Energy and Economic Growth
Applied Research Programme

Energy in Nepal

The Applied Research Programme on Energy and Economic Growth (EEG) aims to influence energy policy in developing countries. EEG brings together world-class academics to produce new evidence on the links between energy and economic growth in low-income countries. This evidence will be specifically geared to meet the needs of policymakers, filling in the knowledge gaps that obstruct their ability to develop sustainable, reliable and inclusive energy systems.

To this end, EEG will hold a South Asia Policy Workshop in Kathmandu, Nepal on 28 September 2016. The workshop will bring together senior energy policy-makers, researchers and representatives from the private sector, NGOs and donors in South Asian countries to discuss the energy challenges facing the region, and consider policy relevant research questions that could address these constraints. This report offers an introduction to the key challenges and opportunities facing the energy system in Nepal, and aims to facilitate discussion at the workshop.

Nepal's energy demand

Nepal uses little energy, inefficiently, but consumption is growing

From 2000 to 2013, Nepal's energy consumption grew 27%, from 8.04 to 10.17 million tonnes of oil equivalent (mtoe) (IEA, 2016). Consumption is projected to continue to increase, driven by a growing population and increased economic production (fig 1). Between 1990 and 2010, industry's energy demand grew 9% annually, while transport's demand grew 6.4% per year [CITATION ADB15 \l 2057]. Despite this growth, Nepal's energy demand remains among the lowest in Asia [CITATION ADB15 \l 2057].

While the overall quantity of energy that Nepal consumes is low, the amount of energy consumed relative to economic output is very high. In fact, Nepal's energy intensity – the amount of energy consumed per unit of GDP – is 1.8 times higher than India and China, 4.5 times higher than Bangladesh, and 4.5 times the world average [CITATION NEE15 \l 2057]. Nepal's high energy intensity suggests that it has significant potential to increase both its use of energy for productive purposes and the energy efficiency of its production [CITATION ADB15 \l 2057]. In 2013, transport, industry, and commercial and public services accounted for only 7%, 6% and 2% of Nepal's energy consumption, respectively (IEA, 2016).

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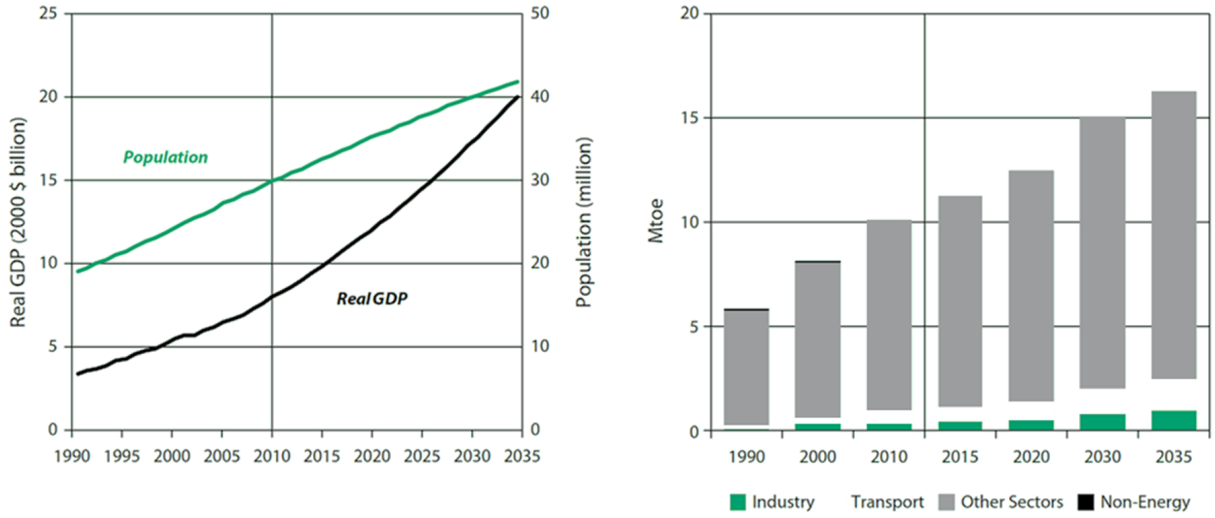

