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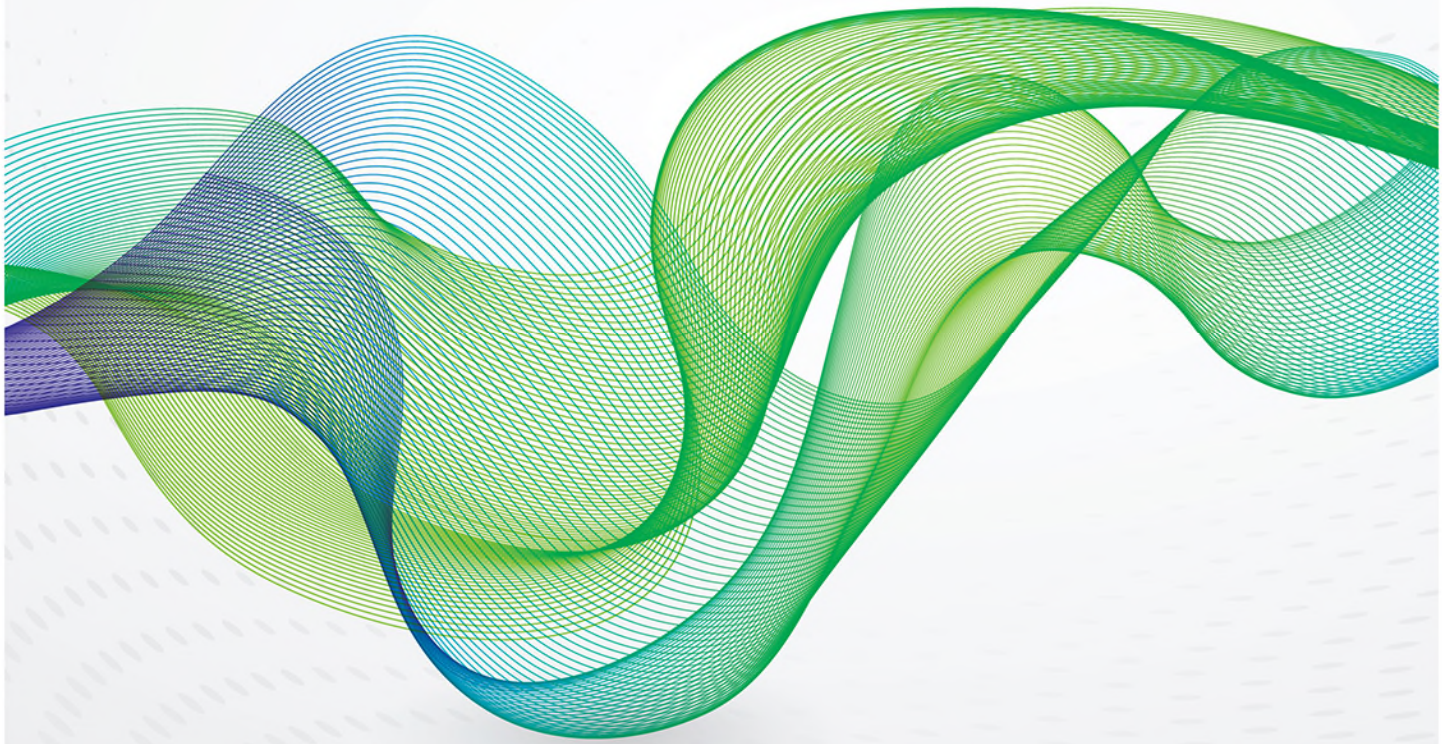
Gas-to-Power Supply Chains in Developing Countries: Comparative Case Studies of Nigeria and Bangladesh



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Gas-to-Power Supply Chains in Developing Countries: Comparative Case Studies of Nigeria and Bangladesh

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Abstract

In response to the dual challenge of decarbonisation and advancing energy access, some developing countries that are endowed with domestic natural gas resources have embarked on the path to develop a gas-to-power supply chain. Nigeria and Bangladesh, two of the most populous countries in the world, have adopted such a strategy. This paper uses a multi-step approach to evaluate the performance of the gas-to-power supply chains in these countries within political, regulatory, and commercial dimensions. The goal is to offer insights for other developing countries which are pursuing or considering the same strategy. By analysing the causal dynamics that are in place in Bangladesh and Nigeria, it suggests measures that may improve gas-to-power supply chain performance. Finally, it discusses the extent to which the causal dynamics observed can be generalised to other countries.

Keywords: Gas to power supply chain, Nigeria, Bangladesh, SCPR framework

Acronyms

AIIB	Asian Infrastructure Investment Bank
APC	All Progressives Congress
ATC&C	Aggregate technical, commercial, and collection
Bcf	Billion cubic feet
BERC	Bangladesh Energy Regulatory Commission
BNP	Bangladesh Nationalist Party
BPDB	Bangladesh Power Development Board
CBN	Central Bank of Nigeria
CNG	Compressed Natural Gas
DESA	Dhaka Electricity Supply Authority
DESCO	Dhaka Electric Supply Company
DfID	Department for International Development
DISCO	Distribution company
DPDC	Dhaka Power Distribution Company
DPR	Department of Petroleum Resources
ECOWAS	Economic Community of West African States
EITI	Extractive Industries Transparency Initiative
EPCL	Eleme Petrochemicals Company Limited
ESPRA	Electric Power Sector Reform Act
GDP	Gross Domestic Product
GENCO	Generation company
GTCL	Gas Transmission Company Limited
IDCOL	Infrastructure Development Company Limited
IEA	International Energy Agency
IMF	International Monetary Fund
IOC	International Oil Company
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
JICA	Japan International Cooperation Agency
LNG	Liquefied natural gas
MHI	Manitoba Hydro International
MMscf	Million standard cubic feet
Mtoe	Million tons of oil equivalent
MYTO	Multi-Year Tariff Order
NBET	Nigerian Bulk Electricity Trader
NDA	Niger Delta Avengers
NDPHC	Niger Delta Power Holding Company
NEEDS	National Economic Empowerment and Development Program
NEITI	Nigeria Extractive Industries Transparency Initiative
NEPA	National Electric Power Authority
NERC	Nigerian Electricity Regulatory Commission
NGC	Nigerian Gas Company
NGO	Non-Governmental Organisation
NIAF	Nigeria Infrastructure Advisory Facility

NIPP	National Integrated Power Project
NLNG	Nigerian Liquefied Natural Gas
NNPC	Nigerian National Petroleum Corporation
NOC	National Oil Company
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
ONEM	Operator of the Nigerian Electricity Market
OPEC	Organization of the Petroleum Exporting Countries
PBS	Palli Bidyut Samity (Rural Electric Societies)
PDP	Peoples Democratic Party
PGCB	Power Grid Company of Bangladesh
PHCN	Power Holding Company of Nigeria
PIB	Petroleum Industry Bill
PPA	Power Purchase Agreement
PSMP	Power Sector Master Plans
REB	Rural Energy Board
RPCL	Rural Power Company
SAARC	South Asia Association for Regional Cooperation
SCPR	Structures-Conduct-Performance-Regulation
SIPP	Small Independent Power Producer
SREDA	Sustainable and Renewable Energy Development Authority
TCN	Transmission Company of Nigeria
TEM	Transitional Electricity Market
TPES	Total Primary Energy Supply
VC	Vesting Contract
WAGP	West African Gas pipeline
WAPP	West Africa Power Pool

1. Introduction

In the coming decades, one of the greatest challenges for non-OECD countries is to develop the infrastructure needed to provide modern energy services to meet rising demand. Parallel to the challenge of universal energy access is the challenge of decarbonising the global energy system to mitigate climate change. The modular investment costs of gas-fired generators make them attractive to investors. At the same time, natural gas is the cleanest-burning fossil fuel and is often portrayed as a transition fuel that will bridge the fossil fuels dominated present to a future powered by renewable energy. Therefore, the successful development of gas-to-power supply chains in developing countries has the potential of positively contributing to the global issues of universal energy access and decarbonisation. However, developing a gas-to-power supply chain is a complex challenge. It requires not only power sector infrastructure to provide universal electrification and to meet rising demand, but also gas sector infrastructure to allow the timely extraction and delivery of fuel to supply the power sector. This is a challenge that is more complex than dealing with the development of the power or gas sector independently.

In response to the dual challenge of decarbonisation and advancing energy access, Nigeria and Bangladesh, two populous developing countries (ranked respectively 7th and 8th in the world), are both developing gas-to-power supply chains. Figure 1 shows that they are the countries with the highest percentage of gas-fired generation among countries which do not yet have universal electricity access. Together, Nigeria and Bangladesh hold 149 million people without access to electricity, or about 10% of the world's population without access to electricity. This warrants a close look at the gas-to-power supply chains in these two countries because their sheer size makes them intrinsically important. Understanding the experiences of Nigeria and Bangladesh can also offer valuable insights for other not-yet fully-electrified countries which have adopted a gas-to-power energy strategy – Tanzania, Côte d'Ivoire, and Bolivia, for instance – and to those that have the potential for doing so.

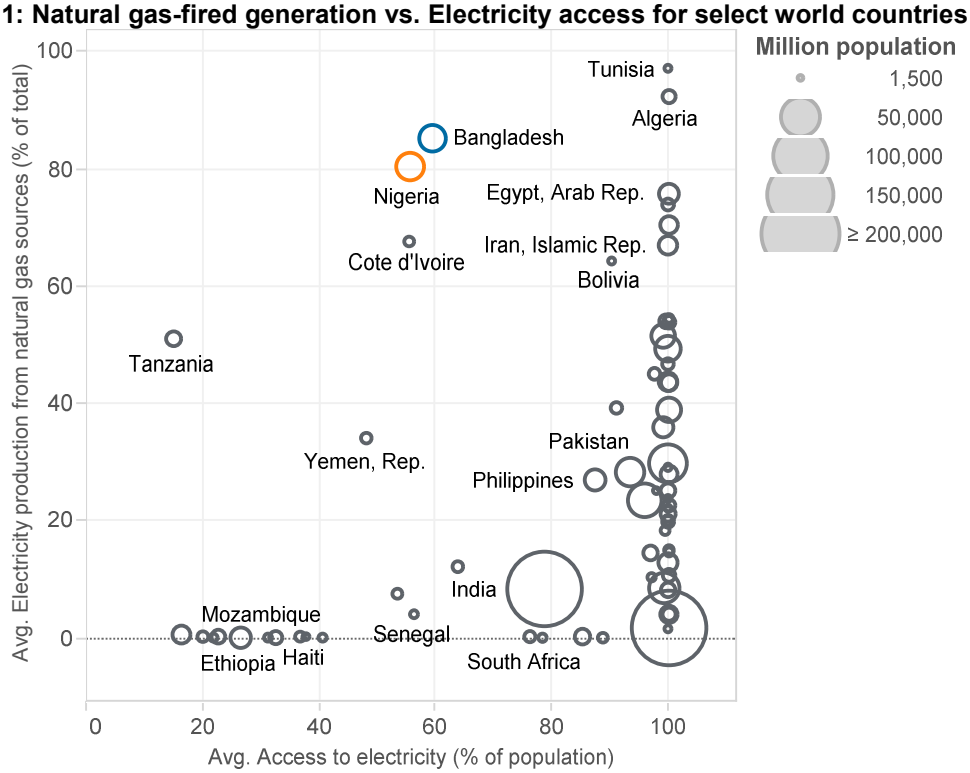
In this paper, we seek to answer the following questions: What is the performance of the gas-to-power supply chains in Nigeria and Bangladesh[1]? What have been the most important factors that have facilitated or detracted from the performance of the gas-to-power supply chains in these countries? What can be done to improve their performance? Finally, to what extent can the findings of this study be generalised to other countries? We use a multi-step approach to answer these research questions, which is reflected in the structure of this paper.

Much of the existing literature on the performance of gas and power sectors in developing countries focuses either on the power sector (especially on power sector reforms) or the gas sector (especially on upstream fiscal regimes). Development of the downstream end of the gas industry in developing countries is overlooked, compared to the establishment of export links between developing producing countries with developed importing countries. Of the small body of research that does focus on gas and power sector interdependences, the focus has been on technical interaction between the two sectors within the context of developed countries with mature gas and power infrastructure. Previously, in response to the narrow definition of gas and power interdependence, the authors developed the SCPR framework which seeks to provide a holistic view of such interdependences, encompassing the regulatory and commercial dimensions (Peng & Poudineh, 2016).

[1] A key analytical focus of this paper is the multi-dimensional nature of performance. Therefore, in the main text, we discuss performance from the perspective of stakeholders in the political arena, government/regulatory bodies, and the commercial arena.

This paper makes three main contributions: First, it consolidates the body of research on gas and power sectors' performance in developing countries, by integrating them within the SCPR framework, a useful tool for mapping the large range of multi-dimensional concepts that populate this research space. Secondly, the literature review performed prompted the inclusion of political dynamics to the SCPR framework, as it is found that political dimension determinants are extremely influential over the performance of institutions in developing countries. Last but not the least, leveraging the updated analytical framework, the comparative case studies of Nigeria and Bangladesh provide the most up-to-date analysis for the period leading up to 2017, one that is extremely dynamic in both countries' recent history, and diagnose causal mechanisms underpinning the performance of their gas-to-power supply chains to make holistic policy recommendations.

Figure 1: Natural gas-fired generation vs. Electricity access for select world countries



Source: Data from World Bank

In the next section, a literature review is performed to gather existing perspectives on the determinants of gas and power sector performance. They are then integrated through the Structure-Conduct-Performance-Regulation (SCPR) framework, a conceptual framework that the authors have previously proposed to holistically integrate the various dimensions of performance determinants for gas-to-power supply chains. Following that, qualitative and quantitative descriptions for the cases of Nigeria and Bangladesh are presented, through the political, regulatory, and commercial agents' perspective in Section 3. Each of these perspectives represents an analytical dimension in the revised SCPR framework. Section 4 infers the most important causal mechanism(s) affecting the performance of gas-to-power supply chains, based on the case description, highlighting virtuous/vicious loops and bottlenecks in all three dimensions. It also discusses measures that may improve gas-to-power supply chain performance in Nigeria and Bangladesh, and the extent to which they can be generalised. Finally, Section 5 concludes.

2. Literature review

The research literature on gas and power sector performance surveyed, representative but not exhaustive, is categorized by the nature of the authors' research questions:

1) Studies that seek to set the future research agenda;
2) Conventional research studies which investigate:
    a. Determinants of sector performance;
    b. Determinants of reform policy/regulation;
    c. Determinants of reform/regulation performance.

In the following presentation, the main arguments or research findings for each category of studies are summarised; we also comment on salient aspects of the research methodologies used.

2.1 Research agenda definition

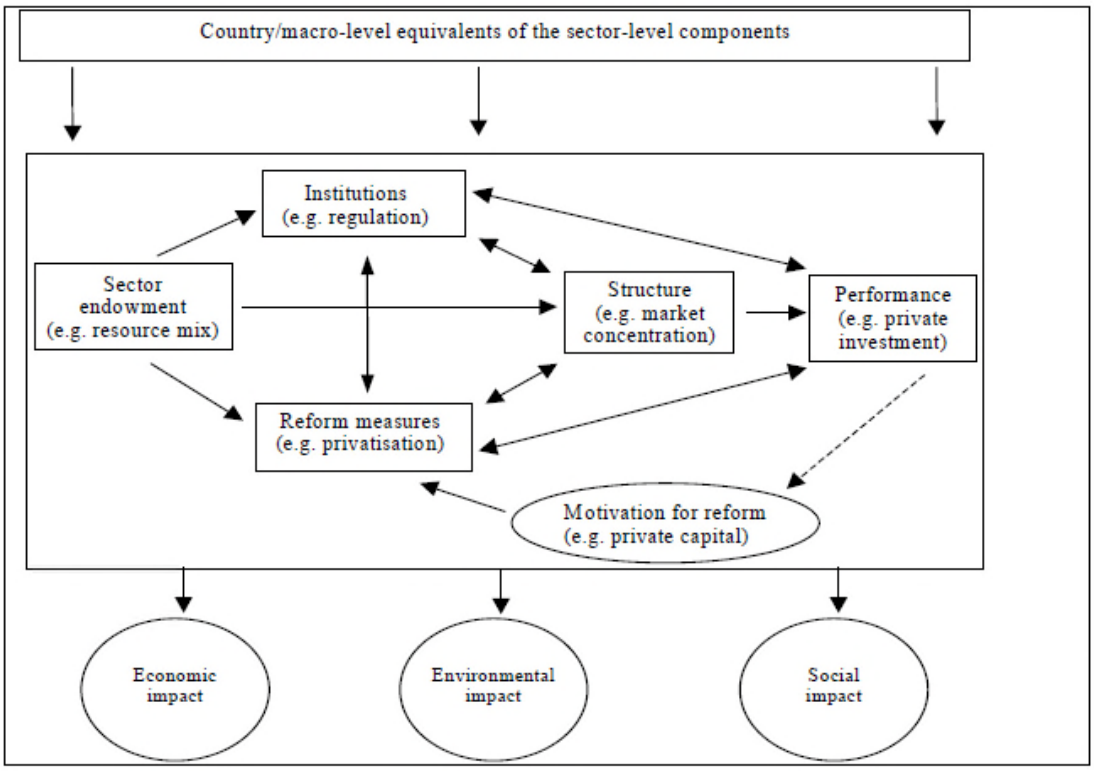
This group of studies aims to review the state of knowledge relative to a phenomenon and to set the research agenda for those in the field by summarising trends in the existing literature and drawing attention to gaps of knowledge. We have identified five such studies that inform the research of gas and power sector development in developing countries.

Jamasb et al. (2005) point out that although substantial efforts have been spent on implementing electricity sector reforms in developing countries their outcomes have only been evaluated in a very limited way, partly due to the lack of a generally accepted framework for key indicators (both dependent and independent variables). They propose a coherent conceptual framework for studying power sector reforms in developing countries, based on the structure-conduct-performance paradigm of industrial organisation[2]. They also operationalise concepts within the framework through a set of indicators, which can be used to coordinate data collection across different countries, feeding future large-sample quantitative studies. The illustration of their conceptual framework is reproduced below in Figure 2.

Gratwick and Eberhard (2008) describe the evolution of the discourse for power sector reforms in developing countries since the 1990s. They also demonstrate that, instead of converging toward the "standard model", one in which corporatisation, commercialisation, vertical and horizontal unbundling, privatisation, and wholesale and retail competition occur, under the auspice of a new energy law and independent regulators, reform outcomes have gravitated toward an unexpected intermediate equilibrium: a hybrid market where the dominant incumbent utilities contract with Independent Power Producers. They argue that the existence of such stable hybrid market structures in many developing countries requires a new research agenda. The main challenges arising with the hybrid market are the coordination between the public and private sector in infrastructure investment (generation capacity planning and subsequent allocation of investment opportunities, procedures for competitive bidding, building-up of the incumbent's contracting capacity) and in the use of infrastructure (dispatch of private and public power plants).

[2] The structure-conduct-performance paradigm is also at the origin of the SCPR framework that we propose, developed independently of the Jamasb (2005) study.

Figure 2: SCP-based framework proposed by Jamasb et al.



Similar to Jamasb et al., Stevens (2008) also proposes a set of indicators, mapping out the multiple dimensions of performance of National Oil Companies (NOCs) and their determinants. He suggests that NOCs should be evaluated not only for their technical and financial performance, but also in their fulfilment of national missions. However, the set of indicators that he proposes is at an early stage of theoretical development: systematic categorisation is limited and no attempts have been made to relate different indicators to determinants through causal hypothesis.

Estache and Wren-Lewis (Estache & Wren-Lewis, 2009) advise that effective regulatory policies need to be designed differently when they are to operate in countries where institutions are weak. The key weakness of institutions in developing countries are: limited regulatory capacity (limited ability to design regulation that promotes the government objective), limited accountability (lower cost for public officials/firms to make non-benevolent decisions), limited commitment (higher probability that political balancing leads to change in government objectives/regulations), limited government capacity to collect and allocate public funds (relatively high cost of public funds so that fiscal redistribution is costlier).

Feigenbaum and Henig (1994) argue that privatisation, a key element of many energy sector reforms implemented in the 1980-1990s, is better understood as a political phenomenon instead of an administrative tool or the inevitable unfolding of economic principles. The political perspective that he proposes uses interest groups as a unit of analysis, perceiving privatisation as a “weapon” to redistribute power and control. He also offers a simple typology of privatisations based on their underlying political motivation: privatisation can be initiated as *ad hoc* solutions to immediate

problems, as ways to increase short-term political benefits for its backers, or as ways to introduce a long-term shift in the balance of power.

Laws (2012) reviews the concept of "political settlement", increasingly used in international development literature as a determinant of institutional performance across different developing countries. The review of different applications of the term reveals two emerging views of the concept. The first group considers political settlement as (relatively static) stocks, in that it represents implicit expectations that society has toward the state in exchange for legitimacy, or in the form of the overall balance of power or the outcome of elite bargains. The second group considers political settlement an adaptive process through which the social contract and the balance of power are changed. In the second case, political settlement is used to refer to the ways in which the state meets social expectations (responsive vs. nonresponsive, inclusive vs. exclusive) and the means through which political balancing is achieved. Laws recognises that the dynamic process view is a more useful definition of political settlement, because it can accommodate the first static view within itself.

The views that that we take from the authors above are

- Power and gas sector performance is a multi-dimensional phenomenon that is difficult to fully characterise;
- The political perspective, defined as one which recognises how the influence of changing social contracts and political balancing in a country affects its institutions, is a promising one for understanding higher level determinants in gas and power sector performance in developing countries;
- Variables (performance and its direct/indirect determinants attributable to different analytical dimensions) need to be defined and described consistently to achieve comparability between case studies.

2.2 Conventional research studies

This group of studies is called "conventional" in contrast to the first group of studies surveyed. Instead of proposing a new conceptual map to inform the formulation of new research questions, conventional research studies focus on answering research questions proposed by existing theoretical paradigms, testing causal hypotheses through qualitative case studies or quantitative econometric studies. Three sub-categories of studies are identified:

- Determinants of sector performance: these studies look at the performance of power or gas sectors in general, identifying some determinants that the researchers considered important;
- Determinants of reform policy/regulation: these studies seek to identify factors which influence government policy or regulatory decisions;
- Determinants of reform/regulation performance: the bulk of the literature surveyed, they examine the performance of established government decisions, either in the form of sector reform or a specific regulation, and identify the factors that determine its performance relative to the government's objective.

Often, qualitative studies supply context-rich data and identify specific causal mechanisms, chains of logically related events linking a determinant to the dependent variable, while pure quantitative studies that apply statistical methods to specific indicators establish (or reject) correlation between potential determinants and the dependent variable, without proposing a detailed causal mechanism. There is a trade-off between these two approaches. The qualitative studies are typically more narrowly focused and limited to a small number of cases (from single country study up to five countries), unless a generalisable theory is developed from these unique instances. Whereas

quantitative studies, typically with sample sizes of 20-100 cases, supply a black-box model which is more broadly applicable (at least for the countries sampled).

Together, the literature reviewed, summarized in Table 1 through Table 3, provide a rich map of causal mechanisms and relations which can guide systematic theory development or be tested against specific cases. However, in most cases, the authors use definitions loosely, without referring to a common set of concepts, making consolidation and comparison of findings across studies difficult. This is especially problematic for multi-dimensional variables such as “performance”, and abstract high-level variables such as “institutional context”. Therefore, before proceeding to our case description and analysis for Nigeria and Bangladesh, we attempt to harmonise the findings gathered by synthesising the causal mechanisms that different researchers have identified within the SCPR framework that we propose in the next sub-section.

Table 1: Summary of studies on the determinants of sector performance

Reference	Sector	Scope	Definition of sector performance	Causal mechanism
Davison et al. (1988)	Gas	Developing countries	Development of domestic gas supply chain	Mutual perception of government/IOCs and their objectives shape their relationships, which then influence the development of the domestic gas market
Kim et al, (1999)	Gas	Global	Overall efficiency	Firms' ability to allocate factors efficiently, exploit economies of scale, and operational efficiency are multiplicative factors of overall efficiency.

Table 2: Summary of studies on the determinants of reform policy/regulation

Reference	Sector	Scope	Definition of reform policy	Causal mechanism
Correljé & De Vries, (2008)	Power	Global	Design of restructured market and the timing of implementation	The regulation adopted by a government is conditioned by physical/geographic and macro-economic external factors. General formal institutions (policy, judiciary, bureaucracy) in place also condition the government's decision, as well as those of the firms participating in the market; Regulatory decisions from the past, interacting with the strategies of market participants, form outcome that feedback into a new round of regulatory decision-making; however, the feedback received is delayed and processed with bounded rationality.
Zelner, et al. (2009)	Power	Global	Retrenchment of previous policy objectives (not repeal, but reinstatement)	Cultural norms (normative value against privatization), domestic political stability, and changing behaviour of peer country governments (via mimicry) or the demands of powerful global actors (via coercive isomorphism), are found to be statistically significant determinants of a government's decision to re-negotiate previous contracts.

Table 3: Summary of studies on the determinants of reform/regulation performance

Reference	Sector	Scope	Definition of reform/ regulation performance	Causal mechanism
Çetin & Oguz (2007)	Gas	Turkey	Fulfilment of reform relative to the standard model (EU Gas Directive)	Without government-directed restructuring (unbundling), the incumbent maintains its monopoly position relative to upstream and downstream customers, therefore a competitive wholesale market is not achieved.
Cubbin & Stern (2006)	Power	Developing countries	Achievement of reform goal (Generation capacity per capita)	Existence of energy legislation, regulatory regime, and regulatory independence (funding from license fees) is positively correlated with generation capacity per capita.
Darbouche, (2012)	Gas	MENA and sub-Saharan Africa	Achievement of regulation goal (Gas price subsidy and its removal)	Government objective (political legitimacy) drives regulation (non-cost reflective gas price), which deteriorates the performance of the sector in terms of efficiency of consumption and supply; Using public campaigns to reset social expectations (price subsidies are wasteful) and establishing alternative mechanism (direct money transfer) to pre-emptively guarantee welfare of those affected by change help the government to implement its new regulation (removal of subsidy).
Estache et al. (2009)	General	Developing countries	Achievement of privatization goals (Access, affordability, quality of service)	Relationship between regulatory regime (new independent regulator), government regulation (private sector participation), and (multi-dimensional) sector performance is not unilaterally positive.
Jackson (2005)	Gas	India	Fulfilment of reform relative to the standard model	Planned government regulation (tariff hikes) couldn't proceed, because its impact on welfare of consumers increased due to external factor (international price target increased), political balancing then occurred to stall new regulation.
Law & Svensson (1999)	Gas	Developing countries and transitioning economies	Fulfilment of reform relative to the standard model	Legislation and regulatory framework should be in place first to facilitate further reform (private participation); Unbundling should occur before privatization to facilitate further reform (competition).
Martimort & Straub (2009)	General	Global	Achievement of reform goals (Public satisfaction)	In countries where the formal institutions and cultural norms are tolerant of corruption (the transactional cost of non-benevolent decision for public officials are low), privatization cannot reduce corruption, instead, it changes the pattern of corruption; Although government regulation (private sector participation) might increase sector performance in some dimensions (higher investment and efficiency), if gains are not passed on to the consumers, its *perceived* distributive impact can lead to social protests, especially if the group affected is relatively empowered (the middle class).
Mathias & Szklo (2007)	Gas	Brazil	Achievement of reform goal (Energy security, efficiency of gas consumption, transmission and distribution capacity)	The problems of energy security (dependency on Bolivia) and efficiency (flaring) were not formally codified to become government objectives, therefore no regulatory action was taken; Most of the gas produced is associated with oil, therefore the producers' main objective is driven by the monetization of oil rather than gas, thus gas flaring has been accepted by the

Reference	Sector	Scope	Definition of reform/ regulation performance	Causal mechanism
				producers; Investment in T&D capacity has not been forthcoming because of non-incentivizing regulation and regulatory regime.
Nepal & Jamasb (2012)	Power	Transition economies	Achievement of reform goals (economic, operational, environmental impact)	The relationship between reform and sector performance is more complicated than previous theory suggests; Reform of government regulatory regime and regulation in interdependent and broader sectors are positively correlated with power sector reform success.
Nepal & Jamasb (2015)	Power	Nepal and Belarus	Achievement of reform goals (Frequency of outage, technical reserve margin, utility's finances)	Government regulation (tariff hikes) upsets social expectations; Weak regulatory regime leads to inadequate government regulation (corrupted reform), also upsets social expectations; Subsequent political balancing to address social concerns change government objective and regulation, stalling reform and limiting performance.
Victor & Heller (2007)	Power	Brazil, China, India, Mexico, and South Africa	Fulfilment of reform relative to the standard model	Narrow government regulation (sequence of reform) can formally impact the ownership structure of the sector, but it does not have much impact on actual firm decision-making; Shifting of responsibilities to the private sector only occur when private firms perceive the government's commitment to maintain an environment for profitable operation (regulation /regulatory regime /formal institutions) as credible; In the case that such an environment is not guaranteed, firms which are sufficiently efficient and have the political organizational capacity to ensure profitable operations emerge, and, to maintain own competitive advantage in the hybrid market, use political influence to stall further reform.
Williams & Ghanadan (2006)	Power	Developing countries	Fulfilment of reform relative to the standard model	Government regulation and regulatory regime change (overall reform) is conducted based on an inappropriate problem definition (to conform to the standard model instead of providing better energy services). In consequence, the reform has not contributed tangibly to improve the performance of the sector as experienced by the public. Thus, the reform fails to gain wider public support in subsequent political balancing and becomes stalled.
Williams & Kahrl (2008)	Power	China	Achievement of environmental regulation goals	Ineffective government regulation (target based on capacity rather than performance based measures) fails to align firm objectives with government objectives; Inadequate formal institutions (incomplete federalism) creates mismatch in control and ownership: central government agencies responsible for enforcing national legislation have little *de facto* power over provincial agencies which pursue their own objectives, resulting in non-compliance.

2.3 The updated SCPR Framework

The SCPR framework is a holistic framework that we have proposed to facilitate diagnostic and prescriptive inquiry in interdisciplinary research of gas-to-power supply chains. Building upon the Structure-Conduct-Performance (SCP) paradigm from industrial organisation and the concepts of endogenous dynamics, stocks and flows, and feedback from System Dynamics, the first version of the SCPR framework made the following claims:

1) As proposed by the SCP paradigm, the ownership structure of the industry influences the conduct of industry agents, by affecting their organisational objectives and by affecting the range of decisions available to them;
2) Industry agents' conduct can be differentiated into two types: long-term decisions that influence stock variables (e.g. capacity of infrastructure) and short-term decisions that influence flow variables (e.g. the use of the infrastructure available);
3) The outcome of the long-term decisions acts as the constraint of shorter term decisions (the use of infrastructure is constrained by the capacity of infrastructure available);
4) The repeated interaction between governmental regulation and industry self-regulation to fulfil their respective objectives, rather than any one of them alone, determines the outcome:
    a. To manage performance relative to organisational objectives, industry agents make short-term and long-term decisions, ranging from day-to-day operations to strategic investments, mergers, acquisitions, or divestitures;
    b. To manage performance relative to the government's policy goals for a given sector, the government also makes short-term and long-term decisions, ranging from the setting of annual targets to reforming the sector's ownership structure.

The first version of the SCPR framework was found helpful in anchoring the analysis of the UK's gas-to-power supply chain development (Peng & Poudineh, 2016). However, it does not include variables pertaining to the political perspective, shown to be instrumental in the development of gas and power sectors in developing countries in the literature review above. Therefore, in this paper we offer the following extension to the SCPR framework.

1) In addition to the two existing dimensions of analysis – one which is focused on governmental regulation and another on industry self-regulation – we propose a third dimension, one that is focused on regulation via political balancing (negotiation, persuasion, and/or coercion):
    a. In the political domain, various formal and informally organised interest groups make short-term and long-term decisions, ranging from lobbying for a given policy to establishing a new political order to manage performance relative to their stated/covert objectives;
    b. We recognise that competing interests can exist in civil society and within the umbrella terms of "the government/regulatory bodies" and "industry firms", although, as agents operating in the same dimension, they have similar types of resources and options for action;
    c. Representatives of the government and industry firms may engage in persuasion and negotiation alongside civil society interest groups, participating in balancing in the political dimension;

2) We recognize that the SCPR feedback structure exists in all three dimensions, and the repeated interaction between the three types of regulatory mechanisms (political balancing, governmental regulation, industry self-regulation) determines the ever-evolving outcome;
3) We highlight the multi-dimensional nature of performance: given differences in the objectives/expectations held by various stakeholders, diverging perceptions of performance are

more likely than not. In turn, the perceived deviation of performance from organisational goals acts as a mental frame in which corrective action from formal/informal interest groups, the government and its agencies, and industry firms are designed[3].

d. A corollary from this point is that the degree to which "politicisation" or "state intervention" is active in a sector is dependent upon the degree to which its perceived/expected performance deviates from social/interest group expectations and government objectives;

4) Finally, we recognise the hybrid nature of sector ownership in many developing countries: infrastructure owned and operated by dedicated industry firms often co-exist with infrastructure owned and operated by dedicated state agencies. There also exists more distributed infrastructure owned and operated by private households/businesses, whose activities are not dedicated to the provision of infrastructure service[4]. The relative importance of each of these three ownership patterns varies between countries.

Figure 3 through Figure 5 illustrates the gradually extending scope of the three dimensional SCPR framework. Table 4 provides more details about the SCPR feedback that is present within each dimension.

In the three figures, the three different colours distinguish the three dimensions: political, governmental/regulatory, and commercial. The dashed boxes (cultural norms, formal political regime and informal power structure, sector regulatory regime) are the "structures" that influence decisions made within. The lozenges represent decision made by interest groups, the government, and industry firms, resulting in different types of steering "conducts" represented by outgoing arrows. They can affect either the "structure" for another dimension, the decision makers' own capabilities in achieving their goals, the goals of other stakeholders, or they can acquire ownership of infrastructure, directly controlling service provision to meet their goals, instead of relying on indirect regulation. Performance, the outcome of the interacting behaviour of the three dimensions, is perceived by stakeholders and evaluated relative to their own sets of expectations and objectives, open to influence. The evaluation of performance then triggers another round of steering action.

Table 4 lays out the fundamental differences between the nature of control that agents from different dimensions exert over sector performance. Industry firms which are dedicated to the ownership and operation of infrastructure has most direct control over sector performance. Unless interest groups and the government take direct control of the infrastructure in question by acquiring ownership rights, displacing private industry firms, they rely on indirect measures to control the behaviour of industry firms. In the political dimension, interest groups compete through the exercise of political influence by using persuasion, negotiation, and coercion, with the goal of shaping government decision. Since legal authority is vested in the government through the institutionalised political regime and the sector regulatory regime, theoretically, the government has the power to influence private firms' decision through various forms of punishments and incentives (punitive fees for not meeting binding target, reward for achieving a suggested target, setting up a market environment which punishes/rewards certain behaviour, etc.).

[3] The choice of corrective action is itself an area of study. In general, we adhere to the findings from decision-making theory, that decision makers are subject to bounded rationality and their choices are partially conditioned by changing external conditions (Eisenhardt & Zbaracki, 1992).

[4] This is especially prevalent in power generation, also known as embedded or captive generation.

