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

In a recent paper we provide a comprehensive analysis of the gas to power supply chains in Nigeria and Bangladesh. This short article draws on the results of that study.

Background

Nigeria and Bangladesh are two populous developing countries (ranked 7th and 8th in the world, respectively) which have adopted a domestic natural-gas centred electrification strategy. Together, Nigeria and Bangladesh have 149 million people that lack access to electricity, or about 10% of the world's population without access to electricity. Figure 1 shows that they are the countries with the highest percentage of gas-fired generation among nations which do not yet have universal electricity access. 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: How have the gas-to-power supply chains in Nigeria and Bangladesh performed[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? And, what can be done to improve their performance? Finally, to what extent can the findings of this study be generalised to other countries? As this is an abridged version of the research paper, we focus on presenting the findings of the comparative study.

The analytical framework used is the Structure-Conducted-Performance-Regulation (SCPR) framework developed by Peng & Poudineh (2016), encompassing the political, governmental/regulatory, and commercial dimensions of two industries. 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. The first version was found helpful in anchoring the analysis of the UK's gas-to-power supply chain development (Peng & Poudineh, 2016).

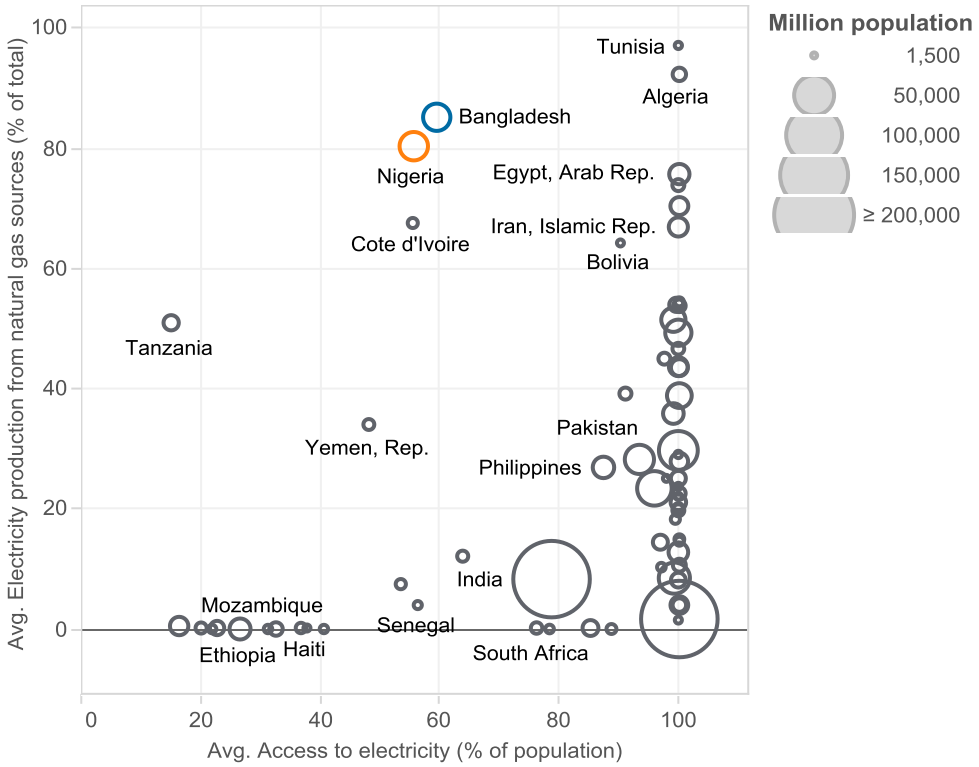
As a tool to study gas-to-power supply chains and their governance, the SCPR framework is original in its broad scope and focus on evolving causal dynamics, both with the goal to support systematisation of findings from different country-based studies. However, it should be stressed that the SCPR framework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

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

developed and tested, and its value lies in the stimulation of future research, compatible for cross-examination and synthesis.

In the following sections we summarise the most important causal mechanism(s) affecting the performance of gas-to-power supply chains in Nigeria and Bangladesh, based on multi-dimensional data gathered using the SCPR framework. For the fully structured case descriptions, please refer to the accompanying full-length working paper.

Figure 1: Natural gas-fired generation vs. Electricity access for select world countries (Data from World Bank)



Political economy of Nigeria and Bangladesh

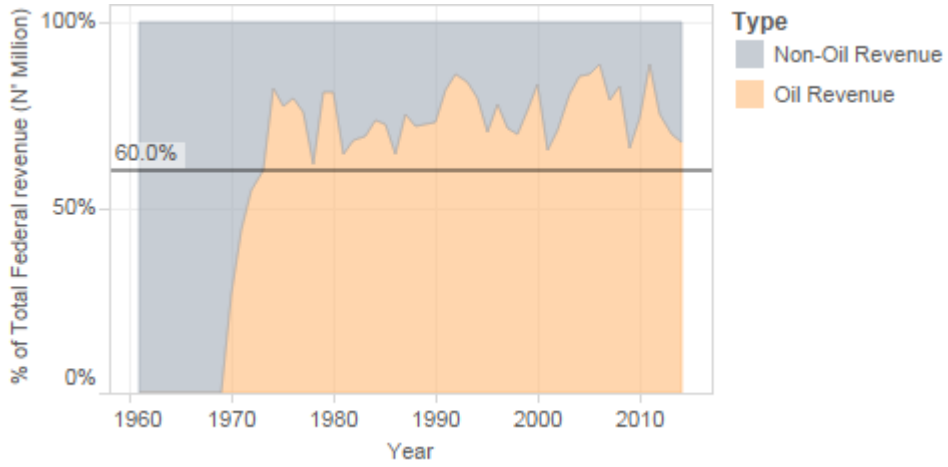
Before evaluating the performance of the gas-to-power supply chains from the perspectives of political, regulatory, and commercial actors, we would like to comment on the political environments of Bangladesh and Nigeria, highlighting how different political dynamics have affected government objectives and their decisions in energy policy. The energy policy in place, subsequently, shape the regulatory environment and commercial decisions made by firms.

Nigeria has three competing majority ethnicities and a host of minority ethnicities, distributed across the country in zones, divided by faith and historical experiences, bound together by their struggle for independence from British rule. Since independence in 1960, the lack of trust between the ethnic groups has bred a highly competitive political culture, in which political affiliation was delineated along ethnic and religious lines and politicians' allegiance was to their own in-group instead of the nation at large (Usman, 2016). Such antagonistic politics continued unfettered from the 1967-70 civil war until the return to civilian rule in 1999. Moreover, Nigeria's key natural resources, its hydrocarbon deposits, are mainly located in the Niger Delta, the territory of the Igbos and Southern minority ethnicities. However, as a federation, the benefits accruing from the development of hydrocarbon resources are to be distributed between all its constituents. Therefore, the perennial debate that has dominated the Nigerian

political arena is framed by different ethnic/regional groups' perception of rightful distribution of costs and benefits from the country's hydrocarbon production.