Figure 1. Historical and projected population and GDP (left) and final energy demand (right). (Figure reproduced from ADB, 2015)

Nepal suffers from widespread energy poverty

Four-fifths of the energy consumed in Nepal in 2013 was biofuels and waste, used primarily for cooking and heating in the residential sector (see fig 2) (IEA, 2016). Over 20 million people in Nepal, 82% of the population, lack access to clean and safe methods of cooking [CITATION SE415 \l 2057]. Household air pollution from unventilated cooking with fuelwood and charcoal presents a serious public health hazard. Inhalation of the fumes contributes to a variety of health issues (asthma, acute respiratory infections, tuberculosis, strokes, low birth weight, and cataracts, among others) [CITATION WHO14 \l 2057].

Nearly a quarter of the population also lacks access to electricity [CITATION SE415 \l 2057]. Urban areas have achieved nearly universal access to electricity (though as discussed later, this access is often highly unreliable). However, Nepal's rugged topography presents a significant challenge to rural electrification. Many rural families continue to light their homes with wick lamps fueled by imported kerosene.

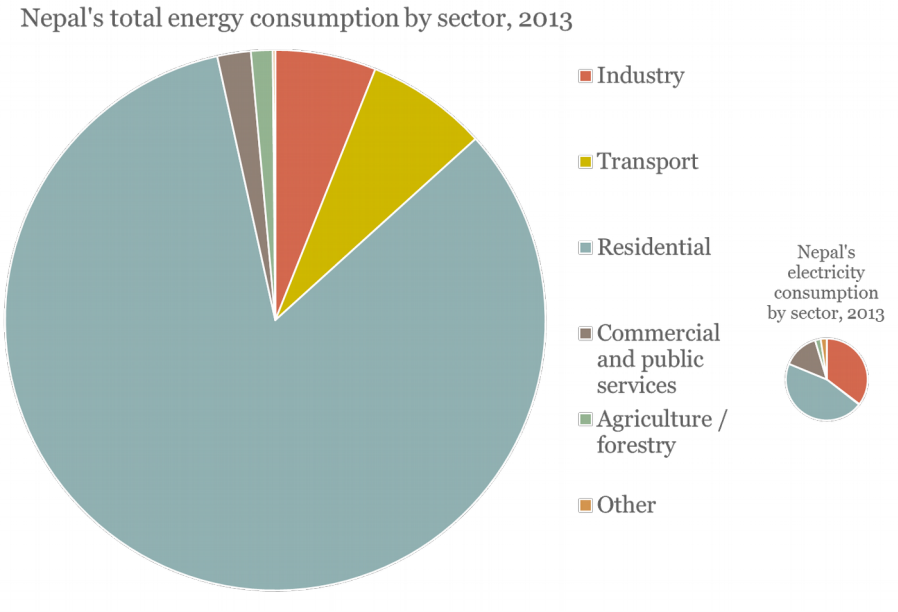

Figure 2. Breakdown of Nepal's energy and electricity consumption by sector. The volume of the pie graphs indicates the relative quantity consumed. Nepal's total energy consumption in 2013 was 10,173 ktoe. Electricity contributed about 3% of the total energy consumed, 303 ktoe or 3529 GWh. (Data from IEA, 2016).

Electricity plays a minimal, but growing role in Nepal's energy system

Nepal's electricity generated per capita is amongst the lowest in the world [CITATION REE12 \l 2057]. Electricity contributes only 3% of the energy that Nepal consumes (Fig 2). Despite low levels of rural access, Nepal's residential sector is the largest consumer of electricity, with a 45% share of total consumption. Industry consumes another third. However, most of industry's energy needs are met through other means: 72% of the energy it consumes is coal for heating and boiling processes in the production steel, brick, lime and cement (IEA, 2016; ADB, 2015). Agriculture, which employs roughly 76% of the nation's workforce, accounts for only 1% of the total energy consumed and 2% of the electricity [CITATION ICI10 \l 2057].

