Energy and Economic Growth
Applied Research Programme

Electricity in Nepal

EEG Energy Insight

Simon Trace

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Introduction

According to a 2018 World Bank paper[1]: '…inadequate access to reliable, affordable, and sustainable electricity is a fundamental reason for Nepal's poor economic competitiveness'. Two-thirds of Nepal's firms identify electricity as a major constraint to doing business in Nepal[2].

A Nepal Government White Paper from 2018 outlines its strategy for developing a reliable, affordable, and sustainable energy sector that can support poverty reduction and shared prosperity in the country.

Key goals include:

- Reaching 5,000 megawatts (MW) of installed capacity in five years and 15,000 MW of installed capacity in 10 years;
- Expanding access to electricity and clean cooking to 100% of the population in five years; and
- Increasing the per capita consumption of electricity to 1,500 kilowatts per hour (kWh) in 10 years.

The road map to achieve these goals is as follows:

- In the short term, minimise load shedding through the reduction of system losses, demand-side management, consumer education, increased power imports, and efficient system dispatch. At the same time, initiate power sector reforms through the establishment of the Electricity Regulatory Commission (ERC), and prepare and implement restructuring and financial viability plans for the vertically integrated utility Nepal Electricity Authority (NEA).
- In the medium term, reach supply–demand balance through investments in new generation, prioritisation of large peaking and storage hydropower projects, expansion of transmission and distribution, energy access and export, and cross-border transmission lines. Alongside this, deepen power sector reforms through the full operationalisation of the ERC, the establishment of a power trading mechanism, the introduction of competitive power purchase mechanisms, integrated system planning, and separation of NEA's generation, transmission, and distribution business.
- In the long term, achieve a sound regulatory framework, competent sector institutions, and a competitive and efficient power market through continued sector reform, sustainable investments in generation, transmission, and distribution infrastructure, grid and off-grid access, and integration in the South Asian regional power market[3].

The Energy and Economic Growth (EEG) applied research programme aims to address pressing policy questions in low-income countries to help shift energy systems towards a more sustainable, efficient, reliable, and equal paradigm. EEG's current 25 research projects derive from one general and two country-specific (Ethiopia and Sierra Leone) calls for proposals. The UK Department for International Development (DFID) is now considering the possibility of future additional energy research investments and, alongside its ongoing research projects, EEG is carrying out scoping studies on behalf of DFID in several countries, including Nepal.

The aim of the Nepal scoping study was to identify potential research questions of use to decision makers and practitioners in the energy sector, and to explore the extent of research capability in the country. An initial literature review established key information about the electricity sector, including data on access levels, energy mix, and generation capacity, sector policies, key constraints, and key actors. Drawing on that material, interviews were held with key stakeholders to discuss potential areas where academic research might be of use to help inform the actions of policy makers and other actors. This paper lays out the key issues and challenges identified during the scoping exercise.

[1] International Development Association (2018) 'Programme document for a proposed development policy credit in the amount of SDR 71.2 million (US$100 million equivalent) to Nepal for a first programmatic energy sector development policy credit', http://documents.worldbank.org/curated/en/104141537500644401/pdf/Nepal-Energy-DPC-Program-Document-08272018.pdf
[2] Based on Nepal Enterprise Survey (2013), carried out by the World Bank.
[3] Ibid.

Institutional structure of Nepal's electricity sector and key players

The publicly owned NEA oversees the total grid supply chain of power, including generation, transmission, and distribution.

