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NEPAL POST-EARTHQUAKE POTENTIAL FOR RENEWABLE ENERGY INVESTMENTS FOR CLIMATE RESILIENT DEVELOPMENT

FINAL REPORT

September 2015

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FINAL REPORT

Asia Regional Environmental Field Support (AREFS)
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ACRONYMS

ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Center
BBB	Build Back Better (principle)
BC	Black carbon
BPC	Butwal Power Company
BSP	Biogas Support Program
CBS	Central Bureau of Statistics [of Nepal]
CDCS	Country Development Cooperation Strategy
CDM	Clean Development Mechanism
CFL	compact fluorescent light
CTIP	Combatting Trafficking in Persons
DO	Development Objective
DoED	Department of Electricity Development
DRR	disaster risk reduction
EA	Electricity Act
ELCC	efficient lighting and clean cooking
ER	Electricity Regulations
ESCO	energy services company
FNCCI	Federation of Nepalese Chambers of Commerce and Industries
FY	Fiscal Year
GBV	gender-based violence
GDP	Gross Domestic Product
GEF	Global Environment Facility
GESI	Gender Equality and Social Inclusion
GHG	greenhouse gas
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GLOF	Glacier Lake Outburst Flood
GON	Government of Nepal

GSP	Gold Standard Biogas Project
GW	Gigawatt (1 billion watts)
GWh	Gigawatt hour
HDP	Hydropower Development Policy
HIDCL	Hydropower Investment and Development Company Limited
HOPE	hospital preparedness for emergencies
IBN	Nepal Investment Board
ICCA	Initiative for Climate Change Adaptation
ICIMOD	International Center for Integrated Mountain Development
ICS	improved cooking stove
IDE	International Development Enterprises
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producer
IR	Intermediate Result
ISPS	Institutional Solar Power System
JICA	Japan International Cooperation Agency
KKREP	Kailali Kanchanpur Rural Electrification Project
KKREUO	Kailali Kanchapur Rural Electrification Umbrella Organization
Km	kilometer
kV	kilovolt
kVA	kilovolt amperes (1000 volt-amperes)
kW	kilowatt (1,000 watts)
kWh	kilowatt hour
kWp	kilowatt peak, i.e. the nominal rated power generated
LAPA	Local Adaptation Plans of Action
LED	light-emitting diode
LPG	liquefied petroleum gas
MCC	Millennium Challenge Corporation
MoE	Ministry of Energy
MoEST	Ministry of Environment, Science and Technology

MoF	Ministry of Finance
MoSTE	Ministry of Science Technology and Environment
MW	megawatt (1 million watts)
MWR	Ministry of Water Resources
NACEUN	National Association of Community Electricity Users-Nepal
NAPA	National Adaptation Plans of Action
NEA	Nepal Electricity Authority
NEEP	National Energy Efficiency Programme
NGO	non-governmental organization
NHDP	Nepal Hydropower Development Project
NMHDA	Nepal Micro-hydro Development Association
NPC	National Planning Commission
NRREP	National Rural and Renewable Energy Program
NSET	National Society for Earthquake Technology
OFDA	Office of Foreign Disaster Assistance
PANI	Program for Aquatic Natural Resources Improvement
PDNA	post-disaster needs assessment
PEER	USAID's Program for Enhancement of Emergency Response
PEER	Program for Enhancement of Emergency Response
PPA	power purchasing agreement
PTA	power trade agreements
PVCs	photovoltaic cells
PVWPP	Photovoltaic Water Pumping Project
RE	renewable energy
Rs	Rupees (US$ 1 = Nepalese Rs. 103.9 on 15/08/2015)
RURESCO	Rural Renewable Energy Service Company
SHP	small hydropower
SHS	solar home system
STIP	Science, Technology, Innovation, & Partnerships
SWERA	Solar and Wind Energy Resource Assessment in Nepal
TIP	Trafficking in Persons

TV	television
UNEP	United Nations Environment Program
UO	umbrella organization
USAID	United States Agency for International Development
USB	Universal Serial Bus
VAT	value-added tax
WECS	Water and Energy Commission Secretariat
WI	Winrock International

EXECUTIVE SUMMARY

This study discusses the current situation of clean and renewable electric power in Nepal. The discussion is prompted by the recent – April 2015 – devastating series of earthquakes in Nepal. This disaster presented the country with an urgent set of needs for immediate and long-term recovery and restoration of physical infrastructure and supporting services like water, power, and other forms of energy as well as economic and social services. This study is a contribution to the planning for post-disaster recovery and a renewed focus on a resilient development path for Nepal. The study first summarizes the current energy situation in Nepal: the supply and demand for energy with a focus on electric power; the institutional and regulatory setting; and future trends. With this base, the study reviews the principal sources of power in Nepal, mainly large and small hydropower followed by solar power and energy efficiency. Finally, the study examines the potential for integrating clean and renewable energy interventions into the current USAID country portfolio, acknowledging the range of energy interventions and programs already being implemented and also considering the potential for interventions in support of Nepal's post-earthquake recovery and restoration under the rubric of "Build Back Better (BBB)."

Nepal is overwhelmingly rural and poor and this is reflected in the country's energy profile, with most Nepalis heavily dependent upon inefficiently burned forms of biomass. Most energy is used in residential and agricultural activities since the commercial and manufacturing sectors are relatively small. Yet, Nepal also has huge potential clean and renewable energy resources, mainly water (hydropower) and solar. Hydropower, both large and small, already dominates the power sector in Nepal. However, a significant proportion of Nepal's population does not have access to the national power grid and those that do have long experienced load shedding blackouts during the winter dry season, when stream flows are relatively low but demand for power is high. Load shedding blackouts have resulted in an increase use of backup diesel generation capacity (~400 MW) as a means to cope with the blackouts. Solar power and micro-hydropower are increasingly viewed as alternative power sources for populations without service and solar is also frequently used to alleviate blackouts for those who can afford it.

Micro-hydropower is an increasingly important source of power for rural Nepali communities. Some of these are community-managed systems, while private sector providers manage others. Micro-hydropower has sometimes experienced management and operational problems, including collection of rate payments, technical maintenance, and managing power demand fluctuations. Attempts to establish "mini-grids" consisting of multiple communities' systems tied together to achieve better efficiencies and costs have not yet been successful due to ownership, management, and power demand management issues but mini-grids remain an important goal.

Solar power is the most important clean and renewable form of energy after hydropower in Nepal. Large-scale solar facilities have not yet been developed in Nepal. The overwhelming applications of solar power are "rooftop solar" installations for residences and public buildings and "small solar," which consists mainly of portable solar-powered appliances such as solar lanterns and cookers. Solar power has spread rapidly, helped by government subsidies and the existence of a relatively large number of certified private sector vendors in the country.

Energy efficiency is a relatively new component of Nepal's energy strategy. There are several strands to this component. The first strand is to review Nepal's standards for energy efficiency in electrical appliances, power distribution and building codes. The aim here is to reduce effective power demand through greater efficiency in transmission, distribution and end use. The second strand is to focus on "win-win" solutions. For example, promoting and supporting improved cook stoves reduces the demand for wood and other biomass and also improves the indoor environment through reduced smoke. The third strand – but one that is relatively far off in the future – is the use of "smart power"

technology to optimize power generation from different kinds of sources (both generation source and resource type). This could include, for example "net metering."

The institutional environment for energy and power in particular is relatively complex. The Nepal Electricity Authority (NEA) is the predominant generator. The Department of Electricity Development (DoED), however, licenses new power plant projects. The Investment Board of Nepal (IBN) is a more recent actor in the power sector but an important partner of developers, often acting as a public-private partnership (PPP) focal point, to facilitate investments for large infrastructure projects and coordinate efforts to attract foreign direct investment. The Alternative Energy Promotion Center (AEPC) researches, promotes, and supports the use of mini/micro-hydropower, solar, wind, biogas, improved cook stoves, and other alternative energy forms along with the finance, institutional governance, and training associated with these. This is mainly through its National Rural and Renewable Energy Program. A number of other government agencies, commissions, and ministries are also involved with the oversight, promotion, and financing of energy investments, especially large hydropower.

Although attempts have been made to streamline the bureaucracies associated with energy and power, the multiplicity of procedures and agencies involved remains an obstacle to streamlined investments, with the exception of the AEPC. A number of donors – both multilateral and bilateral – including USAID, have been engaged in improving the policy and institutional environment for the power sector.

The April 2015 earthquake catastrophe killed and injured many people and destroyed or seriously damaged residences and other structures. It also damaged a considerable amount of energy infrastructure, including mini and micro-hydropower facilities and many rooftop solar installations. Under the "Build Back Better" set of principles, numerous opportunities exist to integrate clean and renewable energy into the recovery and restoration program. The "Post-Disaster Needs Assessment" identified those structures and installations destroyed or seriously damaged by the earthquake and aftershocks. For the most part, these restoration needs are being addressed by both the Government of Nepal (GON) and numerous donors, including USAID, international organizations, humanitarian organizations, and other Non-Governmental Organizations (NGOs). However, a number of opportunities exist for supporting the integration of clean and renewable energy initiatives into the USAID/Nepal program, in addition to those already being implemented.

The very large number of destroyed and seriously damaged structures in both urban and rural parts of Nepal affected by the quakes may also indicate serious deficiencies in the National Building Code and other guidance. However, failure to implement the existing codes at either the design or construction stages appears to be the more important problem. Public awareness and education programs about building practices could be incorporated into the Build Back Better strategy. In addition, a focus on low cost housing designs and materials, including e.g., the use of improved mud brick designs and siting on more stable land, can be important for preventing future earthquake damage. If it is not already planned, this study encourages USAID to work with relevant GON authorities to incorporate efficient lighting and clean cooking (ELCC) standards into residential and public building standards where relevant. In addition, building codes and the mandatory rules of thumb[1] should be reviewed to identify culturally appropriate ways to incorporate passive solar design standards into residential and public building designs and materials to reduce effective demand for power, especially during the winter months.

Because of its modular flexibility and relative simplicity of maintenance, the incorporation of solar power in residences and public buildings (schools, clinics, government buildings, communication, and other

[1] Nepal building codes also include "Mandatory Rules of Thumb" for reinforced concrete buildings without masonry infill as well as those with masonry infill, and load bearing masonry under NBC 205, 201, and 202, respectively. See http://www.dudbc.gov.np/buildingcode

infrastructure, etc.) is strongly recommended. Wind power has less ready applications at the small scale but could be commercially feasible at larger scales though fewer such sites may be appropriate.

In the context of the broader USAID portfolio, this study identified several opportunities in solar, hydro, biomass, and energy efficiency, as well as planning and assessments that build on USAID's long experience with renewable energy. Among the identified opportunities, this study recommends three areas for future action that USAID may consider regarding renewable energy in Nepal (summarized below). To move from concept to design phase, we recommend USAID/Nepal work closely with the Ministry of Science Technology and Environment/AEPC and/or the Ministry of Energy/NEA to identify specific post-earthquake opportunities for targeted clean and renewable energy investments.

As a first step, the study recommends actions to address the need for more comprehensive and accurate wind and solar maps by locality and season. Performance estimates for wind generation and solar insolation by district and sub-district and the development of Geographic Information System (GIS) data layers for these estimates will support planning and investment decisions. For USAID/Nepal existing energy sector projects, there may be opportunities to support the installation and training for solar PV systems and further pilots or the roll-out of wind power installations, especially in rural, un-serviced areas as a part of the post-earthquake recovery effort. In line with a "build back better" approach, the integration of renewables into USAID/Nepal project activities where appropriate will create synergies between USAID/Nepal's energy programs and its agriculture, health, and natural resources management activities.

No specific actions for USAID on energy efficiency were recommended since the single most important of these, supporting the installation of improved cook stoves, is already a part of USAID's portfolio and other donors are implementing other dimensions of the national energy efficiency program. However, attention should be paid to opportunities for scaling up and replicating these efforts. In addition, the World Bank is supporting the NEA as part of the Energy Efficiency Initiative under its Distribution Loss Reduction Master Plan and pilot projects, while energy efficiency in the biomass sector is being addressed by GIZ through AEPC.

Finally, this report recommends USAID utilize its extensive experience with the ESCO model in order to improve the ways renewable power systems are managed at the community-level (or multi community, in the case of mini-grids). The most important area for USAID support is to help develop mini utilities in the form of ESCOs, mainly for off-grid and remote sites. This assistance could help address the technical and managerial weakness at the district and village levels, in support of the development, management and servicing of renewable energy systems.

In addition to the operation and maintenance of power systems, especially micro-hydropower at the community or multi-village level, the front-end planning, siting, and design process is one in which USAID's extensive expertise in incorporating public participation can be very useful. Training and technical assistance in environmental assessment and scoping as well as alternative dispute resolution techniques may help district and village officials better interact with the NEA or private developers to arrive at constructive solutions for well-planned hydropower projects.

1. PURPOSE AND OBJECTIVES OF THE STUDY

The post-earthquake recovery process in Nepal will have both short- and long-term dimensions. The short-term recovery process includes debris removal; post-earthquake health services provision and coordination; restoration of public utilities; resettlement, reconstruction, and rehabilitation of man-made structures; and restoration of critical natural systems. The immediate need for both clean water and basic power is acute in Nepal, but as was the case for Haiti and other countries, it will take years to fully recover from such a large-scale natural disaster. As Nepal starts to put its power and other infrastructure systems back together in both the capital and outlying communities, it has an opportunity to apply a "build back better" approach for long-term recovery. This, in fact, has been adopted in the post-disaster needs assessment (PDNA) as the basic philosophy for reconstruction, so as to build in resilience to future natural disasters and climate change impacts.

This study addresses the issue of building improved resilience in Nepal's energy sector during the post-earthquake recovery, with the main focus being the electric power sub-sector, although some aspects of process heat and fuels have been also considered. The hypothesis underlying this study is that using the recovery process as an opportunity to create or strengthen a distributed power network based on clean, renewable energy systems[2] in Nepal will measurably expand rural economic development and improve resilience to extreme natural disaster events and climate change.

Hence, the objectives of the study will be:

a) Identify opportunities and constraints to building a resilient, distributed power network for Nepal; one that is increasingly based on renewable energy (RE) technologies.

b) Based on this assessment, develop findings and recommendations for USAID/Nepal and the Government of Nepal (GON) and, to a lesser extent, private sector actors, NGOs, and other donors. These findings and recommendations will address both the short-term recovery and long-term investment requirements.

The scope of this study mainly covers the short-term period of the current Nepal Country Development Cooperation Strategy (CDCS), which spans the 2014-2018 time period and the post-earthquake recovery period, which may extend beyond 2018. The transition of Nepal from a low efficiency, traditional biomass energy dependent economy into a clean and renewable energy economy will necessarily be a significantly longer-term process. The activities recommended in this study can provide support for that long-term transition but specific USAID long-term investments (10-20 years or more) are outside the scope of this study.

As noted above, the study's approach will examine energy systems that will be recommended in the study, which, for the purpose of this discussion also includes energy efficiency improvements. These system requirements, especially institutional, financial, and regulatory requirements, will have many similar characteristics across the energy technology alternatives considered.

[2] We use the term "energy systems" to encompass not only energy technologies but also the institutional, social, legal-regulatory and human capital requirements for energy infrastructure.

2. CURRENT STATUS OF ENERGY DEVELOPMENT AND USE IN NEPAL

This section is a brief overview of the status of the energy sector in Nepal. The material summarized in this section is covered more extensively by GON sources, international organizations and specialized agencies to which the reader is directed. [3]

2.1. ENERGY SUPPLY AND DEMAND BALANCE AND ECONOMIC DEVELOPMENT

Nepal has no significant fossil fuel resources, including oil, gas, and coal. As a result, most Nepalese have historically met their energy needs with locally generated biomass, imported petroleum products, and a small share of hydropower generated from its rivers. Nepal has huge hydropower resources but, surprisingly, per capita energy consumption is very low at one-third of the average for Asia as a whole and less than one-fifth of the worldwide average. Seventy-six percent of the population depends on fuelwood, dung, and crop wastes for cooking. Conventional energy per capita production (i.e. excluding traditional biomass fuels) is also quite low; only a relatively small portion of the enormous hydropower potential in the country has been exploited and Nepal is still importing some of its power supplies.

Table 1 provides some overall indicators of development in Nepal. Nepal's population is overwhelmingly rural. GDP per capita is very low and Nepal is classified as a "least developed country" with a quarter of the population at or below the national poverty line. While World Bank Indicators show a relatively large proportion of the population with apparent access to electricity, this access is unevenly distributed and actual supply is unreliable even in Kathmandu, the capital.[4] Nepal's anthropogenic contribution to climate change is extremely low based on CO_2 emissions per capita, though it is not clear whether this indicator fully captures emissions from use of biomass fuels (e.g. wood, dung, crop waste). Nepal has few urban centers but these have a very different energy profile, with electricity and liquefied petroleum gas (LPG) the predominant sources of energy.

