ICIMOD

WORKING PAPER

Renewable energy in Nepal

Key findings and policy recommendations

Published by
International Centre for Integrated Mountain Development (ICIMOD)
GPO Box 3226, Kathmandu, Nepal

ISBN 978-92-9115-755-6 (electronic)
https://doi.org/10.53055/ICIMOD.1023

Production team

Shanuj VC (Consultant editor)
Gillian Summer (Senior editor)
Samuel Thomas (Senior editor)
Rachana Chettri (Editor)
Dharma R Maharjan (Graphic designer)
Punam Pradhan (Graphic designer)

Citation

Malla, A., & Dhananjayan, P. (2023). *Renewable energy in Nepal: Key findings and policy recommendations* (Working Paper). ICIMOD. https://doi.org/10.53055/ICIMOD.1023

WORKING PAPER

Renewable energy in Nepal

Key findings and policy recommendations

AUTHORS
Avishek Malla and Pugazenthi Dhananjayan

CORRESPONDING AUTHOR
Avishek Malla
avishek.malla@icimod.org

International Centre for Integrated Mountain Development (ICIMOD), Nepal

Contents

Abbreviations and acronyms

ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
CapEx	capital expenditure
DRE	distributed renewable energy
GDP	gross domestic product
GoN	Government of Nepal
HKH	Hindu Kush Himalaya
IWM	improved water mill
ktoe	kilo tonnes of oil equivalent
kWp	kilowatt peak
MHP	micro-hydro/mini-hydro plant
MoEWRI	Ministry of Energy, Water Resources and Irrigation
Mtoe	million tonnes of oil equivalent
NDC	Nationally Determined Contribution
NEA	Nepal Electricity Authority
NPC	National Planning Commission
NPR	Nepali rupees
NREP	Nepal Renewable Energy Programme
PEU	productive energy use
PLF	plant load factor
PPP	public–private partnership
PV	photovoltaic
RERL	Renewable Energy for Rural Livelihood
RET	renewable energy technology
SASEC	South Asia Subregional Economic Cooperation
SDG	Sustainable Development Goal
SHS	solar home system
SWMG	solar–wind mini-grid
TFC	total final consumption
TPES	total primary energy supply
Wp	watt peak

Executive summary

This working paper reviews the energy scenario, potential, targets, and gaps regarding renewable energy in Nepal.

Based on its key findings, it makes the following policy recommendations to expand the use and application of renewable energy in Nepal. Implementing these recommendations would go a long way to the country meeting its climate change and developmental goals.

1. **It is necessary to carry out appropriate restructuring, coordination, and capacity building at all three levels of government for effective renewable energy development and deployment.** This is particularly pertinent, given that the responsibilities for the deployment of renewable energy have been delegated to local governments under Nepal's federal structure.
2. **Include the promotion of non-hydropower renewables, establishing firm targets for the share of renewable energy, integrating renewable energy solutions for climate adaptation, and enhancing institutional capacity, when deploying an effective strategy to expand the role of renewable energy in Nepal's energy mix.**
3. **More efforts are needed to mobilise private finance, and in a holistic manner that addresses major market enablers.** The deployment of renewable energy through the AEPC has primarily relied on public finance. Investments exceeding NPR 158 billion are required to achieve the renewable energy targets outlined in Nepal's second NDC. However, the current annual investment by AEPC represents less than 5% of this total.
4. **Holistic reforms need to be carried out, to expand renewable energy technology markets and encourage greater investments via appropriate regulations, taxes, and other enabling policies.** Historically, only providing capital has not successfully attracted commercial investments in the renewable energy sector.
5. **Promote resilient, green enterprises via an ecosystems approach, building capacities across value chains, and developing business plans that emphasise building resilience through new technologies, partnerships, funding, and skill development.**
6. **Gender equity and social inclusion (GESI) must be included throughout the renewable energy project cycle, from its development and implementation to the monitoring and operational phases, including having the necessary supporting ecosystems such as capacity-building.**

As a mountainous country, Nepal has no oil, gas, or coal reserves. Despite an abundance of renewable energy sources, a huge majority of the population relies on traditional fuels to satisfy its daily energy needs. Nepal's significant hydroelectricity and renewable energy potential is largely untapped due to economic and other constraints. One of the primary objectives of the Government of Nepal is to ensure that affordable and reliable energy for all is included in its Sustainable Development Goals. Over the years, the government has consistently prioritised renewable energy for energy access and also targeted rural poverty via renewable energy subsidy programmes and delivery strategies.

In order to ensure the sustainable development of renewable energy, increased investment is required. Scaling up renewable energy infrastructure and use requires proper planning, setting targets, evidence-based policy-making, and an enabling environment. In Nepal, despite the significant demand and market for renewable energy, sales turnover and investments have not been commensurate. It implies the existence of gaps that must be bridged through political commitments, enabling policies, and scaling-up plans.

It is in this context that ICIMOD's Renewable Energy and Energy Efficiency Capability for the Hindu Kush Himalaya (REEECH) programme has been mapping the policy and regulatory landscapes in the region's member countries. This working paper begins by presenting its key findings and policy recommendations. Besides an analysis of the relevant primary and secondary data, the paper paper also relies on interviews with experts from different sectors, pilot studies, and focus group discussions. The paper examines energy supply and consumption in Nepal. It then presents the government's priorities in renewable energy, key subsidy policies, the role of public finance, renewables' deployment in rural electrification and clean cooking, the role of the private sector, and how renewable energy has been integrated into national commitments.

SECTION I

Key findings and recommended policy actions

Scale and investment are required to enable the expansion of sustainable renewable energy in Nepal. The ability to scale up renewable energy capacity depends on appropriate planning, setting targets, evidence-based policy-making, and an enabling environment, all of which must be in place. Significant demand and a sizeable market for renewable energy exist in Nepal. However, commensurate investments, and sufficient annual market sales have not taken place. It implies gaps that need to be bridged through political commitments, enabling policies, and necessary plans at scale. Presented below are some key findings of this working paper and recommendations, based on the findings, to expand the role of, and access to renewable energy in Nepal.

1.1 Renewable energy in Nepal's federal structure

Under Nepal's federal structure, the local government has been given the responsibility for the development of renewable energy and its implementation. Previously, these activities were carried out at the central level. This transition would require the creation of appropriate structures, coordination, and capacity building at the three levels of government for the effective and efficient development and deployment of renewable energy.

CREATE MECHANISMS FOR COOPERATION AND COORDINATION WITHIN THE FEDERAL STRUCTURE TOWARDS THE DEPLOYMENT OF RENEWABLE ENERGY

It is essential to have cooperation, coordination, and co-existence among the three levels of government under Nepal's federal structure. Guided by Nepal's Constitution, clarity of roles based on these principles is urgently needed at each government level for the development and deployment of renewable energy.

The new mandate gives the local government the responsibility for the preparation of plans, policies, implementation mechanisms, and monitoring renewable energy deployment (Amatya et al. 2019). Harmonising the planning, policy, standards, and implementation mechanisms of renewable energy technologies (RETs) across all the local governments will be critical to ensuring uniformity in plans, budgeting, procurement, and implementation. A coordination committee representing all three levels of government, and headed by the designated authority for policy, can be formed for continuous monitoring, updates, and improvements.

The new decentralised process will probably be gradual and may require time for the transition. During this transitional phase, support from the central government in orientation, planning, capacity-building, institutional development, developing implementation mechanisms, and monitoring will be vital in ensuring a proper handover and the successful future deployment and expansion of RETs.

1.2 Expanding the role of renewable energy

RETs have been playing a crucial role in the rapid rural electrification and the promotion of clean cooking in Nepal in recent years. With approximately 210,000 households yet to be electrified, it is essential to continue these efforts but also to identify new sources of RE to enhance the country's energy resilience. Globally, RETs are becoming competitive against fossil fuel energy, accounting for over 50% of the global power capacity additions in recent years (UN 2018). The falling prices of renewable energies such as solar and wind, the growing energy demand, and rising fossil fuel prices present an opportunity for an expanded role for renewable energy in clean energy transitions (in heating, cooling, transportation, industrial processes, etc.), improving livelihoods, enhancing energy security, and promoting green and resilient enterprises. This underlines the importance of understanding and establishing the current and future role of renewable energy in Nepal's energy mix. Developing such an understanding among relevant stakeholders will help in setting appropriate targets, policy interventions, planning, gauging resource requirements and their management, creating appropriate institutional structures, laying out roadmaps for sectoral reforms, avoiding duplication towards the efficient use of funds, and overall, help the government set realistic targets and commitments.

CARRY OUT PERIODIC PROJECTIONS OF ENERGY SUPPLY AND DEMAND TO DETERMINE THE SHARE OF RE IN THE ENERGY MIX

Periodic projections of energy supply and demand are needed to clearly define the role of RE throughout the energy value chain, its production, distribution, and consumption. Such projections will help to generate evidence for the role of RE and its share in the total energy mix to promote clean energy transitions across various sectors such as electricity, transport, agriculture, industry, and others. Further sectoral RE assessments can be carried out to establish sector-specific pathways of clean energy transitions along with mechanisms to track their progress. They can be part of feedback mechanisms to produce better projections for evidence-based planning and policy interventions.

PROMOTE NON-HYDROPOWER RENEWABLES TO STRENGTHEN THE NATIONAL ENERGY SUPPLY

Non-hydropower renewables such as solar energy, bioenergy, and wind energy ought to be promoted to complement hydropower and the distribution system strengthened to make the national energy supply more resilient. This is because hydropower will remain the primary source of energy in the country for several years, where climate change-induced variations in precipitation and the melting of glaciers, can lead to seasonal fluctuations in power generation. Further, hydropower infrastructure is also vulnerable to climate-induced disasters such as floods, glacial lake outburst floods (GLOFs).

ESTABLISH INTEGRATED RENEWABLE ENERGY PLANNING MECHANISMS THROUGH APPROPRIATE DATA COLLECTION ALONG WITH CAPACITY BUILDING FOR THE DETERMINATION OF RE PLANS AND TARGETS

In order to have a clear assessment of renewable energy needs and goals, and for evidence-based decision-making, it is important to establish a data collection mechanism, develop energy modelling tools, and enhance institutional capacities. This would help identify clear plans for access to renewable energy, the required investments, and ways to avoid duplication of efforts. Local governments and line agencies should be appropriately equipped with resources and capacities for appropriate planning.

INTEGRATION OF RENEWABLE ENERGY FOR CLIMATE ADAPTATION

Nepal ranks 10th in the global climate risk index (Germanwatch 2023), making it one of the most vulnerable countries in the world. It is projected that Nepal will experience higher levels of warming compared to the global average and increased rainfall intensity (WB and ADB 2021). Additionally, there has been a rise in the frequency of extreme events such as droughts in Nepal (WB 2023). These impacts have far-reaching implications across various sectors. Therefore, it is crucial to prioritise appropriate climate adaptation measures to minimise the exposure to these climate change impacts. While renewable energy (RE) has traditionally been viewed as a mitigation measure, it also offers significant opportunities for deploying effective climate adaptation strategies. To ensure the success of Nepal's adaptation strategy, it is essential that the policy recognises the intrinsic link between renewable energy and climate adaptation. Renewable energy should be made an integral part of Nepal's adaptation strategy.

Furthermore, the policy should promote appropriate solutions, mechanisms, and instruments to encourage the widespread adoption of renewable energy for climate adaptation. In addition to this, it is crucial to establish a robust monitoring framework to systematically generate knowledge and evidence that support the effectiveness of renewable energy solutions in addressing climate adaptation challenges. Moreover, forging partnerships,building capacity and raising awareness across relevant stakeholders is essential to ensure the successful implementation and integration of renewable energy in Nepal's climate adaptation strategy.

1.3 Attracting greater investments in renewable energy

RE deployed through the AEPC has been largely supported by public finance. Investments of more than NPR 158 billion are necessary to meet the renewable energy targets listed in Nepal's second NDC. The current investment represents less than 5% of this. It is exceedingly improbable that the scale of investment needed will happen through current public finance modalities. In order to mobilise credit for, and encourage private-sector finance in the renewable energy sector, the government established the Central Renewable Energy Fund (CREF) in 2009. The CREF, however, has been unable to mobilise the renewable energy credit market to the extent that was anticipated. Other credit funds such as the micro-hydro debt fund programme were established in the past to subsidise interest rates and share credit risks. However, the repayment rate of loans for the programme that supported 30 MHPs was only 35% (Adhikari et al. 2018). Inadequate tariff collection, poor project management and operations, cost overruns, and natural disasters were cited as contributing factors.

Similarly, a biogas credit unit was established under the AEPC in 2000 to provide wholesale loans to financial institutions such as microfinance institutions (MFIs) and commercial/development banks to promote biogas installations. A soft loan at 6% was provided to MFIs as wholesale lending, but the rate of interest to be borne by the loanee was up to 14%. Between 2001 and 2014, NPR 351 million was disbursed, with 27.8% of it as outstanding loans (CMF 2013). All this suggests that more efforts are needed to leverage private finance, and financing should be implemented in a holistic approach, ensuring that it aligns with key market enablers.

THE NEED FOR TAILORED FINANCIAL INSTRUMENTS AND THE PROTECTION OF PRIVATE-SECTOR INVESTMENT

Organisations such as CREF, established to support the financial ecosystem for RETs, are required to fill in for traditional commercial banks. Conventional credit frameworks are not adapted either to the demands of RET projects, or of rural users. Lending to rural energy projects often require collateral-free debts with risk coverage through guarantees, project insurance, and blended finance to ensure low capital costs and thereby encourage private capital investment. The financial lending terms for a community or rural electrification project must be evaluated keeping in mind that the nature of the project and the risks associated with it are fundamentally different from those of conventional financing. In most cases, banks will finance such projects only if they are counter-guaranteed by a third party. Although rural electrification projects fall under the category 'deprived sector lending', to whom lending is mandatory, soft loans typically available for agricultural purposes are not extended to such projects. Further, in rural energy projects, it is necessary to reduce the high interest rates on loans resulting from the long chain of financial intermediaries.