The key players in Nepal's energy sector, and their roles, are summarised below:

Institution	Role
Government / utility	
Ministry of Energy, Water Resources and Irrigation – Energy Division	• Electricity and energy policy section • Project promotion and permission section • Electrification, and the electricity trade and system expansion section
Alternative Energy Promotion Centre (AEPC)	• Government agency established in 1996 • Promotes and disseminates renewable energy technologies, such as micro-hydro, solar household and mini-grid systems, improved cookstoves, solar driers and coolers, biogas, and improved water mills • >30 MW of micro-hydro power and over 1.26 million household solar energy systems installed up to 2018
NEA	• Publicly owned, vertically integrated organisation • Oversees total grid supply chain of power, including generation, transmission, and distribution
Water and Energy Commission	• Provides energy systems planning and policy advice to the Government of Nepal
Electricity Tariff Fixation Commission (ETFC)	• Reviews and approves tariff applications that are submitted by NEA • Conflicts of interest (the licensees it regulates are represented on the Commission) and a lack of technical capacity has led to its authority occasionally being undermined by NEA[4]
Nepal Electricity Regulation Commission (NERC)	• Provision for a new regulatory body, NERC, which is expected to replace ETFC as a fully independent regulator, was included in a bill passed in 2017 • Appointments to the Commission were only finalised in May 2019 and it has thus only just started work
Private sector and non-governmental organisations (NGOs)	
National Association of Community Electricity Users Nepal	• Oversees community-managed rural electrification utilities (CREEs) that have been developed to address some of the cost and management issues facing NEA in extending the grid into rural areas • 282 CREEs created to date, serving 500,000 households
Independent Power Producers' Association Nepal (IPPAN)	• Established in 2001 to encourage private sector investment in hydropower in Nepal • IPPAN's website indicates a membership of more than 100 independent power producers (IPPs), with 77 projects currently generating electricity with a total capacity of 521 MW (with individual installations ranging from 40 kW to 50 MW)
Donors / funders[5]	
World Bank	• $100 million Energy Sector Development Policy Credit to: improve the financial viability of NEA; establish a regulatory framework that is transparent, autonomous, and accountable; encourage electricity trade;

[4] Ebinger, K. (2011) 'Energy and Security in South Asia: Cooperation or Conflict?' Brookings Institution Press, Washington DC.
[5] IPP arrangements generally include some form of local finance raised from national commercial banks by the IPP itself.

	and restructure NEA to make it easier for the private sector to compete in the energy sector • $5.6 million grant and $2 million loan to support private sector mini-grid access
Asian Development Bank	• Distribution master plan support • Purchase and installation of 90,000 smart meters in Kathmandu valley
Millennium Challenge Corporation	• Signed compact with Nepal in 2017; identified transmission as a key constraint and currently investing $300 million to create a 300 km east–west line, with 120 km spur into India
Chinese and Indian governments	• Direct investors in generating capacity • Figures difficult to obtain
DFID	• Mostly off-grid (current investment – 100,000 households connected via solar home systems or micro-hydro) • Some engagement with and support to World Bank policy lending and NEA restructuring efforts
GIZ	• Off-grid renewables and energy efficiency
Japan International Cooperation Agency	• Has been engaged on development of sector master plan and funding of hydroelectric schemes in the past

Electricity supply and demand

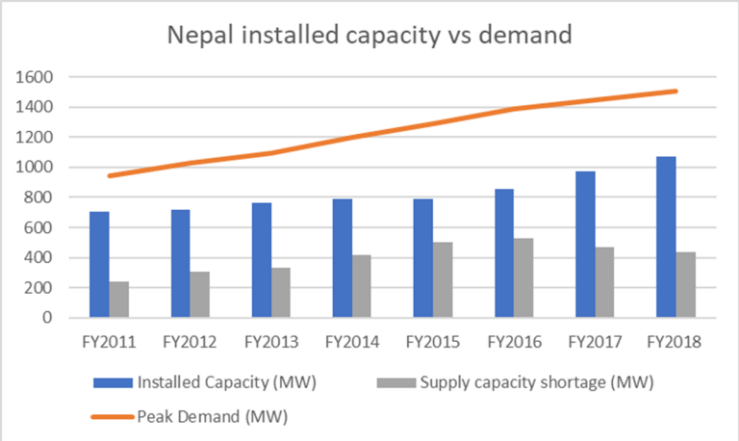
Supply

While 95% of the population of Nepal is estimated to have access to electricity through grid and off-grid connections (according to the World Bank/Energy Sector Management Assistance Program Multi-Tier Framework Surveys from 2018), the annual per capita electricity consumption in Nepal, at 177 kWh, is a twentieth of the global average and a fifth of the South Asian average.

