



THE NATIONAL
RESEARCH INSTITUTE
PAPUA NEW GUINEA

DISCUSSION PAPER

INDEPENDENT POWER
PRODUCERS AND DEREGULATION
IN AN ISLAND-BASED SMALL
ELECTRICITY SYSTEM: THE CASE
OF PAPUA NEW GUINEA

Rabindra Nepal
Ronald Sofo

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Authors' Contributions

Ronald Sofo: conceptualisation, design, stakeholder consultation, data collection, and project management.

Rabindra Nepal: literature review, data analysis and writing.

Abbreviations and Acronyms

ADB	Asian Development Bank
CSO	Community Service Obligation
GDP	Gross Domestic Product
EIP	Electricity Industry Policy
ELCOM	Electricity Commission
ESI	Electricity Supply Industry
IPBC	Independent Public Business Corporation
IPPs	Independent Power Producers (IPPs)
ICCC	Independent Consumer and Competition Commission
NEC	National Executive Council
NEM	Australian National Electricity Market
NEP	National Energy Policy
NEROP	National Energy Roll Out Plan
PNG	Papua New Guinea
PPAs	Power Purchase Agreements
PPL	PNG Power Limited
SOEs	State-Owned Enterprises

Abstract

The island economy of Papua New Guinea (PNG) is facing severe electricity shortages and is therefore turning to implementing broader power sector reforms as a vehicle to attract private investments in electricity generation. This study, based on a case-study approach, revisits the reform progress and plans in the electricity sector of PNG alongside the development and integration of independent power producers (IPPs) in its small power system. Lessons of reform experiences and IPPs integration are drawn from three other smaller power systems belonging to Nepal, Nicaragua and the Northern Territory of Australia including stakeholder consultations, which includes two IPPs of PNG. We found a widening gap between reform ‘theory’ and ‘practice’ in the PNG power sector. Cost reflective pricing is implemented but cost recovery is never achieved by the vertically integrated state-owned utility while the insolvency of this state-owned single buyer poses the greatest perceived revenue risk to the IPPs. This lack of revenue reimbursement to the IPPs by the single buyer is a barrier towards attracting private capital into electricity generation even though IPPs are satisfied with the role of the regulator and negotiation of the power purchase agreements (PPAs) in terms of being cost reflective. We recommend that strong political will and strengthening of institutional arrangements are urgent reform measures in the PNG power sector to attract private sector investments in power generation as political instability continue. Smaller electricity systems with no cross-border electricity trade such as PNG should also focus more on establishing a framework for demand response including storage and supply adequacy so that capacity exceeds peak demand without imposing supply constraints. Market-based reforms when implemented with appropriate supporting institutions and strong political will is an enabler rather than a barrier in attracting private investments in smaller power systems like PNG.

Keywords: reforms; small systems; political instability; independent power producers; regulation

JEL classifications: L94; L50

Introduction

The island economy of Papua New Guinea (PNG hereafter) is one of the world's least electrified countries and is facing major challenges with poor access to electricity. Unreliable power supplies and lengthy daily blackouts are impacting households and firms including the delivery of critical services in the economy. Only an estimated 13 percent of PNG's 8.6 million people have access to grid-connected electricity that is primarily urban-centred (World Bank Press Release, 2021). Low levels of national electrification and the lack of reliable access is detrimental to achieving the objectives of the PNG Development Strategic Plan (PNG DSP) 2010-2030 which aims at '*high quality of life for all*' and '*economic prosperity of PNG by 2030*'. This is because access to reliable and affordable electricity supply is one of the pre-requisites to spur socio-economic development since electricity is an essential factor input in economic production. Unreliable electricity supply translates into households and firms experiencing blackouts and therefore, compelling those to resort to costly self-supply options, often through fossil fuel based generators and eventually constraining production (Steinbuks and Foster, 2010). In a 2015 World Bank survey, 11.5 percent of small businesses (with five to 19 employees) reported that electricity was their biggest obstacle out of the 4.2 percent of all firms surveyed in PNG (World Bank, 2015).

Independent Power Producers (IPPs) offer a viable opportunity to meet the gap in energy demand and supply in the PNG economy especially considering that the vertically integrated and State-owned PNG Power Limited (PPL) is cash-strapped and therefore unable to meet the investment needs pertaining to grid-based national electrification. IPPs, also known as non-utility generator (NUG), are private entities which own and or operate electricity generation facilities and sell electricity to a utility, central government buyer and end users depending on the underlying business models. IPPs are also of greater significance to the PNG economy since boosting electricity supply through electricity imports is not feasible as the benefits of an interconnected power system being an island-based power system does not exist. However, there are only seven IPPs operating in the PNG economy with a combined total installed capacity of 257.3 MW since the enactment of the Electricity Industry Policy (EIP) of 2011 which seeks to bring more private sector investment into the energy industry (Government of Papua New Guinea, 2011). What are the enabling factors to facilitate the involvement of the IPPs in the PNG power sector in ensuring that the government-set target of 70 percent access to electricity is eventually met? Answering this question is urgent in the context of the PNG economy since 70 percent electricity access by 2030 is predicted to increase the Gross Domestic Product (GDP) of the PNG economy by 10 percent from the 2010 levels and is therefore necessary in fostering economic growth (McLeod, 2019).

This study, therefore, focusses on the generation segment of the PNG electricity supply industry (ESI) where the prospect of competition is explored through greater participation of the IPPs. For this purpose, we review the existing power sector reform and status including the institutional framework and IPP policies evolving the PNG power sector; review the international experiences with integrating IPPs among smaller power systems in the context of power sector reforms; undertake PNG power sector stakeholder consultations and draw policy lessons and conclusions.

Our study is timely since the PNG economy implemented the National Energy Policy 2017-2027 also prioritises an institutional reform of the electricity sector (Government of Papua New Guinea, 2017). IPPs offer a viable possibility to raise private sector capital without first requiring the overarching task of completing reform and privatisation of the power sector (Victor and Heller, 2007). IPPs invest in generation capacities and undertake cost recovery from the sale of the electricity. Reducing public spending, expanding generation capacity, improving reliability, attracting foreign capital, introducing competition and technology transfer are the underlying factors supporting the introduction of IPPs. Often unrecognised but an unintended consequence of IPPs is also planting the seeds for a thorough change in the structure and operation of the government-owned power utilities (Elliot

and Malhotra, 1996). However, the predominantly State-owned and vertically integrated PNG power sector has not been effectively corporatised and unbundled till date.