The CREF can also broaden its lending portfolio by providing project and working capital finance to renewable energy distributors and project developers, and capital loans to rural enterprises powered by RETs. Further, it is imperative that mechanisms are created to maintain sufficient funds to mobilise credit for RETs.

BUILD MARKET CONFIDENCE THROUGH MULTI-YEAR PROGRAMMES AND BUDGETS

In the past, multi-year programmes such as the development of solar mini-grids have been implemented. Similar programmes and long-term budget commitments will provide confidence to the private sector to make increased investments in business, improve supply chains, and build capabilities. Muti-year programmes and budget commitments are also important in meeting long-term government targets.

TIMELY DISBURSEMENT OF FUNDS TO MAINTAIN CASH FLOWS FOR THE EFFECTIVE DEPLOYMENT OF RETS

Subsidy delivery policies must be reviewed to improve the efficiency with which RET projects are implemented, and funds disbursed. The average budget expenditure is currently less than 70% of the total budget allocated. Some of the most significant reasons for the inefficient disbursement of funds include extended project procurement lead times, protracted delays in payment due to excessive documentation, and the absence of online monitoring. Further, untimely disbursements lead to a crunch in cash flows for the private sector, which results in increased costs, project delays, and quality being affected adversely.

1.4 Reforms to expand RET markets

Historically, merely providing capital or operational incentives has proved insufficient in attracting commercial investments in the renewable energy sector. Other market enablers such as regulations, taxes, and suitable policies are equally important. As emphasised in the recommendations that follow, holistic reforms are necessary to encourage greater investment.

MARKET INTEGRATION OF RET PROJECTS

The process for obtaining a power purchase agreement (PPA) for both MHPs and utility power plants is similar. However, the size of the plant, investment needed, community capacity, and the developer's ability to participate in a rural electrification project are not comparable to those of a mainstream utility project. Thus, the policies related to the PPA, grid integration, and financial lending mechanisms and terms cannot be the same for both types of projects. A more simplified PPA for rural electrification projects would encourage connections to the electricity grid. Simplified arrangements for power trading could be made where the national grid reaches areas being served by renewable energy projects of less than 1 MW capacity, including MHPs, solar and wind mini-grids, rooftop solar, institutional solar systems, solar pumps, and biogas- and bagasse-based plants.

Private-sector investments have not been able to scale up in rural electrification, although up to 60% capital subsidy is offered. One of the reasons highlighted for this is the risk of encroachment by the national grid. For instance, MHPs of over 2.7 MW have been encroached by national grid expansion and are not functional. Though the Nepal Electricity Authority is required to compensate the MHP under the Electricity Act 1992 when the grid reaches an area, it is reluctant to connect small-sized power plants below 100 kW (Kumar et al. 2015). Several key regulatory measures and instruments are missing, such as protection measures after grid expansion, tariff regulations, etc.

FISCAL REFORMS THAT WOULD MAKE RURAL ENERGY SUPPLY AFFORDABLE

There are variable tax rates applied to RETs. Reducing the current taxes on renewable energy technologies, including their balance of system (components of a PV system other than the solar panels), or even exempting them from taxes, will support cost reduction (see Box 1). A similar duties policy is already in place to encourage the development of utility-scale hydropower projects; the government has imposed only a 1% import duty on equipment, machinery, and tools required for the generation, transmission, and distribution of hydroelectricity, and the operation and maintenance of such plants (Agarwal 2020). Similar tax rebates and incentives can be provided to private renewable energy companies to encourage re-investment in the business, for users to adopt renewable energy, and for local industries to manufacture or assemble RE equipment and machinery.

> **Box 1: Cutting taxes to reduce the capital costs of RE projects**
>
> Battery storage is subject to taxes and duties as high as 43% in Nepal, and it is estimated that exempting these current duties and taxes will save at least 9% of the system's capital costs. The total capital costs will reduce further if taxes are exempted on all components. Battery storage was identified as one of the highest capital costs of solar mini-grid projects when such SASEC sub-projects were evaluated. It accounted for 26% of the total cost on average, with power generation accounting for 18%, power conditioning units for 16%, 14% for transmission and distribution costs, and 14% for other expenditures such as installation and civil charges.

1.5 Promotion of resilient green enterprises

Mountain enterprises are highly exposed to changes in climate and other shocks. There are almost 1 million micro, small, and medium enterprises (MSMEs) in Nepal (ESCAP 2020). A collaborative study carried out by ICIMOD and IRENA on resilient enterprises and the use of renewable energy in enterprises in the HKH region found that they are exposed to several internal and external shocks that can hinder their growth. Thus, it is critical for MSMEs to have business strategies that focus on building resilience through innovative technologies, partnerships, funding, and skills (Nagpal et al. 2022).

The assessment also highlighted that RETs are mature, cost-competitive, and well established but often not tailored for productive end-uses across value chains. With an enabling ecosystem in place, renewable energy can indeed enhance livelihoods, offer opportunities for value addition, improve the resilience of enterprises, and support several development objectives related to gender, food security, health, and employment. Thus, along with access to affordable, reliable, and appropriate renewable energy services, it is equally important to have targeted interventions such as training, education, apprenticeships, improving financial, technical, and business skills, access to finance, and supportive social policies. The absence of these may exacerbate existing gender inequities, hinder entrepreneurship development, and limit the achievement of poverty alleviation goals. Further, the promotion of green enterprises also complements the long-term sustainability of the electricity generation entities (Box 2).

The following interventions, identified in ICIMOD's needs assessment report (Nagpal et al. 2022), would enhance the contribution of renewable energy resources to value chain and enterprise development while ensuring the transition to a gender-sensitive, inclusive, and green economy.

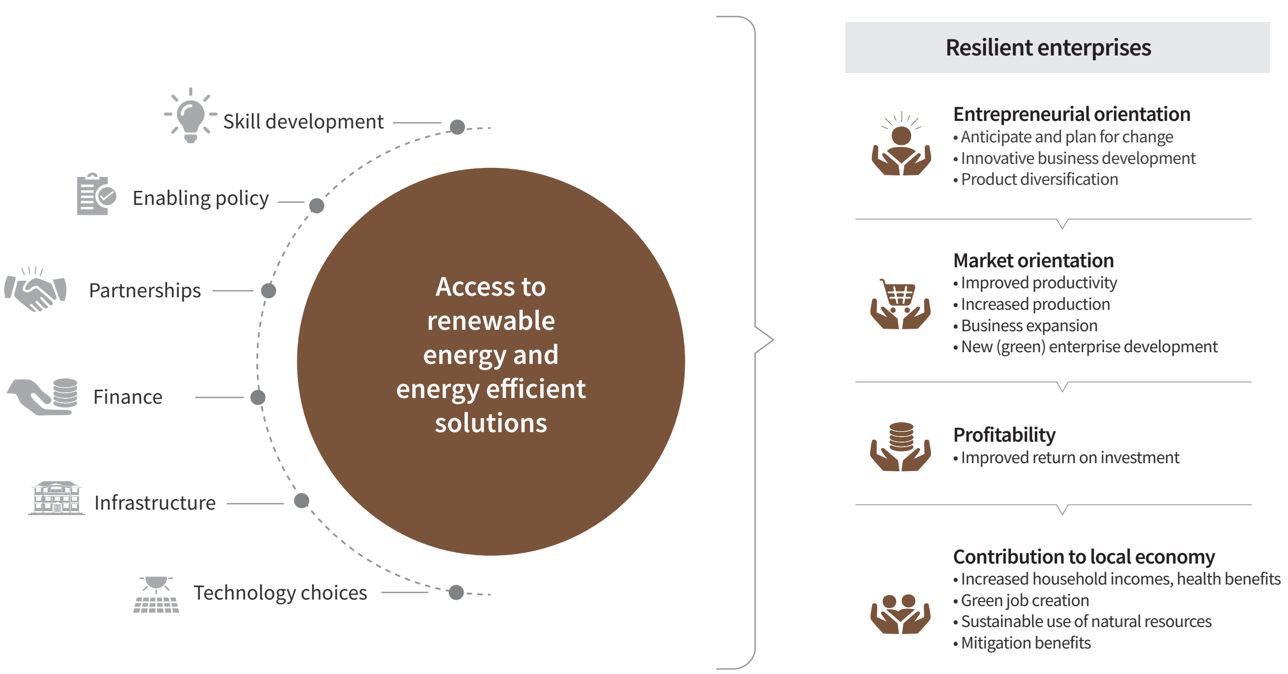
Box 2: Promoting PEU for plant sustainability

Promoting productive energy use (PEU) is one of the key ingredients to operational sustainability, along with other important ecosystem parameters for sustainable power plants. A study carried out by the World Bank reports that the plant load factor (PLF) of MHPs in Nepal was found to be in the range of 18–33%. A PLF of 82% with subsidies was projected in the financials to attain break-even (Kumar et al. 2015). The study shows that the tariff rates and the current PLF only cover salaries, and not the significant maintenance expenses or the capital investments.

ADOPT AN ECOSYSTEMS APPROACH TO SHAPE SUSTAINABLE ENERGY'S CONTRIBUTION TO ENTERPRISE DEVELOPMENT

Local communities and enterprises should be empowered to utilise renewable energy solutions to improve the competitiveness and resilience of value chains through the development of a local ecosystem. Such an ecosystem rests on the pillars of a tailored policy environment, access to finance, end-use oriented technology solutions, capacity development, and multi-stakeholder partnerships (Figure 1). Programmes and initiatives deploying renewable energy solutions in the mountain context are strongly encouraged to adopt an ecosystems approach to support local enterprise development, improve resilience, and bring socio-economic benefits for all.

FIGURE 1 AN ECOSYSTEMS APPROACH TO RE SOLUTIONS FOR ENTERPRISE DEVELOPMENT



INTEGRATE SUSTAINABLE ENERGY MEASURES IN POLICIES AND PLANNING FOR DEVELOPMENT

Policy and planning efforts for strengthening value chains and enterprises need to be tailored to the specific contexts. Incentives for productive end-use of renewable energy solutions need to be strengthened with local enterprises as the key agents of change. Given the cross-sector nature of mountain value chains, different sector development plans (such as for agriculture and tourism) would benefit from integrating sustainable energy as a critical pillar. Accordingly, there is a need to involve energy and non-energy ministries and public bodies.

CATALYSE ACCESSIBLE FINANCING FOR END-USERS AND ENTERPRISES

Access to affordable and tailored financing is a critical part of the ecosystem for deploying renewable energy to enhance the competitiveness and resilience of value chains and enterprises. There is a need to mobilise public and private capital from multiple sources of finance, tailor financial products for end-users and enterprises, layer multiple instruments, and deploy responsive financial intermediaries, such as cooperatives, which can play a crucial role in improving access in remote mountain contexts. The financial products should cover energy technology as well as efficient, productive end-use appliances.

SUPPORT TECHNOLOGY INNOVATION AND ADAPTATION PROCESSES

Technology innovation and adaptation processes are crucial for linking renewable energy solutions and energy-efficient productive appliances with the needs of local end-users and value chains. The value chains for the same goods and services are likely to be uniquely configured to the local conditions requiring tailored technology solutions to meet diverse energy needs. Targeted measures are needed to facilitate participatory technology innovation and adaptation processes, as well as end-of-life management of technologies.

BUILD CAPACITIES ACROSS VALUE CHAINS OF MOUNTAIN PRODUCTS AND SERVICES

To accelerate the adoption of renewable energy and its impacts on value chains and enterprises, adequate capacity needs to be developed of actors across the ecosystem for the various value chains. Such capacity development has to be an ongoing activity, with a focus on skills regeneration and upgradation.

IMPROVE THE DATA AND INFORMATION BASE ON ENERGY FLOWS IN VALUE CHAINS

Data regarding the energy needs for adding value to products and services and the energy consumption of MSMEs is extremely limited. For the value chain development of products and services, an understanding of the existing energy flows is critical for effective policy-making and planning, and for assessing alternative energy sources.

LEVERAGE PARTNERSHIPS TO DELIVER TRANSFORMATION

Key stakeholders identified through the needs assessment include governments, the private sector, technology providers, and financial institutions as well as non-governmental entities such as industry associations, and local communities. Each plays a specific role in developing the ecosystem for enhancing the contribution of renewable energy to enterprise development.

1.6 Mainstreaming GESI in renewable energy

The Rural Energy Policy 2006 and the Renewable Energy Subsidy Policy 2022 both include aspects of gender equality and social inclusion (GESI). However, as mentioned in Table 3, GESI-based incentives are not consistent across various RETs and productive energy uses. More consistency is needed in this. It is important to ensure that GESI considerations are made an integral part of programmes, and mainstreamed throughout the renewable energy project cycle, from the development and implementation, to the monitoring and operational phases, including in supportive ecosystems such as capacity-building.

SECTION II

Context

Energy poverty remains a central challenge to sustainable development efforts in the Hindu Kush Himalaya (HKH) region. A broad range of barriers, including policy and regulatory obstacles, outdated technologies, and the lack of capacity and finance, have prevented the region from taking full advantage of existing and potential renewable energy sources for decentralised sustainable energy solutions in off-grid mountain areas.

