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Low-carbon South Asia: **Nepal**

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Photo above: Installation of solar panels.

Photo credit: Practical Action

Cover: Solar energy in Nepal has huge potential.

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PRACTICAL ACTION Consulting

Contents

1. Country context

Sandwiched between two of the largest nations in the world, China in the north and India in the south, Nepal is a landlocked country with an area of 147,181km^2 and a population of 26.49 million.[1] It has a unique topography which changes dramatically from 70m in the southern region of Terai to the world's highest peak, Mt Everest, at 8,848m in the north within a distance of about 150km to 250km. Rich in biodiversity, Nepal has three distinct geographical regions, tropical south, temperate mid-hills and alpine northern Himalayan range extending from east to west. The scenic beauty of the Himalayas and mountain range that comprises 83% of the land area makes Nepal one of the most popular tourist destinations in the world.

About 83% of people live in rural areas with subsistence agriculture as the main occupation. The agriculture sector contributes more than one-third of gross domestic product (GDP). Remittance contributes 23% of GDP and is the main source of household cash income for many. Tourism is also a major contributor to the economy. Nepal's per capita income in 2012 was $700 and 25.2% of people were living below the poverty line (less than $1 per day) in 2010.[2]

Nepal has been going through a state of political transition for over two decades. Due to political instability and lack of job opportunities in the country, more than 2 million Nepalese – 7% of Nepal's population – work abroad as migrant workers.[3] This number does not include millions of migrant workers in India.

A new coalition government was formed in March 2014 following the peaceful election of constituent assembly members. The new government's main task is to produce a constitution within a year.

About 83% of people live in rural areas with subsistence agriculture as main occupation. The agriculture sector contributes more than one-third of gross domestic product.

2. Current energy situation

Traditional biomass is the main source of energy in Nepal. The residential sector has the largest energy consumption with fuel wood for cooking as the dominant energy source. The second largest energy consumption is petroleum products, largely used in the transport sector.

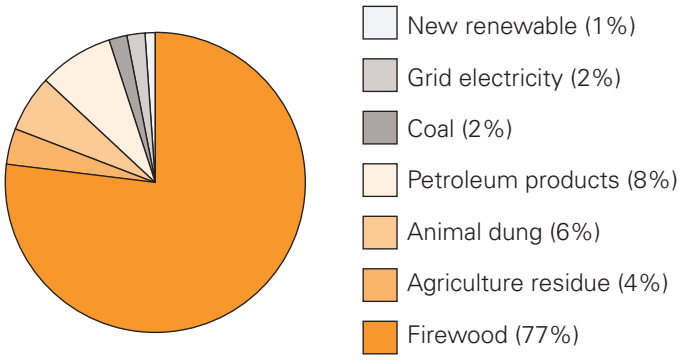
Nepal imports all of its petroleum products, spending a significant share of its foreign exchange earnings. In 2008/09, Nepal imported petroleum products worth NPR41.4bn ($US0.53bn)[4] – 61.5% of its export earnings. In 2011/12, expenditure on petroleum imports increased to 126% of export earnings (NPC, 2013). This has affected the balance of payment indicators. The massive shortfall in electricity supply for over a decade has affected the entire economy, not to mention the drastic inconveniences in people's living conditions due to long hours without electricity. The gap in the electricity supply has brought the industrial sector to its knees.

Nepal has 42,000MW of potential hydropower resources which far exceeds its domestic needs. However, the hydropower generation capacity as of July 2013 was only about 607MW,[5] 1.4% of its potential. The hydropower contribution is the lowest in the energy mix. Combined with 102.5MW imported from India and 10MW of thermal generation, the total supply in 2012/13 was 719.6MW while the annual estimated peak demand was 1,094.6MW. The shortfall in supply was 375MW. Load shedding up to 12 hours or more in the peak dry season months of January to April has been a regular affair in recent years. This deficit is partially met through captive generation using diesel and petrol generators. Capacity of the captive generating sets by industries for their own use in Nepal in 2010 is about 600MW.[6] In 2008/9, the consumption of electricity in the residential sector was 43.4%, industrial sector 38.2%, commercial sector 6.9%, agriculture sector 2.1%, transport sector 0.2% and other 9.1% (Water and Energy Commission Secretariat [WECS], 2010, p86). Exporting hydropower electricity to power-hungry India could turn around the economy of Nepal. The major impediment to harnessing Nepal's hydropower potential has been the political transition and political instability in the country for the last two decades.

2.1. Main sources of energy

Energy sources in Nepal are of three types – traditional, commercial and new renewable. Traditional sources consist of fuel wood, agriculture residue and animal dung cakes. Commercial sources consists of petroleum products, coal and grid electricity. New renewable sources consist of biogas, solar, wind and off-grid micro and mini hydro.

Figure 1. Energy consumption by fuel type



Source: WECS, 2010

Based on the *Energy Sector Synopsis Report*,[7] total energy consumption in 2008/9 was 400,506TJ, of which energy consumption from traditional sources was 87% (348,869TJ), commercial sources 12% (48,902TJ) and new renewable 1% (2,734TJ).

The traditional energy consumption is 77% firewood, 4% agriculture residue and 6% animal dung. The commercial energy consumption constitutes 8% petroleum products, coal 2% and grid electricity 2%. The modern renewable energy consumption constitutes less than 1% and consists of biogas, solar, wind and off-grid micro and mini hydropower. All petroleum products and coal are imported.

Table 1. Trends in energy consumption by fuel type

Fuel type	2000/1	2008/9
Traditional	86.71%	87.10%
Commercial	12.92%	12.21%
Renewable	0.36%	0.68%

Source: WECS, 2010

Table 1 illustrates the trend in share of consumption in each sector with little variation over an eight-year period. However, during the same period, the consumption in absolute quantity of traditional energy increased by 27.16%, commercial energy by 12.8% and new and renewable energy by 125%. This shows annual average increase of traditional energy consumption is 2.4%, commercial energy 1.6%, new and renewable energy 15.6% during the period. The total energy consumption in 2000/1 was 335,420TJ, compared to 400,506TJ in 2008/9. The annual average increase in total energy consumption is 2.46%.

Within the commercial energy, the average annual increase in gasoline is 13.7%, high speed diesel 5.3%, and LPG 23.6%. Between 2000/1 and 2008/9, the consumption of kerosene decreased by 77.8%.

