Pumped Storage Hydropower to support the transition to renewably produced electricity in Nepal, Bhutan and Sikkim state in India

State of Knowledge

Challenges of Integrating Pumped Storage Hydro into Nepal's Energy Planning and Management

Nepal Power Sector Country Report

Dipak Gyawali Sudhindra Sharma Dilasa Shrestha

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List of Abbreviation and Acronyms

ADB	-	Asian Development Bank
AEPC	-	Alternative Energy Promotion
AEPC	-	Alternative Energy Promotion Centre
ANU	-	Australian National University
CEO	-	Chief Executive Officer
COP27	-	Conference of the Parties
CPN	-	Communist Party of Nepal
CREEs	-	Community Rural Electricity Entities
DDG	-	Deputy Director General
DFAT	-	Department for Foreign Affairs and Trade
DFID	-	Department for International Development
DG	-	Director General
DoED	-	Department of Electricity Development
Dr.	-	Doctor
E&S	-	Environmental and Social
ED		Electricity Departement
EDC	-	Electricity Development Centre
EIA	-	Environmental Impact Assessment
ERC	-	Electricity Regulatory Commission
ETP	-	Electricity Transmission Project
FGD	-	Focus Group Discussion
FiT	-	Feed in Tariff
FMIS	-	farmer-managed irrigation systems
FPIC	-	Free Prior Informed Consent
FY	-	Fiscal Year
GDP	-	Gross Domestic Product
GEDSI	-	Gender Equality, Disability and Social Inclusion
GoN	-	Government of Nepal
GW	-	Gigawatt
GWh	-	Gigawatt-hour
HEP	-	Hydro Electric Plant
HIDCL	-	Hydroelectricity Investment and Development Company
HP-EIA	-	Hydropower Environmental Impact Assessment Manual
HSAP	-	Hydropower Sustainability Assessment Protocol

IBN	-	Investment Board Nepal
ICIMOD	-	International Centre for Integrated Mountain Development
IDA	-	Inter Disciplinary Analysts
IFC	-	International Finance Corporation
IHA	-	International Hydropower Association
ILO	-	International Labor Organization
IOE	-	Institute of Engineering
IPO	-	Initial Public Offering
IPPAN	-	Independent Power Producers' Association Nepal
IPPs	-	Independent Power Producers
Ips	-	Indigenous Peoples
IWMI	-	International Water Management Institute
KU	-	Kathmandu University
kV	-	kilo Volts
KVA	-	Kilovolt Amperes
KW	-	Kilowatts
LAHURNIP	-	Lawyers' Association for Human Rights of Nepalese Indigenous Peoples
LPG	-	Liquefied petroleum gas
Ltd.	-	Limited
M US$	-	Million United States Dollar
M$	-	Million Dollar
MCC	-	Millennium Challenge Cooperation
MoEWRI	-	Ministry of Energy, Water Resources and Irrigation
MoF	-	Ministry of Finance
MoFA	-	Ministry of Foreign Affairs
MoFE	-	Ministry of Forests and Environment
MoWS	-	Ministry of Water Supply
MPPUs	-	Multi-Purpose Power-Units
Mr.	-	Mister
Ms.	-	Mistress
MW	-	Megawatts
MWh	-	Megawatt-hour
NACEUN	-	National Association of Community Electricity Users Nepal
NAST	-	Nepal Academy of Science and Technology
NDC	-	Nationally Determined Contribution
NEA	-	Nepal Electricity Authority
NEC	-	Nepal Electrical Code

NEC	-	Nepal Electricity Corporation
NGO	-	Non-Government Organization
NHPC	-	National Hydroelectric Power Corporation
NMHDA	-	Nepal Micro Hydropower Development Association
NPR	-	Nepalese Rupee
NRs.	-	Nepali Rupees
PDA	-	Project Development Assistance
PhD	-	Doctor of Philosophy
PHES	-	Pumped Heat Energy Storage
PIL	-	Public Interest Litigations
PM	-	Prime Minister
PM	-	Project Manager
PPPIA	-	Private Public Partnership and Investment Act
PRI	-	Policy Research Institute
PROR	-	Peaking Run-of-the-River
PSH	-	Pumped Storage Hydro
PTEEL	-	Power Trade & Energy Exchange Limited
PV	-	Photovoltaic
PVPS	-	Photovoltaic Power Systems
Pvt.	-	Private
RECAST	-	Research Center for Applied Science and Technology
RETS	-	Renewable Energy Test Station
RoR	-	Run-of-the-River
RPGCL	-	Rastriya Prasaran Grid Company Limited
RTI	-	Right to Information
SBI	-	State Bank of India
SEMA	-	Solar Electric Manufacturer’s Association Nepal
SOPPAN	-	The Solar Power Producers’ Association, Nepal
SWECO	-	Southwestern Wholesale Electric Company
SWERA	-	Solar and Wind Energy Resource Assessment
TFC	-	Tariff Fixation Commission
TU	-	Tribhuvan University
TWh	-	Terawatt-hour
U.S.	-	United States
UML	-	Unified Marxist–Leninist
UNEP-LEAP	-	United Nations Environment Programme-Law and Environment Assistance Platform

US¢	-	United States Cents
USAID	-	United States Agency for International Development
VDC	-	Village Development Committee
VUCL	-	Vidhyut Utpadan Company Limited
WASP	-	Water Quality Analysis Simulation Program
WB	-	World Bank
WEC	-	Water and Energy Commission
WECS	-	Water and Energy Commission Secretariat

Preface

Pumped storage hydropower in Nepal. Accelerating the transition to zero/low carbon electricity grids.

This report explores an important opportunity for Nepal to dramatically increase access to clean, renewable energy and do it in a way that respects people and their cultures, and conserves the environment.

For decades, Nepal has sought to secure electricity through conventional hydropower development. These dams on rivers have proven technically challenging and problematic by displacing people and flooding farm lands and forests. As a result, a number of proposed developments have stalled. Conventional hydropower dams produce a lot of electricity in the rainy season. While exports of electricity to India are feasible then, in the dry season Nepal has been forced to import coal-fired electricity at great cost.

In this project, Inter Disciplinary Analysts and The Australian National University are exploring options for Nepal to exploit its great natural advantages – height, water and sunshine – to develop a self-sufficient, reliable and sustainable energy supply.

A key driver for this project is exponential and sustained global growth of solar and wind generation capacity. We suggest development of a seasonally counter-cyclical energy system. This would be based on Nepal's existing conventional hydropower capacity in the rainy season and complemented by solar photovoltaic generation linked to pumped storage hydropower (PSH) in the dry season.

Solar photovoltaic is now the cheapest form of new electricity generation. Nepal is blessed with ample sunshine and plenty of roofs and other sites for solar panels. Intermittent generation from solar can be backed up by storing extra electricity in pumped hydropower 'batteries' to generate power on demand.

Many stakeholders are unfamiliar with PSH and are likely to be concerned that it has all the social and environmental problems of conventional hydropower. Any major infrastructure development can have negative impacts on people and the environment that need to be transparently assessed and avoided. This project aims to familiarize Nepalese stakeholders with the costs and benefits of PSH to enable governments, businesses and communities to make more informed decisions about this development option.

Like conventional hydropower, PSH has a high upfront capital cost and involves the construction of roads and powerlines. It also needs installation of solar and wind generators so that the extra energy that they produce may be stored then used on demand. Around 75-80% of energy used in pumped storage can be recovered through later hydropower generation.

Pumped storage has significant differences with conventional hydropower. In PSH, extra electricity is used to pump water from a lower reservoir to an upper reservoir where is can be stored, then released to generate energy on demand. In many cases, existing reservoirs can be adapted to form one of the two required storages, making greater use of previous infrastructure investments. The great number of potential development sites enables the selection of those with the greatest differences in elevation ('head') enabling the generation of a lot of electricity with one or two orders of magnitude less water, with small reservoirs, compared to those of typical conventional hydropower.

The great number of alternative choices means that sites can be selected for development that have the least impact on people, farm lands, culturally or environmentally important places. Because water is recycled between the two reservoirs in PSH, electricity generation is independent of seasonal water supply and resilient to droughts. It may also enable more flexible use of existing water storages, for example, to supply water for farms and urban areas.

Because PSH reservoirs can be built off-river and tend to be small, they are not a risk in lake outburst floods and may be less hazardous in earthquakes.

There are other electricity storage technologies, notably batteries. Each storage technology has its strengths and weaknesses. Batteries have a high environment footprint, need to be imported by countries like Nepal, and supply electricity for relative short periods. In contrast, PSH can generate electricity for many hours and days, up to a week at the largest sites. PSH is a long-used technology where Nepal can apply relevant engineering expertise from its development of conventional reservoirs.

The rugged topography of mountainous countries like Nepal has often been seen as a barrier to development. With a solar – PSH energy generation system, the great elevations in Nepal can become a sustainable development asset. As the world transitions to renewable energy, India will increasingly rely on solar and wind power. Further, India will need to store extra electricity. Could this be an opportunity for Nepal to establish a new export industry on its terms?

We hope that this report may help catalyse new sustainable development options for Nepal.

Professor Jamie Pittock, The Project Team Leader
The Australian National University
November, 2023

Acknowledgements

This report is an outcome of intensive deliberations between the Nepal team and the Australian team over a period of 15 months from October 2022 to December 2023. The Nepal team has also benefitted from interactions with the Bhutan as well as the Sikkim (India) teams.

We are grateful to Professor Jamie Pittock for leading this research and identifying Inter Disciplinary Analysts (IDA) as a suitable partner in Nepal. We have benefitted from his and Dr. Daniel Gilfillan's insights as well as for the overall guidance and feedback at various stages of the research. We have had fruitful discussions and feedback from the rest of the Australian team members, namely Dr. Helen Locher, Dr. Anna Nadolny, Professor Andrew Blakers and Dr. Martin Kennedy.

The Bhutan Team was led by Dasho Sonam Tsering (former secretary of Energy and Water Resources, Royal Government of Bhutan) along with Tashi Dorjee and Tashi Pem. The Sikkim Team was led by Dr. Sarala Khaling and Ms. Abriti Moktan of ATREE Northeast. The field visits we have had in Sikkim, India from April 22 to 29, 2023 and in Bhutan from April 29 to May 6, 2023 proved immensely valuable in understanding the commonality of problems we face in the Himalaya region as well as lessons in unique management approaches and solutions. In both places we have benefitted from interactions with various stakeholders from villagers to senior government functionaries. This collaborative research has been a mutual learning experience for us all and we are thankful to all of them.

We are grateful to the Australian Water Partnership (AWP) and Australia's Department of Foreign Affairs and Trade (DFAT) for funding this research.

Our heartfelt thanks go to all the individuals who participated in the various programs organized by IDA during the 15-month period (Annex 3). These include former ministers, former secretaries of Energy, Water Resources and Irrigation (MoEWRI), current joint secretaries and undersecretaries of MoEWRI, officials from the national utility, Nepal Electricity Authority (NEA), private sector hydropower and solar developers, university professors, scholars, researchers, consultants and media persons. We are grateful to them for coming to the interactions on PSH organized by IDA and for being frank and forthright in sharing their observations and comments.

The staff at IDA worked tirelessly to organize the field trip to Kulekhani as well as the national workshop. To them, sincere thanks are due. Several research associates at IDA provided various inputs at different stages to whom special thanks is due: Tikaram Basnet and Dilli Prasad Baral for managing the trip to Kulekhani (from May 8-10); Rachana Sapkota for managing the national level workshop in Hotel Royal Singhi on May 11; senior statistician and GIS expert Chandra KC, for GIS-related inputs associated with the field visit; Mr. Pankaj Pokhrel who had provided valuable inputs to an earlier study done by IDA on the institutional set up of the power sector in Nepal; Mr. Himal Khanal for preparing various brief write-ups; and Mr. Sandeep Thapa for design and layout of this report.

The energy sector in Nepal is a dynamic and rapidly evolving field with significant players in not only government agencies but also the private sector as well as academia, media and civic movements. New questions and perspectives emerge constantly from non-traditional (and often challenging) approaches of these players. As a result, we need to specify that this report covers facts and figures

as they are at the end of 2023. We hope this report will help different players expand their exploration and development of the sector from their unique perspectives. Since we have relied on publicly available data and concerns from them all, we also hope they will be able to provide us feedback on issues and conclusions we have raised to help us refine our future research agenda and investigations.

Dipak Gyawali and Sudhindra Sharma
December 2023

Executive Summary

Background

The Nepal State of Knowledge (SOK) report of the power sector and the role of PSH offers a comprehensive background document for a collaborative research project involving Australia, Nepal, Sikkim-state (India), and Bhutan. Its primary objective is exploring the prospects and challenges of integrating Pumped Storage Hydro (PSH) into Nepal's energy landscape as part of the transition to renewable energy sources, central to Nepal's over-arching transition toward renewable energy sources. The report delves into key aspects of Nepal's power system, institutional framework, and the multifaceted context that significantly influences the country's ongoing shift towards sustainable energy alternatives. It also addresses a spectrum of technical, social, legal, and political hurdles and debates that are related to this transition.

Nepal's energy sector has a history of efforts by the government, academia, the private sector, and the activists to define and shape the nation's energy-related questions. One of the earliest initiatives was undertaken in the 1970s by Research Center for Applied Science and Technology (RECAST) under Tribhuvan University to assess Nepal's Energy Scenario. This study had raised concerns about the unsustainable use of firewood as energy source. These efforts have catalyzed the usage of technologies such as smokeless stoves, solar water heaters, and small-scale hydropower units. These technologies have since evolved into established industries, making invaluable contributions to forest conservation through community forestry.

The country's diverse physical and social characteristics, including a range of climates, topographic reliefs, as well as a rich tapestry of ethnic groups, languages, and religions play a role in shaping the energy landscape of Nepal. This underscores the need for both holistic and decentralized approaches to address energy transition challenges within the complex socio-environmental context of Nepal.

This report outlines the diversity within the current institutional setup of the country's energy sector. It provides an overview of current energy usages with focus on renewable energy and hydropower, the status of generation and transmission of energy, the country's dynamics of energy markets, and examines the significance of renewable energy and alternative electrical storage with a focus on pumped storage hydropower (PSH). Relevance, opportunities, and challenges of alternative electrical storage like PSH are also analyzed in the context of energy planning and policies.

Institutional Setup of the Power Sector in Nepal

The institutional setup of Nepal's power sector is a result of both the centralized state initiatives over the years, private sector entry, and community-driven projects at grassroot level.

The government agencies and institutions central to Nepal's power sector include the Ministry of Energy, Water Resources, and Irrigation (MoEWRI), the Department of Electricity Development (DoED), the Nepal Electricity Authority (NEA). MoEWRI oversees the country's energy development from the top at the policy level while DoED issues licenses and implements government policies related to the power sector. NEA, established in 1985, serves as the primary generator, transmitter, and distributor of electricity.

The Water and Energy Commission Secretariat (WECS), established in 1981, assists the Government of Nepal and various ministries in formulating policies and planning projects related to water and energy resources, with its structure and mandate currently under revision as per the proposed Water Resource Bill. The Electricity Regulatory Commission (ERC), established in 2017, aims to regulate power generation, transmission, and distribution by introducing competition and providing level playing field in the electricity market. Additionally, entities like Vidhyut Utpadan Company Limited (VUCL), Rastriya Prasaran Grid Company Limited (RPGCL), and Hydroelectricity Investment and Development Company Limited (HIDCL) play roles in power generation, transmission, and funding. The Investment Board of Nepal (IBN), established in 2011 and reconstituted in 2019 focuses on managing large and mega-projects, including that related to hydropower projects of size over 200 Mega Watt (MW). Currently, under the MoEWRI, the Alternative Energy Promotion Center (AEPC) is a separate government entity founded to develop and promote renewable and alternative energy technologies in Nepal – mainly solar and wind.

The private sector's involvement in Nepal's hydropower sector has a significant historical context. The private sector growth in hydropower emerged with Norwegian missionaries contributing to hydroelectricity projects. Nepal marked a major reform in the energy sector three decades back with the enactment of the Electricity Act, 1992. Subsequently, the cancellation of Arun-3 hydropower project paved the way for the entry of the IPPs in the business of hydropower generation, initially international (Norwegian and American) and a few years later Nepali private sector. Since 2001, the private sector has been advocating for private investments through the Independent Power Producers' Association (Nepal). Similarly, the National Association of Community Electricity Users Nepal (NACEUN) focuses on community-driven, volunteer-based electrification, forming a network of Community Rural Electricity Entities (CREEs) and benefitting both the local communities as well as the national utility NEA.

The political economy of various institutions in Nepal's energy and water sector is marked by institutional disjuncture with overlapping responsibilities and contradictory mandates, and issues with staffing and non-cooperation. Historically, MoEWRI has gone through splits and mergers whereas the establishment of DoED undercut the NEA Act. The vertically integrated utility (NEA) has been central to the generation, transmission, and distribution of power and may have served its purposes in the 1980s and early 1990s. But with generation increasingly being done by the private sector, NEA continuing to have all the three jurisdictions is beginning to stifle healthy competition in the sector. The newly established ERC too has conflicts with NEA on operations-, hierarchy- and, staffing- related issues. The WECS, in spite of the lofty ideals which had propelled its establishment, in practice often continues to be used as a "dumping ground" for senior civil servants.

While relatively newly formed entities like VUCL, RPGCL, and HIDCL were formed to carry out generation, transmission, and funding activities at a greater pace for energy development, projects under them have not really proceeded as planned. There continues to exist a lack of trust and cooperation between these entities and older entities in the sector. This has been exacerbated by overlapping roles and functions leading to redundancies, which highlights the need for a new and efficient arrangement in the energy sector. Additionally, after the introduction of federalism, there are challenges in delineating the roles and responsibilities of various units of governance. The emerging interests of the private sector as well as community and local governments in the realm of energy distribution and generation also needs to be addressed. However, those benefiting from the status quo are likely to resist change and may seek to expand their privileges. The political economy analysis of energy and hydropower sector in Nepal in this report stresses the necessity for a legal and institutional overhaul in the energy sector, acknowledging the challenges of implementing such reforms in Nepal's political landscape.