In this context, ICIMOD's Renewable Energy and Energy Efficiency Capability for the Hindu Kush Himalaya (REEECH) programme aims to improve access to modern, affordable, and reliable energy services and enhance essential mountain ecosystem services in the HKH region. It provides a coordination mechanism to foster South–South cooperation for improved access to decentralised, sustainable energy solutions in the region. REEECH contributes to 10 Sustainable Development Goals (SDGs), related to energy, poverty, gender, economic growth and employment, health, water, industrialisation, climate change, and partnership, covering 20 targets. To achieve its objectives, REEECH works on four thematic areas – knowledge management and awareness, inputs to policy development and implementation, capacity development, and promotion of investment, entrepreneurship, and innovation.

One of the objectives of the REEECH Initiative is to support inputs into the development and implementation of renewable energy policies in the HKH. Against this backdrop, REEECH mapped the policy and regulatory landscapes in the HKH regional countries. This working paper reviews the energy scenario, potential, targets, and gaps regarding renewable energy in Nepal. In Section I of the working paper, we present the working paper's key findings and make policy recommendations to promote renewable energy in Nepal, meet its developmental goals and tap future opportunities. In Section II we review energy supply and consumption in Nepal. Section III discusses the government's priorities in renewable energy (RE), key subsidy policies, the role of public finance, RE deployment in rural electrification and clean cooking, the role of the private sector in RE, and how renewable energy has been integrated into national commitments.

The study contextualises the local needs of member countries for the promotion of renewable energy and energy efficiency (EE) solutions. The recommendations presented in this working paper can be considered as inputs into the ongoing revision of the Rural Energy Policy, 2006 by the Government of Nepal. **The working paper provides a policy roadmap to improve the renewable energy scenario in Nepal and meet its sustainable development and climate goals**.

2.1 Methodology

The analysis used a mixed-method research methodology that included both qualitative and quantitative techniques. This approach prioritises gathering, analysing, and blending quantitative and qualitative data at various stages of the research process. The qualitative approach aimed at understanding the essential subtleties, actors, and institutions related to the development of renewable energy in Nepal. The quantitative evaluation complemented the qualitative approach by critically analysing the relevant primary and secondary data. The data was collected from multiple sources and analysed to better understand the problem and provide appropriate policy recommendations. This included a detailed analysis of statistical reports from various governments ministries and bodies and private organisations of national and international repute, policy and regulatory documents, and briefs published by the Government of Nepal. Of great significance was data from different technical reports and documents on Nepal's energy policy and regulatory guidelines. A second major source of information was the databases of articles.

The working paper also uses exploratory research techniques, a qualitative approach that includes case studies, interviews with experts from different sectors, pilot studies, and focus group discussions (FGDs). A policy stakeholder consultation meeting was held on 21 December 2021 with officials from the Alternative Energy Promotion Centre (AEPC), Renewable Energy for Rural Livelihood (RERL), Nepal Renewable Energy Programme (NREP), and other key stakeholders from the government and private sectors. Following this consultation, a series of face-to-face discussions were held with various private-sector entities in Nepal to gather and consolidate essential data and information and validate the findings. A purposive sampling method was chosen to identify relevant stakeholders working in the energy sector in Nepal. During the course of the study, the team also met with senior government officials, domain experts in affiliated technical and academic institutions, and independent research groups to learn about the prospects and growth of the renewable energy sector in Nepal. (For a list of key stakeholders who were interviewed during the course of the study, see Annex 1.)

2.2 Energy scenario

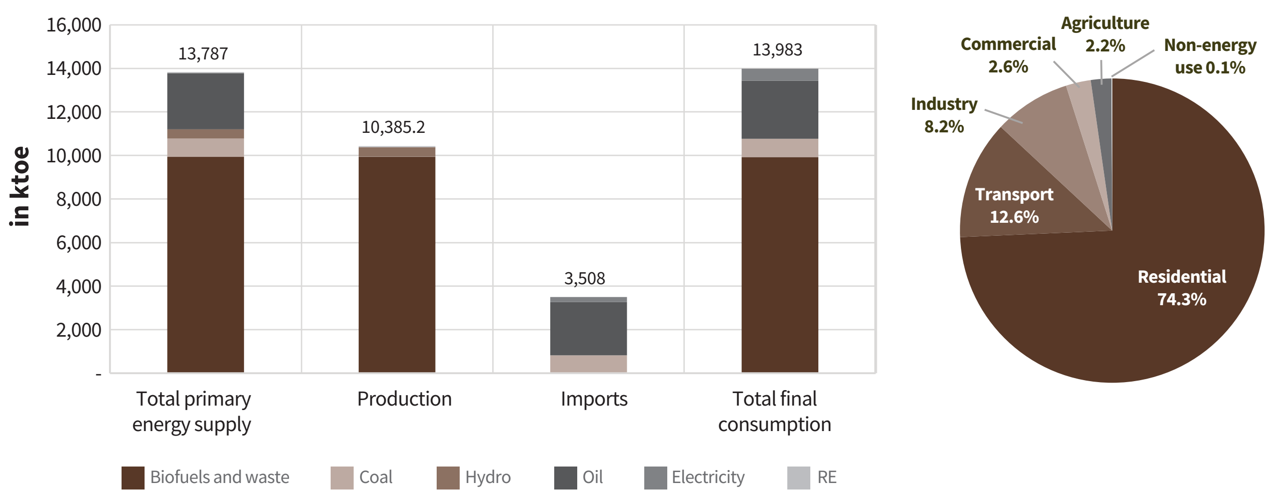
2.2.1 Background

As a mountainous country, Nepal has no oil, gas, or coal reserves and is significantly reliant on traditional energy sources such as biomass, despite the abundance of renewable energy sources. The country's mountainous terrain makes modern energy infrastructure challenging to build in many areas. More than 65% of Nepal's population relies significantly on traditional fuels to meet their daily energy needs, resulting in adverse environmental and public health consequences, particularly for women and children (IEA et al. 2022). The United Nations General Assembly recently approved a proposal to upgrade Nepal to a middle-income developing country by 2026; until then, Nepal will continue to receive support as a least developed country (LDC) (The Kathmandu Post 2021). The ability to harness the country's inherent energy potential will be critical in the successful promotion from an underdeveloped status. Nepal has excellent potential for hydroelectricity and other renewable energy generation, but this potential has gone largely untapped due to a variety of economic and other constraints. These obstacles need to be overcome if the Government of Nepal is to meet its key target, affordable and reliable energy for all, as part of its work towards the SDGs.

2.2.2 Energy supply and consumption in Nepal

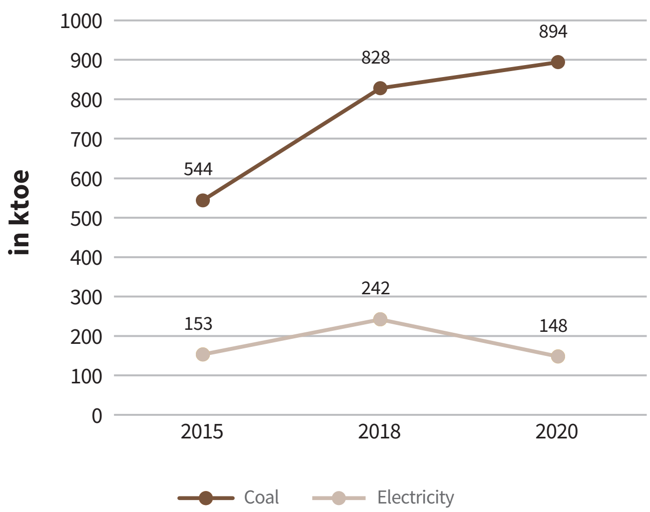
In 2018, Nepal's total national energy production was estimated at 10 million tonnes of oil equivalent (Mtoe), while its total final consumption (TFC) was approximately 14 Mtoe (Figure 1). Nepal's energy consumption is primarily based on biomass, which constitutes nearly 71% of total energy consumption (IEA 2019). The energy deficit of roughly 4 Mtoe is met primarily through imports of electricity, oil, and coal. The residential sector is among the country's largest energy consumers, accounting for 74% of total consumption, whereas the industrial and agricultural sectors consume merely 8% and 2%, respectively. The transport sector's share is a little over 12%.

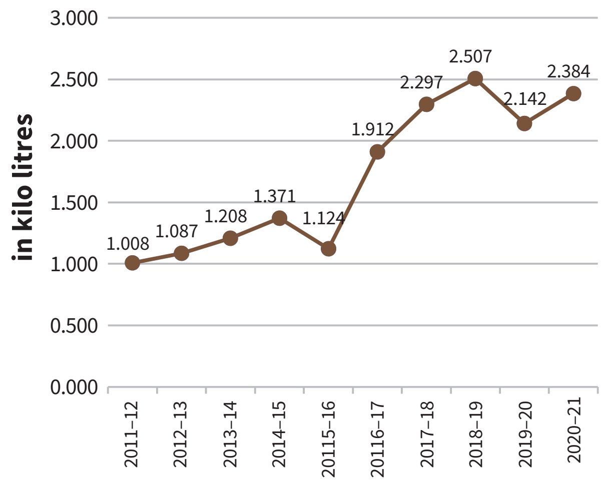
FIGURE 1 TOTAL ENERGY SUPPLY AND CONSUMPTION IN NEPAL IN 2018



Source: IEA (2019)

FIGURE 2 NEPAL'S COAL AND ELECTRICITY IMPORTS, 2015–2020 (LEFT), AND OIL IMPORTS, 2011–2020 (RIGHT)





Sources: IEA (2019); Knoema (2022a); NOCL (2022)

In terms of electricity access, Nepal has witnessed one of the world's fastest processes of electrification in the last decade. As of 2020, 90% of the country's population had access to electricity, compared to only 65% in 2011 (IEA et al. 2022). The people's access to electricity has been increasing at an annual rate of 4.3% compared to the global average of 3.5% (Trace 2021). The Nepal Electricity Authority had been working towards 100% electrification by 2023 (APEC 2018). However, this target has been revised to 2024 in the government's 2022 budget speech.

Regarding the share of renewable energy in total final energy consumption (TFC), it was 6.7% in 2018 (IEA 2019). This share excludes the traditional use of biomass. In terms of renewable energy's share in TFC, Nepal ranks fourth among countries of the HKH. India ranks first, followed by China and Pakistan. Nepal aims to more than double its share of clean energy by 2030 (GoN 2020).

As for energy imports, the imports of coal and oil nearly doubled in 2018 relative to 2015. Oil imports are on an increasing trend, a 148% increase in 2018–2019 over 2011–2012. The import of oil decreased in 2019–2020 due to COVID-19; however, oil imports have been increasing again since 2020 (NOCL 2022) (Figure 2). In contrast, Nepal has had a power surplus during the monsoon season with the addition of hydropower capacity in recent years. It led to a reduction in electricity imports by nearly 40% in 2020 compared to 2018. However, despite this increase in domestically produced hydroelectricity, both local consumption of, and regional trade in electricity have not increased (Shrestha 2021).

National energy demand is estimated to keep on increasing significantly to achieve projected economic growth. The projected national energy demand is 0.6 million terrajoules (or one thousand billion joules) (TJ) and 1.6 million TJ, for 2030 and 2050 respectively, under a high annual GDP growth rate scenario of 6.5% (WECS 2013). Table 1 presents the projections in energy consumption by fuel for Nepal.

TABLE 1 PROJECTIONS OF ENERGY CONSUMPTION BY FUEL FOR NEPAL (TJ)

Source of fuel	2020	2030	2040	2045	2050
Biomass	399,003	464,808	545,351	605,483	699,304
Fossil fuels	81,159	159,643	309,500	453,514	741,627
Electricity	16,677	39,002	71,403	101,760	160,306

Source: WECS (2013)

It has been projected that almost 70% of Nepal's energy supply will be sourced from biomass in 2030, followed by fossil fuels (24%) and electricity (6%). By 2050, the contribution of hydropower is projected to rise to 10% of total energy consumption. This projection differs significantly from the recently published Nepal's Long-term Strategy for Net-zero Emissions (GoN 2021). This document has put forward ambitious targets to reduce greenhouse gas (GHG) emissions by maximising local renewable energy generation to displace fossil fuel use and has recommended clean fuel transitions in different economic sectors. It would require an installed capacity of 53.2 gigawatts (GW), including 9 GW from non-hydropower renewable energy sources, by 2050. Renewable energy will be critical to this sustainable energy transformation. Hence the government must prioritise the development and use of RE in order to accelerate the energy transition in Nepal.

SECTION III

Renewable energy in Nepal

3.1 History of RE in Nepal

Nepal's renewable energy history dates back to as early as 1911, when the first hydroelectricity plant, a 500-kW facility in Pharping, generated power for Kathmandu, the country's capital. During the 5th Five-Year Plan (1975–1980), the first sectoral programme in the energy industry was implemented. Given the challenges of expanding the grid to remote areas and focusing on socio-economic development, distributed renewable energy (DRE) was included for the first time in the 7th Five-Year Plan (1985–1990). The Government of Nepal, through the Agriculture Development Bank, provided credit and subsidies for renewable energy technologies (RETs) such as micro-hydro, biogas, and solar photovoltaic (PV). Later, in 1996, the Alternative Energy Promotion Centre (AEPC) was established under the Ministry of Science and Technology as a nodal agency to develop and promote renewable/alternative energy technologies in Nepal (Amatya et al. 2019). A summary of key government policies, initiatives, documents, and programmes over the last half century regarding energy and climate change is given in Annex 2.

