Energy Policy 116 (2018) 182–192

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

A multi-criteria analysis of coal-based power generation in Bangladesh

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ARTICLE INFO

Keywords:
Coal
Energy Security
Energy Transition
Analytical Hierarchy Process
Multi-Criteria Decision Analysis

ABSTRACT

Socio-technical transformations towards low-carbon energy systems are on the way in developed countries. Conversely, developing countries tend to be locked in fossil fuels and foster coal-based energy structures, emphasizing reliable and cost-effective energy provision and sidelining environmental concerns. In this study, we identified and analysed the predominant factors related to coal-based power generation in Bangladesh. We applied a mixed-method approach, initially conducting a systematic literature review and, subsequently, semi-structured expert interviews to identify and validate relevant factors. We then assessed their relative importance using an Analytical Hierarchy Process based on expert judgments. The results of this assessment reveal that socio-economic aspects and environmental issues scored highest, while technological aspects and sector regulations were considered to be less relevant for large-scale coal power implementation. We conclude that future energy policies created in Bangladesh will need to use appropriate legal instruments and address issues such as human displacement and resettlement, low levels of public acceptance, health hazards and environmental pollution. Participative policy frameworks should be deployed in coal plant projects, and active monitoring systems are necessary to reduce the negative consequences associated with increased electrification and energy consumption. To address foreseeable structural challenges, it furthermore will be crucial to explore sustainable alternatives.

1. Introduction

Around the globe, countries are undergoing socio-technical transformations as they transition towards carbon-neutral or more sustainable energy sources (Allen, 2012; Sovacool, 2017; Araújo, 2014). At the same time, the recent energy transition discourse has uncovered the worrying structural problems associated with the existing, unsustainable energy systems, which are shaped by the scarcity of fossil fuel reserves, acts of cross-border energy diplomacy, the (in)accessibility of energy services and commitment gaps regarding carbon reduction (Araújo, 2014; Sovacool, 2016; Wiseman et al., 2013). Radical changes are expected by 2040 as a result of changes in the world consumption of marketed energy from various fuel sources. Renewables and natural gas are expected to account for more than 50% of this mix (EIA, 2016). Experts predict that coal, as a primary fuel, will experience the slowest growth during the next decades, and that its share in the global power generation mix will drop from 40% (in 2012) to 29% by 2040. While several developed countries are attempting to phase out coal in favour of less carbon-intense resources, developing countries tend to promote coal in their energy portfolio as an important source of base load power generation (WEC, 2016; EIA, 2016). Coal is abundantly available, prices are stable, and it experiences fewer supply disruptions compared to oil and natural gas (WEC, 2016). For these reasons, coal will represent a dominant energy source in the 21st century's energy mix outside the OECD region, at least until 2030. An up to 50% increase in coal use has been projected in countries outside this region, mainly due to, its use for electrification purposes (WEC, 2013; EIA, 2016).

Experts have held debates on the socio-environmental issues of coal power generation, including its contribution to global climate change due to its release of energy-related CO_2 emissions. The generation of coal-based power also contributes to local environmental pollution that affects the health of communities near coal mines and coal power stations (Karplus et al., 2016). For example, coal mining accounts for 15% of the environmental problems in Colombia (Cardoso, 2015), and new Russian coal projects have been delayed due to long-term, socio-environmental liabilities such as mining accidents, safety hazards and the release of toxic air pollutants (Gorbacheva and Sovacool, 2015). To maintain the world temperature cap of 2 °C, the Intergovernmental

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https://doi.org/10.1016/j.enpol.2018.01.053
Received 2 August 2017; Received in revised form 22 December 2017; Accepted 27 January 2018

Panel on Climate Change (IPCC) has urged countries to reduce their global consumption of coal by 73% from the 2013 levels, i.e., 7.8 billion tons by 2035 (Connor, 2016). During the 2015 Paris climate conference, the member countries – including major coal producers, as well as consumers in China, USA and India – pledged voluntarily to reduce greenhouse gas emissions (Clémençon, 2016). Still, the national energy planning policies created by both developed and developing countries, such as Australia, Germany, India, Thailand, Malaysia and Indonesia reveal an obvious preference for coal (Connor, 2016; Renn and Marshall, 2015; IEA, 2015a, 2015b; EIA, 2016).

50% of India's electricity generation will still rely on coal in 2040,[1] and they would, in fact, surpass the USA in terms of their coal production and use in 2020 (EIA, 2016). The increasing demand for coal will present India with significant challenges in that they must address issues related to energy security, land acquisition, delays in authority clearances, bottlenecks in inland transportation and increasing carbon emissions (IEA, 2015a). Experts also expect coal to become Thailand's second most important primary fuel in the future electricity generation mix, with a share of 20–25% by 2036[1], due to nearly-depleted local gas reserves, international fuel price volatility and supply disruptions. Malaysia, Vietnam, Indonesia and Sri Lanka have also joined the league of countries increasing their coal-based power generation[1], despite announcing individual submissions of *Intended Nationally Determined Contributions* (INDCs) in the Paris climate agreement. On the other hand, China is moving away from its decade-long, coal-diet energy strategy, due to their increasing dependency on imports, high levels of haze and smog in major cities, excessive CO_2 emissions and reduction in public health quality (Hao et al., 2015; Yuan et al., 2016).