Economic growth was at 5.5 percent in 2014, which is rather low for a developing country, though higher than in the recent past for the country. This low economic growth rate is related to a reduction in public spending, particularly for infrastructure; low levels of private investment, due especially to power outages, labor issues, policy inconsistency, and political uncertainty, at least until recently; strong linkages to a steadily growing Indian economy, the major trading partner; and increasingly unstable monsoon seasons with resultant variable agricultural growth.[5]

Developments in India have a big influence on the Nepalese economy via (a) exports (India accounts for 60 percent of Nepal's exports); (b) tourism (50 percent of foreign direct investment in tourism value chains originates in India); (c) remittances (transfers from India amount to 5 percent of GDP); and (d) monetary policy (the Nepali rupee is pegged to the Indian rupee).[6]

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[3] Nepal's energy supply and demand and future trends are discussed in: Nepal's Energy Situation, 2015, World Bank Indicators, 2014 and the IEA.

[4] Nepal's Energy Situation finds that only 43.6% of the population with access to electricity so there may be some measurement and definition issues with this statistic.

[5] See World Food Programme, Nepal Country Program, 2013

[6] World Bank, 2014, p.2.

Table 1: Selected Development Indicators for Nepal

Country Indicator	Indicator Value
Total Area *(km²)*	147,180
Population (2014)	28,120,740
Rural Population (% of total population)	82 (2014)
GDP *(current US$)*	19,636,186,469 (2014)
GDP Per Capita *(current US$)*	698 (2014)
National poverty rate (% of population)	25.2 (2010)
Access to Electricity *(% of population)*	76.30 (2014)
Energy Imports Net *(% of energy use)*	13.02 (2011)
Fossil Fuel Energy Consumption *(% of total)*	12.54 (2011)
CO_2 emissions (metric tons per capita)	0.2 (2011)

Source: World Bank Indicators, 2014.

2.1.1. SOURCES OF ENERGY SUPPLY

Given Nepal's overwhelmingly rural and often remote settlement patterns, it is not surprising that the primary source of energy is biomass, especially wood (see Table 2). This has long been a problem for this mountainous country with deforestation and subsequent soil erosion leading to destabilization of the hydrological regime. The use of dried dung and crop wastes as fuels also means that less of these are available for use as soil amendments and fertilizer to improve crop productivity. These fuels also cause considerable indoor air pollution when used as a cooking fuel, especially for women and children.

As discussed further in this report, the potential contribution of renewables has barely been tapped and could become a significantly larger portion of Nepal's energy profile than they are now. On the other hand, given Nepal's poverty and low economic growth as well as its dependence on imports, it is unlikely that the proportion of fossil fuels in the national energy mix will increase much above its current levels, at least in relative terms.

Table 2: Nepal's Energy Sources

Energy Source	Percent of Total
Biomass	77.1%
Petroleum products	11.3%
Coal	5.4%
Hydroelectricity	3.2%
Renewables	3%

Source: MoF (2015). Electricity refers to electricity generated from hydropower plants, import from India and a minor from utility owned multi-fuel plants. Renewables includes mini, micro-hydro, and biogas.

Hydropower is the overwhelming source of power in Nepal. The country is endowed with a huge theoretical hydropower potential of approximately 84,000 MW and a current, economic, viable potential of 43,000 MW.[7] However, the installed hydropower generation capacity as of July 2014 was only 787 MW, of which 782 MW was grid-connected. The remainder took the form of mini/micro-hydropower, some of which supplied electricity to mini-grids.

The peak load (demand) in the year 2013 reached 1,201 MW in the winter months. Due to the seasonality of hydroelectricity generation in Nepal and the lack of dam storage facilities, hydropower generation capacity during the winter months falls to about one-third of installed capacity. Moreover, even with the import of electricity from India (about 200 MW), the gap between demand and supply still amounted to about 500 MW in the winter months of 2013, resulting in load shedding of up to 15 hours a day. This situation remains a binding constraint to economic and human development in Nepal.[8]

2.1.2. ENERGY DEMAND TRENDS

As Table 3 indicates, Nepal's energy demand profile reflects its rural and agricultural economy with nearly 90% of demand from the residential sector. This lopsided demand profile reflects the low level of development of rural and small town services (e.g. utilities, health, education, post-harvest processing, etc.) and light manufacturing and construction businesses. As noted above, poor access to reliable sources of power is an important binding constraint to development of rural (and urban) non-agricultural businesses and services. The 1% of energy demand from agriculture in Table 3 is undoubtedly a sizeable underestimate since it does not include human and animal labor, which is difficult to estimate given widely varying agro-ecosystems across the country and the lack of data for converting labor to energy (joules).

This data also indicate that undoubtedly a very large degree of latency in the demand for power exists in Nepal. This is illustrated by the fact that as many as 200,000 generators are imported each year and the amount of diesel fuel (two-thirds of which is used in the Kathmandu Valley) goes to powering those generators.[9] If significant and reliable power supplies were available to both rural and urban Nepal, this could provide a tremendous spur to economic development. On the other hand, Nepal's very low per capita GDP and household incomes, even for households with overseas remittances, means that it is difficult for households to pay for much more than basic lighting and mobile phone charging, which, in turn constrains development of new power sources, especially in rural areas and relatively isolated communities.[10] A steady expansion of renewable power systems also would need to be accompanied by political stability and more streamlined governance.

Table 3: Nepal's Energy Demand by Sector (%)

Energy Demand by Sector	Percent of Total
Residential	87%
Transport	6%
Industry	5%
Commercial (services)	1%
Agriculture	1%

Source: Nepal Energy Situation, p.3/17.

[7] NEA, 2014, p.1

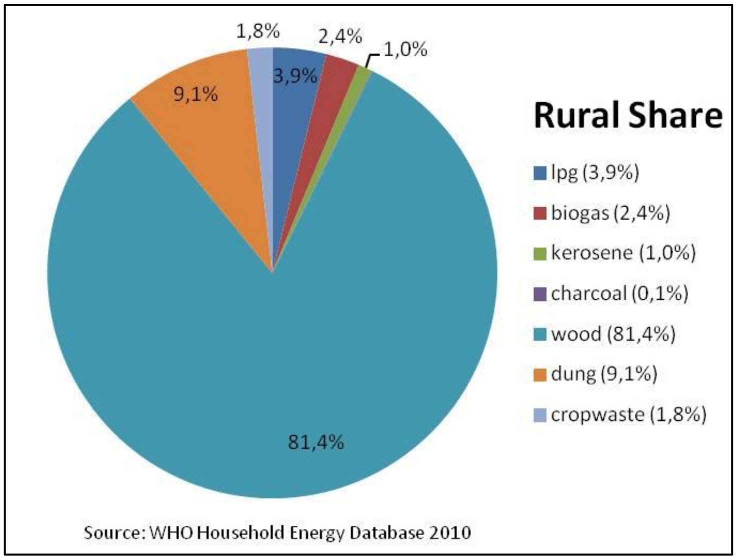
[8] World Bank, 2014, p. 2. See also GON and MCC, 2014, p. 9.

[9] Nepal consumed 949,279 Kiloliters of diesel in the first eight month of Fiscal Year 2014/15 (MOF, 2015).

[10] Ability to pay can be inferred from information available in the Nepal Living Standards Survey of 2010/2011 conducted by the Central Bureau of Statistics of the GoN. Nominal per capita consumption in 2011; All Nepal – US $ 477, poorest 20% population – US$ 180, and highest 20% - US$ 1075 (CBS, 2011).

Given the overwhelmingly rural distribution of Nepal's population, it is useful to examine the composition of rural energy sources. Figure 1 shows that about 96% of rural Nepal's energy is from wood, charcoal, dung, and crop wastes. These are highly inefficient sources of energy and also "dirty" with significant negative health effects, especially for women and children. Biomass harvesting and combustion also leads to environmental degradation and black carbon emissions.[11]

Figure 1: Composition of Rural Energy Supply by Fuel Type



Source: Nepal Energy Situation, p.3/17.

Though still a very small proportion of the total, biogas has recently emerged as one potentially important source of renewable energy, especially for residential use as a cooking fuel. Currently, 95 percent of all cooking fuels are biomass-based.[12] Due to transport difficulties, high import costs and the need for government subsidies, kerosene and LPG are likely to remain a relatively small share of the rural energy market in Nepal. The government monopoly on fossil fuel imports may contribute to making these fuels more costly than they would be under more competitive market conditions.

The potential for biogas to become an important substitute for wood fuels, dung, and crop waste is significant and considerable investments have already been made in rural Nepal. The box to the right provides a brief look at potential and investments in biogas in Nepal.

Biogas Potential and Investment at a Glance

Potential: 1.2 million households own cattle and/or buffaloes; Animal/crop wastes enough to support 1,000,000 household-size plants (57% in the Terai, 37% in the hills and 6% in the remote hills).

Investments:

305,147 biogas plants (2015) under BSP/AEPC

2,907 plants installed under GSP

11 Black carbon or BC is a component of fine particulate matter (PM ≤ 2.5 µm.) It is formed through the incomplete combustion of fossil fuels, biofuel, and biomass, and is emitted in both anthropogenic and naturally occurring soot. It is a significant climate forcing agent though it is much shorter lived than CO2. Black carbon has significant negative impacts on human health.

12 Nepal Energy Situation, p. 3/17.

2.2. CURRENT ELECTRICITY PROFILE IN NEPAL

As noted previously, this study is on the role of renewables in both the short-term, post-earthquake recovery period and in the long-term transition to a climate resilient and growing economy in Nepal. As such, the focus of the study will be primarily on the power sector in Nepal. This study will briefly summarize the power sector by power source and current issues with the growth, reliability, and management of the power sector. The study will then examine the renewable energy sources being deployed for power and the issues associated with these. Although large-scale hydropower is a renewable energy source, this study treats it in the analysis of conventional power sources since it already provides base load power integrated into the national grid or is exported. This study focuses on the remaining obstacles for resilient and sustainable clean energy development.

2.2.1. CONVENTIONAL POWER SOURCES

Nepal's power demand has grown sharply, with an average annual growth rate of 9.7% in Fiscal Year (FY) 2012/14 (NEA, 2014). Despite the growing electricity demand, per capita electricity consumption is still very low at 108 kWh/year in FY 2012 (NPC, 2013). As noted above, total installed capacity is only 787 MW, of which 782 MW is grid connected (NEA, 2014). The estimated grid connected energy demand in FY 2013/14 was 5,909.96 GWh, of which 4,631.51 GWh was actually supplied (NEA, 2014). NEA's grid system loss in FY 2013/2014 decreased to 24.79% from 25.11% in the proceeding year (NEA, 2014).[13] Actual revenue losses are probably greater due to inadequate bill collection from rate payers.[14] The Millennium Challenge Corporation (MCC) has reported transmission and distribution losses as high as 34%.[15] In order to manage the excess of power demand over supply, 1,072.23 GWh (23.2%) energy was imported from India in FY 2013/14 and power cuts as well as rationing resulted in a maximum of 12 hours of load shedding per day in the winter season (NEA, 2014).

While three-quarters of Nepal's population is estimated to have access to electricity (grid and off-grid) according to the 2013 Nepal Census, service is not necessarily available due to shortage of supply, with load shedding in grid-covered areas in the dry season, as noted. In addition, a significant disparity in access to electricity exists between urban (90 percent) and rural areas (30 percent). Average annual consumption remains very low at about 108 kWh per capita, compared to 733 kWh for India and 2,600 kWh for China.[16]

As of 2014, the NEA had more than 2.71million consumers (mostly households). Of those, nearly 95% are domestic consumers (NEA, 2014). This also includes electricity distribution under two community approaches/frameworks: a) Kailali Kanchapur Rural Electrification Umbrella Organization (KKREUO)[17], and b) the National Association of Community Electricity Users – Nepal (NACEUN).[18] KKREUO is an umbrella organization (UO) of 216 electricity user cooperatives. This UO was set up to provide managerial, administrative, and technical services to the individual electricity user groups serving collectively over 50,000 households in two districts of Kailali and Kanchanpur in the western part of Nepal. NACEUN is a national federation of 465 community electricity users' groups from 50 districts. More than 360,000 households have been electrified under this framework. NEA sells power to both

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[13] These are figures NEA presents in the cited report, but they do not fully align with their own report of other data in terms of a full aggregate technical and commercial loss analysis, which suggests a percentage near 33% in 2013-2014.

[14] These are figures NEA presents in the cited report, but they do not fully align with their own report of other data in terms of a full aggregate technical and commercial loss analysis, which suggests a percentage near 33% in 2013-2014.

[15] GON and MCC, 2014, p. 44.

[16] Ibid., p.261

[17] www.kkreuo.org.np

[18] www.naceun.org.np

KKREUO and NACEUN communities in bulk and these community organizations are responsible for the operation and management of the distribution systems in their respective areas.

Apart from these NEA supplied systems, Butwal Power Company (BPC),[19] a private company pioneer in hydropower development since 1966, distributes electricity in four districts of Nepal – Syangja, Palpa, Phyuthan, and Arghakhanchi. BPC supplies electricity to around 36,000 households in 62 village development committees and two municipalities.

2.3. SMALL-SCALE AND RENEWABLE POWER SOURCES BY TYPE OF TECHNOLOGY

The renewable energy sources and technologies that will be discussed in this study include hydropower technologies, solar energy, and wind energy. We will also discuss energy efficiency even though this is not a supply source as such. Energy efficiency has the potential for improving productivity, reducing environmental pollution and reducing the need for additions to power supplies. In off-grid areas, small hydropower and micro hydropower projects are the primary sources of electrification. "Rooftop" solar is quickly gaining momentum although it is still relatively small as a proportion of total energy generation. A recent survey revealed that the main source of household lighting (67.26%) is electricity, with the remainder coming from kerosene, biogas, and solar (CBS, 2012).[20]

Twenty-three major geothermal springs have been identified in Nepal.[21] Most of them lie in the high Himalayas. They have relatively low temperatures compared to most commercial geothermal energy resources in other countries and some are used as bathing facilities for tourists and local Nepali residents. Because of their relatively low temperatures, geothermal is unlikely to have any serious potential for power production in Nepal, although it could displace other fuels for residential heating in those areas immediately proximate to the resource.

2.3.1. SMALL, MINI, MICRO, AND PICO HYDRO

These four forms of hydro are grouped under the general term "small hydro." In Nepal, hydropower is classified by installed capacity according to the types listed in Table 5. Pico power is useful in remote communities that require only a small amount of electricity, for example, to power one or two fluorescent light bulbs and a TV or radio in 50 or so homes. Almost all small hydro installations in Nepal are run-of-the-river (or irrigation canal or small stream) type, i.e. having no storage reservoir or daily storage only. With a few exceptions, this is also true for large hydropower installations in Nepal.

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[19] www.bpc.org.np

[20] Ibid., p. 261.

[21] Mahendra Ranjit, p.275

Table 4. Classification of Hydropower by Size of Installed Capacity

Hydropower Classification	Capacity Limits
Pico	<1- 10 kW
Micro	<0.1 MW
Mini	0.1 – 1 MW
Small	1 – 10 MW
Medium	10-50 MW
Large	> 50 MW

There is increasing interest throughout the developing world in micro hydropower projects. However, all scales of hydropower offer good potential in Nepal. In order to estimate the actual potential for installed hydro, detailed field surveys, and seasonal river and water flow mapping is required to determine potentially feasible locations. However, to date, no comprehensive hydropower potential studies at the river basin level have been undertaken for Nepal.[23]

Table 5: Number and Cumulative Capacity of Projects with DoED

Project Category	**Range/Type**	**No**	**MW**[22]
Survey Licence Issued	Hydropower < 100 MW	14	4262
	Hydropower 25 to 100 MW	10	601
	Hydropower 1 to 25 MW	57	378
	Hydropower Below 1 MW	176	126
	Solar	3	67
	Biomass	2	11.4
	Wind	1	5
Construction License Issued for Generation	Hydropower	96	2203
Reserved By Government	Hydropower	210	10,125

Source: DoED (2015), http://doed.gov.np/. Note: Data are current to August 10, 2015

As of 2014, the total installed capacity of Nepal's power plants was 787.08 MW, including two thermal plants which produce 53.41 MW according to the NEA. There are 11 large hydropower projects producing 459.15 MW, 14 small hydroelectric plants with a total capacity of 14.22 MW, and 23 isolated NEA owned small -hydro plants contributing a total of 4.536 MW of installed capacity usually within local micro-grids. Since the introduction of Nepal's new hydropower policy in 1992, which opened up

22 Rounded off

23 Liu, et al., p. 261. A variety of small basin and sub-basin studies have been undertaken usually as part of the design of small hydro plants.

this sector to private sector participation, 39 projects have been developed contributing 255.647 MW of electricity annually (NEA, 2014).