Renewable Energy in Nepal

Nepal relies predominantly on renewable energy sources, particularly hydroelectricity and biomass, for its energy consumption. Despite historical concerns about deforestation, successful forest conservation initiatives were implemented through community forestry program since the 1980s. Along with the major hydropower plants, traditional water mills, micro and small hydro, solar, and various forms of bio-energy contribute to the country's renewable energy mix. However, challenges, such as the decline in biogas programs due to factors like penetration of LPG and rural outmigration underscores the complex dynamics of Nepal's energy sector.

As of mid-March 2022, according to NEA sources, 94.0 percent of the population has access to electricity.[1] The country's total electricity generation has reached 2,205 MW, a substantial portion of which is comes from hydroelectricity (2,033 MW) along with contributions from solar and thermal sources. Despite preferential treatment in buyback rates favoring electricity produced by the state-owned/invested projects over IPPs, IPPs have played a significant role in this growth. A total of 122 hydropower projects managed by IPPs are currently contributing 1,020 MW, with additional projects in the pipeline.

Despite significant potential for solar energy, the sector faces challenges in grid integration buyback rates, costs, licensing, security, and issues on return on investment. Solar insolation across the country varies, but overall Nepal enjoys high potential on this front. The widespread use of solar water heaters and the estimated 150 MW of solar PV suggests a growing solar industry. The nation has approximately 94 MW of grid-connected solar PV capacity, with a 70% penetration rate of solar PV systems in the Kathmandu Valley. Wind power potential is substantial, with a gross commercial potential of 3,000 MW, primarily in challenging mountainous terrain.

Existing plans and policies, such as the 2018 white paper of Ministry of Energy, the Fifteenth Periodic Plan (2019/20-2023/24), and the National Adaptation Plan (2021), aim to promote renewable energy and reduce reliance on traditional energy sources. Similarly, the second Nationally Determined Contribution (NDC) aims for achieving 15% of the total energy demand from renewables by 2030 whereas the Long-Term Strategy for Net Zero Emissions (2021) envisions a carbon neutral path by 2045 through clean energy. The Renewable Energy Subsidy Policy (2022) focuses on universal access to renewable energy. However, challenges persist in bridging knowledge gaps among the state

[1] According to IDA (forthcoming) the coverage is a little higher – at 97 percent. IDA has just finished conducting a major nation-wide household energy consumption survey, the results of which (in a soon-to-be-made-public document) are briefly touched upon in this main report.

actors, and in executing the plans and policies comprehensively, which hinder the effective implementation and achievement of set targets.

Off-grid renewable energy system face sustainability challenges with many plants operating at subsistence level. With the energy consumption in Nepal still largely traditional (fuelwoods) and the growing use of coal and petroleum products means that off-grid renewable energy systems require support for scaling up.

Nepal's Energy Usage

Nepal's energy-consuming sectors primarily rely on traditional energy sources, with the residential sector being the largest consumer (63.2% of total energy consumed). Within the residential sector, fuelwood accounts for around 85% of the total energy use[2]. The industrial sector is the second-largest consumer and consumes 114.5 Peta Joules (PJ) of energy annually, primarily using coal for thermal processes, while the transportation sector consumes 56.6 PJ of energy and heavily relies on petroleum products. The usage of electricity in the overall energy scenario is very low. It does not come as a surprise that the per capita electricity consumption in Nepal in 2023 is as low as 380 units per capita per annum[3] and underscores the need for increasing electricity generation and consumption. Nepal is current energy usage scenario underscores the importance of a holistic energy policy that incorporates diverse renewables like solar, bio-gas, and wind in addition to hydropower. This approach aligns with the global trend towards two-way grids and decentralized management for optimal utilization of resources.

Hydropower in Nepal

Nepal relies heavily on hydropower, particularly run-of-river (ROR) plants, to meet its electricity demand. However, during the dry season, these ROR plants generate only one-third of their capacity. The Kulekhani hydropower plant is the only seasonal water storage facility in Nepal generating 165 Giga-watt-hours (GWh) of primary and 46 GWh of secondary energy. Despite the growing capacity of the IPPs, the prospects of their investment in storage projects provides several challenges primarily due to high social and environmental costs. Dry season power deficits lead to significant electricity imports from India, while during the monsoon season, Nepal exports electricity. The need for seasonal storage power projects to address peak demand is increasingly recognized but ideal projects like West Seti, Budhi Gandaki, or Tamor have faced longstanding disputes and controversies, hindering their development.

Nepal faces a number of challenges in the hydropower sector – from disputes over major projects to uncertainties surrounding the regulatory bodies. Private sector involvement in hydropower has grown but questions have been raised about the quality of work done by the private sector. Moreover, the sector is handicapped by debates about unbundling the national utility, tariff restructuring, and storage hydro project responsibility.

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[2] While this figure is from WECS 2020, IDA (forthcoming) reveals that over time the usage of firewood, though still high, is declining gradually.

[3] As per NEA. See: https://myrepublica.nagariknetwork.com/news/govt-sets-a-target-of-1-500-units-of-energy-consumption-per-capita-within-12-years/#:~:text=In%20the%20year%202018%2F19,over%20the%20past%20seven%20years.

Similarly, the benefit-sharing mechanisms are crucial to sustainable hydropower projects to ensure local communities and indigenous populations also benefit from the projects. Five primary mechanisms include royalties, equity shares, support for local livelihoods, community development investment, and environmental enhancement. The royalty mechanism allocates a portion of hydropower project royalties to local communities through government levels. However, transparency issues persist. Equity shares provide shares to individuals in project-affected areas, but questions about share ownership after a project's licensing period remain unanswered. These highlight the gaps in the current policy framework.

PSH as Electrical Storage in Nepal: A Promising yet unexplored solution

Nepal has yet to tap into the benefits of PSH, a globally established technology. PSH not only provide efficient means to storing surplus electricity but serves as an economical and environment friendly option for grid stability. It may also contribute to local economies and provide solutions for optimum load management.

Despite the clear advantages of PSH, Nepal faces challenges due to the flat-rate tariff system that lacks incentives for incorporating energy storage in conventional hydropower plants. Overcoming these barriers requires a detailed study of institutional and political economic landscape, identifying suitable PSH sites, and assessing the various energy sources and market players within the country.

While advocating for PSH, it is important to take into account factors like willingness to pay for PSH-generated electricity and issues related to seasonal and daily load variations. Nepal's unique geographical and socio-political factors, including relatively low resettlements and environmental costs for upper reservoirs (which tend to be relatively small) make PSH development both attractive and challenging. Addressing tariff uncertainty and environmental concerns coupled with a focus on existing hydropower plants can strengthen the case for integrating PSH into Nepal's evolving energy scenario.

Two types of cases need further examination. First, examination of currently undeveloped sites provides insights into the potential for new PSH projects. Second, a detailed analysis of existing ROR plants provides an opportunity to redesign them as PSH systems with marginal capital expenditure. Site visits to proposed undeveloped sites and existing power plants are crucial for undertaking further research and developing robust case studies. Research and analyses should be aligned with the ongoing draft electricity and water resource bills to incorporate the concept of PSH and facilitate policy reforms in line with the country's energy need.

Electricity Transmission in Nepal

Nepal's transmission system has evolved over time, starting with 33 kV and 66 kV lines and gradually progressing to 132 kV, to 220 kV and 400 kV transmission. Initially developed haphazardly to meet the needs of the capital and industrial towns, the transmission lines have been expanded with interconnections to India and proposed links with China. The Transmission Directorate of the NEA manages the current status of transmission lines, and a master plan by RPGCL addresses technical aspects. The growth of the IPPs hydroelectricity projects has increased demand for the expansion and upgrade of the transmission system for them to interconnect to the national grid. However, challenges persist in the construction of transmission lines, including controversies on land acquisitions and public protest. Public interest litigations against both hydropower plants and transmission lines have highlighted issues of misinformation, inadequate compensation, and a lack of due process.

External donor agencies – including the USAID (in the 1960s), the Asian Development Bank (ADB), and the World Bank (WB) – have been historically involved in the development of transmission lines in Nepal. Recently, the Millennium Challenge Corporation's (MCC's) USD 500 million grant aims to build a 318 km long 400KV transmission line with three high-capacity sub-stations to facilitate power trade across South Asia. The Hetauda-Damauli-Butwal transmission line will reach the Indian border, which will enable Nepal to export power from Nepalese hydropower projects which are expected to produce a surplus in the next decade. China's Belt and Road Initiative (BRI) has introduced plans for a 400 kV transmission line connecting Nepal and China at Rasuwagadhi, allowing not only electricity trade but also electrified railway connection to China.

Power Market Dynamics in Nepal

The current debate in power market dynamics in Nepal centers on whether Nepal should focus on exporting electricity or increase domestic consumption to gain multiplier effects in the national industry and commerce. Despite the fact that India has substantial demand for energy, there is no true market for Nepali electricity in India due to India's monopsony market i.e., India being a single buyer. Moreover, India considers water and electricity as strategic goods for its industry and agriculture, seeking them at a low cost. It is generally the case that access to the Indian electricity market for Nepal is determined not by market principles but bureaucratic fiat. Nepal continues to import significant amount of electricity during the dry season at a high market price to meet its demand due to the lack of seasonal reservoir storage project besides Kulekhani-1.

Energy Master Planning in Nepal

Master planning exercises in Nepal have been largely driven by national and donor interests. Informed people are of the opinion that the opportunity for developing "First Generation" standard type masterplan has already been closed because of already awarded feasibility and construction licenses, ignoring which would invite expensive court cases. However there exists a recognized need for a dynamic "Second Generation" plan that recognizes existing arrangements and underscores the advantages of distributed development of smaller hydroelectric projects for cost-effectiveness, resilience to risks, and greater social and economic benefits. It is known that the WECS is working on a new Hydropower Development Masterplan prioritizing national-level benefits. It is also known that the master planning exercise currently lacks specific plans for PSH and other power sector players are not aware of its contents, which may subsequently invite resistance.

Sustainability Issues regarding energy sector and powerplants in Nepal

While planning exercises for hydropower and energy development in Nepal have a long history, their focus has primarily been on technical aspects. Environmental and social concerns have not been addressed to the extent they should. Nepal faces challenges in further empowering disadvantaged sections of society along with women. Despite legislative commitments and constitutional reforms, further efforts are required to achieve actual behavioral changes. In the energy sector, traditionally dominated by men, women's issues have often been sidelined due to traditional gender roles.

Marginalized janajatis in remote areas, where most power plants are situated, express concerns about displacement and loss of land and livelihood. Informed people are of the opinion that the environmental and social impact assessments of the project are conducted superficially and the concerns of the local communities are inadequately addressed. Comprehensive and sustained efforts are needed to address these GEDSI issues and ensure a more inclusive and equitable approach in the development of hydropower projects in Nepal.

Opportunities and Risks with PSH in Nepal

In addition to addressing energy storage and load management, upper reservoir as a part of a PSH project have opportunities for multiple water-related benefits such as small-scale irrigation, forest fire-fighting, and drinking water. Promising PSH projects sites such as Rupa-Begnas, Kulekhani Sisneri, Syapru Daha in Rukum West and Kupinde Daha in Salyan, offer significant potential. Simplifying PSH projects, minimizing environmental and social costs and ensuring profitability during peak hours could attract state or private investment into PSH.

Determining the scale of PSH plant is contingent upon whether Nepal intends to cater to its own internal demands or contribute to fulfilling India's energy requirement. Opting for Nepal's priority may necessitate prioritizing medium-scale PSH schemes. (On the contrary if Nepal were to take India's energy demand into consideration, it would necessitate going for large-scale PSH schemes that might invite socio-political problems the country may have difficulties in handling).

Promoting PSH in Nepal, especially by involving the private sector in PSH, involves challenges. Primary concerns revolve around policy issues, with uncertainties about the licensing mechanism. Among private sector players apprehensions remain regarding the NEA intentions – especially the tendency to capture the best PSH sites for itself. The dilemma of choosing between initiating a pilot PSH scheme or formulating a comprehensive PSH policy adds further complexity. Stakeholders agree on the necessity for clear PSH-related policies to address ambiguities in the current regime. Key obstacles include the existing flat-rate tariff system, requiring differential rates based on season and time of day to attract private sector investments. Additionally, the emergence of alternative technologies like lithium batteries and issues related to Feed-in Tariff (FiT) for solar PV further underscore the need for strategic planning to position PSH competitively.

The PSH Atlas designed by our Australian partners also requires refining, including higher resolution GIS, geological as well as population density information, to make it more useful for power planners in Nepali agencies. A study by Nepali experts (Baniya et al, 2023) have used technical categorization schemes for identifying potential PSH schemes which might also need to be considered in the next iteration of the Atlas to make it more relevant. That needs to be supplemented by more analysis of legal, social and institutional difficulties, which this report is focused on.

1. Background

The primary purpose of this report is to serve as a background document to the joint research project between Australia, Nepal, Sikkim (India) and Bhutan on the prospects and challenges of Pumped Storage Hydro (PSH) in the transition to a renewable energy future. As such, it limits itself to describing the relevant aspects of Nepal's power system, its features, primary institutions and their evolutionary history that supports or hinders such a transition, and the main challenges (and debates within the country) – technical, social, legal and political – on this pathway. Begun in October 2022, this report has benefitted from the comments and suggestions from the ANU team, as well as discussions with the Sikkim and Bhutan teams, and has seen many iterations.

A brief description of what PSH technology is and what it promises[4] follows, which needs to be kept in mind to understand the institutional, social and legal context of Nepal (which covers much of this report) and within which they must fit and operate. PSH essentially entails pumping water from a lower water body (a sump on the side of a river, a pondage within it or a lake) to a pond or lake located higher up. That water is then used in reverse flow and sent back to the lower pond to operate a turbine and generate electricity when the demand is high. There is efficiency loss in using electricity to pump water up, and then to use that water to generate electricity anew; however, that loss is more than offset in two ways.

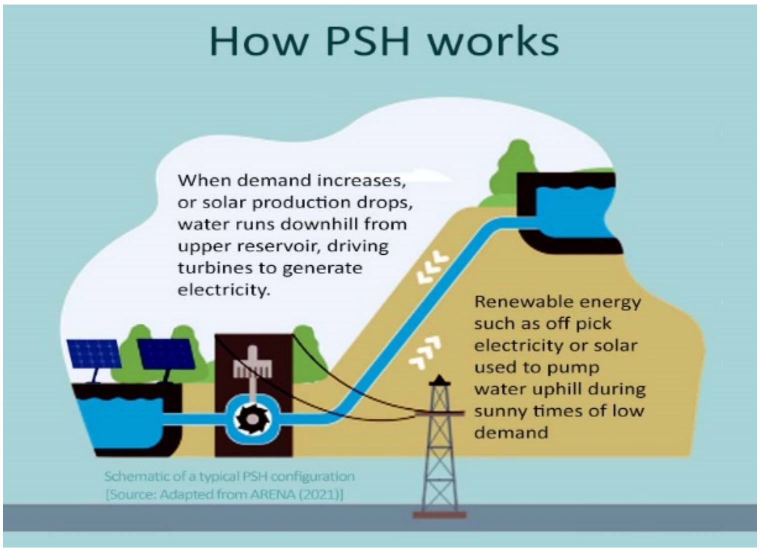

Figure1: PSH Schematic Diagram

First, much of the pumping is done during off-peak hours when demand (often at night) is very low and (if differential time-of-day off-peak tariff is in place) electricity price often is significantly cheap to offset the efficiency loss. If PSH uses reversible turbine (that is used for a pumping motor as well as running a generator) it means effective use of otherwise idle machinery and spilled (wasted) river water. Second – and this is the main reason for renewed interest in PSH which is a century-old technology – the price of solar PV generated electricity has plummeted to only a tenth of what it was a decade ago (and is slightly less than that for hydroelectricity). It is slated to be half of even that within the coming decade. The bad news is that the sun shines usefully for only six to eight hours a day, necessitating the need for energy storage during non-daylight hours. This is where, as solar PVs proliferate in Nepal and even more among its big neighbours India and China, the role of PSH as massive energy storage means becomes invaluable.

[4] See a popular exposition in https://www.spotlightnepal.com/2023/05/23/how-pump-storage-hydro-forces-rethinking-hydropower-development/

While the hydrotechnical and economic logic favouring PSH is irrefutable, the legal and institutional hurdles to its uptake seem as insurmountable. Critical among these are: tariff reforms incorporating daily and seasonal differences of peak and off-peak rates for overall system efficiency; clarity of licensing regime including ownership period that would encourage and not discourage developers; and legal as well as institutional reforms (including a new electricity act) that clarify and streamline agency roles and responsibilities. In Nepal's rich plural institutional milieu, this is easier said than done, given how a new electricity act has been pending in parliament for over a decade and a half.

One distinguishing feature of Nepal's energy sector is the long history of engagements by governments, academia, the private sector and activists in defining and redefining the energy question faced by the country. The earliest assessment of Nepal's energy scenario was in the 1970s by Research Center for Applied Science and Technology (RECAST) under Tribhuvan University. It raised questions about the dominant but unsustainable use of firewood leading to deforestation, health-damaging open-hearth cooking, the inefficient use of dung in cowpies, and many other issues. It provided the impetus for the development of smokeless *chulos* (stoves), solar water heaters, small-scale hydropower development through multi-purpose power units (MPPUs, especially by the Nepal Agriculture Development Bank, see (Joshi and Amatya, 1995) and (Karki 2017)), local manufacture of small turbines etc. These have become established industries in Nepal today. It also contributed to the shift in forest management to community forestry that has seen a complete reversal of the deforestation of the 1970s (Ojha, 2017).

Such a decentralized energy development is also demanded by the physical and social diversity of Nepal. Land-locked Nepal which lies on the southern slope of the Himalaya between China (to the North) and India (to the East, South, and West), is a lower-middle-income country with a GDP of $ 36 billion. Its population of almost 30 million people comprise of 126 caste and ethnic groups, speak 124 languages and follow five different religions with Hindus being the majority (MoFA, 2023). Among the oldest nation in South Asia founded eight years before the United States, its guiding state principles were laid down by King Prithvi Narayan Shah as a "flower garden of different species, each to follow its own *kul dharma* (clan traditions)".