Figure 3: Commercial dimension of the SCPR framework

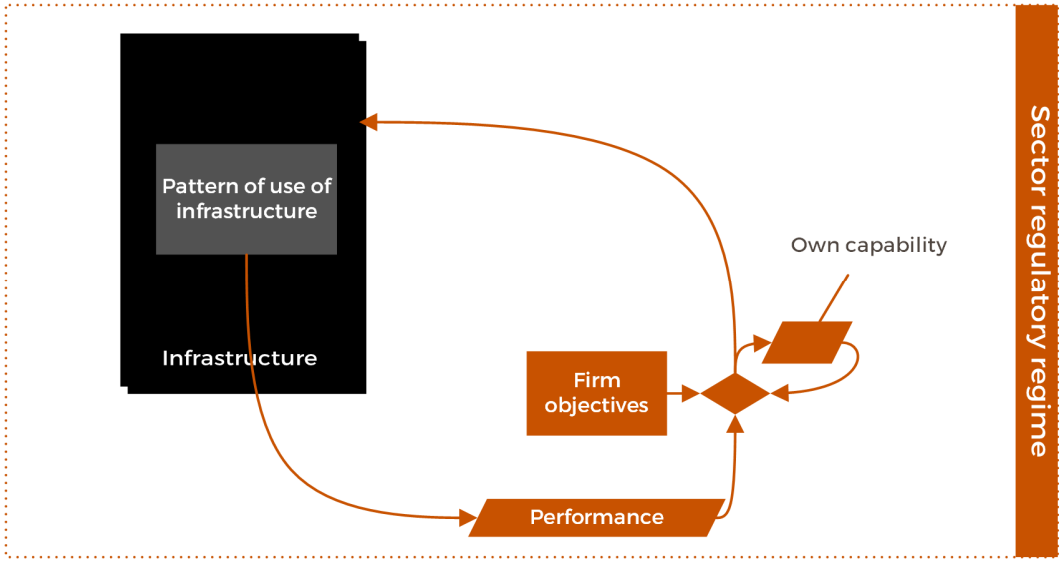


Figure 4: Governmental /regulatory dimension of the SCPR framework

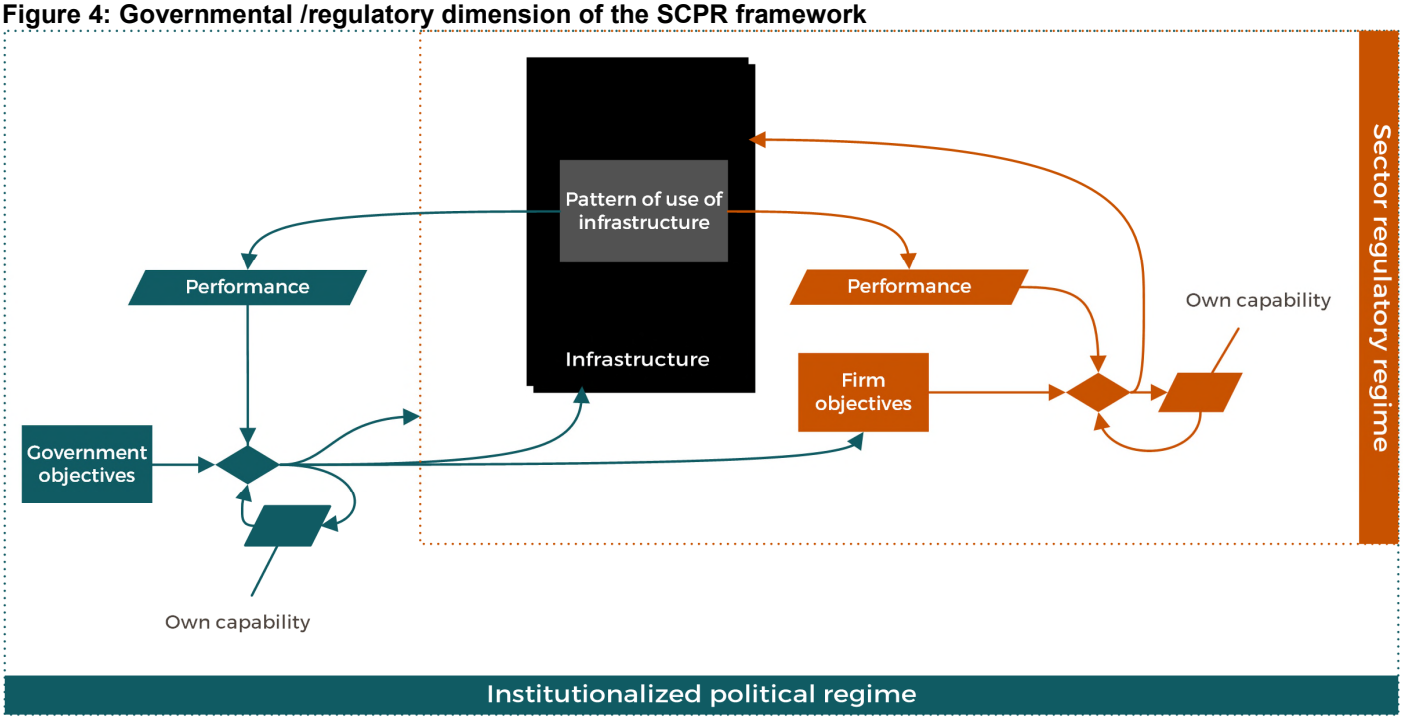


Figure 5: Political dimension of the SCPR framework

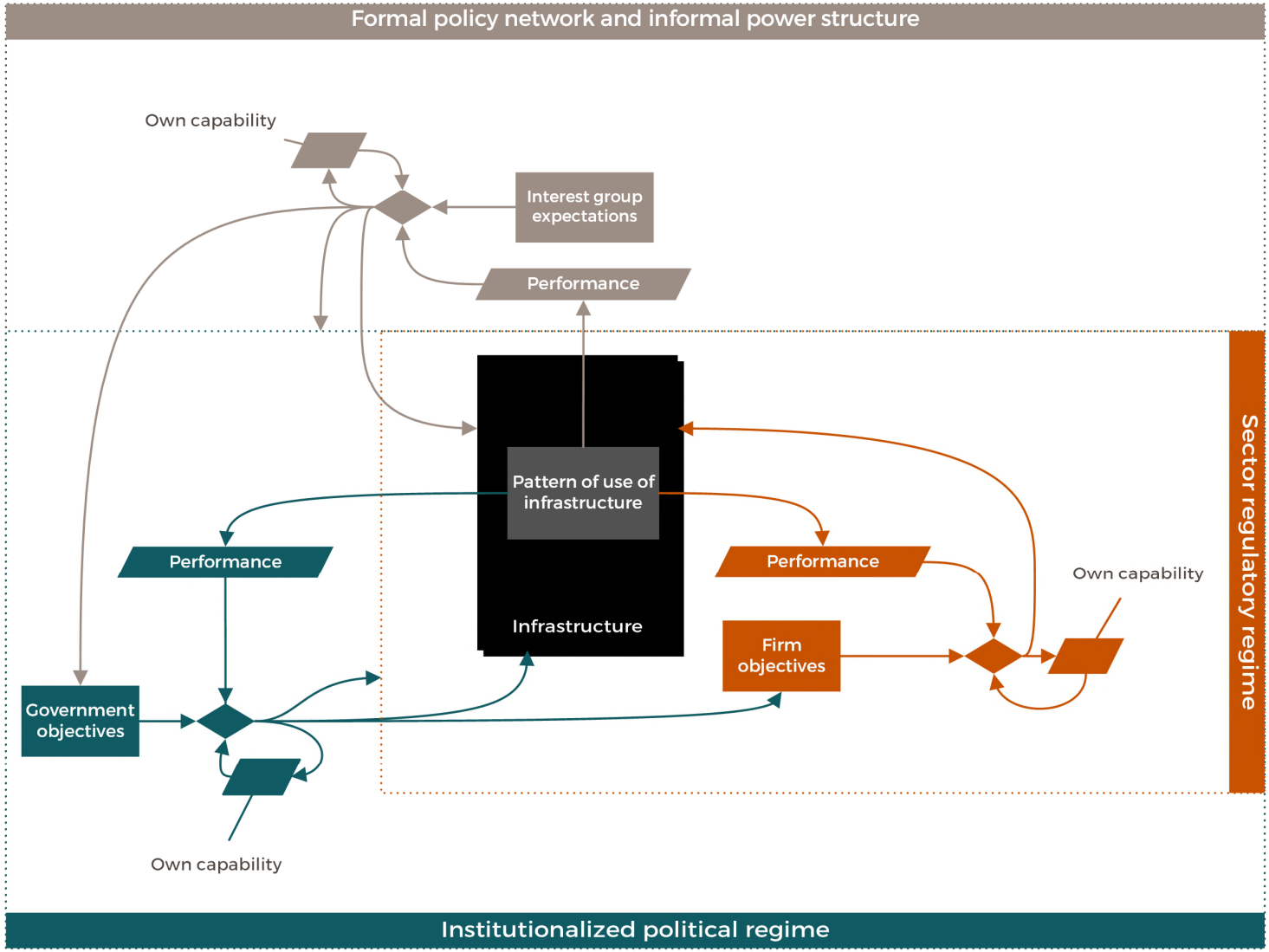


Table 4: Structure, conduct, performance, and regulation within the three decision dimensions

Domain	Key agents	Structure	Conduct	Performance	Regulation
Commercial	Industry firms	Exogenous: regulatory regime Endogenous: own infrastructure	Increase own commercial and operational capacity Own and operate infrastructure;	Sector performance perceived relative to heterogeneous firm objectives	Direct regulation of performance through ownership control
Regulatory	Government and its agencies	Exogenous: formal political regime and informal power Endogenous: sector regulatory regime Optional: own infrastructure	Implementations of new sector regulatory regime Increase own regulatory capacity Influence goals of agents in other dimensions through authority Own and operate infrastructure (e.g. nationalisation of infrastructure)	Sector performance perceived relative to heterogeneous government objectives	Indirect regulation of performance by exercising regulatory authority, constrained by sector regulatory regime Direct regulation of own performance through ownership control
Political	Interest groups (including representatives of government and industry firms)	Exogenous: cultural norms Endogenous: formal political regime and informal power structure Optional: own infrastructure	Enforcement of new political regime Increase own political influence Influence goals of government agents through persuasion and/or exchange Own and operate infrastructure (e.g. grid defection)	Sector performance perceived relative to heterogeneous interest group expectations	Indirect regulation of performance by exerting political influence on the government, constrained by cultural norms Direct regulation of sector performance through ownership control

The range of relationships between the government and industry firms which has been discussed in Peng & Poudineh (2016), illustrated through the centralised and decentralised archetypes. In the first case, where the state exercises direct control over the infrastructure, there is relatively little differentiation between the governmental and the commercial dimensions; in the second case, the governmental and commercial dimensions are distinct, and the government indirectly steers industry firms through economic regulation. With the addition of the political dimension, the archetypes can be extrapolated to the relationship between civil society and the government. In the hypothetical centralised archetype, there is no differentiation between the political and governmental dimensions; all political balancing occurs within the government and its agents (applicable to a fully authoritarian society). In the ideal decentralised archetype, the governmental and political dimensions are distinct and political balancing is open to all those who are able to self-organise. It occurs outside of the government and indirectly steers governmental policy (applicable to a fully democratic

society). However, all archetypes are mental abstractions, real societies are most likely a mixture of these extreme cases.

Our current view of the multiplicity of regulatory mechanisms within the gas-to-power sectors is consistent with the most recent research literature on governance. The often ill-defined term "governance" is here defined as "a wide-angle lens to capture the way in which we organise our societies and the interaction between government, market, civil society and individual citizens" (Meuleman, 2008, p. 11). The political, governmental/regulatory, and commercial dimensions that we describe, when distinct from each other (in more decentralised cases), correspond roughly to the network, hierarchy, and market modes of governance: the three ideal types identified in meta-governance research. At different times in the recent past, theorists have embraced each of them as a panacea for organising societal coordination in general, believing that a single, context-free set of principles is functionally and normatively superior[5]. Our stance is that real societies are more likely hybrids than the embodiment of any of these single modes of governance. The most promising way forward in governance research and design is in practising meta-governance: designing and managing sound combinations of governmental/hierarchy, commercial/market, and political/network governances, harnessing the capacities of all parties to achieve the best common outcome. With these considerations, the role of the public administration going forward is that of the meta-governor, which has at its disposal, in addition to conventional command-and-control type law and decree, regulation based on market principles and indirect regulation based on persuasion and negotiation in the political arena.

As a tool to study gas-to-power supply chains and their governance, the SCPR framework is original in its broad scope and focus on evolving causal dynamics, both with the goal to support systematisation of findings from different country-based studies. However, it should be stressed that the SCPR framework is *not* a fully-specified theory; it is an intellectual scaffolding based on which theory can be developed and tested, and its value lies in the stimulation of future research, compatible with cross-examination and synthesis.

By accounting for the influence of interest groups on the government and, by extension, industry firms, and the fact that the same performance indicators may elicit different responses from agents, depending on their goals, we are now able to explain within the SCPR framework important political dynamics observed in the developing world, such as popular resistance to privatisation and the stalling of reform efforts. This broadened scope is consistent with the political economy perspective, a view in which "political factors are crucial in determining economic outcomes, and economic factors are crucial in determining political outcomes" (Heywood, 2013, p. 129). It allows us to compare countries with different formal policy networks, informal political structures and institutionalised political regimes, and to infer their effects on the regulatory regime and commercial performance of a given sector.

At its core, the SCPR framework offers a view of gas-to-power supply chains as a complex dynamic system, emerging over time from interlocking decisions made by firms, governments, and social coalitions. This is a stance which unites functionalist views, focused on the role of relatively static structures (existing infrastructure, regulatory regime, formal political regime, etc.), and those that emphasize the preference and agency of individual decision makers (competing firms, ruling politicians, interest groups, etc.). In the short term, the decision makers are bound by existing institutions. However, over the long-term those decision makers can redesign the existing institutions. This is an important consideration when executives, policy makers, and civil society leaders are deriving lessons from the experiences of other countries; they need to be mindful of the differences in political/ regulatory institutions and the maturity of infrastructure between countries which might make immediate direct borrowing infeasible. However, they can learn from how others in their position have incrementally reshaped specific institutions to meet their goals.

[5] In Western European nations, hierarchical Weberian government was pursued as an ideal in the post-war years. Market governance became dominant since the 1980s riding the neo-liberal wave. Finally, since the 1990s, network governance which focuses on consensus building and participation has been embraced (Meuleman, 2008, p. 43).

3. Case description

Using the updated SCPR framework as a data collection guide, the recent performance of gas-to-power supply chains in Nigeria and Bangladesh is described in four parts.

1) Country background: a brief presentation of demographic and geographic context, which are potentially influential exogenous factors;
2) Performance viewed within the political dimension;
3) Performance viewed within the governmental/regulatory dimension;
4) Performance viewed within the commercial dimension.

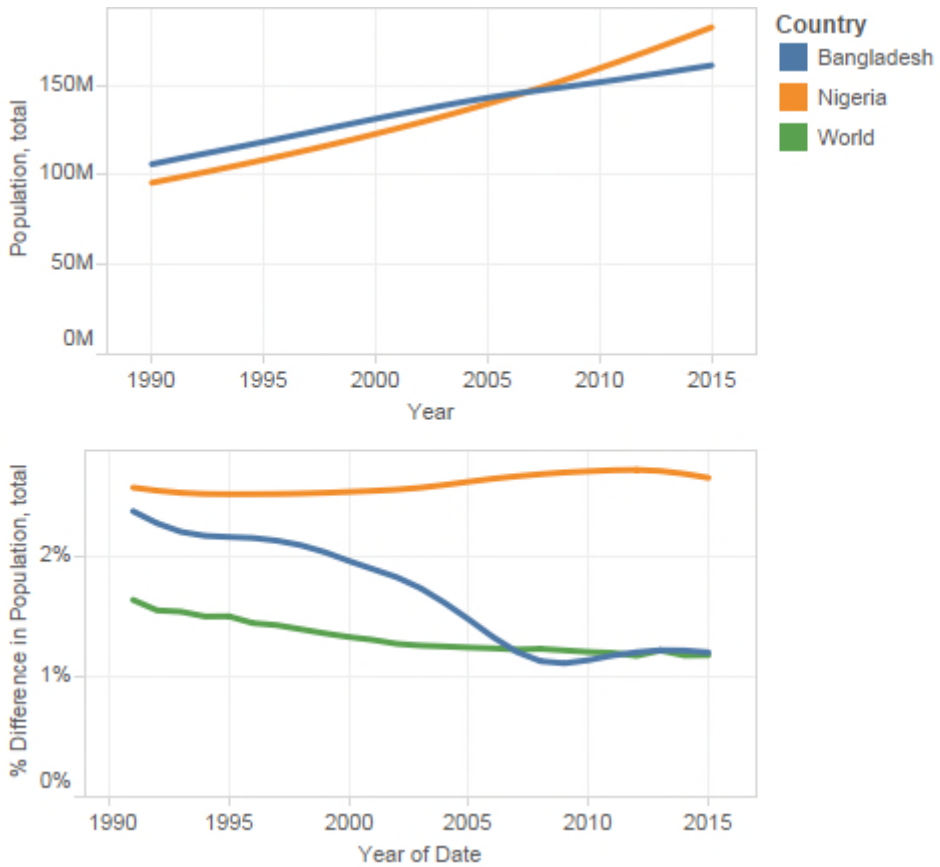
This section is focused on presenting structured information on the two countries. A synthesized discussion of the information presented, including the role of political balancing on the development of the gas-to-power chains, can be found in Section 4.

3.1 Country background

Before presenting gas-to-power supply chain issues observed within the political, governmental/regulatory, and infrastructure dimensions, the current demography and geography of Bangladesh and Nigeria are compared to illuminate key differences between the two countries.

In terms of demography, both Nigeria and Bangladesh have large populations: more than 100 million in the early 1990s, rising to more than 150 million by 2010. However, plotting the rates of change of population over the years reveals very different dynamics in the last twenty years (Figure 6).

Figure 6: Recent trends in Nigeria and Bangladesh population growth

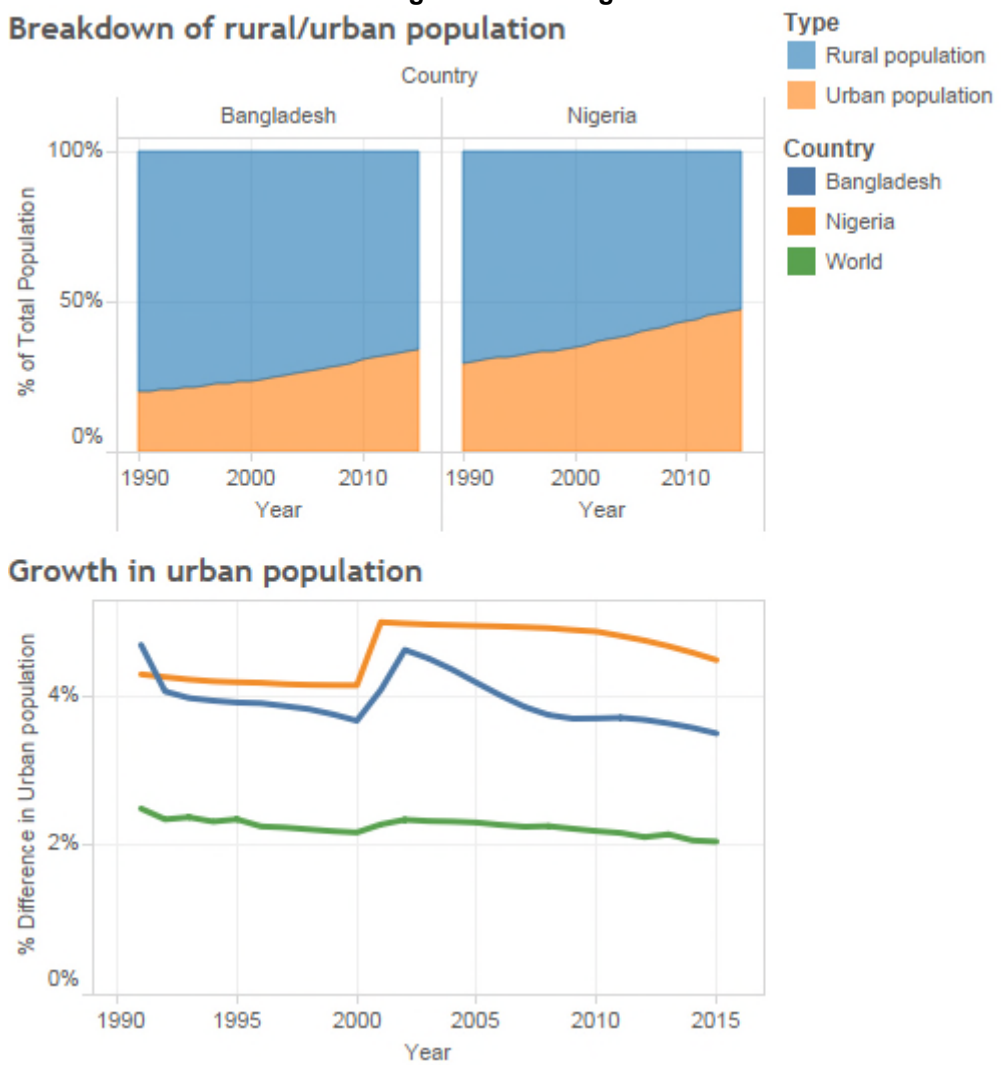


Source: Data from the World Bank

In Nigeria, the population increased steadily in an exponential manner, at an annual rate above 2.5%. In Bangladesh, the population was increasing at 2.4% a year in the early 1990s, but during 1995-2005 that rate slowed to about 1.2%. The decline in population growth rates in Bangladesh not only impacted the absolute size of the population, it also had implication for the population's age structure. In 2015, the working age population (15 to 64 years old) represented 65% of the total population, compared to 54% in 1990. For Nigeria, that percentage has remained constant at 52%. This change in fertility dynamics in Bangladesh is known as the demographic dividend: the higher share of working age population increases economic growth and lowers the burden on families, as there are fewer dependents.

Currently, almost 50% of Nigeria's population is in urban areas, while only 34% of Bangladesh population is urban. Both Bangladesh and Nigeria have a higher urbanisation rate than the world average (Figure 7). The increase in urban population (>4% per year) is higher than the rate of total population increase (1.2% and 2.5%, respectively), which indicates a net migration of people toward cities. In 2015, 32% of Bangladesh's urban population lived in Dhaka, the capital and the largest city, whereas 15% of Nigeria's urban population lives in Lagos, the economic centre, indicating that urban population is spread between more cities in Nigeria.

Figure 7: Recent trends in urbanisation in Bangladesh and Nigeria

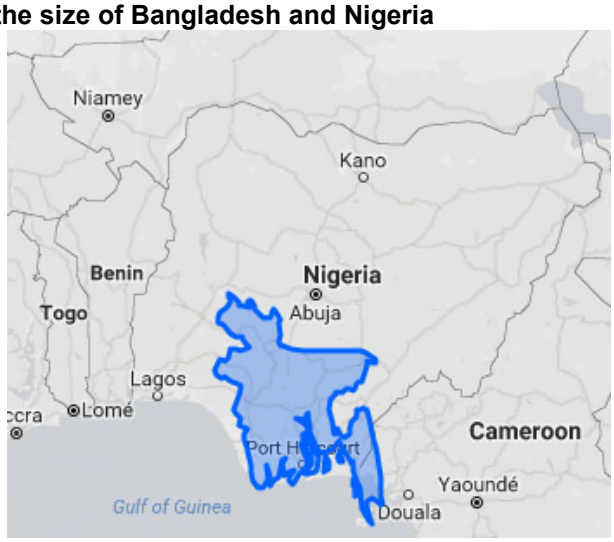


Source: Data from the World Bank

In terms of geography, the areas of the two countries are directly compared by superposition. Figure 8 shows that although Bangladesh has around the same size population as Nigeria, it only occupies an area that is

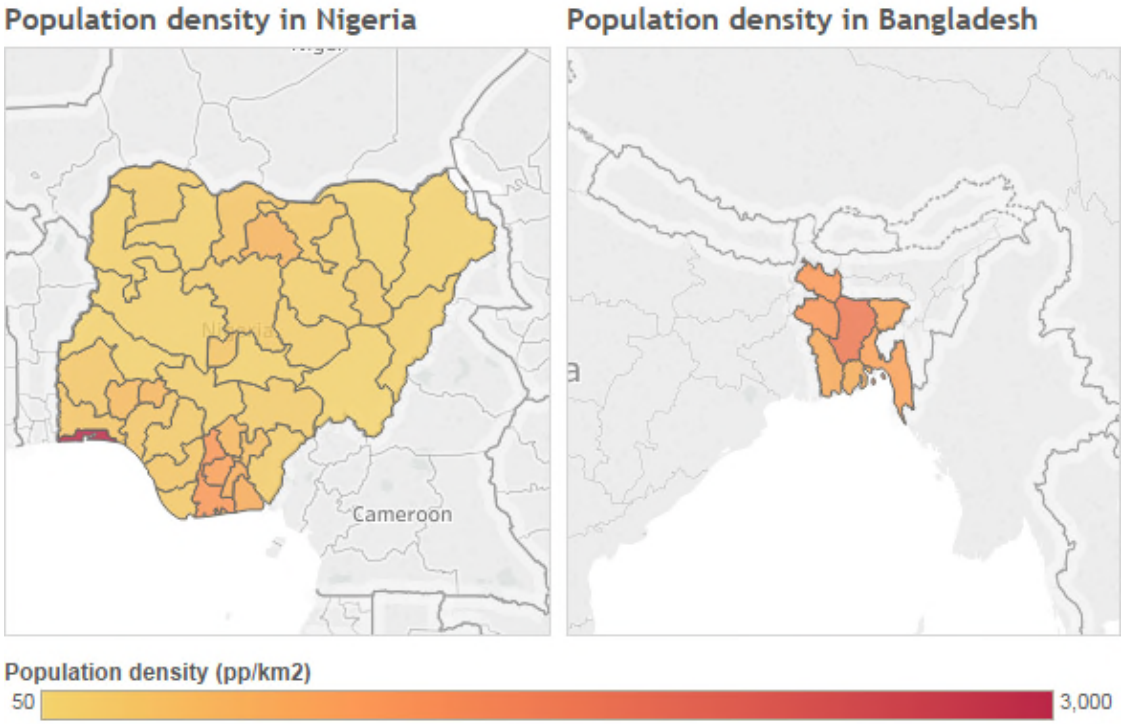
roughly equivalent to Nigeria's Southern coastal regions. Unsurprisingly, the average population density in Bangladesh is much higher than in Nigeria (Figure 9). In fact, Bangladesh is the most densely populated country in the world, outside of the small city states such as Singapore or Hong Kong. The distribution of population density is also more uniform in Bangladesh. Nigeria's population centres are the megacity Lagos and its surroundings, located along the South-Western coast, Kano in the Northern West, and the Niger Delta in the South-South.

Figure 8: Comparison of the size of Bangladesh and Nigeria



Source: thetruesize.com

Figure 9: Population density distribution of Nigeria and Bangladesh

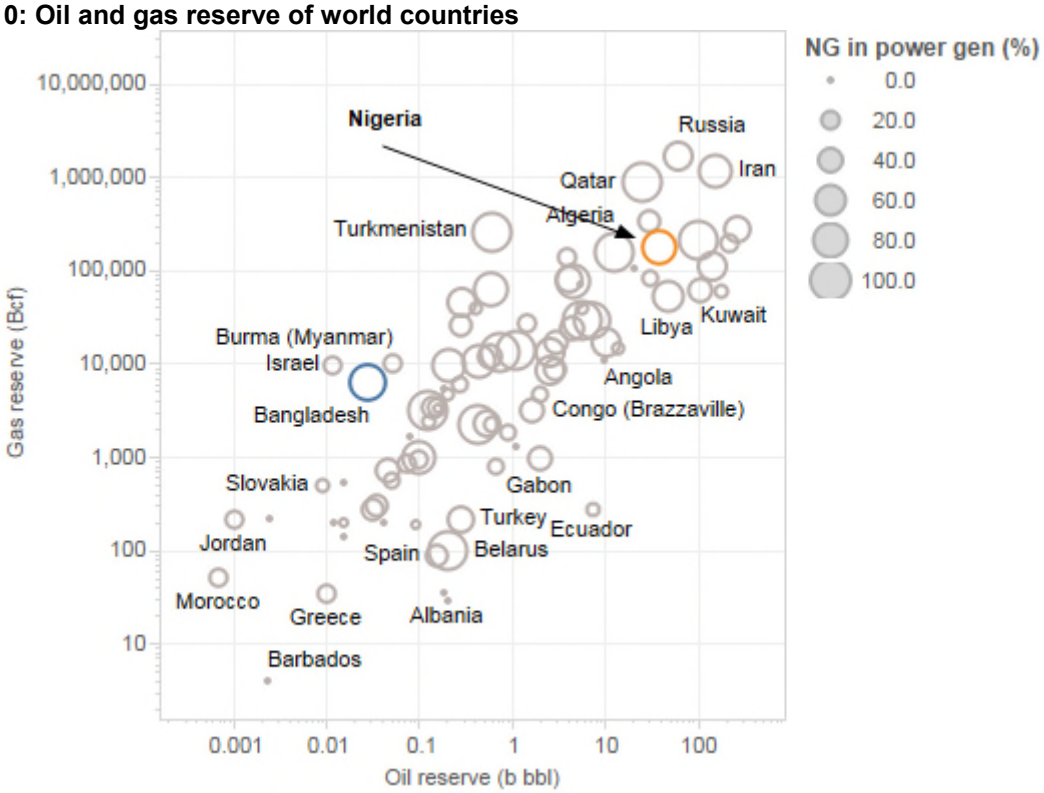


Source: Data from the Nigeria National Bureau of Statistics and the Bangladesh Bureau of Statistics

Figure 10 shows that Nigeria is endowed with abundant reserves of oil and gas (2.6% of world proven gas reserve and 2.2% of world proven oil reserves), comparable to that of other resource-rich countries such as

Algeria, Qatar, and Kuwait. Bangladesh has discovered a notable amount of gas (0.1% of proven world reserve, comparable to Myanmar), but not much oil.

Figure 10: Oil and gas reserve of world countries



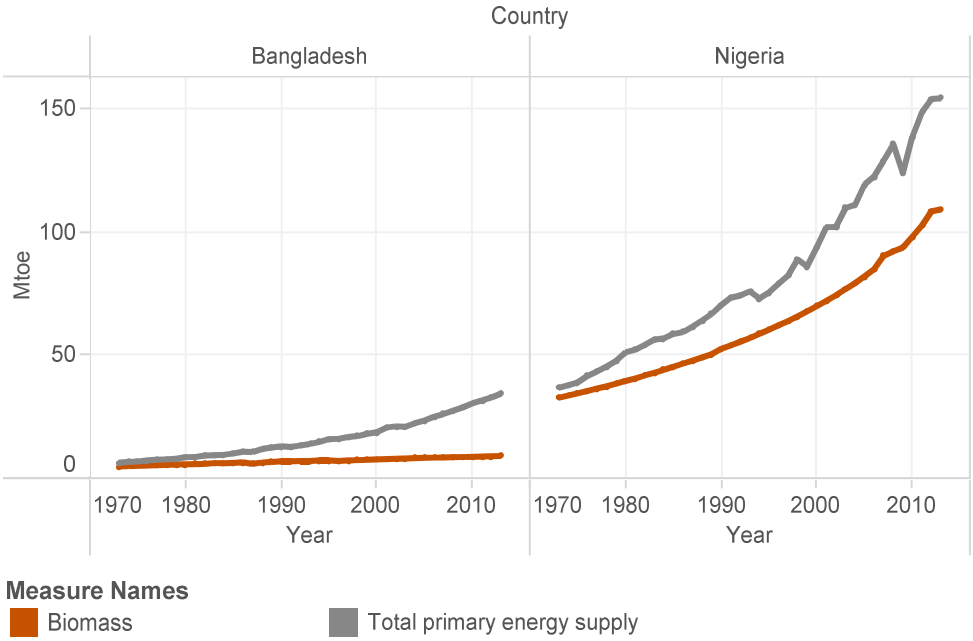
Source: Data from EIA

According to the renewable energy country profiles compiled by the International Renewable Energy Agency (IRENA), relative to other countries, Bangladesh has high resource potential for the development of solar and biomass projects, but more limited potential for the development of wind and hydro projects (IRENA, 2012). On the other hand, Nigeria is rated as having high resource potential for wind, solar, hydro, and biomass projects (IRENA, 2011). In total, Nigeria enjoys a superior natural energy resource endowment compared to Bangladesh.

Although the two countries have comparable populations, the total primary energy supply (TPES) used by Nigeria is almost four times that of Bangladesh[6]. The difference in energy supply is so large that Bangladesh's TPES only recently reached the level of TPES Nigeria achieved in the 1970s (Figure 11). Most of this difference (99.9 of 119.6 Mtoe, or 84%) comes from the much higher biomass fuel consumption in the residential sector in Nigeria. After eliminating the traditional use of biomass, the energy consumption of the two countries are more comparable, yet Nigeria's adjusted TPES is still double that of Bangladesh. It also becomes more apparent that, compared to Bangladesh, the evolution of non-biomass energy supply in Nigeria is more volatile, with non-negligible rises and falls in its trajectory (Figure 12).

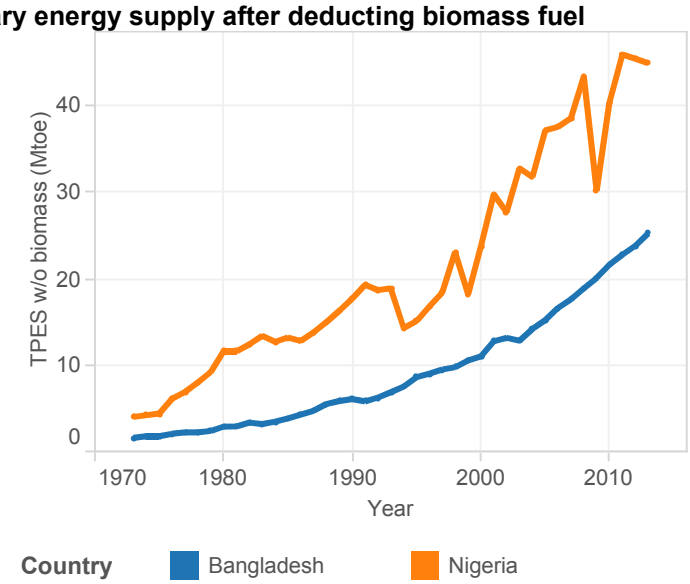
[6] Total primary energy supply here is defined as the difference between total energy production and imports into the country and its energy exports.

Figure 11: Total primary energy supply and biomass fuel consumption in Bangladesh and Nigeria



Source: Data from IEA

Figure 12: Total primary energy supply after deducting biomass fuel



Source: Data from IEA

3.2 Performance viewed within the political dimension

In this section, the interaction between the two countries' institutionalised political regimes and formally/informally organised interest groups is laid out. We pay attention to the roles that various interest groups have played in bringing about the current political regime, their composition and motivation, and the confluence of regime change with external conditions. We also discuss the current constellations of key interest groups active in politics in Nigeria and Bangladesh, their core objectives in political balancing, and their success in meeting these objectives.

3.2.1 Nigeria

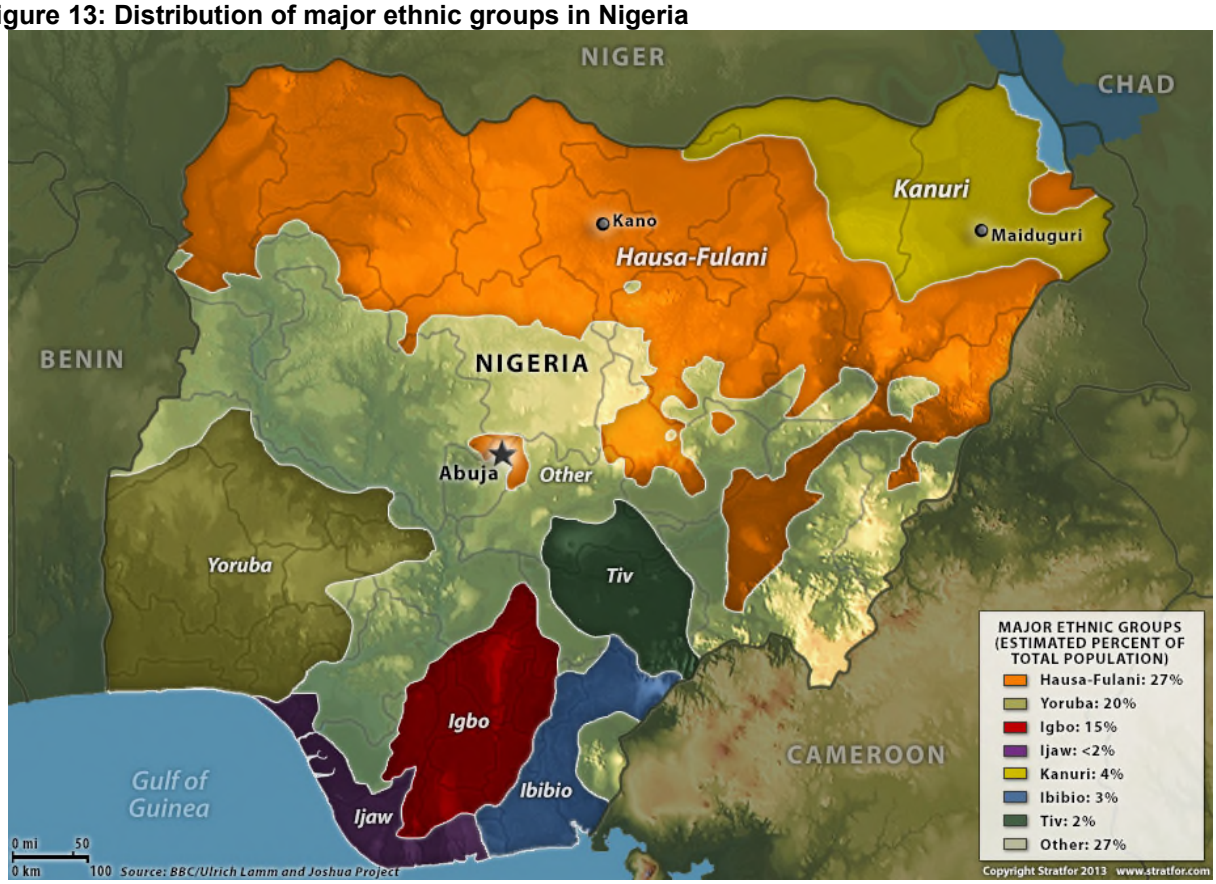
Nigeria transitioned from military authoritarian rule to civilian-electoral rule in 1999. Despite the end of military rule, the transition to democracy has not always been transparent and peaceful. The 2003, 2007, and 2011 elections were marred by widespread violence and election rigging. However, the 2015 election, dubbed the most credible and transparent election since independence, saw the first time in Nigeria's history an opposition party unexpectedly defeated the entrenched ruling party (Owen & Usman, 2015; Schultze-Kraft, 2013). It marked the beginning of a new political age with unknown longevity, in which the power to rule has been transferred from the incumbent Peoples' Democratic Party (PDP) to its opponents.

Since its independence in 1960, Nigeria's nation-building process had to periodically defuse recurring regional and ethnic tension. Three numerically and politically dominant ethnicities, the Hausa and Fulani in the North, the Yoruba in the south-west, and the Igbo in the south-east, superimposed with Islam in the North and Christianity in the South, constitute the ethnic and religious structure of Nigeria, as illustrated by Figure 13 (Z. Usman, 2016). Political and socio-economic inequalities among the regions drive a perennial fear of domination by one ethnicity-led region over another. Since then, formal political institutions have been developed to manage these persistent ethnic/regional tension[7].

Ever since the mid-1970s, oil revenue has made up more than 60% of the federal government's total revenue (Figure 14). When oil prices quadrupled in 1973-1974, the ruling regime of the time cut taxes and increased salaries and wages, making the government critically dependent on oil almost overnight (Thurber, Emelife, & Heller, 2012). Since then, Nigeria has been described as a rentier state; the ruling coalition's dependence on hydrocarbon rent paid by non-Nigerian clients, which is significantly higher than domestic taxation, has isolated it from the demands of Nigerian citizens. The government maintains its power through the control of petroleum resources rather than through popularity (Falola & Heaton, 2008). Concomitantly, control of oil resources and distribution of oil revenue flowing from that have been the hotbed of power struggle and conflict in the country, in the formal political arena and informally through grassroots (and at times, violent) social mobilisation. The dependence on oil revenue also exposes Nigeria's public finances to volatility in the international oil market.

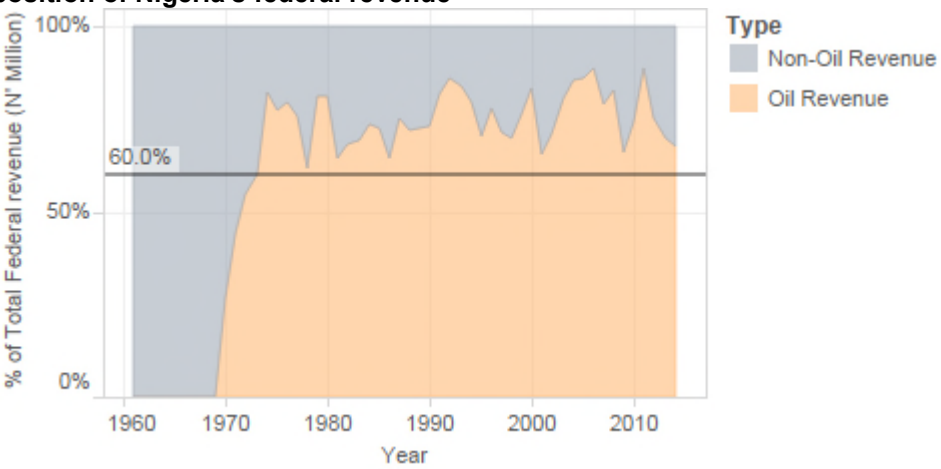
[7] Nigeria is a federal rather than a unitary state; the "Federal Character" principle (affirmative action based on ethnic-regional affiliation) is applied to the National Assembly, the military, civil service, and public education; and election majority needs to be achieved through pan-ethnic support. Informally, alternation of the position of president between the north and the south (zoning) is practiced as a norm within the PDP, although it is not recognised by the constitution (Ololajulo, 2016)

Figure 13: Distribution of major ethnic groups in Nigeria



Source: Stratfor

Figure 14: Composition of Nigeria's federal revenue

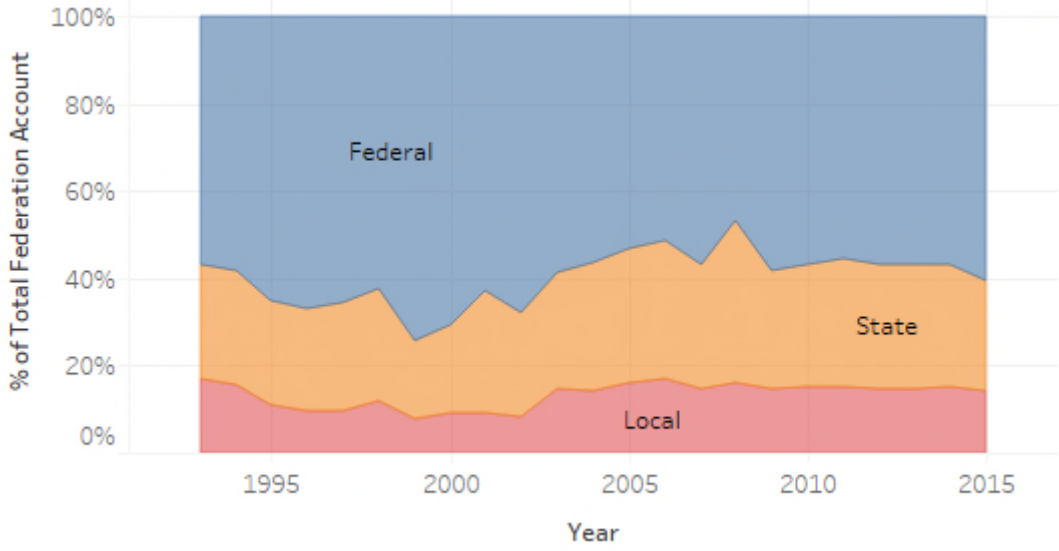


Source: Data from the Central Bank of Nigeria

In Nigeria, formal government governance is carried out through a three-tiered structure, with responsibilities distributed between the federal government, the state governments, and local government authorities. The Federation Account is the instrument through which federally collected revenue is shared between different tiers of the government. About 40% of the Federation Account has been transferred to state governments and local government authorities (Figure 15). Furthermore, the allocation of the Federation Account between different states has always been contentious, with different states favouring different distribution principles

that favour their circumstances. The principles for horizontal revenue allocation adopted and their weights used in the allocation of revenue continuously evolve under political influences (Okauru, 2012).