In the 1970s, when the military regime in power shifted the core of government revenue from taxation to oil-based revenues (as oil price soared due to the 1973 oil crisis, see Figure 2), it went on to create a culture of non-accountability: instead of working on improving socio-economic development of the society over which it rules to maintain legitimacy, the government only needs to hold on to control over the country's oil resources and the revenues deriving from that to maintain its operations and basis of power (Falola & Heaton, 2008). The decoupling of performance from revenues is a dynamic that is also observed in other parts of Nigerian society, as wells as in the state governments and Local Government Authorities (which receive revenue allocated from the Federal Account rather than local taxation) (Taiwo & Moyo, 2011).

Figure 2: Composition of Nigeria's federal revenue (Data from the Central Bank of Nigeria)



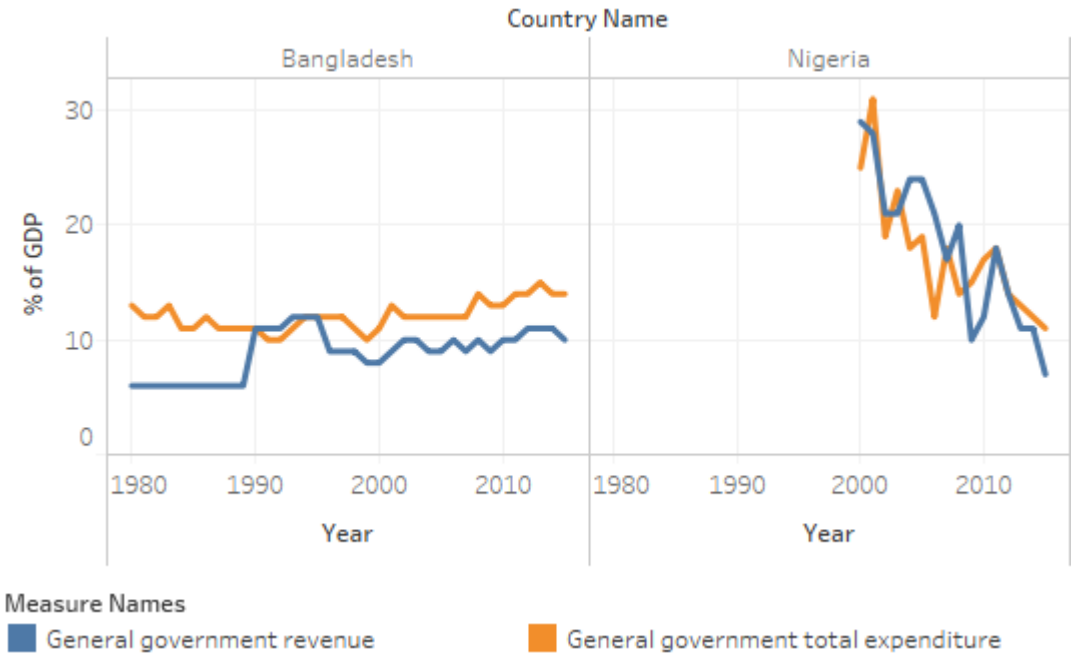
After the transition to civilian rule in 1999, power sharing practices such as zoning and the Federal Character Principle have evolved to diffuse ethnic/regional tension (Ololajulo, 2016). The victory of President Buhari and his All Progressives Congress party in the 2015 election is believed to be a return to the zoning principle, after a relapse during the rule of former President Goodluck Jonathan. The attempt to draft new legislation for the petroleum sector since the democratic transition (Petroleum Industry Bill (PIB) of 2008 and its successors), where legislators representing different regions explicitly debate oil revenue allocation (among other items) is also reflective of the movement of Nigerian society toward further formalisation of political interests.

The transition to civilian rule has done little to ease the Nigerian economy's dependence on oil revenue. Low tax collection means that the government has not able to expand its revenue base as the non-oil economy has expanded since the 2000s; government revenue as a share of GDP fell instead of remaining constant or increase (Figure 3). Given the centrality of oil revenue to all government levels, different regional perceptions on what constitutes a fair share have stalled the passing of the PIB for almost a decade, to the detriment of the development of an independent natural gas sector. The structural weakness of the Nigerian economy, widely known, but easily ignored during years of high oil prices, was revealed once more after 2014, as decreased oil revenue compounded by other events/actions (ineffective monetary policy, militant attacks on oil and gas infrastructure) pushed the country into a recession in 2016 (FT View, 2016).

It is likely that previous and the most recent waves of militant attacks arise from a mutually reinforcing pair of factors – dependence on oil revenue and a culture of non-accountability. In the long term, militancy in the Niger Delta evolved out of local communities' grievance for the non-proportional cost and benefits they bear regarding oil production. The low level of socio-economic development in the region, a consequence of government non-accountability, sustains militant movements, providing them with legitimacy, while the lack of meaningful opportunities (especially outside of the petroleum sector),

a consequence of dependence on oil revenue (or non-development of non-oil sectors), sustains militant movements with fresh recruits (Schultze-Kraft, 2013). Even when militant attacks are curbed by financial incentives, such as the 2009 Amnesty Programme, non-accountability and dependence on oil revenue makes it a solution viable only in the short term: the funds that are used to pay for the amnesty programme are eroded by questionable oil revenue remittance practice and exogenous price shocks.

Figure 3: Trends in fiscal revenue and expenditure for Nigeria and Bangladesh (Data from the IMF)