Nonetheless, Nepal's electricity demand is growing rapidly. The Nepal Electricity Authority reports that electricity consumption and the number of electricity consumers is growing at a rate of 9% annually. Between 2005 and 2014, peak demand more than doubled from 557 to 1200 MW [CITATION ADB15 \l 2057]. As discussed in the following section, Nepal's growing demand and insufficient supply has placed severe pressure on its electricity system. Load shedding (scheduled power cuts) has become a factor of daily life, forcing some industries to halt or reduce production.

Nepal's energy supply

The national biomass balance is in deficit, but biogas offers a promising alternative in some regions

Biomass – wood, agricultural residues and dung – is the most prevalent energy source in Nepal, providing more than 80% of all energy consumed and 96.5% of household energy. The majority

of biofuel used in Nepal is sourced as wood from forests. Along with other human activities, fuelwood collection has placed strain on Nepal's forest stocks and contributes to forest degradation in some areas. Data on fuelwood removal and supply in Nepal is poor. According to Nepal's Water and Energy Commission Secretariat [CITATION WEC10 \l 2057], the national biomass balance is in deficit. Wood consumption in 2005 was estimated to at 17 million tonnes, with over-exploitation estimated at 10 million tonnes. Nonetheless, increased penetration of biogas and liquefied petroleum gas (LPG) for cooking may have helped reduce annual wood removal in some regions [CITATION Mag \l 2057].

According to the Alternative Energy Promotion Centre [CITATION APE16 \l 2057], over 300,000 households had installed a biogas plant by 2015. Household biogas has the greatest potential in regions with numerous livestock, such as the Tarai plains. Beyond efforts to promote household biogas, AEPC is currently implementing an Extended Biogas Programme with support from the World Bank, which aims to build 1200 large-scale biogas plants by mid-2017. Unlike household biogas plants, which are fueled primarily by cow dung, the large commercial and municipal plants will convert municipal wastes into thermal or electrical power.

Nepal's reliance on imported fossil fuels leaves it vulnerable, and provides impetus for developing domestic energy options

Petroleum is the second largest source of energy in Nepal after fuelwood, accounting for 11% of the country's primary energy supply. Roughly two-thirds of the oil imported by Nepal is used for transport. The rest is used mostly for household lighting, cooking and heating; agriculture and forestry; and commercial and public services. Coal provides 4% of Nepal's energy supply, and is consumed almost entirely by industry [CITATION IEA16 \l 2057].

Nepal has no known large-scale fossil fuel reserves. Aside from some minor coal production, all of the oil and coal used in the country is imported (natural gas does not factor into Nepal's energy mix). In a business-as-usual case, the ADB (2015) projects that consumption of coal and oil is projected to roughly double by 2035, with the net import ratio of each fuel remaining high, at 95% and 100%, respectively (fig 3).

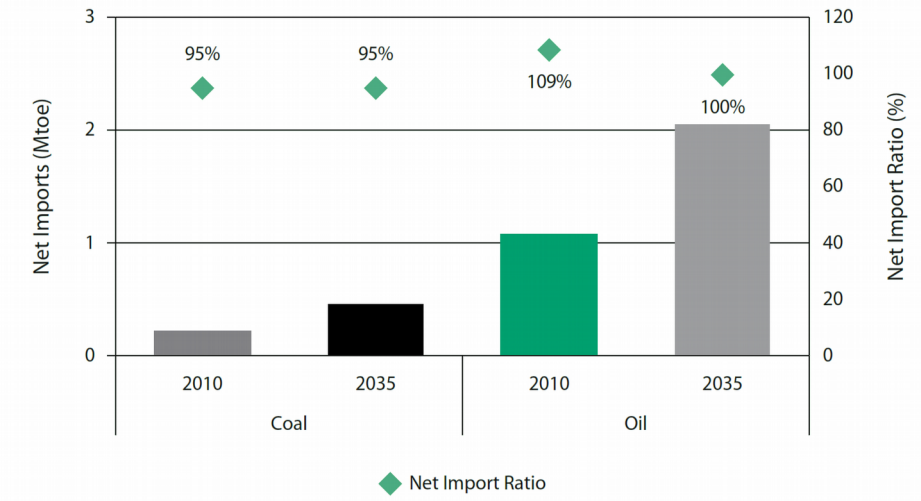

Figure 3. Net Imports of Coal and Oil, and Net Import Ratio: Business-as-Usual (Figure reproduced from ADB, 2015)