Figure 15: Share of the federation account between different government tiers



Source: Data from the Central Bank of Nigeria

Compared to their expenditure responsibilities (primary education and healthcare, development of agriculture and non-mineral resources, roads), lower level governments are significantly underfunded. Also, local council officials frequently rely on connections to influential "kingmakers" to carry out their election campaigns, therefore the federal allocations to local councils have become the means of paying back these favours: entrenched political interests come before the needs of local constituents, explaining the poor delivery of basic services (Taiwo & Moyo, 2011).

Nigeria's oil and gas resources are mainly concentrated in the Niger Delta, a densely populated coastal plain that spans nine Southern states. The major ethnicities in the region are Ijaws, Ibibios, and Ogonis. Since commercial oil production began in the 1960s, the people of the Niger Delta have borne a disproportionate share of the cost of oil extraction, as environmental degradation due to oil spillage and natural gas flaring endanger traditional subsistence and human health, for which compensation has been perceived as inadequate[8]. All oil-related revenue is centrally collected by the Federal Government, which then allocates a fraction to oil-producing states per the derivation principle. But this has not translated into increased public service delivery in the Niger Delta communities, and little institutional capacity has been developed to uphold legislation related to environmental protection. In addition, the derivation fraction of oil revenue going to the oil-producing states decreased from 60% in the 1960s to 3% by 1999[9]. Such a skewed distribution of costs and benefits is tied to the centralisation of petroleum resources and land in the hands of the federal government, following the Petroleum Act of 1969 and the Land Use Act of 1979, passed under the rule of the first military regime. The revenue deriving from these centralised resources diminishes the Federal Government's responsiveness and accountability toward the people, while driving it into a symbiotic relationship with IOCs. This relationship is recreated at the sub-national level between the Federal Government and the State Governments.

[8] United Nations Environment Programme conducted an environmental assessment of Ogoniland, a 1000 km^2 area in the Niger Delta, in 2011. It found that, even after the end of Shell's operations (1958-1993), oil spills continue to occur with alarming regularity. Oil contamination is widespread and severely impacting the environment, and environmental restoration is possible but may take 25 to 30 years (United Nations Environment Programme, 2011).

[9] The 1999 Constitution increased the derivation percentage to 13%, which is the current weight, since the southern delegates' demand to increase it to 25% (and eventually to 50%) was not met in 2005 (Obi & Rustad, 2011).

Violent conflicts first erupted in the Niger Delta in the 1990s. In the 2000s, militant alliances emerged, leveraging hardened attitudes of local youth, continually unaddressed grievances given the under-development of the Niger Delta, and the low opportunity cost for violence that it creates. Militants used lethal attacks, bombings of oil installations, and global media to publicise their campaign to regain control over the Niger Delta's resources (Obi & Rustad, 2011; Oyefusi, 2008). Ongoing inter and intra-community violence, indirectly related to oil development (disputes over oil-bearing lands, compensation payments, and the establishment of local government councils to receive oil revenue from the federal government) forms the background of violence directed at the state and oil companies (Watts, 2009). The looting of oil resources provides income to militant groups, which are motivated by a mixture of grievance and greed, and to organised crime groups that take advantage of the lack of governance in the region, using the resource control conflict as an opportunistic excuse. Some of them are allegedly condoned by or consist of representatives of the military (Gboyega, Soreide, Le, & Shukla, 2011). In 2009, a unilateral presidential amnesty was declared with the condition that militants would disarm and join a demobilisation and reintegration programme, with a monthly stipend for ex-militants and lucrative security contracts to ex-militant leaders to protect oil infrastructure. It did appeal to the bulk of militant leaders, but the original grievances of the Niger Delta people – oil production related pollution, inadequate infrastructure and public service delivery, and widespread unemployment – remains unresolved (Schultze-Kraft, 2013).

President Buhari, once elected in 2015, ended the security contracts awarded to ex-militant leaders and began investigating some ex-leaders for alleged corruption. Moreover, Buhari's cuts to the amnesty programme's funding, combined with his cancellation of the Nigerian Maritime University, perceived by the Niger Delta communities as a move to deny them development and educational opportunities, have started a new round of militant activities in 2016, sending oil production to an almost 30-year low (Ebiede, 2016; Wallace, 2016). The President's appointment of key officials has also been condemned for being heavily unbalanced, with an overwhelming majority from the North; to these accusations, Buhari responded that his appointments were made based on personal confidence and trust (Odunsi, 2015).

3.2.2 Bangladesh

Bangladesh's population is predominately Muslim and, based on ethnicity, language, and culture, Bengali. Bengal's Muslim-majority population supported the Pakistan movement in their conflict with India in the 1940s, eventually leading to the region breaking away from India to become East Pakistan in 1948. Later, the Bengali identity is what fuelled the struggle for the national self-determination of Bangladesh, gaining independence from Pakistan. Nevertheless, about 10% of the population is made up by Hindu, Christian, and Animist minorities.

Since the return to civilian rule from military rule in 1991, the executive power of the Bangladesh government has alternated between two powerful women representing two different parties: Khaleda Zia, widow of assassinated former leader General Zia, heading the Bangladesh Nationalist Party (BNP), and Sheikh Hasina, daughter of founding president Sheikh Mujibur Rahman (whose assassination was followed by the rule of General Zia), heading the Awami League. The two parties developed antagonistic ideological positions, not based on policy differences, but on the origins and fundamental characteristics of the country. The Awami League's ideology of Bengali nationalism (Bengali vs. non-Bengali) developed while fighting for independence against Bangladesh during the Liberation War; the BNP's ideology of Bangladeshi nationalism (Bangladeshi vs. nationals of other countries) developed subsequently to unite political organizations that had been excluded by the Awami League and to strengthen the Muslim identity of Bangladesh. Each party portrays the other as an illegitimate ruler and a threat to the survival of the country as defined by themselves (M. H. Khan, 2011).

Elections have taken place in 1991, 1996, 2001, 2008, and 2014, with Zia claiming victory for the 1991 and 2001 elections, and Hasina the other three. Traditionally, instead of engaging in parliamentary debate, the opposition party frequently boycotted the parliament and relied on street agitation (locally known as *hartal*) and general strikes as the main political tactic. This tendency has increased with time: the percentage of parliamentary sessions boycotted by the opposition party was 34 during 1991-1996, but increased to 83% for 2009-2013 (Islam, 2016). Since 2014, given the "real" opposition parties (BNP and its allies) is completely displaced from parliament, attendance has nominally improved; at the same time, it could be said that the

boycott is now for 100% of parliamentary sessions[10]. Since the start of 2015, BNP has launched continuous calls for strikes and blockades and asked for midterm elections, among other requests. Allegedly in reaction to these incidents, the Hasina government has "disappeared" prominent figures from the opposition, while cracking down on the media and journalists. Overall, the latest episode of a long-lasting and bitter rivalry between the two leaders has sent Bangladesh into a period of heavy-handed political repression (Mallet, 2015). This is a worrying sign, as the seed of confrontation – the inability of the two leading parties to share power peacefully – has not been resolved, and may give rise to a crisis for the next election planned for 2018-19 (Liton, 2017).

In 2016, the location of the planned Rampal coal power plant, 14 km away from the Sundarbans, one of the largest mangrove forests in the world, polarised public opinion. Opposition to the Rampal power plant comes from at least two sources. NGO coalitions such as the National Committee for Saving the Sundarbans and the National Committee to Protect Oil, Gas, Mineral Resources, Power and Ports claim to oppose the projects because they perceive the proposed design to be insufficient for preventing environmental damage to the Sundarbans. The BNP leadership alleges that the Awami League government is constructing the plant in the interest of India at the expense of the environment (The Daily Star, 2016a, 2016b). The Awami League government has responded that public concerns over environmental damage results from a lack of understanding of the project, and that the BNP has provided fabricated and false information concerning Rampal to mislead the people (Daily Sun, 2016; S. Khan, 2016).

Foreign aid has played an important role in Bangladesh's development since independence. By the end of the 1980s, three fifths of the country's total investment were funded by official annual aid, provided as grants or as soft-loans. Consequently, the political influence of donors in Bangladesh has been substantial. Since the 1970s, foreign donors have played a major role in promoting privatisation and economic liberalisation; the need for aid steered the government to economic reforms and continued aid dependence has kept subsequent governments on the same path (Lewis, 2012). Perhaps due to institutional continuity and collaboration with development partners, government policy in Bangladesh has continued in the same direction despite bitter in-fighting among its ruling elite. Grants and loans from Bangladesh's chief development partner, the Asian Development Bank, is strongly aligned with the government's long-term strategy and the Five-Year Plans that the Planning Commission prepares.

Today, non-governmental organisations are a great force in Bangladeshi society. Modern NGOs in Bangladesh are rooted in Bengali traditions of religious charity and philanthropy, first appearing in their current forms in the aftermath of the 1971 independence from Pakistan, when the country was devastated and suffering from natural disasters. Given the government was non-responsive, progressive young Bangladeshis founded several of the largest NGOs in Bangladesh today (e.g.: BRAC, Grameen Bank) to provide humanitarian relief, infrastructure development, and poverty alleviation (S. Rahman, 2006). Later, global development funding encouraged the growth of NGOs, favouring the channelling of funding and support through NGOs to deliver development assistance. Today, there are about 22,000 formalised NGOs that operate in Bangladesh, directly delivering credit, education, health, sanitation, and other services to 35% of the population. The extent to which the state has devolved the provision of providing essential public services to NGOs has earned Bangladesh the title of a "franchise state" (Wood, 1997).

3.2.3 Comparison

For all their political differences, Bangladesh and Nigeria are united by their reputations for ineffective formal governance. In 2001, the corruption perception index, published annually by Transparency International, ranked Bangladesh and Nigeria as the countries perceived as the most corrupt and the second-most corrupt, respectively, among 81 countries that it had surveyed (Transparency International, 2001). By 2015, the

[10] In 2012, the Supreme Court declared the caretaker government system to be beyond the power of the constitution, abolishing the practice. In the most recent 2014 elections, BNP refused to accept election under the incumbent government and decided to boycott the election. The Awami League was able to proceed with the election despite the BNP boycott, given there is little popular and international pressure to include BNP. In consequence, a government led by Awami League and not having any representation of BNP has been formed.

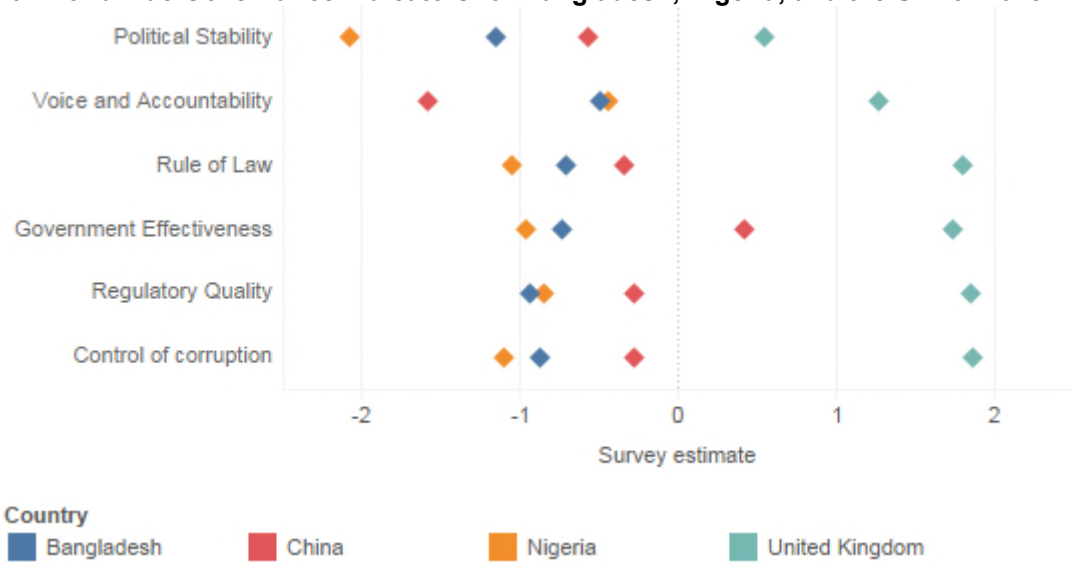
standings of these two countries improved somewhat, now ranked as the 19th and 24th most corrupt by perception, among a surveyed list of 147 countries, ceding the top two positions to Somalia and Afghanistan.

The Worldwide Governance Indicators describes governance in terms of composite measurements in six dimensions, which respectively represent:

1) Political stability and absence of violence: perceptions of the likelihood of political instability and violence, including terrorism;
2) Voice and Accountability: perceptions of the extent to which a country's citizens can participate in selecting their government, expressing and organising themselves freely;
3) Rule of Law: perceptions of the extent to which agents have confidence in and abide by the rules of society, especially the rule of contract enforcement, property rights, the police, and the courts;
4) Government Effectiveness: perceptions of the quality of public services, the quality of policy formulation and implementation, and the credibility of the government's policies;
5) Regulatory Quality: perceptions of the government to formulate and implement sound policies and regulations that permit and promote private sector development;
6) Control of Corruption: perceptions of the extent to which public power is exercised for private gain (petty and grand corruptions), the extent of "capture" of the state by elites and private interest.

Figure 16 compares the different dimensions of governance for Nigeria and Bangladesh in more detail. The United Kingdom and China are included as reference points. It shows that, other than for the political stability dimension, for which Nigeria is perceived as significantly less politically stable/prone to politically-motivated violence, the two countries perform comparably.

Figure 16: Worldwide Governance Indicators for Bangladesh, Nigeria, and the UK for 2015

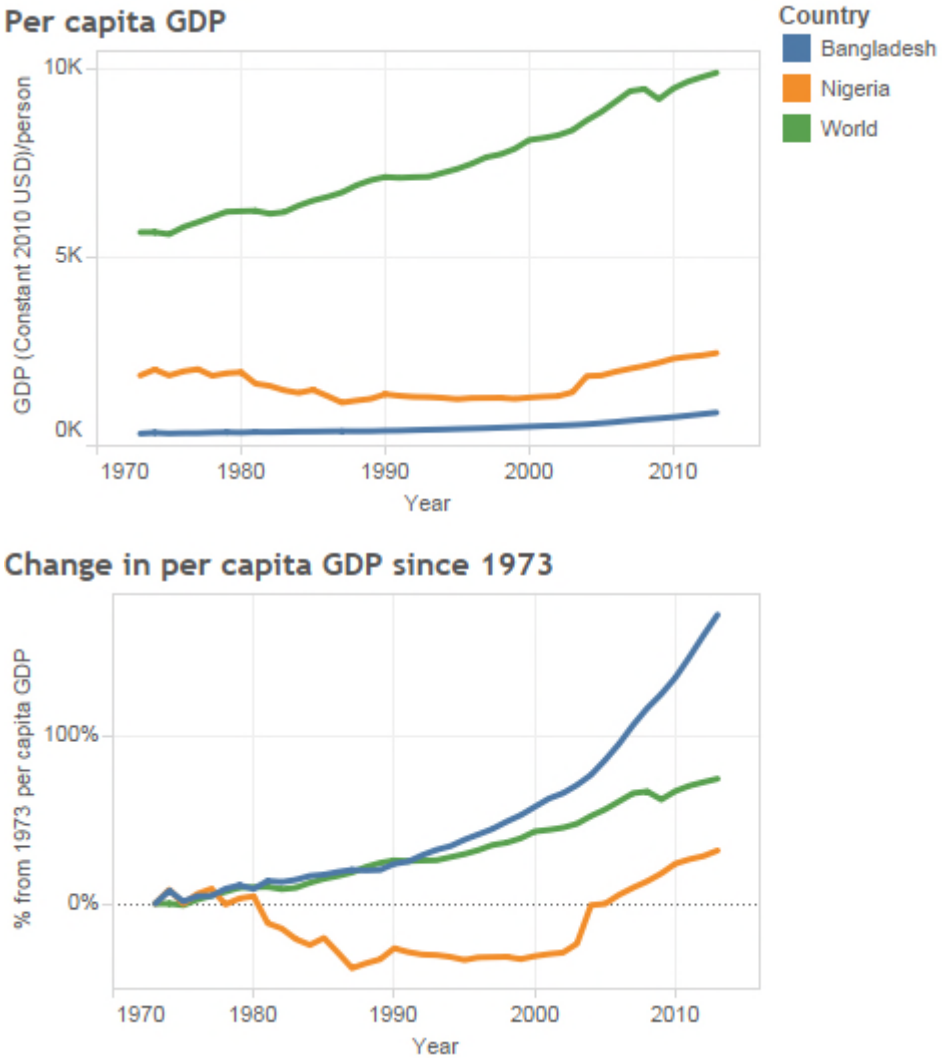


Source: Data from the World Bank

Beyond the direct comparison of politics, economic indicators are also compared to illustrate the two countries' performance in terms of macroeconomic stability and growth, providing the context in which general and sector-specific policy decisions, discussed in the following section, are made. From the 1970s until now, the per capita GDP of Nigeria and Bangladesh, after removing the effect of inflation and converted to US dollars at market prices, remain significantly below average world per capita GDP (Figure 17). Throughout the same period, the per capita GDP of Nigeria has also been significantly greater than that of Bangladesh. However, during the past four decades, the Bangladeshi per capita GDP has grown by 170%, which is larger than the increase of the world average (75%) and the growth in Nigerian per capita GDP. In fact, the latter experienced a decline from 1980 to 1987, which was only recovered to the original 1980 level in 2004. Figure 17 only displays trends up to 2013. Since then, the Nigerian economy has contracted for the first two quarters of 2016, meeting the technical definition of a recession. The fall in global oil prices and the

consequent fall in oil revenue is one of the causes of the recession, but Buhari's foreign exchange policy has also been blamed (FT View, 2016) .

Figure 17: Trends in per capita real GDP of Nigeria and Bangladesh

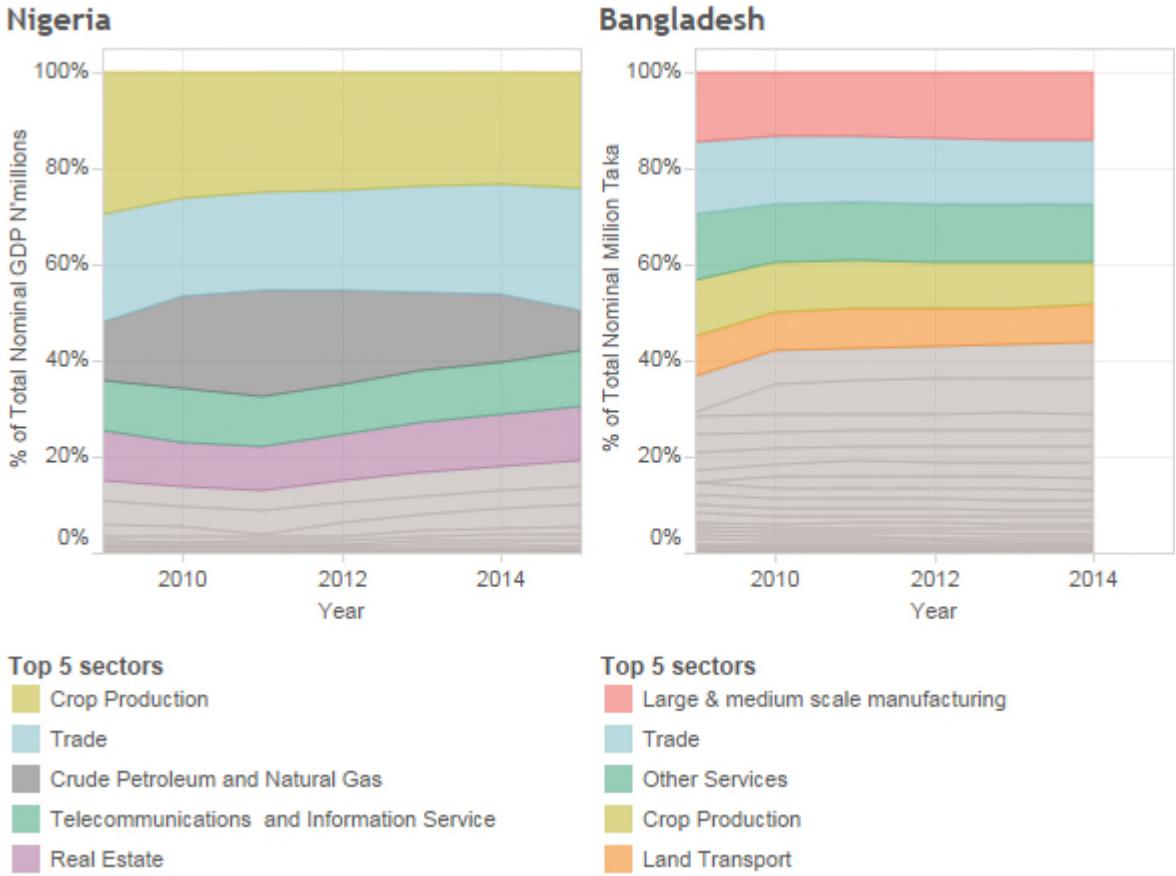


Source: Data from the World Bank

Figure 18 offers a more detailed view, comparing the roles of the most important five sectors in the two countries' economies: agriculture (crop production) is the most important sector in Nigeria in terms of contribution to GDP (24% in 2015), it has been eclipsed in Bangladesh by large and medium scale manufacturing (dominated by ready-made garment), trade, and uncategorized service sectors[11]. Petroleum is the most important industrial sector in Nigeria, although its relative importance has been declining since 2011. The five most important sectors in the Nigerian economy account for almost 80% of GDP. On the other hand, the five most important sectors in the Bangladeshi economy account for 60% of GDP. Thus, although both economies are heavily influenced by a few sectors, Bangladesh's economy is relatively more diversified than that of Nigeria.

[11] In the late 1970s, a confluence of factors made the rise of the export-oriented ready-made garments (RMG) industry in Bangladesh possible: technology transfer to a level that achieved global competitiveness required domestic readiness, favourable external circumstances, and targeted innovation (M. H. Khan, 2012)khan.

Figure 18: Comparison of GDP structure for Nigeria and Bangladesh



Source: Based on data from Central Bank of Nigeria and Bangladesh Bureau of Statistics

3.3 Performance viewed within the governmental/regulatory dimension

In this section, we describe the current regulatory regime applicable to the gas-to-power supply chains in Bangladesh and Nigeria, and the influence that domestic and external interests have had on these regulatory regimes. The performance of the gas-to-power supply chain relative to the government and/or regulating authority's objectives is then presented, divided into key issues.

3.3.1 Nigeria

In 2004, the Nigerian Federal Government launched the National Economic Empowerment and Development Program (NEEDS), which included plans to reform the downstream oil and gas sectors and the entire power sector. Far-reaching reform is one of the conditions that Nigeria has agreed in exchange for an important debt relief (60% of $30 billion) package from some of its major creditors, the Paris Club. The Minister of Finance of the time recounts that, given strong negative feelings about IMF and World Bank-led adjustment programmes in the country, it was not possible for the government to implement a formal IMF Supervised Economic Reform programme, as required by the Paris Club lenders among other conditions. Instead, it was decided that the Nigerian Government would craft its own economic programme which was to be as strong or stronger than what the IMF would have put in place, and inviting the IMF to monitor the implementation of the program (Okonjo-Iweala, 2012).

3.3.1.1. Gas sector regulatory regime and reform

The most striking characteristic of Nigeria's current gas sector regulatory regime is that it is not differentiated from that for oil, the country's key natural resource. Therefore, the development of the gas sector's regulatory regime cannot be separated from that of oil, which has been highly tumultuous given contention over

resource and revenue control. In comparison, regulatory reform implemented in the power sector has been more extreme, but encountered significantly less political resistance.

The principal piece of legislation for oil and gas activities is the Petroleum Act 1969. It mainly addresses the operations of oil exploration, prospecting, and mining activities, and provides little on the development and use of natural gas (Oyewunmi, 2014). Therefore, the regulatory regime for the gas sector in Nigeria is tantamount to the Nigerian regulatory regime for the oil sector. The 1969 Act vests ownership and control of all petroleum in the federal government. Such centralisation of resources was implemented under authoritarian military rule, at the end of the 1967-1970 civil war. Under the Petroleum Act, the granting of licenses and the allocation of acreage are at the sole discretion of the Minister of Petroleum Resources, supposedly with the approval of the President. The government reserves the right to participate in any block's operations and to determine the contractual relationship between the licensee/lessee and itself. As for gas production, the law concerning the transmission of gas is also mainly framed around oil transportation rather than that of gas: The Oil Pipelines Act 1956, amended in 1965, governs the licensing and permitting process for the construction and operation of oil (and gas) pipelines. Licenses are not issued to companies, but to specific pipelines. The Ministry of Petroleum Resources has discretion to determine the terms and conditions of pipeline access and the corresponding charge.

Since 1985, the Ministry of Petroleum Resources has been responsible for the government's formulation and coordination of policy on petroleum matters, except for a brief interruption in 2007[12]. A division of the Ministry, the Department of Petroleum Resources (DPR) has been appointed to be the *de jure* regulator, ensuring compliance with petroleum laws/regulations and processing applications for licenses and leases. However, concession and licenses of oil blocks were granted through an arbitrary exercise of discretion throughout the 1970s-1990s, during which the ruling military regimes bought political support through the award of oil blocks and other oil sector rights (Amaduobogha, 2015; Gboyega et al., 2011). Since the 2000s, the civilian government has shown a greater commitment to allocate concessions and licenses based on open competitive bidding rounds, but preferential treatment of some companies has still been observed[13].

The Nigerian National Petroleum Corporation (NNPC) is a holding company with twelve subsidiaries, one of which is the National Petroleum Investment Management Services which managed the federal government's investment interest in joint ventures (Nwokeji, 2007). Another NNPC subsidiary is the Nigerian Gas Company (NGC), tasked with investing in gas transmission and distribution pipelines and contracting with potential customers. The NNPC is also responsible for marketing the crude oil that the government is entitled to through its contracts with the IOCs, then transferring revenues to the government.

Despite the current formal separation of power between DPR and NNPC, DPR is allegedly treated like another arm of the NNPC rather than its regulator, subject to directives from the national oil company, the Ministry, and the presidency. This suggests regulatory capture has taken hold. DPR also suffers from staff shortage – qualified candidates are offered better employment packages by NNPC – and a lack of resources (records were kept manually as late as 2006) (Nwokeji, 2007). On the other hand, NNPC is neither a real commercial entity nor a meaningful oil operator, since it lacks control over its revenue and strategy (its share in joint ventures are funded directly from the federal budget). Also, it is not a government agency: its portfolio is too diverse and incoherent, putting it beyond the government's reach (Thurber et al., 2012). NNPC operations are extremely opaque. Seen by local stakeholders as "a mystery", it has not reported any annual financial data between 2005 and 2015 (Raval & Fick, 2016; Z. Usman, 2016). Nominations to positions in the Ministry of Petroleum Resources and NNPC by the president are perceived as important prizes in Nigerian politics; these highly coveted appointments are monitored to assess which ethnic/religious/regional group has gained ascendancy, as they bring access to oil revenues (Gboyega et al., 2011).

[12] The Ministry for Petroleum Resources was merged with the Ministry of Power and Steel to form the Ministry of Energy by then President Obasanjo, who doubled as the Minister of Energy, but the merger was soon dissolved.

[13] As an example, the Korean National Oil Corporation was granted the right of first refusal over two blocks in return for a 745 mile gas pipeline from the Niger Delta, a 2250 MW power station, and the construction of a rail way line (Gboyega et al., 2011). Discretionary award to Nigerian companies to promote local entrepreneurship also exists.

After the democratic transition in the early 2000s, the civilian government created committees to probe the oil and gas sectors as part of wider macroeconomic and structural reforms that were occurring under NEEDS. In 2008, the Petroleum Industry Bill (PIB), based on the findings of the committee, was introduced to the National Assembly. First and foremost, the bill is aimed at increasing government revenue from the petroleum industry and restructuring NNPC in a way that allows it to access capital markets. The legislation, though, is also a response to the militancy in the Niger Delta for resource control[14]. After several redrafts and an extensive amendment by government officials, the original PIB 2008, very varied in scope, attracted opposition from a wide range of interests and failed to pass during the 6th National Assembly. The PIB 2012 suffered a similar fate. It failed to be passed before the 2015 elections. In April 2016, answering calls to enact the stalled PIB in a piecemeal way, the Petroleum Industry Governance Bill was submitted to the legislature, focusing on the regulatory regime for the petroleum industry. It was drafted by the National Assembly, which became unsatisfied with the delay of the Executive in transmitting the bill. However, senators from the Niger Delta stalled the passing of the bill. They were displeased that the provision of Petroleum Host Community Funds was not mentioned in the new bill, which they saw as necessary to ending the resurgence of militancy in the region. In addition, the Executive saw this as an attempt to undermine the presidency, and in turn stalled the Senate's effort (Ogunmade & Okafor, 2016). Instead, the State Minister of Petroleum Resources announced that the Presidency will present three harmonised bills based on the PIB 2012 to the National Assembly at an unannounced date (Nwachukwu, 2016).

Despite the standstill with the PIB since 2008, Buhari's election brought a major shakeup within the NNPC. The entire NNPC board was fired by the President in June 2015, and the company's executive directors were dismissed in August (Platts, 2015). In March 2016, the new Group Managing Director Emmanuel Kachikwu ordered a major restructuring of the NNPC into seven units, which are more reflective of a business orientation (T. Usman, 2016). A new Managing Director was appointed in July 2016, while Kachikwu remains in the post of State Minister for Petroleum Resources and Chairman of Board[15] (Okafor, 2016a).

The government is aware of the weakness of the existing regulatory framework when it comes to the development of natural gas. A plethora of policies, plans, and frameworks (The National Oil and Gas Policy 2004, the Natural Gas Master Plan 2008, the National Domestic Gas Supply and Pricing Policy 2008, etc.) were devised under the Obasanjo administration. They all recognised the need to have a set of regulations in place to specifically address the downstream gas sector (beyond gas production), and proposed plans to set up a regulator to control and monitor gas pricing to spur the development of the domestic gas market. However, attempts to pass the legislation (the Downstream Gas Bill 2005, less extensive in scope than the PIB) failed and the initiatives were later absorbed in to the PIB 2008 and PIB 2012 (Oyewunmi, 2014). In the absence of new legislation, the Gas Aggregation Company Nigeria was incorporated in 2010 to act as the intermediary between gas buyers (power generators, large customers, and gas distribution companies) and gas producers, facilitating the negotiation of Gas Sales & Aggregation Agreement and transfer payments from the buyer to suppliers via escrow accounts that it manages (Gas Aggregation Company Nigeria Limited, n.d.).

3.3.1.2 Gas flaring

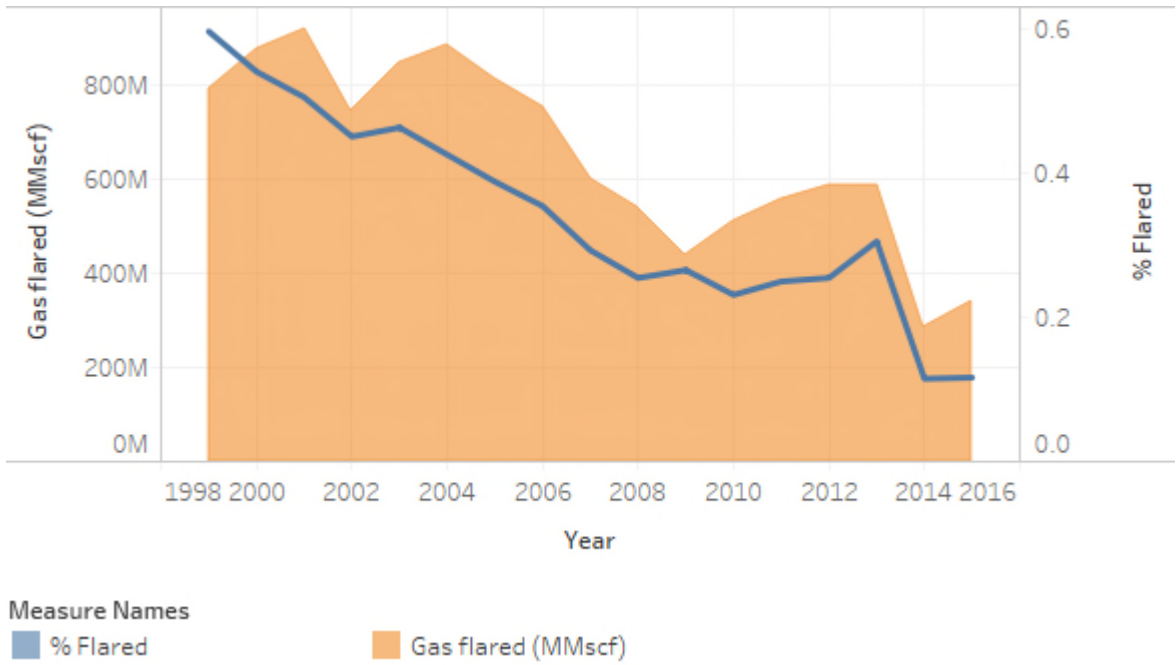
Since the start of commercial oil production in Nigeria, oil companies have flared the gas associated with oil production in the Niger Delta, which they consider to be the cheapest method for removing the gas, given there is no infrastructure to deliver it to the Nigerian domestic market and re-injection is not economic in most Nigerian oil fields. Multiple bills that deal with the use of natural gas associated with oil production have been passed: The Petroleum (Drilling and Production) Regulation Decree of 1969 provides that the licensee/lessee can flare gas for five years, after which a feasibility study for gas utilisation is required; The Petroleum Amendment Act of 1973 gives the federal government the right to take associated gas at the point

[14] The PIB 2012 dealt with the regulatory reform of the sector (establishment of separate upstream and downstream regulators, and separation of the Nigerian Gas Company from the NNPC through re-registration), the taxing of oil revenue (increase in overall tax rate, and incentive for on-shore production and development of marginal fields), and the allocation of oil revenue (creation of Petroleum Host Community Funds which direct 10% of revenues to host communities) (Oyewunmi, 2014; Pérouse de Montclos, 2014).

[15] President Buhari heads the Ministry of Petroleum Resources as Minister.

of flaring without cost, with the intention of ensuring that it was used instead of flared, in doing so removing companies' rights over the gas (Davison et al., 1988); The Associated Gas Re-Injection Decree of 1979 attempted to ban flaring from 1984 unless permission is granted by the Minister of Petroleum Resources (Amaduobogha, 2015). The target to stop gas flaring then moved to 2008, and 2011. In the early years of the ban on flaring, these laws have had limited effect on flaring in absence of infrastructure to capture associated gas for alternative uses. Since the return to civilian rule in 1999, as gathering networks and gas transmission networks have expanded, the amount of gas flared per year has dropped by more than half (from 800 Bscf to less than 400 Bscf) (Figure 19). The percentage of gas flared has declined from 60% in 1999 to 12% in 2015.

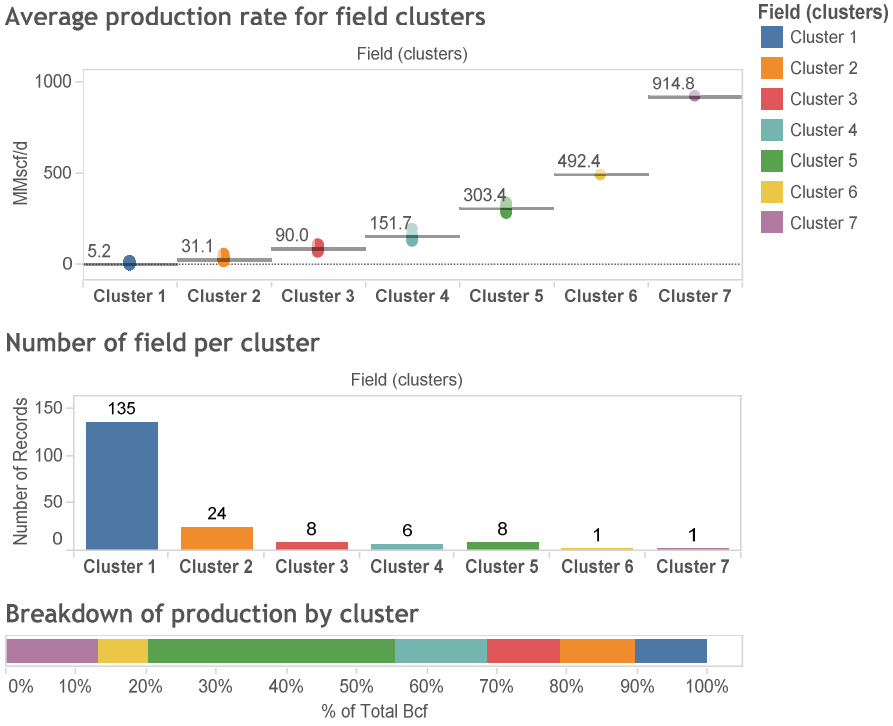
Figure 19: Absolute and relative gas flaring in Nigeria



Source: Data from NNPC annual statistical bulletin

To better understand patterns of gas production and flaring, the gas fields active in Nigeria are clustered using the k-means method per their annual production (Figure 20). Of the 183 gas producing fields, 135 produce at an average rate of less than 20 MMscf/d, accounting for 10 % of overall production. The remaining 48 fields produce 90% of all gas, with the top 10 producing fields making up 55% of overall production. Of the four types of (oil and) gas operations in Nigeria, Joint Ventures and Production Sharing Contracts dominate gas production; sold risks/independents and marginal field operations only produce the smallest fields (those of cluster 1). As for the use of gas produced from different clusters of fields, monetisation of gas – selling the gas to off-takers, instead of flaring and self-use – is less prevalent for the fields with the smallest gas production (about 20% of gas produced in cluster 1). For the other fields, the fraction of gas that is monetised range from 50-90% (Figure 21). The biggest producing fields, cluster 6 and 7, operated by Joint Ventures have dedicated use. The most important customers for gas are the LNG liquefaction plant, the Nigerian gas company (NGC), or the Eleme Petrochemicals Company Limited (EPCL). The greatest source of gas flaring is from cluster 1, small fields operated by Joint Ventures, with annual production 0.2 to 4 Bcf, for which gas is a byproduct of oil production (Figure 22).