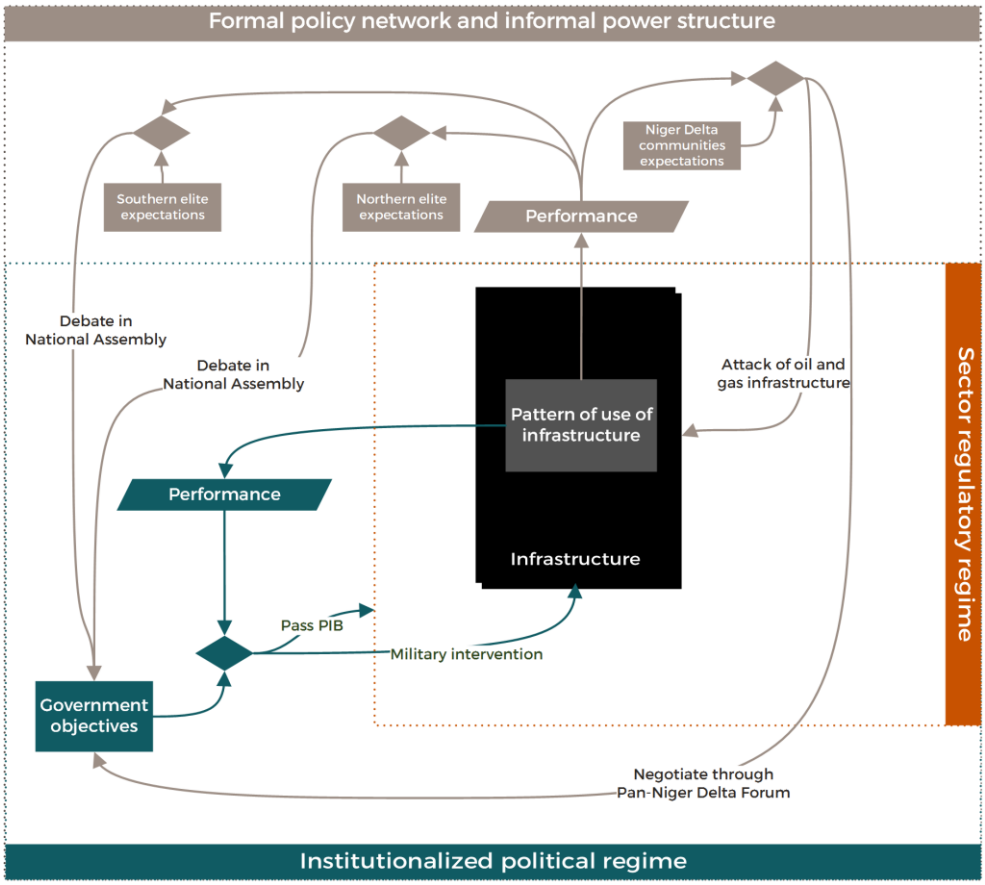
Bangladesh, compared to Nigeria, is a country that is much more homogeneous in its demography. The national identity was forged as it pursued independence, shedding other religion and ethnicities in the process. The competition for political power is thus organised around the patronage networks of the two major parties, which cannot readily call upon ethnic or regional differences to reinforce their own positions (Khan, 2011). However, judging by developments since 2006, the Awami League and the Bangladesh Nationalist Party (BNP) have not yet agreed on any formal or informal mechanism to share power peacefully. Their antagonism has not had the same divisive impact over citizens, though, as antagonistic politics have had on Nigerians. Thus, Bangladesh benefits from a national cohesion not yet achieved in Nigeria.

In the absence of significant resource rent, most of the Bangladesh government's revenue comes from taxation. Maintained at a rate of 10%, revenues grew as the economy took off thanks to the development of the export-oriented ready-made garment industry, an opportunity that the country seized through specific enabling measures to exploit advantageous external conditions (Figure 3). Thus, the downturn in global oil and gas prices have not been stressors to the Bangladeshi economy (other than discouraging upstream investment from international oil companies (IOCs). As Bangladesh is preparing for the import of LNG, a low-price environment is even to the country's advantage. More importantly, the non-centrality of the petroleum sector to the economy means that passing natural gas-related legislation in Bangladesh is much less contentious than in Nigeria. In addition, development partners such as the Asian Development Bank have played important roles in shaping energy sector legislation, by granting sector-specific development assistance associated with conditions such as the promotion of private sector investment and the corporatisation and unbundling of state-owned entities. Such a source of funding provided specific targets that the government is required to meet, encouraging continuity in government policy making, regardless of the party in power.

The Awami League's hold on power has appeared stable ever since the complete exclusion of the BNP from parliament in the 2014 elections. When she assumed office in 2009, Prime Minister Hasina, now also serving as the Minister of Power, Energy, and Mineral Resources, has promised to improve the performance of the power sector, then plagued by a shortage of gas supply and power generation capacity. Despite being opposed by some observers concerned with procedure transparency, the emergency act to procure rental power did attract investment from Bangladesh's private sector (Ebinger, 2011; Sultana, 2016). The increase in generation capacity is perceived as improved performance by the public, further legitimising the current government's rule. Continued expansion of non-gas generation capacity, 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.

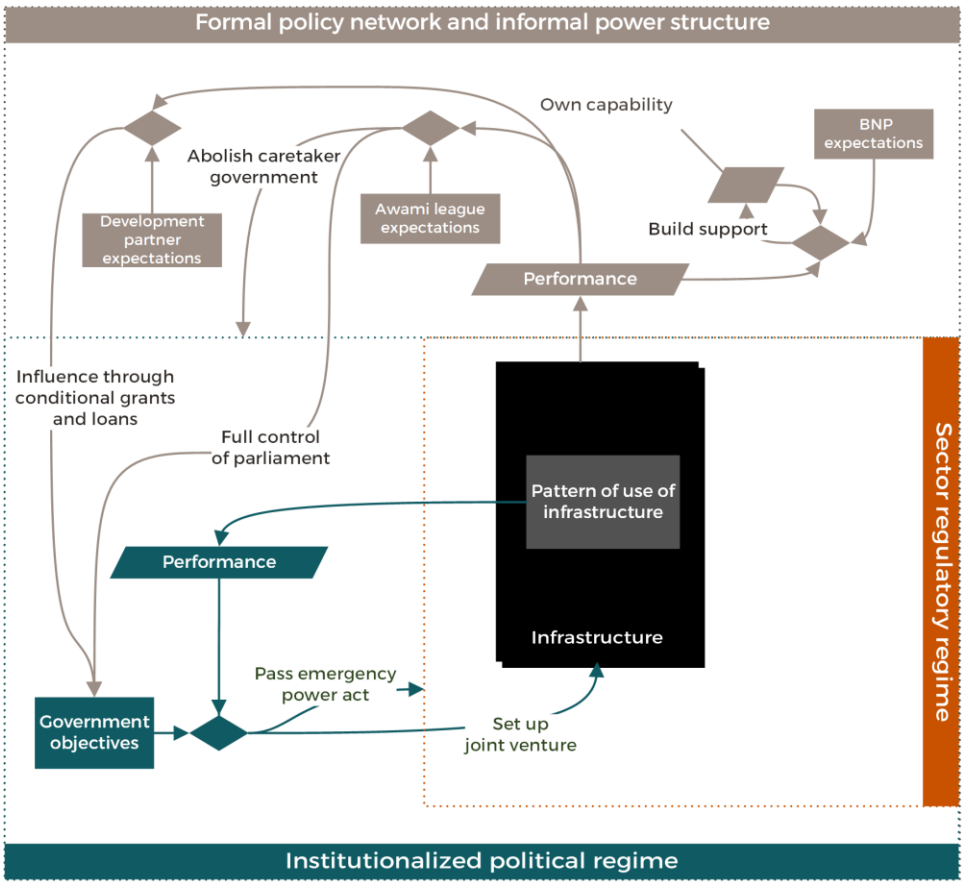
In sum, the political balancing that has taken place in Nigeria and Bangladesh is fundamentally shaped by the basis of political affiliation (ways in which core interest groups are defined), and the key sources of government revenue (tax vs. resource rent, domestic vs. external). The main political dynamics active in the two countries are illustrated in Figure 4 and Figure 5. 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. In Bangladesh, the most politicised segment is power generation, where planned mega-projects such as large scale coal and nuclear power plants may create division in civil society.