2.3.2. STATUS OF HYDROPOWER DEVELOPMENT BEFORE THE EARTHQUAKE

More than 20 years ago, the GON realized that it didn't have the financial resources to exploit its hydropower resources on its own, while still devoting its limited investment resources to priorities like health and education. Hence, the Hydropower Development Policy (HDP) of 1992 was approved and, based on this policy, the Electricity Act (EA) in 1992 and the Electricity Regulations (ER) in1993 were enacted to provide incentives for national and foreign private sector investment in the development of hydropower. Since then, the private sector has increasingly become interested in the development of hydropower. The Government established the Department of Electricity Development (DoED)[24] in 1993. Table 5 shows the number and capacity of electricity projects at different stages of development licensed by the DoED. With the exception of solar, wind, and other small renewables which are supported by the AEPC, the NEA has been the primary developer in the power sector, especially hydropower. There have been some positive achievements in the hydro power sector development in recent years. These include the establishment of the Investment Board of Nepal (IBN) and its initiative to promote and support Project Development Agreements.

In Nepal, the most common application of power from micro hydropower plants has been household lighting. However, services such as agro-processing activities (grinding, hulling and milling) as well as radio, TV, computers and other end uses also are typical applications. The Government established the Alternative Energy Promotion Centre to promote and expand the use of alternative energy sources, including micro-hydropower in 1996.

According to the Nepal Micro Hydropower Development Association (NMHDA), Nepal's "techno-entrepreneurs" have greatly improved their level of expertise in hydropower technology over the last 40 years. Nepalis now have the expertise to carry out all services for feasibility study, survey, design, manufacturing of turbines and other machinery and equipment, installation, commissioning, and repair/maintenance that is required for micro-hydropower plants. According to the AEPC, as of July 15, 2015 a total of about 25 MW of capacity has been installed from 1460 micro hydropower plants ranging from very small pico power plants to varying sized micro-hydropower installations that have electrified around 250,000 households. Additionally, 99 plants are under construction stage with an additional cumulative capacity of 4.4 MW that will electrify a further 40,000 households.

Currently, the NMHDA states that 78 privately run firms in Nepal operate in the micro-hydropower sector and are generating more than 5000 kWh of electricity annually in the country.

2.3.3. EARTHQUAKE IMPACTS TO THE HYDROPOWER SECTOR AND NEEDS

According to the Post-Disaster Needs Assessment undertaken by the National Planning Commission, 115 MW of hydropower facilities are estimated to have sustained damage, including both large and small hydro. It is estimated that it will cost $US186 million to repair or replace these facilities. Much, though not all, of this cost is covered by insurance. Moreover, about 800 km of distribution lines at different voltage levels and 365 transformers of different capacities were put out of service by the earthquakes. For generation plants under construction, about 1,000 MW of hydropower projects, owned both by

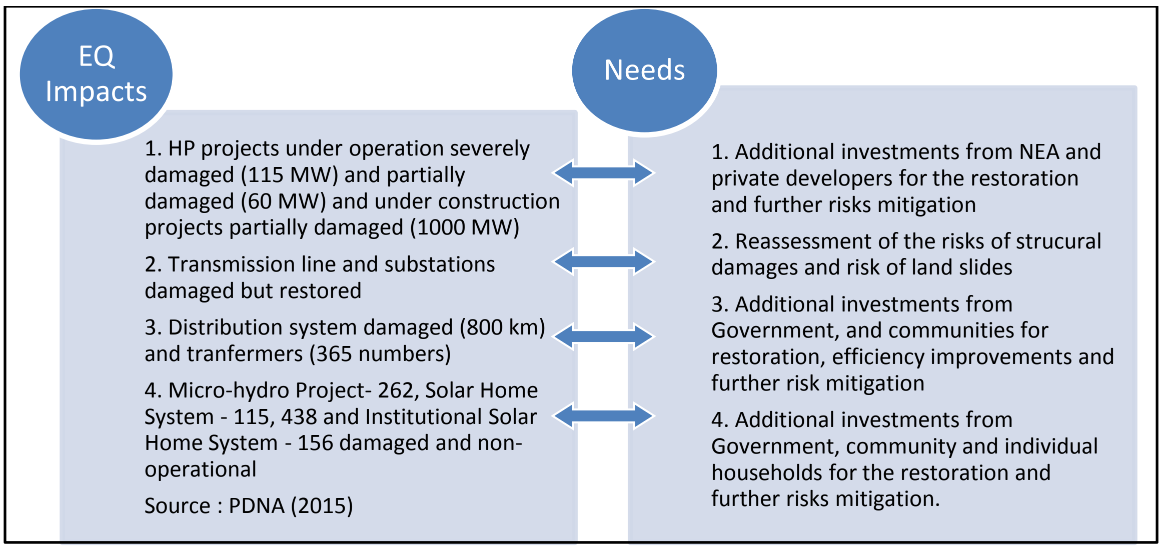
[24] The Department is responsible for assisting the Government in implementation of overall government policies related to power/electricity sector. The major functions of the Department are to ensure transparency of regulatory framework, accommodate, promote and facilitate private sector's participation in power sector by providing "One Window" services and licenses to power projects.

independent power producers and the NEA, have been partially damaged.[25] The transmission network, by contrast, seems not to have been significantly damaged (or was quickly repaired).

In a number of sites, including operational small hydropower plants and those under construction, damage from the earthquake was followed by further damage from flooding and landslides since the annual monsoon season began in June. In all, about 600,000 households were directly affected by the loss of access to electricity due to damage to power installations, both grid connected and off-grid, or to the loss or severe damage to houses.

The earthquake also affected construction of big projects, e.g. the Upper Tamakoshi, Rasuwa Gadi, Sanjen, Khanikhola, and others. These projects will be delayed by at least a year, according to the respective project chiefs. With no signs of big projects being completed for at least two years, the NEA is planning to increase power imports from India. Other small projects under construction (Upper Chaku, Lower Modi, and Lower Khare) totaling 43 MW were reported to be severely damaged. An additional complicating factor is that the earthquake now requires that many sites with existing facilities or those under construction or planning be re-surveyed geologically to factor in possible underlying tectonic shifts, which could result in potential changes of location and construction designs (PDNA, 2015). Figure 2 summarizes the earthquakes' impacts and current needs for repair and restoration.

Figure 2: Earthquake Impacts to Hydropower System and Repair/Restoration Needs



2.3.4 OPPORTUNITIES IN THE HYDROPOWER SECTOR

One of the most promising opportunities in this sector, especially in Asia, has been the creation of "mini-grids." Large numbers have been developed in China, Vietnam, Thailand, and other Asian countries. This technology connects two or more plants in a locally controlled distribution system. These decentralized networks can improve the "reliability, quality, and availability" of electricity produced by isolated plants, and give communities the option of selling their surplus electricity to the grid when it finally does arrive. It should be noted, however, that selling surplus power back to the grid or "net metering" is at present not allowed in Nepal despite indications on the GoN's part that they consider it an option.

Micro-hydro can comprise a sustainable resource base for rural mini-grids, depending upon the seasonality of rainfall and water flows. In July 2011, the AEPC piloted a micro-hydro based mini-grid

[25] PDNA, 2015, pp. 12-13.

system in the western district of Baglung, a remote hilly area, close to a tributary of the Kali Gandaki River. They connected six micro-hydro plants (ranging in capacity from 9 kilowatts to 26 kilowatts) within a distance of 8 kilometers, to form a 100-kilowatt capacity mini-grid. The system served 1,180 households and is owned by the local community.

However, currently, the Baglung mini-grid has ceased operations. While the mini-grid network model has a lot of intuitive appeal and has worked elsewhere in Asia, the Baglung experience has shown that the requirements can be formidable in Nepal. There are institutional issues regarding who owns and manages the system. There are currently very few chances for load factor improvements because all the plants have their peak and off-peak loads at the same time, which is exacerbated by the limited use of power mainly for lighting. Hence, while the plants are operational, the institutional governance issues have caused the mini-grid to fail.

The most successful mini-grid schemes have been developed where their design has carefully considered local economic, social, and environmental conditions; where sustainable financial models have been developed; and where the national policy and regulatory context is sensitive to the requirements of building mini-grids. Many of these factors are very context specific.[26] With regards to management, one of the most successful models has been a hybrid public utility/private sector partnership, which leverages the larger resources of the utility and the flexibility and entrepreneurship of the private sector partner.[27]


Ghandruk Micro-Hydro Power Plant

In general, if serious economic constraints can be overcome and the enabling environment and regulatory system more supportive then limited opportunities still exist to increase generation capacity from licensed, but not yet realized installations as well as new micro-hydro installations. Expansion of new sites is limited; however, as most of the feasible sites, except in the far western part of Nepal, have already been developed or licensed.

An important set of opportunities for both hydropower and combined (hybrid) hydro and other renewables (solar or wind) exists in restructuring and strengthening community-managed power distribution systems. The NEA serves around 2.5 million customers across all 75 districts of the country. However, only 56% of the population has access to NEA's grid systems; an additional 12% have off-grid facilities served mainly by micro-hydro plants or solar home systems through local entrepreneurs and other alternative energy providers. Along with expansion of the distribution network to rural areas, improving the efficiency of the power supply will be critical to feed more electricity to the network.

[26] GVEP International, 2011, p.6.

[27] Van Der Plas, 2009 and Tenenbaum et al., 2014.

Currently, one large privately owned hydropower company supplies electricity to 36,000 consumers, and further grid-based community distribution systems electrify more than 400,000 consumer households. Apart from these, many community-managed generation systems provide electricity in rural areas. These community-managed generation systems are scattered across the country based mainly on pico and micro hydropower schemes.[28] Both grid-connected and off-grid schemes suffer from technical losses (old, poor equipment) and financial losses due to the inadequate pricing policy, metering, and revenue collection systems of NEA.[29] For community-managed systems, load factors, i.e. the ratio of average consumption to peak consumption, tends to be quite low, meaning that the generation scheme is operating well under full capacity and so is likely to be unprofitable. Factors contributing to unprofitability could be attributed to socio-economic conditions generally found in rural villages, low-voltage demand, and unreliable distribution networks.

To address this issue, wherever possible, attention should be paid to a) upgrading pico hydropower to the micro hydropower level and to create mini-grids wherever possible, and b) expanding and strengthening community managed systems under the framework similar to the Kailali Kanchanpur Rural Electrification Project (KKREP) and its management umbrella organization (KKREUO) or the National Association of Community Electricity Users-Nepal (NACEUN).[30] This, in turn, would allow a more efficient load factor resulting from improved sustainability on its operation.

The distribution grid under mini-grid systems will need to be managed automatically to account for the contributions of each of the mini-grid's generators and daily shifts in demand. Asian Development Bank (ADB) is supporting a pilot test of an innovative business model for mini-grids in Nepal. A feasibility study conducted by Gham Power led to the development of a pilot project for 35 kWp of solar power to provide electricity to local businesses and households in 3 remote rural communities in Nepal.[31] The quality, siting, and maintenance of distribution lines in these off-grid systems need to be addressed if mini-grids are going to be successful. However, according to the AEPC, a number of advances in protective relaying, power sharing and voltage profile improvement, which especially deal with the unique nature of the distribution system, have been made and can be used in Nepal. These include the introduction of islanding detection schemes, droop power sharing method and smart voltage regulating devices.[32]

An important advantage of hybrid systems is their capacity to smooth out seasonal variations in the available resource (e.g. high solar input but low hydro output during the dry season and vice-versa). Nepal's first wind-solar hybrid system was installed in Dhaubadi village of Nawalparasi district in December 2011, under Asian Development Bank's support, for which AEPC was the implementing agency.[33] On the other hand, most "rooftop solar" systems are not intended to supply power to a mini-grid or to supplement a village pico hydropower system (though they could do so). Hybrid systems also become financially competitive with diesel gensets where transportation and imported costs make the

[28] 1400 micro hydro plants with a cumulative capacity of 25 MW able to provide electricity to 400,000 households (Kumar et al., 2014).

[29] Most micro-hydropower households are not metered and the extensive use of power-based tariff is discouraging energy conservation. The distribution networks of most MHPs are not up to NEA standards (Kumar et al., 2014).

[30] These are grid-connected systems that due to good management and better revenue collection are experiencing tremendously low technical losses.

[31] News from Nepal, Asian Development Bank, 2014

[32] See, AEPC, Experience sharing on mini-grid and biomass gasification workshop, 2012

[33] News from Nepal, Asian Development Bank, 2014

latter prohibitively expensive. However, the initial capital costs are high and will continue to require either significant subsidization or more rapid amortization of the investment. This means that enlarging the customer base and associated distribution system becomes a critical factor. This is why it is recommended that an ESCO approach be encouraged to manage community-based power generation and distribution systems (and certainly this would be required for mini-grids). On the other hand; the operation of community managed distribution systems should be strengthened to operate like a business entity such as an ESCO. Given the predominantly agricultural nature of the economy, investments in post-harvest processing, support for aggregators where power may be a constraint and other activities in critical value chains that could benefit from more and reliable power could be a strategic theme for donors like USAID.

Restoration and strengthening of community managed micro-hydro plants is an important opportunity, in those facilities damaged in the earthquakes as well as those that have suffered from poor management and maintenance. As discussed above, community-managed micro-hydro plants have not always been a sustainable power source. Some of the problems can be traced to inherent design, siting, and construction problems (e.g., siting in geologically unstable areas or use of poor construction materials and methods by the developer). However, other problems can be traced to the management and operation of the plants by village committees with inadequate training and experience.

As noted above, low load factors, exacerbated by poverty and lack of small industries and businesses, have made the power business in isolated community micro-hydro plants often unattractive investments, including repairing and restoring offline systems. Unprofessional management has compounded operation and maintenance. Often, the micro-hydro plant developer is more interested in quickly recovering his construction costs and less interested in training local operators or ensuring that operational problems (and attendant costs) are quickly addressed. As discussed above, the two potential solutions to management problems are to create a local utility and, wherever possible, to create mini-grids and improve the sustainability of system utilization, cost recovery, and operations. This can be achieved by upgrading the existing micro-hydropower systems to exploit the possible maximum generation capacity from existing river flows so that the generated power can serve purposes such as providing local communities with better lighting and power to local enterprises, as well as selling surplus power to the grid.

2.3.5. CHALLENGES

While pico and micro-hydropower plants have brought much-needed electric power to isolated Nepali villages, the operational model may not be sustainable in most cases. Local communities often construct micro-hydro projects with support from the government, local NGOs, or donors. Once the project is completed, their operation, collection of energy bills, and maintenance lie in the hands of community user groups, which requires good management and technical capacity, which is not always available for each community-run system. In addition, the sustainability of the micro-hydro plant is in question when grid-electricity is extended to the village.

Regarding hydropower development, as noted, a large number of projects have been licensed and are under various stages of development, including a number that have delayed construction for various reasons. The IBN is regarded to be performing well and moving along projects. Constraints include the credit rating and risk profile of investments in Nepal. Reducing the risk through political stability, dealing with labor problems, and addressing the other above-mentioned constraints will help increase investment. Finally, without a developed transmission sector and a functioning power trade corporation and associated agreements, there is not a viable off-taker for the generation that is currently in development.

The capital market in Nepal is emerging but is in a very nascent stage. While there are a few large, Class A banks, hydropower projects typically require relatively large front-end capital investments and, in some cases, a long time before an income stream is able to liquidate the loan or provide returns to an equity stake. Large and medium hydro projects especially face domestic funding hurdles, not the least due to the high risk political and economic environment. This funding hurdle is also further burdened by an ongoing state of political instability, even though it has been years since the end of the Maoist insurgency.

Hence, dozens of attractive and approved projects have not begun construction because financing for them has not been finalized. Promoters of eight different projects with a combined installed capacity of 271 MW have signed loan agreements with the Hydropower Investment and Development Company Limited (HIDCL) worth Rs 3.23 billion but have not used their loans.[34] The government formed the HIDCL with the aim of boosting investment specifically in the hydropower sector. The HIDCL signed loan agreements to develop co-financing arrangements with various banks and financial institutions when it became operational in 2010. Loan agreements have ranged from a minimum of Rs150 million to Rs1 billion, depending on the designed installed capacity of the proposed projects. According to one source,[35] HIDCL is a very inexperienced operation and has mainly been sitting on the undisbursed loan funds earning interest from them. The April 25th earthquake and subsequent aftershocks as well as monsoon flooding have added to the problem by putting a hold on new construction and delayed repair of damaged installations.

Another potential deterrent to investment in hydro as well as solar and other renewable energy investments is the Finance Ministry's insistence on levying the national value-added tax (VAT) on all hydro or other renewable energy-related construction and equipment as well as tariffs on imported energy equipment and commodities. The Chair of the Nepal Energy Development Council has argued that these financial measures are significant investment disincentives in a country facing chronic power shortages and that the Finance Ministry is putting its own revenue interests ahead of the national power crisis.[36]

Smaller scale renewable energy projects have been able to access funding more readily, including small-scale micro-hydro.In addition, technical support has come from the AEPC and the Nepal Micro Hydropower Development Association. The latter is a training and promotion group established in 1992 to support micro hydropower development. It has an ongoing program of training power technicians, managers and supporting operators with information on regulations and reliability measures. As with some of the other clean energy sources discussed below, projects could be developed in feasibility and cost studies by ESCOs and funded through a special clean energy fund, possibly combined with other clean energy sources such as solar power particularly in partnership with the NMHDA. The other challenge is overcoming a lack of knowledge by, in part, sharing knowledge of the practical experience and best practices from other countries for small hydro projects. Besides finance, the lack of field expertise and technical skills are the largest barriers impeding the development of hydro hydropower.