Figure 20: Clustered view of gas fields

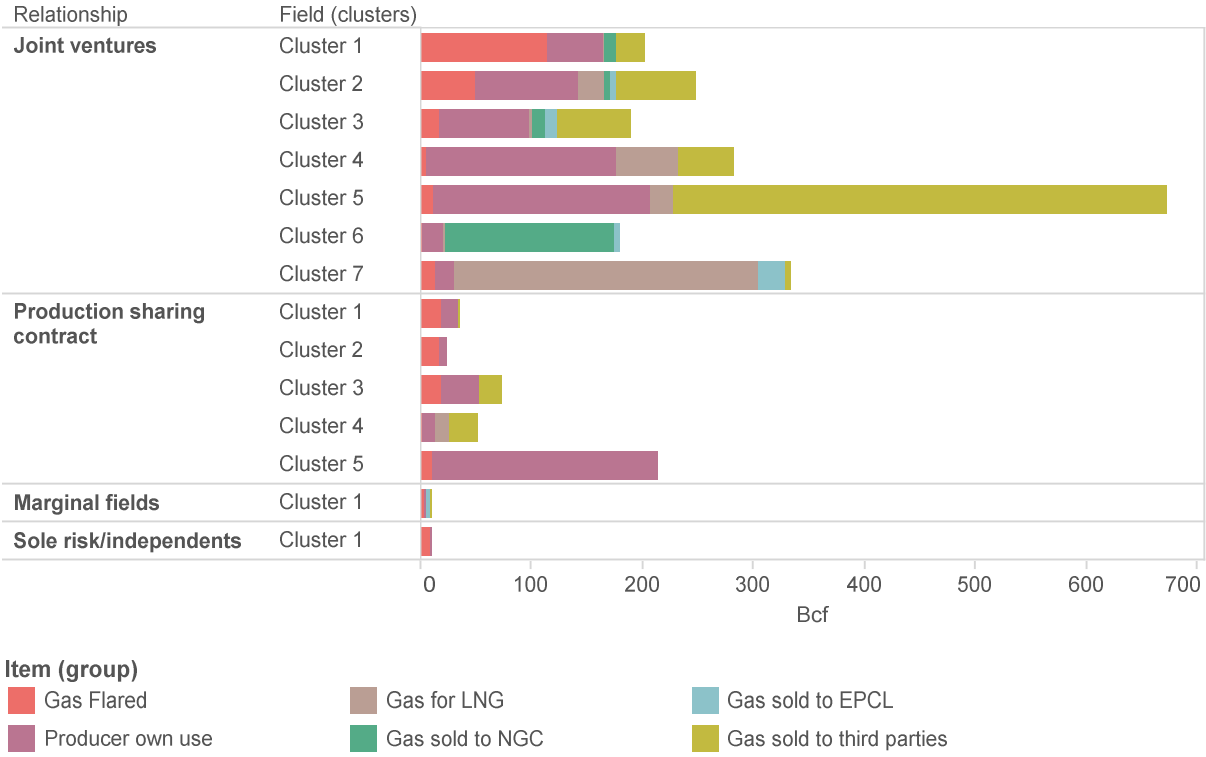


Source: Based on data from NNPC 2014 annual statistical bulletin

Figure 21: Gas use and operatorship for different gas field clusters

Source: Based on data from NNPC

Figure 22: Volume of gas use by operator and field cluster



Source: (Based on data from NNPC

3.3.1.3 Infrastructure sabotage

The relative peace bought by the 2009 amnesty programme was disrupted in February 2016, by attacks claimed by the militant group Niger Delta Avengers (NDA). The militants blamed Buhari for his "mentality of oppression and subjugation", declaring that the Niger Delta shall no longer sacrifice for the peace of Nigeria (Niger Delta Avengers, 2016b). Shortly before this, in December 2015, Buhari announced that he would reduce the budget allocated to the militant amnesty program from N63 billion to N20 billion. This prompted some to argue that the NDA is made of former militants hoping to keep up amnesty payments (Searcey, 2016). In March 2016, a pre-existing shortage of gas to thermal power generation plants, aggravated by vandalism of pipelines, led to a complete collapse of the national power grid (Alike & Okafor, 2016). Nigeria's oil output, typically at 2.2 million barrel per day, was also reduced to less than 1.3 million. Buhari announced in May 2016 that he was willing to "re-engineer" the amnesty programme to address the issues that affect the Niger Delta communities in a sustainable way (Bakare, 2016). However, attacks on infrastructure persisted until August, when the militants announced a ceasefire, as long as the government stops "harassment of innocent civilians"; as the alleged intimidations and blackmails of Niger Deltans by security forces were not stopped, hostilities resumed once more in late September (Niger Delta Avengers, 2016a). The August attacks forced operators of Nigeria's LNG export terminal to declare force majeure on supplies (Burkhardt & Bala-Gbogbo, 2016). After an attack in October 2016, the Niger Delta Avengers warned international oil companies not to carry out repairs on damaged infrastructure while negotiation/dialogue is pending (Owolabi, 2016).

On November 1st, a unified Niger Delta front, the Pan-Niger Delta Forum, met with President Buhari, and submitted 16 conditions which the federal government must meet for peace to be possible; they range from providing genuine employment opportunities for ex-militants following the amnesty programme, to decreasing the military's presence in the Niger Delta, to increased involvement of the local communities in oil and gas production and development decisions (Soniyi, 2016). Altogether, the 16 conditions reflect the Niger Delta's desire to experience social and economic development that is commensurate with its perceived contribution to Nigeria, a desire which has been continuously stifled by ineffective development/integration initiatives and an antagonistic relationship with the federal government. President Buhari is aware that even

a successful negotiation with the Pan-Niger Delta Forum might not guarantee peace, as there is fragmentation of interests among militant groups, which interferes with collective coordination (Vanguard, 2016b). Nevertheless, the purpose of the meeting was presented as "to remove the trust deficit" between the different parties, given an absence of dialogue between the many Niger Delta stakeholders and the Presidency, and the federal government has emphasised the intention to look for fundamental solutions rather than quick wins (Amaize, 2016).

3.3.1.4 Power sector regulatory regime and reform

The Electric Power Sector Reform Act (EPSRA) was enacted in 2005. The government intends to place the power industry primarily under private ownership and control, complementing and ultimately reducing the use of public funds. The ESPRA established the independent sector regulator, the Nigerian Electricity Regulatory Commission (NERC), responsible for the monitoring and regulation of the sector, issuing licenses to market participants, and ensuring compliance with sector regulation and codes. Although private participation in the generation segment was already allowed under the Electricity (Amendment) Decree 1988, through IPPs, the ESPRA provides the statutory basis for the phased, more extensive privatisation and liberalisation of the power sector (Eberhard, Gratwick, Morella, & Antmann, 2016).

Electricity, under the Nigerian constitution, falls on the concurrent legislative list, meaning that legislative power is shared by the federal government and the regional governments, with the legislation of the former superseding that of the latter. Policy making for the power sector issues has historically been undertaken by ministries overseeing multiple sectors: Ministry of Power and Mines, Ministry of Mines, Power and Steel, Ministry of Power and Steel, and since 2015, the Ministry of Power, Housing and Works[16]. Under the ESPRA, the Minister of Power may issue general policy directions to NERC, which the Commission shall take into consideration if they do not conflict with the law. NERC is responsible for the monitoring and regulation of the power sector, the issuing of licenses, and the safeguarding of compliance with market rules and operating guidelines that it establishes. It is also responsible for setting electricity tariffs.

Funded by the UK's Department for International Development (DfID) through the Nigeria Infrastructure Advisory Facility (NIAF), a private consultancy (Adam Smith International) has been providing technical assistance to Nigerian power sector stakeholders since 2007, over the areas of privatisation, market reform, and service delivery. The influence that NIAF has over the Nigerian power sector is far-reaching; projects completed range from supporting NERC for the development of interim market rules, tariff revisions, and the establishment of a key performance indicator framework for market monitoring, to providing training for the transmission and distribution network operators (Nigeria Infrastructure Advisory Facility, 2017).

The federal government announced its plans for the evolution of the sector through roadmaps, first published in 2010, revised in 2013, and followed by a new plan in 2016. The 2010 roadmap sets forth reform goals in three areas: removing obstacles to private investment, clarifying the government's strategy for privatisation, and reforming the gas industry in a complementary way. It also sets specific targets for the improvement of service delivery, for which the government is accountable during the transition period, in gas supply, generation, transmission, and distribution infrastructure capacity (The Presidency of Federal Republic of Nigeria, 2010). Progress has been made relative to privatisation and commercialisation (establishment of NBET, publication of revised tariff by the regulator, and privatisation of PHCN). In 2013, a revised roadmap was published to address cases of slipped projections, recommitting various project owners to undelivered milestones. It mentions delays in procurement, in appointing key regulatory/public company staff and protracted labour negotiations, land disputes, and incomplete budget execution as the causes of slippage (The Presidency of Federal Republic of Nigeria, 2013). In May 2016, the current Minister of Power, Works and Housing announced a new roadmap for changes in the power sector. It is significantly different from the previous roadmaps: instead of focusing on the reform/privatisation process, the Minister emphasises solutions such as rehabilitation of existing capacity, completion of delayed projects, alignment of commercial interest, and diversification of the fuel mix to achieve incremental power, eventually overcoming the supply-

[16] As a previous footnote indicates, the Ministry of Petroleum Resources and that of Power and Steel was temporarily fused in 2007. The Ministry of Power was in existence between 2007 and 2014. The latest round of merger was declared to be a cost-saving measure and a move toward decrease of direct government participation in the power sector (Okafor, 2016b).

demand gap to achieve steady power deployment and engaging in demand-side measures to achieve uninterrupted power (Fashola, 2016a).

3.3.1.5 Progress of public asset privatization

As part of the gradual privatisation of the sector, the state power monopoly established in the 1970s, the National Electric Power Authority (NEPA) no longer exists. The phased privatisation consists of four consecutive stages:

1) Pre-transition stage;
2) Transition stage;
3) Medium-term stage;
4) Long-term stage.

As part of the first stage, NEPA's assets and liabilities were transferred to the Power Holding Company of Nigeria (PHCN) in 2005 in unbundled form. By 2013, the appointed initial owners of successor companies, the Ministry of Finance and the Bureau of Public Enterprises, sold off the 6 generation and 11 distribution successor companies, only retaining the transmission grid as a public entity under the Transmission Company of Nigeria (TCN)[17]. TCN hosts the Operator of the Nigerian Electricity Market (ONEM), who is to act as the wholesale market and settlement operator. The Nigerian Bulk Electricity Trader (NBET) was also set up to act as the single buyer, contracting separately with generators and distributors during the transition stage via Power Purchase Agreements (PPAs) and Vesting Contracts (VCs), respectively (Ley, Gaines, & Ghatikar, 2015).

In February 2015, on the advice of NERC, the Minister of Power declared the start of the Transitional Electricity Market (TEM), signifying that coordination between market participants is now wholly contract based rather than based on administrative choices (Kukoyi, 2015). NERC market rules set out the evolutionary path of the market for the forthcoming mid-term and long-term stages: for the medium-term stage, instead of contracting with the single buyer NBET, distributors may enter into bilateral contracts with generators, the wholesale market would be open to new entrants in competitive segments, and there will be a daily balancing market; for the long-term stage, consumers will be allowed to choose their suppliers and there will be separation between supply (retail) and distribution (KPMG, 2013).

Parallel to the privatisation of PHCN successor companies is the development of several government-funded power plants under the National Integrated Power Project (NIPP), conceived as a fast-tracking initiative to add new generation capacity, transmission, and distribution infrastructure on a large scale in the oil producing states. In 2005, the Niger Delta Power Holding Company (NDPHC) was incorporated to serve as the legal vehicle, holding and managing the NIPP's assets. In 2007, a change in administration at the federal level brought the funding arrangements for NIPP under scrutiny, resulting in an interruption in funding of two years. The NIPP projects are is funded by the Excess Crude Account. The Excess Crude Account is where part of oil revenues is deposited when the price of crude oil is above a set benchmark price. The portion saved is the "excess" over the benchmark price, while the remaining portion is allocated to the federal, states, and local government authorities. Therefore, the NIPP assets are owned by all three tiers of government proportionate to their respective shares of the Excess Crude Account (Oni, 2013). Upon completion, the plants were supposed to be privatised, and the returns from privatisation would be paid back into the Excess Crude Account. The privatisation of these newly built plants began in 2013, even though not all 10 planned plants have been commissioned. The sale of 80% of the government's stake in the plants yielded $5 billion, while the plants had reportedly cost the government over $8 billion (Ali, 2016). In June 2016, all executive directors of the NDPHC were ordered by the federal government to handover affairs to the newly appointed Managing Director and the most senior officers in their respective departments (Vanguard, 2016a).

3.3.1.6 Performance targets for privatised entities

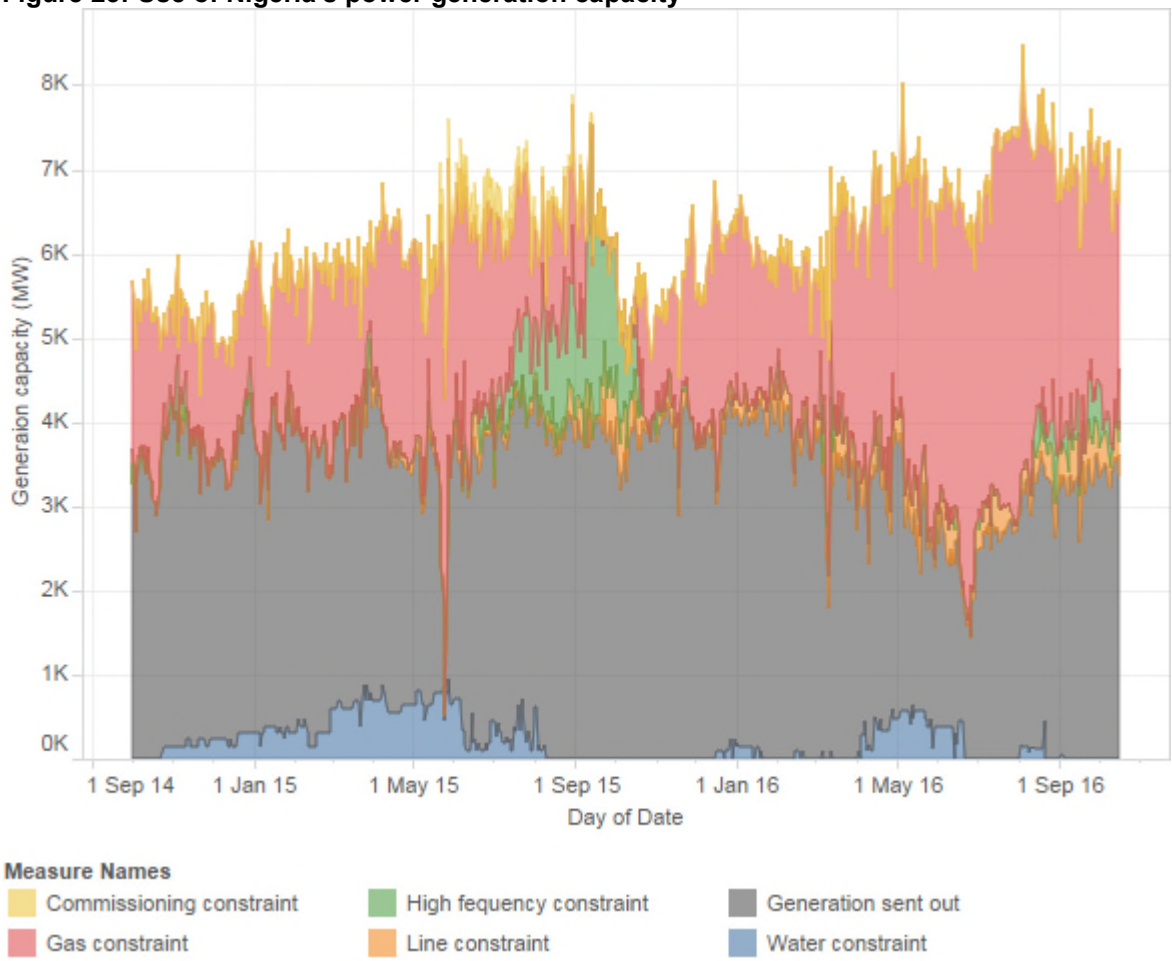
Privatisation of GENCOs and DISCOs was tied to performance targets, contained in various performance agreements signed by the private investors and the Bureau of Public Enterprise. While GENCOs' investors were required to improve the available capacity of the generation asset that they acquire, DISCOs' investors

[17] The three hydro power plants were placed under concession and not privatised.

were required to reduce Aggregate Technical, Commercial, and Collection (ATC&C) losses as well as increase customer connections.

On the generation side, overall generation capacity has been gradually climbing from about 5000 MW in late 2014 to more than 7000 MW by late 2016. However, actual generation is severely constrained by upstream gas supply, which is beyond the control of GENCOs: roughly 2000 MW of available generation capacity was constrained by a lack of gas supply before, which increased 4000 MW by summer 2016 (Figure 23). To a smaller extent, generation capacity is also constrained by water non-availability at hydro power stations and grid constraints (line capacity and frequency stability).

Figure 23: Use of Nigeria's power generation capacity



Source: Data from NESISTATS

Comparing the estimates made by NERC in its 2012 Multi-year Tariff Order and the 2015 figures supplied by the federal government, losses (especially collection losses) have gone up since privatisation in 2013 (See Table 5). It could be argued that the baseline loss level assumed by NERC, based on which loss reduction trajectories were set, is lower than the actual loss level for some DISCOs. However, it should also be noted that, compared to generation data, which is publicly disseminated, the absence of reliable and timely data on actual loss levels continues to undermine efforts in loss reduction and independent evaluation and monitoring of such efforts.

Table 5: Comparison of ATC&C losses in Nigeria

Type	2012 (pre-validated estimate)	2015
Technical (transmission)	8.05%	7.4%
Technical (distribution)	10%	12.5%
Commercial	12%	6.9%
Collection	6%	36.5%
Total	36.05%	63.3%

Source: Data from NERC, 2012; Yemi Osinbajo, 2015

3.3.1.7 Attraction of private generation investment

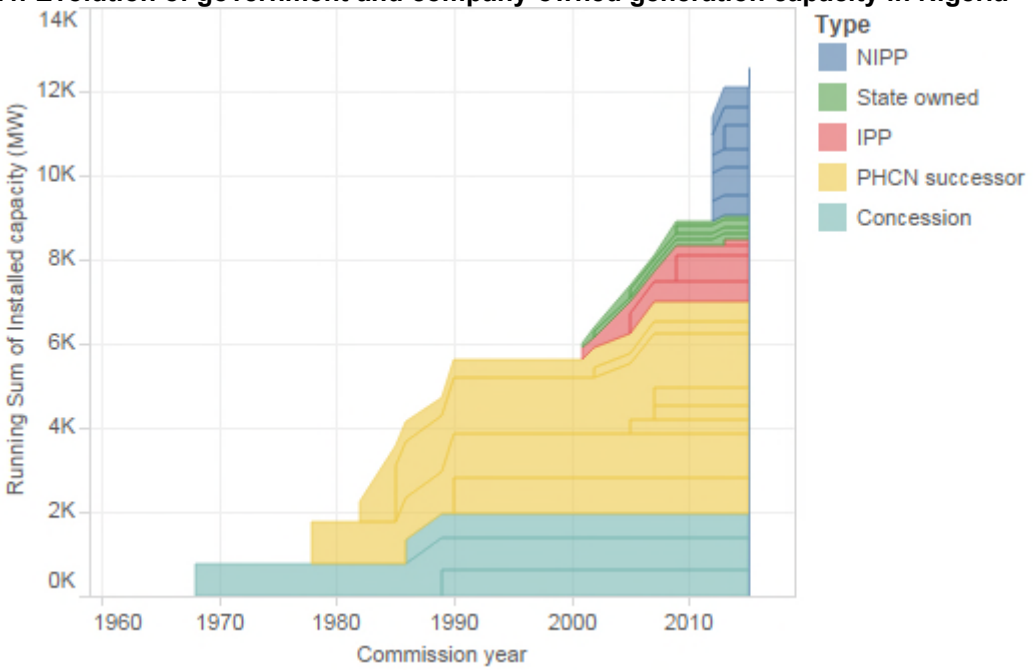
Power generation infrastructure ownership in Nigeria is divided between dedicated private generation companies, the government, and private individuals/organisations[18]. It is relatively easier to keep track of the company-owned and government-owned generation assets that deliver power to the transmission grid, since they are larger in capacity (100 MW +) and fewer in number compared to the self-owned oil-fired generators (1-10 MW). But, self-owned non-documented generation, also known as captive generation, is non-negligible. A recent study estimated that as much as 800 to 1400 MW of decentralised diesel generator capacity was installed in the country by 2015, which was about 10% of installed on-grid generation capacity (Ley et al., 2015).

Figure 24 illustrates the growth in centralised generation capacity since the 1970s. It shows that the expansion of generation capacity in Nigeria can be divided into three phases: from 1970 up to 2000, between which the monopoly was responsible for all investment (with periods of complete stagnation in the 1970s and 1990s); 2000 to 2011, during which privately-owned independent power producers and state government units added to the mix; and from 2012 to present, during which the main source of growth comes from the completion of the publicly-financed National Integrated Power Plan (NIPP) power plants.

Although power generation in Nigeria has been open to private investment for the past 15 years, only a few greenfield generation projects backed by private developers have been realised. Of the four existing IPPs (AES, Okpai, Afam VI, and Aba integrated power project), two have been developed by Nigerian Agip Oil Company – a subsidiary of Eni – and Shell (Okpai and Afam VI, respectively), due to generous tax incentives that allow them to offset these costs under their oil and gas joint venture with the government. Three other similar plants were proposed but never built by the proposed sponsors (Chevron, ExxonMobil, and Total). AES was developed by Enron, before reform legislation and regulation were put in place, and the original Power Purchase Agreement (PPA) was skewed in favour of the private developer, triggering public objections. As for the Aba integrated power project, it was championed by a local company – Geometric Power, whose head served as Minister of Power – and included distribution of power as well as generation to industrial customers in the city of Aba. In other words, it does not recover its cost through a PPA with the single-buyer NBET; instead, it directly collects revenue from customers that it serves. For this specific reason, the Aba project entered a dispute with the distribution company serving the area over which company is entitled to these customers (note that retail competition is not yet in place) (Eberhard et al., 2016). The latest IPP, Azura, which is still under construction, is the first one negotiated since 2008, though development costs are high due to its credit enhancement arrangements and the time required for procurement capacity building. The lead developer is also a major investor in Seven Energy, a private company participating in gas production, processing, and transportation. The state government in which the project is based is a minor shareholder through in-kind contribution (land and infrastructure).

[18] The latter refers to private individuals/organisations who are not engaged in the business of power generation, but nevertheless are in possession of generation equipment for their own use.

Figure 24: Evolution of government and company-owned generation capacity in Nigeria



Source: Based on Data from (Eberhard et al., 2016)

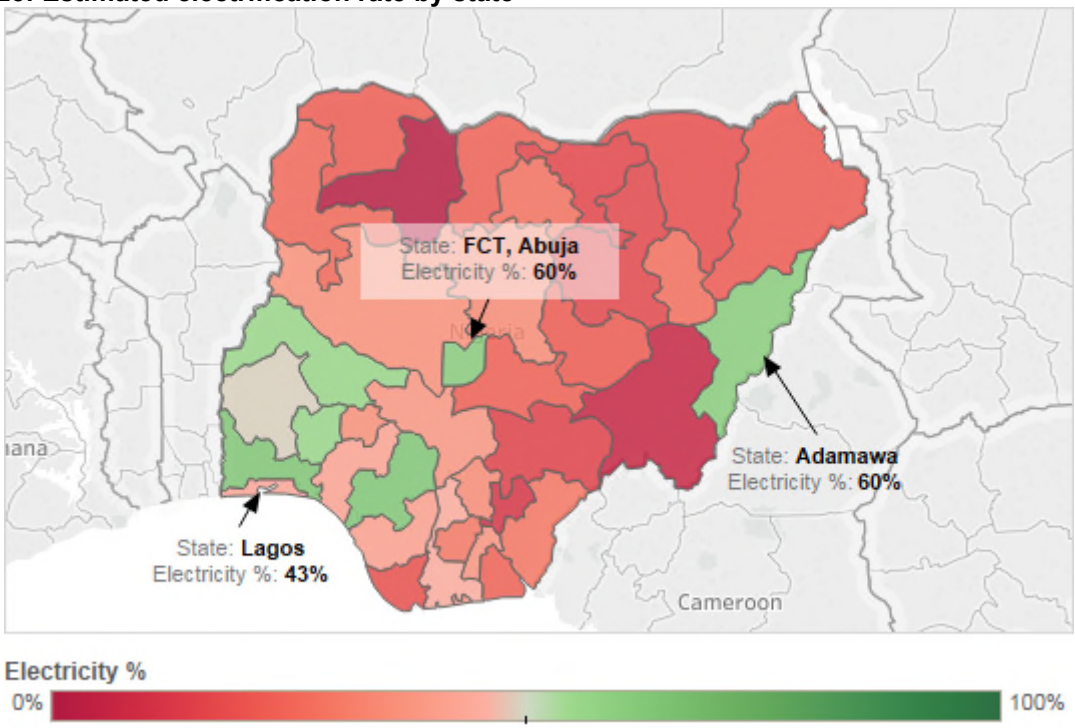
In 2012, NERC passed regulations to complement centralised generation that allow for generators which have a capacity of less than 20 MW to apply for embedded generation licenses, which allow them to evacuate power generated without being centrally dispatched (this may be called distributed generation in other power systems). However, to be able to procure embedded generation, distribution licensees, whose networks are involved in power evacuation, will need to apply for approval by NERC; also, they shall not impose charges to connect embedded generators except as approved by NERC. The tariff for the end-users are also to be negotiated between the embedded generators and the involved parties. Under the ESPR Act of 2005, NERC also grants off-grid generation licenses to a collection of off-takers within a defined area, such as an industrial park or a housing estate, via a single source (this may be called a mini-grid in other power systems) (Omoboriowo II, 2012). Of the 800 to 1400 MW captive generation capacity, about 350 MW, have obtained embedded generation or off-grid licenses with NERC, to be able to sell the surplus electricity generated to other parties. The constraint to further growth in embedded generation is believed to be the poor liquidity of distribution companies which hinders them from signing Power Purchase Agreements with embedded generators (Ley et al., 2015).

3.3.1.8 Rural electrification

Figure 25 shows the estimated electrification rate for Nigerian states[19]. The South-West area reports the highest electrification rate, on average. The Federal Capital Territory of Abuja, located in the centre, also enjoys a relatively high electrification rate. The North-Eastern state of Adamawa has a relative high electrification rate, because it is the least populated state, of which most population resides in the state capital which is electrified. Note that, despite being the area in which much of generation is located, the South-South's electrification rate lags that of the South-West. Lagos, on the other hands, suffers a relatively low rating due to it having the largest population among all Nigerian states, but it has the largest absolute number of electrified households.

[19] The electrification rate is assumed to be approximated by the percentage of population using electricity as the main lighting fuel (as opposed to natural gas, kerosene, candle, solar, or other), based on the 2006 figures reported in the Annual Abstract of Statistics 2012.

Figure 25: Estimated electrification rate by state



Source: Based on data from the Nigeria National Bureau of Statistics

From 1980s to the early 2000s, local government headquarters and important towns were connected to the power grid, but the grid was not extended to provide access to rural areas. Since 2006, The Rural Electrification Agency, established under the Electric Power Sector Reform Act of 2005, is the federal government agency mandated with mobilising resources for rural electrification. It is responsible for managing the Rural Electrification Fund, disbursing capital subsidies to expand the network in rural areas based on feasibilities studies. The Rural Electrification Fund is funded every year by the federal government through budget allocation and fines obtained by NERC. However, no continuous measurement of electrification rate is available (the latest values reported in literature dates from 2008), nor is there a specific target/implementation plan for rural electrification (Bhattacharyya, 2013).

3.3.1.9 Service provision and cost reflective tariff

NERC first exercised its right to regulate the electricity tariff in 2008, the first change in tariff since 2002, through the 2008 Multi-Year Tariff Order (MYTO), valid between July 2008 and June 2013. The 2008 MYTO sets the path of the all power sector tariffs for five years, with an annual review of the retail tariff taking place and a major review planned in 2012. Tariff levels were gradually increased during the five-year period and were intended to reach cost reflective levels by 2012. But, shifts in gas prices and exchange rates further increased costs after 2009 (Ogunleye, 2016). Also, the quantity of energy billed, the quantity based on which the tariff was determined, did not grow as projected based on aggregate technical, commercial, and collection loss reduction plans. This led the tariff to be reviewed earlier than scheduled: the second MYTO was issued for July 2012 to June 2017. MYTO 2012 specified wholesale generation prices that are differentiated by fuel used (gas, coal, hydro, wind, solar, biomass), and the nature of asset (successor, new entrant). More importantly, the revenue retail tariff was determined separately for the 11 distribution companies, based on their revenue requirement; in other words, cross-subsidisation between regions was no longer held as a rate-making principle, each distribution region is charged based on its incurred cost instead.

Since 2015, every change of the electricity tariff has encountered opposition from either DISCOs or end-user representatives. In January 2015, the 2012 MYTO was reviewed and increased upward 40-50% for

various classes of customers, to reflect a change in the regulated cost of gas, directly passed through to power customers[20]. In April 2015, considering the petitions of industrial and commercial consumer groups, NERC amended its January increase, lowering tariffs to levels that are 20-30% above the 2012 MYTO levels, by disallowing the pass-on of collection losses (non-payment of bills) on to customers. It also placed emphasis on the gradual reduction of network and commercial losses passed on to customers. This time, distribution companies argued that tariffs became artificially depressed and threatened to declare force majeure. The latest tariff review, effective since February 2016, was signed in December 2015. It removed fixed charges in the retail tariff, making distributor revenue based only on the energy charges. The tariff increase was another 40-50% increase from the tariffs approved in April of the same year. The most recent increase attracted opposition from the Senate and was challenged in Federal High Court by a human rights lawyer on the basis that there was no commensurate increase in power supply. NERC has been ordered to rescind the 2015 MYTO, as the Federal High Court declared it to be illegal; the court order is in turn being resisted by NERC (Udo, 2016).

3.3.2 Bangladesh

Since the late 1980s, Bangladesh has been gradually unbundling the state-owned monopolies which controlled its gas and power sectors, under the influence of its development partners. However, there was no large-scale privatisation of these public assets. Today, the state still retains control over most major entities active in the power and gas sectors via many agencies and public corporations, which are interconnected in a vast hierarchy. At the apex of this hierarchy is the Ministry of Power, Energy, and Mineral Resources, currently headed by the Prime Minister Hasina. The Ministry is divided into two divisions: The Power Division and the Energy and Mineral Resources Division, responsible for managing all matters and policies related to the power sector and those relating to liquid petroleum, natural gas, and mineral resources, respectively. An agency within the Power Division, the Power Cell, is responsible for enacting the reform programme for the power sector.

3.3.2.1 Gas sector regulatory regime and reform

The principal legislation for natural gas activities is the Bangladesh Petroleum Act of 1974 and the Gas Act of 2010. The first legislation provides for the exploration and production of natural gas, while the latter provides for the transmission, distribution, marketing, supply, and storage of natural gas and liquid hydrocarbons.

The Petroleum Act 1974 places the exclusive right to explore, develop, and process petroleum in the hands of the government. Other parties may carry out petroleum operations after entering into a production sharing contract with the government. The Bangladesh Oil, Gas and Mineral Corporation (Petrobangla for short), established in 1974, acts as the signing agent on behalf of the government. Petrobangla is active in all segments of the natural gas supply chain, from exploration and production to distribution, through its subsidiary companies.

Petrobangla's unbundled structure along functional lines can be attributed to the institutional re-organisation required by the Second Gas Development Project funded by the World Bank in the late 1980s, but it has not been implemented to the extent that was first envisaged by the bank (Sector and Thematic Evaluation Group, 2004a). Local vested interests resisted the merger of the multiple gas producing companies and the transition of transmission assets from various distribution companies to the centralised transmission company took more than 10 years. By 2004, the various Petrobangla subsidiaries were still considered to be tightly controlled by the government (Sector and Thematic Evaluation Group, 2004b).

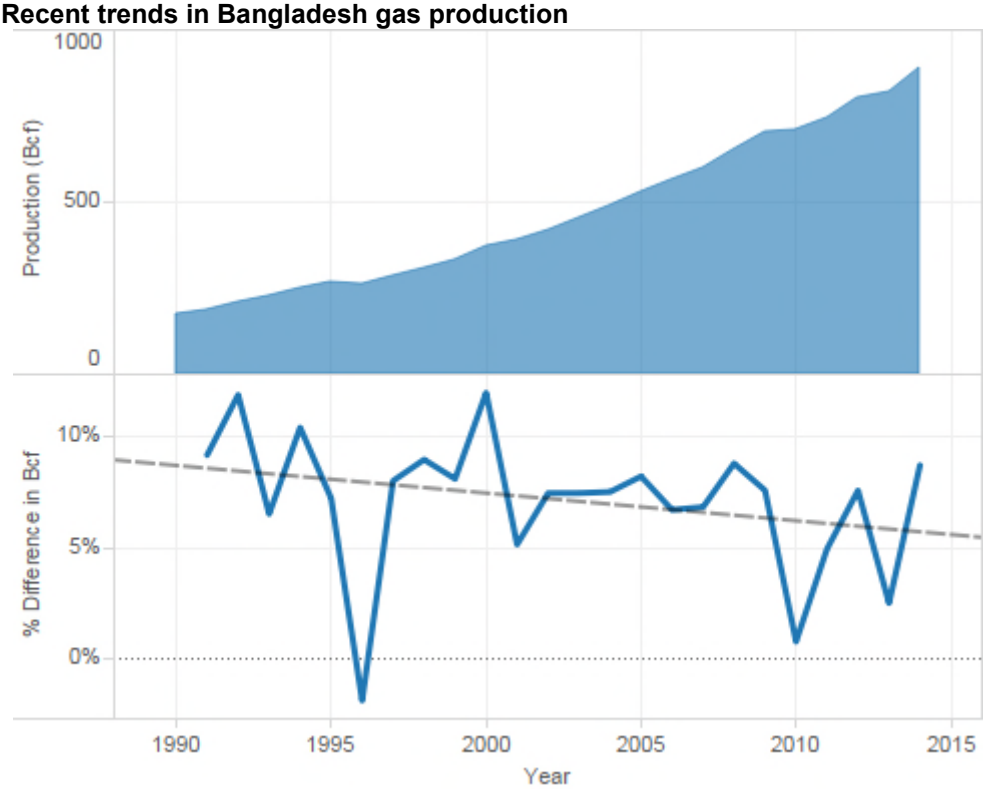
[20] The regulated price of gas for 2014 was $1.80/MMBTU. However, the Ministry of Petroleum Resources, the Ministry of Power, the Central Bank of Nigeria and NERC reached an understanding to increase the (informally regulated) price of gas to $2.50, with $0.80/MMBTU as transport charges payable to the Nigeria Gas Company, provided NGC can establish it as a prudent cost (NERC, 2015). This is an *ad hoc* form of gas price regulation, since a separate regulatory regime does not yet exist for the downstream gas sector.

The Asian Development Bank, along with other development agencies, influenced the government's development and passing of the 2010 Gas Act, with the aim to improve governance in the natural gas sector. However, it took nearly a decade for the Gas Act to pass after first being proposed in 2001 (Murshid & Wiig, 2001). According to the 2010 Act, a license granted by the Bangladesh Energy Regulatory Commission (BERC) is required for the transmission, distribution, storage, and supply of gas; for surveying and testing related to downstream gas operations; for the construction of downstream gas infrastructure; and for the establishment and operation of compressed natural gas refuelling stations and future LNG facilities.

3.3.2.2 Upstream fiscal regime

The first international bidding for hydrocarbon exploration was held in 1993. Before that, petroleum operations were carried out solely by Petrobangla. Gas production grew from 188 Bcf in 1990 to 892 Bcf by 2014, but year-on-year production growth rates have been decreasing, from around 10% in the 1990s to closer to 5% in the last five years (Figure 26).

Figure 26: Recent trends in Bangladesh gas production



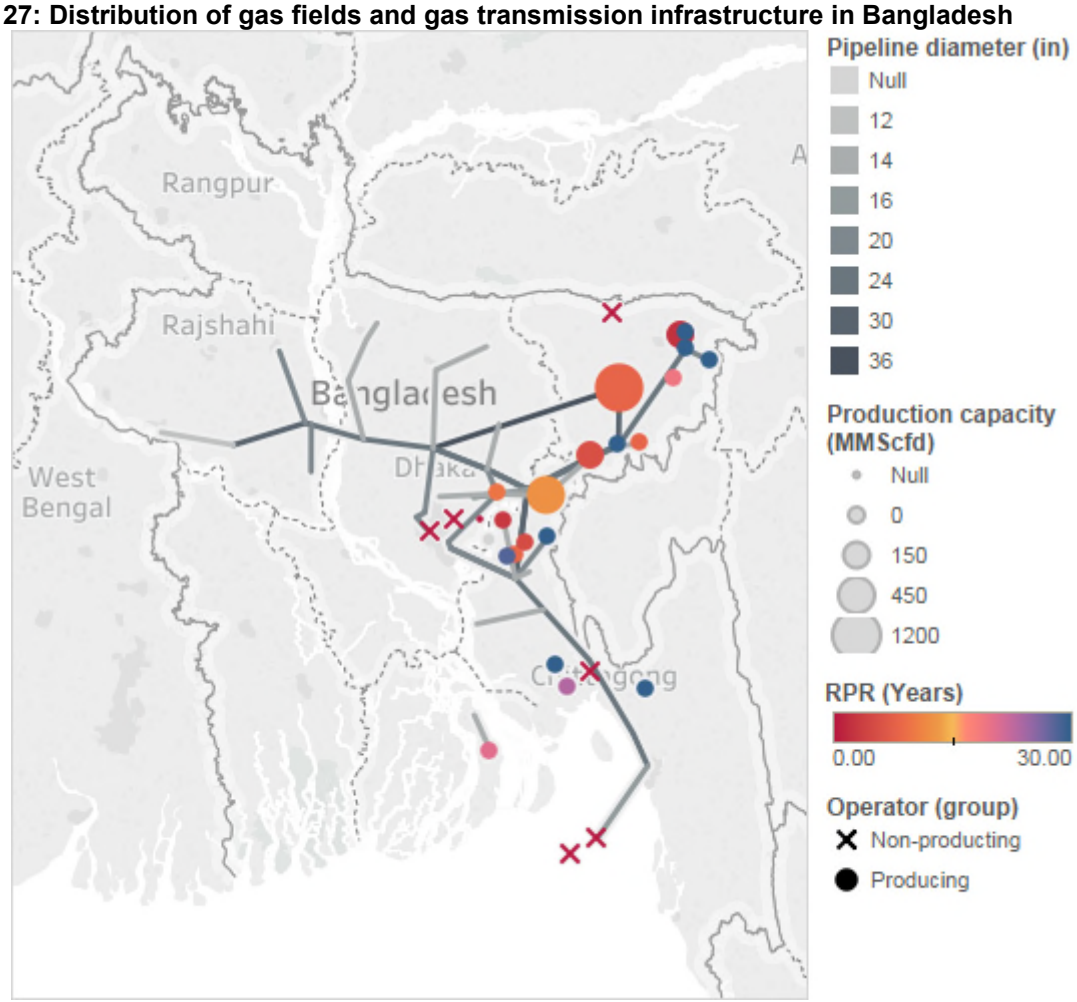
Source: Based on data from Petrobangla 2015 annual report

Most gas fields in Bangladesh are in the eastern part of the country, with a set of not-yet fully exploited or suspended fields (including the two off-shore ones) located in the Chittagong division, covering the south-easternmost areas of the country (Figure 27). Many of the big producing fields deeply embedded in the transmission network have a reserves to production ratio of less than 15 years, while those located on the periphery, possibly connected of late, have relatively higher reserves to production ratios.

