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Building climate resilience into power systems plans: Reflections on potential ways forward for Bangladesh

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ABSTRACT

The consideration of climate resilience in power system planning and operations by utilities around the world is very limited to date. This article assimilates some of the initial thoughts developed as part of a World Bank project on climate resilience for Bangladesh. It briefly reflects on the current literature, and focuses on the specific flooding risks faced in Bangladesh to illuminate the way forward to enhance planning practices.

1. Introduction

While there is a rich global conversation on climate change and the need for building resilience in infrastructure, there has been surprisingly little change in the way power systems are planned and operated in response to the changing climate. Rather, the typical impact on the power planning community tends to be ad hoc response to a major event like an extreme heat wave, a hurricane, or tsunami.[1]

A conspicuous lack of evolution in planning and operations is particularly apparent in developing countries that continue to rely on deterministic least-cost planning methodologies with little or no consideration of some of the climate-change-related risks even when these thwart multiple projects or have led to common mode failures. Power system master plans developed using such a methodology in many cases do not consider risks around current weather variability (e.g., rainfall seasonality, flooding, heat waves, etc.), not to mention the additional variability due to climate change, which includes increased intensity and frequency of weather extremes such as heavy precipitation that impact flooding risk and water availability for cooling, and extreme heat waves that impact peak demand. In addition to the extreme events that have a sudden impact on the power system performance, it is also important to consider slow onset events that are induced by climate change, e.g., increasing temperatures, sea level rise, salinization, etc. Such slow onset events often result in persistent poor performance and inadequacy of the system. Although site-specific information is taken into account for renewable resources such as hydro, wind, and solar, historic data is used rather than projections for these resources that incorporate future climatic conditions. Operational profiles are thus drafted based on historical information on river flows, wind velocities, and radiation. Historical data on storm records, for example, are typically used for design of transmission towers and wind turbines.

In countries or systems where risks associated with climate change are already taking their toll, the significant financial or even human losses, and the magnitude of investment required to strengthen the system against future risks, make it clear that there has to be a more systematic way to screen projects at a system level. Additionally, the observed frequency of extreme events in recent years has raised concerns among planners about the validity of the probabilities of extreme events that they now rely upon. Anecdotal evidence suggest that even developed countries seem to learn the hard way, via crisis. As an example, heat waves in Australia have been on the rise, and eventually took 173 lives in a disastrous bush fire before regulatory changes were implemented

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1 Nye (2010) provides a fascinating account of the technical as well as social and cultural impacts of power system failures.

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to force the use of underground cables in sensitive zones.[2] Likewise, better design of wind turbines is being put in place to withstand storms after they have been damaged severely in different parts of the world.

Enhancement of power system resilience can be achieved through multiple solutions (U.S. Department of Energy, n.d.). However, the list of options is richer and probably less expensive at the early planning stage, rather than after the infrastructure is put in place. For example, the location of a power plant is fixed after the planning stage, and any re-design to make it more resilient – say, by a change of cooling technology or elevation of critical assets – will probably be costlier or even infeasible after construction commences. As a result, the electricity industry is beginning to recognize the need for development of methodologies that can assist it in building resilience into the system (WBCSD electric utilities, 2014). Regulators have also started considering updates on related standards and laws. Using climate-aware and climate-resilient power systems planning practices could likely help save money, improve service delivery, and even save lives.

The opportunity to build a resilient system instead of retrofitting it is more pronounced in developing countries, where significant investments on new assets are planned for the near future. In this article we use the case of Bangladesh to illustrate these points. It is a country that urgently needs to increase its generation capacity from 11 GW today to 57 GW in the next 25 years to meet demand growing at an expected annual growth rate of 6%. With limited remaining reserves of domestic natural gas, and no other significant primary energy resource in the country (including hydro), the major option for generation expansion is likely to be in the form of imported coal or liquefied natural gas (LNG). The Bangladesh government aspires to build 24 GW of coal-fired power plants by 2022 (Reuters, 2016) and multiple LNG terminals that will allow for the import of natural gas (Senior Correspondent, 2016). Currently, only one small coal-fired power plant (250 MW) operates in Bangladesh using domestic coal. The latest Power System Master Plan supported the government's aspiration to build several mega coal-fired power stations including 12 GW capacity in coastal areas that would run on imported coal (Japan International Cooperation Agency Tokyo Electric Power Company, 2016). There is, however, very little consideration of flooding risks—an issue that should be given more prominence as we highlight in a later part of this article.