The smallness in power system size as in the case of PNG prohibits the scope for restructuring the power systems and benefit from the arising competition due to limited economies of scale possibilities. According to the data from Energy Information Administration (EIA), the total installed capacity of the PNG power system is around 965 MW (less than 1000 MW) in 2019 while the per capita electricity consumption is around 42 KW. A power system is defined as a “small system” when the overall system peak load reaches up to 1000 MW (Bacon, 1999; Kessides, 2004). The small power system size and low density of the power market mean that the theoretical benefits of competition resulting from vertical separation of competitive segments of the ESI from the monopoly segments can be minimal in small power system such as PNG and thereby the costs of liberalisation not outweighing the benefits. The smallness of the power market, in particular for small island countries as PNG, cannot effectively allow the introduction of wholesale markets so that electricity distribution companies end up buying power directly from the IPPs (Domah, 2002). An earlier study by Nepal and Jamasb (2012a) have argued that the creation of an effective regulatory commission and attracting private capital in electricity generation is actually more urgent than unbundling the sector in smaller systems like PNG characterised by distorted electricity tariffs, low electricity access rate, chronic supply interruptions, and operational inefficiency.

Market-based reforms in the electricity sector also require appropriate institutional arrangements to support the transition towards markets. However, reform measures including the introduction of effective sector regulation in developing countries is constrained by low levels of institutional environment such as limitations in regulatory capacity, accountability, commitment and fiscal efficiency (Laffont, 2005). Power sector reform is also highly inter-dependent with wider reforms in other sectors of the economy and therefore, there is a need to harmonise inter-sector reforms in the economy for power sector reforms to generate successful outcomes (Nepal and Jamasb, 2012b). Using an institutional economics framework, Bhattacharya (2007) concluded that political instability, poor overall acceptance, slow adaptation and poor transition management affects power sector reform so that hard decisions promoting efficiency are difficult to take. Slow reform progress also eventually generates adverse effects on power sector investment and performance. In small power systems experiencing political instability, attracting private capital and private ownership is urgent to minimise the bureaucratic influence in power sector decision makings (Nepal and Jamasb, 2012a).

Establishing effective regulatory agency and introducing effective regulation in developing countries is challenged by significant human resource constraints which limit the scale and, hence, the scope and potential effectiveness of electricity reforms (Pollitt and Stern, 2011). An earlier study by Domah et al. (2002) showed that developing countries face high fixed costs relative to market size in establishing independent regulatory agencies. On the other hand, a regulatory system cannot be considered independent under the political nature and terms of regulatory appointment, publicly funded regulatory body and dominant participation of the politically unaffiliated regulators in designing regulatory content such as tariff methodology as in many developing economies (Stern and Holder, 1999). In small power systems experiencing political instability and interventions like in PNG, Nepal and Jamasb (2012a) have argued that regulatory decision making suffers from political influence and instability often lengthening and delaying the decision-making process.

Against this backdrop, this report attempts to synthesise the policy lessons conducive to IPPs development for small power systems like PNG aiming to increase national electricity access such that the three important functions of IPPs are fulfilled (Gardiner and Montpelier, 2000), namely, a) attracting outside capital to meet rapidly growing electricity needs without imposing large strains on the nations internal financial capabilities; b) reducing electricity costs through competitive pressures; and, c) assign risks in a more efficient or desirable manner. The remainder of the report is structured as follows. Section 2 provides a review of reform progress

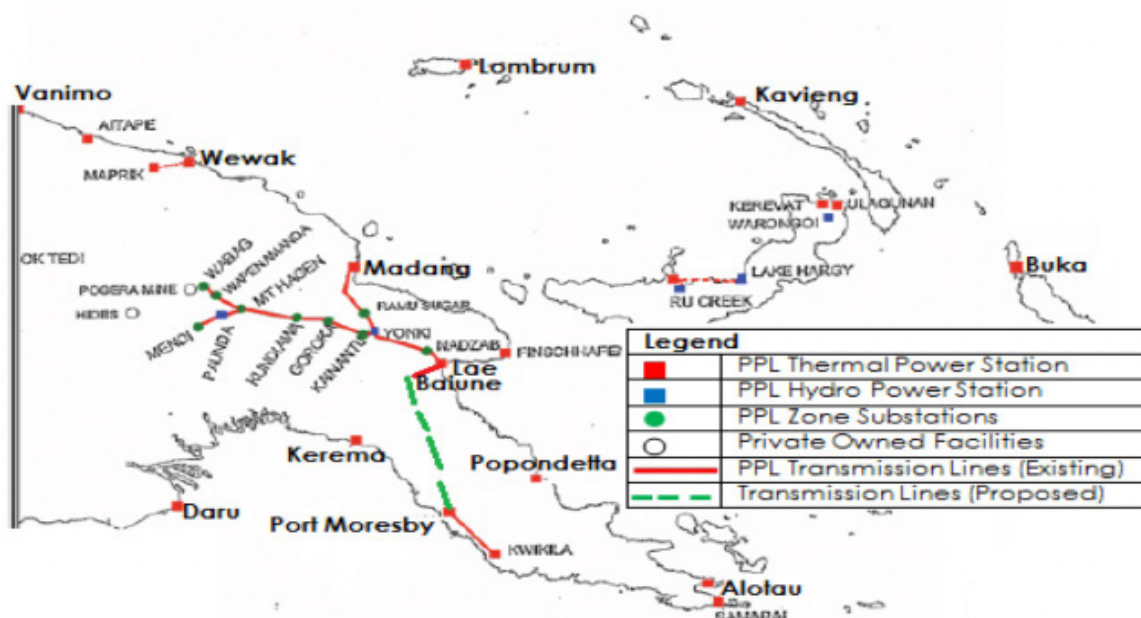
and institutional framework inclusive of those pertaining to the IPP in the PNG power sector. Section 3 undertakes a case-study approach by reviewing the reform progress and IPP integration across three smaller power systems of Nepal, Nicaragua and the Northern Territory of Australia. Section 4 discusses the case studies alongside the findings from the stakeholder consultations. Section 5 concludes the report with relevant policy recommendations.

Reform progress and institutional framework (IPP Policy) in the PNG power system

PNG is the largest economy in the Pacific. The need to achieve expansion of installed capacity is important to less developed economies in increasing electricity access and provide a major motive for undertaking power sector reforms (Jamash et al., 2005). In 2015 alone, PNG experienced an average of more than 40 blackouts per month – the third highest in the world (World Bank, 2015). A recent study by Kabuni et al. (2021) highlighted the crisis of governance in the PNG power sector and the need for implementing electricity reforms since electricity reform affects industry structure, governance and ownership. Average residential electricity prices in PNG were among the highest in the world between 2010 and 2015 with a per KWh price of 39 cents (USD) as the nation primarily relies on a high-cost diesel generation. Despite high electricity prices to residential customers, PPL is financially unsustainable in supporting system expansion with a debt of US\$130 million while high electricity prices has also translated into non-payment of electricity bills (through illegal connections and theft) of about US\$7 million per month. The financial constraints of PPL implies that infrastructure upgrade is impossible while private electricity providers are also not paid on a timely basis. For example, POSCO International Power Ltd cut electricity to Lae due to PPL's failure to settle a K60 million (PNG Kina) debt.