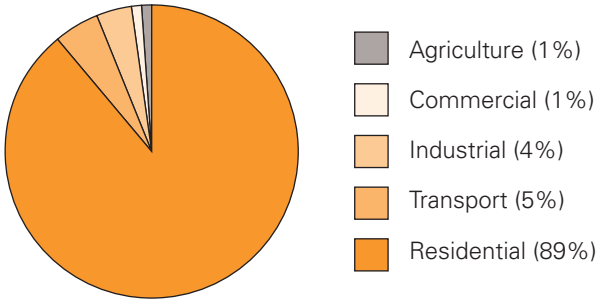
Between 2000/01 and 2008/09, the increase in utility-supplied electricity was 76% (WECS, 2010, p82). This shows an annual average increase of electricity consumption of 9.5%, which is close to the Nepal Electricity Authority's (NEA) demand forecast. Within commercial energy, the average annual increase in gasoline is 13.7%, high speed diesel 5.3%, and LPG 23.6%. Between 2000/1 and 2008/9, the consumption of kerosene decreased by 77.8%.

3. Energy consumption by sector

In 2008/9, the energy consumption in the residential sector was 89%, transport sector 5%, industrial sector 4%, commercial sector 1% and agriculture sector 1% (WECS, 2010). About 96% of residential energy consumption is from traditional energy sources – 86% fuel wood, 3.7% agriculture residue and 6.5% animal dung (WECS, 2010 p88).

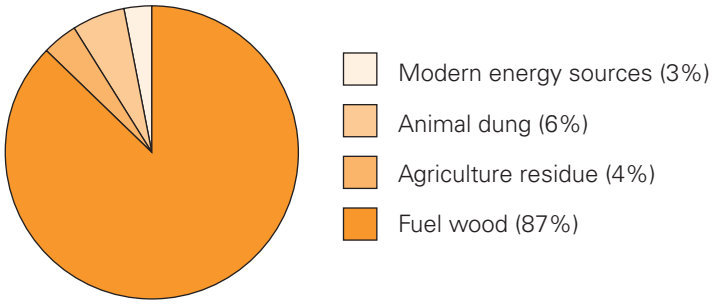
The energy consumption data below on residential sector, industrial sector, transport sector and agriculture sector is for 2008/9, based on the *Energy Sector Synopsis Report* by WECS (2010), and is the most recent data available.

Figure 2. Energy consumption by sector



Source: WECS, 2010

Figure 3. Share of fuel types in residential sector energy consumption



Source: WECS, 2010

3.1 Residential sector energy consumption

In 2008/9, the share of energy consumption in the residential sector was 87% fuel wood (87,308,590TJ), 4% agriculture residue (13,219TJ), 6% animal dung (23,224TJ), and 3% modern energy sources. The modern energy sources are 0.9% LPG (3,215TJ), 0.6% kerosene (2,143TJ), 1% electricity (3,573TJ), 0.6% biogas (2,144TJ), 0.2% solar and micro hydro (714TJ).

The 2011 census showed 64% of households cooked with firewood, 21% LPG, 10.38% cow dung, 2.43% biogas, 1.03% kerosene and 0.08% electricity (CBS, 2012, p1). There is some inconsistency in data available from various sources for population having access to electricity – estimates range from 53% to 74% (NPC, 2013, p6). Based on the census data, 74.7% of households use electricity from grid and off-grid sources for lighting; this is 94% of urban households and 70% of rural ones (CBS, 2012, p28). This is close to International Energy Agency 2011 electricity access data for Nepal. Of the 5.4 million households in the

country, it is estimated that 11% use improved cook stoves, but 53% were still using inefficient traditional cook stoves in 2012 (Alternative Energy Promotion Centre [AEPC]/ NRREP, p17). There is immense potential for fuel wood savings from using efficient stoves and biogas.

3.2 Industrial sector energy consumption

The share of energy consumption in industrial sector is 3.3% (13,369.8TJ) in 2008/9. Coal is the dominant fuel source in the industrial sector with 58% (7,754TJ) consumption followed by 23% electricity (3,075TJ), 10% agriculture residue (1,337TJ), 5% fuel wood (668TJ) and 4% petroleum products (535TJ).

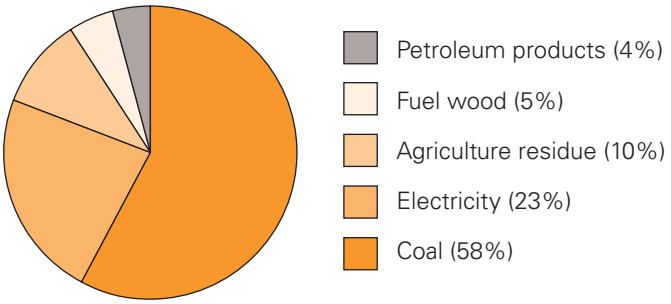
The main uses of energy in the industrial sector are for process heat, motive power and lighting. The main consumption of coal is in brick making and operating coal fired boilers. The shortfall in supply of electricity has adversely affected industrial production and their product competitiveness as some of them rely on expensive diesel generator for back up supply of electricity.

3.3. Energy consumption in transport sector

The share energy consumption in the transport sector in 2008/9 was 5.2% (20,876TJ). The transport sector consumes various types of petroleum products all of which is imported. These fuel types consist of 67% high speed diesel (13,986TJ), 20% gasoline (4,175TJ), 12% air transportation fuel (2,505TJ), 1% LPG (29TJ) and 0.1% light speed diesel (21TJ).The transport sector is primarily fossil fuel based. Except for one cable car and hundreds of public transport electric vehicles in Kathmandu, clean energy transport systems are almost non-existent in Nepal.

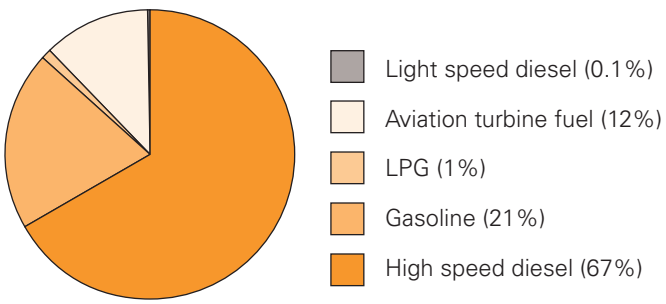
The transport sector contributes 49% (409,101 tons) of GHG emissions.[8] There is potential to take a low carbon path, with increased biodiesel and bioethanol. Other measures are promoting electric vehicles and electric mass transport systems such as electric tram and railways, electric ropeways and cable cars, improving the road network, and vehicle and traffic management.

Figure 4. Share of fuel types in industrial sector energy consumption



Source: WECS, 2010

Figure 5. Share of fuel types in the transport sector



Source: WECS, 2010

3.4. Energy consumption in agriculture sector

Agriculture sector energy consumption is only 0.9% (3,646TJ), the lowest of the five sectors. The main uses of energy are for operating agro-equipment and pump irrigation, mostly using diesel engines. Nearly all (95%) energy consumption in the agriculture sector is diesel (3,464TJ), with 5% from electricity (182TJ).

