Electrical Energy Transition in the Context of Ghana

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Abstract

Background

In Ghana, energy transition as a research theme is new and its manifestations are not glaring. It is inconclusive as to whether energy transition has occurred or not, and in what form if it has occurred. The study sought to find out if energy transition has occurred in Ghana's electrical energy sector and how.

Methods

Pieces of information on Ghana's electrical energy transition manifestations were obtained from reviews of Ghana's renewable energy policy documents, namely the Ghana Renewable Energy Act (2011) and the Ghana Renewable Energy Master Plan (2019); reviews of Ghana energy sector reports, newspaper articles and information on the websites of Ghana's energy sector institutions such as the Volta River Authority, Ghana Grid Company Limited, Electricity Company of Ghana and the Northern Electricity Distribution Company; and personal observations.

Results

The study found that fundamental changes have occurred in Ghana's electrical energy sector: in the form of transition from exclusive hydro energy to hydro-thermal mix, with thermal constituting about 69% of the 2020 generation mix; and transition from exclusively State supply to State-private supply mix, with about 56% of present supply coming from private companies. These changes have been motivated by need to expand energy supply in response to increasing demand of 10-15% per annum. Renewable energy has attracted attention in policy, with targets such as 10% renewable energy in the energy mix by 2030 and provision of renewable energy to 1,000 off grid communities by 2030. However, renewable energy currently constitutes less than 1% of the electrical energy mix. There has been no change in heavy reliance on fossil energy for vehicular transportation.

Conclusions

Energy transition in its broad sense of fundamental changes in a country's electrical energy system has occurred in Ghana but sustainability energy transition in the sense of transition to greener energy has not occurred in Ghana. It is recommended that further studies are conducted on why Ghana's renewable energy agenda has so far only been agenda in policy with very minimal implementation in practice.

1. Background

1.1 Background to the study and study objective

Energy transition has emerged as an important theme within energy governance literature and practice. This is happening against the background of increasing push for green energy as the world strives to contain greenhouse gas emissions and global warming within limits (Gallo et al., 2016). For instance in

Germany, the energy transition agenda, dubbed 'Energiewende', has taken firm roots: supportive policies and legislation have been enacted; nuclear power plants have been shut down; the proportion of green energy in the energy mix has increased significantly; there is localized production and distribution of energy; vehicles with higher emissions have restricted access to certain places; and diesel cars are being banned in places (Hauff et al., 2014). In some countries, electricity is replacing fossil fuel in powering vehicular transportation within and between cities (Hauff et al., 2014).

Although there is no universally-accepted definition for the term Energy Transition (Smil, 2010), it has been described as an inevitable shift away from cheap, centralized, largely fossil-based energy systems (Verbong & Loorbach, 2012). Literature on energy transition reveals two categories of definitions for the term. The first category defines energy transition as structural changes in a country's energy system (Guan *et al.*, 2018). Structural changes here imply changes that are significant and not ad hoc or temporal. This is exemplified by the World Energy Council Deutschland's definition of energy transition as 'long-term structural change in energy systems' (Hauff et al., 2014). This definition is inclusive but somewhat general. It is how the term was defined when it was coined by early modelers like Naill (1977). The second category defines energy transition as transition towards greener energy (Gibbs & O'Neill, 2015). This is exemplified by IRENA¹'s definition of energy transition as 'pathway towards transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century'. This definition is more specific. The prefix 'sustainability' is sometimes added to distinguish this green energy definition of the term from the somewhat general earlier definition.

Literature reveals two principal motivations for energy transition: firstly, to secure energy supply, e.g. energy transition in the United States of America to reduce import dependency; and energy transitions in China and South Africa to expand supply to meet rising energy demand; and secondly, to respond to environmental concerns such as climate change (Hauff et al., 2014). Furthermore, Hauff et al. (2014) identified two drivers for energy transition. The first is government policy, e.g. renewable energy targets and energy efficiency standards, and associated incentives. The second is technological innovation and business strategies of energy companies, e.g. the US shale gas revolution based on shale gas technological innovation. Of the two drivers, government policy is recognized to be the main driver of energy transition (Bridge, et al., 2013; Hauff et al. (2014).

In Ghana, energy transition as a research theme is yet to gain traction and its manifestations are not that glaring. There is no conclusive research knowledge on whether energy transition has occurred or not, and in what form if it has occurred. Against this background, this overview paper provides insights into electrical energy transition in the context of Ghana.