This social diversity is matched by the mountainous country's ecological diversity as well. It experiences climatic zones ranging from humid tropical to arctic conditions. Nepal's climate is dominated by the monsoon season between mid-June and early October, which provides up to 80% of the country's annual rainfall, the remaining coming from winter Westerlies in December/January. While the monsoon precipitation is more in the east of the country and declines westwards, the winter rains are heavier in the west and decline towards the east. Winter rains, smaller in volume though they might be are important for spring recharge and soil moisture replenishment as they occur just before the pre-monsoon hot months of April/May. Springs are the mainstay of domestic water supply as well as agriculture in the hills and mountains, and they, together with groundwater backflow, also are the primary source of water in most Nepali rivers that contribute to the Ganga basin, not glacial melt (Armstrong et al, 2019). However, springs are drying up all across the Himalaya, including Nepal; and the driving causes are misuse of technology (rampant groundwater pumping, bad road construction, decline in recharge pond maintenance etc.) and not as yet climate change which is expected to make the situation worse in the years ahead (Sharma et al, 2016). Agriculture covers 31.5% of Nepal's area and uses less than 5% of surface water and less than 10% of groundwater. It contributes 23.1% to the country's GDP and partially employs more than 80% of Nepalis.

2. Institutional Setup of the Power Sector in Nepal

Institutions are a product of history, including those in the energy and water resources sector; and that history encodes much of their functioning style. In physically and socially diverse Nepal, traditional water and energy use have been matters dealt with at family and hamlet levels, and in many places still do with the state only interested in tax revenue classification as per resource endowment. State entry in these sectors began with the advent of modern technology (first hydroelectric plant in 1911, and the first modern state-led irrigation Chandra Nahar irrigation system in 1927). With the end of the Rana Shogunate in 1951, the official bodies managing these systems – *Bijuli Adda* for electricity, *Pani Goswara* for water supply and *Chhemdel Adda* for irrigation canal construction -- were incorporated into a formal ministry of "canal and electricity" with their subsequent expansion and diversification into the agencies that prevail today described below. (Given that electricity is primarily hydroelectric, it has not been possible to separate them into different ministries, although they have been tried and found unsatisfactory.)

While state-led water and energy agencies are dominant in current water and energy developments, a strong counter-current of what are called "people-led" developments are also in the play. In irrigation, for instance, "farmer-managed irrigation systems" (FMIS) still comprise almost 70% of the total irrigated area in Nepal (Pradhan, 2000 and Shrestha 2017). The same institutional push-and-pull holds true for hydroelectricity as well: small-scale, bottom-up decentralized development of hydropower, though resisted by the mainstream agencies, has seen path-breaking successes in Nepal (Liechty, 2022). Similarly, attempts at decentralization of electricity distribution has also achieved some success through its communitization while also having strong gender-positive aspects.[5]

The chart in Fig 1 below provides an overview of various entities involved in the electricity sector across the spectrum from government to private and social organizing styles. The core government agencies in the power sector are Ministry of Energy, Water Resources and Irrigation (MoEWRI); Department of Electricity Development (DoED); Nepal Electricity Authority (NEA); Water and Energy Commission Secretariat (WECS); and Alternative Energy Promotion (AEPC); Electricity Regulatory Commission (ERC). Relatively newer government agencies are Vidhyut Utpadan Company Limited (VUCL, 2016), Hydroelectricity Investment and Development Company (HIDCL, 2011) and Rastriya Prasaran Grid Company Limited (RPGCL, 2015). Independent Power Producers (IPPs) constitutes the private sector, whereas, National Association of Community Electricity Users Nepal (NACEUN), which emerged from a more voluntary, egalitarian social organizing style (different from both the state and private), is responsible for the bulk distribution of electricity in selected communities.

Since 2011, new intuitional arrangements have come into existence as per pressures of marketization (and donor pressure) with the initiative taken by the Finance Ministry. The rationale for the creation of these new bodies seems to be guided by the principle of unbundling the NEA. However, neither has NEA been unbundled nor has a new electricity Act that encompasses major changes come into existence as yet to reflect the reality of the phenomenal rise of the private sector in generation, as

[5] Currently some 300 community electricity distribution groups operate in Nepal across some 53 districts, some run entirely by women. See: https://www.adb.org/sites/default/files/project-document/182306/44135-012-dpta-03.pdf as well as https://www.nepjol.info/index.php/HN/article/download/7123/5773/0 and https://journals.sagepub.com/doi/pdf/10.1177/0096340214523253

well as community electricity in distribution. This aspect of institutional pluralism (or anarchy) is also dealt with in the section below under "institutional disjuncture".

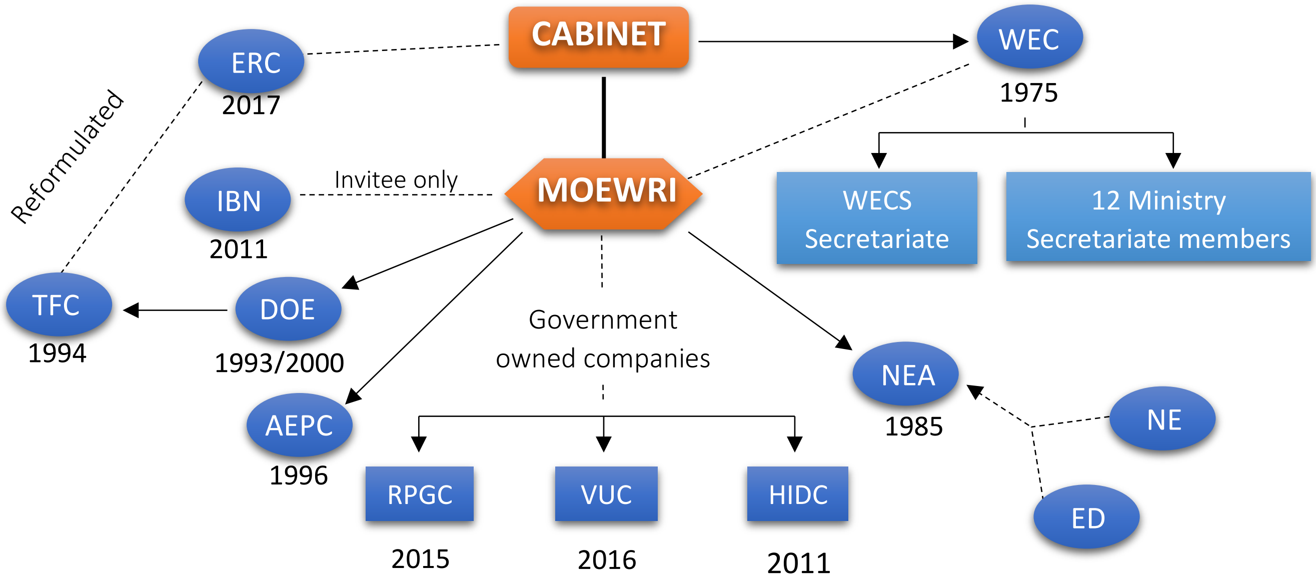

Figure 2: Map of various government entities involved in the Nepali electricity sector (and year they were established)

2.1 Government Agencies

Ministry of Energy, Water Resources and Irrigation (MoEWRI)

The Ministry of Energy, Water Resources and Irrigation (MoEWRI) is a governmental body that governs the development, use and distribution of energy, including its conservation, regulation and utilization. It also oversees agencies that develop and operate electricity projects including hydropower projects. Its predecessor was for many decades the Ministry of Water Resources, which was split in 2009 into two ministries (Ministry of Energy and Ministry of Irrigation), mainly for the political necessity of a coalition government to accommodate more ministers. In 2018, under the second Oli cabinet, the split was reversed and the portfolios of Water Resources and Irrigation were added to the then Ministry of Energy. (https://moewri.gov.np/)

Department of Electricity Development (DoED)

The Electricity Development Centre (EDC) was established on July 16, 1993 under the Ministry of Water Resources to develop and promote the electricity sector, including large-scale hydro and trans boundary cooperation, and to improve its financial effectiveness by attracting private sector investment. It comprised of senior figures of the erstwhile Department of Electricity who, when the NEA was established in 1985 with the merger of the government's Electricity Department (ED) and the parastatal Nepal Electricity Corporation (NEC), did not want to be part of NEA and chose to remain as government civil servants under the Ministry of Water Resources. EDC was later made into a full-fledged department and renamed as Department of Electricity Development (DoED) on February 7, 2000. The mandate of DoED is to issue licenses and implement the overall government policies related to the power/electricity sector. Its major functions are to ensure transparency of the regulatory framework, accommodate, promote and facilitate the private sector's participation in the power sector by providing one-window services to power projects. In effect, the establishment of this body is seen as the revival and restoration of the erstwhile Electricity Department before its merger with NEC to form the NEA. It thus contradicts the provision of the NEA Act (1984) that envisaged a single, vertically integrated electricity authority overseeing all aspects of electricity within the country. This, together with the emergence of a vibrant private power development sector, as well as community electricity distribution groups, is the primary reason necessitating a new more relevant electricity act as will be discussed further below. (https://www.doed.gov.np/)

Nepal Electricity Authority (NEA)

Nepal Electricity Authority (NEA), founded on August 16, 1985, is the primary generator, transmitter and distributor of electric power under the supervision of the Government of Nepal (GoN). This government-owned vertically integrated electricity utility was established – by merging the Electricity Department of the Ministry of Water Resources (that constructed new generation projects as well as transmission lines) and Nepal Electricity Corporation (which ran the distribution system as well as completed generation projects) – through the NEA Act (1984). Its purpose was for the making of "appropriate arrangements to supply power by generating, transmitting and distributing electricity" in an accessible, efficient, and reliable manner. The Act establishes NEA as a corporation, and authorizes it to formulate projects as well as perform all other functions "necessary for the performance of its function." In addition, the Act gives NEA the function of making recommendations to the GoN for the "formulation of long and short-term policies regarding power supply." Since its establishment, the NEA enjoyed a monopoly over Nepal's power sector by virtue of being in charge of generation, transmission, and distribution of electricity throughout the country. There are three main directorates under NEA, each headed by separate deputy managing directors. (https://www.nea.org.np/)

- **The Generation Directorate** is responsible for the construction of new projects with license owned by NEA and smooth operation and maintenance of existing power plants. At the present, there are two under-construction hydropower projects, 18 hydropower stations and two thermal power plants under this directorate.
- **The Transmission Directorate** is responsible for constructing, operating, maintaining, and monitoring high voltage transmission lines and substations from 66kv-400kv voltage level that are necessary for transmission of power generated from the various NEA- and IPP-owned power plants to the distribution system networks. It also undertakes reinforcement/upgradations of existing transmission lines and substations. There are four departments under this directorate—Grid Operation Department, System Operation Department, Grid Development Department and Major 220 kV Transmission Line Department.
- **The Distribution and Consumer Service Directorate** is the largest directorate of NEA and is responsible for the overall management of electricity distribution services and networks of NEA including planning, expansion, operation, maintenance and rehabilitation of the electricity distribution networks and substations from 400V/11kV up to 33 kV voltage level. In addition, new consumer connections, meter reading, billing, revenue collection and customer grievance handling also fall under its jurisdiction.

After several years of financial struggles, NEA has been making profits from the sales of electricity since FY 2016/17, and has now become one of the few profit-making public organizations in operation, although question is being asked if a wholly government-owned monopoly has a right to make expensive profit over break even. In FY 2022/23, electricity exports to India saw a remarkable increase, reaching 1,346 GWh, a significant jump from the previous year's 493 GWh. Earnings from the export of electricity to India increased to NPR 10.45 billion in FY 2022/23 compared to NPR 3.94 billion in the preceding FY (2021/2022). However, it is worth noting that the import of electricity from India is also increasing. Power purchase from India stood at NPR 19.44 billion in FY 2022/2023 compared to NPR 15.43 billion in the previous FY. In FY 2022/2023, NEA had a deficit worth NPR 8.99 billion in its trade of electricity with India (NEA, 2023).

Electricity Regulatory Commission (ERC)

The Electricity Regulatory Commission was established in August 2017 to oversee power generation, transmission, distribution and trade, replacing and expanding the power of the previous Tariff Fixation Commission under the EDC formed in 1994. The Electricity Regulatory Commission Act 2017 authorizes it to implement a code of conduct pertaining to grid development and power distribution, set the power purchase rates and introduce competition in the electricity market. The ERC Act has also envisioned regulating the quality and efficiency of the national grid and transmission safety to ensure reliable power supply to consumers. In practice, however, those knowledgeable about the sector mention three main reasons why ERC has not shown, and will probably not show, much promise expected of it even though it has come into existence only a short time ago. (https://www.erc.gov.np/)

First, ERC hastily was brought into existence (widely suspected as due to pressure from a particular donor as a precondition to its project being funded) even before an electricity act had been enacted that would clarify what the new institutional structure of the electricity sector, and the authority relationship between federal units as well as public, private and community groups in generation, transmission and distribution would be like. As a result, the newly formed ERC has found itself, even before its office setup and staff were in place, in conflict with NEA and IPPs over existing and pending power purchase agreements and other issues. Indeed, currently power purchase agreements are effectively in suspended mode and tariff reforms are not going forward as needed.

Second, much of the friction between ERC and MoEWRI has to do with the individuals who have been drafted into the ERC, especially its current head who used to head of DoED. The ERC being an independent commission tends to see itself as being higher than MoEWRI while the current and former secretaries of MoEWRI have tended to see things differently, i.e., that DoED is lower than the ministry in terms of official hierarchy and the individual who heads it earlier being their junior. Thus perception-issues as to who is higher in the governmental hierarchy and the personality of the current head of the ERC has led to frictions between the ministry and the ERC.

Third, it has to do with operational issues such as human-resources and finance. ERC machinery is manned by the bureaucrats who are seconded from the ministry and are few in number. They see themselves as being in ERC only temporarily and do not foresee a long-term career at ERC as the salary they receive is the same as they would have if they were at the ministry. Another related issue has to do with financial and administrative autonomy: it is dependent on government allocated budget and is unable to independently hire professionals at decent market rates.

Regulation is the primary job of a government, which is also responsible for formulating policies, laws, and guidelines. The entity it creates for this purpose should issue regulations and guidelines, undertake licensing, monitor markets and utility services, and undertake dispute resolution. The issuing of survey and construction licenses, at present, remains under the ministry’s Department of Electricity Development (DoED) and has not moved to ERC, nor has the purposed new electricity act managed to clarify this matter as yet.

Investment Board Nepal (IBN)

A government body chaired by the Prime Minister, the IBN was established through the Investment Board Act, 2011 and was reconstituted by introducing the Private Public Partnership and Investment

Act (PPPIA) in 2019. IBN functions as a central fast-track government agency to facilitate the country's economic development by creating an investment-friendly environment, mobilizing and managing domestic as well as foreign investments. It deals with large projects—with cost over Rs6 billion and hydropower projects above 200MW. However, IBN is beset with several sets of problems, one stemming from the organizational culture, while the other relates to legal provisions. (https://ibn.gov.np/)

IBN has two sets of employees: main government employees official deputed/seconded to IBN from concerned ministries; and temporary consultants hired by the CEO and whose salary is paid for by external donors such as DfID/FCDO. These are professionals who have received good education from abroad in their respective areas (even though most are fairly young and without long history of professional experience) and who receive good consulting fees much higher than official government staff. DFID/FCDO-funded consultants are there basically to support the government officials while the formal decisions are taken by the government officials. Thus, unlike ERC, IBN does indeed have professional experts who are well paid with good incentives to perform their professional roles.

The main problem with IBN, however, is that the head of the organization and the core government staff who are seconded from the ministry, tend to be risk-averse. The government officials who have the state mandate do not have the right incentives to perform their role well. Since they have not been recruited by IBN per se but rather have been seconded to IBN from government ministries, they do not see a long-term career at IBN. They see their stay at IBN as a short stint and avoid doing things or taking decisions that might hamper their long-term career. Signing in on ambitious projects of which they generally do not have a proper technical understanding and for which they have to rely on consultants leads to foot-dragging in one pretext or the other. This also stems from their thinking that there is the very real possibility for them of being investigated by CIAA and charged with corruption. So, the government officials who have the state mandate generally drag their feet as much as they can and do not sign off on projects. This is especially true in the electricity aspects of the work of the IBN: the Energy Ministry is not part of the IBN but only an "invitee" as and when deemed necessary (thus essentially bypassing the "institutional memory" of the MoEWRI), leading officials in the IBN to avoid falling into future controversies since political decisions on water resources are often highly controversial.

In addition, there is another factor that has led to the lack of cooperation on the part of concerned ministries with IBN. This stems from an amendment to the original IBN act with the Private Public Partnership and Investment Act (PPPIA) in 2019. Earlier IBN used to be mandated up to the Project Development Assistance (PDA) stage. It used to be responsible for developing the project, identifying the potential investors, persuading the investors and negotiating the agreement. PPPIA 2019 gave IBN further mandate related to implementing the projects as well. Though the intentions behind this may have been good, this created the unwanted impression on the part of concerned ministries that IBN, by implementing projects, was encroaching into their rightful domain and as a consequence of this perception, concerned ministries were unwilling to cooperate. Pushing IBN's mandate into actually implementing the projects has inadvertently led to the rest of the government machinery being uncooperative towards the IBN.

Water and Energy Commission Secretariat (WECS)

The Water and Energy Commission (WEC) was established by GoN in 1975 with the objective of developing water and energy resources in an integrated and accelerated manner. It comprised of permanent secretaries of twelve different ministries (e.g., forests, supplies, finance, foreign affairs, housing and physical planning etc. along with the ministry of water resources) and was chaired by the minister of water resources. Consequently, a permanent secretariat of WEC was established in 1981 and was given the name, Water and Energy Commission Secretariat (WECS). The primary responsibility of WECS is to assist the GoN, different ministries and agencies working on water and energy resources in the formulation of policies and planning of projects in those sectors. Its structure and mandate are being revised under the proposed but contested (discussed further in Section 8) Water Resources Bill 2077 B.S.