3.5.Energy consumption in commercial sector

The share of energy consumption in the commercial sector is only 1.3% (5,122TJ). The commercial sector mainly includes academic and health institutions, offices, shops, hotels and restaurant. The main fuels used are LPG and kerosene (approximately 50%), fuel wood (approximately 35%) and electricity (approximately 10%) for cooking, heating, lighting, boiling, cooling, water pumping and using other electrical appliances. The sector suffers from an unreliable supply of LPG as well as electricity and often has to make its own fossil fuel-based back-up systems with high environmental and financial costs.

4. Efficiency of energy use

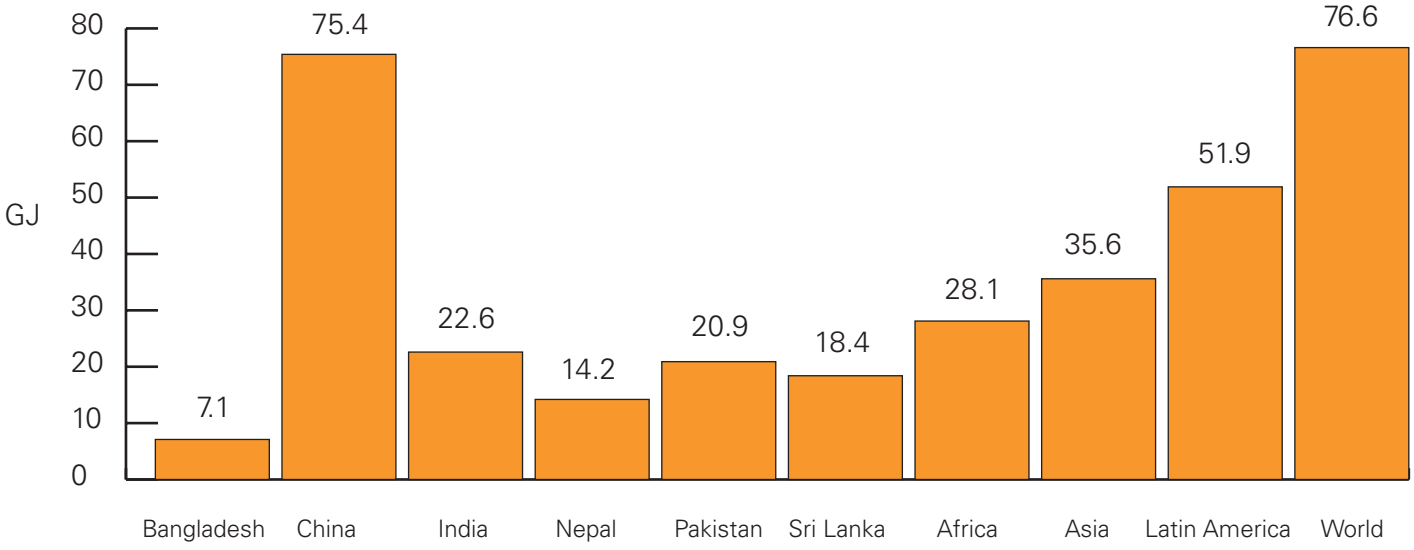
Nepal's per capita annual energy consumption of 14.32GJ[9] in 2010 was one of the lowest in the world – the world average was 77GJ.[10] World electricity consumption was 2,806kWh per capita in 2009,[11] according to the World Bank, so Nepal's 106kWh per capita in 2011 is also very low.[12] Based on the household electricity use for lighting data from the national census in 2011 (CBS, 2012), 74.7% of the population in Nepal has access to electricity from both grid and off-grid solutions (94% of the urban and 70% of the rural population). In 2011, 74.38% of households relied on traditional energy sources for cooking, of which 64% used fuel wood and 10.38% cow dung (CBS, 2012, p1).

One-fifth of the world's population has no access to electricity and two-fifths rely on traditional energy sources for cooking.[13] The population with access to electricity in Nepal is lower than the global average, while the percentage of the population relying on traditional energy sources for cooking is close to twice the global average. The per capita electricity consumption is about 27 times lower than the global average.

The 2013 SE4ALL report, *Nepal: Rapid Assessment and Gap Analysis*, uses the IEA definition of energy access as a household having reliable and affordable access to clean cooking facilities, an initial connection to electricity and then an increasing level of electricity consumption to reach a regional average. The report indicates that the initial threshold level of electricity consumption for rural households is 250kWh per capita and for urban households 500kWh per capita. Nepal's SE4ALL target is for rural households to reach the threshold of 250kWh and urban households to come near to 800kWh per capita by 2030.

The two major indicators for household energy poverty are access to electricity and dependence on traditional biomass fuels for cooking. About 25% of the population in Nepal have no access to electricity for lighting and more than three-quarters of households rely on traditional biomass fuels for cooking (AEPC/NRREP, p17). It can be argued that about 75% of the population lives in energy poverty. Both AEPC's NRREP project (2012-2017) and Nepal's SE4ALL aim to reduce energy poverty. The National

Figure 6. Per capita total primary energy consumption in GJ



Source: IEA, 2010

Energy Strategy and Low Carbon Economy Development Strategy will provide further impetus in addressing energy poverty and setting the goals for low carbon path; these are expected to be completed in 2014.

4.1.Current status of energy efficiency use in different sectors

Compared to the international standard of the ration of total primary energy supply (TPES) to GDP, Nepal has much higher energy consumption (1.01 TPES/GDP[14]) than the global average (0.25 TPES/GDP). The country has no energy conservation policy, legislative mechanism or specific institutional arrangement for energy efficiency. Neither are there any mandatory energy audits for industry or other sectors. Historically, generation capacity expansion has been the main focus of energy policy, programmes and projects from the government, donors and NGOs, with little attention given to supply side capacity utilisation, demand-side management and energy efficiency.

Following two initiatives in the mid-1990s and 2000-2005 which focused on energy efficiency improvements in some of the industrial sector, the Nepal Energy Efficiency Program (NEEP) was initiated in 2009 with the cooperation of WECS and GIZ. NEEP promotes energy efficiency in residential and industrial sector and supports government in developing a national energy strategy.

There are two partners for promoting energy efficiency – Alternative Energy Promotion Centre for households and Federation of Nepal Chambers of Commerce and Industries for the industrial sector. NEEP plans to finalise its energy efficiency policy by June 2014.

NEEP is working to develop an energy scenario up to 2030, modelling demand projections of energy consumption in different sectors in order to assess energy efficiency contribution potential. A biomass energy strategy is expected to be prepared by April 2014, which will be presented by WECS to the Cabinet for endorsement. A National Energy Strategy is also under preparation at WECS. A National Energy Information System will be established at WECS and such information made accessible through its dedicated website to researchers and public at large. Standardisation of improved cook stove is under way in cooperation with AEPC.