Strengthening Resilient Hydropower Policies in the Face of Climate Change. As described in previous sections, Nepal is overwhelmingly dependent upon hydropower (more than 90%) for its electricity supply. Hence, the resilience of the system is extremely important. Resilience in this context has two aspects. One is climate resilience and the other is institutional resilience. Climate resilience is of increasing concern in Nepal's hydropower sector. In-depth analyses of water resources in Nepal have revealed two critical impacts of climate change on hydropower: a) glacial lake outburst floods

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34 "RS 3.23B od HIDCL Remains Uninvested", Karobar Daily, 7-31-2015

35 Santosh Thapa blog, 5 April 2015.

36 Sujit Acharya, "Budgeting for energy self-reliance", 7-31-2015.

(GLOFs), and b) the increasing variability of river runoff. Both of these impacts are affecting not only hydropower generation but also rural livelihoods and agriculture. It has been estimated that a global temperature rise of 4° C could result in the loss of 70% of snow and glacier area due to the melting of snow and ice. The melt water will accelerate development of glacial lakes and increase the potential of GLOF events with potentially catastrophic results downstream, including destruction of hydropower facilities and adjacent communities.

Hydropower companies in Nepal have reported generation losses between 3-8% per annum due to GLOFs, landslides, and variations in rainfall patterns that have led to unusual floods or low water flows. These phenomena have also resulted in increased sediment concentration, accelerated erosion of turbines, and increasingly frequent maintenance shutdowns. Hence, the GON needs to prioritize policies that focus on climate-proofing streams and other watercourses on which vulnerable hydropower facilities and nearby communities are sited. These include requiring operating hydropower facilities, as well as those under construction or in the planning or financing stage, to carry out additional environmental impact studies to incorporate climate change scenarios and adaptation measures in the design (or re-design), siting, construction, and operation. Since these measures may increase capital investment costs considerably for some projects, the GON will need to identify ways to finance these additional costs. The International Finance Corporation (IFC) is currently designing an expansion of its pilot program to finance climate proofing of vulnerable infrastructure in Nepal, mainly hydropower facilities[37], but more will need to be done to adapt to increasingly erratic water supplies than is currently the case in Nepal, including more use of dam storage. Environmental and social impacts, however, may limit the feasibility of increasing the application of large storage dams.

The other dimension to resilience is institutional. As discussed previously in this study, a number of institutional problems exist in Nepal's hydropower sector. Although many licenses have been approved for independent power projects at both small and large scales, only a relatively small number of them have been executed. Developers continue to regard Nepal as a high risk from a business standpoint, due to many factors including political instability and conflict, inadequate financial incentives and public-private partnerships, complicated bureaucratic procedures, and the lack of technical support from the GON and NEA. Having in place an off-taker such as is provided in power trade agreements (PTA) would contribute to the financial stability of the hydropower sector, though this measure would primarily benefit large hydropower projects. The GON needs to focus on policies to reduce institutional instability and to broaden participation in the sector. This is especially important for larger sized hydropower (including larger micro-hydropower projects) that may be stalled due to community animosity and demands for compensation, a lack of public participation in planning, and inadequate investment in small industries and businesses.

Furthermore, in the wake of the recent earthquake, Nepal's hydropower development plans and policies must be reassessed for more rigorous and resilient seismic safety provisions applicable to existing as well as future plant construction.

2.3.6. RECOMMENDATIONS

It is clear that hydropower (including small and micro) provides the primary base load power for the national grid and the biggest potential to electrify off-grid settlements and businesses in Nepal. It is also clear that serious financial, policy, management, and institutional capacity constraints have held back the full development of Nepali hydropower. In addition, the future effects of climate change on stream flows is a new order of uncertainty and risk that needs to be factored into siting and design of small and large hydropower projects.

[37] Expansion of IFC-PPCR Strengthening Vulnerable Infrastructure Project. PPCR means Pilot Program for Climate Resilience.

In order to estimate the full potential for installed hydropower, a bigger effort to carry out detailed river basin planning including field surveys and seasonal river/water flow mapping would be required to determine potentially feasible locations, including the need to factor in the scenarios from downscaled climate models for various river basins in Nepal. USAID could provide support to the GON for integrated, landscape level, river basin planning that could also indicate those measures e.g. revegetation of steep slopes that would also be useful for hydropower planning by District or regional authorities. This support could take the form of technical assistance and training, where needed, to assess data flows and locations of perennial streams and other fresh water bodies. This could also be a useful contribution to the national GIS if additional data layers for demography, infrastructure, and economic indicators are included.

USAID Nepal recently awarded of the Nepal Hydropower Development Project (NHDP). This is a five-year, $9.8 million project that will support the GON's efforts to expand access to hydropower services and to become an energy exporter in South Asia. The project will work with the IBN, the NEA, and the Ministry of Energy (MOE). It is intended to facilitate private sector investment in hydropower resources in an environmentally and socially sustainable manner.In addition, the project will support the restructuring of the electricity sector to create viable, efficient national power services and to promote expanded electricity trade between Nepal and India. This project platform might also be a mechanism for engaging the GON and the private sector to support the enabling environment for public-private partnerships in rural village mini-grids.

Given the problem of mismanaged community operated small hydro systems (mainly pico and micro-scale), the development of ESCOs serving multiple villages and rural industries, including mini-grids, would appear to be a potentially good model to support. Essentially, they would be operating as developer and utility. To date, in many rural communities, tariff rates are very low. In fact, the NEA incurs a loss on collections compared to the cost of power provision. This situation, of course, is due to widespread poverty so community-based micro-hydro schemes have not attracted much private sector interest, especially those under 1 MW in installed capacity. Hence, the Mission's focus might instead be to improve the professionalism of community-managed schemes, perhaps in projects under Development Objective 1 that might eventually lead to a kind of multi-village utility cooperative, a model used in a number of other countries, including parts of the US.

2.3.7. SOLAR AND WIND ENERGY

This section addresses solar and wind energy applications. Solar is used for direct heating and drying purposes and for generation of electricity. Wind energy is overwhelmingly used for generating electricity though wind has other traditional applications, e.g. water pumping. Solar power is mainly produced through photovoltaic cells (PVCs) in arrays of varying sizes. In Nepal solar PV is the most important alternative power source after hydroelectricity. As described below, solar energy applications both for power and process heat are much more developed than wind power. The primary source of information on wind energy is the 2008 Solar and Wind Energy Resource Assessment in Nepal (SWERA). This assessment concluded that relatively large scale wind energy had commercial potential and these sites covered only 10% of Nepal, usually in very remote mountainous areas. While large-scale wind energy development potential may cover only a small area of Nepal, it is quite likely that many more small-scale wind energy applications could be feasible for individual villages.

2.3.7.1. BACKGROUND AND CURRENT STATUS/ DETAIL

Solar energy is an abundantly available clean energy source in Nepal that can be deployed widely in both rural and urban areas, though the greatest benefits will likely come to rural, off-grid producers and consumers. A supply of reliable electric power has long been shown to support improved social services (e.g., health and education) and to enable significant improvements to rural value chains, especially in post-harvest processing and non-agricultural activities. This section primarily discusses direct generation of electric power from the use of PVCs assembled into arrays or wind turbine assemblages. However, other systems employing solar thermal conversion to electricity (via a steam turbine), such as concentrating solar power and hybrid solar-waste heat systems, also exist. These are designed to produce large amounts of power and so are more appropriate for bridging seasonal and peak demand from the national grid rather than providing power to Nepal's largely dispersed rural population and its low level of industrialization. They are also much more expensive to build.

In Nepal, average solar radiation varies from 3.6 to 6.2 kWh/m^2 per day and the sun shines for about 300 days per year. Based on this, the commercial potential of solar power for grid connection is about 2,100 MW (based on the modelled solar resources from satellite data).[38] Solar power generation systems are relatively easy to install in locations close to load centers, and thus could be a very attractive option for Nepal to combat load shedding in the short to medium term (5-20 years). Hydropower, by contrast, is constrained by the location of the resource, which for large hydro may be far from load centers such as cities. Moreover, in Nepal, solar radiation is strongest during the winter dry season, which is also when electricity demand is highest but hydropower-based generation is at the lowest levels due to the low availability of water (and lack of dam storage). Therefore, solar power may be an ideal power generation source to complement hydropower's base load electricity generation in Nepal. The SWERA proposes that concentrating solar power plants or large wind turbine farms could meet this seasonal hydropower gap in the national grid. While grid-connected solar power generation has been technically proven and is economically viable in a number of countries, it currently would entail a cost that is more than double the current retail power tariff in Nepal (based on grid supplied power) and so would require capital subsidies, VAT tax relief, and/or generous feed-in tariffs to encourage investment.[39] On the other hand, in rural villages, in particular, "rooftop solar" and "small solar" (i.e. solar appliances) would displace biomass, candles, and kerosene lanterns, all of which have health, financial, and environmental costs associated with them that could justify applying subsidies for investment/purchase.

In addition to large-scale solar generation facilities (sometimes called "solar farms") intended to be connected to national or regional grids either full-time or for peak load or seasonal loading, there are also small-scale applications of solar and wind energy for off-grid and remote sites and natural disaster and emergency needs.

The use of solar PV power in Nepal is a relatively recent phenomenon. Large-scale solar power generating stations (either large-scale "solar farms" or concentrating solar power installations) do not yet exist in Nepal though one is under construction. The largest solar power installation is a 680.4 kW solar plant financed by the Japan International Cooperation Agency (JICA) in Dhobighat, Lalitpur, which went online in 2012. The fastest growth in solar power has been in off-grid applications, notably "rooftop solar" (or solar home systems (SHS), which consist of solar PV arrays placed on the roofs of houses, clinics, schools or other structures to provide power directly to the end-user. Small solar home systems provide minor amounts of power (see Table 6 for data on installations and Figure 3 for a description of the systems). It is believed that about 11% of the country's households have been using solar PV as their primary source of light energy.[40] A third category consists of portable solar devices such as solar lanterns, solar cookers and ovens and solar-powered water purification systems. Finally, solar-powered irrigation systems have been piloted in Nepal but already appear to be feasible and may become more commercial in the near future.

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38 These data are taken from the "Solar and Wind Energy Resource Assessment in Nepal (SWERA)", July 2008, supported by United Nations Environment Program (UNEP) and Global Environment Facility (GEF).

39 SWERA, 2008, p. 5.

40 SNV, Pico Solar Power in Nepal, p. 34

Table: 6. Types and Numbers of Solar Energy Applications in Nepal

Type of Solar Energy Application	No. Installed	Total Installed Capacity
Solar Home System (SHS)	561,471	13.4 MWp
Small Solar Home System (SHS/mainly solar appliances)	50,176	501.76 kWp
Institutional and Pumping System (ISPS & PVPS)	1195	1.31 MW
Solar Dryer and Cooker	2,225	

Source: AEPC, 2015, NRREP Booklet, p. 23.

Electricity from solar PV home systems is currently limited to an average of about 20-25 watts per household, though this is not an inherent, technical limitation but mainly a fixed cost limitation vis-à-vis many Nepali household income levels. Operating costs, on the other hand, are quite low but not negligible (spare parts, batteries). Solar rooftop power has not generally penetrated the poorest households in Nepal because, even with AEPC subsidies, the costs of installation and maintenance are still too high for these households. Still, rooftop solar is a significant *potential* market opportunity if rural incomes rise and community enterprises diversify beyond subsistence agriculture. However, a range of smaller solar-powered devices can help these households, including solar "lanterns," some of which also have USB outlets to power mobile phones or low power radios and mini-fans. A variety of solar task or desk lamps and semi-portable solar arrays also known as micro solar home systems have also been developed and are available in Nepal.[41] These small, portable devices have already been important in the post-earthquake recovery operations.

Solar power actually got started in the early 1990s in Nepal. Private sector involvement is very prominent in the solar sector. Currently, Nepal's solar private sector consists of 108 Solar PV companies, out of which 75 are AEPC pre-qualified companies for disseminating SSHS and SHSs throughout Nepal. The pre-qualification enables the companies to participate in the GON's subsidy of the solar PV sector. Most of these companies are located in Kathmandu and have distributers in different areas with well-established outreach. They either function through distributers located in development regions, district headquarters, district hubs or through traveling agents.[42]

[41] Ibid., p. 32.

42 SNV. 2015, Solar Pico PV Market Potential in Nepal, p. 66.

Figure: 3 Principal Small Solar Systems Available in Nepal

		
Solar Lanterns (1 Wp to 2.5 Wp)	***Small Solar Home System (2.5 Wp to 10 Wp)***	***Solar Home System (More than 10 Wp)***
General Features		
• Comparatively new and widely available in Nepalese market • A portable light fixture composed of a LED or CFL lamp, a photovoltaic solar panel and a rechargeable battery. • Not for mobile charging and running radio/TV. • Various models from D. Light Design are available in the Nepalese market; S2, S20 and S300 • Alternative to kerosene lamps in rural settings and backup to load shedding in urban areas.	• Commonly known as Solar Tuki • Integrated system consisting of battery, charge controlling mechanism and appropriate number of DC or WLED lights. • 5 Wp systems have single socket for radio with at least 2 lights each of 1.5 W for 4hrs. • 10 Wp system have facility to use 3 LED lights and ports for mobile charging and small radio. • Rural households with small families and backup to load shedding in urban areas	• Integrated system consisting of battery, charge controller and an appropriate number of DC lights. • In rural households commonly used 20 Wp and 40 Wp. • With a 20 Wp system, the users have a facility to use CFL lights of 3 W each and/or LED lights of 1.5W each. Mobile charging and power outlet for radio are available • With a 40 Wp System, the user have facility to use 6 LED lights, mobile charging, radio and power for B/W TV. • Both rural and urban areas.
Investment		
Total Cost : USD 9.5 to USD 33	Total Cost: USD 67	Total Cost : USD 163 to USD 364
Subsidy: no subsidy	Subsidy: USD 45 to USD 50	Subsidy: USD 60 to USD 100

Source: SNV, Solar Pico PV Market in Nepal, p. 37.

The GON expects that around 100 MW (by 2020) and 2,100 MW (by 2030) of grid connected solar PV plants will be installed in Nepal. As of May 2015, the NEA had placed a request for expressions of interest from bidders for a 25 MW PV power plant. The plant would be financed with assistance from the World Bank, and would address the winter dry season power supply drop in the national grid.[43] Three solar (grid-connected) and one wind power plant licenses have been issued by the DoED as of August 2015.[44]

2.3.7.2. IMPACT OF THE RECENT EARTHQUAKE ON SOLAR POWER DEPLOYMENT

The April 25th earthquake and aftershocks caused damage to solar power installations that were directly associated with damaged or destroyed structures that may have had rooftop solar arrays. The recent PDNA has estimated that the number of rooftop solar home systems seriously damaged or destroyed was 115,438. The rural/urban breakdown of this damage was not available. The PDNA estimated that the number of "institutional" solar installations (schools, clinics, businesses, etc.) either damaged or destroyed was 156. These data also suggest that, though a relatively recent phenomenon, the uptake of solar power systems has been quite rapid.

Currently, solar hot water heaters have been classified as completely commercially available products (not requiring licenses) and, hence, the actual number of installations is not now known. However, in

[43] Ibid., p. 29 and http://www.nea.org.np/tender_prequalification/page-2.html .

[44] DoED, 2015

2009, 185,000 solar hot water heaters had been installed. While these are not power generators, they do substitute wholly or in part for hot water heating from electricity or fossil fuels.

2.3.7.3. OPPORTUNITIES

In the immediate aftermath of the earthquake, the clear opportunity for identifying energy opportunities in Nepal's "building back better" approach to recovery should include pico solar power devices and systems. These are already popular in Kathmandu and other cities connected to the grid, to deal with winter blackouts and in rural areas with households and other institutions off the national grid but not necessarily linked to small hydro mini grids. Another opportunity consists of solar thermal systems, primarily used to generate hot water. These could supplement rooftop solar for supplying hot water to schools and clinics and process hot water needs for certain types of small industry. Other solar applications currently being deployed but at a smaller scale include solar cookers and solar dryers. As of 2011, 3,000 households were using solar cookers and dryers. Figure 3, above, shows the main types of small or pico solar systems for households and public institutions that are available now in Nepal.