The financial, regulatory and governance crisis facing the PNG power sector opportunely invites reforming the electricity sector nested within a fragile economy characterised by political instability. Network investments and expansion is also very much limited in PNG where long-distance transmission of power is currently limited to the Port Moresby, Ramu (in Morobe and Madang), and Gazelle grids. The provincial centres are served by 19 isolated and independent power grids which often rely on high-cost (including social costs) diesel generation. Figure 1 below shows the most regional centres in the PNG power system are operating in isolation with scattered networks.

Figure 1: PPL Electricity Supply Network



Source: Aiau and others. (2016)

Some recent studies including Fallon and Sofe (2019) and Sandu et al. (2020) discussed the governance perspective of electricity sector development in PNG including providing an overview on the status and progress of electricity reforms. Initiatives to restructure the electricity sector started in 2002 when the Electricity

Commission (ELCOM) was established after the enactment of the PNG Electricity Act of 1961 was corporatised under the Electricity Commission (Privatisation) Act 2002. The Electricity Commission (Privatisation) Act 2002 was instituted under the PNG Electricity Industry Act of 2002 which allowed establishing of an Electricity Commission and regulate the generation, supply and sale of electricity. ELCOM's assets, liabilities, rights, titles and personnel were transferred to PNG Power Limited (PPL). Under the Independent Public Business Corporation of Papua New Guinea Act (2002), the State ownership of PPL was later transferred to the Independent Public Business Corporation (IPBC). The Independent Consumer and Competition Commission (ICCC) Act 2002 also led to the creation of an independent regulatory entity, ICCC, responsible for ensuring effective economic regulation of both State-owned and private enterprises. However, the ICCC has only been performing the economic regulation tasks while delegating the technical regulation functions to PPL due to constraints pertaining to human and financial resources in performing all its regulatory functions (Ain, 2018). The PNG Government released the National Energy Policy 2016–2030, which was eventually approved in 2018 and advocates further reforms of the electricity industry such as unbundling (or vertical separation of PPL), promotion of renewable generation, and establishing an entire sector responsible, Energy Regulatory Commission. The PNG Government also introduced the Kumul Consolidation Agenda in 2015 to consolidate all State-owned enterprises (SOEs) to improve the financial position of the SOEs (Sandu et al., 2020). The IPBC (Amendment) Act of 2015 led to the transfer of all assets of PPL to Kumul Consolidated Holdings.

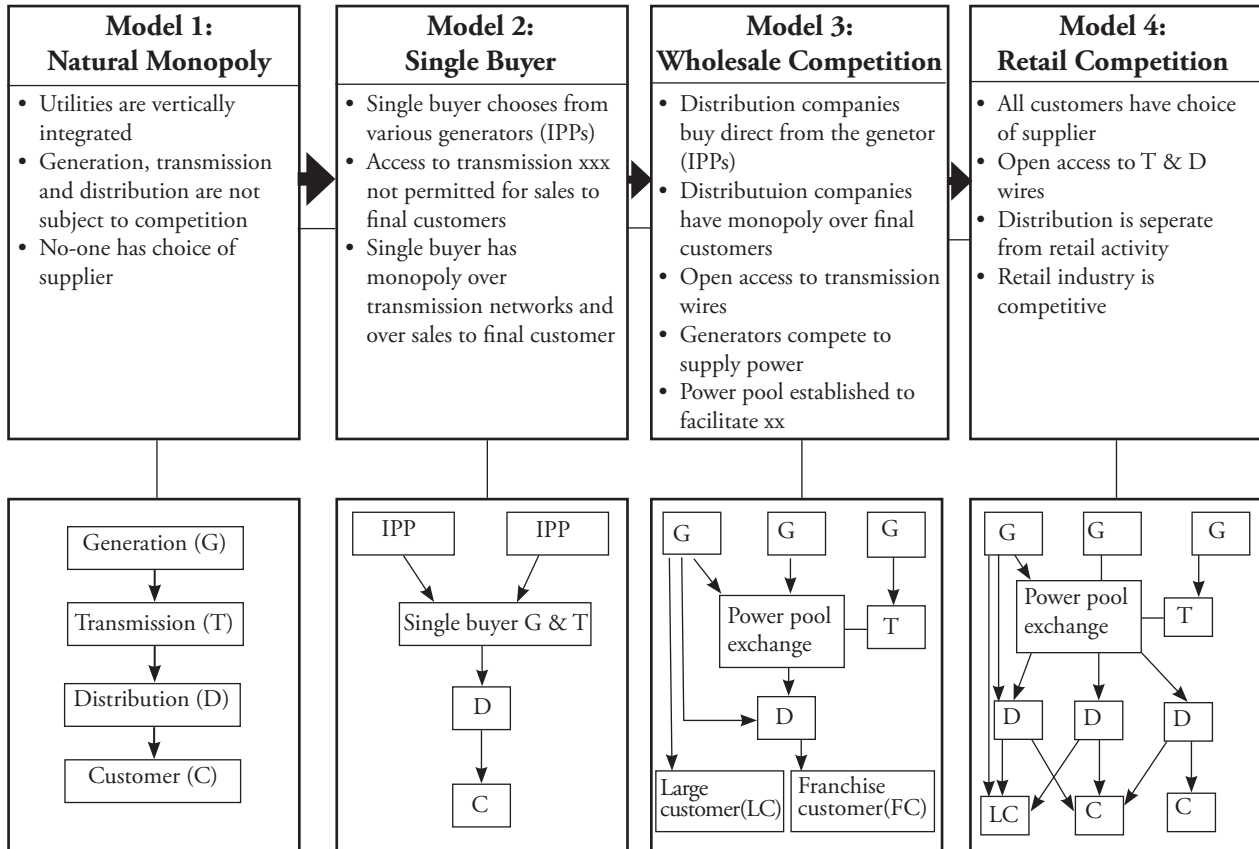
A recent reform initiative in the PNG power sector includes the PNG Parliament passing the National Energy Authority Act 2020 and the Electricity Industry (Amendment) Act 2020 (Amending Act) (together the Acts) on 21 April 2021 (Allens, 2021). Once the operation is commenced, the Acts will allow the establishment of the National Energy Authority (the Authority), which will be responsible for the regulation of the electricity supply industry in PNG, including the technical and economic regulation of the industry. The Electricity (Industry) (Amendment) Act 2020 will amend the Electricity Industry Act of 2002 by repealing the list of functions of the ICCC even though the division of tasks between the Authority and ICCC is not clarified. The Authority will have the ability to charge levies and fees, including levies on generation licences while also establishing a tariff system for the electricity and energy supply industry. It is expected that the commencements of the Acts will also change the licencing and regulation of the electricity supply industry for independent power producers in PNG.