1.2 Indicators of Energy Transition

In assessing if electrical energy transition has occurred in Ghana and how, indicators of energy transition were deduced from literature to help arrive at this conclusion. This section presents some indicators of energy transition found in literature.

Change in energy source type: this refers to changes in energy source type, for instance from thermal or nuclear sources to greener energy sources like solar or wind energy. It is a widespread indicator found in literature on energy transition (Naill, 1977; Hauff et al., 2014; Gallo et al., 2016; Şanlı, 2017). It also includes changes within same category of energy source e.g. change from coal to natural gas as both are thermal energy sources. Also admissible in this indicator category is transition in domestic energy source from biomass energy to more modern energy sources in developing countries (Leach, 1992; Pachauri and Jiang, 2008).

Change in energy ownership and management: this refers to change in the ownership or management of a country's energy system, for instance from state to private energy or from state to community-based energy or vice versa (Yadoo and Cruickshank, 2010; Melo, De Almeida Neves and Pazzini, 2011; Burke and Stephens, 2018; Klagge and Meister, 2018; Rommel et al., 2018). The transition from centralized energy to localized energy has been termed 'democratization of energy' (Burke and Stephens, 2018).

Transition to greener vehicular transportation: this refers to transition to greener vehicular transportation, and takes the energy transition discussion beyond domestic and industrial energy to energy transition occurring in vehicular transportation (Hauff et al., 2014; Gallo et al., 2016; Nilsson and Nykvist, 2016; Silvia and Krause, 2016; Şanlı, 2017). This is important because the transportation sector is a major consumer of energy (Yin et al., 2015; EIA, 2016).

^{1]} IRENA: International Renewable Energy Agency, www.irena.org

2. Methods

Information on the Ghana's manifestations of energy transition was obtained through reviews of Ghana's renewable energy policy documents, namely the Ghana Renewable Energy Act (2011) and the Ghana Renewable Energy Master Plan (2019); reviews of energy sector reports, newspaper articles and information on the websites of Ghana's energy sector institutions such as the Energy Commission, Volta River Authority, Electricity Company of Ghana and the Northern Electricity Distribution Company; and personal observations. The indicators of energy transition presented above provided guidance in concluding on how energy transition has occurred in the context of Ghana.

3. Results

3.1 Ghana's electricity supply: Origins and highlights

State-operated electricity supply in Ghana dates back to 1914 under the then colonial government. These were fossil-powered stations that supplied limited electricity to selected cities such as Takoradi, Koforidua, Accra, Kumasi, Tamale, Cape Coast, Winneba and Tema (Clark, 1994; Eshun and Amoako-Tuffour, 2016). The biggest of these stations, the Tema diesel power station, had a generation capacity of 35,298 kilowatts. The first grid electricity transmission system was installed in 1963. It was a 161 kV transmission system to transmit electricity from the Tema power station to mostly Accra. The

inauguration of the Akosombo hydroelectric power station in 1966 by the then independent Ghana Government marked a significant turning point in Ghana's electricity sector. This large dam project resulted in the creation of one of the world's largest man-made lakes, the Volta Lake. It is about 500 km long and about 8,500 km² square large. The Akosombo hydropower station has a generation capacity of about 1,000 megawatts (MW). At the time of its inauguration, about 60% of the electricity output was used to power the smelter of the Volta Aluminum Company Limited. The remaining provided almost all of Ghana's grid electricity. Ghana's population then was about 5 million compared to the present population of about 30 million people. Moreover, the majority rural population had not been connected to the national grid. There was even surplus energy that was exported to neighboring countries Togo, Benin and Burkina Faso². With increase in electricity demand as a result of increasing population, increasing industries and expansion of grid electricity to rural areas, the power supply from the Akosombo hydroelectric power station soon became inadequate. The supply shortfall has been addressed over the years through smaller hydroelectric stations and thermal power stations.

3.2 Ghana electricity supply: Present situation

The present Ghana electricity sector has three major actors: electricity producers, a transmitter company and distributors. The power producer category comprises both State companies and private companies. The State power producer is the Volta River Authority (VRA). It owns and operates the Akosombo hydroelectric power station, the Kpong hydroelectric power station, five thermal power stations and one solar plant. Collectively, the State-operated power stations have a present installed capacity of 2,269.5 MW and a dependable capacity of 2,031.75 MW (Energy Commission, 2020). The private power producers are termed Independent Power Producers (IPPs). The major IPPs are twelve thermal power stations and one hydropower station, with a total installed capacity of 2,867.5 MW and a total dependable capacity of 2,625.6 MW Commission, 2020). This energy is sold to the State for onward transmission and distribution. Table 1 provides further details of the present situation of electricity supply from State and private producers.