There is little information on the current status of energy efficiency use in different sectors besides some study carried out by NEEP in some of the industrial sector. With the support of NEEP, Nepal Energy Efficiency Centre has been established at Federation of Nepal Chambers of Commerce and Industries. A baseline study of a select eight energy intensive sectors of industries show that there is 15% electric energy saving potential and 30% thermal energy saving in these sectors.[15] These eight sectors are cement, pulp and paper, food, steel, soap and chemicals, hotel, brick and cold storage. The total saving potential in the select sectors in the country per annum is 157GWh electrical energy and 8 million GJ thermal energy, with a combined CO_2 saving potential of half a million metric tons annually (Pace Nepal, 2013).

Following success of a CFL distribution pilot project in 21 locations, as reported in the Nepal Electricity Authority's *A Year in Review, 2012/13*, NEA planned to distribute 750,000 14W CFLs to 460,000 residential consumers beginning in September 2013. This is expected to save 23GWh of electrical energy annually. The project is funded by the government and Asian Development Bank. In 2013, total number of residential consumers is projected to be 2.47 million. The saving can be increased over five-fold if this programme is extended to all residential consumers.

In the residential sector, about 0.74 million traditional stoves have been replaced until November 2012 with improved cook stoves through AEPC's Improved Cook Stove (ICS) programme, which began in 1999. The efficiency gain in the transition from traditional to improved cook stoves can be about 8% (NPC, 2013, p39). About two-thirds of Nepal households (3.47 million) use fuel wood as their primary fuel for cooking and 0.57 million households use cattle dung cake for cooking (AEPC/NRREP, p17). The AEPC target is to disseminate 0.475 million ICS and 35,000 metallic stoves (designed for high mountain use) by 2017.

5. Future energy demand and options for energy supply

The main reference document for energy data is the *Energy Sector Synopsis Report* published by WECS (2010). The report has energy consumption data for different sectors, but does not include an energy demand projection. As mentioned in the previous section, NEEP is working on developing energy demand projects in different sectors until 2030 through modelling exercises. The NEEP report on demand projection is expected to be complete in December 2014.

5.1.Energy demand projection by sectors

A 2013 research paper[16] estimated energy demand projection by sectors for the year 2015, 2018, 2021, 2024, 2027 and 2030 with the formulation of simple linear logarithmic energy consumption model. Status of energy consumption between the period of 1996 and 2009 and growth of economic parameters for the same period are assessed. The projections are made for three scenarios, business as usual, medium growth scenario and high growth scenario. The primary energy consumption in residential, commercial, industrial, agriculture and transport sector in 2009 is taken as base year and projections of primary energy consumption made for every three years starting with 2012 until 2030. Taking the energy demand projections in each sector, primary energy consumption projections for period until 2030 by fuel types is also made based on the model as shown in Table 2.

Table 2. Predicted energy consumption for 2030 by fuel type

	2008/9	2030		
Fuel		**BAU**	**MGS**	**HGS**
Fuel wood (%)	77.69	86.46	75.8	75.46
Fuel wood (PJ)	311	474	495	600
Agriculture residue (%)	3.67	3.75	3.15	2.59
Agriculture residue (PJ)	15	21		
LPG (%)	1.42	7.68	15.91	21.47
LPG (PJ)	6	42	104	171
Petrol (%)	1.04	3.18	2.67	2.19
Petrol (PJ)	4	17.45	17.45	17.45
Kerosene (%)	0.63	0.05	0.04	0.03
Kerosene (PJ)	3	0.27		
Biogas (%)	0.65	2.55	6.13	17.85
Biogas (PJ)	3	14.01	40.03	142.01
Electricity (%)	2.07	5.23	7.24	10.53
Electricity (PJ)	8	29	47	84
Total primary energy	292	549	653	796

BAU = business as usual; MGS = medium growth scenario; HGS = high growth scenario

Source: Ranjan Parajuli et al, 2013.

Table 2 indicates the share of fuel wood consumption will remain dominant until 2030, with a slight reduction in percentage of total energy consumption. However, in absolute terms, the consumption will increase by 52% in a business as usual (BAU) scenario (474 petajoules [PJ]), 59% (495PJ) in a medium growth scenario (MGS) or 93% (600PJ) in a high growth scenario (HGS), compared to 311PJ consumption in 2009.

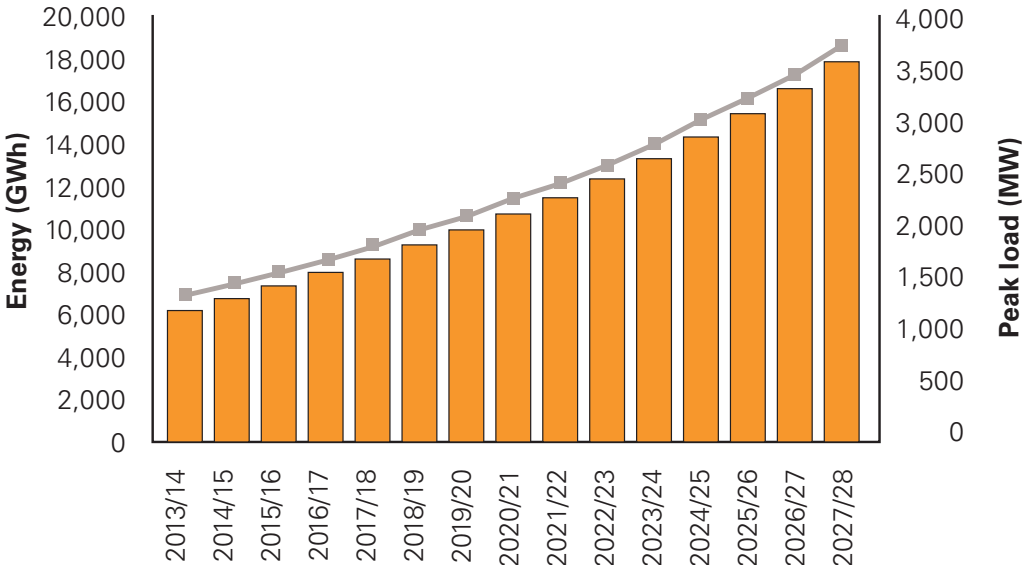
The sustainable supply of fuel wood in Nepal for 2008/9 was estimated as 12.5 million tons or about 1,837PJ-primary (WECS, 2010). However, Nepal is ranked eighth worst in the world for the deforestation of primary forest. The annual deforestation rate is said to be over 0.5%. Nepal lost 7,000ha of primary forest each year during 2000-2005.[17] The annual average increase in quantity of fuel wood consumption is 2.5%. And since fuel wood will remain the most dominant source of energy consumption for decades to come, sustainable forest management and conservation, efficient use of fuel wood with rapid promotion of household and institutional improved cook stoves (ICS) require the highest priority.