The primary problems of WECS have to do with it being perceived both by the civil servants deputed to it and by the politicians leading the ministries as a convenient place to dump undesired senior civil servants from major line ministries ("shunting yard", in common parlance). Also, given that it is chaired by the minister of MoEWRI, secretaries from other ministries rarely bother to attend WEC meetings. Indeed, no WEC meeting has been held for many years. An attempt was made to reform WEC in 2003 by having chairmanship of WEC rotate among participant ministries. It was also to have permanent deputation of senior staff from all represented ministries to work on policy issues of water and energy pertaining to their ministries. A change in inter-ministerial and cabinet file movement procedures would have also required formal WEC opinion on major water and energy projects before they were submitted to the cabinet for approval. These reform measures have not moved forward (Gyawali, 2013). (https://www.wecs.gov.np/)

Alternative Energy Promotion Centre (AEPC)

Alternative Energy Promotion Centre (AEPC) is a government institution established on November 3, 1996 under the then Ministry of Science and Technology with the objective of developing and promoting renewable/alternative energy technologies in Nepal. Although it has had to migrate to different ministries such as science and technology or environment in the past, it is currently under the MoEWRI but functions independently with an 11-member board with representatives from government, industry and non-governmental sectors. The AEPC has also traditionally been the outfit that is involved in the promotion of solar photovoltaics, and recently the Renewable Energy Test Station (RETS) has been set up under the Nepal Academy of Science and Technology (NAST) to test and certify solar installations.[6] (https://www.aepc.gov.np/)

Vidhyut Utpadan Company Limited (VUCL)

Formed with the slogan "People's investment for Nepal's Hydropower" **Vidhyut Utpadan Company Limited (VUCL)** was established on November 20, 2016. VUCL was established and registered in Ministry of Industry, Office of the Company Registrar, Government of Nepal, under the Companies Act 2006 AD. VUCL has a plan to become a leading electricity generation company in Nepal. (https://www.vucl.org/)

The authorized capital of VUCL is Rs. 20 billion and its issued capital is Rs. 10 billion, while the paid-up capital is Rs. 2 billion. Out of its total paid-up share capital 71% is promoters' share and 29% is public share. The main share-holders are the various government entities like MoEWRI, Ministry of Finance, Employees Provident Fund, Nepal Electricity Authority, etc. Though it was initially under the Ministry of Finance, it was later on brought under MoEWRI. VUCL is mainly a government owned company where the secretary of MoEWRI is the chairman of the company, the other board of directors representing the other shareholders such as joint Secretary of Ministry of Finance, etc.

[6] See https://www.retsnepal.org/

The various projects it is taking up are Phukot Karnali PROR, Kimathanka Arun, Mugu Karnali, Jagdulla PROR, Nalgad Storage. The actual stage these projects are at, is unclear.

Rastriya Prasaran Grid Company Limited (RPGCL)

Rastriya Prasaran Grid Co Ltd (RPGCL) was established by the Government of Nepal on 12 July 2015 to transmit and evacuate the power for the development and operation of the hydropower sector. The main objectives of RPGCL are:

1. Construct, expand and modernize the Transmission system to wheel 40 GW power (By the year 2040)
2. Construct the full functional Load Dispatch Center
3. Acquire all High Voltage (400kV and 220 KV) Transmission Assets of NEA. (https://www.rpgcl.com/)

This too is a government owned company. The Company's authorized capital is Rs. 25 billion and issued capital is Rs. 10 billion. The chairman of the board of directors is the secretary of MoEWRI while other board members are joint secretary of the ministry of finance, etc. The actual status of the various projects RPGCL is undertaking is unclear. It has also run into resistance from the established NEA that owns all the transmission system in the country. These matters are expected to be solved by the proposed new Electricity Act.

Hydroelectricity Investment and Development Company (HIDCL)

Hydroelectricity Investment and Development Company Ltd. (HIDCL) was formally established on 11 July 2011. It aims mainly to mobilize funds from domestic and international sources to cater to the needs of investments in middle to mega hydroelectricity generation, transmission and distribution projects. When conceived, its main objective was to collect investment, equity and loan. It is a funding arrangement, and not a generating, company. However, it has also been involved in building projects. (https://www.hidcl.org.np/)

Established as a public investment company, 80% equity belongs to Government of Nepal (50%) and three state owned companies (30%). 20% has been set aside for general public to be called though Initial Public Offering (IPO). The secretary of MoEWRI is the chairman of the company, the other board of directors representing the other shareholders such as joint secretary of ministry of finance, etc. There seems to be a considerable overlap in the role and functions of VUCL and HIDCL, in addition to that of NEA.

Institutional disjuncture

The three relatively new electricity-related entities formed by the government, VUCL, RPGCL and HIDLC have all been formed as companies and initially though were under the Ministry of Finance, are nominally under MoEWRI in that the Secretary of the ministry is the chairman of the board of each of these entities. There is considerable overlap between the role and functions between VUCL and HIDCL. Since both of these are mainly involved in hydropower generation, if one takes into account the fact that NEA and IPPs also are involved in power generation, there seems to be a lot of redundancies in the sector as a whole. Similarly, the main role of RPGCL is in transmission; however, since one of NEA's core mission is also transmission (and it is also the owner of the national grid), in this regards too there seems to be duplication in the role of RPGCL and NEA.

These new electricity-related entities have not been functioning well nor have the projects they hold licenses for moved forward as per expectations. According to independent experts in the sector, the individuals who are at the helm of these entities are mainly political appointees. In principle, these entities seem to have been formed to undercut the monopoly of NEA and to provide the mandate for transmission and generation to other government entities. In practice, however, according to experts in the sector, these bodies have turned out to be simply platforms for providing jobs to the party faithful. The individuals who head these organizations are so-called intellectuals associated with the ruling political party who have been “rewarded” with these positions for having remained faithful to the party.

Not surprisingly both MoEWRI and DoED, long established government entities in the sector, tended to see these entities as rivals created by other line ministries such as the Finance Ministry. With these entities coming nominally under MoEWRI, the animosity has declined to a certain extent. However, the relationship between these entities and the parent government body such as DoED, MoEWRI and NEA, to a certain extent, continues to be marked by lack of trust and cooperation. Hinted at during interviews at local levels, one possible reasoning behind the setting up of these institutions may indeed have been propelled by the need on the part of powerful government agencies (and supporting government agencies) to circumvent existing institutions that they did not feel comfortable with, or fell under multi-party coalition government under a different party.

A majority of bureaucrats, politicians and private sector players do not see a rationale for the establishment for HIDCL and VUCL arguing that the role of the government should be that of a regulator and should leave generation to entities that are already there, i.e. IPPs and NEA. Indeed, formed under the populist slogan, “Nepal ko paani, janata ko lagani” (“People’s investment in Nepal’s water"), government is investing in small projects of 20-40MW through HIDCL and VUCL. Private sector players and former bureaucrats there being no rationale for forming these kinds of entities. Rather, with NEA and IPPs fully capable of doing generation projects, the experts argue, there is the need for the government to instead focus on identifying, studying and building medium-sized multipurpose reservoir projects that need coordinating between agencies of electricity, irrigation, disaster and flood control as well as fisheries and navigation.

The institutional setup of government sector entities dealing with electricity and their overlapping and often contradictory mandates with the existing electricity and NEA acts, points to both the necessity and complications of crafting a new, efficient institutional arrangement for the sector. This is in addition to the difficulties of deciding, with the introduction of federalism, the roles and responsibilities of various units of governance, and of integrating the private sector, which has grown to significance equal to the NEA in generation, as well as community and local government interests in distribution and generation. However, those who benefit from the status quo will fight not just to retain their privileges but to actively expand on them.

Once the institutional and legal arrangements within the electricity sector have come into effect, they just tend to exist in a way that serves their interest despite their mutual conflicts. A unique type of vested interest is the tendency in official bodies to ignore their regulatory and other functions and to push for construction and other procurement-related ventures. Contrary to their official mandates focused on licensing and regulation or economic and policy planning, many of the government entities directly under MoEWRI or MoF or seconded to HIDCL and VUCL are also getting involved in implementing projects and thus entering into unhealthy competition with the NEA and the private sector. That there is a political economy of high volume "procurement benefits" in the sector, which pays out attractive rents, is beyond doubt and is probably the explanatory factor for why the various government entities want to get into implementation rather than sticking to their higher-level official regulatory and planning mandates.

A strong political will and decisive action by the government are the requisites for the legal and institutional revamp. However, in a country that has not seen one political party commanding the government and where all the shaky coalition governments have just been inclined to cling on to power, it is highly unlikely for the government to overhaul the sector in the foreseeable future[7].

2.2 Private & Community Sector in Hydropower

The involvement of the private sector in Nepal's hydropower development has an old but slow history. Although the first hydropower plant was the 500kW Pharping (1911) and second the 640 kW Sundarijal (1934), they were both state-commissioned enterprises. It was only between 1939 and 1942 that a private company, Morang Hydroelectric Supply Pvt. Ltd., was established that supplied electricity to the town of Biratnagar and its Jute Mill.[8] However, because of the slowdown due to World War II and as its Letang plant itself was washed away in a landslide, the private company went defunct and was later revived by the government as Poorvanchal Bidyut Corporation. Similarly, in the early days of the Panchayat and its implementation of land reforms in Nepal that limited land-holding size, large landowners of West Nepal decided to shift their landed assets to electricity and formed the Bageshwari Electric Company in Nepalganj. However, it was unable to establish a secure toe-hold due to lack of government support and went defunct.

The big boost to the private sector came during the latter part of the Panchayat regime when Norwegian missionaries under the United Mission to Nepal were able to build the 1 MW Tinau plant in Butwal, the 5 MW Andhi Khola and the 12 MW Jhimruk under Butwal Power Company (BPC: see Liechty (2022)). Also, during this period, small scale developers in partnership with the electromechanical workshops of Balaju and Butwal were able to access loans from the Agriculture Development Bank to build off-grid, small-scale multipurpose power units for both electricity and agro-processing. It is on the foundation of the technical skills developed in designing, constructing and operating those plants that peppered the hills of Nepal which have helped today's private hydro developers grow to maturity. Many of these entrepreneurs are not members of IPPAN but have grouped themselves under a different umbrella called Nepal Micro Hydropower Development Association (NMHDA).

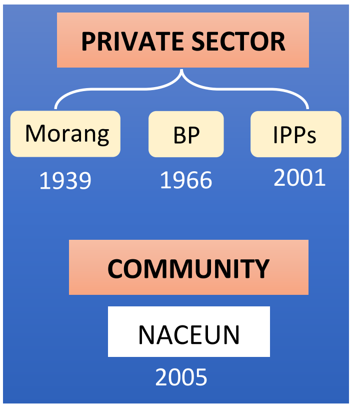

Figure 2: Map of the private sector and community organisation in the Nepali electricity sector.

Independent Power Producers' Association Nepal (IPPAN)

With the collapse of the World Bank-led Arun-3 (see Gyawali, 1997), there was a scramble to find ways to meet the growing demand. It took the boldness of Nepal's first woman deputy prime minister and minister of water resources to force the national monopoly NEA to announce a buyback rate for private sector produced electricity in 1997.[9] Although American and Norwegian foreign private

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[7] Economists looking at public sector expenditure in Nepal are of the opinion that this phenomenon i.e., multiple institutions that have considerable overlap in their roles, are widespread across the government machinery and not just specific to the energy sector. These take up substantial resources from the government, without however, contributing anything substantive. Interview with Naveen Adhikari, February 4, 2023.

[8] See Laxman Biyogi in Urja Khabar (in Nepali) "History of electricity law till today's 22-year captivity by political parties". Year 3, No. 4, 16 June 2023.

[9] See https://portals.iucn.org/library/sites/library/files/documents/2005-056.pdf as well as https://archive.nepalitimes.com/news.php?id=6686#.Y9r1XHZBxD8

investment had arrived earlier in the 36MW Bhote Kosi and 60MW Khimti projects, that decision by Acharya opened the sector to Nepali private sector investment in hydropower and led to private sector entities banding together as Independent Power Producers' Association, Nepal (IPPAN). Although established only in the year 2001 with the intention of lobbying for the interests of private power producers and encouraging the private sector to work in the area of hydropower in Nepal, its membership today has more developments underway than the government's NEA (although NEA projects are larger in scale).[10] The organization also helps exchange technology, expertise, knowledge, financial and management information among the independent power producers in the country. IPPAN was established with a vision of being the umbrella organization of IPPs (Independent Power Producers) in order to advocate for an investor-friendly environment of power development in Nepal. One of its main purposes is to act as a link between the private sector and government organizations involved in developing hydropower in the country. IPPAN is primarily a membership organization. The General Assembly comprises both institutional and individual members. The General Assembly elects the Board of Directors, which then formulates the organization's plans and policies.

National Association of Community Electricity Users Nepal (NACEUN)

Very different from the market-driven IPPs, is the National Association of Community Electricity Users-Nepal (NACEUN), which is guided not so much by profit of markets or control of state agencies but volunteerism and service. It was established in 2005 under the NGO Registration Act as the common umbrella of different community electricity users' groups that were legally allowed to function since 2003. NACEUN is a national federation of Community Rural Electricity Entities (CREEs). Since its establishment, NACEUN has grown into a strong network comprising almost 300 CREEs from 53 districts of Nepal.[11] It has 17 district chapters and six province chapters. The CREEs are established through the communities' participation after they contribute 10 percent of total estimated cost of electrification (the remaining 90 percent is covered by the government); and they operate the local distribution system leased from NEA. CREEs buy electricity in bulk from the NEA and distribute it to their consumers under creative local arrangements, allowing them to introduce new labour-saving rural technologies and opening the door to local employment.

The benefit of CREEs to NEA is two-fold: first, it saves the national utility the massive administrative cost of meter reading and bill collection at the local level, which – given Nepal's terrain can be an onerous job for a centralized agency; and second, the double accounting – at the bulk transformer or feeder level by NEA and at the local level by community groups – ensures that theft of electricity is practically eliminated because of policing by the local groups. NACEUN has been working with the NEA on policy formulation and preparation of guidelines for various community rural electrification cooperatives for the last 18 years. It has acquired expertise on preparing guidelines for community rural electrification. Geared to managing electricity distribution in a decentralized manner, it is now moving into generating its own electricity (ostensibly at cheaper rate than the NEA and the private sector) either from small hydro, solar photovoltaics or cogeneration from biowastes. In this endeavour, it is a major stakeholder in the proposed new electricity act and has argued vigourously for a separate rural electrification law.

[10] Of the 122 operating power plants, NEA and its allied sub-companies own some two dozen power plants, the rest being those of IPPAN members spread across the country. See: https://www.doed.gov.np/license/54

[11] See https://naceun.org.np/

3. Renewable Energy in Nepal

Nepal's energy consumption is mostly renewable energy, primarily in the form of hydroelectricity and biomass. Even traditionally, water mills have been a major source of agro-processing with recent developments of micro and small-hydro, solar, and various forms of bio-energy. However, despite the deforestation scare of the 1960s and '1970s, forest conservation has seen a major success with the introduction of community forestry in the 1980s with villagers themselves managing and harvesting forest products[12]. Nepal achieved great success in biogas development in the 1980s and 1990s, especially at domestic household level with dung from livestock. Of late, however, with the penetration of LPG into rural areas, the decline in rural youth labour due to outmigration to the Gulf, Malaysia and other places, as well as official neglect, biogas program has seen a decline (Rai, 2017). Briquette making from agri-wastes as well as poorer quality forest biomass saw a tremendous spurt during the Indian economic blockade of Nepal following the earthquake of 2015 and the promulgation of the constitution. However, this too, as with biogas, is in decline.

3.1 Total Power Generation in Nepal

By mid-march 2022, population having access to electricity reached 94.0 percent. The total electricity generation reached 2,205 MW out of which 2,033 MW is generated from hydroelectricity, 49.73 MW from solar plant, 53.4 from thermal plant and 80 MW from others which include renewables and co-generation (Economic Survey 2078-79, MOF). As of mid-march of fiscal year 2021/2022, 398 kilowatts (KW) of micro and small hydropower and 200 KW of solar and wind projects have been commissioned whereas 1,733 biogas plants, 11,956 solar household power system have been installed (Economic Survey 2078-79, MOF). Table 1 below summarizes the total power generation in Nepal, including the hydro-power generated by NEA and its subsidiary companies, solar power generated by NEA, plus, the hydro and solar powers generated by the IPPs:

	NEA			Private Sector IPPs	
	NEA-Hydro		NEA-Solar	IPPs Hydro	IPPs Solar
	Main	Subsidiary Companies			
Number Operating	19	2		122	8
MW	573.6	478.1		1,020.5	33.1
Number Under Construction	7	6		125	10
MW	487.1	447.3		2,775.8	57.8
Total MW	1,060.7	925.4	21.5	3,796.3	90.9

Table 1: Total power generation in Nepal[13]

[12] A national-wide household energy consumption survey by IDA with Sweden's Lund University LUKSUS showed that unlike 3 decades back firewood use –still a major source of cooking – has declined somewhat but forest cover has increased indicating not mining but sustainable harvesting of forest products, mostly thanks to the community forestry.

[13] NEA, 2022. Annual Report 2021/2022, Kathmandu, Nepal: Nepal Electricity Authority

Over the period of time IPPs have grown tremendously. As shown in Table 1, currently, there are a total of 122 IPPs involved in the hydropower sector. These have begun producing 1,020.5 MWs. Likewise, many schemes led by the private sector are currently under construction. Once completed, these will generate an additional 2,775.8 MW. The private sector is also involved in solar PV. While 33.1 MW are already being generated by the private sector involved in solar, a number of schemes which are expected to generate 57.8 MW are under construction.

NEA and its subsidiary companies currently produce a total of 1,051.7 MW of hydro- power whereas a total of 934.4 MW from 7 main and 6 subsidiary NEA companies are currently under construction. Once the ongoing schemes are completed, NEA and its subsidiaries, will generate 1986.1 MW of hydro-electricity. Additionally, NEA also generates 21.5 MW of solar power. Once the ongoing schemes are completed, NEA will produce a total of 2,007.6 MW of power, while the IPPs will contribute 3,887 MW.

The major complaint of the rising IPPs is that the playing field is not level, that NEA as generator, transmitter and distributor gives preferential terms to its own projects compared to IPPs; and indeed, this is seen in the case of the Chilime hydropower company that is owned by the NEA and its staff. The table below discusses the buyback rate for RoR during both wet and dry seasons, the buyback rate for PRoR, and the buyback rate for storage projects for IPPs.