The installed generation capacity (1,073 MW) has not kept up with the growing electricity demand (1,450 MW), leading to power outages of up to 16 hours a day (until 2017). The economic loss from load shedding is estimated to have been as high as $1.6 billion per year (in 2016 prices) during 2008–2016[6].

However, electricity production has improved in recent years (see Figure 1[7]).

Figure 1: Installed capacity vs demand 2011–2018

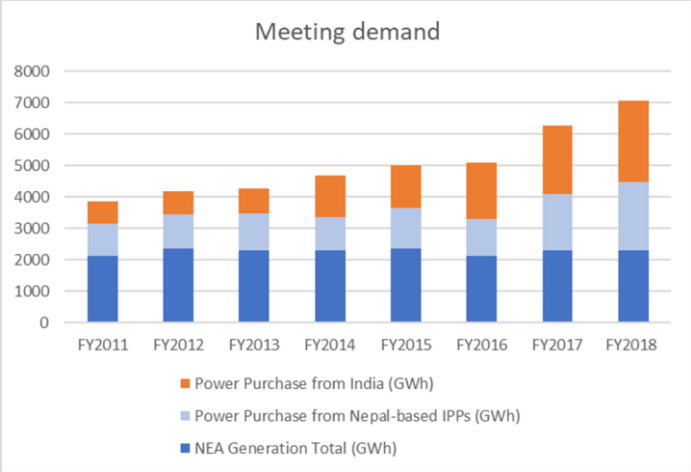


[6] Govinda, T., Sapkota, P.R., and Steinbuks, J. (2017) 'How Much Has Nepal Lost in the Last Decade due to Load Shedding? An Economic Assessment Using a CGE Model', Policy Research Working Paper WPS 8468, World Bank, Washington DC.
[7] Data from NEA's Annual Report, A year in Review 2016-17, 2017-18', and the Asian Development Bank's Nepal Energy Sector Assessment, Strategy, and Road Map 2017.

The current 1,073 MW of installed electricity production is made up of 1,016 MW from hydroelectricity, 54 MW from diesel and multi-fuel, and 2.68 MW from solar energy.

The NEA's contribution to the national generating capacity stands at 562 MW, while the private sector contributes 511 MW. The current demand on the national electricity system is of the order of 1,300 MW, with the gap being filled by importing around 450 MW of electricity from India (see Figure 2)[8].

Figure 2: Source of electricity generation



Decentralised Renewable Energy systems, supported by the AEPC, have played a significant role in extending electricity access in rural areas, with production of over 55 MW of renewable energy production benefitting around 3.6 million households. In addition to micro-hydropower and household energy systems, significant numbers of improved watermills and cook stoves, solar dryers and coolers, institutional solar photovoltaic (PV), and biogas systems, as well as solar mini-grids, have been supported through AEPC programmes and other development organisations.

Demand

A recent study[9] commissioned jointly by the Nepal Planning Commission and the National Investment Board explores electricity demand under different GDP growth scenarios.

By 2030, electricity demand more than doubles under a 5% GDP growth rate and almost quadruples under a 10% GDP growth rate. In the high-growth scenario, manufacturing sees the greatest increase in demand, but under all scenarios, domestic demand is set to be one of the (if not the) largest component of electricity consumption for the foreseeable future, even under relatively high rates of economic growth (see Table 1).