An independent Rural Electricity Authority was proposed to be established in 2004 but did not materialise. Instead, the Rural Electrification Policy which was originally initiated in 1993 was redrafted in 2006. The government eventually endorsed the Electricity Industry Policy in 2011 with the specific aim of promoting rural electrification since the revised Rural Electrification Policy draft did not translate into policy. In late 2018, the PNG Electrification Partnership was signed where four Organization for Economic Cooperation and Development (OECD) economies - Australia, Japan, New Zealand, and the USA – formed an agreement with the PNG Government to help achieve PNG's energy ambitions of 70 percent electricity access by 2030 (Sharma et al., 2021). This partnership recognises and builds on the existing electrification policy instruments of the PNG Government including the National Energy Policy (NEP). PPL has also drafted the Independent Power Producer and Major Infrastructure Policy in 2018 with the objectives of clearly defining avenues and extent of participation of PPL's development partners and the private sector. This policy document clarifies the conditions in which the private sector can participate in implementing PNG Power's Least Cost Development Plan and other strategic and economic enhancing opportunities in the power sector (PNG Power Limited, 2018). An industry advocacy group (IP3 Industry Group) representing the interests of IPPs was established in 2018 by four founding IPPs in PNG, namely – NiuPower, PNG Biomass, PNG Forest Products, and POSCO International. There are currently five industry members in the group with the addition of PNG Hydro Development as of 2021 (IP3, 2021).

PPL has an installed capacity of around 390 MW owned by the National Government and vertically integrated implying that it is responsible for the generation, transmission, distribution and retailing of electricity to the major centres and regions. PPL operates as a single buyer model (SBM) where hydro and thermal generated electricity is purchased from the private sector (the IPPs) based on long- term power purchase agreements (PPAs). Figure 2 shows the different models for integrating IPPs into the power system even though there is a

country specific autonomy in integrating the IPPs into the electricity market. The IPPs do not have access to transmission networks and therefore, not permitted for electricity sales to final customers under a single buyer model (Model 2).

Figure 2: Different Models for Integrating IPPs



Source: Gardiner and Montpelier (2000)

Case studies

IPPs require investing domestic or foreign private capital in power generation and therefore, IPPs naturally prefer an economic environment that is risk free or one that offers all the hedges against the risks. There are three primary types of risks facing the IPPs: revenue security risks, market demand risks and risks involving contract procurement. Table 1 below summarises the different risks of IPPs in developing economies. Successful power sector reforms such as restructuring can minimise some of these risks such as management risks even though political stability is a pre-requisite for undertaking any effective power sector reforms. Reform programs are conceived as instruments to open up external investment and financing to the power sector in developing economies (African Development Bank, 2019). A stable government and policy play a crucial role to reduce risks for parties involved which often include sharing of risks and eventually lowering the financial and construction costs.

Table 1: IPPs Risks

Risk Type	Description
Currency risks owing to varying exchange rates	Payments to IPPs maybe in local currency even though many IPP costs (fixed and variable) such as fuel costs, equipment and repair costs and cost of capital maybe in US dollars.
Risks of non-payment	The IPP power purchase maybe financially weak and therefore, creating the risk of non-payment.
Political instability and policy uncertainty	The incumbent or future government may change the rules and policies.
Management risks	The risk pertaining to loss of IPP management oversight is high as IPP participation through minority equity ownership increases.
Technology and performance related risks	The selected technology may not perform as originally expected.

Source: Gardiner and Montpelier (2000)

In this section, we review the case studies of Nepal, Nicaragua and Australia's Northern Territory as examples of small electricity systems implementing power sector reforms and integrating IPPs in their power system. A case study approach is suitable when studying electricity reforms because market-based reform measures are multi-dimensional activities with many interacting factors and generating a variety of impacts which quantitative studies may inadequately capture (Nepal and Jamasb, 2015). We selected the case of Nepal, Nicaragua and the Northern Territory market of Australia because these cases

- cover varying power sector reform stages that are relevant to PNG as the power sector evolves and reforms deepen;
- span across different regions globally and therefore, allowing us to capture varying political and institutional settings;
- exhibit varying electricity generation mix in their power sectors;
- suffer from limited (and scope of) cross-border interconnections; and,
- are relatively less discussed in the literature and therefore, provides an opportunity to revisit and update the reform literature.

It is expected that the PNG power system will size gradually as in the case of Nepal, Nicaragua and the Northern Territory of Australia through additions of installed capacities. For instance, installed capacity in 2008 was 580 MW (ADB, 2009) consisting of hydro (39%); diesel (37%); natural gas (14%) and geothermal (10%) in the PNG power system as compared to the system size of 965 MW in 2019.

Nepal

Nepal (officially the Federal Democratic Republic of Nepal) is a landlocked economy in South Asia which is internally challenged by a difficult topography and externally sandwiched between two energy intensive and fastest growing economies of the world – India and China. Despite halving the poverty rate in seven years (between 2010 and 2017) and a significant decline in income inequality; Nepal still remains one of the poorest and slowest-growing economies in Asia (World Bank, 2017a). Around 90 percent of Nepal's population (around 29 million as of 2020) had access to electricity according to Government of Nepal's Economic Survey (2019/20) compared to only 43.6 percent electrification in 2009. Nepal is also considered as one of the fastest electrifying countries in the world with electricity access increasing at an annual rate of 4.3 percent – much higher than the 0.8 percent global average (Khanal et al., 2021). What factors have led to this remarkable turnaround considering that Nepalese households used to suffer from up to 16 daily hours of power cuts especially during the winter periods between 2006 to 2016?

The power sector in Nepal is dominated by hydro-based generation occupying 96 percent of the power mix in 2021 (1396.6 MW hydro installed capacity out of 1451.3 MW total electricity installed capacity) (Nepal Electricity Authority, 2021). Nepal Electricity Authority (NEA), which was established in 1985 as a vertically integrated and state-owned monopoly is the primary generator and distributor of electricity under the supervision of the Government of Nepal. The power system size of NEA has grown from being a small system with 720 MW total installed capacity in 2012 (grid connected installed capacity of NEA and IPP (approximately 174 MW by 23 IPP projects in 2012)) to 1446.799 MW in 2021 (grid connected installed capacity of NEA and IPP). Interestingly, the hydro installed capacity from IPPs owned project amounted to 814.7 MW in 2021 surpassing the NEA owned hydro installed capacity of 581.9 MW.