Nepal's reliance on imported fuels makes it highly vulnerable to international price fluctuations, and, as a landlocked nation, to foreign trade policy. For example, in 2015, a dispute between India and Nepal over the latter's new constitution led to a months-long blockade causing severe fuel shortages in the country. The state-owned Nepal Oil Corporation, which is responsible for the import and distribution of fuel in Nepal, declared a "fuel emergency", while the government distributed firewood to citizens to help them cope. Nepal accused the Government of India of deliberately cutting off Nepal's fuels supplies, a charge that India denied [CITATION Pok15 \l 2057]. Nevertheless, in December 2015, Nepal signed a long-term deal to purchase petroleum from China [CITATION Tim15 \l 2057]. Beyond diversifying suppliers, Nepal's reliance on imported fuel provides impetus for it to further develop its domestic energy options.

Despite vast hydropower potential, Nepal imports more than a fifth of its electricity supply

Nepal's mountainous terrain endows it with plentiful fast moving water. The majority of its installed generation capacity is hydropower, owned either by the Nepal Electricity Authority (NEA, the national utility), or by independent power producers (IPPs) (fig 4). Nepal's total technical potential to generate hydropower is estimated at 83,000 MW, enough to meet its own projected needs and to export to neighbouring countries. However, Nepal has only harnessed 1% of this potential, and is currently a net importer of electricity. In 2013, Nepal imported 1072 GWh from India, 23% of its total domestic supply [CITATION IEA16 \l 2057].

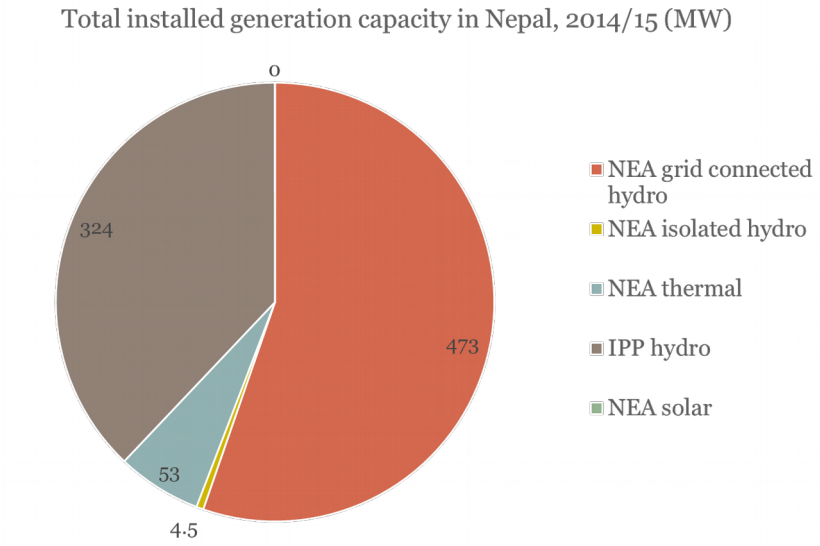

Figure 4. Breakdown of total installed electricity generation capacity in Nepal. The total capacity was 856 MW in fiscal year 2014/15, with 851 MW feeding into the grid, and 4.5 MW installed as isolated mini-grids (Data from NEA, 2016).

Alternative electricity technologies are effective for electrifying mountainous rural areas, and hold much greater potential

Nepal has numerous isolated power stations powered by hydro, and a few others powered diesel and solar [CITATION NEA16 \l 2057]. These have been instrumental in providing electricity to homes and businesses in areas that are difficult to reach with transmission lines [CITATION ADB15 \l 2057]. However, Nepal's substantial solar and wind resources have not been harnessed to their full potential – either for reaching mountainous areas or supplying the

national grid. The average solar radiation in Nepal variation from 3.6 kWh to 6.2 kWh per year, with roughly 300 days of sun each year. AEPC's Solar and Wind Energy Resource Assessment in Nepal estimates that the country has the commercial potential for about 2,100 MW of grid-connected solar PV and 3,000 MW wind power potential. To date, the solar supplies only a negligible amount to Nepal's national grid. Wind has not been exploited [CITATION APE16 \l 2057].