[8] Ibid.
[9] Investment Board Nepal 'Energy Demand Projection 2030: A MAED Based Approach' (see http://ibn.gov.np/uploads/files/Working%20Classification/reports/Energy%20Demand%20Projection%202030.pdf)

Table 1: Domestic electricity demand vs other sectors under different economic growth scenarios

	Base Case (5% GDP Growth)			7% GDP Growth Rate			10% GDP Growth Rate		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
Population (Millions)	29.89	31.97	34.18	29.89	31.97	34.18	29.89	31.97	34.18
GDP (USB billions)	24.11	30.78	39.28	27.01	37.88	53.12	31.88	51.34	82.69
GDP per Capita (USD per person)	807	963	1,149	904	1,185	1,554	1,067	1,606	2,419
Sectoral GDP Growth Rates									
Agriculture	3%	2%	2%	5%	4%	4%	8%	7%	7%
Construction	6%	6%	6%	8%	8%	8%	11%	11%	11%
Mining	17%	12%	10%	19%	14%	12%	22%	18%	16%
Manufacturing	8%	8%	8%	10%	10%	10%	14%	13%	13%
Service	5%	5%	5%	7%	7%	7%	10%	10%	10%
Energy	19%	13%	11%	21%	15%	13%	25%	18%	16%
Total Electricity Demand (GWhr)	13,079	21,567	33,437	13,666	23,521	38,299	14,664	27,217	48,706
Electricity Usage by Sector									
Agriculture	1%	1%	1%	1%	1%	1%	1%	1%	1%
Construction, Mining and Manufacturing	30%	30%	32%	32%	34%	37%	35%	40%	46%
Service Sector	6%	7%	9%	6%	7%	9%	6%	8%	8%
Freight Transport	4%	6%	6%	4%	6%	7%	5%	7%	9%
Passenger Transport	1%	2%	2%	1%	1%	1%	1%	1%	1%
Household	57%	54%	51%	55%	50%	44%	51%	43%	35%

Challenges

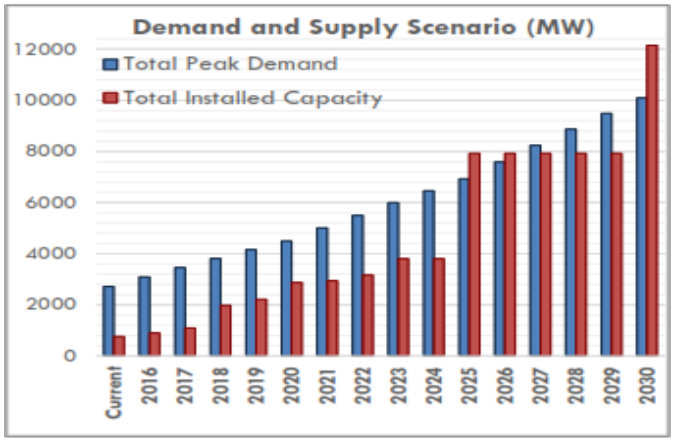
The following challenges to sector performance emerged from interviews carried out during the scoping study.

Under-investment in infrastructure

Nepal's electricity sector faces significant under-investment due to weak sector governance, and the World Bank estimates that investments must increase at least four-fold to meet the growing electricity demand in the country.

That said, recent and planned investments in generating capacity have already had an impact on reducing load shedding, particularly in Kathmandu, and some scenarios show installed generating capacity matching or exceeding peak demand between 2025 and 2030 (see Figure 3[10]).

Figure 3: Projected installed capacity vs demand to 2030



The bottlenecks in electricity supply are therefore gradually shifting away from the generation of electricity towards limitations imposed by the transmission and distribution networks.

The construction of transmission lines has often been slow (more than 60 projects are currently underway). A common problem seems to be delays in resolving issues related to land acquisition, with the new Nepal constitution

[10] Ibid.

and federal structure putting local parties in a stronger position to negotiate compensation for land lost to right of ways for power lines. As distribution improves, the bottleneck is likely to shift to the state of distribution networks. System losses remain high in the distribution system, at 20–25%, compared to 7–8% for transmission and 1–5% for generation[11].