Figure 4: Key political dynamics in Nigeria's upstream gas-to-power supply chain[2]



[2] 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 Nigerian Electricity Regulatory Commission's 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 4 to maintain legibility of the diagram.

Figure 5: Key political dynamics in Bangladesh's gas-to-power supply chain



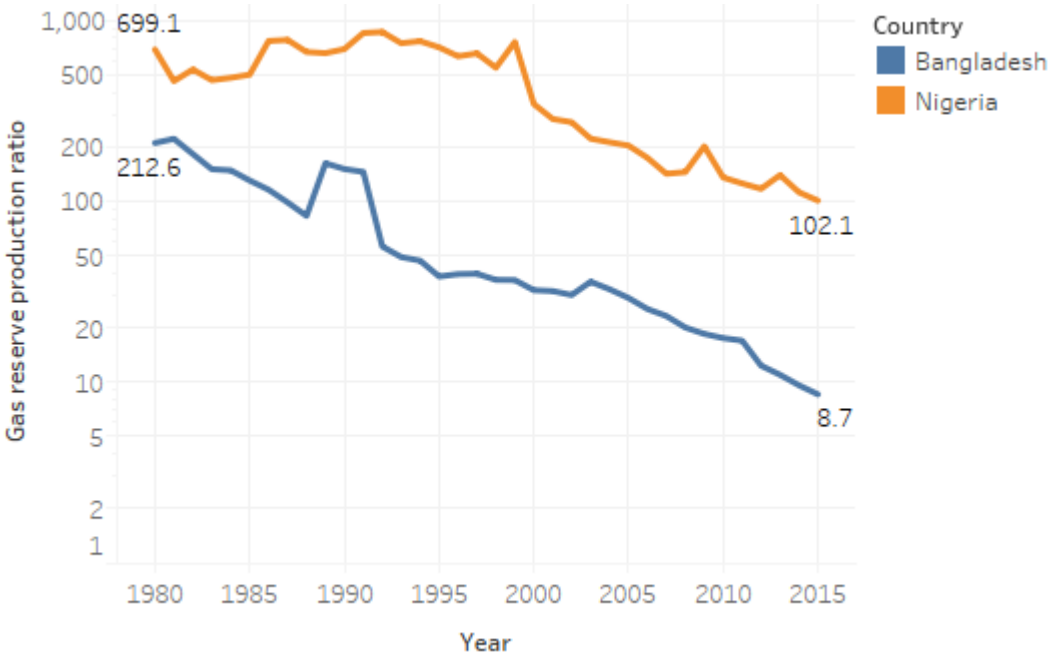
Evaluation of three-dimensional performance

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? We begin our analysis from the most upstream segment of the supply chain (i.e., gas reserves and extraction) and gradually move towards the most downstream segment (electricity provision). In each segment the analysis will include political, regulatory and commercial dimensions.

Reserve addition and extraction

The oil and gas endowments of the two countries have shaped, especially in the early years of their independence, the governments' attitudes toward natural gas. 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 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 6). A jump seen in Nigeria's gas production in the early 2000s came from the commissioning of its main gas export facility (Nigerian Liquefied Natural Gas, NLNG); it did not significantly expand domestic gas usage. On an absolute scale, the domestic consumption of natural gas in Nigeria is about 50% lower than in Bangladesh.

Figure 6: Reserve production ratio of natural gas for Bangladesh and Nigeria (Data from BP)



Gifted with vast reserves of oil, the more valued of the two energy commodities for direct revenue generation, Nigeria's petroleum fiscal regime focuses on oil at the expense of natural gas. This not only has had implications for the industry's upstream segment but also downstream. The entanglement with oil, the country's most valuable natural resource, 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, among other goals, has not yet achieved a conclusion. It is currently being rewritten into several of its constituent 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 venture agreements between the national oil company Nigerian National Petroleum Corporation (NNPC) and IOCs. NNPC is expected to pay, as one of the joint venture members, its share of expected capital and operating expenditure upfront to the operating partner of the venture (locally known as cash calls). However, 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 finance 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 incentives 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 recent agreement that will see NNPC change the financing arrangement for its joint ventures (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 does not have a significant amount of proven oil reserves. Natural gas is thus at the centre of its energy policy. It could be argued that declining Bangladeshi gas reserves are 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 regulator Bangladesh Energy Regulatory Commission have charged a gas tariff that reflects the domestic production cost – thus keeping Petrobangla a solvent and profitable entity. The tariff does not, however, 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 the reserves to production ratio drops 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, and the government may have to change course. 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 reflects these concerns. 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 exports, the government's hopes for attracting upstream investment will be at risk; if the gas tariffs are adjusted upward, there is likely to be opposition from gas users from all sectors of society. An alternative to increase 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 gas imports has the potential of being lower than exploiting domestic off-shore gas, especially when the exploration of off-shore resources is at a very early stage. However, if the price of imported gas is higher than that charged for domestic use of gas, the government will be facing the same conundrum. It will either face domestic opposition over increasing the gas tariff to reflect the cost of imported supply or it will have to 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 gas imports rise[3]. The negative view development partners have towards 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.