The share of petrol consumption will rise from 1.04% in 2009 to 3.18% in BAU, 2.67% in MGS or 2.19% in HGS in 2030. In absolute terms, the consumption of petrol is estimated to increase more than four-fold by 2030 in all three scenarios.

The share of LPG will rise from 1.42% in 2009 to 7.68% (BAU), 15.91% (MGS) or 21.47% (HGS) in 2030. The absolute increase in consumption will be seven (BAU), 17 (MGS) or 285 (HGS) times as much as 2009. The increment is very sharp. All LPG is imported from India.

The share of kerosene is projected to reduce from 0.63% in 2009 to 0.05 (BAU) in 2030. Kerosene consumption is projected to reduce from 8PJ in 2009 to 0.27PJ in 2030.

Figure 7. Electricity demand and load forecast 2013-2028



Source: NEA, 2012/13

The share of energy consumption by biogas will increase from 0.65% in 2009 to 2.55% (BAU), 6.13% (MGS) and 17.85% (HGS) in 2030. The increase in absolute terms is projected to increase from 3PJ in 2009 to 14PJ (BAU), 40PJ (MGS) and 142PJ (HGS) in 2030.

The share of electricity (both grid and off-grid) supply is projected to increase from 2.07% in 2009 to 5.23% (BAU), 7.24% (MGS) and 10.53% (HGS) in 2030. The increase in absolute terms is from 8PJ in 2009 to 29PJ (BAU), 47PJ (MGS) and 84PJ (HGS) in 2030. The consumption of electricity in 2009 was 2,300GWh. The projected consumption in 2030 is 7,970GWh (BAU), 13,130GWh (MGS) and 23,000GWh (HGS). The corresponding installed capacity is estimated to be 2,235MW from grid and 82MW off-grid (BAU), 3,706MW grid and 82MW off-grid (MGS), 6,600MW grid and 82MW off-grid (HGS). The projections for off-grid installed capacity are the same in all scenarios.

Electricity demand and load forecasts by NEA show a load demand of 3,679MW and energy demand of 17,403GWh by 2027/28; about five times peak load capacity and four times the energy supply capacity of 2012/13 (NEA, 2012/13, p109). To meet such demand requires annual average capacity addition of 200MW and annual average energy generation capacity addition of 913GWh. The current investment in electricity generation expansion is inadequate to meet this demand (SREP, 2011, p11).[18]

Strategically, on the supply side, the challenges ahead for in Nepal are to reduce fuel wood consumption, reduce fossil fuel imports, increase electricity generation at a price competitive to the Indian market to meet domestic consumption and for cross-border power trade, and achieve energy security.

On the demand side, the challenges are to improve access to electricity and other modern energy services, improve energy efficiency, decrease energy intensity, make the transition from a fossil fuel-based transport sector to an electricity dominated transport system, move from traditional cook stoves to improved cook stoves and biogas for cooking (in the household and commercial sectors), and move from LPG cooking to electric cooking in urban areas.

Time-bound targets with quantified numbers, budget and a national programme at much larger scale than currently exists are required to make the turnaround from fossil fuel and traditional energy to a low carbon, modern energy economy. Nepal's Sustainable Energy for All has a goal of universal access to electricity and cooking on solid biomass to be completely done with improved cook stoves by 2030. Achieving these goals will have high poverty reduction impacts.

6. Energy resources availability and renewable energy potential

As stated earlier, the sustainable supply of fuel wood in Nepal for 2008/9 was estimated as 12.5 million tons – about 1,837PJ-primary. Ranked eighth worst in the world for deforestation, the need for sustainable forest management and conservation and efficient use of fuel wood through widespread use of efficient cook stoves is warranted. There are 3.7 million households in rural Nepal (where fuel wood is the main source for cooking), but only 0.74 million improved cook stoves have been distributed as at 2012.[19] The national ICS database shows only around 0.6 million households use ICS. AEPC has a target to disseminate 475,000 ICS and 35,000 metallic cooking stoves by July 2017. A WECS estimate shows that in 2008/9, the energy equivalent resource from agricultural residues was 244PJ. Agricultural residue also has other uses, such as fodder and for burning to ash to use as manure. If half the agriculture residue was available for energy use, it would provide 122PJ of energy.

Hydropower holds the highest potential for use of renewable energy. With a potential 42,000MW, which far exceeds Nepal's requirement for decades to come, the country has a vast potential to export electricity to its power-hungry industrial neighbour, India. Six projects with a total generation capacity of 732MW are under construction by NEA (NEA, 2013). These projects are expected to be commissioned in next few years. Six other projects with a total generation capacity of 1,892MW are planned, although the start and completion dates of these projects are not yet known (Table 3). These projects are initiated by NEA as a public undertaking.

There are also 27 projects being constructed by independent power producers (IPPs) with total generation capacity of 471MW. The combined capacity of projects by IPPs and those under construction by NEA is 1,203.8MW. In addition, new power purchase agreements have been signed with 86 IPPs with a total generation capacity of 673MW.

The government formed a task force in 2009 with a vision of generating 25,000MW of electricity over 20 years. The task force has listed hydropower projects of combined capacity 2,057MW to complete by 2014, 12,423MW by 2019, 5,114MW by 2024 and 18,034MW by 2029. This makes a total additional 37,628MW generation capacity by 2029. How much of this can actually be realised will depend on foreign direct investment and bilateral negotiations on the larger size projects, including export of power to India, because the financial outlay needed is beyond Nepal's reach.

Table 3. Nepal Electricity Authority projects

NEA projects under construction, capacity, MW	
1. UpperTamakoshi Hydropower Project	456
2. Tanahu Hydropower Project	140
3. Chameliya HEP	30
4. Kulekhani III HEP	14
5. UpperTrishuli 'A' IIIHEP	60
6. Rahughat HEP	32
Total	**732**
NEA planned and proposed projects, capacity, MW	
1. UpperTrisuli 3 'B' HEP	40
2. Upper Arun HEP	335
3. Upper Modi 'A' HEP	47
4. DudhKosi Storage HEP	640
5. Tamor Storage HEP	530
6. Uttar Ganga Storage HEP	300
Total	**1,892**

The SE4ALL for Nepal estimate of off-grid power is 29MW by 2015, 61MW by 2020 and 219MW by 2030 to achieve its goal. The estimate of grid-connected hydropower is 3,078MW by 2015, 5,555MW by 2020 and 13,902MW by 2030; and for grid-connected solar is 100MW by 2020 and 2,100MW by 2030. This differs from the vision to generate 25,000MW over 20 years. An estimate of the investment required to meet the SE4ALL goals by 2030 is given in the final section of this report. There is some inconsistency in the national goals for hydropower generation capacity.