Power sector reforms in Nepal were initiated in 1985 in accordance with the provisions of NEA Act of 1984 while the Electricity Act of 1992 and the Hydropower Development Policy of 1992 enabled the participation of IPPs in the Nepalese electricity generation sector since 1992. The Electricity Tariff Fixation Committee (ETFC) was established as a regulatory body to review and approve tariff filings by NEA and other licensed entities under the Electricity Act 1992 and Electricity Regulation Act 1993. The ETFC was reconstituted in September 2011 even though the expectation that replacing ETFC with an independent regulatory body never materialised. The Hydropower Development Policy of 1992 was revised in 2001 and led to the introduction of the Water Resources Development Policy while Community Electricity Distribution by-Laws was introduced in 2003. This reform period in the Nepalese power sector coincided with the civil war in the name of Maoist insurgency, which lasted for a decade in Nepal between 1996 to 2006 as well as frequent changes in the government leadership. An earlier study by Nepal and Jamasb (2012a) summarised the performance of the NEA after more than two decades of reforms as being problematic with NEA resembling the conventional problems of a monopolistic public utility suffering from chronic underinvestment and insufficient capitalisation, politically determined low and distorted tariffs coupled with poor operational and financial performance. In 2016, with the Maoist government in political leadership appointed Kulman Ghising (a NEA employee) as the managing director of NEA based on a cabinet decision. Soon after Ghising's appointment, the power supply has significantly improved through additions to domestic generation capacity, improved load management, and increased imports from neighbouring India, and the load shedding has been eliminated (within two months of taking office) (Timilsina and Steinbuks, 2021). The financial and operational performance of NEA has been superior since 2017 as the NEA is recording a positive net operating profit after a prolonged period of financial losses while power system losses have decreased from 25.8 percent in 2016 to 17.2 percent in 2021. NEA has also been able to undertake network investments, upgrades and maintenance. The political will to continue with improved power sector outcomes was signalled through the re-appointment of Ghising in 2021.

NEA trades power with India across borders and Nepal was also the first country to participate in the Indian Energy Exchange (IEX) after the first 400 Kilo Volts (KV) cross border transmission line between Nepal and India (from Dhalkebar in Nepal to Muzaffarpur) came into operation in 2020. Nepal Power Trading Company Limited (NTPC) was established with the responsibility of undertaking power trading both within and outside of the country while Power Transmission Company Nepal Limited (PTCN) as a subsidiary of NEA is charged with developing high voltage transmission interconnection between Nepal and India. The average electricity

import capacity from India was 537 MW in 2020. However, an earlier study by Singh et al. (2018) concluded that efforts to expand cross-border electricity cooperation and trade in South Asia need to address not only regional barriers, but also barriers stemming from domestic electricity sector policies such as incomplete reforms.

NEA as a single buyer of electricity facilitates the participation of IPPs through PPAs whereby fixed rates for electricity purchases from three different categories of hydroelectricity plants are posted: run of river (ROR) projects; peaking run of river (PROR) projects; and storage type projects. There were 108 IPP owned projects in operation in 2021 while the participation of IPPs have increased since the establishment of the Independent Power Producers Association of Nepal (IPPAN) in 2001. IPPAN is a not for profit and non-governmental membership-based organisation with the core objective of encouraging the private sector to work in the area of hydropower in Nepal. Since 2003, community rural electrification entities (CREEs) has become popular in Nepal. CREEs are electricity-distributing entities registered by community-based organisations at the district level through the Community Rural Electrification programme and offers an alternative electrification model than relying on a tradition utility-based model through NEA's own Distribution and Consumer Services (NEA-DCS) offices. Nepal's rapid electrification is largely these schemes, through which more than 360,000 households have been electrified since 2003 (Khanal et al., 2021).

Nicaragua

Nicaragua (officially the Republic of Nicaragua) is the largest country in Central America but also one of the poorest nations in Continental Americas with a population of 6.5 million people. The nation is characterised by a chronic cycle of poverty owing to constant political instability, high inequality between urban and rural populations, agricultural exports dependency and natural disasters (World Bank, 2017b). Around 88 percent of the population had access to electricity as of 2019 while electricity access has been increasing since 2001 even though the rural-urban divide in electricity access exists (ESMAP, 2021). For example, Nicaragua had 100 percent electricity access in the urban areas in 2019 while access to rural electricity stood at 71 percent. The national electrification has considerably progressed given that the nation's overall electrification rate was less than 50 percent in 2002. The increased use of small hydroelectric power plants in rural areas has helped the electrification quest in Nicaragua since the enactment of the Rural Electrification Policy (REP) in 2005. The REP prioritises the use of renewable sources in remote areas through subsidies, pricing structures as well as promoting local capacity for renewable energy project development at smaller scales. An earlier study by Nepal et al. (2018) concluded that electricity reforms and renewables could be complementary in smaller power systems when supported by appropriate instruments and incentives.

Electricity reforms in Nicaragua were initiated during 1992 when private investments in electricity generation was allowed. The deepening of reforms continued and eventually culminating in 1999 with the privatisation of the distribution subsector and the sale of several power plants to private investors (World Bank, 2007). In 1995, the State-owned monopoly, INE (Instituto Nicaragüense de Energía), separated into operations company, ENEL (Empresa Nicaragüense de Electricidad) responsible for the generation, transmission and distribution of electricity, and transmission dispatch company, ENATREL (Empresa Nacional de Transmisión Eléctrica) responsible for the operation and maintenance of the electrical transmission system. INE (Instituto Nicaragüense de Energía) is responsible for the regulation of the power and hydropower sectors. Electricity reform legislation was passed in 1998. This led to the establishment of a wholesale market-based on spot price (system marginal cost) alongside long-term contracts market (futures market) with generators (12), distributors (5) and large users (9), which hedges against currency fluctuations (Sen et al., 2020). The end user market was regulated and regulated end-user market served by distributors at regulated prices. In 2007, the government also created a separate State entity-Comision Nacional de Energia that was responsible for planning, policy, rural electrification and legal initiatives. The Ministry of Energy and Mines was created as a successor to State entity-Comision Nacional de Energia as a result of a 2007 legislation. Nepal et al. (2018) have thoroughly captured the important attributes of the Nicaraguan wholesale electricity market such as economic dispatch, spot market price formation and traded products. Private participation in the generation segment is more than 70 percent of installed capacity while the distribution segment has 100 percent private participation. INE implemented an electricity tariff reform in 2006 such that the difference between costs and tariffs went from a 12.4 percent shortfall at the end of 2005 to a 7.9

percent surplus by the end-2006.