3.2 Renewable energy governance in Nepal

The Ministry of Energy, Water Resources and Irrigation (MoEWRI) is the line ministry and governs the electricity and alternative/renewable energy sector at the central level. The energy division is one of seven divisions in the ministry. The Alternative Energy Promotion Centre (AEPC) is under the energy division. AEPC is the nodal agency for renewable energy promotion in Nepal and responsible for policy formulation, planning, implementation, and monitoring (AEPC 2022a). It is a semi-autonomous government body and was established by the government after a cabinet decision to that effect, and through an Alternative Energy Promotion Development Board (AEPDB) order. The board is represented by the government, private sector, non-governmental organisations (NGOs), and financial institutions (Amatya et al. 2019).

After the new Constitution was promulgated in 2015, the government operated at three levels – central, provincial, and local. Nepal has seven provinces and 753 local-level governments. At the provincial level, renewable energy is governed by the energy-related line ministry, while an infrastructure development committee implements energy-related activities locally. Under Schedule 8 of the Constitution, the list of local-level power, alternative/renewable energy is delegated to the local level.

While technical assistance and capacity development for actors in different sectors are currently federal (AEPC) obligations, this may gradually decline and eventually be passed on to local and provincial organisations. The AEPC may support provincial and municipal governments in creating institutional arrangements, including policy support and capacity development, in order to enable renewable energy to be mainstreamed in addressing energy consumption and production (Amatya et al. 2019; Pokhrel 2020). However, greater clarity is needed for better coordination and cooperation, and co-existence of all the relevant renewable energy organisations at the three levels of government.

3.3 Government priorities in renewable energy

Renewable energy has long been one of the Government of Nepal's top pathways to expanding energy access. In 2000, it introduced a subsidy delivery policy for renewable energy. In 2006, the government promulgated the Rural Energy Policy intending to reduce rural poverty and conserve the environment through clean, reliable, and appropriate access to renewable energy. Thereafter, several subsidy policies and subsidy delivery mechanisms for renewable energy have been adopted. The AEPC currently implements the Renewable Energy Subsidy Policy 2022, which focuses on encouraging private entities and financial institutions to invest in the renewable energy sector and provide quality services in rural areas (MoEWRI 2022). Table 2 highlights the Government of Nepal's priorities in renewable energy as presented in key national documents and relevant SDGs.

3.4 Renewable Energy Subsidy Policy 2022

The Renewable Energy Subsidy Policy 2022 has replaced the preceding RE subsidy policy of 2016. The need for the revision is stated as accelerating the promotion of renewable energy to make it pro-poor, making timely adjustments in the subsidy amounts and loan period, and encouraging private-sector investment in providing high-quality renewable energy services in rural areas. The key areas of intervention covered by the 2022 subsidy policy are presented in Annex 4.

Though the 2022 RE subsidy policy remains similar to the 2016 policy in many respects, there are some significant changes in the capital subsidies for micro-hydro and solar-powered mini-grids, which have been increased. The capital subsidies for other technologies have not been reduced. However, considering the inflation over the last five years, it can be understood effectively as a reduction in the subsidies. Further, as with the previous policy, there is inconsistency in GESI incentives for various technologies promoted. The key changes in the 2022 subsidy policy with respect to varied technologies are highlighted in Table 3.

ELECTRIFICATION TECHNOLOGIES AND HISTORICAL TRENDS IN THEIR SUBSIDY RECEIVED

Rural electrification has been one of the flagship initiatives of the Alternative Energy Promotion Centre. Chiefly six rural electrification technologies, namely solar home systems (SHSs), solar–wind mini-grids (SWMGs), micro-hydro plants (MHPs), improved watermills (IWMs), biomass gasifiers (BMGs), and waste-to-energy (W2E) plants have been listed in the subsidy policies. Figure 3 illustrates the trends in the subsidies these technologies have received over the last few years.

The AEPC has promoted SHSs, MHPs, and IWMs since the early 2000s, whereas the first SWMG was piloted in 2011 with the support of the Asian Development Bank (ADB). Barring SHSs, capital subsidies for all the other rural electrification technologies have increased over time. The subsidy on SHSs[1] has been reduced by more than half in just the seven years between 2009 and 2016, and remained at that level since. Over 0.5 million

TABLE 2 GOVERNMENT PRIORITIES REGARDING RE IN KEY NATIONAL DOCUMENTS

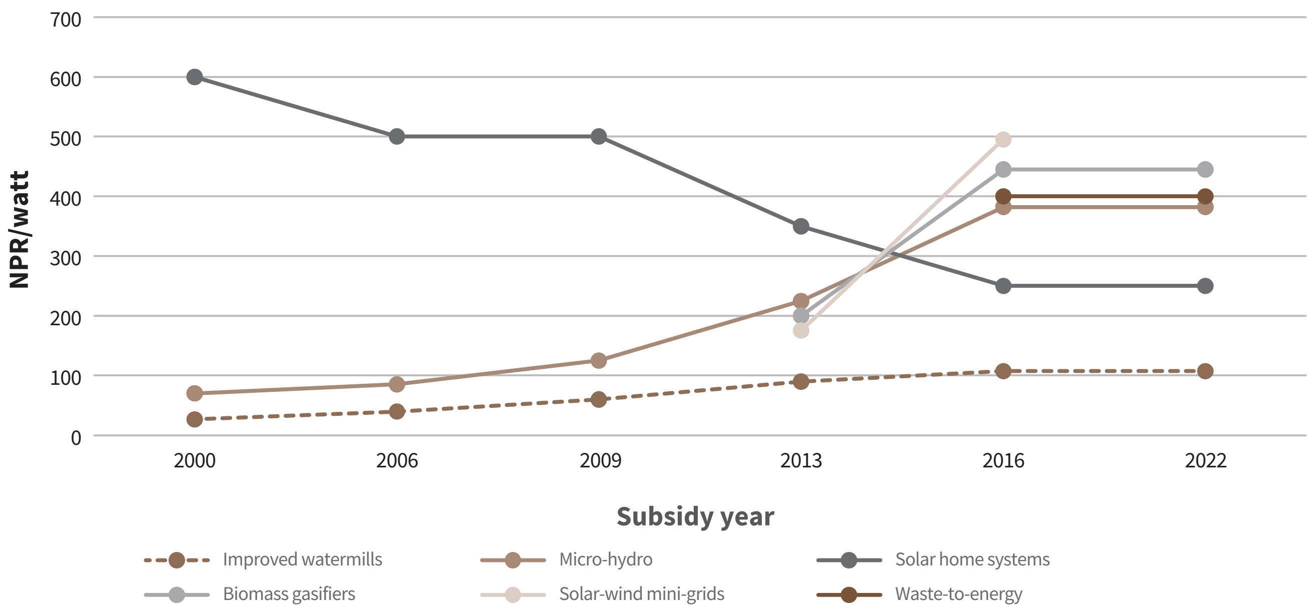
Government document	Key highlights
Constitution of Nepal	Article 51 (f) 3 mentions "ensuring reliable and affordable energy supply and proper utilisation of energy by generation and development of renewable energy for the fulfilment of citizens' basic needs".
National periodic plans	Renewable energy has been a part of the government's periodic plans since the 7th Five-year Plan (NPC 2022.). A summary of the highlights of some key plans is presented in Annex 2.
MoEWRI White Paper, 2018 titled 'Current status and future course of energy, water resources and irrigation sector'	The white paper aims to increase renewable energy access at all three government levels, central, provincial, and local. A summary of its highlights is presented in Annex 2.
Sustainable Development Goals	The relevant primary targets are to attain 99% electricity access, increase the share of clean energy to 50% of the total primary energy supply (TPES), instal 15,000 megawatts (MW) of clean energy generation, and increase per capita electricity consumption while transitioning towards electric transport and improved cooking solutions. SDG 7 targets and indicators for Nepal are presented in Annex 3.
Second Nationally Determined Contribution (NDC)	The energy targets in Nepal's second NDC include transitioning towards a clean and low carbon economy by installing 15,000 MW of clean energy generation and its reaching at least 15% of total primary energy supply. It also aims to promote electric passenger vehicles and electric and improved cooking technologies to reduce GHG emissions by 23% by 2030 from a business-as-usual (BAU) scenario (GoN 2020) (see Table 4).

Sources: Amatya et al. (2019); GoN (2020); MoEWRI (2018); NPC (2022)

TABLE 3	KEY CHANGES IN THE 2022 SUBSIDY POLICY WITH RESPECT TO VARIED TECHNOLOGIES
Subsidy headings	**Key highlights**
Micro-hydro/mini-hydro plants (MHPs)	1. The ownership structure is defined as: • Local government and local community-based institutions • Private institutions or public–private partnerships 2. In the earlier policy, the subsidy was calculated based on the number of households served, the cost of generation equipment per kW, and civil structure cost per kW. Private institutions were allowed to claim subsidies based on energy generation. In the 2022 policy, publicly owned plants are subsidised up to 90%, while private sector projects have the option of either a capital expenditure (CapEx) subsidy based on number of households, cost of generation equipment per kW, and the cost of civil structure per kW, or an operating expenses (OpEx)-based subsidy based on electricity generation. 3. The additional incentives for gender equality and social inclusion (GESI) remain unchanged. 4. The subsidy for MHPs with capacities less than or equal to 10 kW remains unchanged. 5. Support for productive end-use on MHPs remains the same.
Incomplete MHPs that could not be completed and improved water mills (IWMs)	Same as the 2016 policy – up to 80% of the cost. GESI incentives are not included in the 2016 or 2022 policy.
Solar home systems (SHSs)	Same as the 2016 policy. A flat subsidy rate with respect to system size (per HH per system) and according to geography (higher subsidy for defined remote locations). GESI incentives are not included in the 2016 or 2022 policy.
Solar mini-grids	1. The ownership structure is defined as: • Local government and local community-based institutions • Private institutions or public–private partnerships 2. The capacity for publicly-owned solar mini-grids increased to 250 kilowatt peak (kWp) from 100 kWp previously, and the subsidy limit for such privately-owned grids is 100 kWp 3. The subsidy was previously based on the number of households and plant capacity. Private institutions were allowed to claim subsidies based on energy generation. In the 2022 policy, publicly-owned plants are subsidised up to 90% and private plants up to 60%. OpEx or generation-based subsidies are not included. 4. The institutional solar PV system and community-owned or private irrigation systems have the same subsidy provisions as before, while the subsidy for community or local government-owned solar drinking water systems has been increased to 90% of the capital expenditure 5. Private sector-operated solar drinking water systems are excluded 6. No additional incentives for GESI, same as previous policy. Moreover, the GESI incentives for solar drinking water systems have been removed.
Solar PV in grid-connected areas but with irregular supply	Same as the 2016 policy. NPR 20,000 for off-grid solar PV ≥200Wp.To incentivise the adoption of solar net metering, a 75% interest buy-down is offered for residential systems above 500 Wp, while a 50% interest buy-down is available for commercial systems above 1500 Wp. GESI incentives are not included in 2016 or 2022 policy.
Solar thermal systems	Same as the 2016 policy. The subsidy rates for the solar thermal systems is identical. GESI incentives are not included in the 2016 or 2022 policy.
Biogas	The annual reduction in the subsidy on domestic biogas has been excluded. GESI incentives are only included for domestic biogas and not for other listed biogas applications.
Bio-energy	GESI incentives are only included for domestic improved metallic stoves and not for other listed bio-energy technologies.
Wind energy	Same as the 2016 policy. A maximum generation and electricity distribution subsidy of NPR 495,000 per kWp. GESI incentives are included in the 2016 or 2022 policy.
Solar–wind hybrid	Same as the 2016 policy. A maximum generation and electricity distribution subsidy of NPR 495,000 per kWp. GESI incentives are not included in 2016 or 2022 policy.
Productive energy use (PEU)	Same as the 2016 policy. The subsidy varies between 30% and 60%, depending on the type of enterprise.

Source: MoEWRI (2022)

FIGURE 3 TRENDS IN CAPITAL SUBSIDIES FOR RURAL ELECTRIFICATION IN NEPAL



Sources: Adhikari et al. (2018); MoEWRI (2022)

SHSs were installed during this period. While the cost of SHS batteries has increased during the period, the drop in the price of solar panels and in LED prices, and the government's push for significant volumes are the most likely reasons for the subsidy cost to have decreased.

Solar, wind, and MHP mini-grids receive one of the largest capital expenditure subsidies under the present subsidy policy. The solar mini-grid subsidy increased by 250% in 2016. The rise is likely due to the significant transmission, distribution, storage, and transportation costs. Only a few mini-grids had been installed before 2017. In 2018, ADB's South Asia Subregional Economic Cooperation (SASEC) project[2] was launched to instal solar and solar–wind mini-grids over 0.56 MW. The capital cost of AEPC's solar mini-grid projects under the SASEC project averaged NPR 597/watt peak (Wp), with an average capital cost per household of NPR 0.25 million[3]. Similarly, the CapEx subsidy of MHPs has grown over the period. It was increased by 125% in 2010, 180% in 2013, and 174% in 2016 relative to the previous policy. Only a few pilot projects of biomass gasifiers and W2E have been conducted, and no large-scale adoption has occurred to date.

Historically, the AEPC has been able to make significant headway toward higher tiers of electricity access. In the early 2000s, there was a significant push to promote pico hydro systems up to 5 kW and 5 Wp solar lighting. Plant sizes have gradually increased over time, such as micro-hydro and larger-sized solar home systems. Current developments indicate that the AEPC is focusing on Tier 3 solar mini-grid and mini-hydro projects (greater than 100 kW) under the Government of Nepal's Ujalylo Nepal Special Minigrid Programme. This programme, announced in February 2020, aims to supply electricity to over 100,000 households via more than 600 mini-grids (Urjakhabar 2020).

