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Contextualizing hazard mitigation policy for electricity grids in the Sudan Sahel Region of Nigeria

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ABSTRACT

Electricity grid resilience in the face of unending hazards plays a crucial role in energy security of a nation. Based on hazard impact variability across different regions of Nigeria, formulating and implementing a contextualized environmental hazard mitigation policy to reduce grid vulnerability to the multiple effects of hazards and disasters is a strategic imperative that can result to longevity of grid networks, with increased probability of critical success factors such as safety, reliability of electricity supply and electricity access in the Sudan Sahel region of Nigeria. Policies outlined in the Nigeria's National Disaster Management Framework (NDMF) and the scope of its National Disaster Response Plan (NDRP) takes no cognizance of the peculiar environmental hazards and disasters that impinges on sustainability of electricity grid infrastructures, and the mitigation strategies to reduce their risks, with reference to the Sudan Sahel region. This paper provides insight on the Sahelian hazards, overview shortcomings of the NDMF and NDRP, and advocates for the contextualization of hazard mitigation policy for electricity grids in the Sudan Sahel based on international best practices and findings of field surveys of the Zamfara Sahel.

1. Introduction

The deleterious impacts of climate change in developing countries such as severe flooding, drought, extreme heat, landslides and severe storms has led to a new way of thinking about operations and safety of electricity infrastructure (grids, substations, support systems). There is an increasing shift from the business – as - usual culture of planning and managing critical infrastructure to adoption of initiatives towards holistic development aimed at preserving them and minimizing exposure to factors that potentially affect their lifespan. Beyond the analytical works of researchers and the political statements of governments, the electricity sector in developing countries are largely in their traditional states, bugged down by the inefficiency of traditional grid technology. Consequently, the operation of electricity systems is still manual and paper-driven, while the maintenance culture is also largely manual and inefficient, with little or no computer-assisted decision-making processes. In contrast, developed countries have advanced beyond traditional grid structures by adopting smart grid technology in the economy of power transmission and distribution and marketing, resulting in computer-assisted decision making, reduced manual maintenance functions and better service delivery (Arnold, 2012; Balta-Ozkan et al., 2014; Trygg, 2009). The potentials and benefits of smart grids to developing countries are well known, and have been roundly propounded by experts in recent years (Fadaeenejad et al., 2014; Madrigal et al., 2017). However, few developing countries including China, India, Mexico, Brazil and South Africa have demonstrated commitment to adopt smart grids technologies in power system operations (Acharjee, 2013; Madrigal et al., 2017; Republic of South Africa, 2013). Lack of modernized electricity infrastructure, compounded by poor strategic planning and short-sighted policies have remained the bane of smart grid development in African countries. Instructively, African countries have continued to grapple with the challenges of sustaining their inefficient, aging and deteriorating electricity grid infrastructures in the face of supply and demand imbalances engendered by population explosion, increasing urbanization and pervading presence of power-dependent infrastructures, with no end in sight. This background aptly captures the dilemma of the Nigeria's electrical power sector, with her grossly inadequate and underdeveloped national transmission grid networks, which predictably, has been at the receiving end of probing attentions in intellectual circles in recent years (Emodi and Yusuf, 2015; Oricha and Olarinoye, 2012; Oseni, 2011). The intractable challenges of the electricity sector spanning decades, has resulted in a shift in attention to maximize alternative energy sources for widespread utilization in the Nigerian State. Unfortunately, the alternative energy sector

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is also bedeviled with multifarious challenges ranging from policy summersault to inadequate funding and legal and regulatory issues (Ajayi and Ajayi, 2013; Emodi and Boo, 2015; Emodi and Ebele, 2016; Ohunakin et al., 2014). These challenges have constrained growth of the sector during the past decades. It is thus, no gainsaying that the Nigeria's energy sector challenges are hydra-headed, and requires more than just academic pontifications to resolve. Electricity access, good financial performances and reliability of electricity supply have remained sore points, with Nigeria having a low annual per capita electricity consumption of 128 kWh per capita/person/year (U.S. Central Intelligence Agency, 2016) and ranks second in global ranking of the 20 countries lagging in electricity deficit (World Bank, 2017a). The problems of capacity increment and system expansion for wider electricity access is exacerbated by overdependence on expendable petroleum and natural gases which has predictably constrained the parallel development of alternative fuel sources for electricity generation (Aliyu et al., 2013; Kenedy-Darling et al., 2008; Paul et al., 2015). Despite the enormous potentials of renewable energy as alternative and complementary source of electricity generation, the statistical picture of the rate of utilization by the government and population during the last decades has not commensurate with the projections of stakeholders (Emodi and Boo, 2015; Emodi and Ebele, 2016; Oyedepo, 2012). This snail speed in paradigm shift in energy use, sectoral technical challenges and politico-economic variables such as unpatriotic vested interests by investors and capital flights in the polity are plausible reasons to believe that grid-based electricity, although unreliable, will remain the major source of power in Nigeria for a long time to come. This reality provides a strong basis for the need to beef up the security of existing electricity grids. Moreover, the current electricity grids in the Sudan-Sahel of Nigeria are crucial to the materialization of the proposed 20-year electricity transmission development plan of the Nigerian government, which seeks to appreciate power transmission capacity from the current fluctuating capacity of 4000 MW to 10,000 MW by 2020 and 28,000 MW by 2035 respectively (Nigeria Electricity Hub, 2018).