In the most recent licensing rounds, during which off-shore oil and gas blocks were offered for bids, Petrobangla encountered lukewarm responses from IOCs. Two reasons are cited for the lack of interest: first of all, border disputes with India and Myanmar arose during 2008, which prevented the disputed blocks from being offered; secondly, the terms of the model production sharing contract (Petrobangla's right of first refusal to buy all gas production, at typically lower than international prices) also decreased investor interests (Gomes, 2013). Since 2014, international arbitration has clearly demarcated Bangladesh's offshore areas,

settling decades-old maritime-boundary disputes (FE Report, 2015). Also, Petrobangla has announced a willingness to increase wellhead price of gas produced from deep-water blocks, as well as allowing direct sales of gas to third parties (instead of selling to Petrobangla, the central gas buyer). For the latest bids, launched in 2016, no model production sharing contract has been finalised prior to launching; the government hopes that having more flexibility in the contract terms will lure more IOCs into the country (M. A. Rahman, 2016).

Figure 27: Distribution of gas fields and gas transmission infrastructure in Bangladesh



Source: Based on data from Petrobangla and GTCL

3.3.2.3 Promotion of gas use in transport

In the capital, Dhaka, air pollution increased with the rapid rise in the number of automobiles and auto-rickshaws, concomitant with rapid urbanisation. A grassroot movement emerged around the problem of air pollution and pressured the government to enact legislation to address the issue. The pressure found release through the promotion of compressed natural gas (CNG) vehicles, championed by a few private niche importing companies. Following the passing of more foundational legislation such as the Bangladesh Environment Conservation Act of 1995, the Bangladesh government partnered with the World Bank in the Air Quality Management Project, which included a ban of most polluting two stroke three-wheeler auto-rickshaws in Dhaka on January 1st, 2003 (Ullah, 2012). Most of them were replaced by four-stroke auto-rickshaws that run on CNG. Rupantarita Praktik Gas Company Limited, a subsidiary of Petrobangla responsible for the extraction and marketing of LPG, petrol, and diesel obtained by fractionating natural gas liquids, was entrusted with the responsibility of promoting the use of CNG in 1995. It has contributed to the increased use of CNG by setting up CNG refuelling stations, approving workshops qualified to convert vehicles to run on CNG, and converting government-owned vehicles. Although the sector experienced

explosive growth, the consumption of gas by the transport sector remains relatively low, at 5% of overall gas consumed (see Section 3.4.2.4 Non-power gas demand).

3.3.2.4 Power sector regulatory regime and reform

The Bangladesh Power Development Board (BPDB), a statutory body established by the Bangladesh Power Development Boards Order, is central to electricity sector planning and operation. In 1990, BPDB was split to create the Dhaka Electricity Supply Authority (DESA) at the behest of the World Bank to improve sector governance (delays in DESA start-up led to the suspended disbursement of funding for power distribution projects) (Sector and Thematic Evaluation Group, 2004b).

In 1996, the government adopted the Private Sector Power Generation Policy, based on recommendations from an inter-ministerial committee in consultation with major development partners including the Asian Development Bank (Sultana, 2016). This new policy allowed private participation in the generation segment through IPPs on a build-own-operate basis. IPPs were to sell their generation to BPDB, which acts as the single buyer for all generation. Power Cell, a new organisation, has been established within the Ministry to facilitate promotion, development, and implementation of private power generation projects as a “one window” stop. It also has the mandate to recommend power sector reform/restructuring (likely to further the goal of private participation). The policy also sets out that private power companies are exempt from the corporate income tax, import duties, and the value-added tax for 12-15 years.

In the late 1990s, new companies such as the Rural Power Company (new generation company whose shares are mainly held by several Rural Electric Societies or PBSs), the Power Grid Company of Bangladesh (PGCB, to which all transmission assets are to be transferred), and the Dhaka Electric Supply Company (DESCO, to which part of DESA’s distribution assets are to be transferred) were created, to further disaggregate decision making in the power sector (Choynowski, 2004).

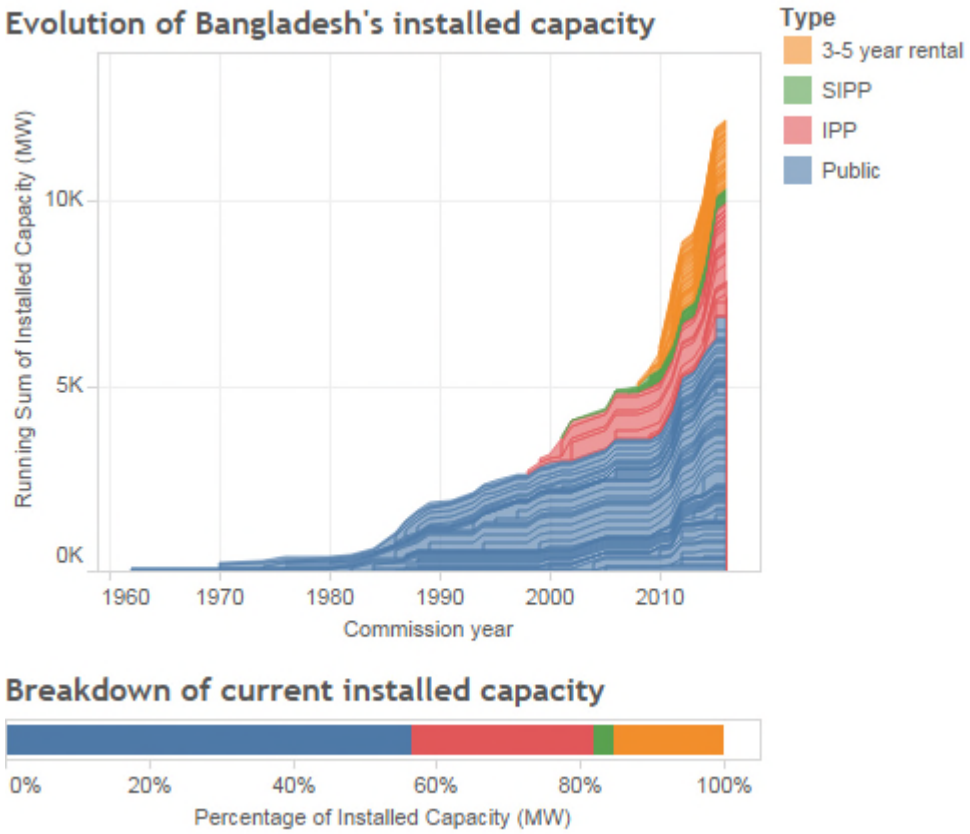
In 2004, the government enacted the Bangladesh Energy Regulatory Commission Act (known as the Electricity Reform Act during drafting), which established the corresponding statutory body (BERC), an independent energy sector regulator responsible for issuing licenses for gas and power sector activities, setting power and gas tariffs, establishing codes and standards, and acting as an arbitrator in disputes between licensees and consumers (also see The Gas Act 2010). Since then, BPDB has been unbundled into more subsidiaries. Three generation companies, one distribution company, and a new company, Dhaka Power Distribution Company (DPDC) have replaced DESA, taking over all its assets and liabilities.

During the early 2000s, development in power generation capacity did not keep pace with the rapid increase in electricity demand. Therefore, the 2007-2008 caretaker government approved the use of rental power plants to alleviate the shortage of electricity. The election manifesto of the Awami League in 2009 made electricity a central problem that it promised to address. Upon election, the government led by Hasina passed the Speedy Supply of Power and Energy (Special Provision) Act in 2010. It was meant to expedite electricity generation procurement by allowing the government to bypass the tendering process when awarding contracts for short-term rental generation projects, and includes a clause that stops any legal action against the government official in the matters of allowing controversial rental power plants and other irregularities, if applicable (Ebinger, 2011; Sultana, 2016). This has raised concerns over transparency among international observers and civil society. It is expected that once large scale long-term power generation capacity becomes available, the (mostly) oil-fired rental power plants will be retired or only kept for stand-by capacity. However, when the 3-5 year rental contracts for short-term generation expired, development of long-term generation capacity had not reached a point to be able to retire the rental units; hence, most rental contracts have been extended. The Speedy Supply of Power and Energy (Special Provision) Act, initially enacted for two years, has been extended until 2018 (Platts, 2014).

The evolution of power generation capacity in the country reflects the changes in the sector’s regulatory regime. Until the late 1990s, all power generation capacity in the country was owned by the government. Since then, three types of privately owned generation capacity have been added to the overall capacity: Independent Power Producers (IPPs), Small Independent Power Producers (SIPPs) which differ mainly by their small sizes, and short-term rental power plants with (renewable) contracts to supply power for 3-5

years[21] (Figure 28). Today, 40% of generation capacity in Bangladesh is privately owned. Beyond officially measured installed capacity, it is estimated that there is about 2000 MW of captive generation capacity, owned by private industry operators that supply their own electricity. They emerged in relative recent times, when on-grid generation capacity was no longer able to keep up with electricity demand growth.

Figure 28: Evolution of government and company-owned generation capacity in Bangladesh



Source: Based on data from BPDB

3.3.2.5 Diversification of generation fuel

The power sector policy of the Bangladesh Government is significantly influenced by its development partners. The latest Power Sector Master Plans (2010 and 2016), each taking years to finish and consisting of more than 500 pages, is drafted by a team from the Japan International Cooperation Agency (JICA) and Tokyo Electric Power Company, with consultation from local stakeholders and other development partners.

The 2010 Power Sector Master Plan identified six areas for actions and specific targets for some of them. The two most important being the diversification of fuel for power generation, while maintaining certain target for energy security: achieve supply mix of 50% coal, 25% gas, 25% oil, renewables and others by 2030, while ensuring that >50% of energy used to come from domestic coal and gas[22]. PSMP 2016, a draft document still in progress, reveals that the progress in development of domestic gas and coal resources has been much weaker than that assumed. However, it also points out that there is much advance on the front of renewables: the deployment of off-grid renewable energy has been the fastest in the world (JICA, Tokyo Electric Power Services, & Tokyo Electric Power Company, 2016). Consequently, the newest PSMP reflects

[21] The Bangladesh government also distinguishes long-term rental power plants. However, given the typical Power Purchase Agreement (PPA) awarded to IPPs are of the same length as the so-called 15 year rentals, power plants with a 15-year rental contract are classified as IPPs.

[22] Between 1995–2010, natural gas-fired generation constituted more than 80% of overall installed capacity, but the rapid rise in oil-fired generation under rental contracts since then reduced its share.

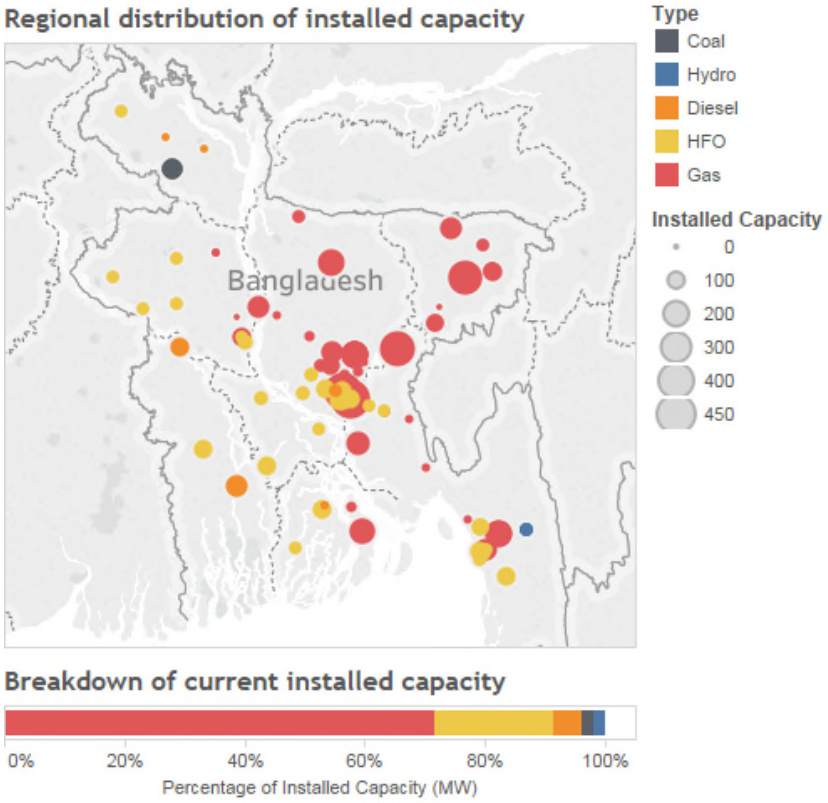
a shift in focus away from reliance on domestic fossil fuels to energy import (fossil fuels and electricity) and domestic low-carbon technology[23].

In 2012, the Sustainable and Renewable Energy Development Authority (SREDA) was established based on an eponymous act. This new agency is responsible for maintaining Bangladesh's energy security through the promotion of renewable energy and demand side energy efficiency/conservation measures. More specifically, the new authority acts as the coordinator within the government for issues related to renewable and energy efficiency and the counterparty for international and government loans, with a goal of reaching 10% renewable generation capacity by 2020. Many of the renewable energy-based technologies promoted by SREDA are distributed solar applications embedded within end-uses: solar irrigation, water heating systems, and pumps for drinking water.

Currently, the total installed generation capacity in Bangladesh consists of 72% gas-fired generation, followed by liquid fuel (25%), and very small quantities of coal and hydro (2% each). The major gas-fired power plants are in the Eastern gas-producing regions, with the areas west of the Jamuna river mainly dependent on liquid fuel (Figure 29). The only existing coal-fired power plant is located adjacent to a domestic coal mine, commissioned in 2006, and the only existing hydro power plant is in Chittagong, was the first power plant commissioned in Bangladesh in 1962.

To meet its ambitious energy security and diversification goals, the government of Bangladesh is planning a series of mega projects in power and related sectors (Table 6). Most of them are financed by foreign government long-term loans to (various branches of) the Bangladesh Government, and none of the planned power plants will be relying on domestic natural gas as fuel source. If all of them were to be realised, the newly procured generation capacity would be 8310 MW, about 70% of installed capacity in 2016 (12180 MW).

Figure 29: Regional distribution of generation capacity in Bangladesh



[23] By 2041, 70% of gas consumed in Bangladesh is expected to be imported.

Table 6: List of planned power sector mega projects in Bangladesh

Name	Type	Capacity (MW)	Sponsor	Owner	Status
Rooppur	Nuclear	2400	Russia	Bangladesh Atomic Energy Commission, operated by the newly created Nuclear Power Company of Bangladesh	Agreement signed with Russia in 2011 and approved in 2016. Construction is expected to begin in 2017 and last until 2024
Matarbari	Supercritical coal	1200	Japan	Coal Power Generation Company Bangladesh	Tender submission by January 2017
Rampal	Supercritical coal	1320	India	Joint-venture between the National Thermal Power Corporation (India) and BPDB	Construction agreement signed in 2016, but faces protest from domestic and international civil society
Payra	Ultra-supercritical coal	1320	China	Joint-venture between BPDB subsidiary NWPGL and China National Machinery Import and Export Corporation	Construction agreement signed and land acquisition is underway
Barguna / Patuakhali	Ultra-supercritical coal	1320		RPCL	Project approved and land acquisition is underway
Meghnaghat	Gas (from LNG)	750		Reliance Group (India)	Project approved

3.3.2.6 Rural electrification

In 1977, under the recommendation of the National Rural Electric Cooperative Association, the organisation representing consumer-owned, not-for-profit electricity cooperatives in the United States, the Bangladesh Government established the Rural Energy Board (REB). The Rural Energy Board is the central agency that monitors the activities of Palli Bidyut Samity (PBSs), which are Rural Electric Societies organised along the lines of American co-operatives, operating on no loss-no profit basis for the mutual benefits of all its members (Chowdhury, 2011). The REB also recommends the electricity tariff that PBSs should be charged by the BPDB. The electrification goal that the Government has set for rural electrification is 100% access by 2020. It thus recognised that a two-prong approach, combining grid extension via PBS and off-grid electrification via small solar home systems, is necessary (Chowdhury, 2011).

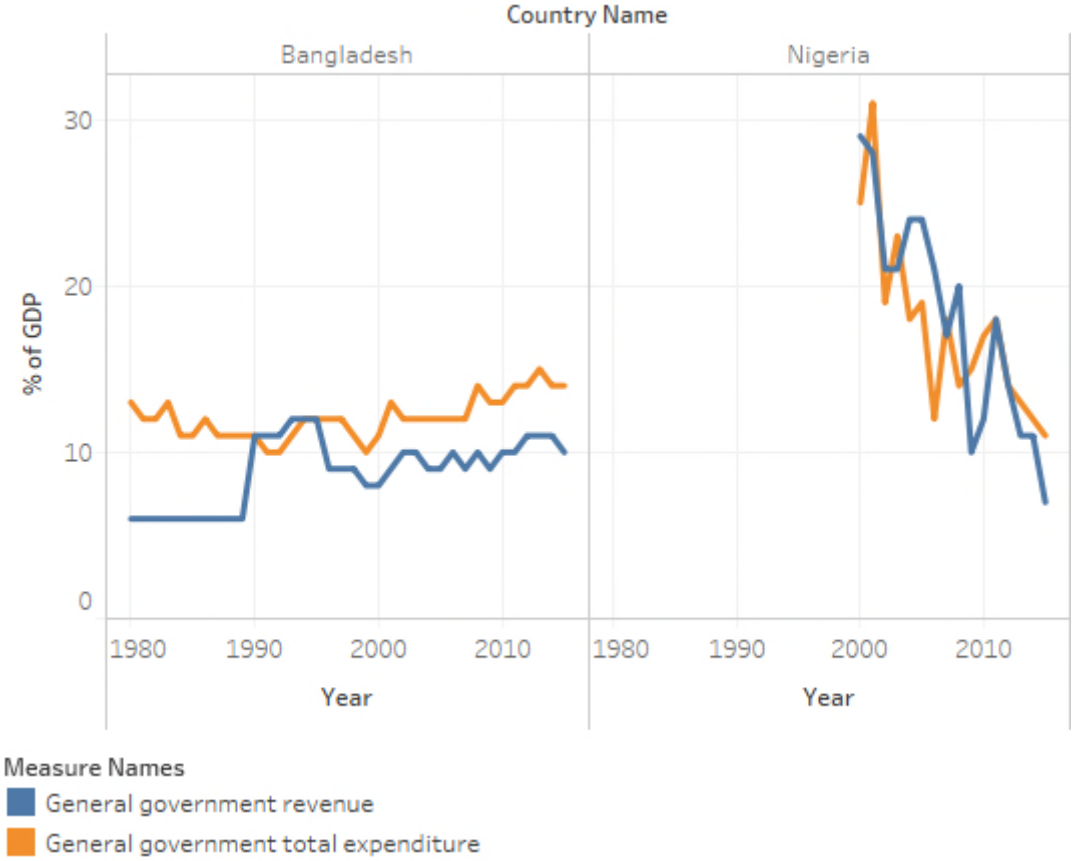
Expansion of the distribution network, the bulk of which is undertaken by the REB, is financed by soft loans from the government and development institutions with extended repayment periods and grace periods. In areas where grid extension is not feasible (economically or technically), off-grid applications such as solar home systems are installed by NGOs selected by the Infrastructure Development Company Limited (IDCOL). Grants and loans from development partners are funnelled to eligible NGOs, which provide the installation and services that end-users repay in monthly instalments (M. M. Rahman, Paatero, Poudyal, & Lahdelma, 2013). By 2015, more than 3.8 million of solar home systems with a total capacity of 125 MW have been installed, averaging 33 W each (IDCOL, 2015). However, due to the small size of individual units, they represent less than 1% of grid-connected generation and import capacity.

3.3.3 Comparison

Before directly comparing the evolution of two countries' gas-to-power supply chain in terms of scale (expansion of service provision and access being a fundamental government objective for both countries), data on the public finances of Nigeria and Bangladesh is used to situate the reach of the government in the economy, and, by extension, its ability to direct the economy. The fiscal balances of Nigeria and Bangladesh

paint very different pictures of public finances: Figure 30 shows that, since 1990, the Bangladesh government's revenue has grown in proportion to overall GDP to stay at 10% of GDP; meanwhile, the Nigerian government's revenue has not kept pace with the growth of the economy, falling from 30% of GDP to 10% in 15 years[24]. The Bangladesh government's expenditures have also grown in time; the budget deficit is consistently 2% to 4% of the country's GDP. Before 2009, Nigeria enjoyed a fiscal budget surplus, likely due to the buoyant oil prices during the early 2000s and the delinking of expenditures from revenue through the Excess Crude Account. But, in the past five years, government revenues are no longer enough to cover the expenses. As a percentage of their GDPs, Bangladesh has been receiving more official development assistance (ODA) than Nigeria (Figure 31). But, since the 1990s, the dependency on development funding has gradually declined. Nigeria, on the other hand, is experiencing a slight increase in ODA. The spike in 2005 corresponds to a significant debt relief granted by the Paris Club, with the condition of comprehensive economic reform.

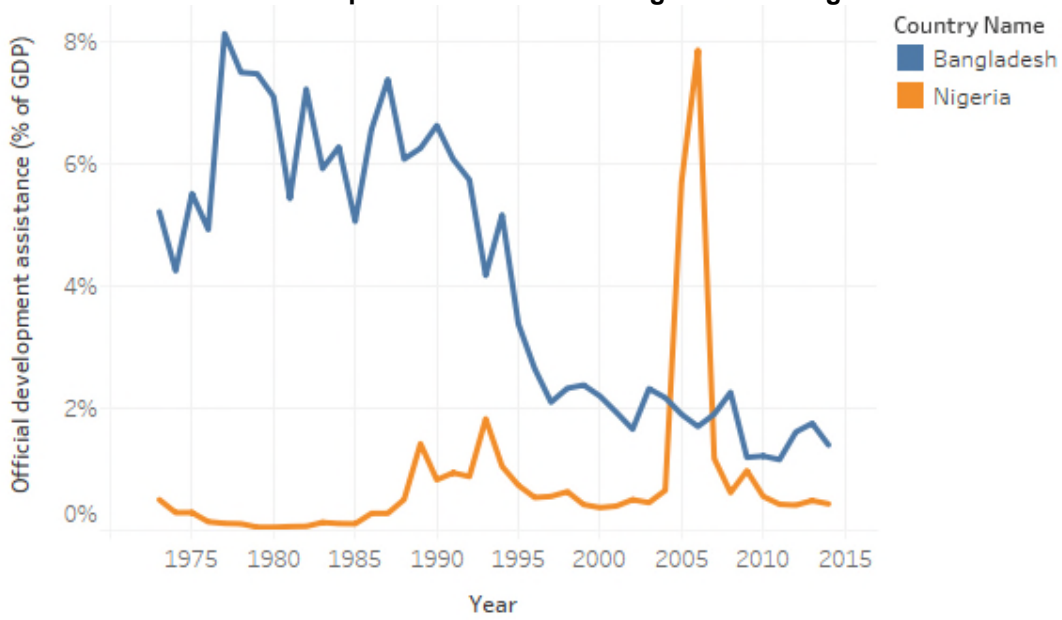
Figure 30: Trends in fiscal revenue and expenditure for Nigeria and Bangladesh



Source: Data from the IMF

[24] This fall in relative importance of government in the economy is suspected to be caused by the decreasing importance of the petroleum sector, from which the government draws most its revenue. While other sectors of the economy maintained growth from 2010 to 2014, oil revenue fell despite high global oil prices due to oil theft, revenue withholding by NNPC, and an increase in suboptimal oil sales arrangements (Sayne et al., 2015).

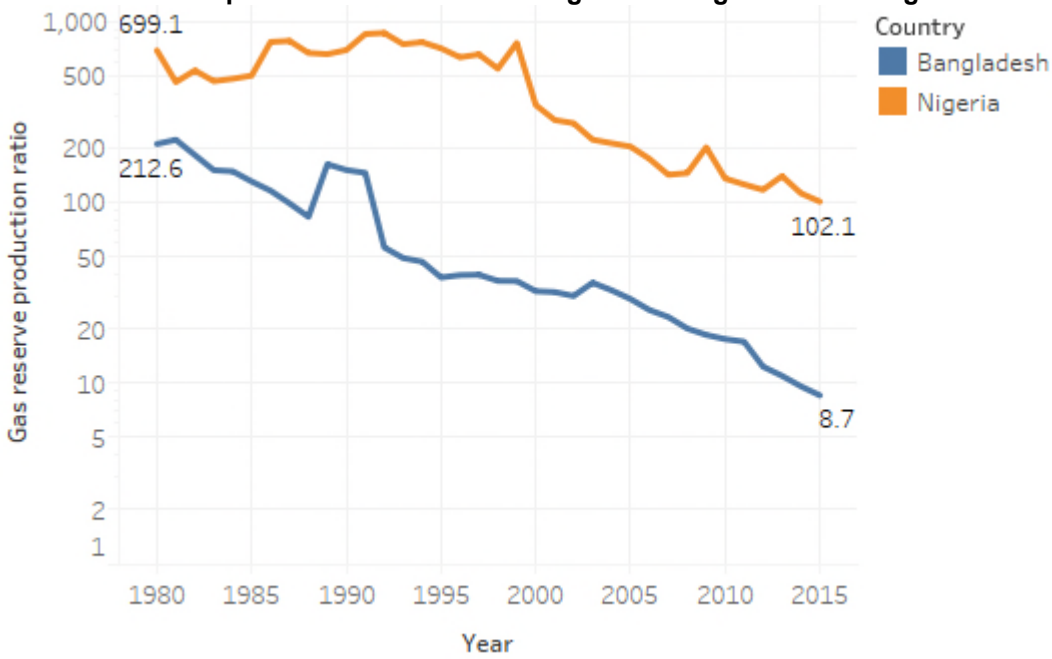
Figure 31: Trends in official development assistance for Nigeria and Bangladesh



Source: Data from the World Bank

The historical gas reserves to production ratio, an indicator of the size of gas reserves relative to production levels, for both countries has been declining. Neither of the two countries has made significant additions to their proven gas reserves since 2002. For Bangladesh, the rate of decline is more alarming: assuming gas production continues at the current rate, existing proved reserves can only sustain production for less than 10 years. Nigeria, given its great existing endowment in gas resources, can sustain gas production for much longer, even if gas production level starts to rise (Figure 32).

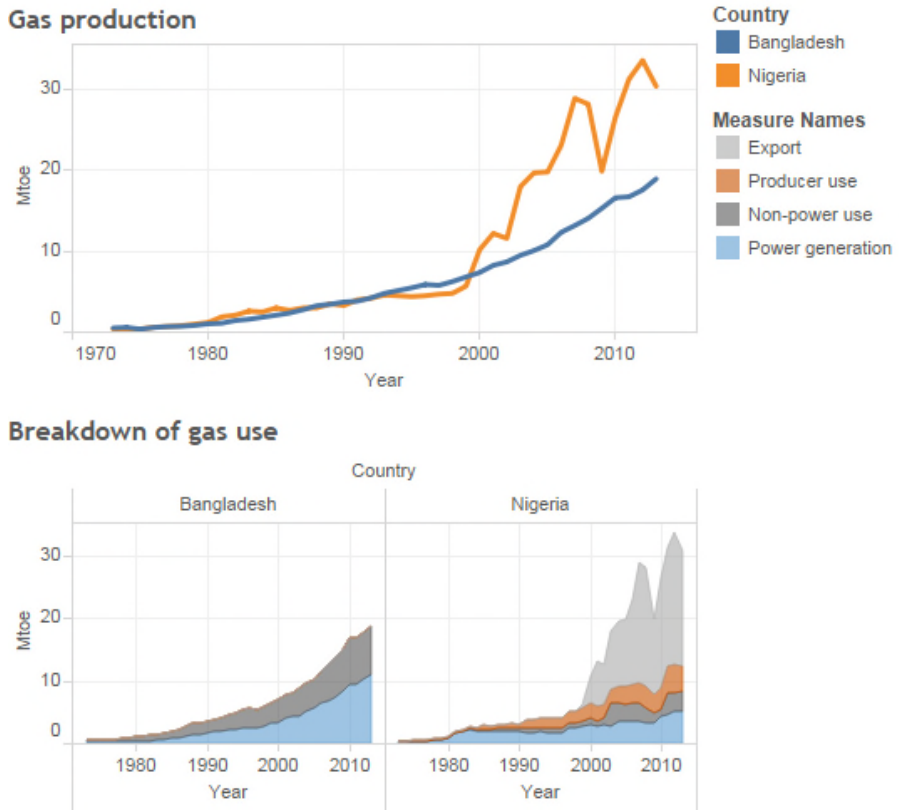
Figure 32: Reserves to production ratio of natural gas for Bangladesh and Nigeria



Source: Data from BP

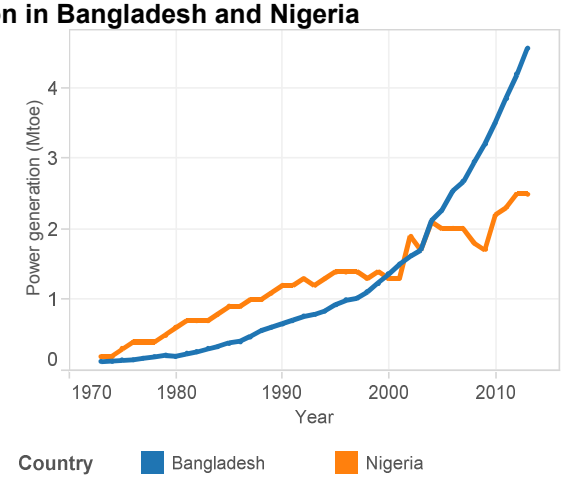
Comparing the physical output of the gas-to-power supply chains, we find that overall gas production in Nigeria has exceeded Bangladesh's since 2009. However, most of the additional gas produced has been exported. Moreover, in Nigeria, a proportion of natural gas produced that is associated with oil production is either flared, re-injected or used as fuel by producers due to the lack of marketing infrastructure (shown under the category producer use in Figure 33). Over the years, flaring has decreased but it has not been completely phased out. Finally, power generation in Bangladesh has exceeded the Nigerian level since the early 2000s and it remains on a steady upward trajectory. On the other hand, power generation in Nigeria grew faster than that in Bangladesh in its early years (1970 – mid 1980s), it then stagnated between 1990–2000 and is now following a staggered trend marked by unsteady rises and falls (Figure 34).

Figure 33: Comparison of gas production and use in Bangladesh and Nigeria



Source: Data from IEA

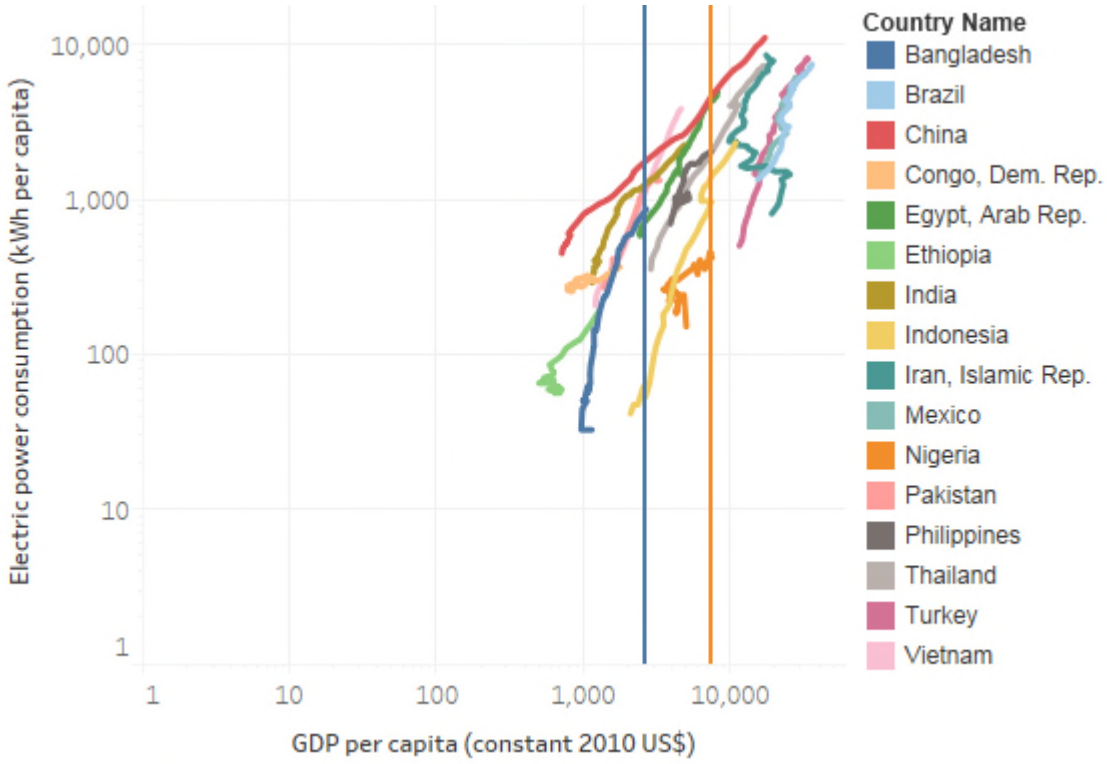
Figure 34: Power generation in Bangladesh and Nigeria



Source: Data from IEA

We also compare the two countries' electricity consumption relative to the size of their economies. Figure 35 plots the 1971-2013 historical trajectory of per-capita electricity consumption for major developing countries (low, lower-middle, and higher-middle income countries with average population higher than 50 million) as a function of per-capita GDP.

Figure 35: Annual per capita electricity consumption as a function of per capita GDP for select countries



Source: Based on data from the World Bank[25]

It shows that, compared to countries like Indonesia, Thailand, and Egypt, the average citizen in Nigeria is consuming 10-30% of electricity for the same per capita GDP level (426 kWh vs. 1422 kWh, 2127 kWh, 4479 kWh, respectively). Therefore, it can be argued that, if unconstrained, the demand for electricity in Nigeria will be much higher than the current level of consumption. As for Bangladesh, the average Bangladeshi citizen's electricity consumption seems to track the historical trajectory of that of Egypt, and that it was previously aligned with that in Pakistan and Vietnam. This suggests that, although un-met power demand is observed in Bangladesh, given its burgeoning local industry, it is not on a scale that is severely constraining economic growth.

3.4 Performance viewed within the commercial dimension

In this section, the commercial performance of firms involved in the gas-to-power supply chain is presented. The state-owned and privately-owned companies are presented in the order that they participate in the supply chain. Whenever possible, financial statements and annual reports of the commercial entities were consulted.

3.4.1 Nigeria

In Nigeria's gas-to-power supply chain, the state-owned monolith NNPC dominates the gas end of the supply chain, connecting most downstream users to upstream gas producers (IOCs and independents). On the

[25] The reference lines are located at the 2013 Nigeria and Bangladesh per capita GDP levels (orange and blue)

power-end, extensive privatisation in recent years means that state ownership is much less visible. The only public entity remaining is the TCN, while all GENCOs and DISCOs are either fully or partially privately owned. The most pervasive issue in the entire supply chain is that of liquidity: non-payment of bills is observed throughout the gas and power sectors. It can be ultimately traced to the low collection efficiency of DISCOs, who act as the interface with retail energy users. Consequently, starting in 2015, the Central Bank of Nigeria established the Nigeria Electricity Market Stabilization Facility, valued at $1.3 billion in 2015, to address revenue shortfalls in the sectors. GENCOs, power and gas sectors DISCOs eligible to access the facility need to repay loans from the fund at a 10% interest rate (Fashola, 2016b).

3.4.1.1 Gas production and processing

NNPC is the commercial interface between the Nigerian Federal Government and IOCs through their joint-ventures. Most existing joint ventures between IOCs and the NNPC date from the 1970s. The Nigerian federal government has acquired 55-60% ownership in all joint ventures. Since the 1990s, however, NNPC has found it increasingly challenging to contribute toward cash calls[26] for its joint ventures. In response, the government has introduced Production Sharing Contracts, in which the operating contractor finances the expenditure, but recovers it through deduction from the sales revenue of petroleum, before profits are shared in agreed proportions between the contractor and the government (Amaduobogha, 2015). Raw natural gas gathered from at the wellhead needs to be processed before it can be transported through long-distance pipelines. Most of the gas processing plants in Nigeria were initially owned and built by IOCs, of which some, in a wave of divestment of on-shore assets by IOCs since 2014, have been acquired by local oil and gas companies such as Seplat and Eroton.

Revenues from the NNPC, the government's largest revenue stream, have been repeatedly contested[27]. An independent review by the Natural Resource Governance Institute finds that NNPC's approach to oil sales suffers from high corruption risks and fails to maximise returns for Nigeria. According to the Nigerian constitution, NNPC must hand over all oil revenue to the federal government before being paid back based on the budget approved by the National Assembly. However, since 2010, a rising number of *ad hoc* practices (e.g. poorly designed oil-for product swaps and deducting operating expenses prior to transferring revenues to the government), which might have begun with credible goals, have evolved to be overly discretionary and complex over time (Sayne, Gillies, & Katsouris, 2015). This led to a decline in treasury receipts from oil sales even as oil prices soared between 2011 and 2014.

In early 2016, under new management appointed by President Buhari, for the first time since 2005, NNPC published monthly statements on its 2015 operations, and it has been updating these publications regularly and consistently since then. This is the Nigerian petroleum sector's greatest move toward transparency since 2005, when audit reports for the years 1999-2004 were published by the Nigeria Extractive Industries Transparency Initiative (NEITI) (Raval & Fick, 2016). NEITI, an Agency created to spearhead the Extractive Industries Transparency Initiative (EITI) in Nigeria, has reviewed the monthly statements for the period January 2015 to September 2016. It found that, since 2016, there has been a large drop in average daily production of crude oil and gas due to increased militant activities (by about 26% and 20%, respectively). Output from the joint ventures have been hit harder than production sharing contracts, since the latter are mainly operating in deep-water regions, mostly out of the militants' reach. Throughout the period reviewed, NNPC's operating revenue has been negative except two months (NEITI, 2016). This confirms that NNPC operations were not sustainable even before the resurgence of militancy that increased the expenses of pipeline repairs and decreased revenues through product losses.