Currently, wind power is only being piloted in a few locations in Nepal but is estimated to have a potential of 3,000 MW.[45] The ADB has supported a pilot project of a 5 kW wind turbine village electrification scheme in Nepal. Of interest is the fact that the project also includes establishment of a "Rural Renewable Energy Service Company (RURESCO)" to better ensure project management viability, knowledge sharing and to encourage proactive private sector participation. This report recommends monitoring the development of this company to gauge whether it is a potentially useful and replicable model. The scheme also incorporates solar and biogas and is in a poor and marginalized community. [46]

2.3.7.4. CHALLENGES

With rapid economic growth targets as the driving force for energy development projects (and, for renewable energy, the additional benefits of avoided carbon emissions and reduced fossil fuel dependence), it is very likely that renewable energy and solar power in particular will increasingly become widespread. While cost is an issue for both large- and small-scale solar energy applications, this is primarily an initial capital investment cost with relatively minor maintenance and repair costs and, of course, no fuel costs. As noted above, the private sector is actively engaged in this market with technical support from the AEPC and the Solar Energy Manufacturers Association. For large-scale PV installations, there is also some risk that siting may become an environmentally-sensitive issue as well as a security one. Land availability for a large-scale solar installation or "solar farm" may pose a constraint for widespread use of large-scale solar (except, perhaps, for concentrating systems, which have a smaller footprint but still generate large amounts of power). Siting, however, is likely to be less of an issue for small-scale, residential (and especially rural) electrification systems and, in fact, solar or wind could be combined with micro-hydro to create more robust hybrid systems in areas where this is feasible. Large wind turbines can be visually obstructive and their impacts on birds can be an issue, though this appears to be highly variable by species and the location of the turbines. Finally, institutional, infrastructural, and human capacity-related challenges present barriers to achieving solar power targets in Nepal but many of these issues are common to the power sector in general and not peculiar to solar.

Perhaps the most important challenge facing solar power is the issue of "net metering". This is the practice of an electric power consumer producing power from their own certified generator and feeding the unused excess power back into the utility distribution system and so offsetting an equivalent amount of supplied power during a given billing period. Solar is not the only energy source to which net

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[45] SWERA, p. 17. This figure is actually conservative since the assessment assumed that only 10% of the large-scale, commercially exploitable wind energy area could realistically be used for power.

[46] http://www.adb.org/results/wind-energy-empowers-poor-nepal

metering applies; wind and micro-hydro also have supplied power back into the grid in various countries though solar is the most likely such source of net metering in Nepal. But, unlike the US and many other developed countries where utilities are required to buy surplus consumer-generated power, this practice is not allowed in Nepal. This represents a significant barrier to the economic viability of larger solar systems and is likely to be more important than the other, relatively minor, challenges described above. If there is an economic incentive to install solar, through net metering, then enterprising Nepalis will want to become trained to install and maintain a technology from which they can earn a steady income.

A wide variety of solar products are available in the Nepali market. More than 180 different types of solar panels (from 44 manufacturers world wide) are available in the market with capacities ranging from 10 Wp to 260 Wp. AEPC has prequalified 71 companies and these local companies are directly engaged in importing these products to supply the Nepali market either as packages ready for installation or by individual component so that varying types of combinations can be marketed at various prices. Some concern in Nepal exists about quality, warranties and servicing availability, although most consumers are concerned with the initial cost.[47]

The AEPC, in cooperation with donor agencies, private companies and NGOs has developed a program to promote efficient lighting and cooking technologies. With respect to lighting, solar-powered lanterns utilizing long-lasting light-emitting diode (LED) lights have been promoted, as noted above. These are portable and often include USB ports for powering mobile phones, small fans or radios. LED or compact fluorescent (CFL) lights also can be used for rooftop solar systems. Solar-powered flashlights also exist. Solar lanterns are very important for those earthquake-affected areas still in the process of rebuilding ruined or structurally degraded buildings. AEPC already subsidizes the cost of efficient lighting systems but typically the very poor cannot afford even the subsidized technologies. An installment payment plan would probably be the best way to involve the poorest households.

Figure 4: A solar oven

Source: Modern Survival Blog

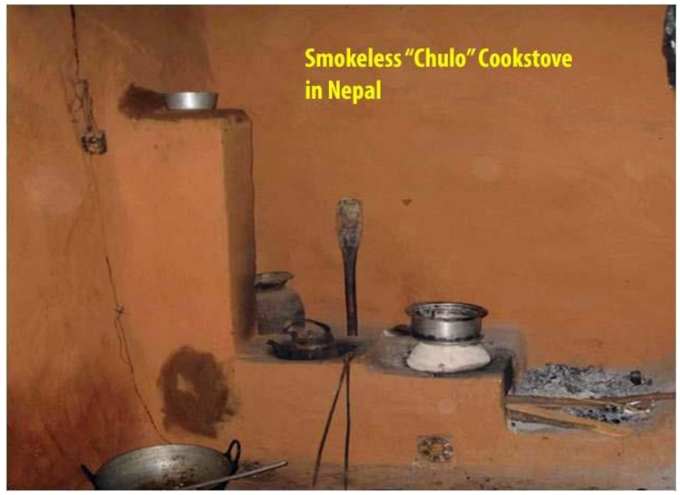
Clean cooking takes several different forms in Nepal, including solar cookers, efficient biomass burning stoves/ovens (known as improved cookstoves or ICS), briquette stoves, gasifiers, and biogas fueled cook stoves/ovens. Solar cookers come in three basic types: solar box ovens, which not only bake but cook foods in pots; parabolic cookers, which look like parabolic dishes with a cooking platform in the center; and solar panel cookers, which are elongated box cookers but are less stable than a solar oven. Solar ovens are the most popular solar cookers worldwide.

Improved biomass stoves take many different forms around the world. In Nepal, the smokeless chulo stove has been introduced. This stove is, in fact, a variant of the venerable improved Lorena cookstove, developed more than 30 years ago in Central America. The smokeless chulo uses a well-insulated fire pit, usually ceramic with an earthen exterior and incorporates a built-in chimney that carries the smoke outside of the house (see photo below). Some stoves employ briquettes that can be made out of any plant or animal waste thus potentially relieving pressure on forests. The "smokeless" aspect makes for a much healthier environment for women and children. Chronic indoor air pollution is a serious health threat for women in many countries. Finally, because of the significantly greater

[47] SNV, p. 42.

efficiency of the stove compared to more traditional stoves, women and children spend less time collecting and hauling fuelwood freeing up more time for productive activities or schooling.

Biogas-fueled cookers were pioneered by China and India starting in the 1970s. They are still popular there but Nepal and many other countries have also begun to develop them. Nepal's biogas program is considered to be one of the more successful programs and is now being replicated in other parts of Asia and Africa by the Netherlands Development Organization – SNV among others. Biogas is methane gas (CH4) created from the digestion of carbon and nitrogen by anerobic bacteria, usually from a combination of animal manure and plant wastes. Biogas yields not only a clean, flammable fuel but also a co-product of clean fertilizer. While methane is a powerful greenhouse gas (GHG), it is consumed in the combustion process and releases carbon dioxide, which is a less potent GHG. Biogas can be used in any standard tabletop burner or stove/oven combination that accepts bottled gas. Nepal's biogas program is also registered in the clean development mechanism (CDM), which has helped further expand the program more sustainably in other parts of the country.



For the purposes of post-earthquake recovery, the smokeless chulo and biogas systems are more appropriate to the process of residential construction under the BBB principles.

2.3.8 CONCLUSIONS AND RECOMMENDATIONS

Opportunities for USAID investment in activities in solar PV and wind are similar to those for deploying renewable energy technologies in general, as discussed earlier. Resource-specific needs include:

1. More comprehensive and accurate wind maps by locality and season, building upon the country-wide assessment undertaken by SWERA in 2008; and
2. Solar insolation estimates by district and sub-district and the development of GIS data layers for these estimates, which can be compared with demographic, economic, and physical infrastructure data layers for planning and investment purposes.

For USAID sector projects, such as food security, health, education and water supply, there may be opportunities to support the installation and training in solar PV systems and further pilots or roll-out of wind power installations, especially in rural, un-serviced areas as a part of the post-earthquake recovery effort. As part of the "Build Back Better" strategy for reconstruction, public building codes, especially for rural schools, hospitals/clinics and other facilities should have renewable energy and energy efficiency specifications built in. Investment in public-private partnerships to stimulate domestic manufacturing of RET equipment, especially small hydro, wind and solar PV, is also a promising area, since it could potentially reduce overall costs due to import tariffs and transport. This is discussed further in Section 4.

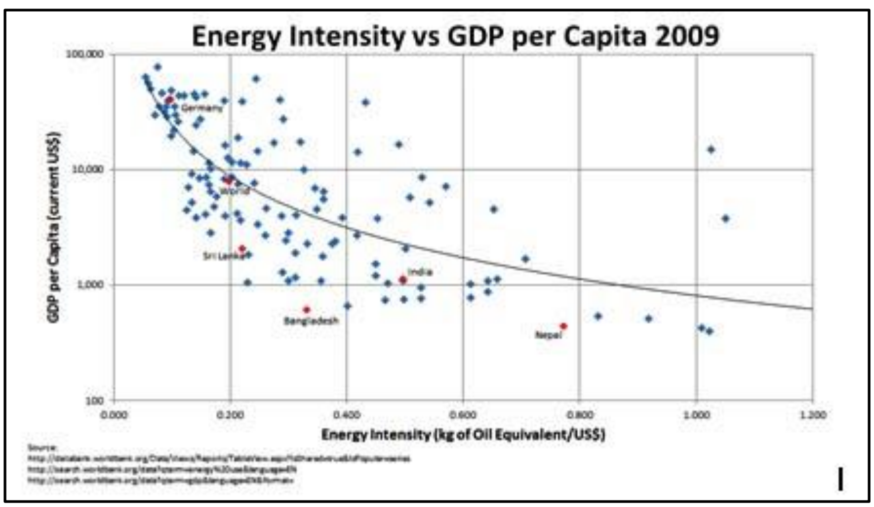
Currently, USAID/Nepal has two projects that incorporate renewable energy as part of other projects. Both are climate change adaptation projects. They are the Hariyo Ban project, which works in two of the most important biodiversity landscapes in Nepal and the Initiative for Climate Change Adaptation (ICCA). The recent mid-term evaluation for the Hariyo Ban has recommended expanding the use of renewable energy in the program. The ICCA project is a $2 million, five-year effort to support targeted communities to help them to adapt to adverse climate change impacts. It complements the Feed the Future Initiative activities in Nepal, which aim to sustainably improve the food security of smallholder farmers. ICCA is aligned with the GON's local adaptation plans of action (LAPA). The forthcoming Program for Aquatic Natural Resources Improvement (PANI) project may also be an appropriate venue for renewable energy activities, especially small hydro. PANI is a five-year biodiversity conservation and climate change adaptation activity that focuses on water management at the national level, and more specifically on the Karnali river basin in the Mid-Western and Far Western Development Regions of Nepal at the field level, as this basin is a focus area under the current CDCS.

As noted previously, perhaps the most important area for USAID support is to help develop mini utilities in the form of ESCOs mainly for off-grid and remote sites since this remains a persistent shortcoming to the adoption, operation, payment and servicing of renewable energy systems.

2.4 ENERGY EFFICIENCY

Because 87% of primary energy used in Nepal comes from biomass combustion, nearly all of which is burnt very inefficiently, Nepal has the highest energy intensity per unit of GDP in South Asia and one of the highest in the world. This can be seen dramatically in Figure 5. Nepal is also a significantly greater GHG emitter than its level of development and GDP would suggest, again because of very low energy efficiency. In general, as incomes increase, energy intensity decreases. In part, this is due to a change in the composition of consumed energy. Low efficiency forms of biomass energy are replaced by more efficient forms of fuels and electricity. In the case of Nepal, which has no prospect of becoming a "petro-state" and where clean and renewable forms of energy are likely to be used as incomes rise, this inverse correlation of incomes and energy intensity is likely to hold. Still, energy efficiency has become a high priority for Nepal. This takes three forms: a) substitution of dirty fuels (biomass) for clean fuels (solar, hydro, wind, and biogas); b) improvements in biomass combustion, and c) improved energy use efficiency in appliances and other end uses for electricity and fossil fuels.

Figure 5: Nepal's Energy Intensity Against Per Capita GDP



Source: NEEP website: http://energyefficiency.gov.np/article-component3

Nepal has an energy efficiency program (NEEP). The NEEP is a collaboration between the Nepal Ministry of Energy and the German aid agency GiZ. The NEEP will develop an energy efficiency strategy for the GON and the Ministry of Energy specifically while the AEPC will develop a parallel biomass efficiency strategy. Energy efficiency is widely recognized as a "low-hanging fruit" for achieving energy security, inclusive development, and the transition to a low-carbon economy. Investments in energy efficiency can be very attractive since the incremental capital investment is usually recovered in a reasonable time period, especially where the old system or equipment uses costly fuels or generates large amounts of pollution and other wastes. With energy efficiency codes and standards in place, the overall cost of energy in the economy is lowered and energy productivity is enhanced.

The GON's Three Year Development Plan identified energy efficiency issues under the headings of industry, hydroelectricity, alternative energy, and environment & climate change. The National Electricity Crisis Mitigation Action Plan of 2008 clearly outlined specific action and policy measures to be taken for better energy efficiency as part of the effort to deal with the problem of load shedding. In addition, the Ten Year Hydropower Development Plan of 2009, the National Climate Change Policy of 2011, the National Water Plan of 2005, and the 2010 National Adaptation Programme of Action (NAPA) have also highlighted the need for energy efficiency for better energy management. The kinds of measures highlighted in these documents include periodic energy auditing and reporting; public awareness and sensitization; development of standards; certification and labelling; enacting energy efficiency codes, and providing incentives (both technical and financial) for energy efficiency measures.[48]

In the context of the post-earthquake recovery, energy efficiency should be an important component to the BBB approach. Building codes need to incorporate energy efficient construction standards. Cement and concrete consume a lot of energy (usually fossil fuels) in their production and are expensive for most households to use for construction. However, extensive research has been done on improving the tectonic resistance of adobe mud brick; the most widely used residential building material in the developing world. Use of proper clay soils combined with reinforcement structures using local, readily made materials (like sand and straw) and using good design standards have dramatically improved the earthquake proof capacity of adobe.[49] While the right soils exist in Nepal, it is not clear if improved mud brick structural materials and housing designs are part of the Build Back Better strategy.

Use of energy efficient lighting and household appliances are discussed in Section 4, below. Given the very large proportion of Nepal's population that is rural, the emphasis of the NEEP should continue to focus on this population. However, opportunities for introducing or reinforcing energy efficiency in Nepali industry should be pursued as well. To date, there has been a perception that energy efficiency represents a trade-off for economic growth. However, this is actually incorrect since greater efficiency reduces the marginal cost of energy, which depending on its end use can produce significant savings and/or increased productivity. Given Nepal's economic profile, energy efficiency policies will most likely improve economic growth even in the short term as well as creating new business opportunities.

[48] See NEEP, 2013. NEEP: An Introduction, pp. 1-2.

[49] See Blondet et al., 2011.

3. CONSTRAINTS TO FUTURE POWER DEVELOPMENT IN NEPAL

Future development of the power sector in Nepal faces a number of constraints. As discussed above, Nepal's power development has been constrained by the country's geography and population distribution. In addition, its most widespread "conventional" energy resource is hydropower, which is site-constrained and seasonal (given the lack of storage capacity in Nepal) and also involves very high front-end capital costs. The country's unstable tectonic history also significantly increases the risks for large hydropower projects. Nevertheless, it will continue to provide the base load for the country while solar can provide peak load and seasonal (dry season) supplement for the base load.

The rapid expansion of solar power has the capacity to relieve the constraints posed by reliance on hydro and the lack of fossil fuel resources, especially if large-scale solar and/or wind power can address the winter peak power demand. But solar and other renewables also face their own constraints, which are reviewed below.

3.1. GEOGRAPHIC, DEMOGRAPHIC, AND POWER SUPPLY CONSTRAINTS

Nepal is one of the most mountainous countries in the world with many very steep slopes and isolated valleys. In addition, 83% of the population is rural,[50] most living in relatively small villages. About half of the population lives in the Terai, which is mostly lowland, alluvial plain subject to seasonal flooding but also a lack of physical infrastructure. The bulk of the rest of the population lives in the middle hilly lands with the smallest part of the population in the steep, isolated mountains and valleys. The widely scattered, rural population and difficult geography pose a great challenge to establishing a truly national power grid. Hence, the future of power development outside the central valley will most likely be a mix of the national grid and local mini grids (if these can be made to work) throughout the country. Some of these local mini-grids may get large enough to be eventually tied into the national grid but many will likely remain outside of it.

3.2. INSTITUTIONAL CAPACITY AND LEGAL/REGULATORY CONSTRAINTS

The NEA implements large-scale power generation as do independent power producers (IPPs) licensed by the NEA. The latter may sell their power to the NEA but at least some are dedicated for export to India through long-term power purchasing agreements (PPAs). Table 7 shows the distribution of power sources by energy source. IPPs are largely focused on hydro.

Banks and non-bank financial institutions have only recently begun to take an active interest in supporting lending for renewable energy technologies and associated systems. The most active institution is the Clean Energy Development Bank, which is the leader in this lending sector and provides extensive subsidies, especially to the poor, where funding remains a constraint.