Nepal's 'national energy crisis' is partly caused by inconsistent hydropower, which climate change will likely exacerbate

Nepal's river flows vary by season. The South-West monsoon delivers roughly 80% of Nepal's rainfall between June and September. In these months, the hydro plants installed are nearly sufficient to meet demand. In the dry season, however, Nepal's reduced supply falls far short of peak load. Most of existing hydro plants in Nepal are run-of-the-river, and lack reservoirs to enable storage [CITATION ADB15 \l 2057]. As a result, NEA has been forced to impose widespread load shedding during the dry winter months, particularly in the evening hours when demand is highest (fig 4). Reservoir-type hydro plants could help Nepal overcome this challenge [CITATION ADB15 \l 2057]. However these come with other social and environmental considerations.

Nepal declared a 'national energy crisis' in 2008 after a flood of the Kosi River destroyed a key transmission line importing electricity from India, and drought in another part of the country reduced supply [CITATION Ban11 \l 2057]. Similar extreme events, and the inconsistency of Nepal's hydro resources, may be exacerbated by climate change. While the impacts remain uncertain, likely effects include changes to patterns of precipitation and glacial retreat. Projections show that Nepal's runoff could decline by as much as 14% due to climate change, reducing the generation capacity of existing plants, and the economic feasibility of new ones [CITATION Pat10 \l 2057].

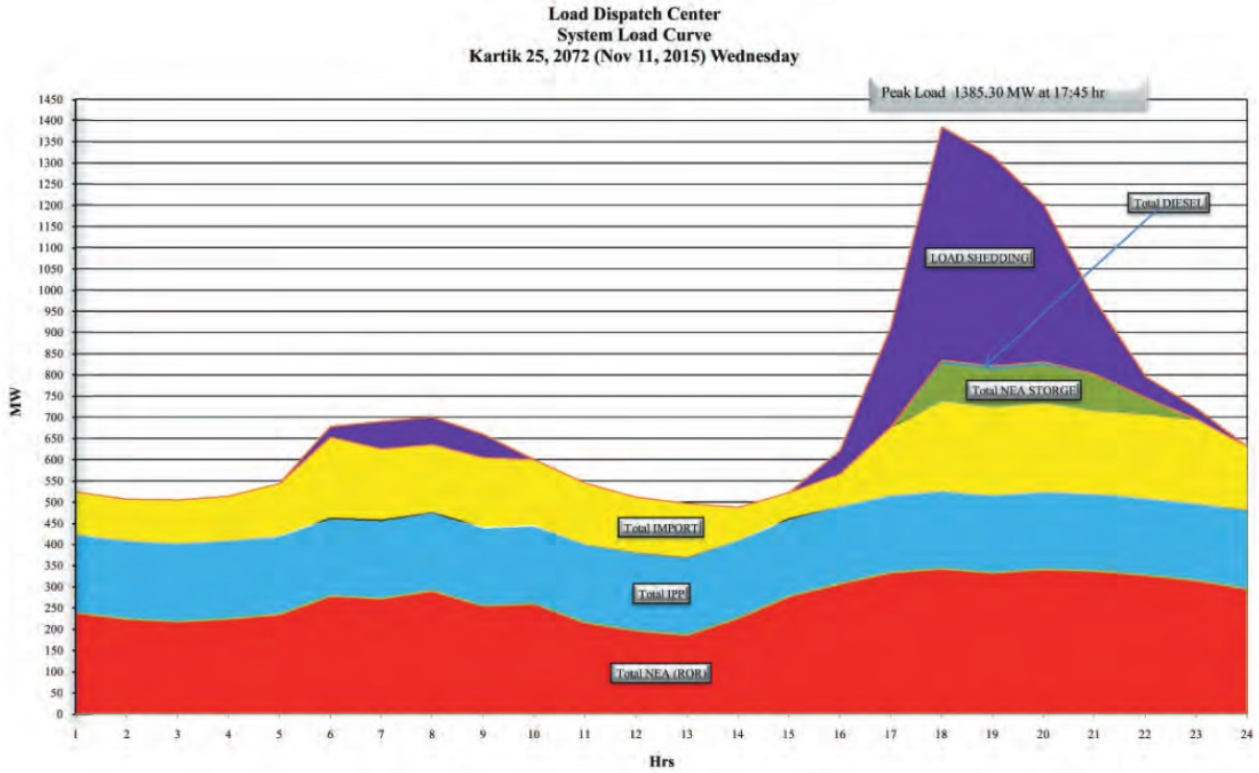

Figure 4. Nepal's electricity system load curve. Legend: red = electricity supplied by the NEA; blue = electricity supplied by independent power producers (IPPs); yellow = imported electricity; yellow/purple = electricity released from NEA's storage capacity; purple = unmet demand due to load shedding. (Figure reproduced from NEA, 2016)