For 2020, the peak electricity demand was 2,957 MW, a marginal increase over the 2019 peak demand of 2,665.68 MW (Energy Commission, 2020). The total dependable grid capacity was 4,657.35 MW: approximately 30% hydro, approximately 69% thermal and about 0.64% solar; and approximately 44% State and approximately 56% Private (See Table 1).

The electricity transmitter category is a State company called Ghana Grid Company Limited (GRIDCO). It operates high voltage electricity lines that convey electrical power from the production areas to cities and towns where the power is consumed. The power distribution category is composed of two State companies: the Electricity Company of Ghana (ECG) which is responsible for electricity distribution in the southern and middle parts of Ghana, and the Northern Electricity Company Limited (NEDCO) which is responsible for electricity distribution in the northern part of Ghana. These two companies are responsible for bringing down the high voltages of the transmitted electricity to consumption voltages, distributing the power to homes and industries, and collecting revenues from the power users. There were attempts in

2019 to privatize electricity distribution in Ghana, but controversies surrounding the privatization stalled the process.

When the present situation of Ghana's grid electricity situation is compared to situations in the past, the notable changes over the years are: transition from exclusive hydro electrical energy to hydro-thermal mix, with thermal constituting approximately 69% of present production; and transition from exclusively State supply to State-private supply mix, with approximately 56% of present supply coming from private companies (Table 1). These changes have been motivated by the need to expand energy supply to meet increasing demand of 10–15% per annum from increasing population, industries and grid expansion. Additional thermal plants and private electricity producers have mostly been brought on board during periods when the nation had run into power crisis. Ghana's unstable electricity problems started as far back as 2001. It however peaked in 2014 and 2015, partly due to prolonged dry seasons during the period resulting in decreased electricity generation from the Akosombo hydroelectricity station. In 2015, the blackouts were so severe that the term 'dumsor', literally meaning 'power off and on' became a household term in Ghana. As quick fix, the then Government entered into a 10-year contract with the Turkish Karadeniz Energy Group for the provision of thermal electricity from two floating power ships. The agreement did not require Ghana to pay the upfront cost for the power ships but rather for the about 450MW electricity to be fed into the national grid.

The increasing transition to thermal electricity in Ghana has been accompanied by astronomical increases in electricity prices over the years. This is well captured in a remark the Managing Editor of the Insight local newspaper, Kwasi Pratt, made during a radio discussion at Adom FM in 2016:

"How can electricity bill that was around GH₵ 300 move to GH₵ 1200, when I complained, it jumped to GH₵ 1800; while we were still deliberating on this, it shot up to GH₵ 2000 something. The bill that was brought last month was just too serious, it was GH₵ 6000, I don't even know whether to cry or to laugh about this," Kwasi Pratt, Managing Editor of the Insight newspaper (2016)³.

There is no written government policy driving the increasing transition from hydro power to thermal power. The increasing transition from State power production to private production is backed by a general government policy of Public-Private partnerships for infrastructure and better public services delivery, which is enshrined in a written National Policy on Public Private Partnerships (2011).

3.3 Ghana's renewable energy agenda

New renewable energy has attracted attention in policy, with policy targets such as 10% of renewable energy in Ghana's energy mix by 2030 (Renewable Energy Act, 2011), and renewable energy to 1,000 off grid communities by 2030 (Renewable Energy Master Plan, 2019). There is however limited action on the ground towards achievement of these new renewable energy targets. There are scattered solar energy projects in Ghana by both State and non-state companies but overall, Ghana has not moved beyond demonstration projects on new renewable energy to large scale adoption. New renewable energy presently accounts for less than 1% of the grid electrical energy mix (see Table 1). Ghana's larger scale

hydroelectricity projects (of over 100 MW) are not considered here, as the Ghana Renewable Energy Act (2011) considers only hydropower projects of up to 100 MW capacity as renewable.