S. No.		
1.	Buy back rate for RoR during the wet season	NPR 4.80
2.	Buy back rate for RoR during the dry season	NPR 8.40
3.	Buy back rate for PRoR	NPR 8.50 – 10.55 Depending on peaking hours
4.	Buy back rate for storage projects	NPR 7.10 during wet season NPR 12.40 during dry season

Table 2: Buy back rate for hydroelectricity

3.2 Status of Solar and Wind Energy Generation

Related to solar energy, solar insolation in the country varies with geographic location, altitude, and seasonal factors. Nonetheless, the abundant solar radiation in Nepal shows encouraging atmosphere for its expansion including in solar farming ventures. A major success story has been the proliferation of solar water heaters. It was begun in the late 1970s with mainly Swiss and local Nepali initiatives to support manufacturing of solar water heater panels and storage tanks. Today, this technology is pervasive across the country in almost all newly built homes but a proper survey establishing its spread has not been done. In private conversations, industry insiders estimate that perhaps there are 20,000 solar hot water panels across the country. Individuals associated with solar Alliance estimate that some 87 MW of large solar PV and 6MW of smaller less than 1MW are grid connected totaling 94MW. Nepal Telecom has its own solar PV in all its offices as have Nepal Army and Police but hard survey data is not available. Solar PV are mandatory in all housing colonies and it is estimated to have 70% penetration in Kathmandu Valley. Overall, industry insiders estimate that there is probably around 150MW PV solar in Nepal.

A report by Solar and Wind Energy Resource Assessment (SWERA) in 2002–2007 suggested that Nepal's gross commercial wind power potential could be 3000 MW (AEPC, 2008). An area of about 6074 sq. km has a wind power density greater than 300 W/m2 (AEPC, 2008); however, this is located mostly in difficult mountainous terrain. A study conducted along the valley between Kagbeni and Chusang in the Mustang District of Nepal, which is one such area with limited accessibility, concluded that 500 GWh could be generated annually from wind resources, equivalent to an installed capacity of 200 MW of electrical power (Ghimire et al., 2011).

The theoretical solar potential in Nepal is around 50,000 TWh per year, which is 7,000 times higher than the current electricity consumption in the country (of 7 TWh). Nepal has also scope for Pumped hydro energy storage which allows for accommodation of the daily and seasonal solar cycle in balancing solar electricity system. Its potential for off-river PHES with total storage capacity of 50TWh from 2800 potential sites has been identified by the Global Pumped Hydro Atlas, and is discussed in greater detail in sections 4 and 5.

3.3 Solar Energy Generation Challenges and Needs

The primary problem with solar PV is how to achieve synergy within the larger national electricity context, including with grid electricity. While household installations are pervasive, they are mostly not interconnected with grid supply via reversible metering; and the national monopoly utility NEA is resistant to facilitating this connection, preferring instead to develop its own system in the range of 15-30MW. This approach of the NEA has been criticized as its systems occupy valuable agricultural or forest lands whereas household PV systems use otherwise wasted unproductive roofs (using wasted surface in NEA powerhouses and other locales is fine). The following table gives the potential benefits of individual household PVs versus NEA's larger systems.[14]

Type of System	100 MW	1 KW in 100,000 rooftops
Cost of land	Low to high	Free
Land restriction	Not allowed in forest area and discouraged in arable land	No restriction
Power evacuation cost	Very high: transmission lines and land allied land compensation	Free
Operation cost	Low to medium	Free
Maintenance cost	Low	Free
Licensing cost/time/completion	2 years	No licensing cost/some weeks for completion
Security	Low	High
Cost of installation/transportation	High	Negligible
Government subsidy	None	75% on bank loan interest

Table 3: Comparison of 100MW PVPS and 1kW PVPS in 100,000 rooftops (with same solar insolation value and same energy generation, i.e., 400 MWh/day)

Feed-in tariff has not progressed at the pace it should, given the potential for its development. And the general reluctance on the part of NEA to buy electricity from rooftop solar PV seems to be motivated by the suspicion that doing so will lead to reduction in revenue generation. However, this

[14] Information from Prof. Jagan Nath Shrestha, Center for Renewable Energy, Institute of Engineering, Pulchowk Campus.

apprehension is misplaced as more reliable and distributed grid supply and proper tariff would be able to cater to the suppressed demand that exists all over Nepal[15].

Another problem related to solar energy generation in Nepal is the buyback rate for solar plants set by the National Utility, NEA. Previously, NEA had been paying NRs. 7.30 per unit for solar- generated electricity; however, in March 2022, the NEA opted to revise this tariff unilaterally and reduced it to a maximum of NRs. 5.94 per unit. This decreased tariff rate set by NEA meant that it would not be financially viable for solar manufactures who had already made significant investments with the expectations of receiving the previous rate of NRs. 7.30 per unit for their solar generated electricity ventures (Shrestha, 2023). Against this decision, a writ petition was filed by the Solar Electric Manufacturer's Association Nepal (SEMA), which was initially granted a stay order by the district court. However, later on, this petition was squashed (Shrestha, 2023).

Private sector solar developers are of the opinion that an adjusted tariff of 6.60 rupees per unit would offer greater economic feasibility as opposed to the reduced rate of 5.94 rupees[16]. Alternatively, in the event that this tariff revision is not possible, there could be a system in place similar to India's 'Solar Parks'[17] and policies and the provision for soft loans. For instance, in India, the Asian Development Bank (ADB) and the World Bank (WB) have given grants and soft loans to certain banks such as State Bank of India (SBI) under the green finance scheme. When a private developer then gets a loan from SBI, they benefit from a low- interest rate and increased profitability.

It has also been remarked that, given that Nepal's primary need in moving away from fossil fuels to renewable energy is in domestic cooking and transport especially in hill hamlets with the challenge of sheer verticality, the use of solar energy to power small scale goods carrying ropeways would be very beneficial. This is especially so because much of the goods carrying occurs during daylight hours when solar power is freely available without the need for storage. They cost only a third of what it costs to build an equivalent cheapest dirt road, can be built eight times quicker and would use only about half the energy (that too hydropower or solar) per ton than diesel-powered trucks.[18]

3.4 Existing Plans and Policies

The **white paper of Ministry of Energy, Water Resource and Irrigation (2018)** has provisioned the policy to establish the challenge fund to develop the 100-150 KW solar energy in each local level.

The **Fifteenth Periodic Plan** has been adopted by the government of Nepal in FY 2019/20 and up until 2023/24. Related to renewable energy, the plan has set the strategy and working policy to utilize the resources from carbon financing and other climate financing including Green Climate Fund for the promotion of renewable energy in Nepal. The plan aspires for a 12% contribution of renewable

[15] A system of proper accounting, with smart inverters, could be able to deduct the total units that have gone to the national grid from solar PV in that household, from the monthly units of energy consumed by that household. This requires some pilot research projects and survey to be able to come up with more reliable figures

[16] This was mentioned by the private sector solar developers in the interaction program held at IDA on May 24, 2023.

[17] 'Solar Park' is a well-constructed area designated for the development of solar energy projects, that offers proper infrastructures, convenient services and greatly reduces the paper work requirements necessary for implementation of the project (Jose, 2016).

[18] See Gyawali et al (2004). The chapter by a village entrepreneur Bir Bahadur Ghale building the goods carrying ropeway in his Gorkha village is highly instructive, operated as it was by an initially 12 kW micro-hydro later upgraded to 25 kW.

energy in the total energy and envisages to install 0.2 million household biogas plants and 0.5 million improved cooking stoves and thermal gasifiers, 20 thousand metric ton annual production of bio briquette and pellets, 2 more carbon projects under its belt and annual replacement of 40 thousand metric ton of liquefied petroleum gas through installation of 500 large biogas plant.

While these national policy targets are highly commendable especially from a climate change response perspective, as mentioned previously, in practice the larger economic forces at work – including that of hitherto unprecedented outmigration and the concomitant dynamics of a remittance economy – mean that Nepal's rural agriculture economy is in decline and little of these alternative energy targets may be achieved. Industry insiders estimate that meeting biogas targets is questionable, and even with existing plants some 30% have stopped operating with the decline in livestock keeping. On the other hand, it is targeted to keep LPG penetration (which was 18% in 2015) to below 40% by 2030; however, it has already reached 43% in 2023. [19]The only bright glimmer of hope is in urban waste recycling via gassifiers: the Pokhara one processes 45 MT of organic waste to produce approximately 120 gas cylinders per day; and under World Bank and AEPC project, there is plan to have 20 such gassifiers in other cities of Nepal. However, as with discussions on hydrogen economy, given that there is surplus seasonal and off-peak grid electricity which has reached most of the population, it currently makes little sense from an energy efficiency perspective to convert gasifier energy to electricity. Also, entrepreneurs in the waste treatment sector complain of lack of cooperation from some municipalities.

The second **Nationally Determined Contribution (NDC), 2020** has set a target to ensure that 15% of the total energy demand is supplied from renewable energy sources by 2030. Similarly, the determination has set target to cover 25% electric vehicles by 2025 and increase this to 90 percent by 2030. The determination has also set target to ensure that 25% of the households use electric stoves for cooking by 2025. It has also envisaged installing 500,000 improved cooking stoves in rural areas, installing additional 200,000 household biogas plants in 5000 large scale biogas plants by 2025.

Long Term Strategy for Net Zero Emissions (2021) envisions bold policymaking, social transformation and technological innovations that will lead to a carbon neutral, inclusive and climate resilient path. The strategy was developed with the intentions of developing pathways for reducing emissions and hence achieve net zero carbon emission by 2045 by increasing the use of clean energy, improve energy efficiency, increase carbon sinks, expand circular economy and invest in carbon neutral and circular economy compatible technologies etc.

National Adaptation Plan (2021) aims to help the country achieve the objectives of the NAP process that have been agreed under the UNFCCC. These objectives are to reduce vulnerability to the impacts of climate change by building adaptive capacity and resilience and to facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes and activities, in particular development planning, processes and strategies, within all relevant sectors at different levels as appropriate. The NAP has been formulated to help the country adapt to the effects of climate change over short term (until 2025), medium term (until 2030) and long term (until 2050).

[19] IDA household survey of 2023 indicates 62.4% of penetration.

RE Subsidy Policy (2022) focuses on providing universal access to clean, reliable and affordable renewable energy by 2030 by expanding access to renewable energy while reducing reliance on traditional and commercial energy sources. Reduction and re-adjustment of the subsidy amount to increase access to RE technology. Empowerment of women and indigenous people by creating employment opportunities through the use of renewable energy technology, encourage private and financial sectors to invest in renewable energy by reducing risk and hence assist in developing market for renewable energy.

With the new political administrative delineation in the country, bridging the knowledge and information gap existing at state actors at different levels of governance poses an enormous challenge. With the newly established federal structure, there is a challenge to integrate and harmonize renewable energy initiatives at all three levels of governance. The local governments have enhanced roles and responsibilities in overall planning and implementation of RE. However, the local and provincial governments have limited technical and managerial capacities to carry out their roles related to RE promotion.

3.5 Off-Grid Systems - Challenges and Prospects

Sustainability of off-grid RE systems has posed a big challenge to the sector. Plants that can generate surplus revenue are doing very well but the rest are operating at subsistence level and do not provide reliable and quality electricity as envisaged and generate revenue that barely covers operating costs. While small and micro-hydro did contribute significantly to the upliftment of rural economy, with national grid expansion their maintenance proved a burden to the local developers. A success story was the interconnection of some six mini-hydro plants in Baglung into an off-grid system: even as major cities in Nepal were suffering load-shedding, villages of this small valley was getting 24-hour supply that earlier was not possible with isolated small hydros. It led to a spurt in electricity demand with establishment of milk chilling plants, small furniture works etc. This spurt that arose with the lifting of the lid on suppressed demand was not possible with the small hydros and needed either the development of more interconnected small hydros or interconnection with the grid. Industry insiders say the refusal by the NEA to interconnect this off-grid system – on grounds of safety and other excuses – meant that it ultimately withered away, and local investment resources and effort wasted.

If such systems are considered as a ‘community assets’ with peoples’ investments involved that should not be junked, it would be possible to provide for a healthy two-way power system with communities as active generators of energy and not just fatalized, passive one-way consumers of what the state entities provide. This is a challenge that will be faced by solar PV systems as well; and it will not be solved until a new, more decentralized framework of national electricity – and an appropriate electricity act – is effectively implemented. The bigger political question it raises in terms of national governance is whether electricity should be considered exclusively a private or, a public good or a mix of both, with also common pool, community good that involves issues of intergenerational equity (or one that is a mix of all three).

Scaling up of the renewable energy technology, appropriate promotion of end use activities and grid interconnection of the electricity produced by renewable energy system need high-level political propulsion for the sector to gain momentum. Awareness on energy and financing options are still not widespread enough, and limited organized effort is being made for demand creation. Significant financial barriers persist, and the transition to a market-enabled or credit-based model has been slow. Furthermore, the renewable energy market is not significantly benefitting from innovative approaches, best available technologies, and global best practices.

3.6 Energy Consuming Sectors

Nepali energy sector is still largely dependent on traditional energy resources like fuelwood, agri-residue, and animal waste, putting pressure on natural resources and environment. A significant portion of the rural population still rely on traditional energy sources for cooking purposes, making it a sectoral challenge. As depicted by the pie- chart below, in the year 2021, top three energy consuming sectors in Nepal have been identified as: Residential at 63.2%, Industrial at 18.3%, and Transport sector at 9.0%[20].

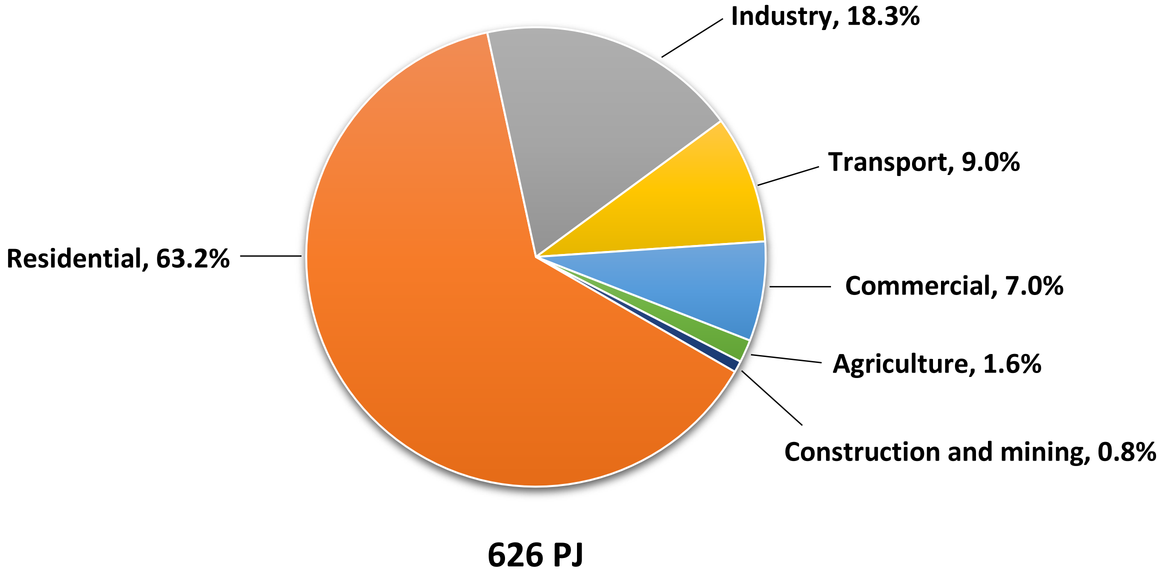

Figure 2: Sector-wise energy consumption in 2021

Source: From "Nepal Energy Sector Synopsis Report- 2022", by WECS, 2022, p. 51. Retrieved from https://wecs.gov.np/source/Energy%20Sector%20Synopsis%20Report%2C%202022.pdf

As mentioned previously, the residential sector in Nepal stands out as the most energy-consuming sector. According to the Nepal Energy Sector Synopsis Report- 2022, in the year 2021, this sector consumed a total of 396 petajoules (PJ) of energy. Fuelwood, agricultural residue, animal waste, biogas and biomass are the major sources of energy used in the residential sector. Among these, fuelwood is the most used energy type at 84.9%. However, compared to 2009 when the fuelwood usage accounted for 87%, in 2021, its usage has slightly declined. Over the past decade, the consumption of LPG gas in the residential sector has increased to 2.8% -- more than double the usage a decade ago. The promotion of alternative energy sources has also helped increase the share of

[20] The facts and figures presented in this section are drawn from "Nepal Energy Sector Synopsis Report – 2022" published by Water and Energy Commission Secretariat in 2022.

biogas usage to 2.5% and solar energy to 0.5%. Furthermore, the use of electricity as an energy source has witnessed an increase from 1% in 2009 to 3% in 2021[21].

After the residential sector, the industrial sector ranks as the second- largest consumer of energy in the country, consuming a total of 114.5 PJ of energy. Thermal purposes primarily drive the use of energy in this sector. Coal represents the most extensively used energy source for furnaces at 48%, followed by fuelwood at 17%. Additionally, for boilers, agricultural residue is used. Diesel consumption is also quite evident in this sector, which is primarily used for motive power and running generators. In recent years, the trend of using electricity for thermal purposes is slowly increasing due to the presence of modern technologies; however, it appears that the use of old technologies is going to persist unless the pace of replacing them increases.

Finally, with the total energy consumption at 56.6 PJ, transportation sector is the third most energy consuming sector in Nepal. Over time, its share of energy consumption has been increasing due to influence of both economic and demographic factors. Transportation sector relies heavily on petroleum products for energy, utilizing less than 1% of electricity. When considering only energy derived from petroleum products, the transportation sector emerges as the highest energy-consuming sector among all sectors. Diesel is the most consumed fuel type in this sector, primarily used by freight vehicles and heavy passenger vehicles. Conversely, petrol is mainly consumed by small private vehicles. Regarding the aviation fuel, more than 50% of the total aviation fuel is consumed by international flights and rest is consumed by domestic flights.