Nigeria's joint venture agreements with IOCs require the state-owned oil company to contribute capital to cover exploration and production costs, which is locally known as a cash call. Given NNPC is supposed to

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[26] They are requests for payment for anticipated capital and operating expenditures by JV operators to non-operating partners.

[27] In 2014, the then central bank governor alleged that the NNPC did not remit an estimated $20bn in oil sales revenues to the treasury between January 2012 and July 2013 (Sanusi, 2015). A 2015 PwC audit report found that of the non-remitted revenue of $18.5 billion, after the payment of petroleum and paraffin subsidies, and the deduction of NNPC operational costs, $1.48 billion remained (Wallis & Raval, 2015). In 2016, an official audit claims that NNPC has failed to remit $16 billion in 2014. In its response to the allegation, NNPC justified the outstanding amount as petroleum subsidies, crude and oil product losses from vandalism and theft, as well deduction of operational costs.

remit all revenue, then receive funding from the federal budget, historically, NNPC has consistently failed to pay its share. By 2016, the arrears accumulated in cash calls amounted to over $6 billion. Also under the new management, in late 2016, NNPC negotiated to have new financing agreements in place to replace the cash calls: the five IOCs agreed to finance exploration and development upfront, then recover their costs from the resulting revenue[28]. The remaining arrear is to be paid with a one-off cash payment and barrels of new crude production over the next five years (Alike, 2016b).

Given the uncertainty in the long-running petroleum sector reform process, theft and sabotage by Niger Delta militants, and, since 2014, the need to cut costs since the fall in crude prices, IOCs have been reducing their onshore oil presence, selling on-shore oilfields to domestic buyers (Raval & Blas, 2014). Despite divestment of onshore oil-producing assets, Shell has said it is willing to investment in natural gas in Nigeria for domestic consumption and export (Reuters, 2015). But, the outlays for exploration that can be expected from IOCs have all shrunk since the fall in oil price: for example, the 2017 investment programme announced by Chevron (which does not include investments in Nigeria), is 42% lower than its 2015 budget (Chevron, 2016).

The Nigerian Federal Government has approached China and India about the possibility of investing in Nigeria's upstream oil and gas sector. Memorandums of understanding involving impressive figures have been signed ($80 billion for China and $15 billion for India). The Chinese agreement covers projects throughout the supply chain: from rehabilitation of decaying refineries to new pipelines and power plants (Fick, 2016). At this early stage, it is not yet clear how these deals would be financed and implemented, but a Chinese delegation has met with a new inter-ministerial implementation committee, which further formalised plans (Okafor, 2016d). The agreement with the Indian government is an upfront payment to Nigeria to purchase crude, and it will be repaid by firm term crude contracts over time and by future collaboration with Indian public sector companies in Nigeria's petroleum sector (Alike, 2016a).

3.4.1.2 Gas transmission and distribution

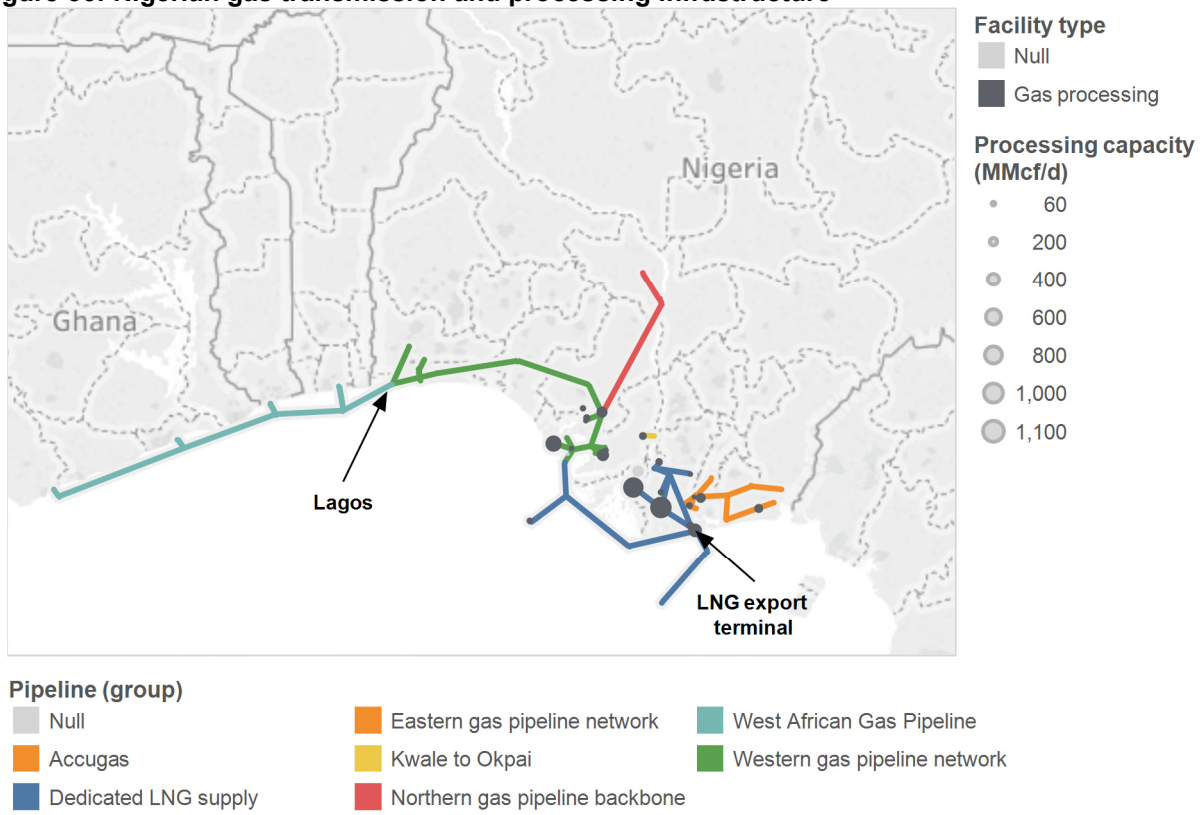
The Nigerian Gas Company (NGC), a subsidiary of NNPC, owns the gas transmission network that is dedicated to serving domestic demand. Despite the absence of legislation and regulation targeting the downstream gas sector, according to a NGC presentation from 2013, small volume customers can purchase gas from NGC through a Gas Sales and Purchase Agreement, while larger customers such as generation companies are to purchase the gas directly from upstream producers, while entering into a Gas Transportation Agreement with NGC (NGC, 2013). The national network consists of the Eastern Gas Pipeline Network, east of the Niger, its western counterpart, the Western Gas Pipeline Network, and a pipeline constituting the backbone of the yet-to-be-developed Northern Gas Pipeline Network. By themselves, these domestic gas networks amount to over 1250 km of pipelines. The Eastern network is more limited in reach, while the Western Network delivers gas to Lagos, the largest Nigerian city, more than 400 km away (See Figure 36). As the Petroleum Amendment Act of 1973 attributed all associated gas to the federal government, free of cost, investment in associated gas gathering and transmission is financed by NNPC, as authorized under its government-approved capital budget. Non-associated gas development, on the other hand, is financed by joint venture cash calls (Davison et al., 1988). NNPC's inability meet joint venture cash calls, therefore, also means that the company can no longer self-finance additional gas transmission infrastructure.

Although there is no formal regulatory framework around downstream gas transmission and distribution, as legislation development in this area has continuously stalled, privately owned gas transmission and distribution companies exist. For the moment, licenses for operation in the downstream gas sector are granted by NGC. Oando Gas & Power is licensed to distribute gas in the greater Lagos area, Falcon Corporation Limited is licensed for distribution in Ikorodu, and Accugas, and a subsidiary of Seven Energy has constructed 227 km of pipeline, connected to the Eastern Gas Pipeline Network, which supplies gas to two power plants in the area. The profitability of the gas distribution business is difficult to assess, as the companies disclose their financial statements for the entire conglomerate, which also includes operations in upstream oil production. However, all private companies express optimism about the development of their business in gas distribution, as it has experienced important growth supplying gas to industry and power sectors in the recent past. Nevertheless, the poor creditworthiness of their customers, especially power

[28] Effectively, such an agreement converts joint ventures, in terms of financing model, to production sharing contracts.

generators, poses a great concern for additional investment[29] (Okere, 2016). The industry also calls for more efficient and effective regulatory bodies to carry out licensing and other regulatory activities.

Figure 36: Nigerian gas transmission and processing infrastructure



3.4.1.3 Gas export

The West African Gas Pipeline (WAGP), a joint-venture between Chevron, NNPC, Shell, and power/gas companies from Benin, Toga, and Ghana, offtakes gas from Lagos and export it to Nigeria's West African neighbours. The project was initiated in 1982, as the IOCs and NNPC looked for ways to monetise Nigeria's gas, while the other partners, wanted to secure the much-needed fuel for power sectors in the region. The project's final investment decision was only made in 2004, followed by first delivery of gas in 2008. However, as the West African Gas Pipeline receives its supply via the Western Gas Pipeline Network from the Niger Delta, sabotage of pipelines in the Delta by militants has severely disrupted gas export. The growing demand for gas within Nigeria also puts constraints on the quantity of gas that can be exported. Ghanaian authorities claim that WAPG has hardly ever supplied the contracted volume of 133 MMscfd since its completion, which is one of the root cause for the Ghana power sector's lack of liquidity (B&FT Online, 2016). Pipeline damage and repair between 2012 and 2013 forced the Volta River Authority, the main state-owned power generator of Ghana, to switch to expensive alternative liquid fuel; unable to pay its bills of $180 million, the operator of WAPG curtailed gas supply to Ghana between June to October 2016, which further strained Ghana's power supply chain.

Another export operation, the Nigerian Liquefied Natural Gas (NLNG) plant is supplied by six dedicated pipelines (two off-shore and four on-shore) that gather gas from the Niger Delta. The multiple pipelines and dedicated gas processing plants make LNG production and loading possible, even when one or more pipelines is damaged. NLNG is a joint venture between NNPC, Shell, Total, and Eni, with the IOCs controlling 51% of the shares; sourcing gas from NNPC-IOC joint ventures, NLNG markets gas through long-term

[29] NNPC estimates that the power sector's gas invoice arrears in May 2016 was $500 million, which grew by 150% since December 2014.

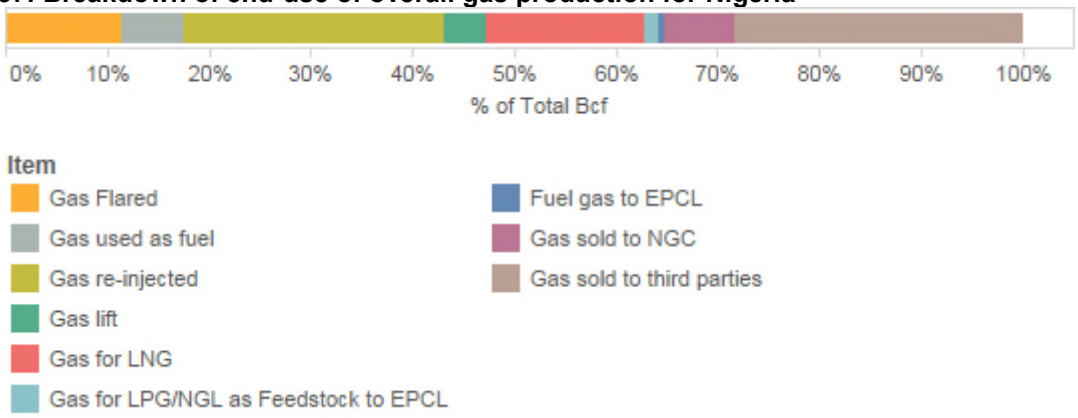
contract with large power and gas companies in Europe and Asia, supplemented by spot sales. NLNG is a thriving company that reported close to $7 billion in revenue for 2015, despite a drop of 37% from that of 2014 given lower oil and gas prices. Currently, the company is in the final stage of deciding whether to proceed with a seventh liquefaction train at a cost of about $12 billion. The final investment decision is threatened by a glut in the international LNG market, instability in Nigeria, and a national debate to amend the NLNG Act, ending an indefinite tax holiday granted to the corporation at its inception through legislation (Ohuocha, 2016; Okeke, 2016).

Both of Nigeria's working gas export facilities were originally financed by shareholder equity from NNPC, IOCs, and other partners. Several other export projects have been proposed in the past (The Trans-Saharan pipeline, Brass LNG, Olokola LNG), but all of them have failed to reach final investment decisions to this date.

3.4.1.4 Non-power gas consumption

In Nigeria, after eliminating producers' own use (including flaring, use as fuel, reinjection, and gas lift) and export (LNG), overall domestic demand only represents about 40% of total gas production (and this potentially includes supply to the West African Gas Pipeline as well) (Figure 37). The domestic demand (Gas sold to EPCL, NGC, and third parties) is further split between power generation and industrial demand, in the form of fuel and process feedstock. The customer base is limited to the area that the gas transmission network serves. Prior to the development of networks, only industrial customers in Port Harcourt, located within the Niger Delta, could access gas. Throughout the 1980s, as NNPC gradually built up segments of the present network to serve steel plants, fertilizer plants, and power stations based on government instructions (Davison et al., 1988). More recently, the industrial city of Aba and the Greater Lagos Industrial Area have been connected, along with the NNPC-Chevron backed Escravos Gas-to-Liquid plant, and two urea fertilizer plants (Indorama and Notore). The Escravos facility opened in 2014 after a decade of delay and a 500% cost over-run, just as depressed oil prices took a bite out of the profitability of the gas-to-liquid business model (Gallucci, 2015). Both Indorama and Notore, Nigeria's largest fertilizer producers, entered the Nigerian market through acquisitions of former state-owned petrochemical facilities and currently have plans to expand fertilizer production for export. The fertilizer projects attracted loans from international financial and private equity. However, the export of fertilizer in light of domestic shortages (import of fertilizer and a number of other goods has been banned in 2015 to boost patronage of local products) has drawn controversy (Mutum, Yahaya, & Yusuf, 2016).

Figure 37: Breakdown of end-use of overall gas production for Nigeria



Source: Data from NNPC

3.4.1.5 Power generation

Generation companies (GENCOs) currently active in Nigeria can be divided into three types: PHCN successor companies which have been privatised or put under concession, IPPs, and privatised NIPPs. At the time of privatisation, all private investors made Post Acquisition Plans which promised an improvement in generation performance. But outcomes have differed between generators. Transcorp and Sahara are two companies that have reported significant progress in repairing and overhauling previously unavailable

generation capacity (Giwa, 2016; Udo, 2015). However, these generators have also raised concerns about the negative impact of upstream gas constraints and downstream power transmission constraints on their actual generation levels. Moreover, the failure of DISCOs to pay for 100% of power generated is leading to a sector-wide liquidity crisis. DISCOs have only remitted between 20% and 30% of the amount invoiced by GENCOs through NBET, the state-owned single buyer. Between November 2013 and November 2016, the amount owed to GENCOs amounted to more than N 400 billion[30] (Oketola, Adeoye, Nnodim, & Alagbe, 2016). NBET, established to remove counterparty risk in contracting between GENCOs and DISCOs, has been blamed by GENCOs' representatives for ineffective collection from DISCOs and for its failure to buffer the liquidity gap, in the event of DISCO non-payment.

3.4.1.6 Power export

Nigeria is a member of the West Africa Power Pool (WAPP), a specialised institution of the Economic Community of West African States (ECOWAS). Other members include Benin, Côte d'Ivoire, Burkina Faso, Ghana, Gambia, Guinea, Guinea Bissau, Liberia, Mali, Niger, Senegal, Sierra Leone, and Togo. Like the three other regional power pools in Sub-Saharan Africa, WAPP was established to promote mutually beneficial cross-border trade in electricity, since market integration would enable investment in countries with a comparative advantage in generation, lowering costs for all participants. It would also dampen irregularities in national power supply and demand. Nigeria accounts for two-thirds of electricity consumption in WAPP. However, given it is not centrally located relative to other WAPP countries and its high untapped large hydro power potential, Nigeria is not expected to contribute significantly in terms of electricity import/export (Eberhard, Rosnes, Shkaratan, & Vennemo, 2011).

Currently, Nigeria is connected to Niger in the North (190 MW), and to Benin in the South-West (200 MW). The electricity that it exports to Niger, although small in quantity (551 GWh, or less than 2% of overall Nigerian power generation), represents 75% of Niger's national electricity demand (Gado, 2015). The first of four lines connected to Niger, Birnin Kebbi-Niamey, was commissioned in 1976 under the original state-owned power monopoly NEPA. Nigeria agreed to export electricity to Niger to prevent the latter form building the Kandaji Dam, a proposed hydro power plant located upstream of Nigeria's first power plant Kainji (commissioned in 1968) (Adewumi, 2006). A preferential rate of about ($0.04/kWh) was negotiated between the two countries (The World Bank, 2015). The power interconnector between Nigeria and Benin was jointly financed by the African Development Bank, Banque Ouest Africaine de Developpement, ECOWAS, the Nigerian Federal Government, and the Communauté Électrique du Bénin (the public entity responsible for joint power generation and transmission in Benin and Togo). The project was initiated as it was perceived as the most economical alternative available for supplying power to Togo and Benin. Since its inception, power imported from Nigeria has supplied about 50% of Benin/Togo demand. The sustainability and expansion of this interconnector are threatened by current reality: it had been assumed that Nigeria would have excess generation capacity that would allow it to export electricity to Benin without constraints, but the actualised generation capacity is substantially below what was projected. However, so far, Nigeria has managed to meet its export obligation despite its serious internal deficits (Mbekeani, 2011).

3.4.1.7 Power transmission

Currently, the transmission capacity of the national grid is smaller than the installed capacity for power generation by about 6000 MW, leading to grid congestion and stranded generation capacity (Omonfoman, 2016). As Figure 38 shows, most power generation is in the South-South, near the gas transmission infrastructure, but the most important fraction of load is in the South-West, around Lagos. In the Northern region, where the gas network does not yet reach, there are only three hydro power stations which are connected to the grid in the west, and no on-grid generation at all in the vast area in the North-East, where power grid coverage is also less complete and laid out in a radial configuration. Planned power transmission lines that will bridge the power generating South with the North (shown in orange, forming a North-South loop) are essential to relieve grid constraint and increase grid stability.

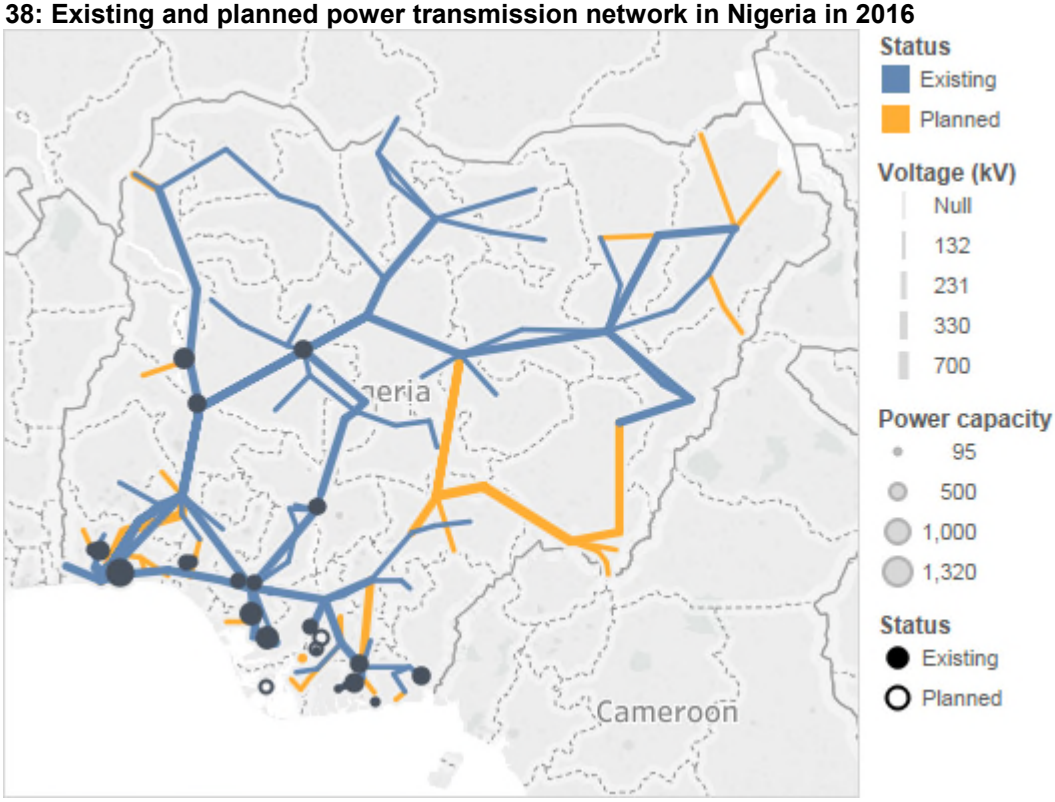
Between 2012 and early 2016, the state-owned transmission network owner and operator TCN was put under a management contract by Manitoba Hydro International (MHI), a subsidiary of a Canadian crown

[30] The equivalent of $2.4 billion before the devaluation of the Naira in 2016.

corporation. The main objectives of the management contract were to improve the technical and financial performance of TCN and to enable knowledge transfer between MHI and the Nigerian personnel. However, like GENCOs, the TCN, the only state-owned infrastructure owner remaining in the power supply chain, is dependent on revenue collected by DISCOs, remitted via the NBET. The lack of funds to expand the transmission network remained an issue under the management contract. The actual outcome of the management contract is debated by MHI and the Nigerian authority (Anuforo, 2016b).

In 2016, the Nigerian transmission network recorded over 20 system collapses[31]. TCN's managing director states that whenever generation falls by a relatively large amount (300 MW, in this case, relative to a spinning reserve of 20-30 MW and an overall generation of 3000-3200 MW), the transmission grid becomes susceptible to collapse (Alike, 2016c). The company has blamed the poor performance of the power grid on generation shortfalls caused by gas shortages, non-payment of bills by DISCOs, and on a lack of funds to maintain and update obsolete equipment (Okfor, 2017). Most recently, NERC has fined the TCN for allegedly refusing to submit its audited financial statements for 2013 and 2014 (Njoku & Anuforo, 2016).

Figure 38: Existing and planned power transmission network in Nigeria in 2016



Source: Based on data from African Development Bank

3.4.1.8 Power distribution

Most distribution assets in Nigeria, since the privatisation of PHCN, is controlled by 11 distribution companies, each with their specific franchise area, consisting of one to several states. At the time of privatisation in 2013, private investors bid to decrease the Aggregate Technical, Commercial and Collection (ATC&C) losses over a five-year period; the performance bid was binding and used to select the winner. However, at the time, there was no credible baseline loss data to ascertain the value of various losses at the time of handover. Even by 2014, only 54% of customers were metered [32]. Thus, the actual ATC&C losses

[31] The number of system collapse in 2013 was 22 and 6 in 2015, according to MHI.

[32] In 2013, the NERC initiated a pre-payment scheme (Credited Advance Payment for Metering Implementation, or CAPMI) which allowed DISCOs to charge customers upfront for meter installation, then subsequently deduct it from fixed charges. But, the programme wound down in 2016 because of the DISCOs' disappointing performance in deploying meters even after collecting funds from customers (Okafor, 2016c).

for some DISCOs are higher than assumed. Current measures of ATC&C for the eleven DISCOs range between 30 to 60%, though a detailed breakdown of losses of different type is not available (NERC, 2015).

While DISCOs are being blamed by GENCOs and TCN for their liquidity gap, the Association of Nigerian Electricity Distributors have stated that the DISCOs themselves are owed more than N100 billion by their customers, with the biggest debtors being the military and government ministries, departments, and agencies (Oketola et al., 2016). The liquidity issue has been cited as one of the reasons for the slow deployment of meters. The DISCOs rely on estimated billing for unmetered customers, a practice which, although regulated by NERC through the publication of a standard methodology, lead to what are locally known as "crazy bills", fiercely contested by power end-users, who sometimes refuse to pay the bills (Asu, 2016). The confusion and lack of transparency in revenue collection is bidirectional: it is alleged that DISCOs cannot account for most of the revenue remitted to them by consumers (Umoro, 2016). Unsurprisingly, The Minister of Power, Works, and Housing has ordered the DISCOS to submit their audited accounts covering 2013-2015 to the NERC for benchmarking (Anuforo, 2016a).

3.4.1.9 Power consumption

Given that a sizable portion of Nigerian industry and businesses rely on their own diesel-fired generators to generate for themselves, it is unsurprising that, currently, most of Nigeria's grid-provided electricity is consumed by the residential and commercial sectors (57% and 24% in 2014, respectively). This means that many power end-users' ability to pay is greatly dependent on their income from non-power-use-related sources in the general economy, because, unlike industrial customers, their income is not directly correlated with electricity consumption. Bill collection records from the Port Harcourt Electricity Distribution Company, submitted as part of the latest tariff review, reveal that residential customers are the source of the greatest collection losses (43% of all bills collected vs. 77.4% for commercial customers and 75.3% for industrial customers) (Port Harcourt Electricity Distribution Company, 2015) . A survey conducted with low-income consumers recognises anomalies at the distribution and demand interface: many low income consumers did not know the name of their DISCO and had never interfaced with them; most customers were unmetered, thus wrongly classified and received estimated bills; the prevalance of estimated billing has enabled the emergence of illegal bill collection rackets, resulting in voluntary disconnection of customers (which may continue to be billed based on estimations) (Odiase & Nwaoha, 2015).

3.4.2 Bangladesh

The two most important entities operating in the gas and power sectors, Petrobangla and the Bangladesh Power Development Board (BPDB), are state-owned corporations that report to the Energy and Mineral Resources Division and Power Division of the Ministry of Power, Energy & Mineral Resources, respectively. Previously monopolies in their respective sector, Petrobangla and BPDB have both been unbundled, over the years, to become holding companies of many subsidiaries. It is through these two bodies that the government engages with the private sector: Petrobangla enters Production Sharing Contracts with private oil and gas companies, while BPDB enters Power Purchase Agreements with private generators. Intra-group decisions for Petrobangla and BPDB are subject to government influence, and contracting among private firms in the gas-to-power supply chain is uncommon.

3.4.2.1 Gas production

There are 20 gas fields which are actively producing in Bangladesh: eight of the twenty fields produced less than 10 MMscfd, and account, altogether, for less than 3% of total production capacity; on the other hand, the top two fields are responsible for more than 60% of total production capacity (Petrobangla, 2016). The two biggest fields are operated by Chevron and the Bangladesh Gas Fields Company Limited (BGFCL), a subsidiary of Petrobangla. Together, the two companies are responsible for about 85% of total gas production capacity in the country. Two other Petrobangla subsidiaries, Bangladesh Petroleum Exploration & Production Company (BAPEX), Sylhet Gas Fields Limited (SGFL), and Tullow Oil, an independent oil exploration and production company, complete the set of gas producers.

Chevron, one of two IOCs operating in the country, is currently in talks to divest it natural gas assets in Bangladesh. It is the latest in a series of divestments in Asia as Chevron cuts costs and adapts to an environment of lower oil prices (Stacey, 2016; Wu & Strumpf, 2016). In 2013, Tullow Oil sold 100% of its Bangladesh subsidiary to KrisEnergy Asia Holdings, an independent upstream oil and gas company that is

focused on Asia (Tullow Oil, 2013). The latter is not sheltered from the fall in oil prices. KrisEnergy's budgeted capital expenditure for 2016 was 78% lower than the 2015 figure.

Revenue from the gas produced by state-owned gas production companies is distributed to the Government of Bangladesh (55%) and Petrobangla group companies (45%). Between 2013 and 2015, as a group, Petrobangla and its subsidiaries reported a gradually declining operating profit (from 13%, 0.8%, to -1.6%). Nevertheless, the group has a healthy balance sheet, with over 90% of its assets financed by equity rather than debt (Petrobangla, 2016). More than half of its equity comes from its revenue reserve, created from past operating profits. Another 28% comes from the Gas Development Fund, established by BERC through a 2009 increase in gas tariffs. Revenue from the higher gas tariff is channelled for use in upstream exploration and development (Ahsan, 2015). Of 30 total projects for all state-owned companies active in the gas supply chain in 2014 and 2015, 21 are funded by development aid or the government budget and only 9 are financed by the companies themselves. Allegedly, Petrobangla's affiliated companies receive the revenue from gas sales according to a fixed ratio, and do not have sufficient autonomy or financial independence (Oriental Consultants, 2012).

3.4.2.2 Gas import

In 2010, Petrobangla first floated the construction tender for a LNG regasification terminal. In 2016, after much delay, Excelerate Energy, an American company specialising in the import and marketing of LNG, Petrobangla, and the Government of Bangladesh executed the Terminal Use Agreement and Implementation Agreement for the construction and operation of Bangladesh's first LNG import terminal, to be sited off-shore in the Bay of Bengal. Excelerate will develop, design, construct, install, finance, and operate the terminal for 15 years, after which ownership of the 500 MMscf/day terminal will be transferred to Petrobangla[33] (Excelerate Energy, 2016). This is the first terminal for which all services will be provided under a single contract by a single provider, acting as a single point of interface to the counterparty Petrobangla. Petrobangla will be purchasing re-gasified gas that Excelerate sources from Qatar on a take-or-pay basis, then distributing it to downstream consumers. The Petrobangla group development programme includes the development of a pipeline connecting the regasification terminal to Chittagong, a major costal city starved of gas since off-shore gas fields ended operations. To meet the LNG import contract obligation (about $1.56 billion per year, of which $90 million goes to the use of the terminal), an upward adjustment in the gas tariff (an area under the mandate of BERC) has been proposed (Byron, 2016). The government talks of plans to build two more on-shore LNG regasification terminals, each with a capacity of 1000 MMscf/day (Siddique, 2016).

3.4.2.3 Gas transmission and distribution

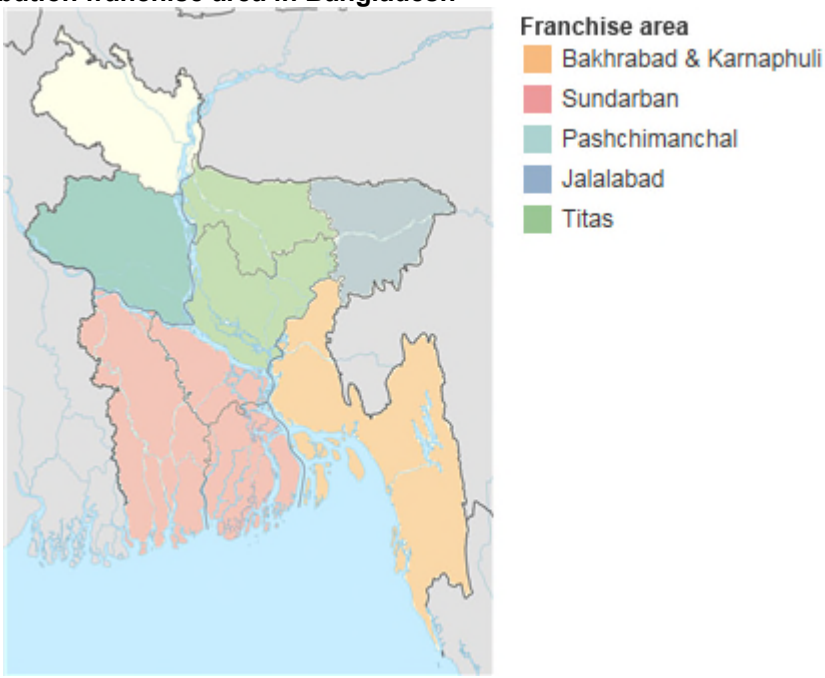
Given the location of gas production, the existing transmission network, wholly owned by the Petrobangla subsidiary Gas Transmission Company Limited (GTCL), transports natural gas from the East to the centre (Dhaka and Mymensigh). Transmission to the west of the Jamuna river is more limited, with some connections in Rajshal, but not beyond (Figure 27). In total, the existing transmission network amounts to about 1400 km in pipelines. In addition, there are about 400 km of pipelines projects currently under construction, funded by various development institutions (Asian Development Bank, World Bank, etc.) to expand the network in the Western regions. Moreover, another 300 km of pipelines financed by the government, Petrobangla, and GTCL are under construction to expand existing grid capacity and to receive gas from the planned LNG floating regasification terminal in the South.

The six existing gas distribution companies, all subsidiaries of Petrobangla, each have their assigned franchise area (Figure 39). The northernmost division of Rangpur does not have a dedicated gas distribution company, as it is not yet connected to the gas transmission network. The biggest and oldest distributor Titas serves the central region where the capital Dhaka is located, which has two thirds of all customers (Figure 40). The newest gas distribution companies, Karnaphuli, was created in 2010 by splitting off the franchise area of Bakhrabad in the Chittagong Division (this explains the fall in Bakhrabad customers in 2010). Sundarban is currently responsible for the development of the 845-km Southwest Regional Gas Distribution

[33] The Moheshkhali Floating LNG terminal is a joint effort between Excelerate and the International Finance Corporation (IFC), with the IFC mandated to provide and arrange the financing for the project.

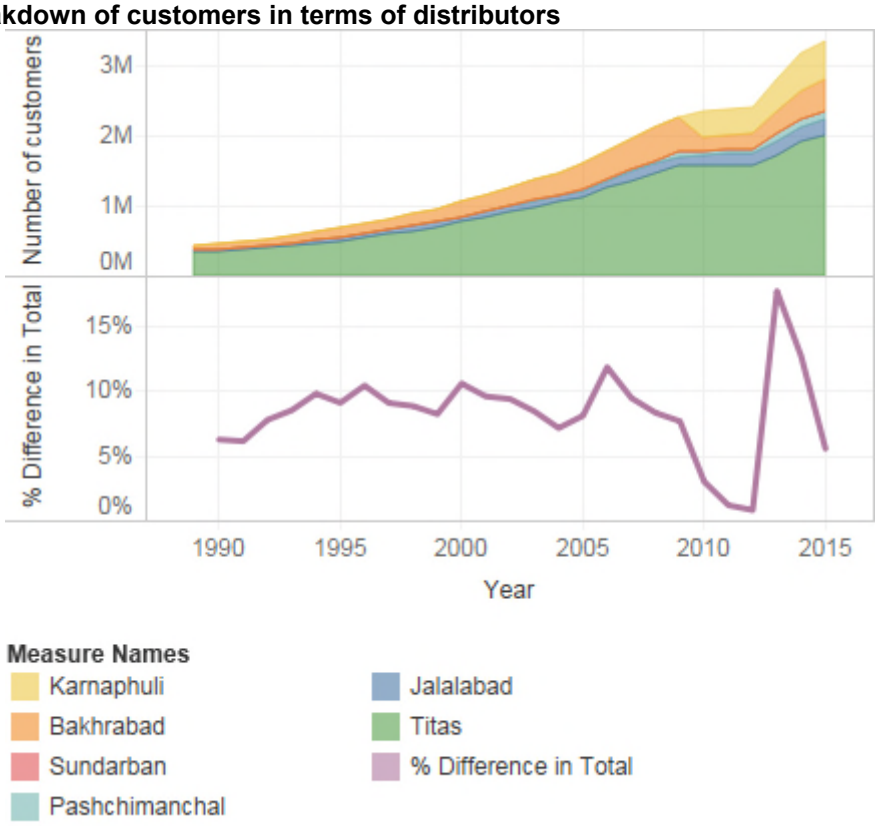
Network, financed by the Asian Development Bank, connected with the Titas and the Pashchimanchal franchise areas. Therefore, as of now, it is not yet serving any customers.

Figure 39: Gas distribution franchise area in Bangladesh



Source: Based on gas distribution companies' websites

Figure 40: Breakdown of customers in terms of distributors



Source: Based on data from Petrobangla

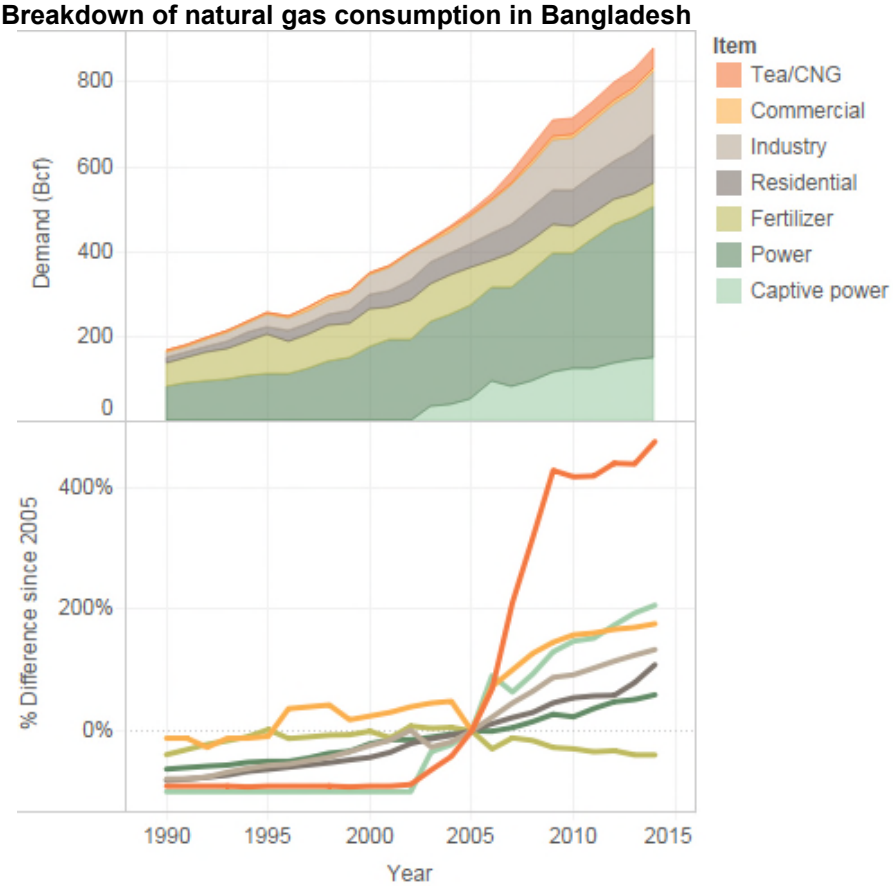
Throughout the 1990s and the early 2000s, the total number of natural gas customers grew at close to 10% per year. However, since 2006, growth has been more erratic and generally slower. Restrictions on connections to new industrial and residential customers, enforced by the authorities to alleviate gas shortage in 2009 and 2010 respectively, is believed to be a cause for the slow down (M. Rahman, Tamim, & Rahman, 2012).

3.4.2.4 Non-power gas demand

Currently, all the gas produced in Bangladesh is consumed domestically, with about half of production going toward power generation (including 20% going toward captive generation since the mid-2000s, see Figure 41). The production of fertilizer, which used to be a third of overall consumption, decreased to 6% by 2014. This was due to governmental intervention to ease the gas shortage faced by the power sector, which persisted despite growth in gas production (M. Rahman et al., 2012). This was achievable given most of the urea fertilizer production plants are wholly owned by the government. Given Bangladesh is dependent on the use of fertilizer to maintain its agricultural production level, the decrease in domestically produced fertilizer is likely to be replaced with imports.