²Source: <https://www.energymin.gov.gh/sector-overview>

³Source: <https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Gov-t-must-be-forced-to-reduce-electricity-bills-Pratt-442220>

4. Discussions

Clearly, there have been structural changes in Ghana's electricity sector, in the form of transition from hydro to hydro-thermal mix with thermal presently accounting for a higher proportion of Ghana's grid electricity; and transition from exclusively State-produced electricity to State-private supply mix with private companies presently accounting for higher proportion of Ghana's electricity production. These transitions have been motivated by the need to expand energy supply to meet the increasing demand and driven by a general government policy of public-private partnerships for infrastructure and public services delivery. This Ghanaian experience of energy transition is comparable to energy transitions in China and South Africa, where the transitions were also to expand supply to meet increasing demand (Hauff et al., 2014).

The increasing transition from hydroelectricity to thermal electricity is quite unexpected, given the comparative advantages hydroelectricity has over thermal electricity and also the somewhat global consensus on the need to move towards greener energy sources (Miescher and Tsikata, 2009; Akpinar, 2013; Bahadori et al., 2013; Killingtveit, 2013; Bagher et al., 2015). Besides the obvious comparative environmental advantages of hydroelectricity in terms of lower carbon emissions and lower pollution to host communities, hydroelectricity is cheaper for the power consumer compared to thermal electricity (Fakehinde et al., 2019). Hydroelectricity relies on renewable water power to run the plant turbines whereas thermal electricity relies on expensive fossil fuel to run the electricity plants. Ghana's thermal plants mostly run on light crude oil and gas (See Table 1).

For a developing country like Ghana, environmental concerns are not always considered in the pursuit of economic and development aspirations. This can be seen in the widespread occurrence of livelihood practices like artisanal mining of minerals and sand that continue to happen even though they cause massive environmental degradation (Mensah, 1997; Bonzongo et al, 2003; Hilson, 2011; Agyei-Mensah and Oteng-Ababio, 2012; Obiri et al., 2016). It is nevertheless expected that the price cost to the ordinary citizen shall be an important consideration in choosing between development pathway options, given the generally low levels of wages and salaries. One may therefore wonder why different governments have over the years resorted to the expensive thermal energy in addressing Ghana's electricity shortfalls and not further investments in hydroelectricity or some other cheaper renewable energy. The answer lies in Government's tendency to resort to 'quick fix' solutions in addressing societal problems. Hydroelectricity projects are highly capital intensive and take considerable period of time to start producing electricity.

Since the Akosombo dam project, Ghana has constructed two additional hydroelectric dams (See Table 1). The most recent is the Bui dam, a 400-megawatt hydroelectric project completed in 2013 through public-private partnership between the Ghana Government and Sino Hydro, a Chinese company (Kirchherr et al., 2016). The project cost 622 million USD and took over 50 years since its inception to be completed. The cost and long duration makes such projects unattractive to governments with four-year mandates and limited funds. The thermal energy option has thus been more appealing to governments over the years because it provides a quicker fix and reliable solution that enables governments to be seen by the citizenry to have provided solutions during their four-year terms, and thus earn them political points which they need to remain in power. For instance, the Government's decision to resort to floating thermal power ships to address the 2014 and 2015 power crisis could be explained by the speed within which the already assembled power plants could be sailed to Ghana and connected to the national grid within weeks (Kumi, 2017; Gyamfi et al., 2018).

The increasing transition from State electricity production to production by private companies is expected. There is a general Ghana Government policy to partner private entities in the quest to deliver infrastructure and social services, necessitated by limited State financial resources against high public demand for infrastructure and social services (Robert et al, 2014). Public private partnerships are presumed to enable governments deliver essential infrastructure and public services effectively and efficiently. These presumed benefits have made public-private partnerships appealing not only in Ghana, but in many countries across the globe, particularly in developing countries (Jamali, 2004; Nsasira et al, 2013; Sapri et al., 2016). There is however overwhelming evidence to the fact that public private partnerships have largely failed to deliver the presumed benefits of secured and better social services (Jamali, 2004; Van Dijk, 2008; Hall, 2015; Pusok, 2016; Tariq et al, 2019). In the Ghanaian electricity sector, the public private partnerships have resulted in a present excess electricity generation capacity: 4,593 MW production as against a 2019 peak demand of 2,665.68 MW. Many stakeholders have raised concerns about the nature of contracts the State has made with the private power producers which require Ghana to pay for the excess power whether the power is used or not. It has been reported that Ghana presently pays about \$450 million yearly for the unused excess power from the private producers (Dzawu and Vuuren, 2019). This cost is passed on to consumers and contributes to the high cost of electricity. Even with the excess generation capacity, there have been periods of sporadic power supply caused by government's inability to pay the private power producers and suppliers of the fossil fuel for the running the plants. The present generation overcapacity could be a setback to transition towards green energy in Ghana, as it will be difficult to justify further investments in electricity production when there is already generation overcapacity. The higher cost of thermal energy however provides a justification for investment in cheaper renewable energy. Considering the political cost of expensive energy and Ghana's accumulating energy sector debt of over \$2 billion, it can be expected that the Government would be interested if presented with electrical power alternatives that are reliable, cheaper and deliverable within a four-year term through public private partnership arrangements.