AEPC was established in 1996 as an apex body for promoting alternative energy in Nepal. AEPC has been successful at putting Nepal on the world map as a leader in the promotion of decentralised small-scale renewable energy technology. The outreach of its micro and mini hydro, improved water mills, solar energy, improved cook stoves and biogas programme speaks for itself with the scale of installed numbers and their success rates over the last 15 years of actual implementation. AEPC has supported combined installation of 18.1MW of micro hydro projects (including improved water mill electrification projects), which provide electricity to 180,755 households (AEPC/NRREP, p27). The target is to support installation of additional 25MW to electrify 150,000 households by 2017.

Based on its domestic cattle population, Nepal has the technical potential in the range of 1.3 million-1.9 million biogas plants (WECS, 2010, p60). The economic potential is estimated to be 600,000 plants (WECS, 2010 p46). There are 290,510 household biogas plants in Nepal as at 2012 (AEPC/NRREP p14). AEPC target is to install additional 130,000 household biogas plants, 200 community and 1,000 institutional and 5,000 urban biogas plants by July 2017. A typical household biogas plant is $4m^3$.

Nepal has 300 days of sunshine in about 70% of land area, with average solar radiation in the range from 3.6-6.2kWh/m^2/day (NPC, 2013, p16). The performance of a PV system in the high altitude of the Himalayas has been found to be good. Nepal is therefore considered as having favourable conditions for using solar energy. The Solar and Wind Energy Resource Assessment in Nepal shows commercial potential of 2,100MW grid-connected solar power (WECS, 2010, p64). There is a huge potential for solar thermal devices such as water heaters, dryers and cookers. Solar water heaters have been commercialised for decades and there are more than 185,000 installations in the country (WECS, 2010, p64).

As at February 2014, there are 411,258 solar home systems with a combined 9.9MWp and 39,483 small solar home systems with a combined 1.97MWp; these have been installed since the start of AEPC's solar energy programme in 1999 (AEPC/NRREP p23). These systems are used mainly for lighting in rural areas. Additionally, 1,071 institutional and solar pumping systems have been installed with combined 1.15MWp capacity. AEPC has supported the installation of 3,272 solar dryers. AEPC has a target to disseminate additional 600,000 solar home systems and small solar home systems by July 2017, along with 1,550 institutional solar PV systems and 7,500 solar dryers and solar cookers.

A study by WECS, Department of Hydrology and Meteorology and AEPC in 1999-2002 shows that wind energy potential in Nepal is limited to few places in high mountainous regions like Thakmarpha, Khumbu and Kanjiroba, which have little infrastructure development. AEPC's most recent study in 2008 shows a potential 3,000MW of commercial wind power.

The key drivers for success in large scale dissemination of these decentralised renewable energy technologies are financing mechanisms, institutional arrangements, deregulation, quality control, market approach in service delivery and a well-designed project implementation approach. The financing mechanism involves some subsidies, line of credit through development and commercial banks and investment by beneficiaries. Subsidy is tied up with monitoring of quality service and product. The subsidies are provided with a mix of funding from the government of Nepal and donor agencies. Projects up to 1MW do not require a licence, but do require a water use permit from the district office. Projects are implemented through a market approach. The project developer can chose any company to build the project based on the offer they receive on cost and quality.

7. Existing low-carbon policy, strategies and mitigation options

Nepal is a signatory to the United Nations Framework Convention on Climate Change. The Initial National Communication was prepared and submitted in 2004, and the Second National Communication is in preparation. The Ministry of Environment is the Designated National Authority.

Nepal's global GHG contribution is 0.025%, one of the lowest in the world. However, Nepal ranks as the fourth most vulnerable country affected by climate change, according to the Climate Change Vulnerability Index.

Some of the mitigation measures taken after the Rio 2012 climate conference are:

- High priority given to renewable energy technologies to reduce poverty in rural areas through establishing AEPC.
- Energy efficiency measures introduced in industrial boilers and lighting.
- Control in vehicular emissions by introducing a mandatory requirement for vehicles to comply with EURO-I standard.
- Incentives for electric vehicles, via customs and VAT subsidies.
- First national communication submitted in 2004, the second, with national GHG inventory, is in the final stage.
- REDD-Forest and Climate Change Cell established at Ministry of Forest and Soil Conservation.
- District climate and energy plans have been prepared for select districts.

In July 2009, a 25-member Climate Change Council was set up under the Chairmanship of Prime Minister of Nepal and thereafter climate change has been in the national development agenda. A climate change policy was prepared and approved by the government in January 2011.

The main goal of the Climate Change Policy is to improve livelihoods by mitigating and adapting to the adverse impacts of climate change, adopting a low carbon emissions socio-economic development path and supporting and collaborating in the spirit of the country's commitments to national and international agreements related to climate change.[20]

Some of the key objectives are:

- To reduce GHG emissions by promoting the use of clean energy, such as hydro-electricity, renewable and alternative energy and by increasing energy efficiency and encouraging use of green technology.
- Adopt a low carbon development path.
- Establish a climate change fund, encourage investments in clean energy sources with priority on hydropower projects from national and international sources.

One of the key targets of the policy is the formulation and implementation of a low carbon economic development strategy (LCEDS) to support climate-resilient socio-economic development by 2014. AEPC is the lead organisation for the preparation of this strategy; the first phase was completed in October 2013. The main activity in the first phase was data collection and analysis. The LCEDS is expected to complete in June 2014. It encompasses six major sectors – energy, industry, transport, agriculture, forestry, building and waste. Representatives from six ministries, the National Planning Commission and technical experts are engaged in the formulation process of LCEDS with an intensive stakeholder consultation process. Not much information is currently available as the study is still in progress.

8. Nepal's role in delivering renewable energy and addressing national energy poverty

Nepal's hydropower resource potential far exceeds domestic electricity consumption demand for many decades to come. The priority for the government's 25,000MW hydropower development vision is to meet domestic demand and then export surplus generation to India. Construction of transmission line infrastructure for cross-border power trading is also being planned.

Nepal's SE4ALL initiative aims to provide access to electricity for everyone and replace all traditional cook stoves with improved cook stoves by 2030. Nepal should pursue both goals of eliminating energy poverty in the country and also developing its hydropower potential for export to India. These goals are not contradictory.

In future, Nepal will have surplus of electricity in the wet season (June-September) when the generation capacity will be in peak. This spill energy can be exported to India because the load demand in summer is higher. Nepal's generation potential during low flow period in the winter is low while demand is high. The cross border power trade will allow Nepal to import electricity from India when its generation capacity is low. In the long run, with the construction of storage power plants, Nepal has the potential to meet all its electricity needs and also export surplus power to India and reduce the regional carbon footprint.

These projects have to comply with national and international guidelines to minimise social and environment impacts. It can be argued that they will be more sustainable than projects in other countries because no rigorous compliance procedures were put in place in the past to minimise social and environmental impacts. Projects have to undergo a thorough social and environmental impact assessment and public hearing with the affected people in the project area to ensure minimal impacts and sustainability of hydropower projects.