What the picture presented above points to is the need for a more holistic energy policy. Currently the government is in the process of revising its Hydropower Policy 2058 B.S. (2002). A new holistic energy policy would need to bring in not just hydro but also other renewables such as properly harvested (not mined) firewood and its efficient use via smokeless chulos and briquettes, thermal and solar PV, biogas and waste gassifiers as well as wind and geothermal. It would also need to consider the global move away from one-way to two-way grids that includes small producers of energy. And all these objectives would need to be codified into appropriate electricity as well as water resources and decentralized (suited to the concept of federalism) management acts. Without these measures, the country would not be able to benefit from the synergy of solar PV and PSH.

[21] According to IDA report (forthcoming) 74.1% reported using firewood, 62.4% reported using LPG, 15.5% reported using agricultural crop residuals, 11.9% rely on animal waste or dung, 8.4% employ electric energy and 2.8% employ biogas. The figures add up to more than 100% because households could use more than one type of fuel.

4. Hydropower in Nepal

Nepal relies heavily on its hydropower plants to meet the baseload demand which, in turn, is supported largely by run-of-river (r-o-r) hydropower plants whose actual capacity in the dry season (March-May) reduce to only one-third of their installed capacity.[22] Only a single hydropower plant – the 60MW Kulekhani-1 Hydropower Plant with 83 million cubic meters of gross and 73 MCM live storage of the monsoon (June-September) flow – offers seasonal water storage in the country, generating 165 GWh of primary and 46 GWh of secondary energy.[23]

This seasonal storage is far from sufficient to fulfill the system's peak demand load of 1500-1800MW (and total energy consumption of 7319 GWh) only through these r-o-r plants with Kulekhani-1 as the system stabilizer, constituting as it does less than 3% of the total energy budget of the grid. As outlined in *Table 1: Total power generation in Nepal* the IPPs have now installed total MW capacity that rivals the national utility NEA, and in numbers and geographic spread exceeds the NEA and its subsidiary companies by almost four times. They have not, however, invested in seasonal storage plants. Moreover, while most r-o-r plants of the NEA have daily pondage that is capable of meeting a few hours of evening peak demand, the IPPs are reluctant to build daily pondage since there is really no tariff advantage to this additional investment. Private developers also complain of the NEA being both an off-taker of their power as well as a near-monopoly competitor.

The figures 3 and 4 below show (1) System Load Curve for April 26, 2021, which is the dry season, and (2) System Load Curve for July 6, 2022, which is the wet period. As these figures make clear, the power generated by both IPPs and NEA and its subsidiaries is the lowest during this period. The shortfall is recovered by significant import of electricity from India – through the Dhalkebar-Muzaffarpur transmission as well as other transmissions lines. In contrast, as shown in fig 4, the power generated by IPPs and NEA and its subsidiaries increases substantially during the monsoon season. There is also export of power from Nepal to India during this period.

[22] It should be kept in mind that till the mid-1980s, the government of Nepal – via the Water and Energy Commission Secretariat (WECS) would conduct a "generation expansion plan" to identify the most suitable next project to meet the grid demands. That is no longer done, and r-o-r hydro development licenses are awarded to literally anyone who asks for it. The current imbalance of "flood-drought" syndrome is the result of it.

[23] To meet the increasing peak demand, in the absence of any plan to build other storage projects, it was decided to use the tailrace of Kulkekhani-1 and use that to produce peak electricity via the downstream 32 MW Kulekhani-2 and the 14 MW Kulekhani-3 which are currently in operation.

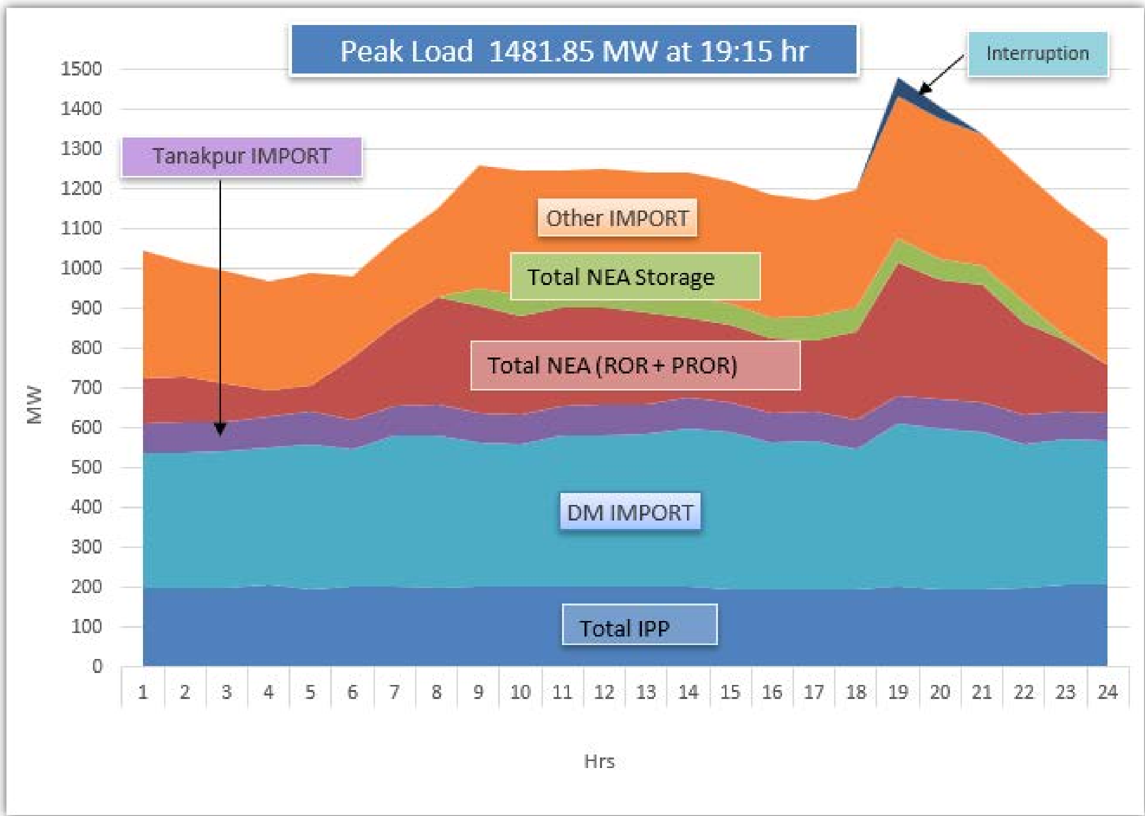

Figure 3: System Load Curve: April 26, 2021 (Baisakh 13, 2078)

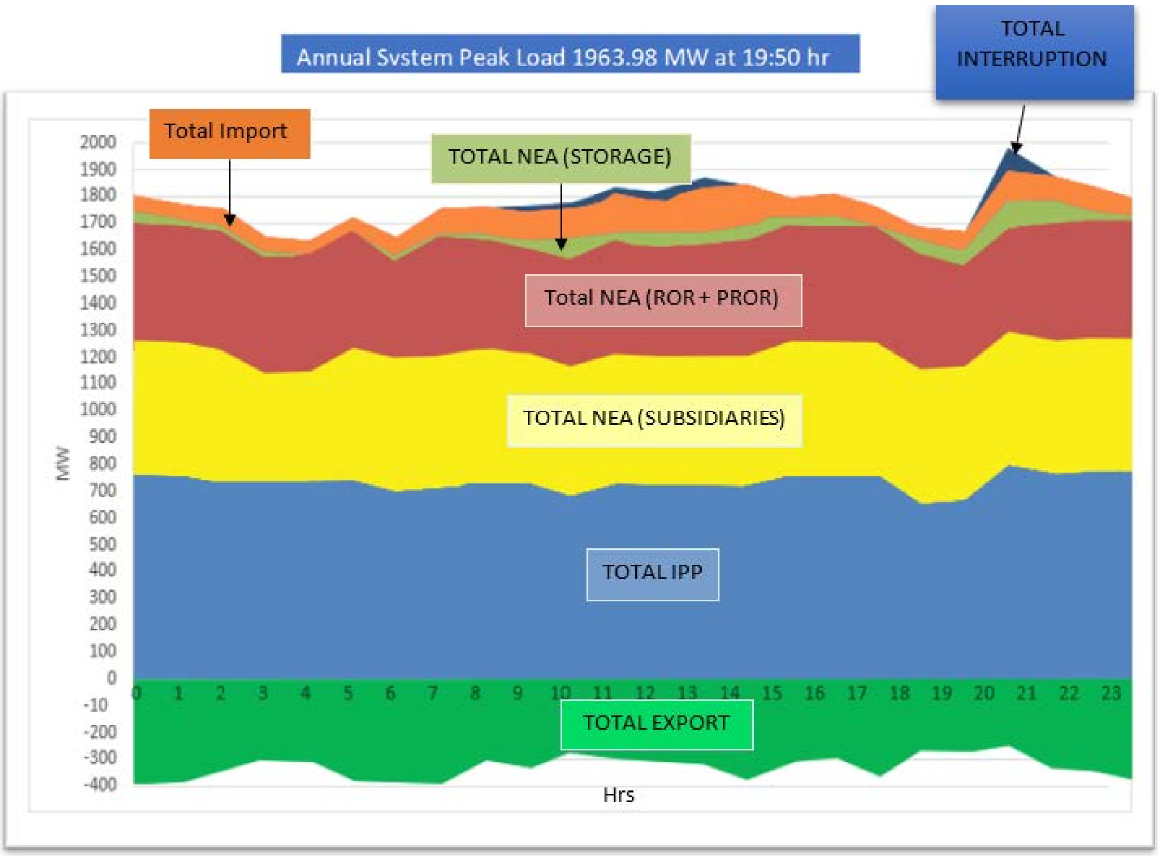

Figure 4: System Load Curve: July 6, 2022 (Asar 22, 2079)

4.1 Need for Seasonal Storage Power Projects

There is a growing realization in Nepal of the need to develop seasonal storage power projects to fulfill the country's need for peak load demand especially in the dry non-monsoon months and to balance its system of electricity generation. However, some of the most ideal storage-type hydro projects for Nepal's needs such as West Seti, Budhi Gandaki or Tamor have been mired in controversy over the last decades; and currently no storage hydro has been built or are under construction in Nepal after Kulekhani-1 (with additions of the 2 and 3 cascades). Disputes and impasse have also been the fate of larger storage hydro projects meant for export to the Indian electricity market such as the 10800MW Karnali Chisapani, the 5000MW+ Kosi High Dam or the 6480MW Pancheshwar High Dam signed under the Mahakali Treaty some 25 years back.

Nepal saw its first major controversy over hydropower development in the demise of the World Bank promoted 203MW Arun-3 in 1995 due to opposition over its high costs (Gyawali, 2013a). This resulted in Nepal opening the door to private developers, both local and foreign, to develop hydropower plants in Nepal. Today a booming Nepali private hydro sector with many more power plants across the country and more installed capacity under construction than the national utility is involved in a protracted debate over unbundling the national utility, tariff restructuring, as well as who should be developing counter-balancing storage hydro. All these debates have also been milling around proposed new electricity as well as water resources acts since almost a decade and a half.

To add to those old controversies, there are newer ones as well related to the hydro sector in Nepal. A national electricity regulatory commission formed and appointed in 2019 was suspended by the new government, leading to uncertainties about how and from whom should private sector developers conclude their power purchase agreements. It has been reinstated but is still having difficulties finding its feet and collaborating constructively with the different institutions related to electricity and energy described earlier.

There are several lessons in all of this for our proposed PSH. Hydroelectricity project development in Nepal and much of South Asia (including PSH but as argued in this report at a much lesser scale than conventional hydro development) is intrinsically linked with the challenging socio-political context related to multipurpose uses of water, especially daily or seasonally stored water. Neither the existing electricity nor water resources acts have taken this adequately into cognizance; but hopefully the proposed new acts on these matters will have resolved these issues before their passage by parliament. COP27 has finally come around to declaring that climate change problem is a water problem. Even as energy managers stay focused on the broader technical, economic and institutional questions of renewable energy replacing fossil fuel to meet the challenge of climate change, what climate change will do to the global water cycle and as a corollary to hydropower plants including PSH becomes a much more "wicked problem" to handle.[24]

4.2 Benefit- sharing Mechanisms in Hydropower Development

The World Commission on Dams in 2000, for the first time highlighted a significant concern related to the potential adverse effect of dam construction on the delicate ecosystem, its impact on the natural resources, and subsequently, the potential effects to the livelihoods of local communities

[24] See https://www.thethirdpole.net/en/climate/opinion-is-water-sectors-uncomfortable-knowledge-missing-at-cop28/

heavily dependent on these resources. By underscoring this critical issue, it urged the state governments and the hydropower developers to figure out a mutually beneficial, fair and equitable benefit sharing mechanism that would benefit the affected local communities as much as the project developers (Shrestha et al., 2016). The World Commission on Dams also proposed that its report "Dams and Development: A new framework for decision- making (DAD)" be utilized as a fundamental basis for engaging in constructive dialogues regarding development outcomes and arriving at mutually beneficial solutions. DAD has outlined seven key strategic priorities that should be incorporated into the decision- making processes related to the selection, construction, and management of dams: "gaining public acceptance, conducting a comprehensive options assessment, addressing existing dams, sustaining rivers and livelihoods, ensuring compliance, recognising entitlements and sharing benefits, and sharing rivers for peace, development and security" (Dixit et. al., 2004).

Since then, benefit sharing with local communities and the indigenous population is seen as one of the most important criteria for any hydropower project to be called as a 'sustainable hydropower project'. The existing literature on 'benefit- sharing' defines it as "measures which go beyond their expected obligatory limits in quality and time" (SWECO, 2011, p. 12, as cited in Shrestha et al., 2016), thereby distinguishing it from concepts such as 'compensation' and 'mitigation'. For instance, the relocation of the displaced local communities as the result of the project construction and the compensation that they are provided for their losses is not regarded as 'benefit- sharing'. For it to be a benefit sharing mechanism, it needs to go 'beyond the mitigation of project impacts and beyond compliance to a situation where the local affected population directly benefits from the project'. At present, Nepal's hydropower sector employs five main types of benefit- sharing mechanisms and they are: The royalty mechanism; Equity investment: Local share offers in hydropower projects; Support for local livelihoods: Employment and training; Investment in community development and local infrastructure and Environmental enhancement activities.

The following paragraphs discuss the first two mechanisms.

Royalty Mechanism: Nepal government revenue to local bodies from hydropower development

The single most formalized benefit-sharing policy in the Nepali hydropower sector is the royalty mechanism. Through this mechanism, for the water resources used by hydropower projects or the developers, the government collects royalties, and a certain portion of it is allocated for communities which is delivered through local governments. Nepal's Electricity Act 1992 serves as the basis to collect royalties from the hydropower plants. Before Nepal became federal in 2015, Nepali hydropower sector followed a royalty system in which 50 per cent of the payments fed the national treasury, 38 per cent formed a regional share that benefitted multiple districts around the dam, and 12 per cent went directly to the dam's district development committee. All the funds first went directly to the central treasury and from there to the regional and local bodies.

After Nepal became federal in 2015, the proportion of royalty going to the federal government, provincial government and local government has slightly changed. At the moment, 50 percent goes from the central treasury to the Nepal government, 25 percent to provincial government and 25 percent to local government. For instance, the 2% royalty from revenues from Kulekhani project are split: 50% national, 25% provincial and 25% to the wards. The stakeholders, however, complain that there is no transparency regarding the information concerning the transfer of royalties from hydropower projects to the central government and subsequently to the districts. Stakeholders claim that when the Department of Electricity Development (DoED) discloses the royalty amount, it omits detailed information regarding the exact source of funds and merely lists the overall amount that goes to the province and local levels.

Local People and Share

Another benefit- sharing mechanism practiced in the Nepali hydropower sector is the equity or 'share' offers to the local people in the project affected area. It differs from the royalty mechanism, in that, while royalty is collected by the government and then a certain portion of it distributed to the provincial and the local bodies to be spent as the local institutions deem appropriate, the equity shares deliver benefit directly to the individual shareholders (Shrestha et al., 2016). Securities Registration and Issuance Regulation 2008 states that a hydropower company that is registered as a public company possesses the capacity to issue up to 30% of their shares to the public, out of which 5% must be separated for the company staff, 10% must be made available to the local people of project-affected areas, and the remaining 15% should be separated for the general public. However, if the local people are unable to purchase the allocated 10% of the shares, the remaining shares from this portion is mixed with the shares that is offered to the general public.

The Nepali hydropower sector classifies individuals as 'local' and affected' in several ways. One common approach out of many is to divide affected people into three groups as "severely affected" (atiprabhawit), "affected" (prabhawit), and "less affected (kaam prabhawit). However, the right to define who qualifies as "local people" when defining the affected population is entrusted to the hydropower company itself. Consequently, some companies define local people as affected citizens from the wards where the project is located, while others may consider residents of the affected municipality or districts as the local population.

While this practice of distributing equity shares to the local people may appear to be a win-win situation for both the residents of the project affected areas and the hydropower investors, there looms a significant question of what happens to the shares once the scheme, having completed 30-35 years of licensing period, reverts back to the state? Regrettably, the current policy framework lacks clarity on this matter. Although there were discussions of incorporating this issue in the drafting of the new Electricity Act, the Electricity Bill- 2020 aimed at amending the Electricity Act (1992), which was under consideration in the National Assembly (upper house) was withdrawn on 16th of September, 2022 by the then Energy Minister Pampha Bhusal (Khanal, 2023; Koirala, 2022). It is now with the parliament's Infrastructure Development Committee.

5. Electrical Energy Storage in Nepal

5.1 Pumped Storage Hydropower and its relevance

The concept of pumped storage hydropower (PSH), though an old technology with over 100 years of application in Europe, has not yet been realized in practice in Nepal, despite its capacity to store surplus electrical energy that can then be supplied during periods of peak demand and to stabilize load variations. PSH offers many additional services and advantages, including being the cheapest and lowest greenhouse gas emitting electrical energy storage technology for grid-scale use. It also offers opportunities for co-location with renewable generators such as wind and solar, being able to be designed and sited to have minimal negative environmental and social impacts. They provide significant local benefits because the majority of development costs are spent locally, as well as being able to provide frequency control services and back start capabilities. Further, the surplus energy generated during the off-peak hours could be utilized to pump back the water from the lower reservoir to the upper reservoir. A pumped storage plant would indeed allow for load management and optimal use of available electricity.