The heavy reliance on fossil fuel for vehicular transportation can be expected to remain same into the foreseeable future. This is so because the charging point infrastructure required for electric cars are

presently not available in the country. Furthermore, there is presently little or no public consciousness on switching to greener vehicular transportation. Studies on vehicular transportation preferences in Ghana indicate that other factors like income level, family status and size, comfort and distance from workplace determine people's vehicular transportation preferences (Abane, 1993; Amoh-Gyimah and Aidoo, 2013). Environmental concerns are not a major consideration.

5. Conclusions

From the study findings and discussions, it can be concluded that energy transition in its broad sense of fundamental changes in a country's electrical energy system has occurred in Ghana: in the form of transition from hydro to hydro-thermal mix with thermal presently accounting for a higher proportion of Ghana's grid electricity; and transition from exclusively State production to State-private supply mix with private companies presently accounting for higher proportion of Ghana's electricity production. These transitions have been motivated by the need to expand energy supply to meet the increasing demand and driven by a general government policy of public-private partnerships for infrastructure and public service delivery. However, these Ghanaian manifestations of energy transition cannot be said to be transition towards greener energy. Thus, sustainability energy transition has not occurred in Ghana. It is recommended that further studies are conducted on why Ghana's new renewable energy agenda has so far only been agenda in policy with very minimal implementation in practice.

Abbreviations

ECG Electricity Company of Ghana

GRIDCO Ghana Grid Company Limited

HFO Heavy Fuel Oil

IPPs Independent Power Producers

IRENA International Renewable Energy Agency

LCO Light Crude Oil

MW Megawatt

NEDCO Northern Electricity Company Limited

VRA Volta River Authority

Declarations

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Authors' contributions

All authors contributed to the development, revision and finalization of the article. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable

Ethics approval and consent to participate

Not applicable.

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Table 1. Ghana 2020 electricity generation sources

[Constructed from Energy Commission (2020)]

Supply from the State Volta River Authority			
Plant	Installed Capacity (MW)	Dependable Capacity (MW)	Fuel Type
Akosombo GS	1020	900	Hydro
Kpong GS	160	140	Hydro
TAPCO (T1)	330	300	LCO/Gas (Thermal)
TICO (T2)	340	320	LCO/Gas (Thermal)
TT1PP	110	100	LCO/Gas (Thermal)
TT2PP	87	70	Gas (Thermal)
KTPP	220	200	Gas/ Diesel (Thermal)
VRA Solar Plant	2.5	1.75	Solar
Total state supply	2,269.5	2,031.75	
Supply from private power companies (Independent Power producers)			
Plant	Installed Capacity (MW)	Dependable Capacity (MW)	Fuel Type
Bui GS	404	360	Hydro
CENIT	110	100	LCO*/Gas (Thermal)
AMERI	250	230	Gas (Thermal)
SAPP 161	200	180	Gas (Thermal)
SAPP 330	360	340	LCO*/Gas (Thermal)
KAR Power	470	450	HFO* (Thermal)
AKSA	370	350	HFO* (Thermal)
BXC Solar	20	14	Solar
Meinergy Solar	20	14	Solar
Trojan	44	39.6	Diesel/Gas (Thermal)
Genser	89.5	18	Gas (Thermal)
CEN Power	340	340	LCO*/Gas (Thermal)
Amandi	190	190	LCO*/Gas

		(Thermal)
Total IPP supply	2,867.5	2,625.6
TOTAL (State and Private)	5,137.0	4,657.35

*LCO: Light Crude Oil; HFO: Heavy Fuel Oil