Since capital subsidies have risen over time, more public money or grants will be required to complete the projects. Public funds are already under pressure as a result of this predicament, making it even more challenging to reach national electrification goals. This necessitates a series of corrective actions, such as optimising and lowering capital costs, demand aggregation, and diversifying the sources of funding.

3.5 Public finance in renewable energy

The AEPC gets its funds chiefly from two sources, the government and international development partners. In the past, international donors have always provided a significant share of the funds; however, this has reduced in recent years. The donor share was 82% in 2009–2010. That dropped to almost 40% in the last five fiscal years, while the government's share has risen to

[1] Subsidy based on 20Wp SHS has been taken as the reference.
[2] Nepal is a founding member of the SASEC programme, joining with Bangladesh, Bhutan, and India to form this project-based partnership in 2001. Maldives and Sri Lanka became full members of SASEC in May 2014, following several years as active observers (SASEC n. d.).
[3] The value has been calculated using the SASEC programme's capital cost.

more than 60%. It shows that the Government of Nepal is committed to the deployment of the renewable energy sector.

In the last five fiscal years, an average of NPR 3.4 billion has been budgeted for AEPC. The largest amount was NPR 4.7 billion, in 2017–2018, while the lowest was NPR 2.6 billion, in 2019–2020. The annual budget allocations do not match long-term government plans such as its Nationally Determined Contribution and the SDG targets, and has created uncertainty about those being achieved. A multi-year budget commitment would enhance market confidence, which may strengthen private-sector capacity and improve competitiveness. Because the limited budget is heavily geared toward capital subsidies, variations in the annual budget impede the private sector and market growth.

In 2013, the Central Renewable Energy Fund (CREF) was founded to gradually phase out subsidies and replace them with credit mechanisms. However, the implementation of this has been very challenging as, historically, a large percentage of the budget has been set aside to subsidise the capital costs of the programme's numerous renewable energy projects. In 2020–2021, 5% of the budget was set aside for project finance to extend credit. The credit disbursement, however, has been extremely low (Adhikari et al. 2018).

Figure 4 (left) depicts the budget's variations from year to year and the funding distribution for AEPC's leading technologies and programmes in 2020–2021 (right). Access to electrification received a substantial share, accounting for 30% of the budget, as did clean cooking technologies. This funding allocation aligns with the period plans' primary goals of ensuring access to electricity and clean cooking sources.

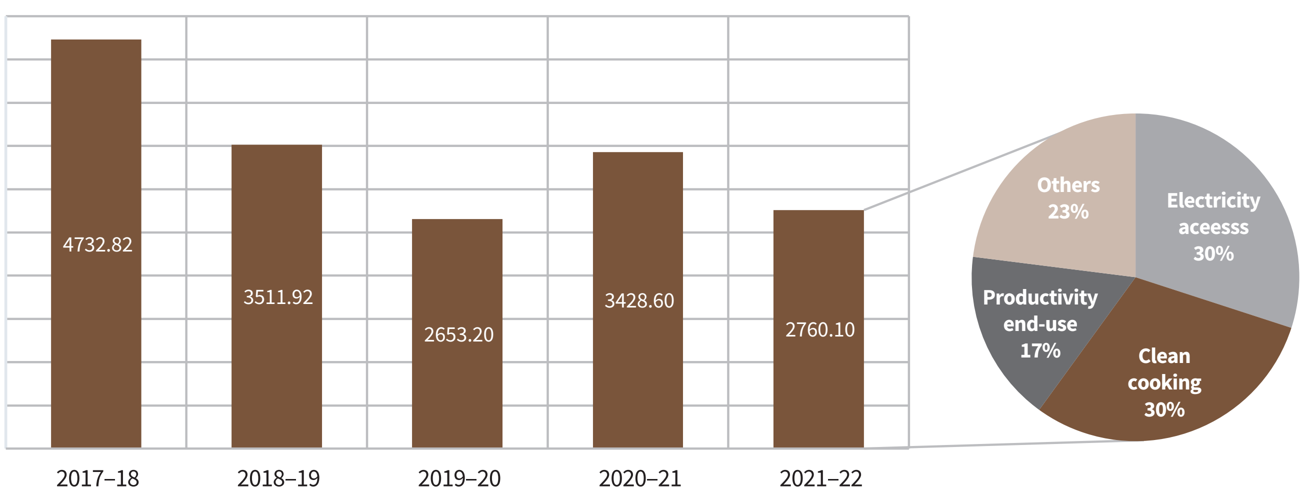
In the last two fiscal years, on average, 34.5% of the total budget was allocated to solar PV technologies for various applications; this is by far the highest allocation among the technologies promoted by the AEPC. NPR 1.14 billion and NPR 0.98 billion were allocated to various solar PV technologies in fiscal years 2020–2021 and 2021–2022, respectively, with a significant portion of these resources allocated to solar mini-grids.

The Government of Nepal allocated NPR 309 million in 2020–2021 and NPR 60 million in 2021–2022 for micro-hydro and mini-hydro projects; this was approximately 9% and 2% of the total annual AEPC budget for the year, respectively. In addition, funding from SASEC's mini-grid support programme totalled NPR 40 million in 2020–2021 and NPR 365 million in 2021–2022, respectively.

Similarly, 25% of the total budget was allocated for cooking technologies in the last two fiscal years. This budget allocation is the second-highest among the technologies promoted by the AEPC. NPR 1 billion and NPR 0.58 billion were budgeted for various cooking technologies in 2020–2021 and 2021–2022, respectively, with a significant portion of the resources allocated to improved cook stoves (ICS).

Though the AEPC's annual budget has consistently been within a comparable range in recent years, in real terms, its allocation has decreased if one takes annual inflation into account. To undertake more powerful interventions for renewable energy at the national and subnational levels, there is an urgent need to catalyse increased investments in, and efficient public spending on renewable energy.

FIGURE 4 AEPC'S ANNUAL BUDGETS, 2017–2021 (NPR MILLION, LEFT), AND THE BUDGET DISTRIBUTION IN 2020–2021 (RIGHT)



Sources: AEPC (2022b); AEPC's annual reports, 2017–2020

3.6 Deployment of renewable energy

The AEPC has played a crucial role in the promotion and deployment of renewable energy technologies to provide end-use services such as electricity, clean cooking, and thermal heating. This section examines the two flagship initiatives, namely rural electrification and clean cooking.

3.6.1 Rural electrification

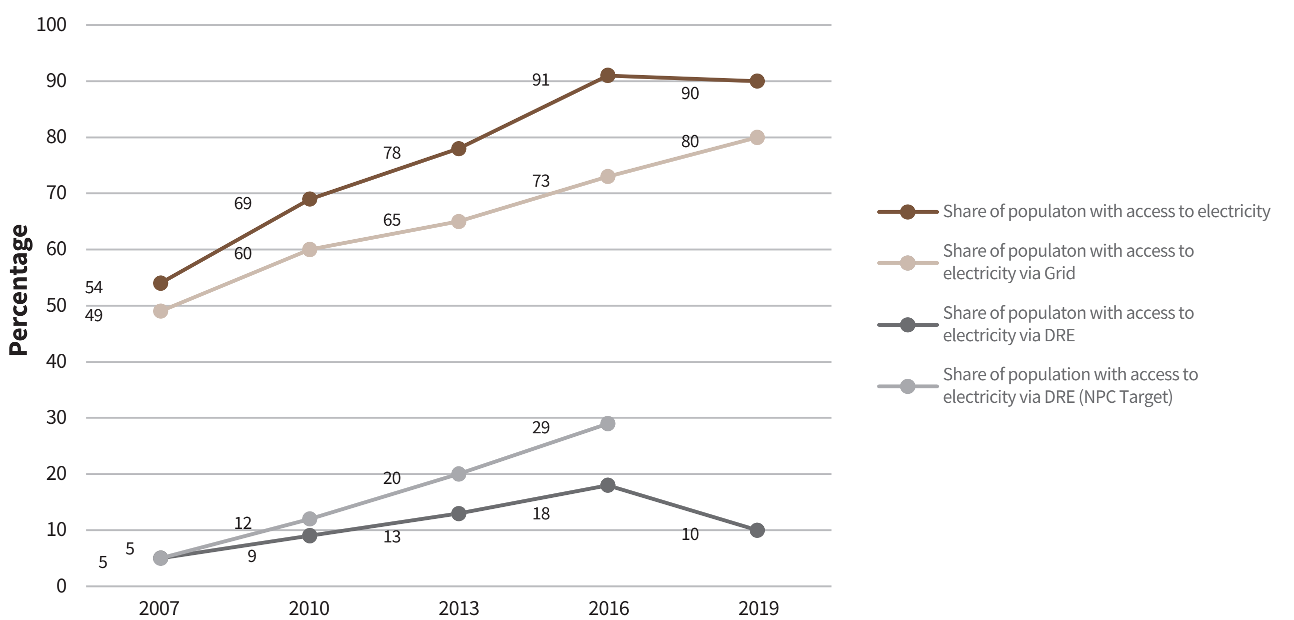
Nepal has made tremendous strides toward providing universal access to electricity. As shown in Figure 5, little over half the country's population had access to electricity 2007; just 12 years later, almost 90% of the population had access to electricity. The rapid expansion of the national grid and the deployment of decentralised renewable energy (DRE) have played a vital role in this accomplishment. Given the level of allocated resources, DRE systems have contributed significantly. According to calculations based on data in AEPC's annual reports, solar household systems and MHPs provided electricity access to around 16% and 3% of the population, respectively, in 2019.

Electricity access for rural populations is a fundamental goal of national periodic plans for renewable energy, reflected in their primary objectives. Over the decade, the AEPC has met, on average, more than 76% of the National Planning Commission (NPC) targets (Figure 5). Two technologies, in particular, have played a significant role in accomplishing this goal: micro-hydro and solar photovoltaic (PV) energy. Figure 6 depicts the total number of houses powered by solar PV and micro-hydroelectric power.

In Nepal, solar PV in particular has played a critical role in expanding access to electricity and supporting the development of productive end-use applications. The cumulative solar PV capacity deployed through AEPC was estimated at 35.6 MWp in 2019 (AEPC 2019). Approximately 59% of this was estimated to be solar home systems, with the remainder comprising solar pumps, mini-grids, institutional systems, on-grid rooftop solar, streetlights, and other applications. By the end of 2019, approximately 1 million households had been electrified through solar home systems, representing 16% of the total rural population (AEPC 2021). Falling solar PV prices, huge volumes set as targets, modular kits that can be easily installed, and them being light and hence enabling easy transportation are the primary factors driving the considerable increase in the use of solar PV.

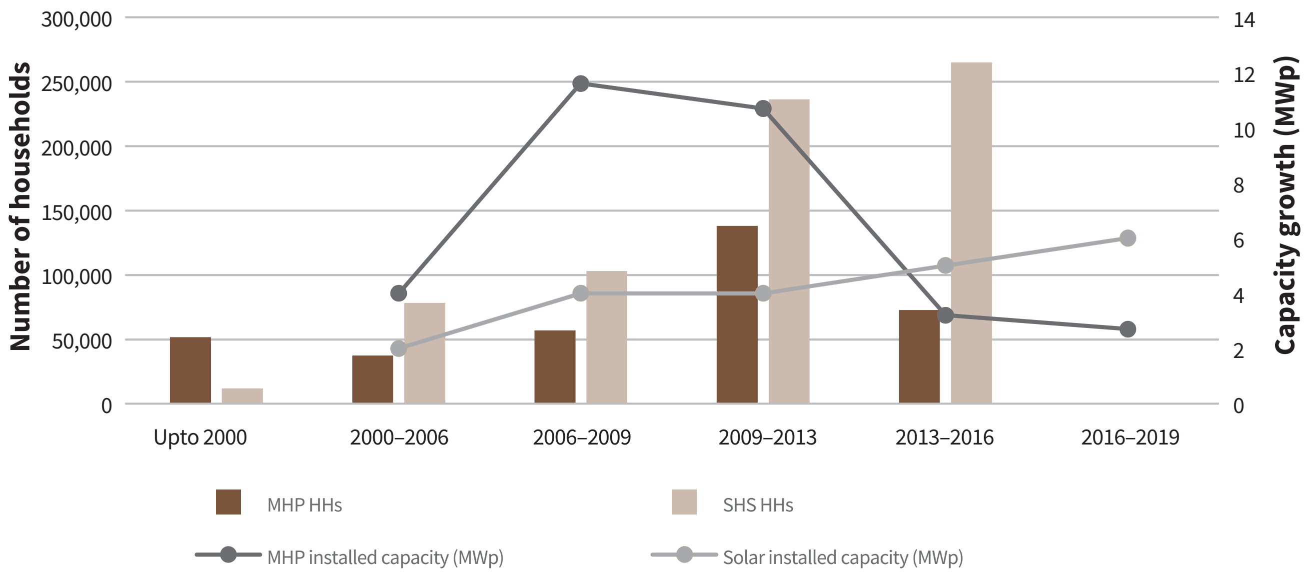
Micro-hydro or mini-hydro plants were one of the first electrification technologies to be promoted in Nepal, dating back over a century. Almost a million people in Nepal are supplied electricity via MHPs. In 2019, the total installed capacity of MHPs was 32.2 MW, supplying power to 3% of the population (NPC 2022).