8.1. Barriers to low-carbon development and energy access

The key barriers to low-carbon development and energy access in the country are political, institutional, financial, policy and regulatory framework and local capacity.

The biggest impact Nepal can make in low carbon development and energy access is by developing hydropower resources. One of the main barriers to developing hydropower projects in Nepal has been the political instability in the country for the last two decades. A new coalition government is in place whose main task is the drawing up a new constitution within a year. The transition to a more stable political situation is expected, which will be a conducive environment for business and investment.

Huge capital outlay is required for investment in medium and large hydropower projects. Foreign direct investment, bilateral agreements, credit from multilateral agencies and other financing institutions in mutually favourable terms are prerequisite for increasing investment in hydropower as Nepal's own investment capacity is inadequate.

Fossil fuel is subsidised. A policy to gradually reduce the subsidy and bring prices up to the real cost is required in favour of a policy to promote electric vehicle and mass electric transport. Technical capacity building is required for introduction of electric transport systems.

There is no rationalised energy pricing due to the lack of an independent regulatory body in the energy sector. The energy sector falls under the purview of a number of ministries, causing delays in the policy and regulatory reform process, not to mention delays in administrative processes for project implementation.

8.2. Potential sustainable development benefits for low-carbon development

Fossil fuel reduction by renewable energy will reduce carbon emissions, improve urban air quality and bring health benefits to citizens. It will decrease the drain on the foreign exchange reserve, improve the balance of payments and provide energy security.

Data from six monitoring stations in Kathmandu show that concentration of particulate matter is several times higher than the international standard.[21] This has adverse impact on residents' health and the economy as a whole. Introduction of clean vehicles and transport management is recommended to reduce vehicle emissions, the main source of deteriorating air quality in the Kathmandu valley (ENPHO, 2007).

Cooking using biomass fuel, which in most cases includes wood, has negative health effects such as acute lower respiratory tract infections in young children, the chief killer of children worldwide, and chronic obstructive pulmonary disease, chronic bronchitis and emphysema in adult women.[22] Globally, it is estimated that between 0.8 million and 2.4 million premature deaths each year are likely to be from the use of solid fuel, mainly fuel wood. Replacing traditional cook stoves with improved cook stoves, biogas, electric cookers or LPG stoves will improve indoor air quality and reduce eye and chest infections. Access to electricity from hydropower or off-grid renewable energy sources will improve overall quality of life, health, education and employment opportunities, as is evident from many case studies.

Harnessing abundant hydropower resources at a competitive cost to completely meet Nepal's domestic needs and provide surplus power for export or cross border trade will have a very positive impact on the economy.

Access to affordable electricity will stimulate agriculture, manufacturing and service industries. Both a shift in focus to investing more in renewable energy to reduce fossil fuel imports and high dependency on fuel wood and the transition to electric transport systems and energy efficiency will stimulate rapid growth in renewable energy and electric end-use in trade and industry. This will generate much-needed employment opportunities in the country.

9. Assessment to manage energy demand and use clean and renewable sources of energy

Following 16 years of successful operation in the promotion of decentralised renewable energy technologies, the government and donor agencies formulated the National Rural and Renewable Energy Programme (NRREP). NRREP is a single programme modality for decentralised renewable energy sector development in Nepal; the five-year, $170m programme is being implemented by AEPC from July 2012. NRREP aims to achieve the following targets by July 2017:

- 25MW micro/mini hydropower projects
- 600,000 solar home systems and 1,500 institutional solar power systems
- 475,000 improved cook stoves
- 130,000 household biogas plants, 200 community and 1,000 institutional biogas plants.

NRREP is supported by Danida, Norwegian Ministry of Foreign Affairs, DFID, KfW, GIZ, SNV, UNDP and the Scaling-Up Energy Programme (SREP). AEPC expects additional development partners to support NRREP to bridge the funding gap to achieve its full targets. AEPC has estimated that $300m for subsidies and $367m for a credit programme are required to meet the targets. The credit programme will consist of soft loans and micro credit.

The energy intensity of the agriculture, service and industrial sectors needs to decrease by 15% by 2026 through using cleaner technologies, energy efficiency measures and replacing fossil fuel with hydropower and renewable energy sources.

The report *Climate Change and Renewable Energy Strategy: An Assessment to Reduce Fossil Fuel Use* proposes to reduce fossil fuel use by 50% by 2026 from the projected fossil fuel consumption in a business as usual scenario.[23] The study proposes a Nepal Strategy Scenario, consisting of various interventions to put fossil fuel reduction strategies in place.

The main interventions proposed to attain a 50% reduction in fossil fuel consumption are mainly in the transport and residential sector, which consumes the highest share of fossil fuel. The research proposes these interventions in a quantified and time-bound manner. Qualitative interventions are noted here for brevity.

In the transport sector, the interventions include introduction of efficient mass transit public transport systems, such as Bus Rapid Transport System, to reduce the use of private motorcycles and vehicles, extensive use of electric vehicles, electric trains and ropeways, and other financial and management instruments.

In the residential sector, the interventions proposed are increasing access to affordable electricity from both grid and off-grid renewable energy systems, using CFLs for lighting, using renewable energy technologies for cooking and water heating to replace LPG, kerosene and fuel wood, and using biogas and improved cook stoves.

The energy intensity of the agriculture, service and industrial sectors needs to decrease by 15% by 2026 through using cleaner technologies, energy efficiency measures and replacing fossil fuel with hydropower and renewable energy sources.

The financial outlay to formulate and implement the fossil fuel reduction programme in the strategy paper is not estimated. The proposal is ambitious and seems to require substantial long-term funding for implementation.

Nepal joined UN Secretary General's SE4ALL Initiative in August 2012. Nepal's Three Year Plan (2013/14 to 2015/16) commits to formulate and implement an action plan to

In the residential sector, the interventions proposed are increasing access to affordable electricity from both grid and off-grid renewable energy systems, using CFLs for lighting, using renewable energy technologies for cooking and water heating to replace LPG, kerosene and fuel wood, and using biogas and improved cook stoves.

achieve the SE4ALL goals (NPC, 2013, p7). The SE4ALL goals for Nepal are:

- All households will have access to electricity by 2030; most of this will be from grid.
- Cooking with solid biomass will be completely replaced with improved cook stoves by 2030.
- Priority should be for energy efficiency improvement in the household sector.
- Decrease energy intensity from the recent 1.166 toe/$1,000 GDP to 0.421 toe/$1,000 GDP by 2030. This will bring Nepal to par with countries in South Asia.
- Analysis indicates that in order to meet Nepal's development needs, electricity's contribution to the energy mix should be of 11% in 2020 and 26% in 2030, compared to over 2% in 2010.

