electricity Regulatory Commission

MYTO Multi-Year Tariff Order

PHCN Power Holding Company of Nigeria

## **Declarations**

### **Ethics approval and consent to participate:**

Not applicable.

### **Consent for publication:**

Not applicable

### **Competing interest:**

The authors declare that they have no competing interest

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### **Availability of data and materials:**

All data used for this study are embedded in the manuscript. Other materials can be provided on request.

### **Authors' contribution:**

This work is sole authored by the corresponding author.

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