Given that the vast majority of Nepal's population is rural and poor, stand-alone clean and renewable energy investment projects will continue to face the problem of a lack of effective demand and ability to pay on the part of most households. Hence, such projects would likely be more viable if integrated into infrastructure and public building projects described previously (schools, hospitals, street lighting,

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[50] The urban population, residing in 58 municipalities, constitute 17% (CBS, 2012).

communications, etc.). In the area of infrastructure, solar-powered public lighting, especially in small towns, solar power for markets (cold storage and simple processing and lighting), and telecommunications (solar-powered microwave relay towers, which is an approach taken in India) are all good opportunities with clear positive returns on investment. Interestingly, as Table 7 indicates, the solar market is completely dominated by the private sector, which suggests the possibility of numerous public-private partnerships for provision of solar energy for public services and institutions.

Administrative burdens like long documentation and the time taken for assessments and collateral bureaucratic delays have been clearly identified as major problems for this sector. While the AEPC has been active in trying to engage banks in outreach and education on the importance of lending for renewable energy, much more remains to be done.[51]

Table 7: Share of NEA and IPPs in Total Installed Capacity

Power Source	NEA	IPP	Total
Hydro (MW)	478.3	292.4	770.7
Solar (MW)	0.1	8.1 [a]	8.2
Thermal (MW)	53.4	n.a.	53.4
Total (MW)	531.8	300.5	832.3
Percentage (%)	63.9	36.1	100.0

Sources: NEA Annual Report 2014, Alternative Energy Promotion Center 2012. Note: "a". This refers to privately- owned solar home system households in rural areas and one grid-connected solar farm owned by Kathmandu valley drinking water utility.

A key part of the institutional support for promotion and adoption of renewable energy is the National Rural and Renewable Energy Program (NRREP) implemented by the AEPC. This is a five-year program (2012- 2017) with the following objectives: of improving the living standards, employment, and productivity of rural women and men; reducing rural Nepal's dependency on traditional energy sources; and moving towards a more sustainable development path through integrating renewable energy with social and economic activities. It is also intended to eliminate the multiple overlapping programs among government bodies and to improve donor coordination in the energy sector. Components of the program have rolled out over the last three years but there doesn't seem to be a mid-term evaluation of the whole program.

The NRREP is a core part of Nepal's climate change adaptation and mitigation strategy through the promotion and implementation of renewable energy systems and the development and implementation of three pilot District Climate and Energy Plans. The MoSTE has designated AEPC as the implementing agency for formulating a Low Carbon Economic Development Strategy (LCEDS) for Nepal. In addition, AEPC has actively been engaged with widening its networking in climate change issues at the global, national and local levels.[52]

In this context, it may be worth examining the Local Adaptation Plans of Action (LAPA). These support priority area 1 of the Nepal's National Adaptation Plan of Action (NAPA), which is to promote community-based adaptation to climate change through integrated management of agriculture, water, forest, and biodiversity sectors in line with National Climate Change Policy of 2011. The LAPAs involve the integration of top-down and bottom-up approaches to mainstream adaptation into development

[51] Ibid., p.56.

[52] AEPC, NRREP Booklet, 2015, pp. 19-20.

planning from the local to the national levels through mechanisms for public participation, which is intended to ensure an inclusive, responsive, and flexible process of development and implementation of action plans. The LAPAs have the potential for more accurately identifying where and what kinds of clean and renewable energy technologies and energy efficiency practices can be integrated across critical sectors of the rural economy in particular.

Despite the improved streamlining of renewable energy promotion and implementation at AEPC, development, at least for hydropower remains divided up between three agencies, which may complicate coordination and efficient regulation, which is mainly the responsibility of the NEA. Table 8 shows the institutional division for hydro, which is on the basis of the size of installed capacity for an installation.

Table 8. Agency Division of Jurisdiction of Hydropower

Agency	Installed Capacity Limits
Investment Board of Nepal (IBN),	≥ 500 MW (large hydro)
Department of Electricity Development (DoED)	100 kW – 500 MW
Alternative Energy Promotion Centre (AEPC)	< 100 kW (micro and pico hydro)

The GON approved a new Hydropower Development Policy in 2001 that provided a number of new incentives for private investment in hydropower generally and small hydro in particular. A number of incentives for investment are available, such as VAT exemption, custom duty reductions for imported small hydropower related machinery or equipment, and income tax exemptions for the first 10 years from the date of plant commissioning, thereafter 50 per cent for the next five years.[53] Administrative complexity and long waiting times for licensing also have delayed small hydropower development in Nepal. Finally, the lack of a functioning Power Trade Company to sell the energy to India, which is required for large hydro to be economically viable, is a significant constraint.

In addition to these constraints, there is no realistic power transmission development plan,[54] frequent changes of ministers and governments cause disruption to plans, frequent changes in working guidelines, lack of inter-governmental agency coordination, overlapping job responsibilities among various government intuitions, prolonged processes and procedures for environmental clearances from the government, and a long list of local community demands that have posed serious challenges to small hydropower development in Nepal.[55]

For solar power, custom duties are reduced but not eliminated while VAT on the actual solar technology is eliminated. However, VAT is still levied on the associated equipment for solar, including wires, batteries, and other equipment.

3.3. CONCLUSIONS AND RECOMMENDATIONS

As discussed above, the geographic constraints posed by Nepal's steep topography or relative inaccessibility, tectonic instability, and the growing impacts from climate change making the hydrological regime more unstable are all very serious, especially for large- and medium-scale hydropower though these challenges will not affect hydropower's critical role in providing base load power for the national

[53] H. Liu, et al., 2013, p. 6.

[54] Though, a Transmission Line Master Plan study is presently being carried out with support from the World Bank and is expected to be ready within this year.

[55] H. Liu, et al, 2013, p.263.

grid as well as smaller local installations. By contrast, solar power faces few, if any, geographic constraints although it faces other problems, especially initial capital cost. Wind power is definitely potentially more commercially viable (i.e. large-scale) in a relatively few places, according to the SWERA assessment, but could be more widely applicable at small generation levels based on the experience of other developing countries. Institutional and regulatory problems have been addressed recently, especially the problem of a multiplicity of overlapping jurisdictions. However, political instability, frequent changes of high agency officials and an uncertain regulatory environment have tended to discourage investments. USAID's new hydropower development project may be able to address these institutional and enabling environment problems. The institutional instability and rigidity appears to be less of a problem for the AEPC, which has considerable scope and flexibility for the promotion and support of solar, wind, biogas and other renewable/alternative energy sources.

This report recognizes that the donor community in Nepal has worked extensively with GON ministries and agencies on institutional capacity strengthening in the energy sector – especially power – and continues to do so. Multiple European donors support the Energizing Development (EnDev) program and, as noted, GiZ supports the NEEP. Both the World Bank and the Asian Development Bank (ADB) have active programs supporting the policy enabling environment, institutional capacity building as well as individual power projects. As noted, USAID has individual field projects in small hydropower and climate change adaptation, which incorporate renewable energy as well as its new hydropower development project. USAID also is integrating clean and renewable energy into several key programs, including food security and climate change adaptation. These include solar-powered irrigation, improved cook stoves, and support for 10 LAPAs at the village development committee level (all under the ICCA project).

In addition to its current renewable energy and energy efficiency activities, it is recommended that USAID focus on the development of ESCOs to address the technical and managerial weakness at the district and village levels in support of the development, management and servicing of renewable energy systems. In essence, the ESCO model could have two primary functions: first, to diagnose and identify potential community-level (or town-level) power projects and to develop a business plan for brokering an investment in the community/town. Second, the ESCO could establish, train, and provide technical support for a village/town utility, including taking an equity stake or other financial partnering with the utility to promote sustainability and good project designs.

In addition to the ESCO model, the AEPC's NRREP appears to be a good vehicle for integrating renewable energy into USAID's rural development portfolio. Encouraging regulatory streamlining and more focus on public-private partnerships is also recommended. Nepal has depended upon donor and international project-based investments in the renewable energy sector. This approach has accomplished much, including demonstrating efficacy and addressing priority isolated sites. But one weakness has been less attention to building local capacity, though many projects do require a degree of "sweat equity" at least at the construction stage. With the exception of the AEPC, the other national actors, e.g. the NEA or DoED, have not focused on strengthening district level capacity in the power sector adequately though the IBN has been a much more active promoter and developer of power projects.

4. OPPORTUNITIES FOR MORE CLIMATE RESILIENT AND SUSTAINABLE POWER DEVELOPMENT IN NEPAL

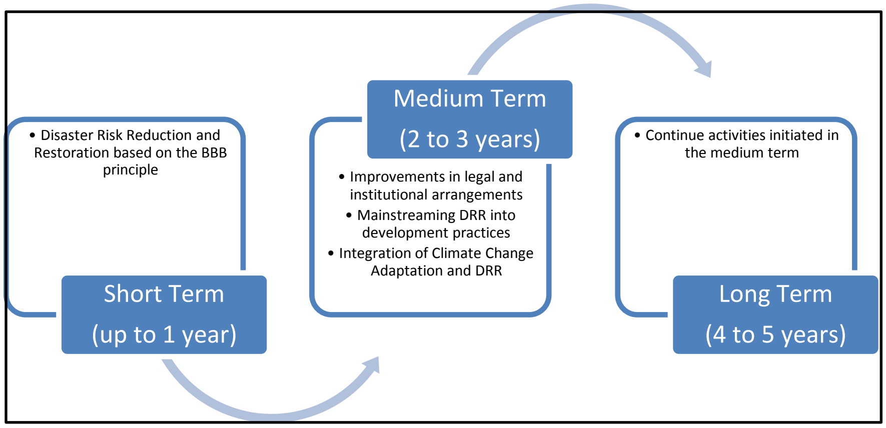
The April 25th earthquake's destruction was widespread, covering residences and government buildings, heritage sites, schools and health posts, water supply systems, agricultural land, trekking routes, hydropower plants, and sports facilities, among others. Rural areas in the central and western regions were particularly devastated and became further isolated due to road damage and obstruction. Poorer rural areas have been more adversely affected than towns and cities due to the generally inferior quality of houses and other structures. More women and girls died than men and boys, partly because of gendered roles that disproportionately assign indoor chores to women and partly because so many rural men have become economic migrants in other parts of South Asia and the Gulf States.

According to the post disaster needs assessment (PDNA), the total estimated value of the disaster's impacts caused by the earthquakes is US$7 billion. Of that amount, 76 percent of the total impacts represent the value of destroyed physical assets, and the remaining 24 percent reflects the losses and higher costs of production of goods and services arising from the disaster. The estimated value of the total damages and losses is equivalent to about one third of the Gross Domestic Product (GDP) in FY 2013/2014. The disaster's impacts were spread unevenly between public and private sectors. The private sector sustained about 3.3 times the value of damages and losses compared to the public sector, which reflects the much larger part of the economy that are households and private businesses.

The Government of Nepal has now given priority to improving the disaster risk reduction (DRR) system in Nepal in the short (up to one year), medium (two to three years) and long (four to five years) term to enhance the resilience of the country (see Figure 6). The short-term priorities include reconstruction of damaged DRR assets and improvements based on the "Build Back Better" (BBB) principle. The medium- to long-term priorities include (i) improvements in legal and institutional arrangements, (ii) measures to mainstream DRR into the development sector, particularly housing, private and public infrastructure, social sectors (health and education), and livelihood, and (iii) measures to improve integration of climate change adaptation and DRR.

The Government of Nepal is preparing to develop a large-scale recovery program based on the PDNA results. The Government has sought international support in implementing this recovery and reconstruction plan. In this section, the study examines immediate opportunities for climate resilient and sustainable power development in the course of the earthquake recovery program as well as long-term opportunities and considerations. This section largely draws on the information available in the PDNA document.

Figure 6: Timeframe of the Disaster Risk Reduction Program



4.1. EARTHQUAKE RECOVERY AND RECONSTRUCTION: "BUILD BACK BETTER" AND RENEWABLE ENERGY

The PDNA assessed the earthquake-related damage and losses and subsequently identified indicative recovery and reconstruction needs in the various sectors/sub-sectors of the economy. Based on the PDNA results, this section further illustrates the applications of clean and renewable energy that could contribute to the process of achieving the objectives of the DRR based on the BBB principles. Further, this section also suggests potential areas for investment in renewable energy in the long term for climate change resilient development.

4.1.1 HOUSING AND HUMAN SETTLEMENTS

The earthquake affected the housing and human settlements sector the most. A total of 498,852 houses were categorized as fully collapsed or damaged beyond repair and 256,697 houses were partly damaged.

The recovery and reconstruction needs include providing transitional sheltering, permanent housing, reconstruction with structural resilience, demolition and debris clearance, repairs and retrofitting, clustering of dwellings to safe locations, training and facilitation, and urban planning, including a heritage settlement plan. In addition, housing and settlements have been reviewed to ensure the disaster resilience of the entire community keeping in mind location-based vulnerability. For remote areas, settlements and urban areas, special assistance packages may be needed over and above the basic recovery package. Providing intensive life support to owners will require a well-defined human resource set-up of master artisans, junior and senior engineers, and community organizers. The PDNA has viewed the housing reconstruction in larger terms to include community infrastructure within the settlements such as access to water, sanitation, waste disposal, energy, risk mitigation measures and others.

Source: Associated Press

Access to ELCC solutions will be the most important factors in the new housing and human settlements. This is discussed further below. Most of the houses and settlements that were damaged by the earthquakes need restoration or new energy provision for meeting their lighting and cooking energy needs. The reconstruction or recovery plan should have built-in provisions for ELCC support. It is not clear whether the Build Back Better strategy explicitly calls for this or not. Furthermore, policies need to be enacted that obliges the house owner to have ELCC solutions and provides support to that end. The new building code and the mandatory rule of thumb should also have provisions for including ELCC. In order to implement the new building code with ELCC provisions effectively, a pool of trained technicians and social mobilizers is needed to identify suitable and feasible energy options, conducting rapid assessments, bridging the market and the consumer, and implementing an effective quality assurance program, which delineates the proper roles of private businesses and local non-governmental organizations. Interventions must focus special attention on the capacity of the poorest households to implement ELCC solutions.

4.1.2 PUBLIC HEALTH

The April 25th and subsequent earthquakes damaged considerably the nation's health infrastructure. A total of 446 public health facilities were completely destroyed. Among them were five hospitals, 12 primary health care centers, 417 health posts, and 12 others. Over 80% of these affected health facilities were from the most damaged districts and this affected the ability of these facilities to respond to the healthcare needs of vulnerable populations in the remote areas. The overwhelming share of damage and losses was borne by the public sector.

The first priority of the GON was to return to operation the disrupted health services in order to address the increased health service demands. The Government has developed a comprehensive plan that includes the repair and reconstruction of damaged health facilities with the objective of making the sector even better prepared for disasters.

The recovery and reconstruction plan for damaged health infrastructure should have a provision of the most efficient and renewable electricity supply to cater for the needs of lighting, refrigeration to preserve vaccines and other medicines, and to operate medical equipment. The GON, while implementing the health infrastructure recovery plan, should establish policies requiring the provision of an efficient electricity supply in order to provide better medical and pharmaceutical services.

4.1.3 EDUCATION INFRASTRUCTURE

A total of 8,242 community (public) schools were impacted in some way by the earthquake, of which 25,134 classrooms were fully destroyed and another 22,097 were partially damaged. Likewise, a total of 956 classrooms were fully damaged and 3,983 classrooms were partially damaged in institutional (i.e. private) schools. In the field of higher education, 1,292 classrooms were completely destroyed and another 3,040 were partially damaged.

The overall recovery strategy of the Government prioritizes the 56 affected districts, but will gradually move to include all education institutions across the country through incorporation of the DRR approach in the sub-sector plans and programs. The major elements of the strategy include strengthening systemic capacity to deal effectively with post-disaster response and recovery and reconstruction. All new education institutions should be resilient to future disasters and ensure the provision of minimum, physical enabling conditions for enhanced learning (e.g. clean water supply, energy and communication connectivity, etc.).

The power supply in most education facilities, especially in rural areas, is either inadequate or completely absent. When education facilities are being rebuilt they should be required to provide efficient and sufficient electricity supplies at least for lighting and basic teaching aids (assuming that these exist in most schools, which may not actually be the case).

Rooftop Solar Power in a Rural Nepali School

Source: Dan Mazur, 2011, Kiji village school

4.1.4 CULTURAL HERITAGE

The earthquake affected about 2,900 structures with cultural, historical and/or religious heritage values. Major monuments in Kathmandu's seven World Heritage Monument Zones were severely damaged and many collapsed completely. In addition, in more than 20 districts, thousands of private residences built on traditional lines, historic public buildings, ancient and recently built temples and monasteries, were affected by the disaster, 25 percent of which were destroyed completely.

The long-term recovery plan envisages complete restoration of all damaged structures with a view to building back better through the use of high-grade materials and seismic-strengthening structural features. The cost of reconstruction has been calculated at the estimated value of damages plus 20 percent to build back better.

Most of the cultural heritage sites are located either in urban or peri-urban areas. Most of these areas are connected to grid-electricity. There will be two areas on which to focus while restoring the cultural heritage sites. These are: a) to implement efficient lighting provision, and b) to introduce a clean lighting option for base load power at the site and/or also as a back-up. Solar energy has been successfully introduced in many areas for street lighting. Solar PV can also become an effective means for backup energy in case of emergency that may occur anytime in the heritage sites.