Any national energy policy analysis will need to include all the dimensions relevant to energy resource exploitation and utilization, including the challenges and impacts. The predominant issues associated with coal-based power generation (Table 1) involve social, environmental as well as health and safety dimensions and a large set of factors (e.g., Hendryx, 2015; Bian et al., 2010; Colagiuri and Morrice, 2015; Hota and Behera, 2015; Saini et al., 2016; Schaeffer and Smits, 2015; Cardoso, 2015). In several studies, researchers have also considered other issues, such as regulatory standards, non-compliance problems, technological and financial aspects and infrastructure or mining methods (e.g., Horbach et al., 2014; Tang et al., 2015; Suwanteep et al., 2016; Zhao and Chen, 2015; Huang and Wu, 2016; Lim, 2013). During these considerations, researchers must consider the relevance of these dimensions and factors in country-specific settings, as each has varying levels of national significance. For this reason, country-specific analyses are necessary to assess the relevance of specific dimensions and factors to the policies (Cherp and Jewell, 2011) and to gain a comprehensive picture of policy options. This is particularly relevant with respect to environmentally problematic energy carriers and critical for developing countries, in which dramatic increases in electricity demand will occur. In Bangladesh, the answer to these increases will be a large-scale implementation of coal-based power generation, which is outlined in the current power system master plan (Power Division, 2016).

Therefore, the aim of this research was (1) to identify the most important challenges, problems and barriers associated with coal-based power generation in Bangladesh and (2) to assess these factors for their relative significance. The factors were identified by conducting a systematic literature review and semi-structured interviews with experts. To assess the factors, we applied a multi-criteria decision analysis method, namely the Analytical Hierarchy Process (AHP), based on expert judgment (Saaty, 2013).

The paper is structured as follows: In Section 2, we address coal-based power generation in Bangladesh and describe our methodological approach in Section 3. In Section 4, we outline the central problems related to the adoption of coal-based power in Bangladesh and assess the importance of the identified factors as well as the coal and respective policies. Finally, we discuss specific policy implications and conclude the paper in Section 5.

2. The case of Bangladesh

Bangladesh is one of the frontier economies in Asia with a rapid potential for growth (Schipke, 2015). As of 2016, it still is a low-energy consuming economy with an on-grid electricity consumption of 281 kWh/capita and grid-based electrification rate of 66% (BPDB, 2016; Power Division, 2016). However, the electricity consumption is expected to rise to about 963 kWh/capita by 2035, and the cumulative, installed generation capacity is expected to reach 24,000 MW and 39,000 MW by 2021 and 2030, respectively (Mondal et al., 2010; BPDB, 2016). Experts predict that the remaining indigenous gas reserves will be exhausted by 2023 unless new major discoveries of gas fields are made (GED, 2015). As a result, policy makers consider coal to be the most cost-effective primary fuel for base load power generation. Several electricity generation mix scenarios appear in the Power System Master Plan (PSMP) 2016, in which the contributions from coal will be at least 35% and up to 55% (Power Division, 2016). The PSMP 2010 also emphasized coal as a leading generation fuel and assigned it a 50% share in the 2030 electricity generation mix (Power Division, 2011). Details on the development of coal-based power development and history, coal reserves and fuel composition in Bangladesh can be found in Supplement B.

The electricity generation mix of low-income and middle-income countries tends to be based on conventional fossil fuels, subject to the availability of substantial local reserves and cost of accessibility (Kileber and Parente, 2015). Commonly, the local coal deposits are used for power generation and imported coal is used when local reserves are no longer sufficient to meet the local electricity demand. In contrast, the use of coal to generate electricity in Bangladesh is a fairly recent phenomenon. The generation mix in Bangladesh has been dominated by locally-available natural gas since the 1990s, and the available local coal deposits remained largely unexplored after their discovery in the 1980s until recently. The only coal mine, located at Barapukuria, began commercial operation in 2005 and has a limited production capacity of only 1 million tons per year (Power Division, 2016). At present, Bangladesh is one of the top-ten countries that will adopt large-scale coal power generation over the next decades; however, it is running into obstacles while implementing its recently-devised energy generation strategy. In January 2017, the government announced that 17 coal power plants with a total capacity of 10,140 MW would be built, of which 3,935 MW, or six projects, are already in a hold position.[2] The construction work for a 270 MW plant has already begun as an extension of the Barapukuria coal power plant (BPDB, 2016; Power Division, 2016).

Policy choices for power generation mixes in Bangladesh have been the subject of academic debates: Gunatilake and Roland-holst (2013) suggested adopting 50% coal-based power in the mix to ensure GDP growth; Ahamad and Tanin (2013) opted for both local and imported coal-based power in the context of energy accessibility, energy availability and reliability. In contrast, Habib and Chungpaibulpatana (2014) argued in favour of a renewables-based energy mix with a minimal portion of imported coal to keep emissions low. Rahman et al. (2016), meanwhile, suggested creating energy policy options based on a combination of fossil fuels and biomass, favouring negligible coal shares and a high allocation for gas. The results of studies on local coal mining have revealed structural coal field flaws, inappropriate mining methods and mining accidents (Kibria et al., 2012; Quamruzzaman

[1] For details, see Supplement A.

[2] Authors' compilation from Coalswarm's summary statistics on Global Coal Plant Tracker as of January 2017, available at http://endcoal.org/global-coal-plant-tracker/ (accessed 7 May, 2017).