As of 2007, lack of political will to apply the regulatory rules implied that tariffs lagged and the distribution company's financial performance suffered. The private sector was not successful in addressing some of the sector's major problems such as electricity losses (around 28% since privatisation) which meant that electricity losses drastically reduced the financial ability to cover both distribution and upstream (transmission and generation) costs. The reforms were not successful in generating new investments in electricity generation by failing to create adequate market incentives. The electricity-installed capacity was 400 MW in 1994, which grew to 1000 MW in 2008, and eventually 1700 MW in 2019 as per the Energy Information Administration (EIA, 2022). The share of fossil fuels in the installed capacity mix was 58 percent (diesel, gas and coal) while renewables share was the remaining 42 percent (respectively, biofuels, wind, hydro, geothermal and solar) in 2019. Nicaragua participates in a regional electricity market through the Central American Electrical Interconnection System (SIEPAC) that became operational in 2013 as a net importer of electricity. SIEPAC is an interconnection of the power grids of six Central American nations, namely, Panama, Costa Rica, Honduras, Nicaragua, El Salvador and Guatemala. The existing cross border interconnector capacity from Nicaragua to Costa Rica and Honduras is 23 MW and 300 MW respectively. A recent study by Timilsina et al. (2021) showed that the SIEPAC region would gain around US\$240 million to US\$300 million in the short term if unrestricted electricity trade between the borders were allowed without any expansion in current electricity generation capacity.

Northern Territory of Australia

The Northern Territory (NT) (formally Northern Territory of Australia) is an Australian territory located in the central and central northern regions of Australia with an estimated population of around 247,000 (as of September 2021). Around 60 percent of the population reside in greater Darwin area while the remainder of the population is scattered across remote areas. Around 30 percent of the NT's total population is identified as being indigenous. The NT is also known for having the deepest poverty in Australia where nearly 45 percent of all Indigenous households are located below the poverty line (Altman, 2017). NT also hosts the greatest poverty disparity between indigenous and non-indigenous households, which is nearly 35 percent. Remote indigenous communities are suffering severe energy insecurity, which worsens during extreme temperatures as around 74 percent of homes using prepaid electricity meters had their power cut more than 10 times (Bunch, 2021). Around 91 percent of homes, overall, in remote NT had their electricity disconnected in 2018-19.

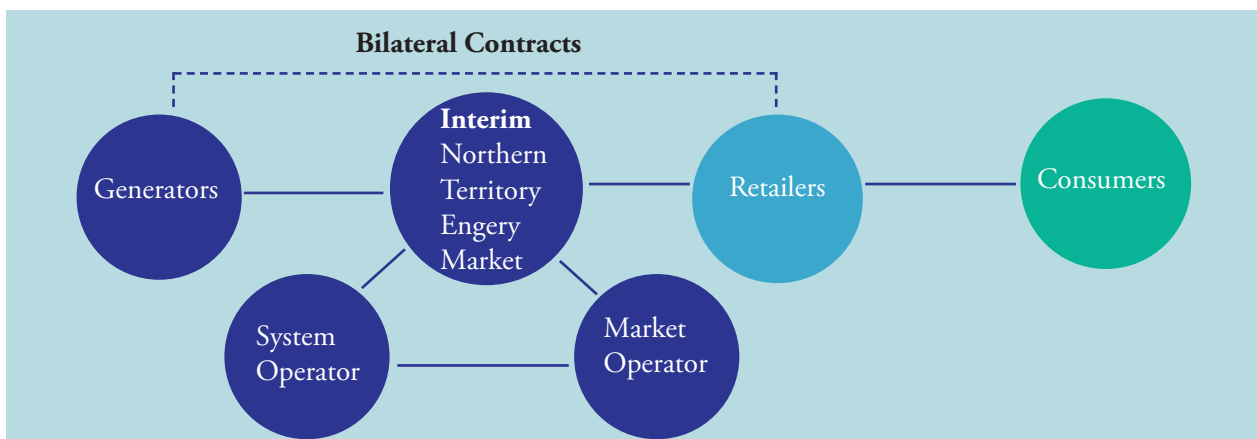
Electricity reform started during 2000 when the NT Government established the Utilities Commission in 2000 through the Electricity Reform Act 2000 and Utilities Commission Act 2000. Other associated legislations include the National Electricity Law and National Electricity Rules. The Utilities Commission of the Northern Territory is responsible for other regulatory functions in the NT electricity market as per the Electricity Reform Act 2000 supply industry except third-party access and network pricing which the Australian Energy Regulator undertakes under the National Electricity Law and National Electricity Rules since 2015. The NT Government decided to improve the efficiency of the vertically integrated and territory-owned Power and Water Corporation (PWC) in 2012 and therefore, undertook accounting and legal unbundling by splitting PWC into Territory Generation (generation): Power and Water (networks) and Jacana Energy (retail) in 2014. A wholesale market for electricity in the interim named as Northern Territory Electricity Market (I -NTEM) also started operating from 2015. In 2020, the NT Government announced to further reform the electricity market to meet the government's target of 50 percent renewable energy by 2030 alongside maintaining the delivery of a secure, reliable and least cost electricity for consumers and tax-payers (Northern Territory Government, 2022).

Territory Generation is the largest electricity producer in the NT with a combined installed capacity of 602.1 MW owning and operating eight power stations, 65 generating units and a battery energy storage system. Out of this total capacity, 5.1 MW is contracted from independent power producers, which includes including 4.1 MW of solar in Alice Springs and 1 MW of gas from the Shoal Bay landfill site. The eight power stations of Territory Generation are operated under five separate networks as the NT does not have a single interconnected electricity transmission network. The Darwin-Katherine interconnected system (132 kV transmission line from Darwin to Katherine) is the largest regulated network hosting three power stations (Katherine Power Station, Channel

Island Power Station and Weddell Power Station)¹. Therefore, the I-NTEM resembles a small electricity market that is isolated with scattered electricity networks but aiming to foster competition through market reforms (Nepal and Menezes, 2017). As of 2016, more than 50 percent of the population in the Territory were not connected to the grid while gas (fossil fuel) has been the dominant source of electricity generation in the NT since 1986 with less than 10 percent of electricity sourced from renewables. The remote communities (around 72 remote indigenous communities and 66 homelands in the Territory under the service of Essential Services of PWC) are benefiting from 177 diesel generators powering around 56 island power stations using over 30 million litres of diesel per year (Nepal, 2016).

Early reform experience of the NTEM by Nepal and Menezes (2017) suggested that average prices for wholesale electricity were highest in the NT when compared with the electricity market serving neither the Eastern Jurisdictions of Australia (i.e. the Australian National Electricity Market (NEM)) and the Western Jurisdictions of Australia (i.e. the Wholesale Electricity Market (WEM) of Western Australia). Network electricity losses in the NT is also relatively higher compared to a much larger but fully liberalised market like NEM, which exhibited a 10 percent loss. Retail price regulation for small consumers ceased in Darwin-Katherine market on 1 August 2015 and in the Alice Springs and Tennant Creek market on 1 January 2016, with a declining subsidy. The previous System Control and Market Operator functions of PWC are now referred to as the Northern Territory Electricity System and Market Operator (NTESMO). However, no independent system controller yet exists in the I-NTEM. Figure 3 below shows the framework that I-NTEM provide to facilitate the wholesale exchange of electricity between generators and retailers.