Given that Bangladesh is one of the most vulnerable countries to climate change, discussion and illustration of its power system vulnerability to climate change can indeed be found in recent research articles too—for instance I Khan et al. (2012), and Shahid (2012). The major risks identified in Iftekhar Khan et al. (2013) relate to inundation due to sea level rise, fluvial flooding, salinity or/and unavailability of cooling water, as well as rising temperatures. Despite the identification of the risks in the literature, the risks briefly discussed in the power system planning documents and are not explicitly included in the planning analysis to date. However, the climate risks are affecting the individual project site design choices as can be seen in feasibility studies.

It is, however, not difficult to see why climate resilience has not been considered as a top priority in developing countries. There are many existing challenges that utilities, policymakers, and investors, including development partners, face in these countries. There is a modest but growing recognition of these issues in the latter countries as we briefly discuss in Section 2. However, for certain countries such as Bangladesh the exposure to climate events is of a scale that makes updating the power system planning process imperative, as we illustrate in Section 3. In Section 4, we discuss how the power system planning model could be updated to be climate aware, and in Section 5 we conclude with recommendations on measures that can be adopted by policymakers and regulatory bodies to formalize a recognition of climate resilience.

2. Impact of climate change on power systems

Resilience of energy systems, and power systems more specifically, to climate change is a relatively new area for research. A recent review can be found in (Panteli and Mancarella, 2015). The resilience of energy systems has been addressed, however, over a much longer period (see, for instance, Arghandeh et al., 2016; Espinoza, et al., 2016; Hamilton et al., 2016; Maryono et al., 2016; Molyneaux et al., 2016; Mukhopadhyay and Hastak, 2016). The climate change resilience issues have also been considered in other sectors like water, agriculture, and forestry (see e.g., Ching, 2016; Ho et al., 2016). The urban and transport sectors also have a growing body of work (See e.g., Bahadur and Tanner, 2014; Friend et al., 2014; Kernaghan and da Silva, 2014; Kiel et al., 2016; Meerow et al., 2016). A wider discussion about the policy issues surrounding resilience can be found in Chmutina et al. (2016). Additionally, the InternationalEnergy Agency has a dedicated website and material on this issue.[3]

Power systems operation (as opposed to planning) has always been closely interlinked with weather conditions and susceptible to extreme weather events that may in some cases be a large, if not the largest, contingency event. It is useful to clarify that the "climate change impacts" we are discussing relate solely to how this interdependence and susceptibility are likely to change over the years. The critical issue arising from climate change is that these natural hazards are projected to intensify, become more frequent, and become more unpredictable, as noted by Ebinger and Vergara (2011a,b), Mideksa and Kallbekken (2010) and Schaeffer et al. (2012), among others. In particular, issues that hold significant implications for power systems planning and operation include:

- Increasing air and water temperatures;
- Changing (and uncertain) precipitation patterns at the seasonal, decadal, and multi-decadal levels;
- Changes in river flows (glacial melting, precipitation, etc.)
- Increasing intensity and frequency of heat waves, storm events, flooding;
- Sea-level rise;
- Changes in wind patterns and intensity; and
- Changes in insolation (solar radiation levels and patterns).

Each of these factors on its own, and in several cases in combination, may lead to systemwide disruptions, including common mode failure of a large part of generation. For instance, increased air temperature would tend to increase demand, reduce thermal conversion efficiency (and thus firm capacity), diminish transmission capacity, and increase the temperature of water for cooling—the collective impact of these events can, in extreme, cases may be a catastrophic event for the power system. Depending on the geography, this may well account for the largest power system contingency and hence an issue that planning should recognize.

Mechanisms describing the relationship between climate change and power system performance are well known for

[2] https://en.wikipedia.org/wiki/Black_Saturday_bushfires.

[3] http://www.iea.org/topics/climatechange/subtopics/resilience/. The U.S government has a partnership related to climate resiliency here: http://energy.gov/epsa/partnership-energy-sector-climate-resilience, and a useful toolkit here: https://toolkit.climate.gov/topics/energy-supply-and-use.