FIGURE 5 SHARE OF POPULATION WITH ACCESS TO ELECTRICITY, 2007–2019 (%)



Source: NPC (2022)

FIGURE 6 ACCESS TO ELECTRICITY IN NEPAL AND THE GROWTH IN CAPACITY OF SHSs AND MHPs DURING EACH SUBSIDY PERIOD



Sources: Adhikari et al. (2018); NPC (2022)

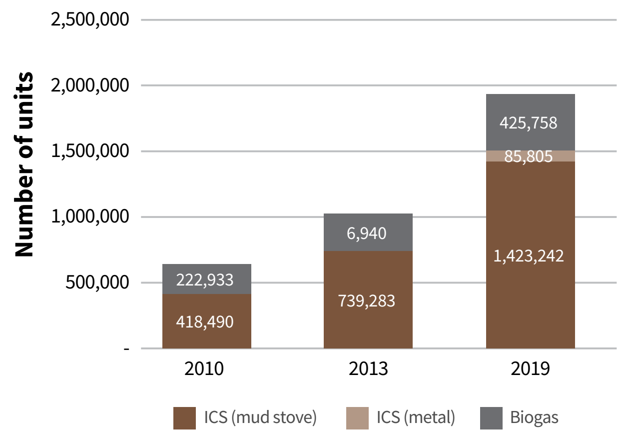
3.6.2 Clean cooking

Along with electrification, clean cooking is also a top priority of the Government of Nepal, as over 65% of the households in the country still rely on traditional fuels such as fuelwood, other biomass, and animal residue. Further, the regular burning of traditional biomass has been linked to indoor air pollution, which has resulted in 18,000 premature deaths, a variety of respiratory illnesses, and deforestation (Paudel et al. 2021).

The Government of Nepal has set an ambitious goal of providing Tier 3 cooking services[4] to all households by 2030. The second NDC, the National Adaptation Programme of Action (NAPA), the 15th Periodic Plan of the NPC, and the MoEWRI White Paper referred to earlier (MoEWRI 2018) all promote clean cooking. According to the National Planning Commission's SDG roadmap for 2016–2030, the share of households using solid fuels should fall to 30% by 2030. Likewise, these targets have been mentioned in the 14th Periodic Plan, the SDG 7 goals, and the second NDC.

Figure 7 shows the expansion of clean cooking solutions such as improved cook stoves and biogas since 2010. This includes domestic, institutional, and commercial units promoted by the AEPC. By 2019, more than 1.9 million households benefited from clean cooking technologies, including 1.5 million improved cook stoves and 0.4 million biogas plants. Under the Terai Clean Cooking Programme, the AEPC distributed 10,000 electric stoves in 2019–2020 (MoFE 2021) to replace traditional fuels. The AEPC aims to deploy 0.5 million electric stoves, 0.49 million

FIGURE 7 EXPANSION IN CLEAN COOKING TECHNOLOGIES, 2010–2019



Source: AEPC (2021)

improved cook stoves for Tier 3, and 10,000 biogas stoves as part of a USD 49 million five-year programme to accelerate investment in, and market development of clean cooking technologies and hence minimise the dependence on imported fuels (GCF 2021).

3.7 The role of the private sector in renewable energy

The private sector has played a major role in the deployment of renewable energy technologies in Nepal and in meeting AEPC targets. Over 400 private companies work in the solar, micro-hydro, and biofuel sectors. Each of the sectors also has umbrella organisations representing private-sector companies.

[4] Tier 3 is the third level in the multi-tier framework for cooking that assesses a household's access to modern energy services. The framework has six attributes – efficiency, exposure to pollutants, convenience in accessing the fuel, its availability, safety, and its affordability.

For instance, the Solar Electric Manufacturers Association Nepal (SEMAN) represents numerous solar PV private companies in Nepal. It has 112 solar companies listed as members; however, the number of solar companies in Nepal is expected to be far greater than 112 (SEMAN n. d.). SEMAN also trains solar technicians in collaboration with the Council for Technical Education and Vocational Training (CTEVT) to generate skilled workers.

Likewise, in 2020, an estimated 60 micro-hydro companies were listed as members of the Nepal Micro Hydropower Development Association (NMHDA). The local companies can manufacture all the MHP equipment except generators and valves up to 100 kW. Historically, turbines and electronic load controllers were exported to more than 12 countries from Nepal, including Japan, Malaysia, India, and Pakistan (Mathema 2014). The umbrella organisation for biogas companies in Nepal is the Nepal Biogas Promotion Association (NBPA), which has over 114 members (NBPA 2022). In 2021, 132 companies met AEPC's qualification benchmarks of experience, financial viability, human resources, and after-sales services. Ninety-seven companies qualified for large biogas-based applications, 12 for domestic biogas applications, and 23 companies for biomass-based applications.

3.8 Role of renewable energy in national commitments

Renewable energy features strongly in the NDCs submitted by most countries to the United Nations Framework Convention on Climate Change (UNFCCC), demonstrating that the transition to renewable energy has become vital to combating climate change. Renewable energy helps Nepal mitigate and adapt to climate change. The accelerated deployment of renewables promises economic growth, job creation, climate change mitigation, air pollution reduction, enhanced health, education, and social capital. The role of renewable energy in achieving national commitments can be broadly categorised under the following heads:

- Electrification
- Energy mix
- Cooking
- Cross-sectoral: Transportation, heating, cooling, etc.

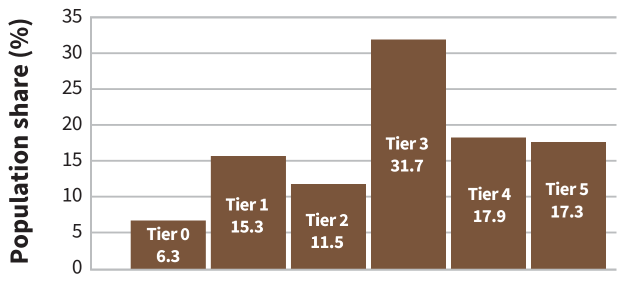
We now examine each of these four areas.

3.8.1 Electrification

In the course of interviews with AEPC officials, we were told that there are approximately 210,000 households yet to be electrified as Nepal aims to reach universal electricity access. The National Electrification Plan aims to meet these targets through the extended grid, intermittent mini-grids, or permanent off-grids. It is estimated that 98,000 households will be served through permanent off-grids (Gesto 2021), which is equivalent to a 33 megawatts peak (MWp) solar PV storage system. Likewise, under the 2018 Universalising Clean Energy in Nepal Plan, the National Planning Commission aims to reach at least Tier 3 level electricity access (NPC 2018). Tier 3 level of access to electricity is when a household is estimated to consume at least 200 W or 1 kWh electricity per day, and gets it for a duration of at least 8 hours per day, including three hours in the evening. The Energy Access Diagnostic Report, based on the Multi-Tier Framework, 2017, estimated that 33.1% of the households in the country are yet to reach Tier 3 access to electricity (Figure 8) (Pinto et al. 2019). It means that an estimated 1.8 million households out of an estimated 5.4 million need to expand their access to electricity (NiD 2021). This would correspond to a requirement of 358 MW power or 1.8 gigawatt-hours (GWh) of electricity per day. This is approximately equivalent to 600 MWp solar PV storage[5] or a 150 MW MHP plant,[6] so as to supply the electricity needed.

One can surmise that renewable energy technologies will play an essential role in transitional grids in areas where the least-cost grid expansion will occur in the future. The required capacities of these intermittent transitional RETs would potentially be determined by the National Electrification Master Plan report to be published this year. As of now, the required capacity has not been determined.

FIGURE 8 THE MTF TIER DISTRIBUTION OF ELECTRICITY ACCESS AMONG HOUSEHOLDS IN NEPAL



Source: Pinto et al. (2019)

[5] Calculation based on Nepal's average solar radiation and system losses.
[6] Estimated at an average capacity factor of 50%.

Building approximately 33 MWp capacity, to meet off-grid needs, would require a capital investment of NPR 19.8 billion[7]. The investment needed would further increase in case of deploying RETs as transitional grids; 20% of the requirement of 600 MWp would mean NPR 72 billion in total capital investment (see Annex 5).

To meet the off-grid targets for 2030, an estimated investment of NPR 2.5 billion is required annually. This amount is equivalent to approximately 90% of AEPC's current annual budget. If the costs of building 20% of the estimated transitional mini-grids are considered, keeping the budget for other programmes the same, AEPC would require an estimated 326% of its current annual budget (Annex 5). AEPC's annual fiscal budget for electricity access is over NPR 8 billion. It seems highly unlikely that these capacities will be built, and demand met, with the current funding mechanisms and policy instruments. Thus, suitable policy and enablers are necessary to meet the ambitious target.

3.8.2 Energy mix

Nepal's second NDC has set a target of 15% of renewable energy in total final consumption by 2030, replacing fossil fuel and traditional fuel use, and of expanding clean energy to 15,000 MW (see Table 4 for key targets in the second NDC). The accelerated deployment of hydroelectricity, as well as non-hydro energy sources, will be key to meeting these targets, and their importance is further highlighted in the long-term Nepal's Long-term Strategy for Net-zero Emissions. As hydropower will continue to face climate-induced variability in generation, other renewable energy sources such as solar, wind, biomass, will supplement and complement hydropower to build greater resilience in the energy system.

The 2019 Multi-criteria Analysis for Planning Renewable Energy (MapRE) by the World Bank estimates Nepal's solar PV market potential to be more than 50 GWp, including the utility, off-grid, and rooftop subsectors (Table 5) (ESMAP 2021). This potential equates to a market opportunity of NPR 5,250 billion. At present, the Government of Nepal has set a cap to RE grid penetration at 10% of total installed hydropower capacity. However, with increasing cross-border transmission connections, bilateral electricity trade, and planned hydropower projects, this cap can be revisited.

3.8.3 Cooking

As stated above, roughly 65% of the households in Nepal are dependent on traditional fuels and energy sources such as fuelwood, and plant and animal residues. Over 62% of the households still use

TABLE 4 TARGETS LISTED IN NEPAL'S SECOND NDC

Description	Target	Remarks
Energy generation	Expand clean energy generation from 1,400 MW to 15,000 MW, of which 5%–10% will be from bioenergy, solar, wind, and mini/micro/small hydro by 2030	Of the 15,000 MW, 5,000 MW is an unconditional target. The remainder is dependent upon funding from the international community
Energy mix	15% of total energy demand is supplied from clean energy sources by 2030	Total clean energy share in TPES
Transportation	25% of all private passenger vehicles (including two-wheelers) and 20% of all four-wheeled public passenger vehicles will be electric by 2025	Reduce the fossil fuel share of the transport sector to 36 million GJ from 40 million GJ in the BAU for 2025. This will result in a 9% decrease in fossil fuel dependence and an 8% decrease in carbon dioxide (CO_2) emissions
	Increase sales of all private passenger vehicles (including two-wheelers) to 90% electric and of all four-wheeled public vehicles to 60% electric by 2030	Reduce energy demand by the transport sector to 34.5 million GJ from 48 million GJ in the BAU for 2030. Around 28% decrease in fossil fuel dependence and CO_2 emissions
	Develop 200 km of the electric rail network by 2030 to support public commuting and the mass transportation of goods	
Clean cooking	Install 500,000 improved cook stoves (ICS), specifically in rural areas, 200,000 household biogas plants, and 500 large-scale biogas plants (institutional/industrial/municipal/community) by 2025	Reduce emissions to 1,774 billion grammes (Gg) CO_2eq from 1,999 Gg CO_2eq in the 2025 BAU scenario. Around 11% reduction in emissions from the cooking sector
	Ensure that 25% of households use electric stoves as their primary mode of cooking by 2030	Reduce emissions to 1,599 Gg CO_2eq from 2,064 Gg CO_2eq in the 2030 BAU scenario. Around 23% reduction in emissions from the cooking sector

Source: GoN (2020)

[7] The average capital cost per Wp is NPR 600.

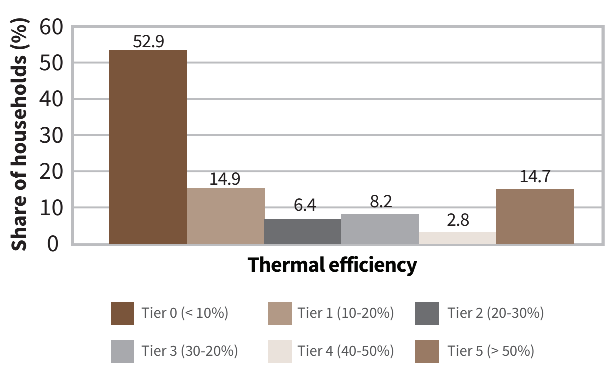
TABLE 5 SOLAR PV MARKET POTENTIAL IN NEPAL

Application	Potential (GWp)	Remarks
Utility-scale solar PV	46	The analysis excludes agricultural land and north-facing mountain slopes and only accounts for 30% of the identified land
Solar PV mini-grid	2	The analysis accounts for municipalities not connected to the national grid and wards with at least 50 households, excluding the north-facing mountain slopes and agricultural land
Solar PV rooftop	3.5*	The analysis considers 10% of the rooftop space

Note: * 266 million sq. m roof area, and calculated at 7.5 sq. m per kW.
Source: ESMAP (2021)

traditional fuels and cook on an open fire, categorised as lower than Tier 3 cooking access to modern energy services (IEA et al. 2022). The government aims to provide clean cooking services to all households by 2030 by promoting cooking technologies of at least Tier 3. It has set as a target reducing the proportion of households using traditional fuels to 30% while increasing the share of those using electric cooking technologies to 25%. This implies lifting 1.6 million households to Tier 3 cooking services and providing 1.8 million households with electric cooking technologies. The cost of this has been estimated at over NPR 15 billion. Figure 9 shows the distribution of households across various cooking tiers in Nepal under the multi-tier framework (MTF).