4.1.5 AGRICULTURE/IRRIGATION

Less than 1% of total energy consumption is utilized in the Nepali agriculture sector, even though agriculture contributes around 35 percent to the country's GDP. Nepali farmers are dependent on monsoon rain or diesel pumps for irrigating the land. Powering Agriculture is an international partnership of donors (including USAID) and a few private sector entities that is trying to identify and support new and sustainable approaches to accelerate the development and deployment of clean energy solutions for increasing agricultural productivity and/or value-added in developing countries. It uses challenge grants as its main instrument. Organizations such as International Development Enterprises (IDE) and Winrock International (WI) are working in a USAID-funded program in Nepal to promote and support solar irrigation pumps (see photo below). These pumps actually can pump water from greater depths than conventional pumps, which are usually diesel-powered, a very expensive imported fuel in Nepal. The solar pumps can work in off-grid applications like direct solar (PV) as well as grid-connected power sources. To the extent that irrigation is a serious constraint on agricultural productivity – and it often is – this innovation will be a significant productivity enhancement. USAID/Nepal's Feed the Future program also promotes the use of solar-powered irrigation pumps. Winrock, meanwhile, is implementing a USAID funded "Accelerated Commercialization of Photovoltaic Water Pumping Project (AC-PVWP)" with a target of creating a commercial market for PVWP for irrigation and facilitating installation of 250 PVWP systems in Nepal.

Source: Paul Polak, International Development Enterprises

The earthquakes damaged small and medium irrigation systems severely. The infrastructure and functionality of about 290 irrigation schemes was affected to varying degrees by the earthquakes. Damaged irrigation systems pose a threat to standing crops as well as risking subsequent crop loss if not immediately repaired.

Reconstruction will focus on replacement of destroyed equipment, machinery and reconstruction/ rehabilitation of damaged physical infrastructure with improved, disaster-resilient standards over a period of 36 months. The majority of the damage occurred on irrigation system civil construction and the pumping systems. Most of these irrigation systems are based on gravity flow of the river. Irrigation is not yet well established in the Nepalese agricultural system but there is significant potential to introduce an irrigation system based on pumped storage with the aid of clean and renewable energy systems.

While this section has focused on irrigation, an important production constraint, there are a variety of other activities within agricultural value chains that can be significantly improved with clean and renewable power supplies. These include post-harvest processing and storage (including cold storage), as well as communications for product aggregation, marketing and distribution.

4.1.6 ELECTRICITY SECTOR

Electricity generation facilities, on-grid and off-grid as well as their distribution networks, were damaged severely by the earthquake. The electric power sector covers generation, transmission, and distribution in on-grid and off-grid systems. It covers generation, transmission, and distribution systems owned by Nepal Electricity Authority and hydropower generation by Independent Power Producers. The distribution system also covers community-managed and operated electrification entities. These include community based micro-hydro projects, solar home systems, and institutional solar PV systems. For facilities under operation, about 115 MW hydropower facilities were severely damaged, and 60 MW were partially damaged. For generation under construction, about 1,000 MW of hydro projects owned both by Nepal Electricity Authority and IPPs were partially damaged. Overall, about 603,000 households lost access to electricity, including 91,200 households for grid electricity and the rest for off-grid electricity, either due to the collapse of their houses or damage to electricity supply facilities. In a number of cases, loss of power was temporary if the house was not severely damaged or destroyed.

Regarding the transmission system under operation, seven substations were damaged. The boundary walls of eight substations, cracks in control room buildings of nine substations, and damage to staff quarters and office buildings at 14 locations were observed. Damages were also noticed in five transmission lines. Despite this, all the affected transmission substations were restored within a short period of time. However, confirmation about the risks of transmission tower foundation damage, vulnerability of towers due to landslide/soil erosion, and structural damage have yet to be confirmed.

Regarding distribution, about 800 km of distribution lines at different voltage levels (33 kV, 11 kV, and 400 V) and 365 transformers at different capacity (from 15 to 300 kVA) were damaged and are non-operational. As for off-grid electricity services, about 262 micro-hydro facilities and 115,438 solar home systems (SHS) or small SHS, and 156 institutional solar power systems (ISPS) were damaged and are non-operational.

Bhotekoshi 100 MW Hydropower Plant Seriously Damaged in Earthquake

Source: Nepali Times

Loss of access to electricity has resulted in many negative impacts. Some of the major adverse impacts are on a) people's ability to provide for their livelihoods, particularly in rural areas, b) women who depend on electricity for their household work and productive activities, and c) the GON's goal for achieving universal access to modern energy services by 2030. Figure 10 illustrates the recovery strategy of the Government for the on-grid electricity sector.

According to the PDNA, the reconstruction of off-grid electricity services will be carried out in two phases, as shown in Table 9.

The PDNA identifies some policy gaps to address the disaster and post-disaster resilience in the on-grid electricity sector. The gaps in the policy are given below.

1. Dam safety and security in public and private hydropower projects
2. Standardization of parameters for seismic safety features in the design of hydropower projects
3. Design of early warning systems in hydropower projects
4. Policies for selection of hydropower projects in various river basins to reduce the impacts of natural disaster
5. Adoption of appropriate insurance policy by public utilities
6. Preparation of guidelines for safety and evacuation of electrical equipment and personnel in the event of a disaster

7. Policy guidelines and procedures for disaster management in timely restoration of power
8. Policy guidelines for asset as well as inventory management

Figure 10: Recovery Strategy for the On-Grid Electricity Sector

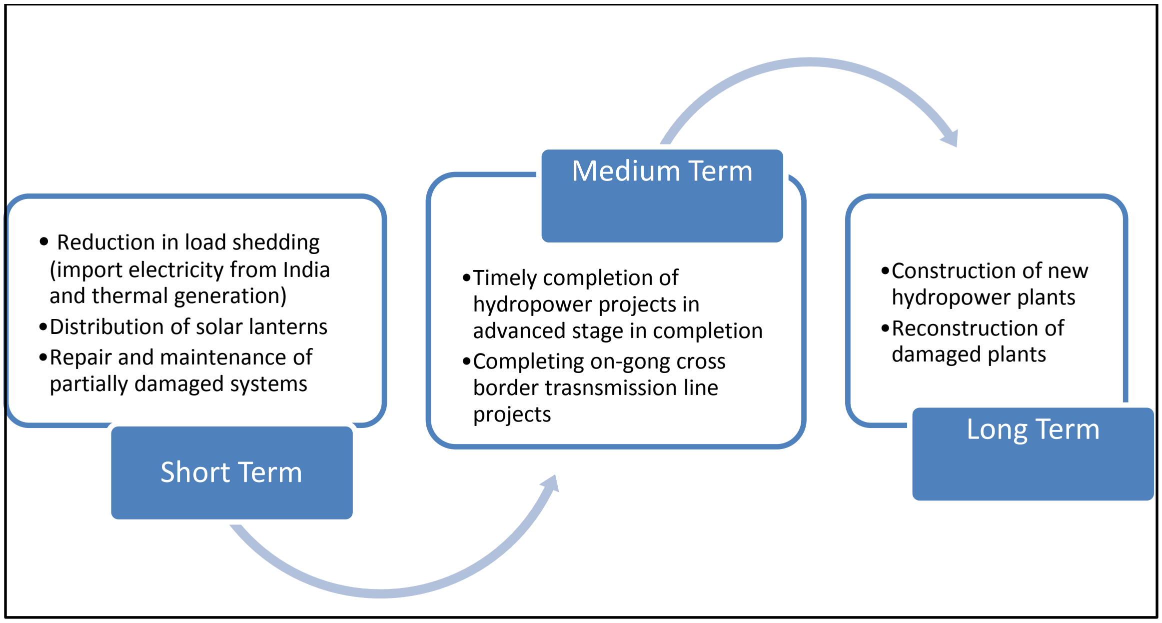


Table 9: Reconstruction Strategy for the Off-Grid Electricity Sector

Short Term (up to Dec 2015)	Medium Term (up to 2016)
1. Immediate relief packages: • Clean cooking and lighting solutions • Solar home system with mobile charging • Improved cooking stoves • Community mobile charging station • Water purification 2. Immediate lighting solutions for health posts and schools 3. Biogas 4. Rapid assessment of Photovoltaic Pump Set and Micro-hydro 5. Income generation activities 6. Activities for micro, small and medium-sized enterprises	Reconstruction, rehabilitation and medium-term relief: • Repair, maintenance and installation of new solar systems for schools • Installation of solar mini/micro grids • Repair, maintenance and installation of new solar systems for health posts • Repair, maintenance of existing systems and installation of new biogas systems • Repair, maintenance, reconstruction and commercial operation of micro-hydro plants • Repair, maintenance and reconstruction of damaged micro, small and medium enterprises • Revival of income generating activities

Furthermore, the PDNA document has envisioned the following implementation arrangements for the short-term recovery and long-term resilience development in the electricity sector.

- A master plan for rural electrification, a transmission system master plan and an integrated river basin development plan that includes a hydropower generation plan will be initiated soon.
- The NEA and IPPs will be responsible for assessment, planning and recovery of their respective hydropower facilities that were damaged by the earthquake.
- The AEPC will be responsible for implementation of the recovery and restoration with respect to off-grid electricity services. Community and individual households should be encouraged to play an active role in restoring and rebuilding the affected schemes.

For donors, including USAID, the PDNA plans are a useful base for incorporation in programming both for the post-disaster situation but also for broader engagement with the energy sector for application in the rest of Nepal.

4.1.6 ENVIRONMENT AND FORESTRY

This section concentrates on the destruction caused by the earthquake on previously installed environment friendly and renewable energy technologies that comprise improved cooking stoves (ICS) and biogas. As noted previously, the Alternative Energy Promotion Centre in Nepal promotes renewable energy technologies such as ICS and biogas. . A rapid assessment conducted by the AEPC indicates that 146,767 ICSs and 16,721 domestic biogas installations have been destroyed. Promotion of ICS and biogas as clean alternatives to traditional cooking practices has substantially reduced the use of firewood and has contributed to lower carbon emissions and so should continue to be priorities for restoration and further expansion.

The recovery and reconstruction of these technologies are planned to be implemented in the following two phases:

- Phase I: Immediate relief package with the installation of 100,000 ICS and 8,360 biogas plants by December 2015, and
- Phase 2: Reconstruction, rehabilitation and mid-term relief solutions for the installation of 46,767 biogas and 8,360 biogas plants by December 2016.

AEPC has been designated as the lead agency to coordinate and implement the recovery activities related to ICS and biogas. Presumably, foreign donors and NGOs will supplement the GON's efforts.

The earthquake caused a number of landslides, a number of them quite large. In some cases, vegetative cover, including pastures and forests, were destroyed. These areas need to be re-vegetated as soon as possible in order to avoid additional soil erosion, habitat loss and the silting up of streams, a number of which have micro-hydro installations. Replacing the lost ICS and biogas installations will also prevent further deforestation.

Biogas digester dome under construction in rural Nepal

Source: Farnek Co., (UAE)

4. 2. INTEGRATING RENEWABLE ENERGY ALTERNATIVES INTO USAID'S CURRENT CDCS FOR NEPAL

While previous sections of the report have included recommendations for USAID for its overall portfolio, in this section, the study will examine possible avenues for integrating renewable energy alternatives into a) the immediate post-earthquake recovery and b) the geographic and sectoral priorities of the current CDCS.

4.2.1. PLANNING AND PROGRAMMING FOR RE/EE INTERVENTIONS POST-EARTHQUAKE

USAID and the GON have cooperated on strengthening Nepal's planning for earthquakes and reducing the damage and death from the earthquakes that will inevitably happen in the future. With USAID/OFDA support, Nepal's National Society for Earthquake Technology (NSET) is promoting public-private partnerships for earthquake risk management and enhancing the capacity of municipal governments to develop and administer building code permits and control systems to better protect against seismic activity. This includes capacity building to utilize DRR approaches. In addition, USAID's SERVIR Project, which uses NASA satellites to support earth observation for development-related information, has played a useful role in supporting the humanitarian effort by, among other things, identifying remote sites that have suffered earthquake damage. SERVIR has three regional centers, one of which is at the International Center for Integrated Mountain Development (ICIMOD) based in Kathmandu.

USAID's Program for Enhancement of Emergency Response (PEER), a regional capacity building program on emergency response is also based in Kathmandu and has provided training in emergency medical response, among other things, which has been useful in the context of the many thousands of injuries from the earthquake. PEER's hospital preparedness for emergencies (HOPE) course is also useful for handling future disasters.

The earthquake traumatized affected Nepalis and left many, especially in rural areas, particularly vulnerable. USAID's Combatting Trafficking in Persons (CTIP) project directly addresses the kind of trafficking in persons that often arises during and after conflicts and disasters. USAID/OFDA recently provided additional funding to expand CTIP's activities to six additional earthquake-affected districts.

The interventions focus on increased awareness of Trafficking in Persons (TIP) and gender-based violence (GBV), promotion and creation of economic and livelihood opportunities, provision of legal support, rehabilitation through psycho-social support, and increased access to rehabilitation services and resources available from the Nepali government. This is a good example of integrating post-earthquake recovery efforts into USAID's existing portfolio.

4.2.2. INTEGRATING RE/EE ACTIVITIES INTO CURRENT CDCS PROGRAMS

During the period of the current CDCS, USAID activities are increasingly being co-located within 20 core districts in the middle hills and Terai portions of Nepal's Far-Western, Mid-Western, and Western Development Regions. However, like many other bilateral missions, flexibility in developing new programs has been constrained by earmarks and Presidential Initiatives. In recent years, approximately 90 percent of Mission resources have been tied to earmarks or Presidential Initiatives such as Feed the Future, Global Climate Change, and Global Health. The separate post-earthquake recovery program may, therefore, provide one of the main ways to support at least some of the recommendations in this report.

The CDCS has identified three development objectives around which the portfolio is being transitioned.

Development Objective (DO) 1: More Inclusive and Effective Governance

Development Objective 2: Inclusive and Sustainable Economic Growth to Reduce Extreme Poverty

Development Objective 3: Increased Human Capital

Of these three DOs, DO 2 is the most directly relevant for opportunities for integrating renewable energy activities and investments. However, the availability of reliable electricity, especially in un-serviced or poorly-serviced areas, can directly support the achievement of DO 3 intermediate results for both schools and residences through the provision of adequate and safe lighting for reading and writing as well as phones, radios and TVs. More reliable electric power supply can also aid the achievement of more effective government and private sector service delivery to improve good governance, reduce poverty, and increase human capital (DO 1).

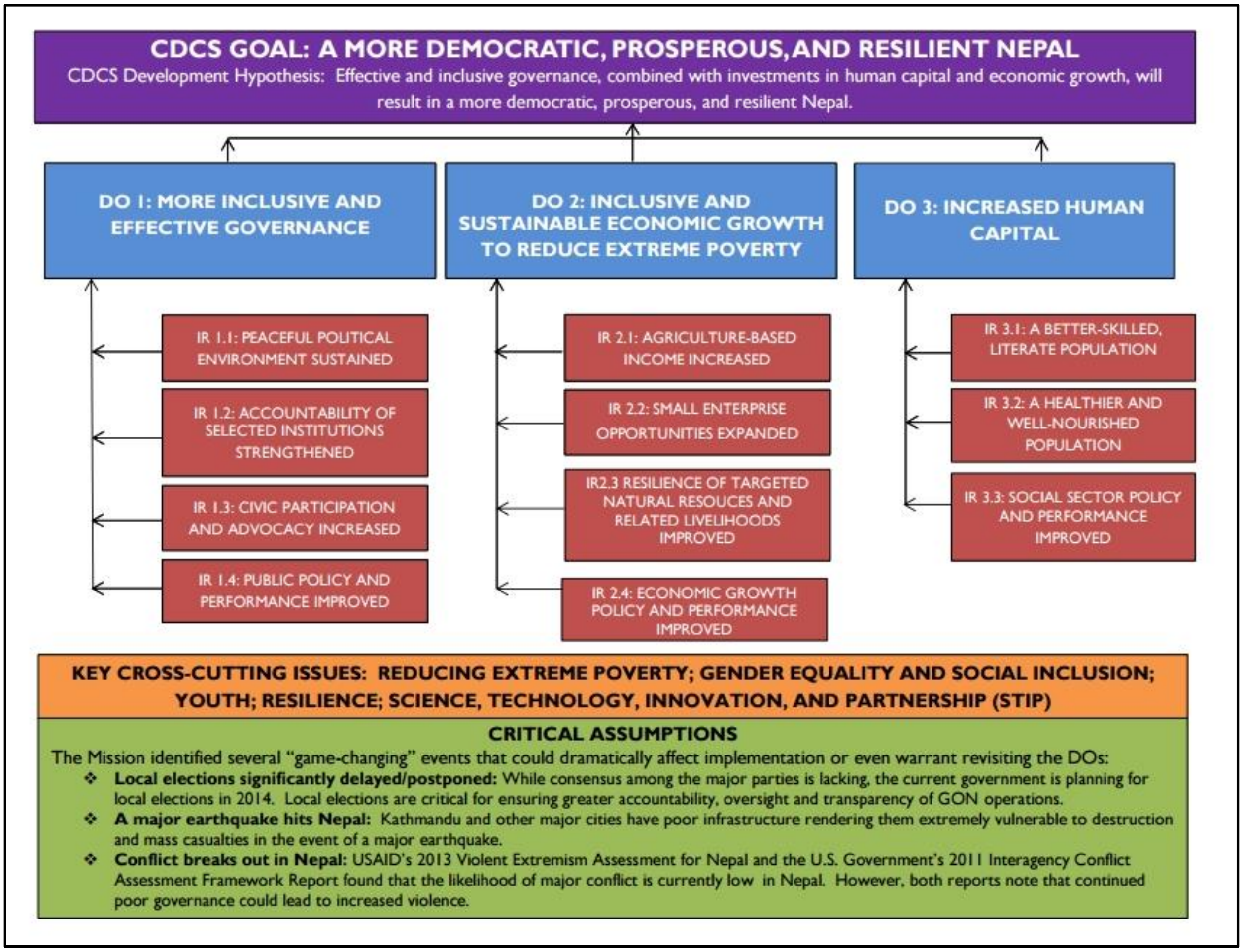
In addition to the three development objectives, USAID/Nepal also identified several crosscutting considerations including:

- Extreme Poverty
- Resilience
- Gender Equality and Social Inclusion (GESI)
- Youth
- Science, Technology, Innovation, & Partnerships (STIP)

The USAID/Nepal Results Framework is presented in Figure 11 below. Reliable supplies of electricity from renewable energy sources directly contribute to all cross-cutting considerations.