Figure 3: The Interim Northern Territory Electricity Market (I-NTEM)



Source: Northern Territory Electricity System and Market Operator (NTESMO)
<https://www.ntesmo.com.au/>

Full retail contestability in the I-NTEM implies that Territory consumers can choose to buy electricity from any of the retailers licensed by the Utilities Commission. However, behind the meter solar installations is on the rise in the NT totalling 59 MW already in the Darwin-Katherine grid during 2018-19. The growing adoption of small-scale and large-scale PV in the NT is changing the energy mix as solar contributed to a 32 percent increase in 2019 as compared to 2018 (CIGRE, 2020). Improving coordination between solar and gas-fired generators, ensuring sufficient generation capacity, facilitating payments between generators and retailers and improving operation efficiency are some of the objectives of the 2020 Northern Territory Electricity Market Priority Reform Program. The I-NTEM is also an isolated electricity market considering that the market is not currently physically inter-connected to either the NEM or the WEM.

¹The Alice Springs grid is the second largest regulated grid connecting Ron Goodwin and Owen Springs Power Station. Tennant Creek has the smallest regulated grid in the NT that connects Tennant Creek Power Station. The remaining two power stations among the eight owned and operated by Territory Generation include Kings Canyon Power Station and Yulara Power Station.

Discussions – Review of cases and stakeholder consultations

The review of reforms status and outcomes in smaller electricity systems including IPPs involvement provide important insights to PNG power sector aiming to undertake broader electricity reforms and attract private sector participation in the electricity sector. The success of the reforms is mixed and not spontaneous in smaller electricity systems like Nepal, Nicaragua and the Northern Territory Electricity market. IPPs have been able to participate at varying extent in these markets and therefore, their contribution in ensuring sufficient generation capacity remains mixed. The discussions of case studies alongside stakeholder consultation inputs gathered through site visits and interviews is carried out against three dimensions: i) revenue security; ii) market demand; and, iii) contract procurement.

Revenue security

Prices that reflect costs such as in competitive markets are Pareto efficient exhibiting the three different efficiency attributes: exchange efficiency, production efficiency and product-mix efficiency. Therefore, market-based reforms are expected to promote cost-reflective pricing, which is welfare maximising even though the distributional impacts of tariff adjustment, for example, through cross-subsidies, is a socially, politically, and political sensitive task and needs to be assessed (Chang, 1997). The PPAs signed between the single buyer (PPL) and the IPPs (POSCO and NiuPower) are cost reflective in the PNG power sector. However, cost recovery has been problematic for IPPs since PPL is insolvent. This empirical evidence is consistent with the findings of an earlier literature by Laszlo (2000) that single buyer model invites corruption, weakens payment discipline, and imposes contingent liabilities on the government in developing economies. Government payments owed to PPL is about US\$130 million and high levels of electricity theft (illegal connections and non-payment of bills) amounting US\$7 million per month are the key factors contributing to the insolvency of PPL (Kabuni et al., 2021). IP3 is concerned that PPL has not fulfilled its contractual obligation of paying the services rendered by the IPPs on a monthly basis with a total accumulated amount owing 200 million (PNG Kina) as of February, 2022 (Yafoi, 2022). Niupower Limited, the only customer of PPL in the Port Moresby grid, which supplies about 54 to 57 MW of electricity to PPL is also concerned over not being able to pay their supplier of gas because of the bills owed and the unsettled debts with PPL (Kidu Jnr, 2022). The independent power plants not paid by PPL include NiuPower (operating a gas-fired power station in Port Moresby), PNG Forest Products (operating hydro-power stations in Bulolo and powering the Ramu grid) and POSCO which supplies Lae and New Britain Palm Oil. The experience from the Nepalese power sector suggests that full cost recovery since 2017 through better management has enabled the single buyer to be financially viable with operating net profits while electricity losses have decreased. The positive net operating profit is supporting system expansion and some modernisation of the power systems such as net metering. Lack of regulatory rules application pertaining to tariffs adjustment also saw the weakening financial performance of electricity distribution companies in Nicaragua. The importance of installing financial payments discipline between the generators and retailers is emphasised in the Northern Territory electricity market reform programme too.

Market demand

Instability in electricity demand by the single buyer creates a political risk for IPPs while many factors can contribute to demand instability in the case of PNG power sector. The system operation is unstable due to supply side incompetence. Discriminatory grid-access to IPP generation is prevalent as PPL favours PPL owned plants in dispatch rather than IPP owned plants despite IPP owned plants contributing to demand stability. Involving more market participants (generators, distributors and suppliers) through the prospect of introducing wholesale and retail competition is also not feasible and is beyond the scope of the cash-strapped PPL.

An independent system operator as in the case of the Northern Territory can be a suitable option for smaller electricity system deepening market-based reforms. However, the Nepalese experience suggests that system operation need not be independent if managed well even when electricity reforms are not advanced like in PNG. Earlier empirical evidence in developing economies suggest that the efficiency of an independent system

operator or a joint owner-operator such as in the case of PNG depends on the system operators being truly independent of ownership and control of market participants (Beatriz et al., 2001). The Nepalese experience further demonstrates that fairer and non-discriminatory grid access to IPPs are possible to achieve under a joint owner-operator model and not necessarily establishing an independent system operator.

Contract procurement

The PPAs are negotiated in the PNG power sector as a preferred approach by the IPPs rather than regulated since the PNG power sector is institutionally evolving. However, negotiating PPAs with greater transparency is necessary to make independent power supply more reliable. A transparent PPA brings certainty for independent power producers, which enables them to generate and supply electricity over the contracted term (often 25-30 years) at a contractually determined price (Abbasov, 2021). In the absence of robust institutions and institutional framework such as changing Energy Laws as in PNG ; a transparent PPA will mitigate some investment uncertainty risks to the IPPs. There is also a worry that centralised purchase agreements such as PPAs are creating excess capacity through over-investment, high tariffs and stranded costs in the Port Moresby grid in line with the international experiences with PPAs as summarised by Arizu et al. (2006) while the Ramu and Gazelle grids are underutilised in terms of IPPs integration.