FIGURE 9 THE DISTRIBUTION OF HOUSEHOLDS ACROSS COOKING TIERS IN NEPAL



Source: Pinto et al. (2019)

3.8.4 Cross-sectoral application of RE

The residential sector consumes around 75% of all electricity in Nepal, followed by the transport sector, which consumes around 12.6% (IEA 2019). Many households in the country do not employ mechanical heating and cooling equipment systems due to their high costs, unreliable electricity supplies, and the availability of fuelwood (Pokharel and Rijal 2021). In 2018, Nepal's fossil fuel energy consumption was 25% of the total final consumption, which was almost double that in 2014 (Knoema 2022b). The country's main energy sources include fuelwood, agricultural residues, animal waste, hydropower, and solar power. Due to its steep mountainous topography, the country has excellent hydroelectric and renewable energy potential. The country's hydropower potential from its 6,000 perennial rivers and rivulets has been estimated at 43 GW. The share of renewable energy currently in total final consumption is low, and this untapped renewable energy potential can be utilised across sectors to fulfil Nepal's NDC commitments. Affordable, reliable electricity from renewable energy resources for cooking and heating in the household sector would raise per capita electricity consumption, which can boost socio-economic development and people's well-being.

Annex

Annex 1: List of the key stakeholders interviewed

Organisation
Alternative Energy Promotion Centre
Nepal Renewable Energy Programme
Rural Energy and Energy Efficiency Programme, GIZ
Renewable Energy for Rural Livelihood, UNDP
SunFarmer Nepal
Gham Power Nepal Pvt. Ltd.
Energy Development Council
Kathmandu University

Annex 2: The government's key energy plans, policies, documents, and programmes over half a century

Year	Plan/polices/programme	Key highlights
1975–1980	Fifth Periodic Plan	First sector-specific policy for the energy sector
1985–1990	Seventh Plan	Renewable energy interventions initiated
1992	Water Resources Act, 2049 (1992)	Focuses on hydropower and other water sector development strategies
1992	Electricity Act, 2049 (1992)	Provides a legal framework for electricity regulation
1992	Hydropower Development Policy, 2049 (1992)	Major emphasis on the utilisation of hydropower potential
2001	Hydropower Development Policy, 2058 (2001)	Major emphasis on the utilisation of hydropower potential
2002	Water Resource Strategy, 2059 (2002)	Focuses on an integrated utilisation of water resources for electricity, irrigation, and drinking
2005	National Water Plan	Focuses on an integrated utilisation of water resources for electricity, irrigation, and drinking
2006	Rural Energy Policy 2006	Aims to reduce dependence on traditional energy sources and conserve the environment by increasing access to clean and cost-effective energy sources in rural areas
2008	Rastriya Bidhyut Sankat Nirupan Kaaryayojana	Thirty-eight-point electricity crisis resolution action plans –immediate, short term, and long-term
2011	Climate Change Policy, 2067 (2011)	Aims to reduce GHG emissions by promoting clean energy, such as hydroelectricity and other renewable energies, by increasing energy efficiency, and encouraging the use of green technologies
2014	Low Carbon Economic Development Strategy (Draft)	Focuses on climate-resilient development
2015	Constitution of Nepal	Highlights energy as a basic need and also the key roles of the federal, provincial, and local governments
2015	Urja Sankatkaal	Focuses on addressing the electricity crisis through multiple approaches
2016	Renewable Energy Subsidy Policy, 2073 BS	Focuses on the promotion of renewable energy technologies in various regions and identifies target groups contributing to modern energy access for all
2016	Renewable Energy Subsidy Delivery Mechanism, 2073	Focuses on the promotion of renewable energy technologies in various regions and identifies target groups contributing to modern energy access for all
2016	Nationally Determined Contribution (NDC)	Focuses on the promotion of renewable energy and energy efficiency for climate change mitigation and adaptation
2016	The Fourteenth Plan	Aspires to provide electricity from solar, hydro (mini and micro), and wind resources to an additional 9% of the population
2017	Biomass Energy Strategy 2017	Promotes biomass energy as a reliable, affordable, and sustainable energy resource
2017	National Renewable Energy Framework	Focuses on the promotion of renewable energy technologies in various regions of Nepal and identifies target groups contributing to modern energy access for all
2018	Energy White Paper ('Current Status and Future Roadmap of the Energy, Hydropower and Irrigation Sectors')	Highlights the status of the energy sector and the way forward for the next decade
2018	Electricity Regulatory Commission	Focuses on the regulation of electricity production, transmission, distribution, and trading
2022	Renewable Energy Subsidy Policy, 2078 (2022)	Focuses on the promotion of RE technologies in various regions of Nepal

List of key relevant institutions in the energy sector in Nepal

- National Planning Commission (NPC)
- Ministry of Energy, Water Resources and Irrigation (MoEWRI)
- Water and Energy Commission Secretariat (WECS)
- Department of Electricity Development (DoED)
- Department of Water Resources and Irrigation (DoWRI)
- Alternative Energy Promotion Centre (AEPC)
- Nepal Electricity Authority (NEA)
- Vidhyut Utpadan Company Limited (VUCL)
- Rastriya Prasaran Grid Company Limited (RPGCL)
- Hydroelectricity Investment and Development Company Limited (HIDCL)
- Water and Energy Consultants' Association Nepal (WECAN)
- Renewable Energy Confederation Nepal (RECON)
- Center for Rural Technology, Nepal (CRTN)
- Renewable Energy Technology Service Center (RETSC)
- Deutsche Gesellschaft fur Internationale Zusammenarbeit GmBH (GIZ)
- Prakrti Resources Centre (PRC)
- People, Energy & Environment Development Association (PEEDA)
- Center for Energy Studies (CES), Institute of Engineering, Tribhuvan University
- Renewable and Sustainable Energy Laboratory (RESEL), Kathmandu University
- School of Engineering (SoE), Kathmandu University
- Practical Action Nepal

Source: AEPC

National periodic plans

The portions of the successive periodic plans that deal with renewable energy focus mainly on electricity access, reducing the dependence on traditional fuels, and improving livelihoods. Table 6 presents how the 11th to the 15th plans, from 2007–2010 to 2019–2023, address renewable energy. It has been part of the periodic plans since the 7th Five-year Plan (NPC 2022). The periodic plans' long-term goals, objectives, strategy, and targets have changed over time, depending on context.

TABLE 6 RENEWABLE ENERGY UNDER THE 11TH–15TH PERIODIC PLANS

	11th Periodic Plan (2007–2010)	12th Periodic Plan (2010–2013)	13th Periodic Plan (2013–2016)	The Fourteenth Plan (2016–2018)	The Fifteenth Plan (2019–2023)
Key areas of focus	Improving the rural economy, quality of life, employment, and the environment by reducing imports and use of traditional fuels by using RETs, with a focus on making them affordable, commercial, and GESI-compliant	Increasing the share of renewable energy in total primary energy consumption (TPEC) and electricity access, appropriate technology, employment, and inclusive development with reduced environmental impacts	Increasing the share of renewable energy in TPEC and electricity access	Renewable energy and sustainable economic development	Clean and renewable energy
Key objectives	RET integration improves the environment, enhances social and economic activities for poverty alleviation, and augments livelihoods through productive end-use, capacity-building, and creating employment opportunities by displacing traditional and imported fuels	RET integration improves the environment, enhances social and economic activities for poverty alleviation, and augments livelihoods through productive end-use and creating employment opportunities by displacing traditional fuels	Promoting and developing alternative and renewable energy to reduce the dependence on traditional fuels and imports and expand energy use in rural areas where the national grid has not reached	Increasing the production of clean and renewable energy to provide increased access to modern energy and increase electricity access in rural areas where the national grid has not reached or is financially not viable	Enhancing the energy mix with alternative and renewable energy and effective transmission and distribution systems
Key targets	Electricity access to an additional 5% of the rural population	Electricity access to an additional 7% of the rural population	Electricity access to an additional 8% of the rural population and clean cooking by 2017	Electricity access to an additional 9% of the rural population and clean cooking by 2030	35 GW of hydroelectricity and 5 GW of alternative energy will be produced to increase per capita annual electricity consumption from 245 kWh to 3,500 kWh by 2044

Source: NPC (2022)

Aims of the MoEWRI's White Paper of 2018

In 2018, the MoEWRI published a White Paper titled 'Current Status and Future Roadmap of the Energy, Hydropower and Irrigation Sectors'. It presented a roadmap towards the sustainable development, conservation, and promotion of renewable energy. It aimed to provide universal access to electricity by 2023. It also aimed to increase renewable energy access at all three levels of government (central, provincial, and local) through the following steps:

- Promote the net metering and net payment solar rooftop programme in all 753 local government units
- Support the development of institutional arrangements to manage the sharing of natural resources between the federal level and provinces, between provinces, and between local units. Build capacities by supporting the preparation of reference templates for policies, acts, and rules for the development of renewable energy
- Provide technical assistance in policy-making and planning, and enable technology transfers for RE development and expansion
- Carry out effective mobilisation and management of RE funds that are received from national and international sources
- Implement, manage, and operate carbon funds through the Renewable Energy Fund
- Establish a local carbon market and access carbon finance to implement climate change mitigation and adaptation programmes
- Establish the Alternative Energy Promotion Centre (AEPC) as a centre of excellence
- Mainstream GESI in RE projects and programmes

Annex 3: SDG 7 targets and indicators for Nepal

Targets and indicators		2015	2019	2022	2025	2030
Target 7.1: By 2030, ensure universal access to affordable, reliable, and modern energy services						
Indicator 7.1.1	Proportion of population with access to electricity (%)	74.0	80.7	85.7	90.7	99.0
1	Per capita final energy consumption (Gj)	16.0	18.1	19.7	21.3	24.0
Indicator 7.1.2	Proportion of the population with primary reliance on clean fuels and technology					
1	Households using solid fuels as the primary source of energy for cooking (%)	74.7	65.0	55.0	45.0	30.0
2	People using liquified petroleum gas (LPG) for cooking and heating (%)	18.0	23.6	27.8	32.0	39.0
3	Annual electricity consumption (kWh/capita)	80	230	542	1,027	1,500
Target 7.2: By 2030, increase substantially the share of renewable energy in the global energy mix						
Indicator 7.2.1	Renewable energy's share in total final energy consumption (%)	11.9	22.1	29.7	37.3	50.0
1	Installed hydropower capacity (MW)	782	2,301	5,417	10,260	15,000
Target 7.3: By 2030, double the global rate of improvement in energy efficiency						
Indicator 7.3.1	Energy intensity measured in terms of primary energy use and GDP					
1	Commercial energy use per unit of GDP (toe/NPR million)	3.20	3.28	3.17	3.15	3.14
2	Energy efficiency in industry (MJ/NPR 1,000 of production)	47.2	45.3	43.8	42.4	40.0
3	Share of high-efficiency appliances in residences and commercial establishments (%)	10	15	30	40	60
4	Share of electric vehicles in public transport systems (%)	1	5	20	35	50

Source: GoN (2017)

Annex 4: Areas of intervention and capacities eligible for subsidy under the Renewable Energy Subsidy Policy 2022

Areas of intervention	Definition
Hydropower	
Micro and small hydro plants	Up to 1,000 kW
Incomplete, old MHP projects	MHP not completed due to the lack of financial or technical resources
Improved watermills (IWMs)	IWMs for hulling and grinding. IWMs up to 5 kW for electricity generation
Solar	
Solar home systems	Solar home systems of 10Wp–20 Wp, SHSs of 50Wp and above include storage, charge controllers, and lights
Solar water pumps	Solar PV and pumps for drinking water and irrigation
Solar mini-grids	Up to 250 kWp if owned by the local government, up to 100 kWp if under private or community ownership, or under public–private partnership (PPP) Captive generation for rural public institutes such as schools, health centres, etc. Solar irrigation operationalised by the local government, water user committee, or the private sector
Solar energy for areas with unreliable grid access	Solar streetlights Solar home systems of 20 Wp and 50 Wp for religious places Solar residential systems of more than 200 Wp for retrofitting existing inverters and battery systems Rooftop solar PV of more than 500 Wp for residential areas and above 1,500 Wp for commercial systems
Solar thermal systems	Encompasses residential and institutional solar cookers and dryers
Biofuels	
Biogas energy	2–6 m^3 residential biogas Categories of biogas based on waste-to-energy: small – 12.5–35 m^3; medium – 35–100 m^3; large – above 100 m^3
Biomass energy	Residential improved mud stoves only through local government 2- and 3-pot improved metal stoves for altitudes above 1,500 metres above mean sea level Improved metal stoves for public facilities 1- and 2-pot gasifiers and rocket stoves for rural and peri-urban areas Gasifiers for agricultural processing in cottage industry, and small or medium enterprises Biomass electrification of 5–100 kW in areas without electricity access
Others	
Wind energy	Up to 100 kW
Solar–wind hybrid	5–100 kW
Productive energy use	MSMEs using renewable energy Establishing micro-utilities for the operation of existing community electrification projects Irrigation systems based on existing micro-hydro plants

Source: MoEWRI (2022)

Annex 5: Investment required to meet targets

Capacity targets	Total investment (NPR billion) *	AEPC 21/22 Annual Fiscal Budget (NPR billion)	Annual investment (NPR billion)	Share of AEPC's 2021–2022 budget (%)	Deficit (NPR billion)
33 MWp by 2030	19.8	2.8	2.5	91	NA
600 MWp by 2030	360	2.8	45	1,630	42.24
20% of 600 MWp by 2030	72	2.8	9	326	6.24

* Note: Estimated at NPR 600/Wp with reference to solar mini-grids totalling 600 MWp as the generational requirement