Natural gas transportation

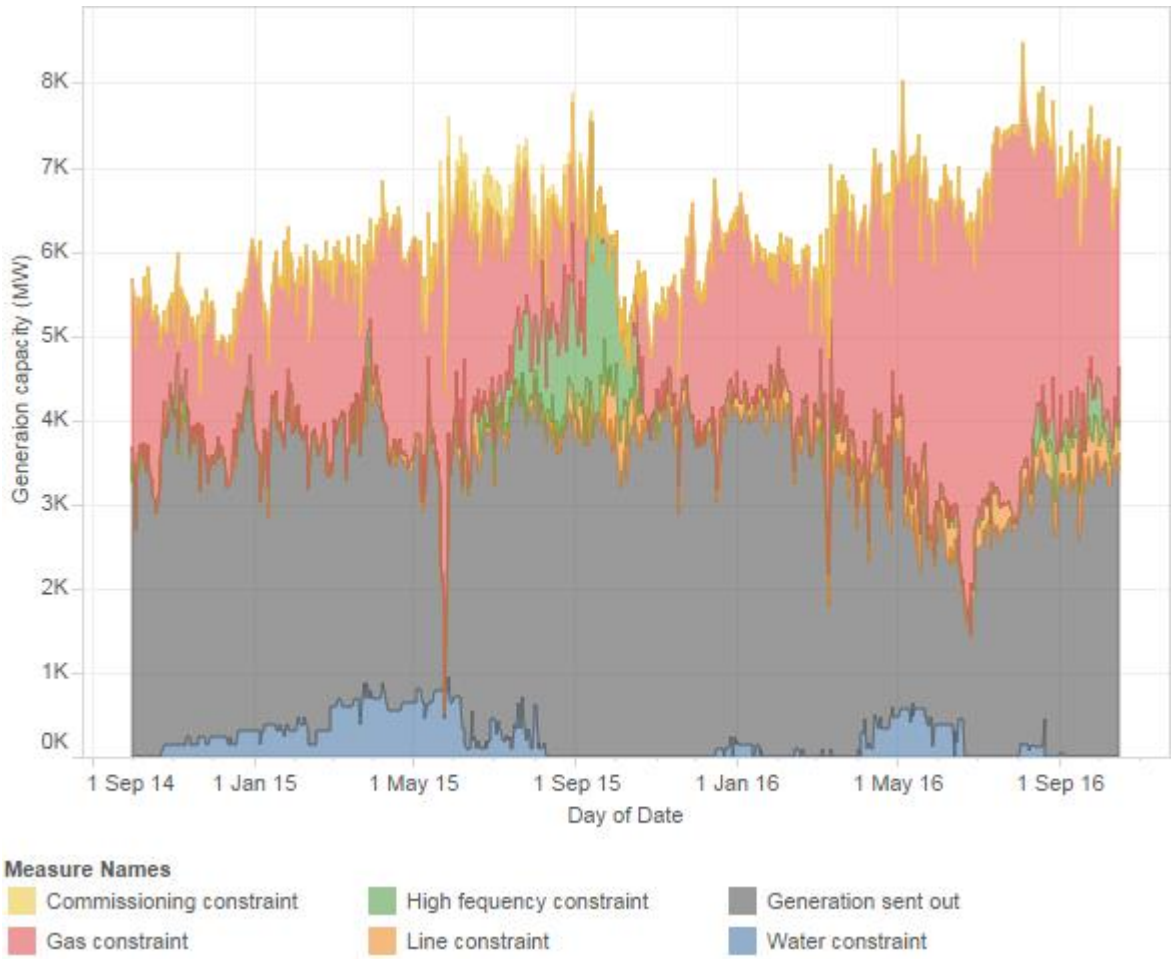
In terms of gas network coverage and reliability, Bangladesh outperforms Nigeria. This is not because the first is exemplar, rather, it is because the gas network in Nigeria is in an extremely worrying state. More of the regions in the South Asian country are connected to the centralised gas grid. The 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 backing up the project (its own operational profit, dedicated loans from the government and international development partners). As explained above, gas shortages have become a problem in Bangladesh since the late 2000s, because gas demand has been outpacing production, and there is no sign of this trend reversing.

In Nigeria, only the Southern coastal states benefit from access to gas. Even before the resurgence of militant attacks in 2016, downstream power generators experienced constraints on gas supply (Figure 7). In sharp contrast, the NLNG facility enjoys access to six supply pipelines, financed by the IOCs which are partners to this joint venture, to guarantee the reliability of supplies for export. This is demonstrative of the perceived profitability of exports compared to expanding domestic gas consumption. Although the country's other gas export facility, the West African Gas Pipeline, does not

[3] 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.

have the luxury of multiple feed-in lines. Delivery of gas to its West African neighbours from Nigeria has been more volatile. Since 2016, a new wave of militant attacks on critical oil and gas transportation infrastructure has severely disrupted the gas-to-power supply chain, exacerbating the pre-existing gas shortage, and undermining progress made in revitalising generation capacity since privatisation.

Figure 7: Use of Nigeria's power generation capacity (Data from NESISTATS)



External factors such as geography and geology also help to partially explain the relatively low level of development of Nigeria's downstream gas supply chain. The task of transporting natural gas to demand centres is more difficult and complex for Nigeria, a country with a much larger territory, where gas producing fields have a wide distribution in size and are located far from industrial use centres (Figure 8 and Figure 9). Gas pipelines need to travel greater distances, and the gathering network collecting gas from the oil and gas co-producing fields benefit less from economies of scale, making them more expensive to build. Bangladesh, on the other hands, benefits from the shorter distances between its gas producing fields and demand centres and the fact that the bulk of its gas production comes from a few large reservoirs (Figure 10). 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 11).

Figure 8: Comparison of the size of Bangladesh and Nigeria (Source: thetruesize.com)