Nepal's energy crisis is also the result of chronic underinvestment in the power sector, caused by political instability

Throughout the 2000s – a decade that saw an end to civil conflict – the Electricity Tariff Fixation Commission (ETFC) denied the NEA its requests for tariff hikes. Tariffs were set at a level that did not cover the NEA's costs, which caused the utility's debts to mount and inhibited large-scale investment power generation, transmission and distribution infrastructure. In 2012, with demand outstripping supply, EFTC granted a 20% tariff hike. However, the NEA claims that the increase was insufficient, and that it is still suffering losses. In January of 2016, the ETFC announced that it was mulling an additional 18% hike. It was also considering a long-term mechanism that would see the power tariff increase by 5% annually, and different rates charged during the dry and wet seasons. The Chairman stated that t of rate increase would be delayed until the political situation improved: "We have put the plan on hold because the people are going through rough times due to the Indian trade embargo and the country is facing a severe power outage" [CITATION Gir16 \l 2057].

The institutional structure of Nepal's energy system

Several government bodies in Nepal are have mandates that affect the country's energy system. Table 1 lists the main bodies and their responsibilities.

Table 1. Main bodies involved in governing Nepal's energy system

Institution	Acronym	Responsibilities
Ministry of Energy	MoE	• Management of Nepal's energy sector and development of its energy resources • Energy policy design, planning, regulation, and research
Department of Electricity Development	DoED	• Sits within the MoE • Develop and promote electricity sector and to improve financial effectiveness of this sector at the national level by attracting private sector investment.
Department of Environment	DoEnv	• Sits within the Ministry of Population and Environment • Enforcement of environmental impact assessments and coordination of climate change adaptation and mitigation programmes.
Ministry of Forest and Soil Conservation	MoFSC	• Management and coordination of land and forest resources in Nepal. • Forest conservation, environmental protection, the development of modern farming and the protection of national biological diversity
Ministry of Commerce and Supplies	MoCS	• Governance of trade and distribution of fossil fuels in Nepal
Nepal Electricity Authority	NEA	• State-owned utility • Planning, development and operation of electricity system.
Electricity Tariff Fixation Committee	ETFC	• Fix electricity tariffs and other charges • Review and approval of tariff filings by NEA
Nepal Oil Corporation		• State-owed trading company • Monopoly to import, store and distribute various petroleum products
Water and Energy Commission	WEC	• Governed by the Water and Energy Commission Secretariat (WECS) • Assist different ministries relating to Water Resources and other related agencies in the formulation of policies and planning of projects in the water and energy resources sectors
Nepal Energy Efficiency Programme	NEEP	• Sits within the Ministry of Energy and supported by German government • Promote efficient use of energy in the public, commercial and household sectors in Nepal
Department of Industry	DoI	• Sits within the Ministry of Industry • Oversee energy efficiency audits and efforts in the industrial sector
Alternative Energy Promotion Centre	AEPC	• Sits within the Ministry of Population and the Environment • Promotes energy access and the use of alternative/renewable energy technology

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Suggested readings on energy in South Asia

Asian Development Bank, 2015, *Energy Outlook for Asia and the Pacific*

Asian Development Bank, 2011, *Energy Trade in South Asia. Opportunities and Challenges*

Christian Aid, 2015, *Energy for Development in South Asia: addressing energy inequality sustainably*

International Renewable Energy Agency (IRENA), 2013, *Asia Country Profiles*

International Energy Agency, 2015, *India Energy Outlook*

World Bank, 2015, Sustainable Energy for All in South Asia: Potential, Challenges, and Solutions

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