Appropriate siting and location of the IPPs can promote operational efficiency by reducing network congestion and reducing electricity losses. IPPs in the PNG power sector are also not opposed to the PPL relying on renewable energy auctions to procure renewables-based electricity at the lowest price in the future. However, the successful implementation of renewable energy auctions such as in Nicaragua relies on an appropriate regulatory and institutional framework, relevant skills and adequate infrastructure to attract investors which the PNG power sector is currently lacking (IRENA, 2013). Nonetheless, there can be a useful role for auctions in electricity markets where competition is hard to arrange and at the same time regulation is difficult as in the case of PNG. A “competition for the market” via the auctioning of long-term contracts to support investment is desirable in the long run alongside a “competition in the market” for short-term wholesale price determination as reforms deepen (Roques and Finon, 2017).

The IPPs view that ICCC needs to be more proactive but the enforcement of the Acts imply that the role and functions of the ICCC needs to be made more clearer first. The Nepalese experience suggest that independent organisations like IPPAN can be effective in encouraging and promoting private sector to participate in electricity generation by exchanging technology, expertise, knowledge, financial and management information among the independent power producers. Therefore, IP3 can also play an important role in the PNG power sector, particularly in dealing with regulatory and commercial matters but requires expanding the IPP memberships being a membership-based organisation.

Table 2: Views from the IPPs

²	IPP 1	IPP 2
1. Revenue Security		
a. Revenue reimbursement by PPA	Not exactly. There have been arrears all the time.	No
b. Cost Reflective PPA	The fuel which is the main portion of costs have been reimbursed in a pass-through basis.	Yes
2. Market Demand		

² Please note that we are not disclosing the names of the consulted IPPs due to confidentiality reasons.

a. Demand stability/non-discriminatory grid access/ operational incompetence of PPL	Plenty of instable cases around the grid due to the instable operation of supply side; PPL prefers PPL owned plants, mainly hydro power in spite of blackouts and instabilities.	Supports demand stability because Rouna Hydro is top of the merit order of dispatch and Kanudi is a peaking plant because it is the most expensive to dispatch ³ .
b. Prospect of wholesale competition: selling power directly to distribution companies	It is too early. All grid system should be fully rehabilitated before going into this market.	It won't fix our issues because we need line of sight to the cash from customers.
c. Prospect of wholesale competition: preference of open access to transmission grid	Since we are fully and legally obliged to PPL under long-term PPA, it is not appropriate to answer.	Not necessarily because you are still exposed to the retail business.
d. Prospect of retail competition: favourable for IPPs if the distribution segment is separate from retail so that consumers can directly choose a supplier	The same as above.	Yes, but not at this point in time.
3. Contract Procurement		
a. On currently negotiated versus regulated PPAs	New National Energy	
Authority law has caused significant interruption for other IPPs on the development stage.		
	Negotiation of individual PPAs are okay. The issue is with the investment decision making by PNG Power. They have over-invested on the Port Moresby grid.	
b. Auctioning of PPAs favourable for renewable energy	As long as the government provides clear guidelines and supports such as land acquisition & government guarantee, the auction system will be quite effective when it comes to competitiveness.	Perhaps in time but right now, the focus needs to be on PNG Power because they are insolvent.
c. Satisfaction with ICCC role	There has not been conflict with ICCC since we got ICCC license.	Yes but needs to be more proactive.
d. Should IP3 play a role in contract procurement?	We expect that IP3 will act as an official window for IPPs to deal with regulatory & commercial matters against the government.	None.

Source: Inputs gathered through stakeholder consultations

³ Both Kanudi and Rouna systems are owned by PPL.

Conclusion and policy implications

This study reviewed the status and future prospects of enabling power sector reforms in PNG in the context of needing to develop and integrate IPPs in the power system. The PNG power sector operates a SBM with the objective of attracting new investments in generation from the private sector through IPPs and alleviate the electricity shortages. However, the rigidity of the contractual arrangements such as PPAs under the SBM can be concerning as the PNG power sector aims to improve efficiency and foster competition in the power sector through wider power sector reforms. On the other hand, reform incompleteness can be a barrier towards the greater development and integration of IPPs into the power system, as risks facing the IPPs are not fully addressed. *It is important for policymakers to understand that the PNG power sector is in transition of growth in terms of power size and therefore, policymakers should plan accordingly as far as sector regulation and industry structure is concerned.*

International experiences with power sector reforms and IPPs integration in smaller power systems suggest that reforms do not impede the development and integration of IPPs. Nicaragua, as one of the advanced reformer among countries having smaller power systems, has around 70 percent participation in electricity generation suggesting that deepening market-based reforms is attractive for the private sector. However, establishment of wholesale electricity markets is challenging and requires creating of regulatory mechanisms for market monitoring that can identify and address emerging design flaws (Rudnick and Velasquez, 2018). The Northern Territory and Nicaragua have wholesale electricity markets that are supported well by the underlying regulatory institutions. *We recommend that the PNG power sector also first devote its resources in creating and establishing appropriate regulatory institutions evolving the power sector to attract private investments in the power sector while establishment of wholesale electricity markets can wait.*

Vast electricity shortage imply that PNG should focus more on developing a framework for supply adequacy so that capacity meets demand without imposing supply constraints. The need for supply adequacy is even greater for in the PNG power system since the market is not interconnected while hydroelectricity generation is prone to seasonal fluctuations. *The best approach to achieve resource adequacy under a SBM would be to provide attractive returns on capital investments to the private sector based on transparent and accountable PPAs.* Once the wholesale market is established as reform deepens in the long-run; auctions and capacity payments to provide adequate incentives for investment in new generation capacity should be implemented. However, the balancing of generation capacity and peak demand can be difficult in smaller electricity systems. Demand response and storage can help alleviate the resource adequacy concerns.

Accountability of responsibilities in the PNG power sector is of utmost importance since the power sector is vertically integrated with chronic problems facing all segments of the ESI: generation, networks and retail. The Nepalese experience suggests that functional separation is necessary in smaller power systems that are operated under a SBM while reform experiences from Nicaragua and the Northern Territory suggest that accounting, legal and ownership separation will be appropriate as reform advances and the power system size grows. An effective separation of the ESI activities is required in order to address the inefficiencies in a system. Vertical separation clearly exposes the inefficiencies in the power system makes it easier to address them. *Therefore, we recommend that functional and accounting separation of the main activities of the PPL should be pursued under a cautious restructuring as an urgent step.*

The current PNG power sector reform experience also demonstrates a classic case of division between reform theory and practice. For instance, cost reflective pricing is often not implemented and, in addition, cost recovery is not achieved either. The reform experiences of Nepal, Nicaragua and Northern Territory suggest that reforms take shape only when financial performance is positive and provides the much-needed financial assurance and confidence to IPPs for investing. *Therefore, it is important for PPL in the case of PNG to remain solvent and improve bill collections while minimising the financial losses.* However, this will require institutional strengthening and strong political will. *We recommended that strong political will and strengthening institutional arrangements are urgent reform measures in the PNG power sector to attract private sector investments in power generation as political instability continue.*

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