Development Objective 1: More Inclusive and Effective Governance. With respect to the relevance of clean and renewable energy to this DO, one of the issues that periodically arises is the nature and extent of civic participation, especially in the development of small hydropower projects. Typically, the issues arise in the siting and construction stages, and may be associated with compensation for damages or lost land and production. Failure to address these issues in the planning and design stages can lead to riots, sabotage and delays in project implementation. These are the kinds of issues that should be discussed in the scoping and assessment stages of environmental reviews during early project design. USAID is an acknowledged leader in the development and use of environmental reviews (which usually also address social issues) and the engagement of the public in such reviews. This expertise could provide an opportunity for technical assistance and training to district level officials and project proponents in the use of civic participation in environmental reviews and the use of alternate dispute resolution techniques in the development of small hydropower projects.

Figure 11. The USAID/Nepal 2014-2018 CDCS Results Framework



Development Objective 2:

A number of intermediate results (IRs) and Sub IRs would appear to be avenues for integrating clean and renewable energy activities into the USAID portfolio. In fact, the Mission already is already incorporating such activities. For Sub-IR 2.1.1 – Agricultural productivity increased, USAID is supporting the use of solar-powered irrigation pumps, as previously noted, which can certainly enhance productivity in cereal crops, legumes and vegetables.

4.3. CONCLUSIONS AND RECOMMENDATIONS

Given the centrality of energy and electric power to social and economic development, there are numerous opportunities for USAID/Nepal to integrate renewable energy solutions into its current and projected portfolio. This is even more the case for the post-earthquake recovery effort, which is embracing "Build Back Better" in the planning and implementation of recovery activities. The earthquake also revealed the vulnerability not only of many rural and urban households, but also hydropower installations both large and small. Many may require new surveys and assessments to determine changes in siting, design and construction requirements. In addition, and unrelated to the earthquake, climate resilience will require changes in the design of hydropower installations to adapt to increasingly erratic changes to hydrological regimes.

In addition to hydropower, this study identified numerous opportunities for providing relatively low cost and reliable solar power for lighting, irrigation, water purification, refrigeration and powering of small equipment. Biogas and more efficient and clean burning biomass stoves also have the potential for reducing environmental destruction and improving women and children's health and productive labor allocation. Portable solar power is particularly important in the post-earthquake recovery efforts for providing light, power for mobile phones, radios and TVs, purifying water, and cooking.

The damages sustained by the energy sector are likely to hamper the rebuilding efforts. The Building Back Better efforts will not be achieved unless the damaged energy services and infrastructure are restored in even better ways. This study recommends that USAID/Nepal work closely with the Ministry of Science Technology and Environment/AEPC and/or Ministry of Energy/NEA to identify specific post-earthquake opportunities for targeted clean and renewable power investments. In addition, for the Mission's existing activities that incorporate clean and renewable energy, attention should be paid to opportunities for scaling up and replicating these. Hence, monitoring the social and institutional governance issues and successful approaches for these interventions should be a priority. In the context of the broader USAID portfolio, the study identified several opportunities in solar, hydro, biomass, and energy efficiency, as well as planning and assessments that build on the Agency's long experience with renewable energy. Finally, the report recommends that USAID utilize its extensive experience with the ESCO model in order to improve the ways renewable power systems are managed at the community-level (or multi community, in the case of mini-grids).

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ANNEX 2: SOURCES OF DATA AND INFORMATION IN NEPAL FOR THE STUDY

Institution/Organization	Type of Information Sought	Types of Data	Data Source
Alternative Energy Promotion Centre	Mini-grid (solar and micro-hydropower), biogas, improved cooking stoves (ICS), climate change, wind, donor involvement, Regional Centers (Like ESCO-operated by NGO), gender and social inclusion	• Total number of micro-hydro, solar, biogas, ICS and other off-grid energy solutions- operating, under construction • Locations, household connections • Energy systems in public establishments (school, health posts, etc.) • Status and number of destroyed/damaged by earthquakes • Earthquakes recovery plan and constraints on implementation • Possible areas for the intervention considering the earthquakes devastation • Regional Centers • Gender and social inclusion	AEPC web page, published reports, AEPC records/database, interview
Nepal Electricity Authority	Hydropower, solar, thermal, community electrification	• Hydropower (generation, transmission and distribution)- number, locations, operating, under construction • Solar • Status and number of destroyed/damaged by earthquakes • Earthquakes recovery plan and constraints on implementation Possible areas for the intervention considering the earthquakes devastation • Gender and social inclusion issues	NEA web page, annual reports, other published reports, NEA records/database, interview
Ministry of Energy	Overall energy plan and policies, energy efficiency, priorities and programs	• Plan and policies, PDNA follow up, Earthquakes recovery plan, constraints • Possible areas for the intervention considering the earthquakes devastation	Ministry web page, published reports, interview
Ministry of Science Technology and Environment	Off-grid energy solutions, climate change	• Plan and programs on off-grid energy, climate change program • Possible areas for the intervention considering the earthquakes devastation	Ministry web page, published reports, interview

Institution/Organization	Type of Information Sought	Types of Data	Data Source
Water and Energy Commission Secretariat	Energy efficiency	• Status of past energy efficiency program and future activities • Possible areas for the intervention considering the earthquakes devastation	Web page, published reports, interview
National Planning Commission	Post Disaster Needs Assessment	• Follow-up on PDNA and other plans and programs • Possible areas for the intervention considering the earthquakes devastation	Web page, published reports, interview
Independent Power Producers' Association Nepal	Hydropower developed by private sector	• Number of private hydro power plants, operating and destroyed by earthquakes, and under construction, • Status and number of destroyed/damaged by earthquakes • Earthquakes recovery plan and constraints on implementation • Possible areas for the intervention considering the earthquakes devastation	Web page, published reports, interview
Nepal Micro-hydropower Development Association	Micro-hydropower	• Status and number of destroyed/damaged micro-hydro plants by earthquakes • Earthquakes recovery plan from private sector if any • Constraints faced by private sector • Possible areas for the intervention considering the earthquakes devastation	Web page, published reports, interview
Solar Energy Manufacturers' Association Nepal	Solar energy (home systems and others)	• Status and number of destroyed/damaged solar by earthquakes • Earthquakes recovery plan from private sector if any • Constraints faced by private sector • Possible areas for the intervention considering the earthquakes devastation	Web page, published reports, interview

Institution/Organization	Type of Information Sought	Types of Data	Data Source
National Association of Community Electrification Nepal	Community distribution	• Status and number of destroyed/damaged community managed distribution system by earthquakes • Earthquakes recovery plan from community organization if any • Constraints faced by community organization Possible areas for the intervention considering the earthquakes devastation	Web page, published reports, interview
Biogas Support Partnership Nepal	Biogas	• Status and number of destroyed/damaged biogas plants by earthquakes • Earthquakes recovery plan from biogas sector if any • Constraints faced by biogas communities • Possible areas for the intervention considering the earthquakes devastation	
Department of Electricity Development	Electricity	• PDNA follow up and possible recovery plans	Web page, published reports, interview
Nepal Energy Efficiency Project	Energy efficiency	• Status of draft energy efficiency standards, energy efficiency program • Possible areas for the intervention considering the earthquakes devastation	Web page, published reports, interview
International Centre for Integrated Mountain Development (ICIMOD)	Climate change	• Climate change adaptation on hydropower projects • Possible areas for the intervention considering the earthquakes devastation	Web page, published reports, interview

ANNEX 3: SUMMARY OF NEPAL'S POST EARTHQUAKE SMALL RENEABLE AND OFF-GRID ENERGY RESPONSE ACTIVITIES

- **Energy rapid needs assessments**
  - WFP has analyzed their rapid assessment data on energy needs - see resources section below for Food Security Cluster report, questionnaire, and data on fuel and cookstove needs
- **Stove/fuel distributions:**
  - Government of Nepal's Alternative Energy Promotion Centre (AEPC) has released a procurement request for 9500 portable cookstoves - see resource list below for more details. Applications from manufacturers/suppliers are due by noon Kathmandu time on June 17.
  - Envirofit is working with Himalayan Stoves Project to bring in 20 institutional 100L stoves (will arrive by June 4), and is planning to bring in another 40 soon. Planning to make available for rental by aid agencies – contact Envirofit if your organization is interested.
  - BioLite stoves are also available for procurement w/in the region if needed.
- **Solar lantern distributions**:
  - AEPC has released a procurement request for solar lanterns and solar PV mobile charging stations - see resource list below for more details. Applications from manufacturers/suppliers are due by noon Kathmandu time on June 17.
  - MSF is planning to send 50-100 IKEA shelters to Arughat town in Gorkha: these include solar panels for lighting/charging
  - Mercy Corps got a D.light donation for 240 D20 grid-like power systems and 50 S300s (mobile charging + lantern). In country procurement will be coordinated via Empower Generation. Will likely be distributed in the same districts as previous distribution: Sankhu, Kirtipur, Kavresthali (Kathmandu Valley), Kavre, Sindhupulchowk,Dolakha, Nuwakot, but need to confirm. They want to procure additional 3,500 S300s (mobile charging + lantern).
  - Mercy Corps has already distributed 20,000 S20 solar lights in Sankhu, Kirtipur, Kavresthali (Kathmandu Valley), Kavre, Sindhupulchowk, Dolakha, & Nuwakot
  - Government of Nepal's Alternative Energy Promotion Centre (AEPC) will be reaching approximately 13,000 households with solar lanterns. See coordination call minutes from May 21, 2015 for details on locations of distributions.
  - Gham Power has created mapping of solar lighting/power needs: has covered 30 requests, 57 are in progress, and 62 cases still need assistance as of 5.26.2015
  - UNHCR distributed 4,000 Bright light SunBell solar lanterns (not sure on location w/in Nepal)

- D.light has donated over 6,000 solar lights, working with Empower Generation
- Empower Generation has distributed solar lanterns in the following locations:
  - 2,340 S2s have been distributed to survivors by Empower Generation in Dhading, Nuwakot, Gorkha, Kavre, Kathmandu, Sidhulpachowk and Lalitpur Districts.
  - 380 S20s have been distributed to survivors by Empower Generation in Dhading, Nuwakot, Gorkha, Kavre, Kathmandu Districts.
  - 50 S250s have been distributed to aid and relief workers by Empower Generation in Dhading, Nuwakot,Gorkha, Kavre, Kathmandu Districts.
  - 3,458 S2s units have been sold to INGOs, NGOs, local community contacts in country for further distribution to survivors.
  - 3,680 S20s units have been sold to INGOs, NGOs and local banks and companies in country for further distribution to victims
  - 2 S250s have been sold to journalists
  - d.light S20s, S300s, D20s and BBOXX BB7 and BB17 will be available in Nepal through Empower Generation soon
- Frontier Markets set up a funding campaign for 5,000 solar lights (not sure on location w/in Nepal)
- WakaWaka has distributed 2,000 WakaWaka lights in Nepal (purchased by Caritas Nepal - Cordaid) and has pledged an additional 2000. They have also raised money for 5000 WakaWaka Powers donations that will be shipped shortly (location for distribution TBD)
- Unite to Light is partnering with Hands in Nepal to send 1000 small solar lights to Nepal within the next month (location for distribution TBD)
- TERI has initiated a fundraising campaign to facilitate access to solar lanterns
- Ecoprise has delivered 500 solar lanterns to survivors from Kavre, Sindhupalchowk and Nuwakot. They also plan to reach 1000 families with solar lanterns from dlight and solar power water purifiers from SOLVATTEN inSindhupalchowk, Kavre, Nuwakot and Rasuwa districts.
- NOTE: Lighting Global has a Guidance Note for emergency/bulk procurement for solar lanterns

- **Power**:
  - AEPC has released a procurement request for solar lanterns and solar PV mobile charging stations - see resource list below for more details. Applications from manufacturers/suppliers are due by noon Kathmandu time on June 17.
  - Gham Power is compiling all the incoming help requests for power in a live map here: http://nepalquake.ghampower.com/request-map

- One Heart Worldwide, with support from We Care Solar and Sun Farmer, is planning to set up 40 birthing tents and will be distributing solar suitcases for health clinic electrification (not sure on location w/in Nepal)
- Empower Generation set up a mobile charging station in Lazimpat, is fundraising to set up more
- SunFarmer has distributed 755 D.Light lanterns in Sindupalchowk, Dolakha, and Dhading, as well as two solar water purification systems in Gorkha and Dhading, and are currently distributing 20 community-level charging stations in Gorkha, Dhading, Sindhuli, and Sindupalchowk. They are also preparing to deploy an additional 20 donated systems from SunEdison and 50 from Simpa Networks.
- AEPC initiated a quick relief program to provide basic electricity services/ technologies for lighting and mobile charging
- Rebuild Barpak initiative has supported funding of a 50 KVA Diesel Genset to ensure access to adequate, safe, and reliable electricity in Barpak. The generator has been connected to the distribution network and will be supplying electricity to temporary shelters, agro-processing mills, construction equipment and communication equipment and infrastructure.

- **Environment**:
  - FAO will support 20,000 of the most vulnerable households w/ agriculture assistance (not sure on location w/in Nepal)

ANNEX 4: INSTITUTIONS, PROGRAMS AND DONORS WORKING ON CLEAN AND RENEWABLE ENERGY IN NEPAL

AEPC

Six Broad Objectives:

- Preparation of short, medium, and long term policies and plans
- Implementation of programs for development of RETs and Energy efficiency
- Standardization, quality assurance, and monitoring
- Providing technical Service and support to rural people
- Facilitating financial assistance
- Strengthening of partners' (i.e. civil society, local agencies and private sector) capacity

Promotion approach of AEPC

- The program is demand based
- Involvement of Community, Cooperatives and Private Sectors
- Private sector responsible for survey, manufacturing, supply, installation and after sale services of the MHP systems Technical support in terms of training, information, guidelines, quality assurance and subsidy and tax exemption through AEPC

Rural Energy Fund

Rural Energy Fund (REF) was established by the GON and the donors (Danida & NORAD) to channel jointly financed subsidies for Micro Hydro, Solar Energy, Biomass Energy Technologies as per the Subsidy Policy and Delivery Mechanisms, approved by the GON in September and November 2006.

Role of REDP

Established in 1996 with the support from UNDP and GoN. World Bank joined later. Program is based on decentralized management of development efforts with emphasis on community organization It has covered 40 districts in promoting RETs

Nepal Micro Hydro Development Association

NMHDA is an Umbrella organization of survey, installation and manufacturing companies
Micro-hydro Users Association is the organization of micro-hydro users along with the participation of other NGOs at the local level

National Rural and Renewable Energy Programme (NRREP)

Donors in the Energy Sector

DANIDA
NORAD
ADB
WORLD BANK
UNDP
SNV
GiZ
USAID SARI/E – Regional Centre of Excellence on Micro Hydro Technology, Winrock International, iDE, Deloitt, others

Capacity Building

AEPC has conducted several training courses to the micro-hydro community to enhance their capabilities. These include:

- Micro-hydro management training for micro-hydro managers
- Training on end use diversification for IWM owners
- Micro-hydro operators training for micro-hydro operators
- Advanced micro-hydro facility operator's training
- District level orientation and interaction program
- Orientation training to government organizations and NGOs
- Trainers training for service center technicians.

Other initiatives have been undertaken including several studies such as micro-hydro users' surveys, cost-benefit analysis of micro-hydro systems, development of micro-hydro manuals and catalogues, etc.

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