1.1. Hazards and electricity grid infrastructures

Hazards are “events or physical conditions that have the potential to fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to environment, interruption of business or other types of harm or loss” (Federal Emergency Management Agency (FEMA), 1997). In the same vein, “natural hazard” has been defined as “natural processes or phenomenon that may cause loss of life, injury, or other health impacts, property damage, loss of livelihoods and services, social and economic disruption or environmental changes” (Government of Kenya, 2009). The document furthermore, defines “disaster” as a serious disruption of the functioning of a community or society, causing widespread human, material, economic or environmental losses which exceeds the ability of the affected community/society to cope using its own resources”. Electricity grids are networks of transmission lines that transports electrical power from generating stations to demand centres and a network of distribution systems that connects consumers (Kaplan, 2009). Grids are critical infrastructure that provide lifeline to modern society, and are inherently capital-intensive (Cook, 2011), and are dependent on supporting systems such as utility poles and towers for transportation (Preston et al., 2016). Utility poles are of different types such as steel, concrete, treated timber (Bolin and Smith, 2011), hybrid wood, plastic composites and fiber-glass (Sommerhuber et al., 2017). Electricity grids and supporting poles are vulnerable to natural hazards such as atmospheric (drought, rainfall, snowfall, wind, cyclones, thunderstorms), hydrospheric (tsunami, flood), lithospheric (landslide, erosion, avalanches) and anthropogenic (human-induced) hazards which could be physical, chemical or biological (Pickering and Owen, 1994), which can result in blackouts, stunted or slow economic growth and development (Organization for Security and Cooperation in Europe, 2016). This calls for efforts to mitigate these hazards. Hazard mitigation concerned long-term, predisaster planning which involves sustained expenditure on structural and non-structural efforts to reduce or eliminate hazard or disaster risks to humans, infrastructure and community. Elements of hazard mitigation include hazard identification, vulnerability analysis, hazard mitigation strategy and implementation activities and projects. Different countries have different hazard profiles and vulnerability levels (Coppola, 2007), which influences the mitigation strategies and regulatory frameworks evolved (Government of India, 2015; Government of Kenya, 2009; Preventionweb.net, 2014; United Nations Economic Commission for Africa, 2015). These profiles result to the establishment of autonomous disaster management agencies which contextualize policies to meet challenges that are peculiar to each region or State. Contextualization of hazard mitigation policy, as used in this paper implies tailoring the policy to fit into the human and environmental peculiarities of the study setting. Policy making is highly contextual (Aro et al., 2016). This paper does not dwell on the nitty-gritty of formulating hazard mitigation policies. Rather, it advocates for the contextualization of these policies for electricity grid infrastructure, by first, using field surveys to providing insights on prevailing hazardous events that challenges sustainability of the grids in the Sudan Sahel region of Nigeria, and secondly, using lessons from international best practices to build a conceptual framework for hazard mitigation policy. These insights should therefore assist policy makers in appreciating the vagaries of the Sahelian ecosystems in the context of disaster management.

The rest of the paper is organized as follows: Section 2 surveys relevant literature on the impacts of hazards and disasters on electricity grid infrastructures and hazard mitigation policies. Section 3 describes the research setting, gives a taxonomy of hazards of the Sudan Sahel, research method and findings of an exploratory field survey. Section 4 highlights the challenges inherent in the Nigeria's disaster management framework. Section 5 highlights some international best practices on hazard mitigation. Section 6 presents a conceptual framework adapted from international best practices, and contextualized for the Sudan Sahel. Conclusion and policy implications are given in Section 7.

2. Literature survey

We surveyed literature that informed on the impacts of hazards and disasters on communities and infrastructures in developed and developing countries during the past decades. Bulk of current information and documents were domiciled in online databases and websites. Information on subject matters of hazards and disasters for African countries is sparse. Consequently, useful information was gleaned from few literatures and verified online new sources. During the last decade, the frequency of occurrences of natural and anthropogenic hazards has increased across the world with perplexing dimensions and complexity. The devastating effects of these disasters is vast with many ramifications that reverberates on all fronts – locally, nationally and internationally (Alesch et al., 2012). Occurrences of Hazards and disasters have defied human prevention, leaving national governments and policy makers with fewer options including the imperative of continuously adapting mitigation strategies in response to their emerging dimensions. Documented occurrences of hazards and disasters that impacted on electricity grids and other power system infrastructure include the Marmara earthquakes in Turkey (Oral and Dönmez, 2010), blizzard in China (Xie and Zhu, 2011), the Sichuan earthquake in China which caused extensive damages to high voltage transmission lines and low voltage distribution systems due to broken utility poles and collapsed pylons (United Nations Children’s Fund, 2011), hurricane Katrina in New Orleans (Hoffman and Bryan, 2009), hurricane Irma in the Caribbean (Cangialosi et al., 2018), the Lothar and Martin cyclones which swept through France, Western Germany, Switzerland and Italy and affected over 0.5% of the erected towers and 180 substations