Source: Authors' findings

References

Adhikari D., Malla, M. B., & Parthan B. (2018). *Modalities for operationalizing challenge fund in decentralized renewable energy: Background paper on existing experience*. Kathmandu: Practical Action. Retrieved from https://www.opml.co.uk/files/Publications/a1594-strengthening-the-disaster-risk-response-in-nepal/challenge-funds-and-renewable-energy-financing-background-paper.pdf?noredirect=1

AEPC (2018). *Progress at a Glance: A year in review. FY 2074/75 (2017/18)*. Kathmandu: Alternative Energy Promotion Centre, Ministry of Energy, Water Resources and Irrigation, Government of Nepal. Retrieved from https://www.aepc.gov.np/documents/annual-progress-report-aepc

AEPC (2019). *Progress at a glance: A year in review. FY 2075/76 (2018/19)*. Kathmandu: Alternative Energy Promotion Centre, Ministry of Energy, Water Resources and Irrigation, Government of Nepal. Retrieved from https://www.aepc.gov.np/uploads/docs/progress-at-glance-a-year-in-review-fy-207576-201819-1572879503.pdf

AEPC (2021). *Progress at glance: Year in Review FY 2076/77 (2019/20) and FY 2077/78 (2020/21)*. Kathmandu: Alternative Energy Promotion Centre, Ministry of Energy, Water Resources and Irrigation, Government of Nepal. Retrieved from https://www.aepc.gov.np/uploads/docs/progress-at-glance-a-year-in-review-fy-207778-202021-1636612548.pdf

AEPC (2022a). R*oles and responsibilities*. Kathmandu: Alternative Energy Promotion Centre, Ministry of Energy, Water Resources and Irrigation, Government of Nepal. Retrieved from https://www.aepc.gov.np/roles-and-responsibilities

AEPC (2022b). *Annual Progress Report – AEPC*. Kathmandu: Alternative Energy Promotion Centre, Ministry of Energy, Water Resources and Irrigation, Government of Nepal. Retrieved from https://www.aepc.gov.np/documents/annual-progress-report-aepc

Agarwal, B. K. (2020, 31 May). *Nepal budget & concise tax update: Highlights from tax perspective. FY 2020–21*. Crowe. Retrieved from https://www.crowe.com/np/-/media/Crowe/Firms/Asia-Pacific/np/CroweHorwathNP/files/PDF-Files/Budget--Crowe-Nepal--FY-207778-202021v2.pdf?la=en-US&modified=20200603113301&hash=D083094E625F351E6A836680D578030DB05B9DC4

Amatya, V. B., Sharma, P., Shrestha, M., Regmi, B. R., Gentle, P., Manandhar, M. D., & Ghimire, P. (2019). *Policy options to inform mandates of renewable energy agencies in federal context*. Kathmandu: Oxford Policy Management.

CMF (2013). *Study on impact of credit on the installation of biogas plant. Final Report*. Kathmandu: Centre for Microfinance. Retrieved from https://aepc.gov.np/uploads/docs/2018-07-09_Study%20on%20Impact%20of%20Credit%20on%20Installation%20of%20Biogas%20Plants.pdf

CRTN (2020). *Renewable energy technologies: Information & guide book*. Kathmandu: Center for Rural Technology, Nepal. Retrieved from https://www.crtnepal.org/document/RET%20Manual-Booklet-2020-CRTN-GIE-MYpt8NgRPR.pdf

ESCAP (2020). *Micro, small and medium-sized enterprises' access to finance in Nepal*. MSME Financing Series No. 3. Bangkok: United Nations Economic and Social Commission for Asia and the Pacific. Retrieved from https://www.unescap.org/resources/micro-small-and-medium-sized-enterprises-access-finance-nepal

ESMAP (2021). *Assessing and mapping renewable energy resources, 2nd edition*. Washington, D. C.: World Bank. Retrieved from https://documents1.worldbank.org/curated/en/317661469501375609/pdf/Assessing-and-Mapping-Renewable-Energy-Resources-Second-Edition.pdf

GCF (2021). *FP172: Mitigating GHG emissions through modern, efficient, and climate friendly clean cooking solutions (CCS)*. Incheon, Korea: Green Climate Fund (GCF). Retrieved from https://www.greenclimate.fund/project/fp172

Germanwatch (2023). Global Climate Risk Index 2021. Bonn: Germanwatch. Retrieved from https://www.germanwatch.org/en/19777

Gesto (2021). *Nepal Electrification Master Plan: Final Stages of Endorsement*. Gesto Energy Consulting. Retrieved from https://gestoenergy.com/nepal-electrification-master-plan-final-stages-of-endorsement/

GoN (2017). *Nepal's sustainable development goals: Baseline report.* Kathmandu: National Planning Commission, Government of Nepal. Retrieved from https://www.npc.gov.np/images/category/SDGs_Baseline_Report_final_29_June-1(1).pdf

GoN (2020). *Second nationally determined contribution (NDC)*. Kathmandu: Government of Nepal. Retrieved from https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Nepal%20Second/Second%20Nationally%20Determined%20Contribution%20(NDC)%20-%202020.pdf

GoN (2021). *Nepal's long-term strategy for net-zero emissions*. Kathmandu: Government of Nepal. Retrieved from https://unfccc.int/sites/default/files/resource/NepalLTLEDS.pdf

IEA (2019). *World energy outlook 2018*. Paris: International Energy Agency. Retrieved from https://www.iea.org/reports/world-energy-outlook-2018

IEA, IRENA, UNSD, World Bank, & WHO (2022). *Tracking SDG7: The energy progress report 2022*. Washington, D. C.: World Bank. Retrieved from https://trackingsdg7.esmap.org/downloads

Knoema (2022a). Nepal: Total primary coal imports, 1949–2021. Knoema. Retrieved from https://knoeme.com/atlas/Nepal/topics/Energy/Coal/Primary-coal-imports#:~:text=Primary%20coal%20imports%20of%20Nepal,by%20our%20digital%20data%20assistant

Knoema (2022b). Nepal – Fossil fuel energy consumption as a share of total energy consumption. Knoema. Retrieved from https://knoema.com/atlas/Nepal/Fossil-fuel-energy-consumption

Kumar, P., Yamashita, T., Karki, A., Rajshekhar, S. C., Shrestha, A., & Yadav, A. (2015). Nepal – Scaling up electricity access through mini and micro hydropower applications: A strategic stock-taking and developing a future roadmap. Washington, D. C: World Bank. Retrieved from https://www.esmap.org/node/70729

Mathema, S. B. (2014). Private sector in the development of Nepal's micro hydro. Presentation made at an IRENA hydropower event, 10 November 2014. Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Events/2014/Nov/10/Nepal-MicroMini-Hydropower-Development-Association-NMHDA.pdf?la=en&hash=FC159EB8561B6D65EC4B835B9A4BEC605211375B

MoEWRI (2018). Current status and future course of the energy, hydropower and irrigation sectors. White Paper 2075. Kathmandu: Ministry of Energy, Water Resources and Irrigation, Government of Nepal. Retrieved from https://www.moewri.gov.np/storage/listies/May2020/white-paper-2075-with-annex02.pdf

MoEWRI (2022). Renewable energy subsidy policy, 2078. Kathmandu: Ministry of Energy, Water Resources and Irrigation, Government of Nepal. Retrieved from https://www.aepc.gov.np/documents/re-subsidy-policy#

MoFE (2021). Assessment of electric cooking targets for Nepal's 2020 nationally determined contribution (NDC). Kathmandu: Ministry of Forests and Environment, Government of Nepal.

Nagpal, D., Kaur, N., Kafle, S., Udas, E., Dhungel, A., Tuladhar, S., & Saklani, U. (2022). Renewable energy solutions for enterprise development in the Hindu Kush Himalaya: A needs assessment. ICIMOD Working Paper. Kathmandu: ICIMOD. Retrieved from https://lib.icimod.org/record/35973

NBPA (2022). About us. Nepal Biogas Promotion Association (NBPA). Retrieved from http://www.nepalb2b.com/company/nepal-biogas-promotion-associationnbpa

NiD (2021). Nepal profile. Nepal in Data (NiD). Retrieved from https://nepalindata.com/data/nepal/#:~:text=The%20country%20has%205%2C427%2C302%20households%20with%20an%20average%20household%20size%20of%204.88

NOCL (2022). Import and sales. Nepal Oil Corporation Limited. Retrieved from http://noc.org.np/import

NPC (2017). Sustainable development goals. Status and roadmap: 2016–2030. Kathmandu: National Planning Commission, Government of Nepal. Retrieved from http://sdg.npc.gov.np/en/resource/SUSTAINABLE-DEVELOPMENT-GOALS--STATUS-AND-ROADMAP:-2016-2030-2017-AD/

NPC (2018). Universalizing clean energy in Nepal: Sustainable distributed generation and grid access to all by 2022. Kathmandu: National Planning Commission, Government of Nepal. Retrieved from https://www.npc.gov.np/images/category/SUDIGGAA_final_version.pdf

NPC (n. d.). Periodic Plans. Kathmandu: National Planning Commission, Government of Nepal. Retrieved from https://npc.gov.np/en/category/periodic_plans

Paudel D., Jeuland M., & Lohani S. P. (2021). Cooking-energy transition in Nepal: Trend review. Clean Energy, 5(1), 1–9. https://doi.org/10.1093/ce/zkaa022

Pinto, A., Yoo, H. K., Portale, E., & Rysankova, D. (2019). Nepal – Beyond connections: Energy access diagnostic report based on the multi-tier framework. Washington, D. C: World Bank. Retrieved from https://openknowledge.worldbank.org/handle/10986/35266

Pokharel, T. K., & Rijal, H. B. (2021). Energy transition toward cleaner energy resources in Nepal. Sustainability, 13(8), 4243. https://doi.org/10.3390/su13084243

Pokhrel R. (2020). Governance in the context of federalisation: A brief overview of energy sector. Kathmandu: Nepal Renewable Energy Programme. Retrieved from https://www.nrepnepal.com/wp-content/uploads/2021/04/GOVERNANCE-IN-THE-CONTEXT-OF-FEDERALISATION-A-BRIEF-OVERVIEW-OF-ENERGY-SECTOR.pdf

SASEC (n. d.). Nepal. Retrieved from Nepal | South Asia Subregional Economic Cooperation (sasec.asia)

SEMAN (n. d.). Our members. Solar Electric Manufacturers Association Nepal (SEMAN). https://www.semannepal.org.np/post/our-members.html (accessed on 30 September 2022).

Shrestha, P. M. (2021, 7 October). Nepal's surplus energy is going to waste as there are no buyers yet. The Kathmandu Post. Retrieved from https://kathmandupost.com/national/2021/10/07/nepal-s-surplus-energy-is-going-to-waste-as-there-are-no-buyers-yet

The Kathmandu Post (2021, 25 November). Nepal to be upgraded from the LDC category. The Kathmandu Post. Retrieved from https://kathmandupost.com/money/2021/11/25/un-approves-proposal-to-upgrade-nepal-from-ldc-category

Trace, S. (2021). Electricity distribution in rural Nepal. Energy and Economic Growth, UK. Retrieved from https://www.energyeconomicgrowth.org/blog/electricity-distribution-rural-nepal

UN (2018). Accelerating SDG 7 achievement. Policy brief # 3: Substantially increase the share of renewable energy in the global energy mix. United Nations Department of Economic and Social Affairs. Retrieved from https://sustainabledevelopment.un.org/content/documents/17537PB3.pdf

Urjakhabar (2020, 17 March). Launch of mini-grid special program: Aimed at serving 1 lakh households. Urjakhabar. Retrieved from https://www.urjakhabar.com/old/archives24599/

WB (2023). Climate Change Country Profile: Nepal. Climate Change Knowledge Portal. Washington, D. C.: World Bank. Retrieved from https://climateknowledgeportal.worldbank.org/country/nepal/vulnerability

WB and ADB (2021). Climate Risk Country Profile: Nepal (2021). The World Bank Group and the Asian Development Bank. Retrieved from https://climateknowledgeportal.worldbank.org/sites/default/files/2021-05/15720-WB_Nepal%20Country%20Profile-WEB.pdf

WECS (2013). National energy strategy of Nepal. Kathmandu: Water and Energy Commission Secretariat, Government of Nepal. Retrieved from https://policy.asiapacificenergy.org/sites/default/files/National%20Energy%20Strategy%20of%20Nepal%202013%20%28EN%29.pdf

About ICIMOD

The International Centre for Integrated Mountain Development (ICIMOD), is a regional knowledge development and learning centre serving the eight regional member countries of the Hindu Kush Himalaya – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan – and based in Kathmandu, Nepal. Globalisation and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. We support regional transboundary programmes through partnership with regional partner institutions, facilitate the exchange of experience, and serve as a regional knowledge hub. We strengthen networking among regional and global centres of excellence. Overall, we are working to develop an economically and environmentally sound mountain ecosystem to improve the living standards of mountain populations and to sustain vital ecosystem services for the billions of people living downstream – now, and for the future.

REGIONAL MEMBER COUNTRIES

AUSTRIAN
DEVELOPMENT
AGENCY

UNIDO

ICIMOD and its Regional Member Countries gratefully acknowledge the generous support of Austria, Norway, Sweden and Switzerland for core and programme funding, and Australia, Canada's International Development Research Centre, the European Union, Finland, Germany, the United Kingdom, the United States of America, and the World Bank for project funding.

International Centre for Integrated Mountain Development
GPO Box 3226, Kathmandu, Nepal
T +977 1 5275222 | **E** info@icimod.org | **www.icimod.org**