5.2 Identified Challenges and Needs

Despite this, the flat rate tariff structure currently used in Nepal, does not incentivize incorporation of storage in conventional hydropower plants, let alone the development of PSH. Lobbying for PSH as a means of energy storage requires a background study in detail of the institutional and political economic context and concerns in addition to investigations into the suitability of specific sites. These are some of the issues that this report has sought to investigate at a preliminary level.

The energy hydropower terrain needs to be properly mapped with constraints to PSH development identified, since the potential contribution of PSH cannot be assessed in isolation. The first steps towards such a mapping would be detailed and regular survey of changing nature of electricity supply and use as well as an assessment of the newer market and institutional players entering the field together with their challenges and constraints. More importantly, the institutional and legal arrangements within the electricity sector should be brought to the fore and the contribution of r-o-r schemes and other alternatives sources of energy should be examined. For example, the contribution of r-o-r schemes constructed by Independent Power Producers (IPPs) as well as Nepal Electricity Authority (NEA) hold tremendous possibilities of developing significant PSH as add-ons to existing power plants. However, a major bottleneck is the rules and regulations for licensing of plants. If developers are not sure of their ownership of the lower power plants (their licenses expire in 35 years of which they will have already expended some 10 or 15 years of it in existing operating plants), they will be reluctant to make new investments in PSH no matter how technically and economically feasible. Similarly, the contribution of imported electricity (which is mostly from India's coal-fired plants) and Nepal's export of clean hydroelectricity in increasing or decreasing the carbon footprint of both countries has to be properly assessed.

As part of innovative research for changes in the electricity market systems, it will be necessary to examine both the advantages and disadvantages that could come from adopting policies to incentivize new PSH and which would require significant institutional tinkering as well as reform. This will require a political economic approach identifying the vested interests for status quo as well as those seeking significant changes such as the IPPs and to ensure meaningful constructive engagement among Nepal's hydropower, solar, biogas as well as non-renewable fossil fuel energy stakeholders.

An example of the difficulties is Nepal's only large seasonal storage project Kulekhani-1 mentioned earlier. Its tailrace water is used to generate 32 MW and 14 MW in the lower cascade with the tailrace from the lowest in the cascade Kulekhani-3 being used by traditional farmers for irrigation and also contemplated for water supply in the industrial township of Hetauda, to say nothing of its environmental flow in the East Rapti river passing through the Chitwan national park. It would make reverse pumping not just physically problematic but highly unpopular as well.

From an electricity generator's perspective, it is also important to assess the willingness to pay for the electricity generated through the PSH. For example, pumping from the lower reservoir to the upper reservoir either within existing flat-tariff regime or through use of other renewables such as solar or wind may not always be feasible. It would have to be related to differential tariff rates – such as day time, night time and seasonal peak periods. In Nepal, daily peaks occur from early evening to about 10PM while seasonal peaks in the hills occur in the winter and in the Tarai plains in the hot season of April and May.

These considerations of an internal to Nepal nature are also relevant in the case of South Asian regional energy grid, especially between north Indian states from Delhi to Kolkata, and perhaps even to Bangladesh, even though the scale difference between these two types of development is immense and would change planning parameters completely. The Indo-Ganga plains south of Nepal, Sikkim and Bhutan is a vast flat expanse with no possibility of any surface water storage by dams. Thus, PSH in the Himalaya becomes both a very attractive and very challenging proposition, the latter linked to social and political issues of resettlements, environmental costs as well as significant restructuring of power exchange tariffs and the nature of transmission interconnections.

There are possibilities of linking PSH developments in the Nepal/Sikkim/Bhutan Himalaya with not only solar and wind generators in India but also primarily fossil fuel based generating systems of India and Bangladesh. The surplus electricity generated by Indian generators (including renewable ones such as solar or wind that are daylight or local weather dependent) could be stored in Himalayan PSH systems, for later supply to Nepal or other neighbouring countries. Indeed, despite uncertainties of tariffs, development of actual transmission infrastructure as well as institutional arrangements, there have been some significant progress in recent talks at the official levels of India and Bangladesh for cross-border power trade. This PSH research could provide significant technical and economic input to such official exchanges.

Reverse pumping when the tariff is low i.e., daytime or night time and from lower to upper reservoir during the low load period could be a more viable option for Nepal instead of relying on solar or wind renewables to do the pumping. The cost-benefit analyses, including those related to environmental costs, need to be taken into account. Rounds of interaction with the tariff commission as well as other stakeholders would also be helpful on these issues.

For the advocacy of PHS to be stronger, two types of "cases" need to be examined. The first is related currently undeveloped sites. The second will be examination of existing r-o-r plants, where adjustments such as including ponding either above or below the plant could enable them to be used as PSH systems with minimal capital expenditure and maximum use of already built infrastructure such as roads, transmission access, staff quarters etc. Site visits to both proposed undeveloped sites and to existing hydropower plants are required to develop strong case studies. For example, this would allow detailed cost projections to be made for re-purposing existing r-o-r plants as PSH systems. This research on PSH should be aligned with, and contribute to, the current draft electricity bill and water resource bill. Further assessment of these bills should be done to properly reflect on what grounds the PSH could be incorporated and provisions be made in the existing and proposed bills/acts for policy reforms.

6. Electricity Transmission in Nepal

6.1 Status of Nepal's Transmission System

Nepal's integrated national transmission grid was developed in a rather ad hoc manner since the very beginning, primarily to supply the capital city and later to some industrial/commercial towns such as Biratnagar and Butwal/Bhairawa in the 1980s. Nepal's transmission system began with 33 KV and 66 kV lines, and later 132 kV line was built between Hetauda and Biratnagar. Recently, the emphasis is on 220 kV and 400 kV transmission, including the interconnection between Nepal-India at Dhalkebar-Muzaffarpur link, that by US's MCC via Hetauda and Bhairawa as well as proposed interconnections at Bhairahawa- Gorakhpur and with China at Galchhi- Rasuwagadhi.

The current status of transmission lines under the Transmission Directorate of the NEA is published in its annual reports.[25] The pressure on the NEA to build more transmission interconnection was exerted following the massive growth in numbers of private sector development of hydro power plants as NEA and its load dispatch centre was the de facto owner of the interconnected grid. A recent master plan has been developed by the Rashtriya Prasaran Grid Company which does the planning from a purely technical perspective and does not examine the social, legal and environmental issues.[26] Also, given the wide spread of power plants across the country by Nepali developers and the changing India (and perhaps Bangladesh) interconnection needs, it is obvious that such a master plan would need regular upgrading to accommodate the fluid development context.

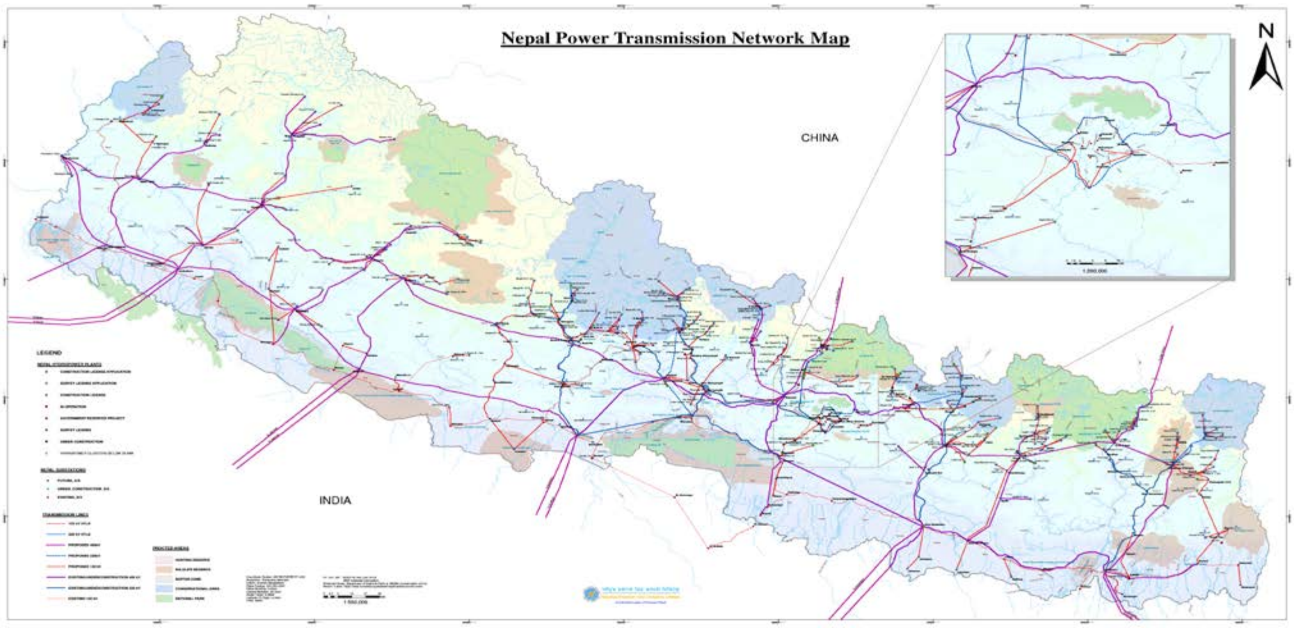

Figure 5: Nepal Power Transmission Network

[25] See: https://www.nea.org.np/admin/assets/uploads/annual_publications/Transmission_2021-22.pdf

[26] See Transmission System Development Plan of Nepal (2018): https://nepalindata.com/media/resources/items/15/bTransmission-System-Development-Plan-of-Nepal.pdf

6.2 Community Concerns surrounding Transmission Lines

Transmission line building in Nepal has always been engulfed in land acquisition controversies and public protests. Local people's concerns in hydro power and energy relate to both the hydropower plants that generate electricity as well as to the transmission lines that transport electricity. In the case of transmission lines, local and indigenous community's concerns revolve around issues of right of way i.e., the land where the towers are erected and the land above which the transmission wires pass (LAHURNIP et al., 2019). Due to the fact that the local and indigenous community generally tend to be adversely affected by the hydropower plants and transmission lines, they tend to oppose such investments. Concerns stem from the fact that the local communities, many of which constitute indigenous people, are generally misinformed, cheated, and not provided due compensation. As a consequence, there have been many Public Interest Litigations (PIL) against hydropower plants and transmission lines in the past.

Those who have been struggling for local and indigenous rights in the context of hydropower related infrastructure projects have advocated that international instruments such as ILO convention 169, the United Nations Declaration of the Rights of IPs and relevant national laws related to electricity, forests, land acquisition and local governance be strongly adhered to in order to protect the rights of local and indigenous people and prevent them from being further marginalized. In operationalizing ILO Convention 169 and in ensuring the rights of indigenous people in the context hydropower projects, those who have been championing the rights of indigenous people point to the importance of

1. Free prior informed consent (FPIC),
2. Benefit sharing and,
3. Mitigation of negative impacts as the main mechanisms,

which if implemented properly, will safeguard the rights and interests of the indigenous and local people.

Those working on rights of indigenous people point out that FPIC is a process as well as a body of rights but that a law to this effect has not yet been made in Nepal. To a certain extent, however, environmental justice embodies some of the principles behind FPIC. These rights activists note that although the Nepali government and international investors have accepted the need for FPIC, and have sought to operationalize it in the projects that have been underway in the past four or five years, there are a lot of loopholes in the actual implementation of FPIC. Moreover, indigenous rights activists also point out that FPIC is closely tied to the Right to Information (RTI), a principle which is enshrined in Nepal's Constitution.

Benefit-sharing is a broad term. Compensation and benefit-sharing are not synonymous. Indigenous rights activists point out that these are two separate issues in terms of law and that they are better captured by the Nepali terms - *muaabja and chyatipurti. Muaajba* refers to the expenses of land or property whereas *chyatipurti* (compensation) covers benefit-sharing. Rights activists argue that the international standards talk about benefit-sharing and that the profit earned should be given as compensation to the concerned community to serve a collective purpose. In Nepal the compensation is given to individuals rather than to the community.

6.3 MCC-Nepal Compact and BRI initiative

External donor agencies also have a history of involvement in the transmission development. In the early 1960s, USAID helped build transmission and distribution network to enable the evacuation and distribution of power to Kathmandu Valley from the Soviet Union-built Panauti HEP, Chinese-built Sun Kosi HEP and Indian-built Trisuli HEP. The Asian Development Bank is the development agency with the history of the longest continuous involvement in transmission development, followed by the World Bank and recently the American Millennium Challenge Cooperation (MCC). While the World Bank had committed itself to build/upgrade two major transmission lines – Hetauda-Dhalkebar-Duhabi 400 kV and Hetauda-Bharatpur-Bardghat 220 kV lines – it suddenly pulled out of these two projects in March 2022 citing inability of NEA to do the land acquisition on time.[27]

The US' MCC-Nepal Compact aims to increase the availability and reliability of electricity, improve roads, and facilitate power trade across South Asia. In September 2017, the U.S. Government's Millennium Challenge Corporation (MCC) signed a $500 million grant agreement with the Government of Nepal. According to the compact, MCC will provide $500 Million, and Nepal will contribute $130 Million for the programme which will complete two distinct projects in energy and transportation within five years. This project intends to build a 318 km long 400KV transmission line with three high-capacity sub-stations to more efficiently transfer power. The Hetauda-Damauli-Butwal transmission line will reach the Indian border, which will enable Nepal to export power from Nepalese hydropower projects which are expected to produce a surplus in the next decade. It is, like all other transmission line projects with right-of-way land acquisition etc, not free of controversy centred around whether Nepal should export electricity or use it for its own, industrialization, high costs and the bypassing of existing transmission related entities.

While China had previously stated (during the Arun-3 debates in the 1990s) that it had no plans to import hydroelectricity from Nepal as its primary load centers were too far away from Nepal and that for Tibet, it was planning to develop solar in a major way, it has now entered the Nepal transmission system debate as part of its Belt-and-Road initiative: a 400 kV transmission is envisaged to Rasuwagadhi in Tibet just north and Kathmandu, and from where the proposed Nepal-China rail connection is to be made.[28] With the soft loan of BRI initiative, there are plans to build Kerung-Rasuwagadhi-Galchhi 400 KVA cross-border transmission line. This project will allow Nepal to trade electricity with China, especially since its Tibet Region is going to be solar PV dominated.

On the positive side for PSH, given that India is developing solar power in a big way and Tibet's power system is primarily solar, it poses serious need for electricity during off-sunlight hours. The magnitude of these developments is so big that they pose serious challenge for the Nepali grid with its interconnections with the Indian and Chinese systems, pointing to the need for large-scale electricity storage in reservoirs, both big and small, in the hilly terrains of Nepal.

[27] See: https://kathmandupost.com/national/2022/03/06/world-bank-pulling-out-of-transmission-line-projects-shows-challenges-for-mcc

[28] See: https://kathmandupost.com/national/2023/01/24/china-proposes-a-meeting-in-february-for-cross-border-power-line-in-nepal

7. Power Market in Nepal

Load forecasting was done seriously pre-1990 when the Water and Energy Commission conducted its generation expansion plan exercise. It used various methods to do so including trend forecast as well as disaggregated forecasts based on "pent up" demand conditions of being-built and proposed businesses and industries. With the power managers in panic after the cancellation of Arun-3 in 1995, and the opening of the doors to private sector investment, load forecasting did not figure as a policy priority, the assumption being that the country would need anything that could be developed while the excess electricity, if any, would find an easy market in India. The power ministry then issued r-o-r hydropower licenses to anyone asking for it anytime. Indeed, the rules even stated that the request could not be held back for a month or so, which resulted in the current massive r-o-r surplus during monsoon months.

7.1 'Demand' and 'Market'

It is important to distinguish between "demand" and "market". It can be argued, for instance, that India has a huge demand for power but there really is no market as far as Nepali electricity is concerned. Not only is India a monopsony, its stated policy is to see water and electricity as strategic goods for its industry and agriculture, to be made available at as close to lowest cost price as possible. Entry into the Indian grid for Nepali electricity is restricted to what is allowed by bureaucratic fiat, to limited megawatts produced by Indian companies or companies having majority Indian shares and not from electricity produced by Chinese or any other foreign investments.[29] As Nepal's r-o-r dominated grid has a huge surplus of hydroelectricity during the monsoon months with the capacity of power plants coming down to one-third of their capacity, Nepal imports anywhere (depending on the monsoon and the winter westerlies) from a third up to half of the total electricity consumed during the winter/dry season often at very high spot market price.[30] Moreover, despite climate change concerns, Nepal exports clean hydroelectricity cheaply to India and import dirty coal-fired electricity from India at substantially higher price. Nepal's request to export electricity during the monsoon surplus has been met in very miniscule amounts.[31]

Currently, the national debate is fierce about whether Nepal's hydropower should be developed for export or for providing competitive edge for national commerce and industry. Advocates of the latter quote a USAID study (Nexant, 2003) that showed that if Nepal exported electricity to India, it would earn only 6 US¢/kWh whereas if it used that within Nepal, it would earn 86 US¢. Their argument is further bolstered by the fact that Nepalis, at 204 kWh/capita/annum in 2021 are some of world's lowest consumers of electricity with corresponding figures for Bangladesh, Sri Lanka, India and Bhutan being 476, 751, 1,218 and 11,576 respectively.[32] They argue that, until we exceed the electricity consumption level of India, we should not even think of its export as a policy. However, it is worth noting that in a recent meeting with the Indian Prime Minister Narendra Modi during the

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29 See: https://www.thethirdpole.net/en/regional-cooperation/indian-developers-replace-chinese-some-of-nepals-largest-hydropower-projects/

30 See: https://www.urjakhabar.com/en/news/0302656660

31 See: https://www.urjakhabar.com/en/news/0411242990#:~:text=Kathmandu%3A%20India%20has%20consented%20to,produced%20by%20Chilime%20Hydropower%20Company

32 See: https://ourworldindata.org/grapher/per-capita-electricity-generation

official four- day visit to India between 31st of May, 2023 to 3rd of June, 2023, PM Pushpa Kamal Dahal made a request to his Indian counterpart for approval to export electricity from Nepal to India, and Bangladesh via the Indian grid[33].