Of the other uses of gas, residential and industrial consumptions have grown at commensurable pace (by 100% since 2005) and each constitutes about 15% of the overall consumption, while demand from commercial uses have remained low at 1% of the overall demand. Given the government has restricted new connections to new commercial, industrial and domestic customers since 2010, the increase in gas consumption from these sectors come from the existing customer base. Since 2003, there has been an explosion of use of gas for transportation in the form of compressed natural gas (CNG), directly but the size of the sector is still small relative to other sectors at 5% of total demand. However, since 2011, the growth rate for CNG has slowed to that of more mature sector at less than 10%. Finally, the reported amount of un-accounted for gas, which is lost between production and sales, decreased to nearly zero by 2010.

Figure 41: Breakdown of natural gas consumption in Bangladesh

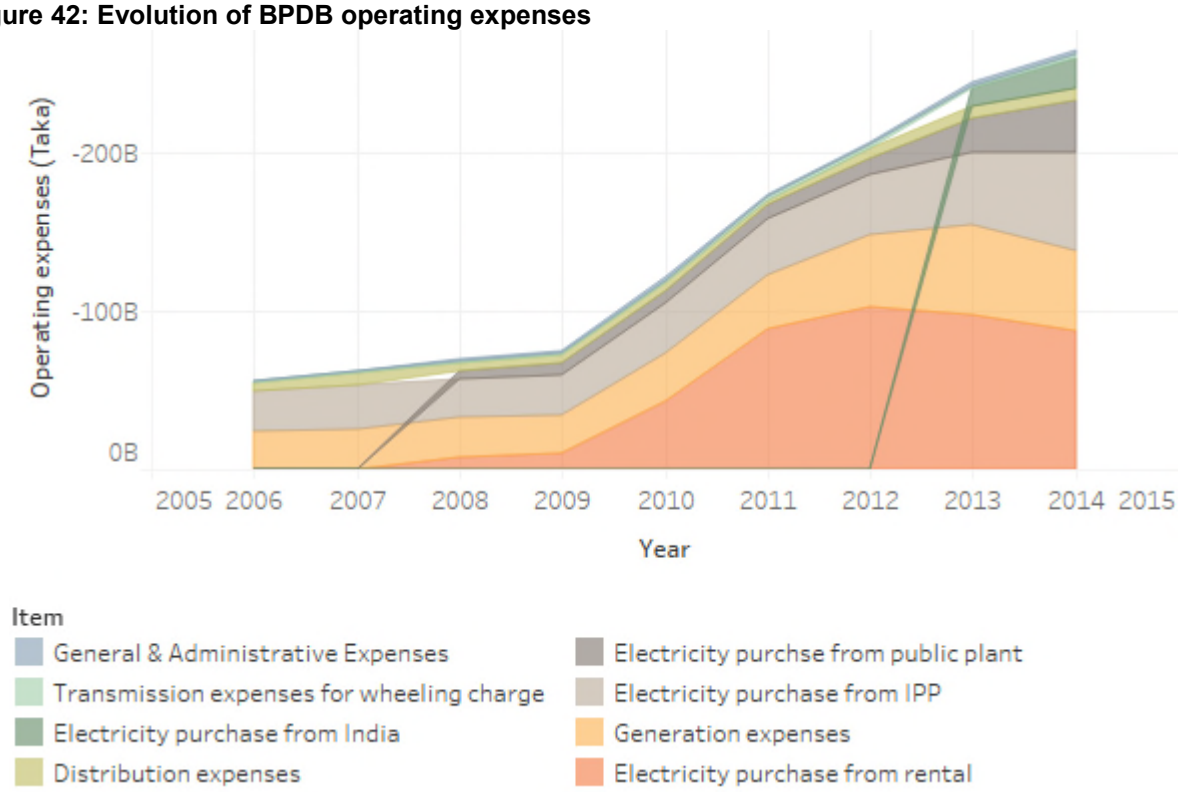


Source: Based on data from Petrobangla

3.4.2.5 Power generation

Public power generators, controlling 60% of all generation capacity, consist of BPDB and its subsidiaries. The consolidated income statement for the BPDB group shows that, before 2009, an annual operating loss of about Tk6 billion was regularly observed. Since then, it has been continuously higher than Tk40 billion. This is mainly due to the ballooning cost of electricity purchased from rental plants. Nevertheless, since 2012, the pay-out to rental plants has been curbed, although the overall operating expenses are still growing (See Figure 42). This heavy burden is also reflected in BPDB's balance sheet. By the end of the 2014-15 fiscal year, the amount of BPDB's liability is greater than the amount of its assets; the corporation is kept afloat by Tk328 billion in budgetary support from the government.

Figure 42: Evolution of BPDB operating expenses



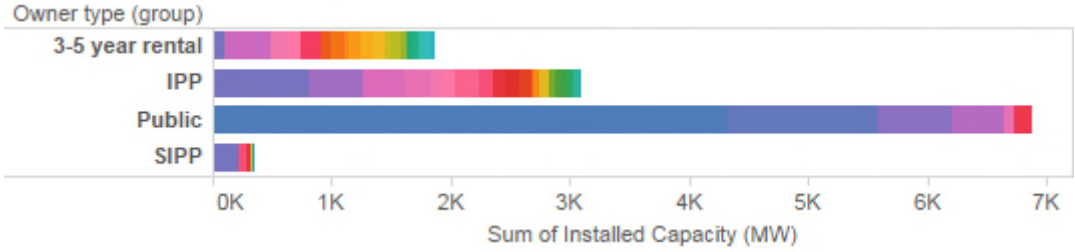
Source: Data from BPDB 2007-2015 annual reports[34]

Given that BPDB acts as the single buyer for most electricity generated in the country (REB also purchases a small quantity of electricity from SIPPs), the bulk of supply tariffs that it pays to various generators, set by BERC, determine their profit margin. On average, rental power plants receive the highest tariff per unit of electricity generated, followed by IPPs/SIPPs, and state-owned generation that is not directly controlled by BPDB. BPDB's own generation is compensated only after all these purchases have been paid. Thus, the investment of private sector companies in short-term rental capacity is mainly motivated by the relatively profitable tariff. BPDB, on the other hand, makes investments planned under government policies, and is supported by transfers from the Bangladesh government instead of commercial expansion.

Many private companies own generation capacity currently contracted through short-term rentals, IPPs and SIPPs (Figure 43). The most important private company, Summit Power Limited, a domestic conglomerate, accounts for 27% of privately-owned capacity, followed by Aggreko with 10%. All other firms, individually, represent less than 5% of privately-owned capacity.

[34] Sales to public plants began in 2008, after the unbundling of BPDB owned generation, while import from India began in 2013.

Figure 43: Disaggregation of ownership for different generation segment in Bangladesh



Source: Data from BPDB [35]

3.4.2.6 Power import

Bordered by India on all sides except for in the south east (border with Myanmar), Bangladesh is part of the South Asia Association for Regional Cooperation (SAARC), whose members also include India, Pakistan, Sri Lanka, Nepal, Bhutan, and Maldives. Many of the SAARC countries (India, Pakistan, Nepal, and Bangladesh) suffer from electricity shortages that lead to load shedding. Regional energy cooperation in the form of intra-regional trade, co-investment in large-scale common infrastructure, and sharing of institutional best practices, has been proposed by the Asian Development Bank to sustain economic growth (S. H. Rahman, Wijayatunga, Gunatilake, & Fernando, 2011). In the power sector, the SAARC Regional Trade Study recommends that existing bilateral trading arrangement between countries be expanded, which may eventually graduate to multilateral trade arrangements.

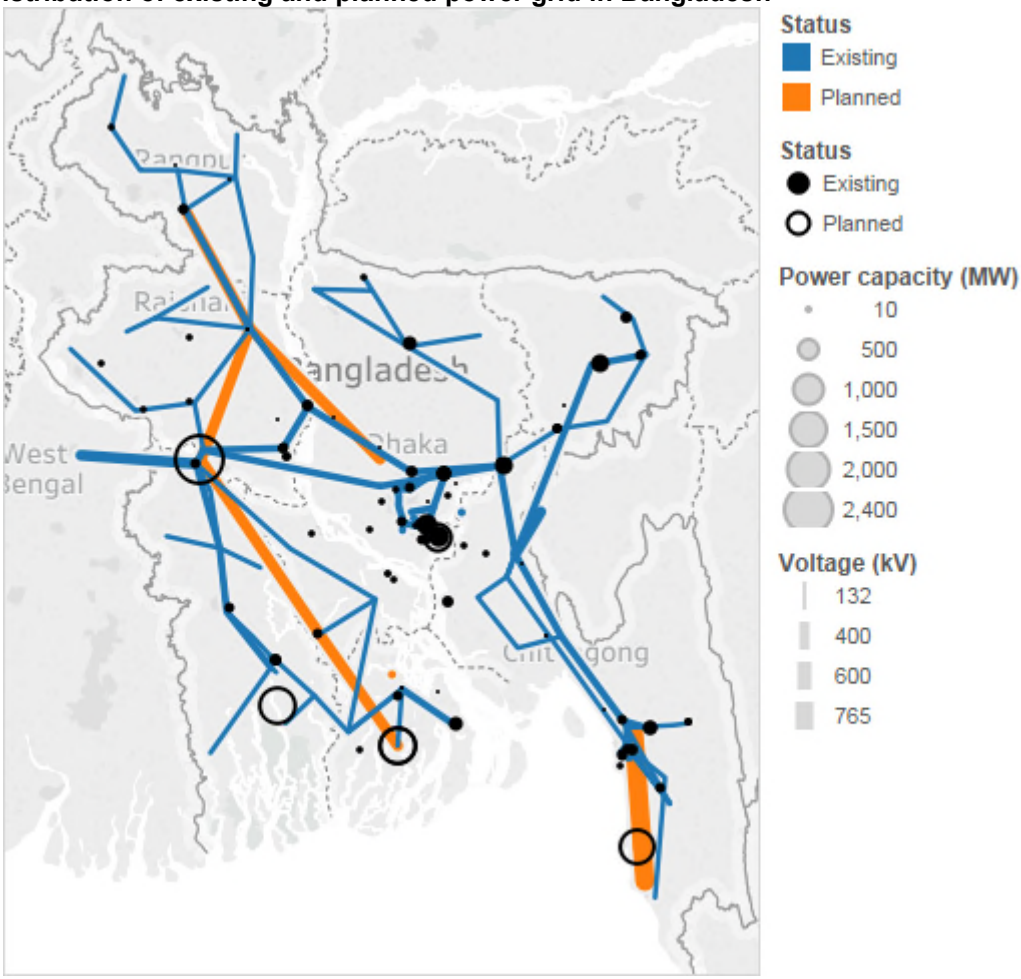
Currently, Bangladesh has two power interconnections with India, totalling 600 MW. BPDB has purchased electricity from India's Power Trading Corporation under long term contracts since 2013. The interconnection facilities in Bangladesh were co-financed by loans from the Asian Development Bank and the Government of Bangladesh, while the Indian portion was financed by the Power Grid Corporation of India. The grid owners and operator, PGCB, were responsible for executing the project and held the loans on their balance sheets (Mahmud, 2016). Given limited domestic hydro, gas and coal production potential, electricity from India is seen as the most feasible and cheapest way of supplying power in the short term (Asian Development Bank, 2010). Bangladesh plans to expand imports from India to 1100 MW.

3.4.2.7 Power transmission and distribution

The power transmission network in Bangladesh has a wider coverage than that of natural gas, especially in the regions west of the Jamuna river. New investments made by the sole owner of the power grid PGCB, a state-owned corporation, are mainly financed by loans from development agencies and multilateral development banks. New power lines are planned to facilitate the proposed major generation projects discussed above (see Figure 44).

[35] Each colour represents the capacity owned by a distinct company.

Figure 44: Distribution of existing and planned power grid in Bangladesh

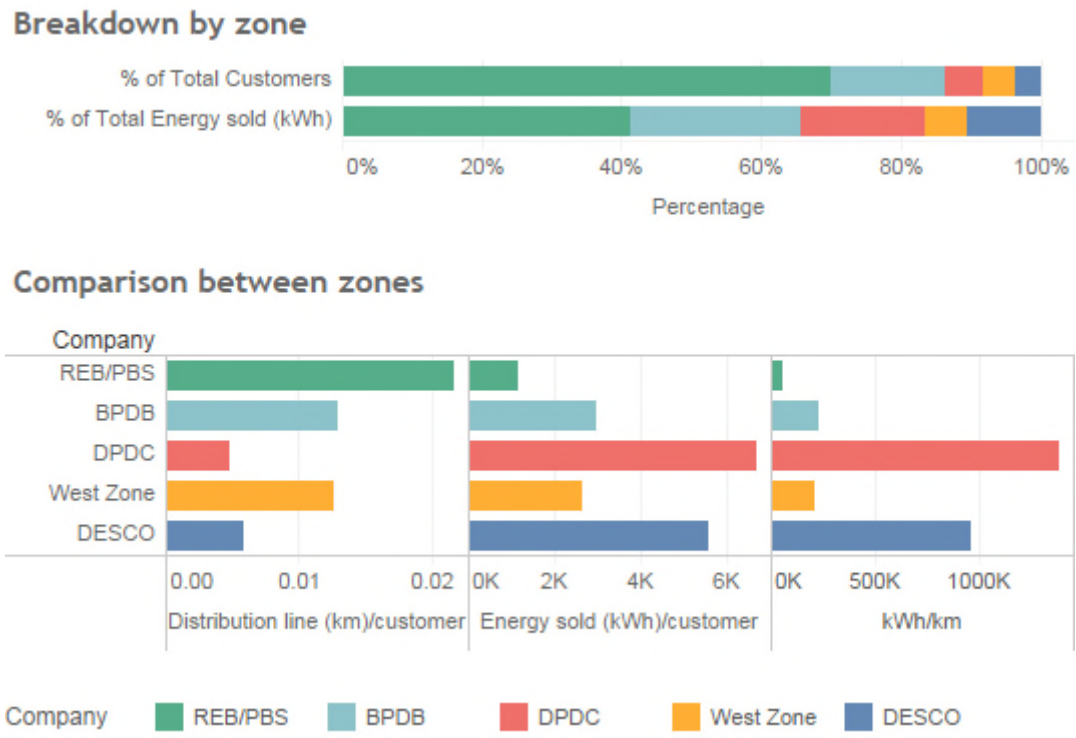


Source: Data from PGCB

Power distribution network ownership is divided between DPDC/DESCO, which serves the Dhaka division, West Zone Power Distribution Company, serving the southwest of the country, and the remaining regions covered by the incumbent BPDB. The rural electricity distribution network overseen by REB forms a parallel track, which is not confined to a specific geographical area. Very recently, BPDB was further broken up: North West Zone Power Distribution Company, first initiated in 2003, was made functional in August 2016 despite resistance from within the BPDB (Rasel, 2016). Two more new companies are expected to be created, thereby removing distribution from BPDB's direct control altogether.

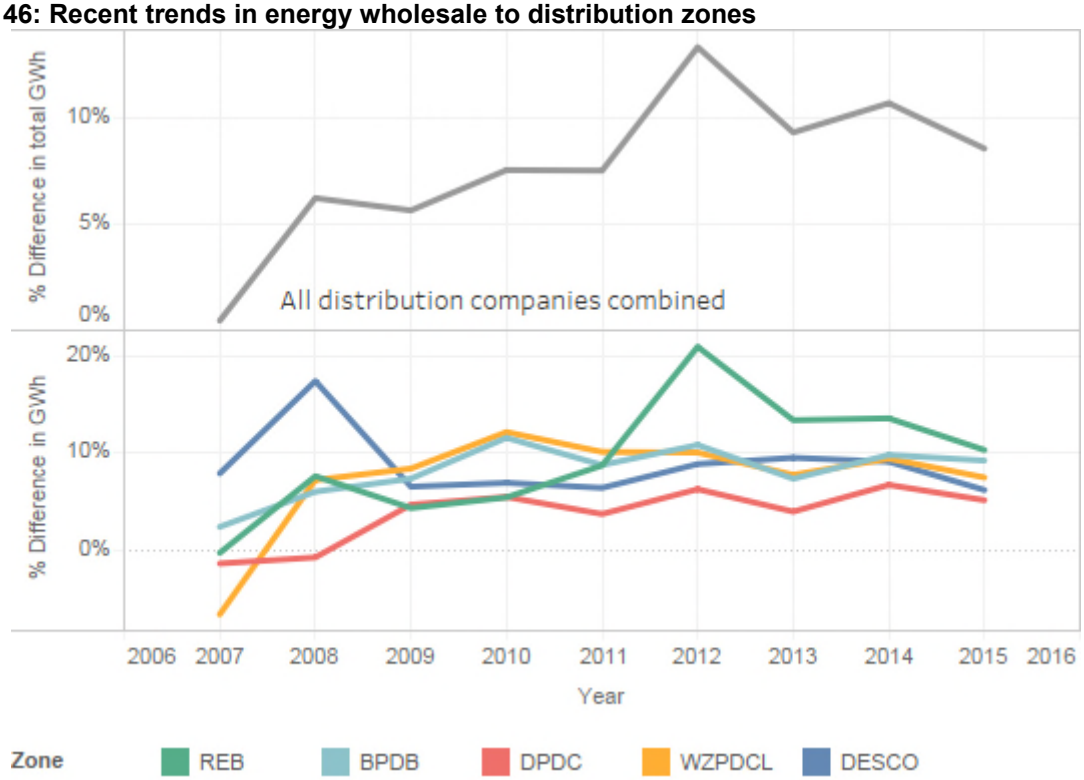
The dual-track nature of electricity distribution in Bangladesh is visible in Figure 45: The Rural Electrification Board (REB, which purchases electricity for retailing by small rural electricity cooperatives PBS) is responsible for about 40% of electricity retailed in the country, and serves more than 60% of all connected customers located in rural regions; on the other hand, DPDC and DESCO distributes almost 30% of electricity retailed to less than 10% of customers located in the capital region. This asymmetrical distribution is visible in the comparison of distribution lines and average sales volume per customer: DESCO and DPDC enjoy the highest average sale per customer, with the lowest network requirement per customer; while it is the opposite for rural electrification. West Zone power distribution and BPDB exhibit characteristics that are in-between these two extremes.

Figure 45: Characteristics of power distribution zones in Bangladesh



Source: Based on data from various companies' 2015 annual reports

Figure 46: Recent trends in energy wholesale to distribution zones



Source: Based on data from BPDB

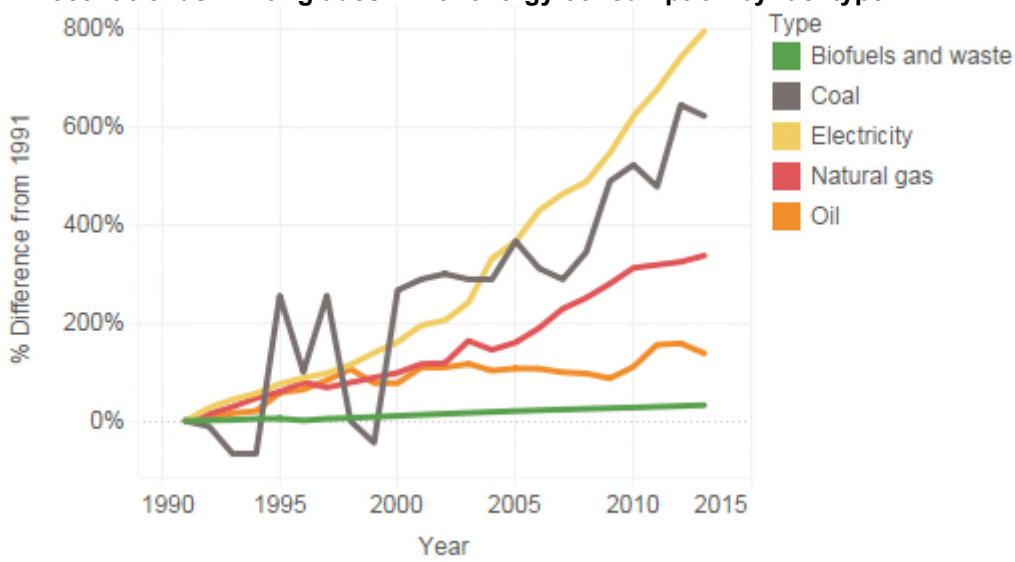
On average, the growth of electricity distributed to all zones has been accelerating: the year-to-year growth was about 5% in 2006, increasing to 10% by 2011. When examining the distributors separately, growth in electricity bought to be distributed by REB via PBS has been faster than that of other distributors (Figure 46). This is consistent with reported growth in electrification rates, since slowing down from 2006–10, as more generation capacity has become available to reduce load-shedding. Between 2009 and 2015, the national electrification rate has grown from 47% to 65% (AIIB, 2016).

Investment in the distribution network undertaken by BPDB is financed by government loans, foreign loans, and government budgetary support, despite the non-sustainability of its financial position. According to their latest financial statements, the cash inflows from operations for DPDC, DESCO, and West Zone have been mostly adequate to cover their investment plans. This means that the retail distribution tariff is set such that DISCOs are adequately funded, given the level of technical, commercial, and collection losses in the system. As described in Section 3.3.2.6 Rural electrification, expansion of the rural distribution network under REB through PBSs (not-for-profit local cooperatives) is financed by soft loans from the government and development institutions with extended repayment periods and grace periods.

3.4.2.8 Power consumption

Since 1991, Electricity consumption in Bangladesh has grown faster than that of any other major energy vector: an increase of 800% by 2013, compared to 340% for gas, and less than 200% for oil and biomass (Figure 47). Together, industrial and residential demand constitute almost 90% of total electricity consumption. Although demand from all sectors has grown considerably (>350% compared to 1991), residential and industrial consumption have grown more, with residential demand growing faster from the early 1990s to the mid-2000s, and industrial demand catching up to grow at the same rate since then (Figure 48).

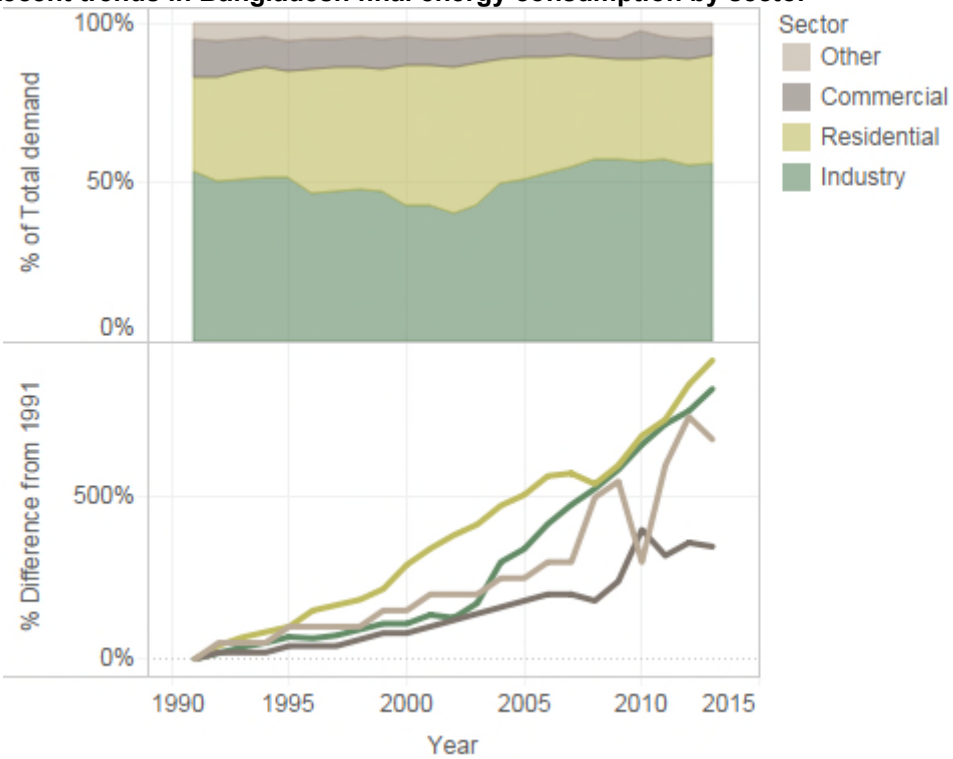
Figure 47: Recent trends in Bangladesh final energy consumption by fuel type



Source: Based on data from IEA[36]

[36] Although relative increase in coal consumption is important, its absolute size (0.65 Mtoe) is very small compared to the other types of energy vector: Biomass at 9 Mtoe, gas at 7.9 Mtoe, oil and electricity both at 3.6 Mtoe.

Figure 48: Recent trends in Bangladesh final energy consumption by sector



The increase in residential electricity consumption is believed to be driven by increasing electrification through the REB, which then slowed down in the mid-2000s, since generation capacity has not been increasing commensurately. The accelerated increase in industrial demand since 2003 can be traced to the expansion of the country's main industry (ready-made garments) due to the emergence of preferable trade conditions. As mentioned previously, part of the industrial demand is met through on-grid generation, but the relatively recent acceleration in electricity demand is also fulfilled by captive diesel and gas-fired generators owned by the industrial sector.

3.4.3 Comparison

Here, we compare the commercial logic of the two gas-to-power supply chains by examining the flow of energy and payments through the different commercial entities (See Figure 49 and Figure 50). The flow of timely payments is the key parameter of interest, because a self-sustainable and self-reinforcing cash flow is the sign of successful commercialisation. Although neither Bangladesh nor Nigeria has achieved full commercialisation of their gas-to-power supply chains, and both governments are still greatly involved in supplying loans and/or grants to sector firms, the way in which they intervene in the supply chain is different.

Figure 49: Regulatory regime and financial operations in Nigeria's gas-to-power supply chain

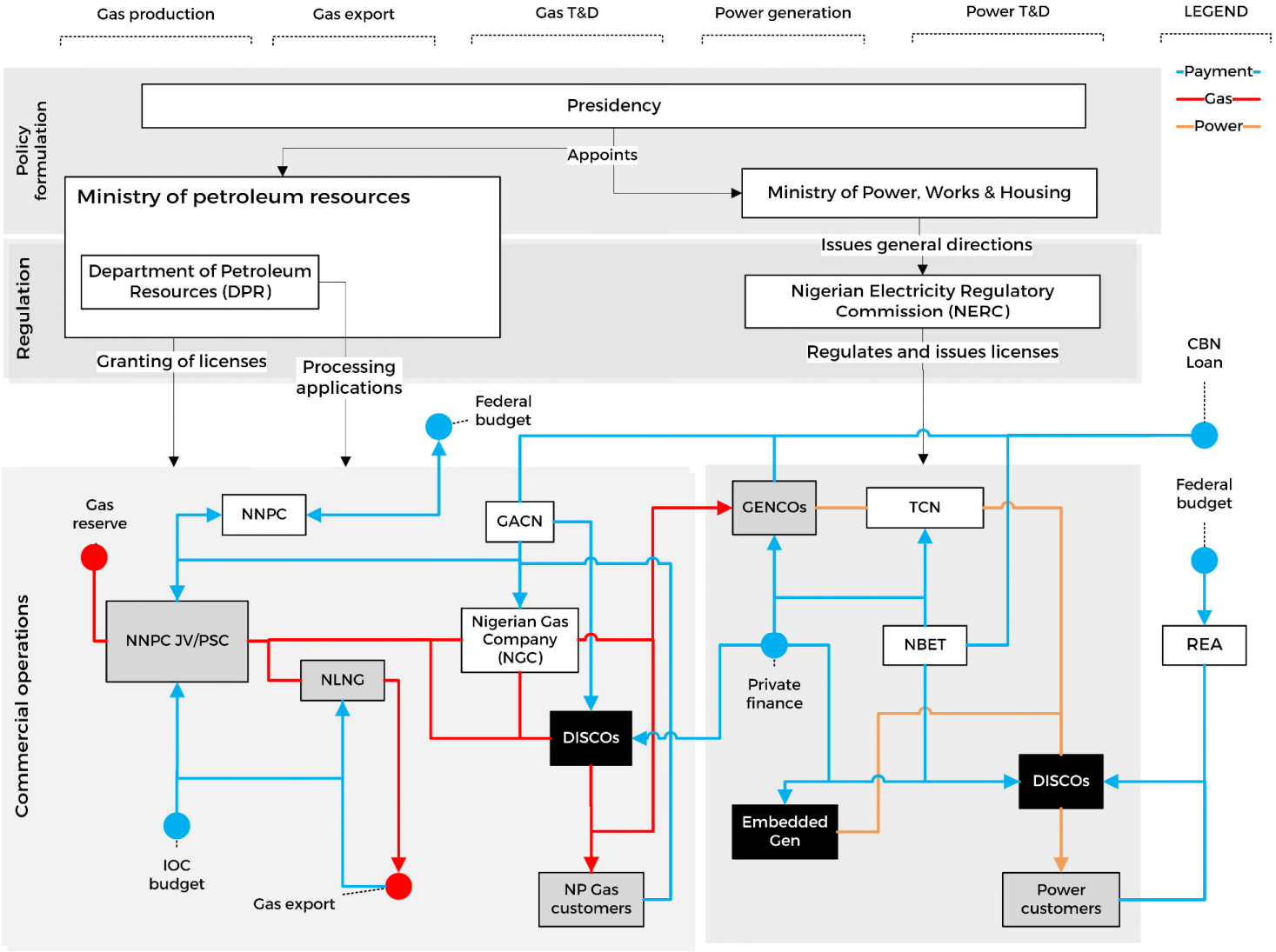
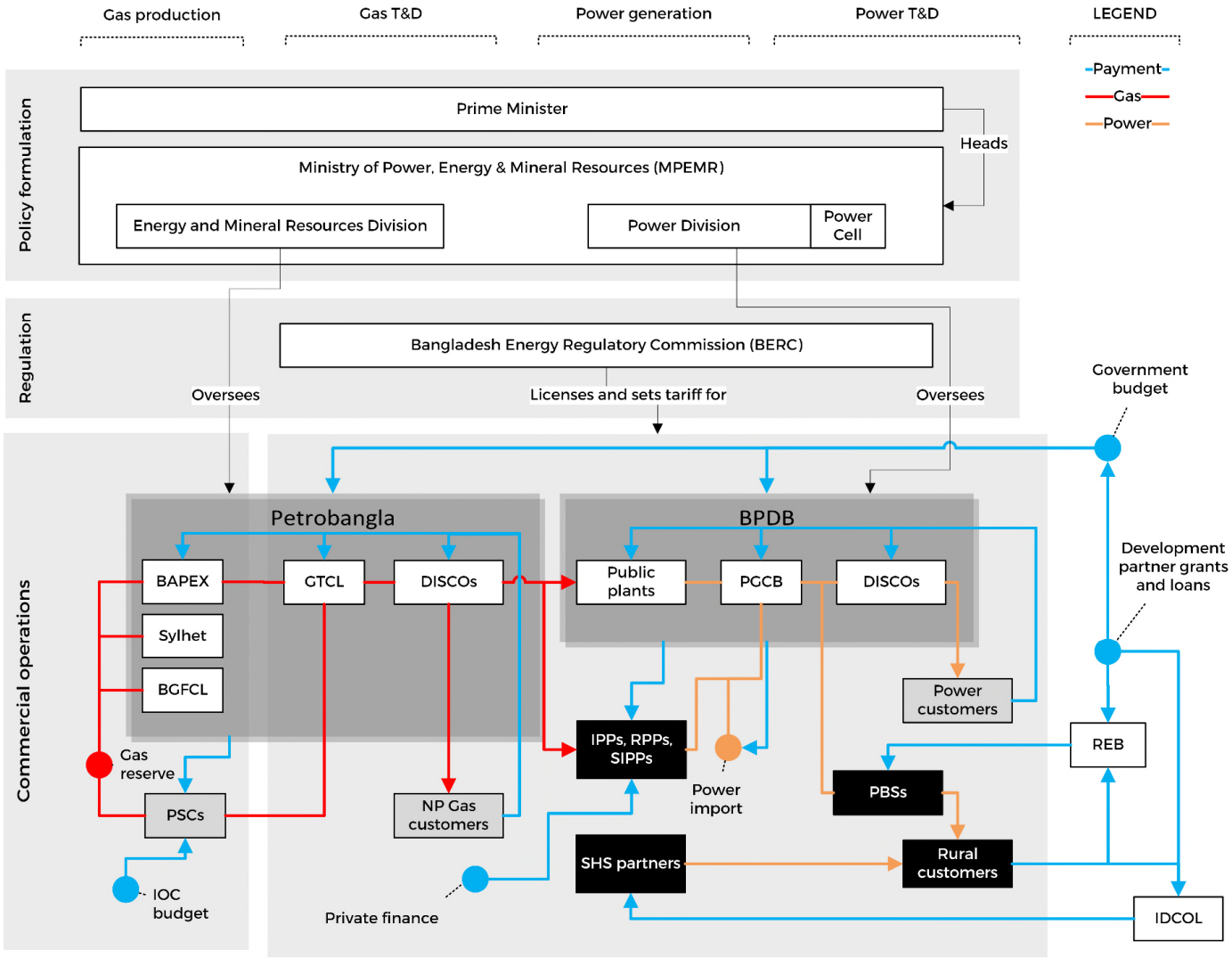


Figure 50: Regulatory regime and financial operations in Bangladesh's gas-to-power supply chain



In Nigeria, the development of gas sector infrastructure historically relied on financing from IOCs and allocations from the federal budget to NNPC (once oil and exported gas revenue has been remitted). This remains the main tendency, except for select areas where grid-connected consumption of gas has seen profitable use (industrial zones near Lagos and fertilizer production), motivating expansion of privately-owned gas distribution networks. The latter, given the lack of formal legislation and regulatory code around downstream use, is based on more *ad hoc* commercial practices. In the power sector, although privatisation at the generation and distribution level was designed to bring in private capital, poor liquidity in the sector, fundamentally traceable to high ATC&C losses, has constrained further private sector investment. As long as the losses are not reduced, even a fully cost-reflective tariff is not sufficient to curb revenue shortages, given that losses passed on to power consumers, without improving service provision, incentivise voluntary disconnection of consumers and further non-collectable bills. The Central Bank has set up a stabilisation facility to fill the revenue gap. Given the sector has been unbundled by ownership, the stabilisation facility disburses to GENCOs and DISCOs on an individual basis.

In Bangladesh, the development of upstream gas infrastructure has also relied on IOCs and government funding. However, much of the corresponding downstream infrastructure, from gas pipelines to the power distribution network, has been greatly supplemented by grants and loans from its many development partners. Compared to Nigeria, Bangladesh has been more successful at unlocking domestic private capital for investment in power generation. The country also has a liquidity problem, not due to high ATC&C losses, but because of a power retail tariff which does not reflect the full cost of power procurement (especially from the private sector). However, instead of being spread across the entire supply chain as in Nigeria, where each segment downstream owes its supplier, the revenue gap is contained in the state-owned entity BPDB (and, starting from 2014, Petrobangla). The government directly intervenes to inject funds into the supply chain through budgetary support of its state-owned corporations.

4. Discussion

This section seeks to answer the research questions presented in the introduction by synthesising the information presented in the case description above. In separating the presentation of information (Section 3) and the presentation of opinions (this section), we hope to enhance the clarity of our arguments.

4.1 On three-dimensional regulation

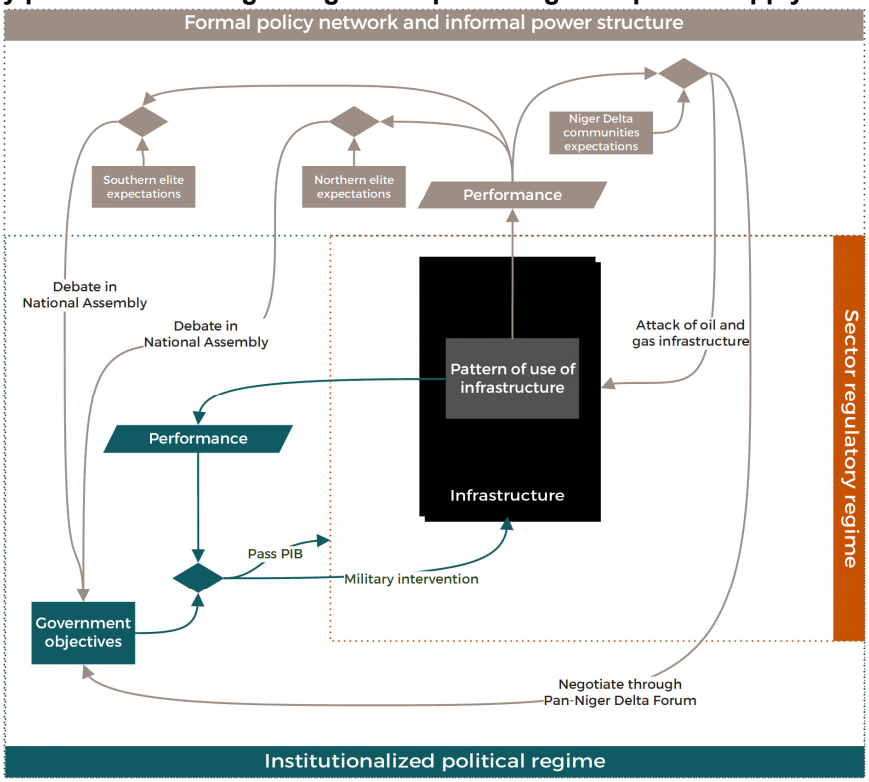
As we have established in the updated SCPR framework, agents based in the political, governmental/ regulatory, and commercial dimensions all take the actions that they perceive to be necessary to bring the performance of the gas-to-power supply chain to a state that is closer to their heterogeneous objectives. Before evaluating the performance of the gas-to-power supply chains in Nigeria and Bangladesh, we would like to highlight the conduct of political actors, governmental or regulatory actors, and commercial actors – in the forms of political balancing, governmental regulation, and industry self-regulation – and their implication for overall performance.

For regulation in the political dimension (political balancing), the basis of political affiliation (the definition of membership to interest groups) and the key sources of government revenue (resource rent vs. taxation, domestic vs. external, etc.) are found to be most influential. As for regulation taking place in the governmental dimension (regulatory in the narrow sense) and the commercial dimension (industry self-regulation), the regulatory regime determines the area for manoeuvre for the government and the industry (government-led vs. industry-led), and the set of actions that are possible to them (direct appointment of management/company objectives by the government vs. indirect influencing through

incentive embedded in tariffs). The regulatory regime in place, on the other hand, is often a product of historical political balancing between the ruling regime and its existing/potential creditors: the government often invites or allows the participation of the private sector when public funds are scarce. Privatisation is put in place either as an end (to allow private investment in IPPs/short-term rental plants to alleviate power shortage, as in Bangladesh) or as a mean (to use systematic power sector reform as a pledge of goodwill in return for debt relief, as in Nigeria).