The report *Nepal Rapid Assessment and Gap Analysis* (published by the National Planning Commission with support from UNDP) estimates an investment requirement of $7.83bn in 2015, $10.92bn in 2020, $16.77bn in 2025 and $25.75bn in 2030 to achieve SE4ALL goals by 2030.

A leapfrog fund could be used to meet the gaps in funding for meeting the target set by SE4ALL programme including AEPC in decentralised renewable energy promotion. This will be in the form of grant, long term soft loans for larger projects and grant, soft credit and micro credit for decentralised RE systems.

Other assistance will be required in awareness program, training and capacity building, technology transfer, R&D, institutional development, market development and long term finance. Some of the projects will be implemented with a private-public partnership model.

10. Case examples

10.1. Biogas partnership programme

Household biogas generates clean cooking gas from cattle dung. Cattle dung and water is fed into the digester of a fixed dome biogas plant. Through an anaerobic digestion process, clean gas is generated which is used for cooking. The most commonly used size of biogas plant is 4m^3 , which is sufficient for a family of five. There are over 100 qualified installation companies, 17 biogas appliance manufacturing workshops, and 264 microfinance organisations which received wholesale loans from AEPC's Biogas Credit Fund to provide loans to farmers for purchase of biogas plant. Biogas Support Partnership Nepal (BSP-N) promotes biogas in Nepal.

Biogas drastically reduces firewood consumption in households, which saves many hours spent collecting wood by women and children. Biogas replaces traditional cook stoves which are a health hazard due to the smoke. Cooking using clean gas improves indoor air quality and kitchen hygiene and protects women and children from eye and chest infections associated with traditional stoves. The slurry, a by-product of biogas, is used as manure for agriculture. Other benefits of biogas are that, on average, 7.4 tons of GHG emissions are reduced per household per year, 1.25 trees per household protected per year and three hours of time saved in a household per day.[24] BSP-N is the first Clean Development Mechanism (CDM) project in Nepal. The revenue from carbon finance partly supports the operation of Biogas Support Partnership Programme in Nepal. Biogas sector provides direct and indirect employment to 9,000 people.[25]

As at July 2011, 258,642 household biogas plants had been installed in Nepal (AEPC, 2011). The technical potential of biogas is estimated to be over 1.3 million biogas plants and the economic potential to be 0.6 million. Over 25,000 household biogas plants are installed each year in Nepal. A 4m^3 biogas costs about $400-500, about half of which is subsidised by AEPC. By July 2011, 111 institutional biogas plants had been installed. Institutional biogas plants are 10m^3 or higher. Support is required for scaling up institutional biogas.

10.2. Community electrification programme

Grid extension is prohibitively expensive for electrification of remote and scattered communities in the mountains. Rich in water resources and with suitable terrain, Nepal has great potential for micro hydropower projects which are more cost effective for electrification of remote and scattered communities. Projects up to 5kW are called pico hydro and those up to 100kW are micro hydro. There were 1,480 pico hydro plants with a combined generation capacity of 3.18MW and 999 micro hydro plants (total generation capacity 18.65MW) installed in Nepal as at July 2011 under AEPC's community electrification programme.[26]

Pico hydro uses an unlined canal to channel water and HDPE pipe as penstock which is connected to a vertical axis pelton turbine. The turbine and the generator are directly coupled with a single shaft. A cheap Chinese motor is converted to a generator by connecting with capacitors. The turbine is locally manufactured and controller locally assembled. Pico hydro is used for lighting about 10 to 40 households, depending on the size of the system. The systems are owned by a group of individuals. They can be built easily in a few months. They cost about $2,500-3,500/kW. AEPC provides a subsidy of about $1,400-1,700/kW (Himalayan Time, 2 April 2014).

Micro hydropower plants generally provide power for agro-processing mills during the day and lighting at night. Other applications include powering computers, TVs, health clinics, saw mills, handmade paper making, bakeries, photo studios, photocopying, printing presses and metal workshops. In most cases, they are owned by a community or cooperative in a village. The investment needed is in the range $3,000-5,000/kW. AEPC provides a subsidy of $2,000-2,650/kW.

Some of the risks in pico and micro hydro include a reduction in generation capacity during dry season due to low flows, lack of safety both for the plant and people from lightning during the monsoon and lack of technical skills operation and maintenance. When the grid reaches

a village with micro hydropower, the hydro plant ceases operation, making the investment redundant. Technical and institutional support is needed for grid connection of micro hydro power plants when the grid reaches them. This will ensure long term sustainability of micro hydropower projects.

10.3. Grid-connected hydropower by independent power producers

Hydropower development policies in 1992 encouraged private sector involvement in the development of hydropower. In 1996, a feed-in tariff for hydropower projects up to 5MW was announced, which stimulated some interest in the private sector for developing small projects. However, it took several years before the private sector was ready for investment in small hydropower.

In 2005, Sanima Hydropower Pvt. Ltd developed Sunkoshi Hydropower Project as a commercial venture. It is a run-of-river grid connected project with a design discharge of 2.7m^3/s and gross head of 124.5m. The headwork consists of low height, boulder-lined diversion weir, side orifice intake, gravel trap and a settling basin. After the settling basin there is a 2.6km penstock pipe that channels the water into two turgo turbine units of 1250kW each, imported from China. The power plant is located 90km north-east of Kathmandu along the Araniko Highway and uses water from Sunkoshi river in Sindhupalchowk district.

The project provided employment to local people, and built the design and construction capability of local engineers. As a model of a commercially successful venture, it has attracted other private sector developers to invest in small hydropower projects.

There are 24 projects below 5MW with a combined capacity of about 58.7MW built by independent power producers in operation, 15 projects with a combined capacity of 45.6MW are under construction, more than 44 projects with a combined capacity of 93MW have signed PPA with NEA (NEA, 2013). Besides these, there are numerous projects in this range with generation licences for construction. These numbers reflect that the private sector sees investment in small hydropower as a good opportunity.

There are technical, social and financial risks associated with investment in small hydropower for independent power producers. Technical risks include low flow due to changes in flow regime, unexpected ground conditions during construction and financial risk due to cost escalation in the market prices of construction material, while social risk arises from local communities' over expectation. The capital investment required to develop small hydropower projects is $US2,000-2,500/kW.

Technical assistance for quality feasibility studies and design is required to minimise the risk at the early stage of project preparation. The assistance could be on a cost sharing basis, and the cost could be recouped from the revenue generated from operating the projects. Establishment of a line of credit for a long-term soft loan and expansion of transmission line network are other supports required in this sector.

Micro hydropower plants generally provide power for agro-processing mills during the day and lighting at night. Other applications include powering computers, TVs, health clinics, saw mills, handmade paper making, bakeries, photo studios, photocopying, printing presses and metal workshops.

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