Figure 9: Nigerian gas transmission and processing infrastructure

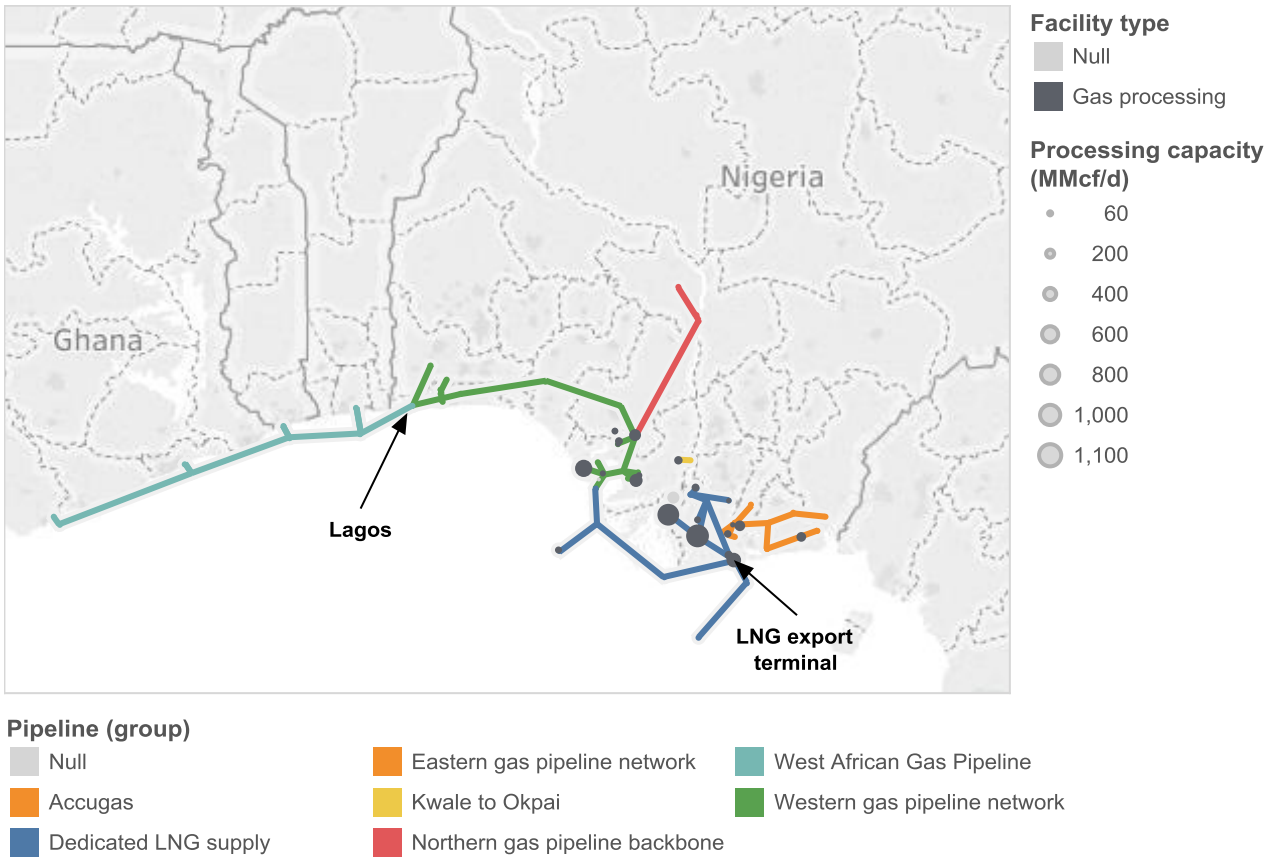


Figure 10: Distribution of gas fields and gas transmission infrastructure in Bangladesh (Based on data from Petrobangla and GTCL)

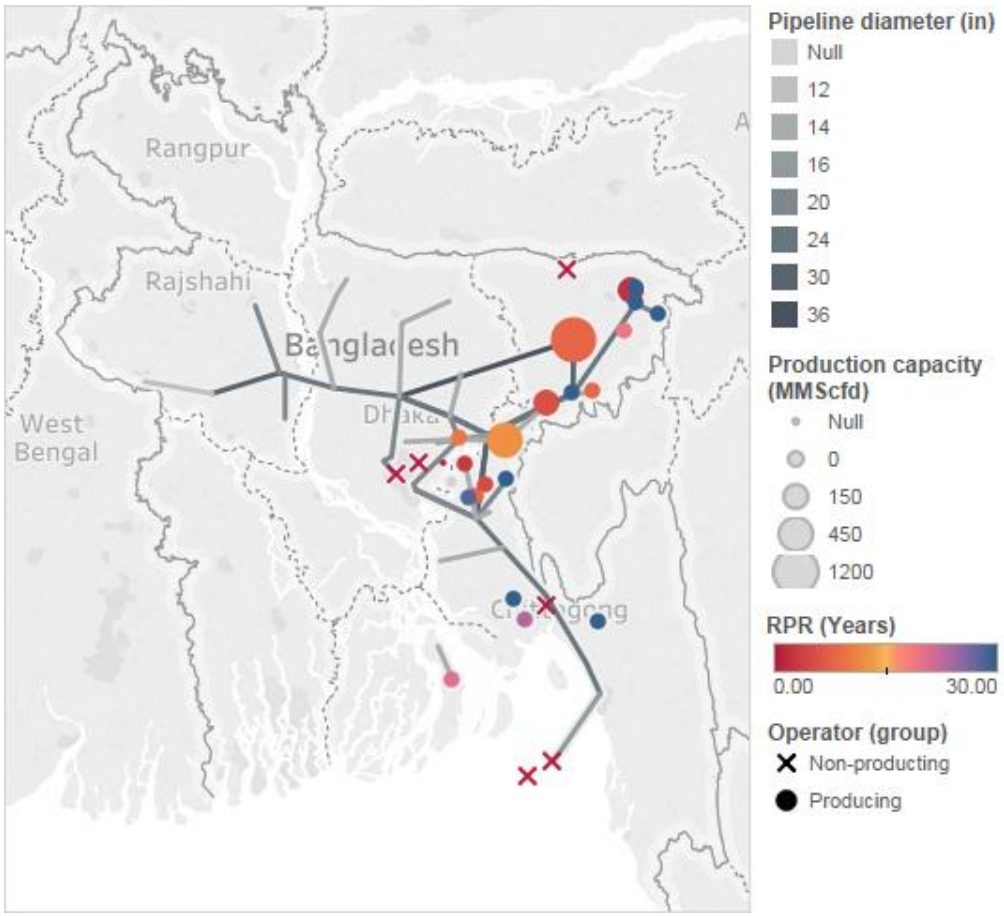
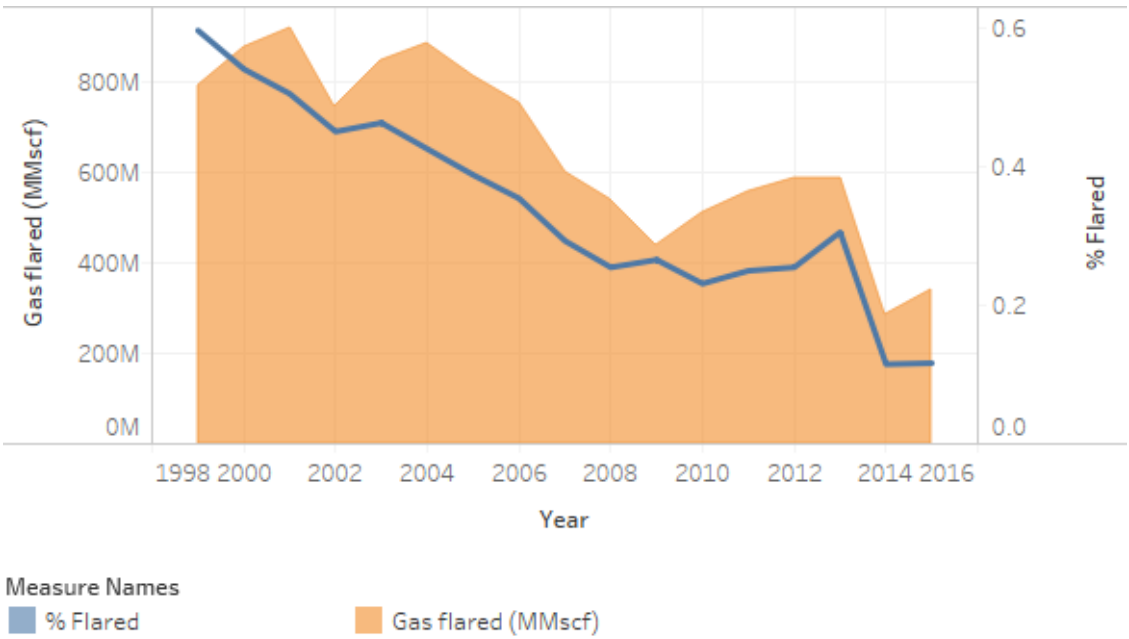


Figure 11: Absolute and relative gas flaring in Nigeria (Data from NNPC annual statistical bulletin)



Conversion to electricity

Recognising available generation capacity as 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.