Financial viability of utility

Historically, the financial health of NEA, which is the sole off-taker, has imposed a significant fiscal burden on the Government and constrained the sector's capacity to mobilise sufficient investments. In the years leading up to FY 2017, NEA posted large losses due to below-cost retail electricity tariffs and high system losses. By FY 2017, the net accumulated losses were Nepalese Rupee (NPR) 28 billion, 0.9% of the country's 2017 GDP. In addition, NEA had a debt liability to the Government of Nepal of $1.0 billion in FY 2016[12].

However, there has been a recent turnaround in the fortunes of NEA, which posted a net profit of NPR 2.84 billion in FY 2017/18, as a result of efforts to control electricity loss and administrative and financial reforms[13].

Immature market

The lack of strong institutions, such as a regulator (only recently appointed) and clear policies (the electricity act has been submitted three times so far but has still not been passed), has been a challenge for progress in the sector. As a result, issues around trading, foreign exchange risk for investors, and the licensing regime remain unaddressed.

New federal constitution

Nepal has recently moved to a new federal constitution, with powers devolved to seven provinces and 753 local government units. In theory, responsibilities related to electricity supply are allocated across the federal structure as summarised in Table 2. In practice, however, final dispensation of responsibilities is still a work in progress, with the responsibilities being pushed down to 753 local government units, not necessarily commensurate with their capacity and capabilities to implement them. An example of one such provision is that local government can plan and commission generation projects of up to 1 MW of hydropower electricity, and also develop their own regulations for the distribution of that electricity at a local level.

Table 2: Constitutional jurisdictions defining mandates of various governments

Government	Jurisdictions
Federal	Inland and inter-State electricity transmission lines Central-level large electricity projects Atomic energy, air space, and astronomy
Provincial	State-level electricity, irrigation, and water supply services, navigation
Local	Water supply, small hydropower projects, alternative energy
Concurrent (Federal and State)	Services such as electricity, water supply, irrigation service fee, charges, penalty and royalty from natural resources Forest, wildlife, birds, water uses, environment, ecology, and biodiversity Royalty from natural resources

NEA and others are still learning how to cope with the new federal arrangements, for example:

- AEPC, the agency responsible for distributed generation, had 75 district energy officers to support district off-grid renewable energy planning under the old constitution, but post-federalisation, district-level government planning

[11] From interview with Niti Foundation.
[12] International Development Association (2018) 'Programme document for a proposed development policy credit in the amount of SDR 71.2 million (US$100 million equivalent) to Nepal for a first programmatic energy sector development policy credit'.
[13] See www.spotlightnepal.com/2019/04/13/nepal-electricity-authority-makes-rs284-profit-auditor-general-report/

is defunct. AEPC cannot afford to station an energy officer in all 756 local government units, but one per province provides insufficient capacity.

- A generation or transmission project may be sanctioned at federal level, but permission for construction, land acquisition etc has to be sought from local government, which can slow things down and increase costs. There is some evidence of local governments now having sufficient leverage to be able to delay licensed developers from starting work, as a negotiating ploy to hold out for additional local development benefits[14].

Barriers to regional power trade

Regional power trade with India is currently critical for Nepal in regard to balancing its peak demand – but it may also be important to justify the investment in much-needed internal infrastructure.

The Millennium Challenge Corporation (MCC) has identified transmission as a key constraint and is investing $500 million to create a 300 km east–west transmission line in Nepal, with a cross-border element extending 120 km into India. Construction is about to start, but MCC's view is that without cross-border power trade, the economic rate of return on the transmission line would have been insufficient to justify the investment. South Asia's total power generation is around 300 gigawatts (GW), while the amount traded across borders is only around 2–3 GW – so less than 1%. MCC's view is that, given the trading opportunities that exist, countries in the region do not need to be self-sufficient in power, and, indeed, it is not optimal for them all to be so. Trading in the region could reduce the total investment needed in generating infrastructure by about $20 billion across the region[15].