In Nigeria, the most politicised segment in the gas-to-power supply chain is the upstream portion, due to its inclusion within existing petroleum legislation. Currently, legislators representing the Northern and the Southern states are engaged in a decade-long battle surrounding the Petroleum Industry Bill. The two camps are unable to reach consensus as to what represents a fair distribution of benefits accruing from the development of the petroleum sector. The formalisation of competition in politics is, arguably, a positive development, compared to pre-democratic times when competition for resource control was conducted informally. However, the prolonged disagreement also means that the regulatory regime for oil and natural gas (the latter being the focus for our study of gas-to-power supply chains) remains uncertain. Outside of formal politics taking place in the National Assembly, militant groups from the Niger Delta are conducting infrastructure sabotage, in order to be able to bargain with the government with respect to natural resource control, a conversation to which they feel the communities that they claim to represent are unduly excluded from (See illustrated dynamics in Figure 51). The Buhari administration is responding to the militant groups through a combination of military intervention and negotiation, but the situation remains unstable. Continued negotiations between the two groups are fragile, given a history of distrust, and any non-collaborative act on either side could be perceived as a threat and lead to an escalation of violence.

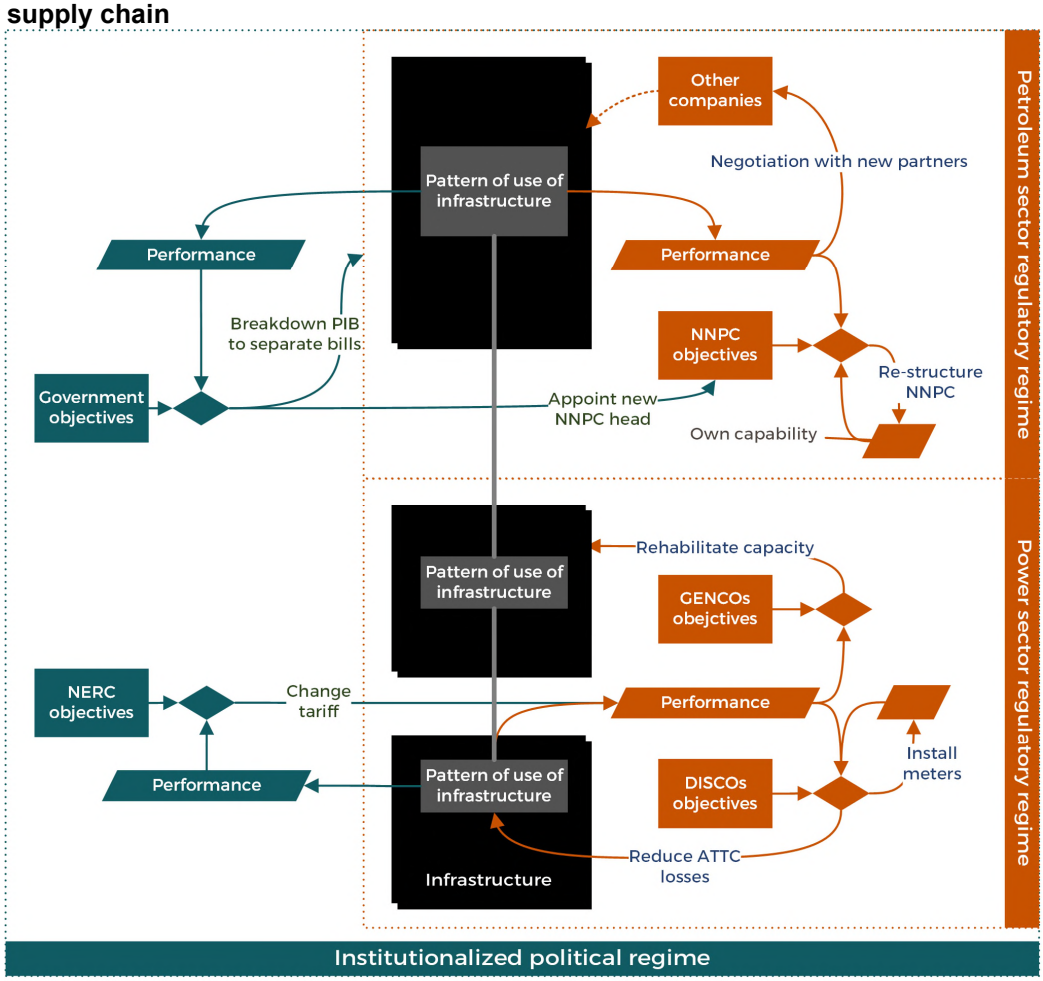
Figure 51: Key political balancing in Nigeria's upstream gas-to-power supply chain[37]



[37] Political dynamics in the downstream portion of the gas-to-power supply chain is relatively more straightforward: electricity consumers and industry firms (DISCOs mainly) both seek to affect NERC decisions relative to the setting of the retail electricity tariff, based on their perception of what constitutes a fair tariff. It is not included in Figure 51 and Figure 52 to maintain legibility of the diagram.

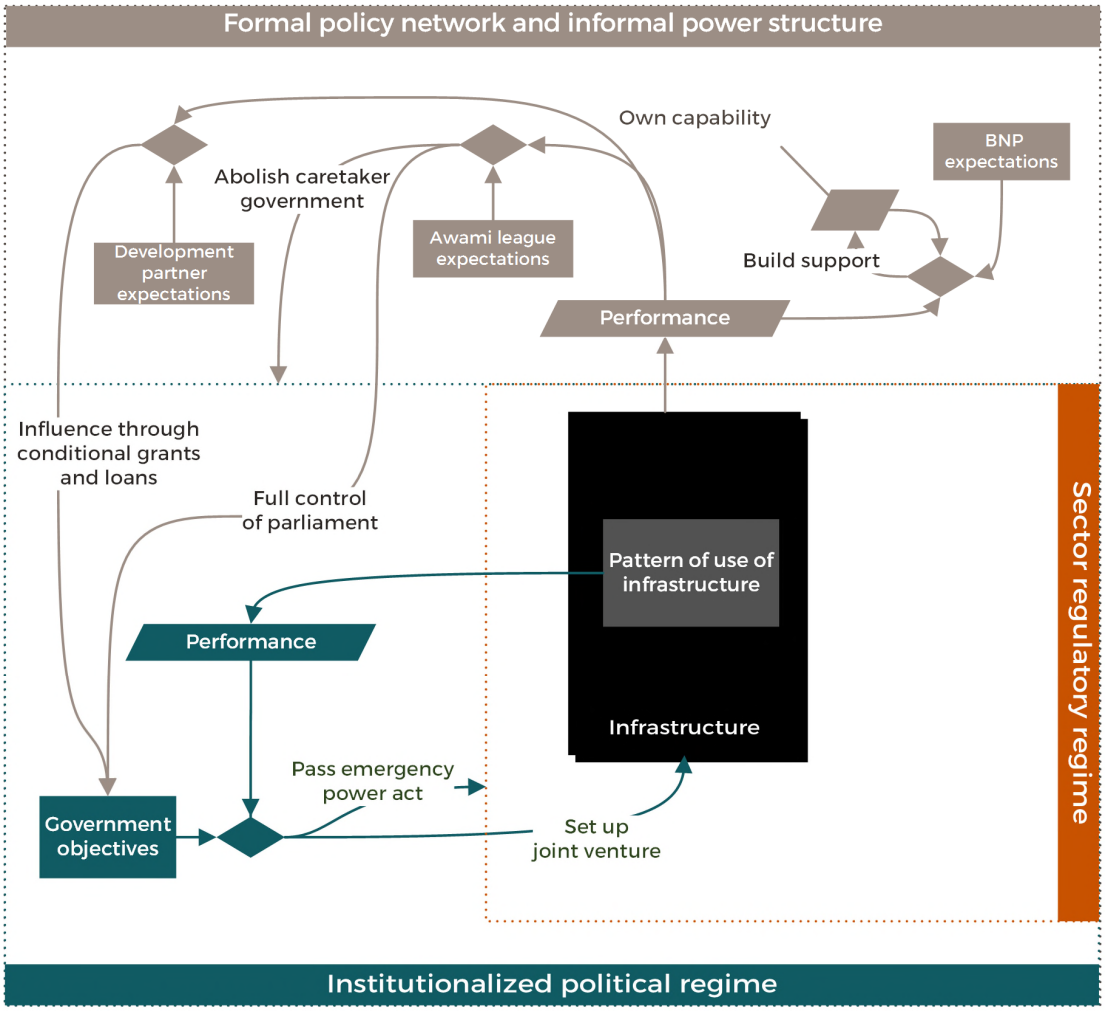
The Nigerian government, in addition to coordinating the re-writing of the newest iteration of the PIB and negotiationing with militant groups from the Niger Delta (participating in political balancing), has also made moves to improve oil and gas sector performance within the existing (pre-PIB) regulatory framework (Figure 52). Because the main entity active in the petroleum sector, NNPC, is state owned, the Buhari government was able to appoint new executives to head the company. The new management team quickly embarked on restructuring the firm, improving its commercial capability, and engaged in negotiations with potential new investors in government-to-government deals (China and India). The success of these negotiations hinges upon the attractiveness of the proposal to the counter parties' definition of desirable performance (access to crude oil, export of national services/products, etc.). On the downstream side of the gas-to-power supply chain, given all infrastructure segments other than transmission have been privatised, the main government body that interacts with private GENCOs and DISCOs is the regulator NERC via its economic regulations (as opposed directly imposing objectives upon the public arm of government involved, to the federal government, via direct impositions as in the case of NNPC). The main instrument at NERC's disposal to incentivise private companies is the setting of the electricity tariff: the allocation of costs associated with aggregate losses to the customers or the distribution companies affect DISCOs' incentive to curb losses. However, the DISCOs' ability to reduce aggregate losses is constrained by their own operational capability (low meter installation). Note that the performance of DISCOs, when measured in terms of energy delivered, is also conditional on the energy delivery taking place in the associated upstream infrastructure (not all illustrated in Figure 52), while the performance of the latter, when measured in terms of payment received, is conditional upon payment collection taking place at the power distribution level.

Figure 52: Key governmental regulation and commercial self-regulation in Nigeria's gas-to-power supply chain



In Bangladesh, the most politicised segment is power generation, where planned mega projects such as large-scale coal and nuclear power plants may prove controversial in civil society. The political balancing surrounding this segment is illustrated in Figure 53. The rule of the Awami League appears stable ever since the complete exclusion of the BNP from parliament in the 2014 elections. Despite being opposed by some observers concerned with procurement transparency, the emergency act to procure rental power, a bill passed by the Awami League government, did attract investment from Bangladesh's private sector. The increase in generation capacity is perceived as improved performance by the public, further legitimising the rule of the current government. Continued expansion of non-gas generation capacity through government-backed projects, given the lack of success with domestic gas supply expansion, remains at the centre of the Awami League's political agenda, as it prepares for new elections in 2018-19. However, it is possible that the weakened BNP leverages controversial issues in the energy sector (i.e. socio-environmental consequences of the Rampal coal power plant) to garner public support and regain its status as the formal opposition.

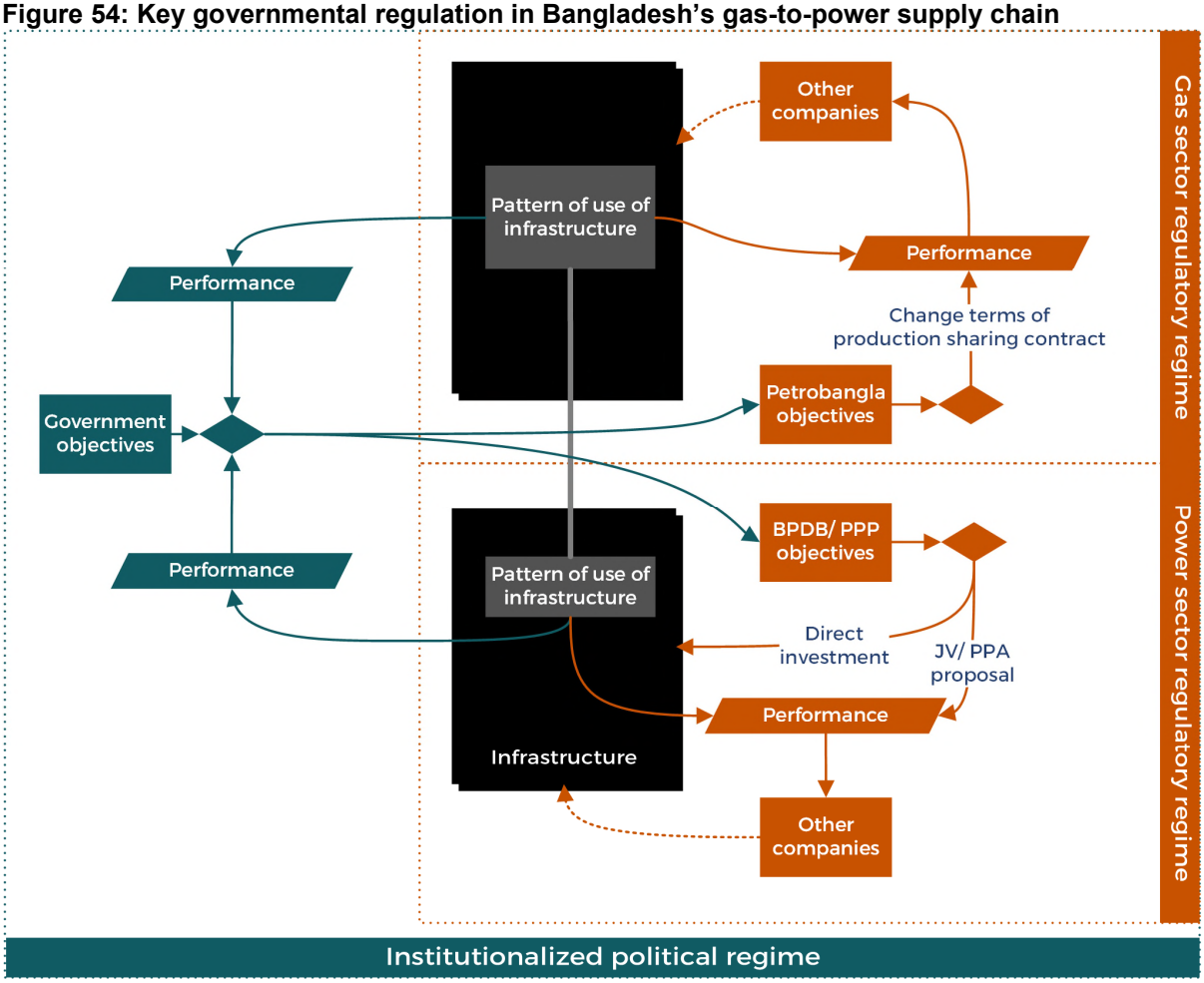
Figure 53: Key political balancing in Bangladesh's gas-to-power supply chain



The regulatory regimes for the gas and power sectors in Bangladesh share many similarities: they have evolved over the years as development partners and applied pressure on the Bangladesh government to unbundle its state-owned monopolies (Petrobangla and BPDB) along functional lines. To this day, the majority of assets in the gas-to-power supply chain are owned by the government. Petrobangla/BPDB and their subsidiaries are not for-profit entities which self-regulate based on their commercial performance; instead, they adhere to the policy directions from the Ministry of Power,

Energy, and Mineral Resources. In other words, the boundary between the governmental/regulatory and commercial dimensions is blurred. Given the mandate to expand domestic gas production and power generation capacity, both entities seek collaboration with other private/state-owned companies, either through preferable production sharing contracts or joint venture and power purchase agreements, given they cannot fulfil their mandate by themselves given their limited technical and financial resources. Petrobangla's performance in attracting foreign investment to expand off-shore gas production capacity could be a constraint for downstream power generation, unless a diverse portfolio of power generation capacity is put in place (See Figure 54).

Figure 54: Key governmental regulation in Bangladesh's gas-to-power supply chain



4.2 Evaluation of three-dimensional performance

In this section, we seek to answer the research questions raised in the introduction: How have the gas-to-power supply chains in Nigeria and Bangladesh performed? What have been the most important factors that have facilitated or detracted from the performance of the gas-to-power supply chains in these countries? What can be done to improve their performance?

4.2.1 Reserve addition and extraction

Both governments' attitudes toward natural gas have been shaped, especially in the early years of their independence, by their oil and gas endowments. Both countries are going through a dry spell in upstream exploration and development investment. Since the early 2000s, Nigeria's proven gas reserves have been stagnant, while Bangladesh's reserves have been gradually falling. However, given the different size of resource endowment of the two countries, the implications are very different:

assuming production continues at its current rate, Nigeria's reserves can sustain production for over a century, while Bangladesh's can do so for less than a decade (Figure 32). The jump in Nigeria's gas production in the early 2000s came from the commissioning of its main gas export facility (NLNG); it did not significantly expand domestic gas usage. In fact, Nigeria's domestic natural gas consumption is about 50% lower than Bangladesh's (Figure 33).

Gifted with vast reserves of oil, the more valued of the two energy commodities for direct revenue generation, Nigeria's petroleum fiscal regime is focused on oil at the expense of natural gas. The entanglement with oil, the country's most valuable natural resources, continues to undermine the development of an independent downstream regulatory regime for natural gas. The decade-long fight over the Petroleum Industry Bill, a comprehensive omnibus legislation, purported to create separate regulatory regimes for downstream oil and gas has not yet come to a conclusion. It is currently being rewritten into several parts, to be addressed in the National Assembly separately.

The uncertainty over the outcome of the issues covered by the PIB, and, in more recent years, the depressed oil price and deteriorating security, have prevented IOCs from further investing in Nigeria's hydrocarbon sector. Even when IOCs do state interest, they focus on off-shore development to steer clear of on-shore assets which are more vulnerable to infrastructure sabotage by militants in the Niger Delta. Another constraint to upstream investment is the nature of the joint ventures between the national oil company NNPC and the IOCs. NNPC is expected to pay, as one of the joint venture members, its share of capital and operating expenditure upfront to the operating partner of the venture (locally known as cash calls). As NNPC must remit its revenue (which involves the monetisation of crude oil through a very complicated and increasingly *ad hoc* and scrutinised process), then receive allocations from the federal budget, the corporation frequently experiences difficulties in fulfilling these cash calls, especially when its revenue and/or public finances deteriorates (the two are often linked, given the importance of oil revenue to the Nigerian government).

Given the above, attracting private investment into upstream exploration and development in Nigeria under existing global conditions requires the improvement of security in the Niger Delta and the finalisation of a fiscal regime that provides incentive and confidence for IOCs. Neither of these seems achievable in the immediate future. The alternatives currently being pursued by the Nigerian government are to court China and India for government-to-government deals. The success of these negotiations will depend on the alignment of strategic objectives of the multiple national governments. A new agreement that changes NNPC's financing arrangement with its joint venture partners (from cash calls to cost deduction from revenue) will lessen the burden on the public purse in the short-term, but it is unlikely to lead to an increase in investment from IOCs under current conditions.

In comparison, Bangladesh has little proven oil reserves. Natural gas is thus at the centre of its energy policy. It could be argued that the declining Bangladeshi gas reserve is a consequence of the gas sector's success: the depletion of reserve is due to the successful channelling of natural gas into its expanding domestic market since the 1970s. In exchange for the gas delivered, the government and, since 2004, the BERC have charged a gas tariff that, although reflective of the domestic production cost – thus keeping Petrobangla a solvent and profitable entity – does not necessarily reflect the opportunity cost of exporting the gas (i.e. the price that natural gas would have fetched if it were exported). As long as state-owned Petrobangla is capable of developing the gas sector by itself, financed by its operating profit, supplemented by government and development grants/loans to the gas sector, such an operational logic can be sustained. However, as Bangladesh's reserves to production ratio has dropped to less than a decade, technical and financial resources that are beyond the reach of existing actors will be required to unlock off-shore petroleum resources. That will likely require changes to the existing model. IOCs which are eligible as partners in off-shore ventures will not forfeit the additional revenue from gas exports as readily as the Bangladesh government, if there exists a significant difference between the domestic gas tariff and the possible export price of gas. The lack of interest in recent bidding rounds for off-shore oil and gas blocks is a case in point. The depressed global oil and gas environment since 2014 further dampens IOCs' appetite for investment in low-margin oil and gas jurisdictions.

The prevalence of natural gas in the country's energy use thus places the Bangladesh government in a double bind: if the gas tariffs are not adjusted to reflect the opportunity cost of export, the government will struggle to attract upstream investment; if the gas tariffs are adjusted upward, however, there is likely to be opposition from gas users from all sectors of society. An alternative to increasing domestic gas production is to increase gas supply via import, which is the route that the government has been pursuing. Given the glut in the global gas market, the current cost of imported gas has the potential of being lower than exploiting domestic off-shore gas, especially as the exploration of new off-shore resources is at a very early stage. However, if the price of imported gas rises to more than what is charged for domestic use, the government will be facing the same conundrum. It will need to face opposition from the increase in gas tariff to reflect the cost of imported supply or subsidise gas use by absorbing the difference. The latter is unlikely to be sustainable in the long-term, as the size of subsidy will balloon as supply of gas through import increases[38]. The general attitude of development partners toward energy subsidies can also limit the government's ability to dispense subsidies for gas consumption, as the financing of several energy sector initiatives require the collaboration of development partners.

4.2.2 Natural gas transportation

In terms of gas network coverage and reliability, Bangladesh outperforms Nigeria. This is not because the first is exemplar, rather, it is because the gas network in Nigeria is in an extremely worrying state. More of the regions in the South Asian country are connected to the centralised gas grid. The regions to the west of the Jamuna and Padma rivers remain isolated from the gas grid, but an extension of the transmission and distribution network has been initiated with credible sources of finance (its own operational profit, dedicated loans from the government and international development partners). As explained above, gas shortages have been a problem in Bangladesh since the late 2000s because gas demand has been outpacing output, and there is no sign of reversing this trend.

In Nigeria, only the Southern coastal states benefit from access to gas. Even before the resurgence of militant attacks in 2016, the downstream power generators experienced gas supply constraint (Figure 23). In sharp contrast, the NLNG facility enjoys access to six supply pipelines, financed by the IOCs that run the plant, which guarantees a reliable supply of gas for export. This is demonstrative of the perceived economic attractiveness of exports compared to expanding domestic gas consumption. Although the country's other gas export facility, the WAGP, does not have the luxury of multiple feed-in lines. Delivery of gas to its West African neighbours from Nigeria has been less reliable. Since 2016, a new wave of militant attack on critical oil and gas transportation infrastructure has severely disrupted the gas-to-power supply chain, exacerbating the pre-existing gas shortage, undermining progress made in generation capacity revitalisation since privatisation.

External factors such as geography and geology also help explain why the development of Nigeria's downstream gas supply chain has lagged. The task of transporting natural gas to demand centres is more difficult and complex for Nigeria, a country with a much larger territory, where the gas production fields have a wide distribution in size and are located far from industrial use centres (Figure 20 and Figure 36). Gas transportation pipelines need to cover greater distances, and the gathering network collecting gas from the oil and gas co-producing fields benefits less from economies of scale, making them more expensive to build. Bangladesh, on the other hand, benefits from the shorter distances between gas producing fields and demand centres and the production of gas from a few large reservoirs (Figure 27). In this context, the reduction of gas flaring in Nigeria since 1999, on an absolute and relative scale, attributable to the development of gas off-take projects despite unfavourable conditions, is laudable (Figure 19).

The militant activity in the Niger Delta cannot be understood outside of the political dynamics of Nigeria, described at the beginning of this section. The true motivation of militant groups, ranging from real grievance to greed, is hard to ascertain when sabotaging the Niger Delta's oil and gas infrastructure

[38] It is financially possible, if increased supply of gas to the economy allows an expansion in government revenue that is capable of off-setting the size of the growing subsidy.

can be so lucrative (looting of oil, potential security contracts, and amnesty agreements pay-out). Nevertheless, the root causes for both grievance and greed are the destruction of traditional livelihoods due to the Niger Delta's degrading environment and the region's low socio-economic development, which creates few meaningful opportunities for local youth. This remains true even for militants demobilised through the amnesty programme: the government cannot indefinitely provide monthly stipends to them. Consequently, although short-term fixes such as military intimidation and financial buy-outs are possible for the curbing of violence, ultimately, to eradicate insurgency in the region, the government will need to deliver basic public services which are overdue to further development of the Niger Delta, a process that can only be accomplished in the long run under consistent and effective policy. Given the above, the recently initiated dialogue between the Buhari administration and the Pan-Niger Delta Forum is an encouraging sign and needs to be sustained.

4.2.3 Conversion to electricity

Recognising that the availability of generation capacity is a key constraint, both countries have opened up the power generation segment to private investment. At the end of 2016, the installed capacity of both countries stood at about 12,000 MW, but their efforts to attract private investment have experienced different levels of success.

The grid-connected generation mix in Bangladesh is characterised by many small units, with the more recently installed ones (procured on 3-5-year rental basis) increasingly fired by liquid fuel given the unresolved shortage of natural gas (Figure 28). Privately-owned generation assets, commissioned since the late 1990s, represent about 40% of the total generation mix. Since 2010, after the passing of The Speedy Supply of Power and Energy (Special Provision) Act, total installed capacity has doubled as a result of combined investment from the public and (mostly domestic) private sectors.

Continued expansion of power generation capacity in Bangladesh is constrained by the continued shortage of gas and the high costs of privately-financed liquid fired plants. These costs are not fully recoverable from the retail tariff that is charged to power end-users.

To address the unresolved problem of domestic gas shortages, Bangladesh is considering both gas imports as well as diversifying the generation mix into other energy vectors. Given the fast-paced growth of Bangladesh's electricity demand, large-scale generation technology with relatively low capital costs (coal and nuclear) has been preferred in the government's energy policy. The emerging preference for these technologies is also contingent upon the availability of technical and financial sponsorship for these technologies (typically countries or state-owned corporations). The uptake of renewable generation technology at a comparable scale in Bangladesh will require the availability of similar commitments from renewable project sponsors.

Currently, instead of adjusting the electricity tariff upward to recover the higher costs incurred by private generation plants, the Government of Bangladesh has been subsidising the use of rental power through budgetary support to the power sector single buyer BPDB. This amounts to the cross-subsidisation between sectors: revenues collected by the government from other sectors are used to lower the cost of electricity for power consumers. The viability of this practice, without external assistance, is dependent on the positive externalities of increased electricity consumption on economic growth, allowing the government to recover what it has spent on electricity subsidies.

Except for three hydroelectric plants, the grid-connected generation mix in Nigeria consists exclusively of relatively large gas-fired units, despite the gas supply constraints that many power generators repeatedly experience (Figure 24). Compared to Bangladesh, participation of private capital in financing new generation capacity is low. Privately funded greenfield generation projects (IPPs), financed typically by IOCs operating in Nigeria with their own equity, only account for 12% of the overall capacity. The latest IPP in the making, Azura, financed by private equity and international financial institutions, seems to be the outlier rather than the norm.

However, it should be noted that since the privatisation of public generation assets in 2013, privately-owned capacity accounts for about 85% of overall installed capacity[39]. The greatest addition to the generation mix has been the NIPPs, which are financed upfront by all three-levels of the Nigerian government with funds from the Excess Crude Account. By building the plants before privatising them through bids, the government assumed the construction risk. In 2013, the NIPPs were sold off to private investors to recover the public funds used for their construction, but the amount raised is believed to be lower than the original expenses. The privatisation bids were tied to performance improvement. However, poor liquidity within the Nigerian gas-to-power supply chain is undermining investment in capacity rehabilitation.

The former Nigerian state-owned power utility, PHCN, no longer exists after the privatisation of its constituent GENCOs and DISCOs in 2013. In its place, a new public entity, NBET, has been set up to act as the single buyer between GENCOs and DISCOs, before transitioning to bilateral contracting. Originally, NBET was to be provided with enough capital from the federal government to plug any payment shortage that may arise in the power supply chain. However, the liquidity crisis that has emerged in the Nigerian power sector is of a scale that required intervention by the Central Bank of Nigeria in the form of an Electricity Market Stabilization Facility. The revenues remitted by DISCOs to GENCOs through NBET (at about 20-30% of amount invoiced) is far from enough to cover their own costs, not to mention supporting the restoration of out-of-service generation units and investment in additional generation. The non-payment of bills then trickles upward and is replicated between GENCOs and their gas suppliers.

4.2.4 Electricity provision

In Bangladesh, the extension of the power grid is planned in concert with power generation projects (Figure 44). Electricity access at the distribution level has improved markedly since 2009, as the commissioning of new generation capacity has been eliminating some of the constraint in supplying power to downstream customers. As further expansion of the grid-connected distribution network proceeds, (mostly through rural electricity cooperatives, overseen and refinanced by the REB, which is in turn supported by international development partners), off-grid electricity access is also expanding through the implementation of small solar home systems. The solar home systems make up the largest off-grid mini solar programme of the world: equipment installation, maintenance, and other customer facing tasks are carried out by select partner NGOs, while the financial backing, passed on to customers as microcredit loans, is also provided by international development partners.

In Nigeria, the state-owned power transmission network is often criticised as “the weakest link” in the power supply chain. Admittedly, the topography of the network and the low reserve capacity available are such that the power grid is easily destabilised by fluctuations in generation and demand (Figure 38). At the distribution level, many citizens express their frustration over the lack of improvement in terms of the electricity provided and the way in which they are charged. DISCOs’ practice of estimated billing, given that about half of all electricity customers are not metered, has left room for demand-side abnormalities such as “crazy bills” or illegal bill collection rackets.

As the main interface of the gas-to-power supply chain with end-users, the DISCOs are ill-equipped to monitor and reduce the aggregate technical, commercial, and collection losses, given the fundamental absence of measurements (customer enumeration and metering). As such, retail tariff adjustment by itself cannot be used to fill the revenue gap that is experienced by the sector in general. That is because increasing the tariff without actually reducing the aggregate losses will result in an increase in electricity bills that are growing non-proportionally with the billed customer’s actual consumption. This has the potential to further alienate electricity customers and lead to further voluntary disconnection and collection losses. Therefore, although external liquidity injection is required in the short term to unblock the flow of financial payment, we believe that, in the long run, capacity building at the DISCOs level for

[39] These figures only counts the hydro plants under concession as state-owned. All NIPP projects are counted as privately-owned, ignoring the breakdown of shares between the government and private investors.

better measurement, monitoring, and implementation of loss reducing practice is essential to improve the liquidity situation in the electricity supply chain in Nigeria.

4.3 Relevance for other countries

The development of a gas-to-power supply chain in Bangladesh, although challenging, has been facilitated by the availability of patient capital and technical advice from international development partners. The deep involvement of development partners has also helped to maintain policy consistency since the 1990s, despite the highly antagonistic nature of domestic politics. The Bangladesh government has retained control over most links of the supply chain through public ownership, but decision making is disaggregated through the unbundling of Petrobangla and BPDB into function-based subsidiaries. This allows it to plan investment in a coordinated fashion, so that supply constraints caused by the mismatch of capacity is detected and addressed in a timely manner. Patient capital from the government and development partners has been important in all segments still under public-ownership. The successful participation of civil society organisations such as rural electricity cooperatives and partner NGOs in the electricity distribution segment, facilitated by dedicated government agencies, has been the most unique aspect of the Bangladeshi experience. The involvement of the private sector in gas production and power generation has had varying performances: in the two cases, the government has shown differing levels of willingness to adjust the bulk gas/power tariff – payable to private investors for gas/power delivered – and to use subsidies to absorb the structural difference between bulk and retail tariff. Going forward, the greatest challenges are in overcoming constraints in gas supply and power generation, as domestic resources no longer suffice for unilateral action. The government's current strategy, to import LNG and to diversify the generation mix, requires existing power sector stakeholders (mainly Petrobangla, BPDB, their new subsidiaries or any newly created public entity) to develop capacities in interfacing with the international energy market and to collaborate with public and private project champions from other countries.

The development of a gas-to-power supply chain in Nigeria is most adversely affected by its political dynamics. Most directly, militant attacks on oil and gas transmission pipelines jeopardise the performance of the entire supply chain. Downstream power generation is interrupted, which can easily lead to the collapse of the national power grid given its topology and low capacity to absorb shocks. Upstream oil and gas production is also interrupted, which reduces the key revenue stream of the government, lowering its capacity to financially intervene in the supply chain.

Militancy in the Niger Delta is a problem that has its root cause in the poor development of the oil and gas producing Nigeria Delta, given a history of government non-accountability and ethnic division. Short-term solutions such as military intervention and truce through financial compensation can alleviate the crisis, but they do not eliminate the ultimate sources of grievance that legitimises militancy, which means that it could resurface whenever the military might/ financial compensation from the government is weakened/lowered (as it did in 2016).

The other key constraint in the Nigerian gas-to-power supply chain is the payment gap, which is most prevalent at the power distribution segment due to extremely high aggregate losses. It prevents revenues from flowing back through the entire supply chain. The power transmission, generation, and gas supply segments all suffer from a lack of liquidity, which endangers their capacity to maintain and expand infrastructure under their control. The reduction of aggregate technical, commercial, and collection losses requires, before all else, timely measurement and monitoring of the loss levels, which the Nigerian distribution companies have not been able to achieve despite privatisation. This deficiency has been recognised by the original architects of power sector privatisation, and the government's policy for the power sector has transformed from one that prioritises structural reform to incremental capacity building, which is a welcome change.

From the experiences of Bangladesh and Nigeria, we distil three lessons for other developing countries hoping to develop their own gas-to-power supply chain. First, in a highly interdependent environment such as the gas-to-power supply chain, the failure of the weakest infrastructural/commercial link can easily cancel out performance improvement in the other segments. In Bangladesh, the weakest link has been the constrained supply of domestic natural gas. The Bangladesh Government has been working

to overcome this core constraint using other generation fuels (liquid fuel in the recent past, and coal/nuclear for the future) and will start to import gas in the near future. In Nigeria, multiple weaknesses exist, but the most urgent one is the frequently sabotaged gas transmission network that can cause technical cascading failure. Insolvency of the power distribution segment, aggravated by poor service provision due to technical cascading failure, on the other hand, causes a cascading failure in financial flow in the opposite direction. Therefore, restoration of the social order in the Niger Delta, and eventually improving electricity provision is required before the liquidity crisis can be definitively addressed. Secondly, privatisation is not an end, but a means to increase operational efficiency and investment in infrastructure development. In countries where technical capacity and investment is not readily available from the private sector, such as the case in Nigeria, especially at the power distribution level, privatisation has been a poor tool to improve performance. In contrast, collaborating with international development partners which are equipped with the needed funds and expertise is an alternative means to increase operational efficiency and investment. Bangladesh has demonstrated that improvement in performance in the state-owned segments is achievable, without resorting to privatisation. Finally, we have found that, while mapping the dynamics of political balancing, the basis of political affiliation and the key source of government revenue are the most salient factors in explaining the differences in political dynamics in Nigeria and Bangladesh, as they pertain to the development of their gas-to-power supply chains. More specifically, these two factors define the interest groups active in political balancing and the mental frameworks in which interest groups define energy sector issues, which subsequently constrain the government's energy policy decisions.

5. Conclusion

Most of the world's future growth in energy demand is expected to come from the developing world. Facing the dual challenge of decarbonisation and universal energy access, some developing countries, especially those endowed with domestic natural gas resources, have embarked on the path to develop a gas-to-power supply chain. Nigeria and Bangladesh, two of the most populous countries in the world, have adopted such a strategy. This paper examines the experiences of these two countries in developing a gas-to-power supply chain, with the goal of offering insights for other developing countries which are pursuing or considering the same strategy. We seek to answer the following questions: How have the gas-to-power supply chains in Nigeria and Bangladesh performed? What have been the most important factors that have facilitated or detracted from the performance of the gas-to-power supply chains in these countries? And, what can be done to improve their performance? Finally, to what extent can the findings of this study be generalised to other countries?

A multi-step approach has been used to answer our research questions. First, we existing perspectives on the determinants of gas and power sectors performance through a comprehensive literature review, which is integrated into our original Structure-Conduct-Performance-Regulation (SCPR) framework. Then, case descriptions for Nigeria and Bangladesh are presented based on our SCPR analytical framework, in turn focusing on the performance viewed within the political, governmental/regulatory, and commercial dimensions. After that, based on the data gathered under the case description, we discuss the causal dynamics that are in place in Bangladesh and Nigeria and suggest measures that may improve gas-to-power supply chain performance. We also discuss the extent to which the causal dynamics observed can be generalised to other countries.

The basis of political affiliation and the key sources of revenue for the government are found to be the most important determinants in shaping political balancing in Bangladesh and Nigeria.

Nigeria's dependence on export-based oil-derived revenue bred a culture of non-accountability at all levels of the government, which further reinforced its dependence on oil rent. It also fostered a highly competitive political environment for petroleum sector legislation, divided along regional/ethnic lines. The exclusion of some interest groups from formal politics eventually evolved into militancy in the Niger Delta, where militant groups use infrastructure sabotage in their home territories to bargain with the

political establishment. The militancy in the Niger Delta has severely disrupted the performance of the entire supply chain through cascading technical failure. Short-term solutions such as military intervention and financial compensation is required to put a stop to the violence, but in the long run, social-economic development of the oil and gas producing regions needs to improve for the eradication of insurgency to be permanent. Moreover, given the Nigerian power sector's heavy reliance on access to natural gas, if gas infrastructure sabotage is not eliminated, performance improvement only focused on the power sector will not be enough to improve end-user experience of service provision.

Bangladesh, relatively homogeneous in demography, has experienced highly antagonistic dynamics among its political elite. But, its people do not experience the same degree of division as in Nigeria. The sustained participation of international development partners, backed by their financial and technical contribution to development projects, has been able to steer energy sector policies in the same direction, regardless of the political party in power. The government's revenue, based mainly on taxation of domestic industries such as the highly successful ready-make garment sector, drives the government to improve electricity provision to society, in support of continued economic development. The measurable improvement in energy services legitimises the current government, improving its ability to exclude the opposition from formal politics, thus Bangladesh experiences a period of outward stability. However, opposition to the government might leverage energy sector controversies to improve their own standing with the public.

The existing regulatory regimes in Nigeria for gas and power demonstrate very different ethos. Reform in the gas sector, entangled with oil, the country's most prized natural resources, is extremely difficult as control over the petroleum sector is heavily politicised. The uncertainty over the petroleum sector regulatory regime is one of the primary deterrents to IOC investment in the sector. Reform in the power sector, on the other hand, has been one of the boldest in Africa, with full unbundling and privatisation of generation and distribution segments. Nevertheless, private investment into the gas-to-power supply chain is discouraged by the liquidity gap that pervades the domestic gas and power sectors. The power distribution companies' inability to implement monitoring and reduction of aggregate losses is at the centre of the liquidity crisis, which eventually required intervention by the Central Bank of Nigeria.

Unbundling of the gas and power sectors is more extensive in Bangladesh. However, the Government has retained exclusive ownership over most of the supply chain, except for the segments of gas production and power generation. Investment in the state-owned segments has been forthcoming due to grants/loans from development partners and the government's expanding revenue base as the economy grows. Success in attracting private investment into power generation has been greater than for gas production, given the smaller scale of the projects involved and the government's willingness to use subsidies to buffer the difference between bulk and retail power tariffs. To relieve the constraint caused by the perennial shortage of gas since the late 2000s, the government is resorting to gas import and diversification of its generation mix.

Together, the evidence from Bangladesh and Nigeria demonstrate that privatisation is not the only path to improve operational efficiency and investment in gas and power infrastructure development. Adopting privatisation does not automatically guarantee improvement in operational efficiency and investment, especially when the private parties involved have low financial and technical resources. In the absence of resourceful private partners, collaboration with multilateral development banks and other development partners is a credible way for the government-owned supply chain segments to access capital and technical expertise.

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