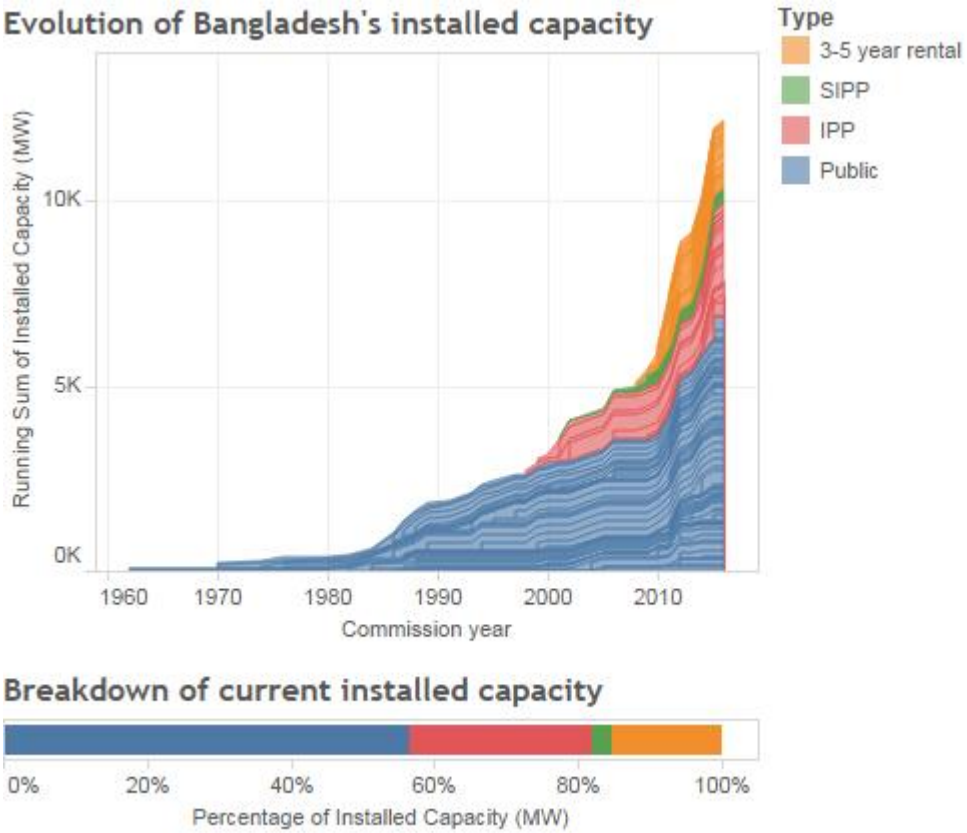
The grid-connected generation mix in Bangladesh is characterised by many small units, with the more recently installed ones (procured on 3-5-year rental basis) increasingly fired by liquid fuel given the unresolved shortage of natural gas (Figure 12). Privately-owned generation assets, commissioned since 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.

The 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, the government has considered both imports and the diversification of Bangladesh's generation mix into other energy vectors. Given the fast-paced growth of Bangladesh's electricity demand, large-scale generation technology with relatively low capital cost (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 Bangladesh Power Development Board (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 such a practice, in the absence of external assistance, is dependent on the positive externalities of increased electricity consumption on economic growth, which allows the government to recover what it has spent on electricity subsidies elsewhere.

Figure 12: Evolution of government and company-owned generation capacity in Bangladesh (based on data from BPDB)[4]



Aside from 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 13). 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 overall capacity. The latest IPP, Azura, which was 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[5]. The greatest addition to the generation mix has been the National Integrated Power Projects (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 have been lower than the original expenses. The privatisation bids were tied to performance improvement measures; but, the poor liquidity within the Nigerian gas-to-power supply chain is undermining investment in capacity rehabilitation.

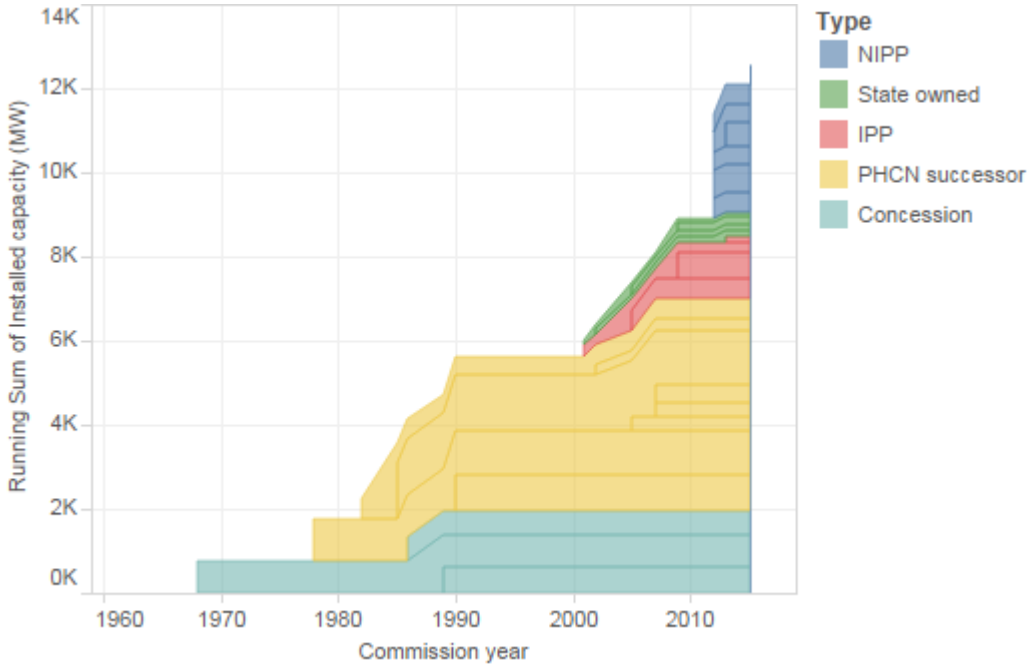
The former Nigerian state-owned power utility, Power Holding Company of Nigeria, no longer exists after the privatisation of its constituting GENCOs and DISCOs in 2013. In its place, a new public entity,

[4] 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.

[5] This 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.

Nigerian Bulk Electricity Trader (NBET), has been set up to be the single buyer acting as the interface between GENCOs and DISCOs, before transitioning to bilateral contracting. Originally, NBET was to be provided with enough capitalisation 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.