There is therefore interest in the potential opportunity to export power to neighbouring countries – but issues have been raised around the politics and economics, and whether it will work for Nepal. Although the potential of power trade in the South Asia region and beyond (e.g. Myanmar and Thailand) is seen by many as an important way for Nepal to realise the full value of its hydroelectricity potential, the political economy of the region has mitigated against significant trade to date.

The South Asian Association for Regional Cooperation (SAARC) is one possible route to reaching agreements, but SAARC's energy centre in Pakistan is essentially dormant, as Indo-Pakistan relationships hamper its effectiveness. Meanwhile, while Bangladesh is an important potential consumer, transit through India either for a direct connection or trade via India connectors still needs to be negotiated.

Sub-optimal use of water resources/reliance on hydropower

According to the Water and Energy Commission, hydropower generation licences have been too easy to obtain in Nepal, resulting in poor planning and failure to optimise water resource use. Licences are often issued based on what the developer can afford to build, as opposed to the full potential of the site itself. A river basin plan is being developed with World Bank support over the coming two years. With many projects having already been constructed, the preparation of an optimal basin plan remains difficult, however, as many sites are already locked down. It may be possible to look at non-hydro sources (such as large-scale solar) to compensate for low optimisation of the hydro resource[16].

Federalisation further complicates this picture, with local government, as noted above, having the ability to commission generation projects up to 1 MW in size. This may eventually have an impact on how some of the above institutions are structured. NEA, for example, is currently reconsidering its own structure in light of the new constitution and may set up separate subsidiaries in each of the seven provinces.

Nepal's endowment of hydro potential also raises some issues around how the right balance can be achieved between large-scale hydro to power the national grid and small-scale hydro to supply communities where it would either be too expensive to extend the grid, or to boost/stabilise unreliable grid performance at the tail end of grid supplies.

[14] See https://cijnepal.org.np/how-local-officials-have-turned-hydropower-projects-into-cash-cow/, which provides a good summary of these sorts of hold-ups.
[15] Interview with Deputy Country Director, MCC Kathmandu.
[16] Interview with Joint Secretary, Water and Energy Commission.

Another important consideration is how resilient the hydro resource is to climate change. Changes in rainfall and water availability, protracted drought events, significant variation in temperature regimes, and more frequent and severe weather events have the potential to negatively impact the sector.

A recent Nepal Government white paper looks at the energy mix and sets a target that the grid should include at least 10% of non-hydro renewable energy.

Conclusion

After engaging with a wide range of stakeholders, EEG has identified priority research areas for Nepal's energy sector. There is clear interest for a programme of policy-related research on some or all of the following areas: development pathways and scenario planning for productive use of electricity; the technical, political, and economic viability of power trade with Bangladesh, Bhutan, and India; the high costs and risks associated with financing hydro in Nepal; energy system resilience to natural disaster; sub-optimal use of water resources; incorporating solar into the energy mix; federalisation and optimal institutional arrangements; the new regulatory function and its future direction; encouraging the right balance between foreign and national finance for the sector; and the interface between the grid and micro-hydro.

About the author

Simon Trace is EEG's Programme Director. He has 35 years' experience working in international development, focusing on access to basic services (energy, water, and sanitation), natural resource management, and technology.

Simon has held senior executive positions in international NGOs, including time as International Director of WaterAid and CEO of Practical Action. He has provided oversight and technical input for several high-profile energy sector publications, frameworks, and strategies, including the UN SEforALL Global Tracking Framework, the World Bank's Regulatory Indicators for Sustainable Energy (RISE), the World Energy Outlook, and the Poor People's Energy Outlook (PPEO).

A chartered engineer with an MA in the Anthropology of Development, Simon has lived and worked in Africa and Asia. He has served on a number of steering and advisory groups for prominent international initiatives related to energy, including the UN SEforALL Tracking Framework Steering Group.

Front cover image: Frank Bienewald / Alamy