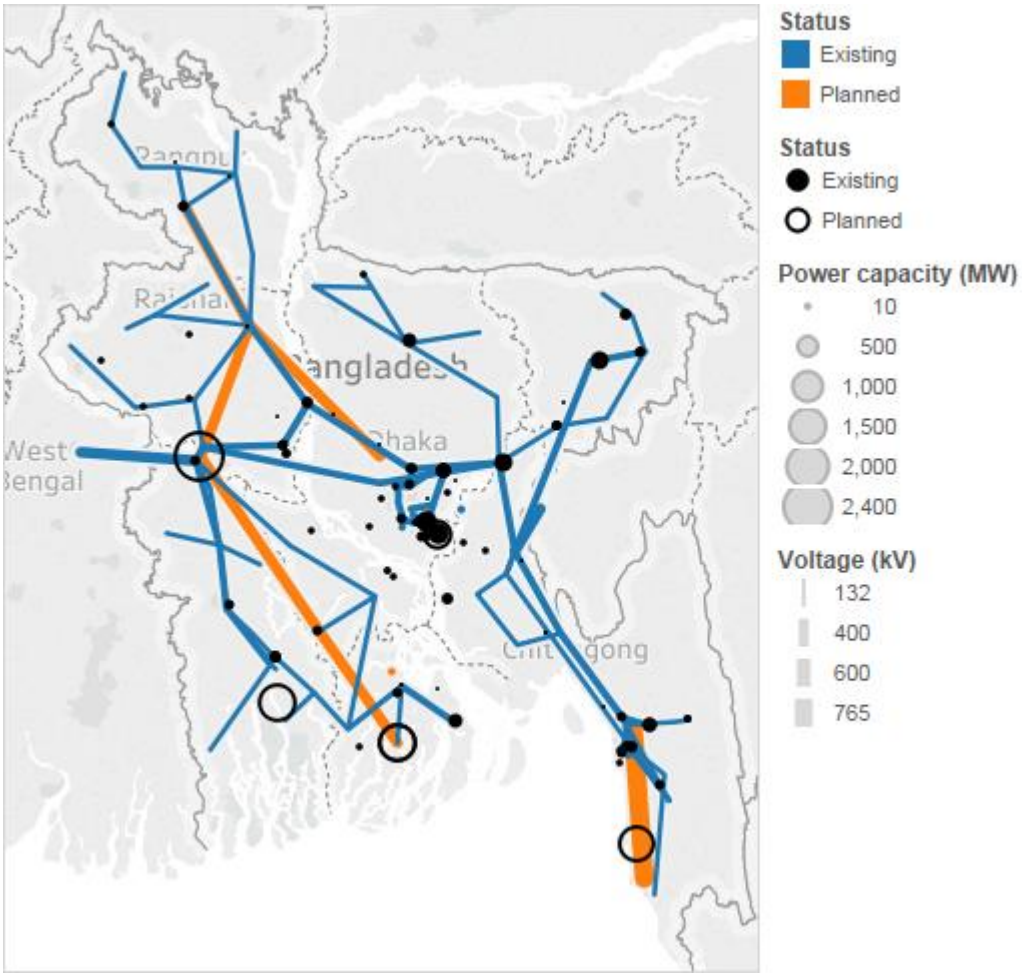
Figure 13: Evolution of government and company-owned generation capacity in Nigeria (Based on Data from (Eberhard, Gratwick, Morella, & Antmann, 2016)**)**



Electricity provision

In Bangladesh, the extension of the power grid is planned in concert with power generation projects (Figure 14). Electricity access at the distribution level has improved markedly since 2009, as the commissioning of new generation capacity has helped eliminate some of the constraints 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 Rural Energy Board, 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 in 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.

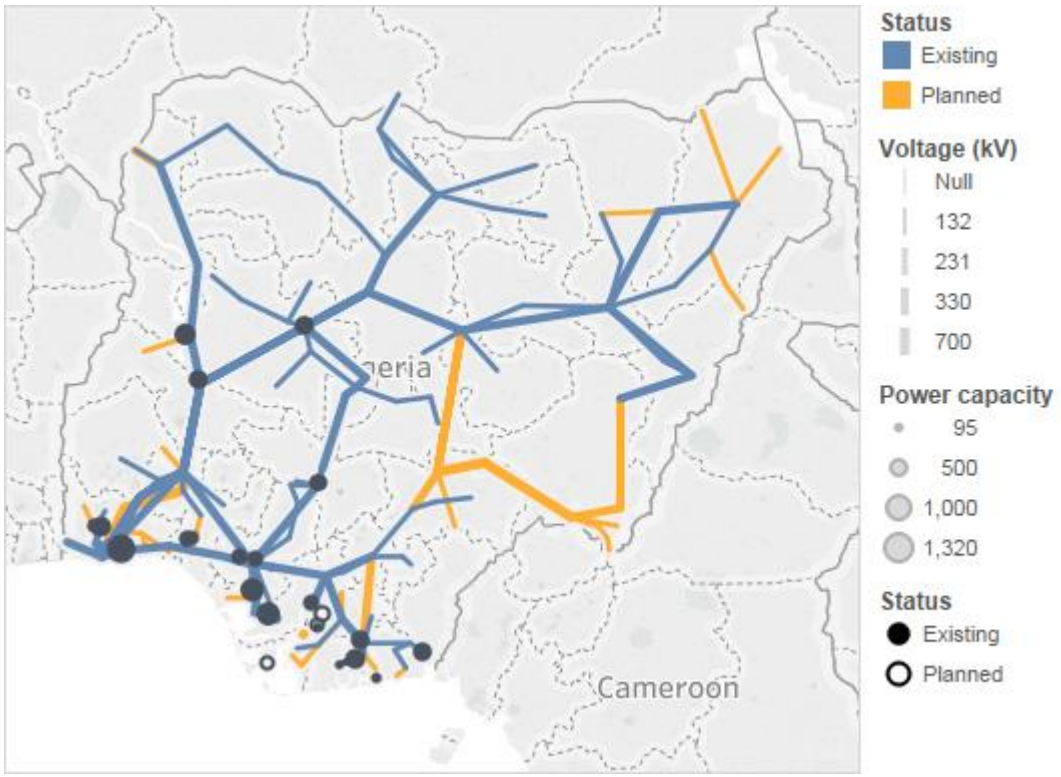
Figure 14: Distribution of existing and planned power grid in Bangladesh (Data from PGCB)



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 15). At the distribution level, many citizens express their frustration over the lack of improvement in their electricity service 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, Nigerian 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, an adjustment to the retail tariff 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 is 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 payments, we believe that, in the long run, capacity building at the DISCOs level for better measurement, monitoring, and implementation of loss reducing practice is essential to improve the liquidity situation in the electricity supply chain in Nigeria.

Figure 15: Existing and planned power transmission network in Nigeria in 2016 (Based on data from African Development Bank)



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 its investments 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 different 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, power 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.

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