7.2 Tariff for residential and industrial use of electricity

In Nepal, domestic consumers pay for the electricity used on an increasing slab basis, meaning, as the number of consumed unit increases, the money they have to pay also increases. For instance, as per the policy of the Nepal government, customers with a 5- ampere meter who consume 20 units or less of electricity are not charged anything by NEA, except for the minimum service charge of NRs. 30 per month (Shrestha, 2023). On the other hand, consumers with a 60- ampere meter need to pay NRs. 12 for every unit of electricity used.

Regarding the industrial and commercial consumers, along with the charge for energy consumed, they are also required to pay a “demand charge” per kilovolt- ampere (kVA) per month. Furthermore, to encourage activities like irrigation, charging of electric vehicles etc. during off- peak hours, the Nepal government has also introduced a differential “time- of- the- day” tariff for industrial and commercial consumers. There are three differential tariff periods: Normal hours from 5 AM to 5 PM, Peak hours from 5 PM to 11 PM, and Off- peak hours from 11 PM to 5 AM.

[33] During the meeting, the two PMs focused on diverse aspects of Nepal-India relationship, including hydropower, power trade, and transmission lines among others (Embassy of Nepal, May 2023). Regarding the same, the main points that were discussed and agreed upon as listed in the Press Release by Embassy of Nepal, New Delhi were: PM Narendra Modi shared that in the next 10 years, India has intentions to increase the import of hydropower from Nepal to 10,000 MW; PM Prachanda requested his Indian counterpart for his approval to export an additional 1200 MW of hydropower to India and also asked PM Modi to approve 456 MW Upper Tamakoshi Hydropower project as soon as it is feasible; and India also agreed to facilitate the first trilateral power transaction, enabling the export of 40 MW of power from Nepal to Bangladesh through the Indian grid (Embassy of Nepal, May 2023).

8. Energy Master Planning in Nepal

8.1 Master planning and Identified Challenges and Needs

As explained earlier, master planning exercises have been done in Nepal since the 1970s but plans have rarely been followed. Instead, the exigencies of national and donor interests have dominated practice and choice of hydro development as the Arun-3 episode demonstrates. Moreover, it is already too late for a "First Generation" standard type masterplan because the feasibility or construction licenses that have already been awarded cannot be undone without inviting court challenges which the government would in all probability lose. There is agreement among senior officials that any new version of the masterplan will need to acknowledge the existing arrangements, the legal rights, the water rights etc. and in a sense, this would be a "Second Generation" masterplan that cannot pretend that it is drawing a plan on a blank slate but on a living, dynamic and fast-changing power sector environment where the government agency alone is not the "master"[34]. Furthermore, many master planning software and models tend to optimize in a manner that privileges large over small according to the "principle of economy of scale". In Nepal's case, however, as highlighted by many including Karki (2017), the benefits of distributed development of many smaller HEPs is strangely cheaper, more resilient to flood damage risks and social as well as difficult-to-quantify social and economic infrastructural benefits significantly greater.

It is learnt that WECS is working on a new Hydropower Development Masterplan[35]. However, representatives from other government agencies were unaware about this development, not to speak of the IPPs. It was learned from the participant from WECS that the primary goal of formulating a new Hydropower Masterplan is to prioritize the overall national benefits, not just narrow private ones. It was acknowledged that there is a need for a meeting of minds between the government and the private sector so that both parties can find a common ground and figure out mutually beneficial solutions. It was also clarified that this master planning exercise at this stage, does not have any plans and policies laid out for PSH development in Nepal. However, it was highlighted that if proper study/ research is conducted on PSH, there is still a chance to include PSH in this version of the master plan. NEA has recently identified, using the PSH atlas, some 17 potential PSH sites that they are currently examining in greater detail.

Today, almost 97% of the electrical energy in Nepal is obtained from hydropower (90% run of river [RoR]), and the national grid reaches more than 90% of households (Department of Electricity Development, 2021).

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34 This insight has been drawn from the group meeting with the representatives of the government agencies (June 5, 2023) and KII with Mr. Sanjay Dhungel (April 12, 2023).

35 This was learnt from Dr. Kapil Gewali during the government stakeholder's interaction on June 5, 2023. During the interaction, Dr. Gewali briefly touched upon certain aspects related to the basin plans, but the specific contents of this new masterplan were not discussed in detail. When asked if the issues related to licensing period and other demands of the Independent Power Producers (IPPs) would be addressed in this version, it was explained that the IPPs are aware of the current master planning exercise; however, it was clarified that all of the demands made by IPPs may not be accommodated.

[36] However, given that past policy of Nepal government was to see electricity provision as one of providing lighting and given the advent of low wattage CFL and even lower wattage LED bulbs, lighting really is no longer a pressing issue to most Nepali consumers since a simple solar panel and battery can easily provide that as well as the other most pressing demand – recharing mobile phones. What is of concern currently is transition to electric cooking and use of other electrical appliances such as washing machines etc in the domestic sphere and to electric vehicles in the transport sector. However, it is being realized that much of Nepal's distribution system geared to lighting (and most of the NEA customers having only 5 Ampere meters) is not adequate for that task. Hydropower is also uniquely susceptible to disruptions from climate change. A non-diversified grid thus poses a reliability risk, and increased electricity demand in Nepal should not be met via hydropower development alone. Rather, the energy mix should incorporate modern and improved traditional renewables alongside hydropower, and include an innovative mix of energy storage solutions including off-river pumped storage (Lohani et al, 2022).

As discussed in the section on institutional disjuncture above, it has been argued that Nepal, with excessive focus on hydropower, has not really had a more balanced, multiple-type energy policy.[37] And even the electricity policy has suffered from blind-spots over the last half a century across a wide range of issues. One is the failure to develop ropeway technology that, despite having come to Nepal a century ago, is more mountain- and climate-friendly and much cheaper to build and operate than hill roads. Others relate to the fixation on exporting electricity rather than using it to the benefit of commerce and industry within the country. There has also been a failure to link the multipurpose benefits of seasonal water storage in irrigation, flood control, fisheries, tourism etc., resulting in the lumping of all development costs on electricity, thus making it expensive and non-competitive.[38]

[36] This is contested by the community electricity federation NACEUN which argues that the number is significantly lower. This issue could be one of the methodology used for counting.

See: https://bulletin.ids.ac.uk/index.php/idsbo/article/view/2822/ONLINE%20ARTICLE

[37] This was pointed out in an IDA consultative meeting on PSH by invited experts on 19th December 2022.

[38] These issues are discussed in Gyawali (2022) in the issue of Urja Khabar, vol. 2 Issue 3, December 2022.

9. Sustainability Issues regarding PSH in Nepal

9.1 Environmental and Social concerns related to Hydropower and Energy Sector

Planning exercises in Nepal have been conducted ever since 1970s. However, the focus of these exercises in relation to the Hydropower and Energy Development, have primarily revolved around technical aspects such as demand and supply, neglecting environmental and social concerns. Policies like the Hydropower Development Policy, both 1992 and 2001, have only briefly touched upon sustainability and environmental concerns related to hydropower and energy sector. Additionally, despite the presence of regulations such as the Environment Protection Regulation (1997) and Environment Protection Act (2019), which emphasize wise and prudent utilization of natural resources to safeguard the right of every citizen to live in a pollution-free and healthy environment, as well as provide compensation for any damages suffered by victims (UNEP-LEAP, n.d.), the complaints from local residents and indigenous communities suggest weak implementation of these measures.

Currently, there are a few manuals that have been formulated based on international best practices that also addresses the GEDSI concerns. International Finance Corporation (IFC), for instance, has made significant efforts to incorporate good international environmental and social practices in the Nepali hydropower development sector. In collaboration with International Centre for Integrated Mountain Development (ICIMOD) and supported by the Australian and Japanese governments, IFC in 2018 funded the drafting of a manual called 'Hydropower Environmental Impact Assessment Manual (HP-EIA) of Nepal'. HP-EIA manual aims to guide the EIA practitioners and the hydropower project developers "in streamlining, identifying and managing environmental and social risks as well as impacts better" (Oli, 2018, para. 6). Under the section "Stakeholder Engagement", this manual has highlighted the need for a stakeholder identification and analysis process because communities consist of individuals who have 'diverse needs, dependencies, vulnerabilities, and perspectives related to a project' (MoFE, 2018, p. 12), and these needs, dependencies and vulnerabilities are always influenced by factors such as 'gender, caste, ethnicity, age, education level, language skills, social status, and cultural nuances. Therefore, it states that the process of a stakeholder identification should be carried out as a means to comprehend and recognize these variations, thereby ensuring representation from different groups.

"IFC's Program in Nepal Fuels Sustainability" (2023) informs that this manual has now become compulsory for all hydropower projects requiring an Environmental Impact Assessment (EIA). IFC ever since 2016 had also initiated the 'Nepal Environmental and Social (E&S) Hydropower Program (2016-2023)' which according to the article has played a crucial role in the development of a sustainability friendly hydropower industry. The article also states that this program has had a positive impact on 67 hydropower projects, with a combined capacity of 3919 MW, including projects in the pipeline.

ICIMOD has also time and again held stakeholder consultations and has advocated for the need of a hydropower framework/policy that focuses on environment and sustainability concerns. On 22nd of September, 2022, ICIMOD published an article, 'Laying the groundwork for sustainable hydropower in Nepal', which discusses the stakeholder consultation that ICIMOD conducted, wherein, representatives from government agencies, private developers, academics, engineers, and researchers recommended "preparing climate resilience guidelines for Nepal with institutional arrangements for resilient hydropower development". The article also explains that the participants recommended "regular awareness programs on environmental issues, climate change impacts, and capacity building of community members and construction workers to mitigate risk and impacts from natural hazards at project sites".[39] Apart from this, Nepal Hydropower Association in collaboration with World Wide Fund for Nature in 2016 has also conducted a study to explore the possibilities of incorporating the Hydropower Sustainability Assessment Protocol (HSAP Protocol) developed by International Hydropower Association (IHA) in different hydropower projects of Nepal.[40]

Despite the noteworthy efforts of these international organizations, more work is needed to ensure a robust planning, implementation and monitoring of the sustainability and the GEDSI framework in the Nepali hydropower development sector. For Nepal, it has been the case that the government and the hydropower developers express contentment with the regulations, guidelines, and requirements that are in place for the Environmental and Social (E&S) concerns. However, the local communities feel that transparency is lacking and that the stakeholder engagement is limited. They also feel that they are not provided with adequate and fair benefits and compensations. The interests and limitations of the government institutions, coupled with a lack of political will, seems to have hindered the successful implementation of the existing favourable policies, regulations, and guidelines[41].

9.2 GEDSI Issues and Considerations

A detailed write up on Nepal's GEDSI status and the status of GEDSI issues related to hydropower--standard and PSH-related-- has been described in a separate paper.[42] The following points are the summary of core concerns highlighted in that paper:

- As with many places around the world, Nepal has been a traditionally patriarchal society with many social practices guided by its norms. Though Nepal is a multi-ethnic, multi-lingual, multi-religious country due to certain historical processes related to its formation, certain caste and ethnic groups remain dominant. People of certain caste or ethnicity, gender and people with disabilities have not accessed and benefited from development to the extent they should. With the advent of development and modern education in the 20th Century, certain communities, especially with stronger base in urban areas and the capital city, were able to take advantage of it, whereas communities in the deeper hinterlands were left significantly behind.
- The Constitution of Nepal 2015, the current five-year plan (i.e., 15th five-year plan) and various laws like 'Local Level Election Act 2017', 'House of Representatives Elections Act 2017', and the 'Civil Service Act 1993' show a strong commitment towards Gender Equality, Disability and Social Inclusion. While these modern legislations and constitutional reforms have tried to redress the imbalance faced by women and marginalized sections of the society, it is obvious that while they certainly help, more work needs to be done to achieve actual behavioural changes.

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[39] See: https://www.icimod.org/laying-the-groundwork-for-sustainable-hydropower-in-nepal/

[40] See: https://static1.squarespace.com/static/5c1978d3ee1759dc44fbd8ba/t/5eb3e949d47d2945368419dc/1588848975609/Hydropower+Sustainability+Assessment+Protocol+07-05-20.pdf

[41] Personal communication with H. Locher, May 11, 2023.

[42] See: IDA (9 Jan 2023). Nepal GEDSI Status: Nepal's Constitution, Related Acts, Policies and the Existing Situation. Kathmandu.

- With respect to the energy sector, which has traditionally been a male-dominated engineering field, women's issues have often been sidelined. Due to the traditional gender roles, women are expected to remain in the house, carry out their reproductive roles, and tend to the household chores. Because of this, it is rather difficult for them to travel to market centers when consultations take place between the energy project and local stakeholders. Generally, Nepali women do not hold the decision-making power, such projects tend to consult men. Another reason why women are not called to public consultations is because do not have access to property. Titles to the land are generally in men's name, and thus, it is men that tend to participate in matters that relates to the program or project.
- Also, as most hydropower projects fall in remote areas far away from established cities and centres of power, their development has often been at the cost of displacement or loss of land and livelihood of the marginalized janajatis[43] dwelling there. Marginalized janajati's concerns in hydro power and energy relate to both the hydropower plants that generate electricity as well as to the transmission lines that transport electricity. Though environmental and social impact assessments are conducted before such projects are commenced; all of the concerns of such communities do not seem to be inadequately addressed.

[43] By 'janajatis', this study means Nepali indigenous groups. The Janajatis of Nepal have been classified into 5 groups and the top three categories—endangered, highly marginalized and marginalized—are understood as being "marginalized Janajatis".

10. Opportunities and Risks with PSH in Nepal

10.1 Opportunities with PSH

In principle and at a theoretical level there are many opportunities for PSH in Nepal. But as one moves from a more abstract to an operational level, there could be various challenges in promoting PSH.

It is generally acknowledged that water storage in its multiple forms is an acute development need. The risks, of course, are those that relate to legal, social and environmental matters common to hydro development. International Water Management Institute (IWMI) has sought to broaden the concept of water storage to include different types of storage appealing to different social solidarities (hierarchic government agencies, private sector, and environmental activists).[44] With COP27, climate problem is now acknowledged as a water problem, where it is not just adaptation (to extremes of flood and drought) but also a major mitigation issue. [45]Broadening the water storage question in this manner away from only for electricity production or regulation to larger issues of multiple forms of storage related to countering climate change presents the biggest set of opportunities for not just PSH but also projects having storage reservoirs in general.

The Kulekhani is Nepal's only seasonal storage plant and as previously mentioned, it falls significantly short of meeting the system's peak demand load. Consequently, there is an acute need for more storage projects to ensure grid stability. Recognizing this, the Nepal Government intends to build 2-3 major seasonal storage plants in rivers such as Buddhi Gandaki, Tamor, West Seti etc. and IDA envisages that PSH could be tied to these projects as upper or lower reservoirs. These would essentially mean tying PSH in the Bluefield sites. Although this presents a substantial opportunity, there is also a whole gamut of issues that need to be addressed when water is seen not just as hydropower but in its manifold multipurpose aspects including irrigation, navigation, flood control, fisheries, tourism and spiritual aspects etc. For instance, the negotiations with India regarding the navigation possibilities is critical as storage of seasonal water in Nepal makes Ganga navigable as per Narendra Modi's plan to make 111 rivers navigable[46].

Besides the state actors, it is also crucial to involve the private sector. Being able to resolve the issues related to tariff, and gaining the support of forward-thinking members within the Independent Power Producers' Association of Nepal (IPPAN), would open the doors for PSH development in Nepal. So far, private developers have been reluctant to build a storage project, including even daily pondages, because of the complexities related to social and environmental (E&S) costs and because investment does not promise a return on flat buyback rate. Given the substantial costs involved, it is the state that has been primarily involved with storage projects. However, if the upper reservoir of the PSH is to be relatively small, with commensurate less E&S implications, the private sector might be interested to invest in this. If the private sectors agree to build a rather simple PSH– just one reservoir– and connect it to the appropriate existing pondage r-o-r or reservoir, it can generate a

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[44] See: https://www.spotlightnepal.com/2023/01/23/why-focus-water-storage/

[45] https://www.thethirdpole.net/en/climate/opinion-is-water-sectors-uncomfortable-knowledge-missing-at-cop28/

[46] Gyawali, D. (2016, August 31). Will inland navigation shift South Asia's water discourse positively? SpotlightNepal. https://www.spotlightnepal.com/2016/08/31/will-inland-navigation-shift-south-asias-water-discourse-positively/

significant profit during peak hours/periods. Low environmental and social costs and high rate of return could, in principle, propel the private sector to invest in PSH.

Additionally, constructing an upper reservoir as part of the PSH project also has multiple benefits of water. The water in the upper ponds of PSH can be used for small-scale drip-irrigated vegetable farming, for forest fire- fighting, and for drinking water. Moreover, water that percolates from the upper reservoir can help recharge springs, and increase soil moisture in the vicinity, thus assist in maintaining forest health. All these multipurpose benefits, unthinkable or uneconomic individually, become attractive when melded with PSH developments that can be financially justified. However, while the multiple usage of water means positive news, it is also imperative to consider water losses from the point of view of one who develops/constructs this project. A plan is necessary on how to compensate the project developers for their losses enjoyed as benefits by others.

Nepal Government is beginning to consider PSH. Some of the projects where very preliminary studies have been underway are:

Rupa-Begnas 150 MW project near Pokhara on two existing lakes. NEA has acquired survey license for this project.

- Kulekhani Sisneri 50 MW project with lower storage in abandoned/diverted riverbed and Kulekhani reservoir as upper reservoir. NEA has acquired survey license for this project.
- Rukum West Syarpu Daha 200 MW project in Bafikot municipality West Nepal, 11 km from Musikot Bazaar. NEA has applied for license.
- Sallyan Kupinde Daha 100 MW project in Bangad-Kupende Daha municipality in West Nepali, 24 km from district headquarters Khalanga.

Among the aforementioned four PSH sites, NEA seems to prioritize Rukum West Syarpu Daha. NEA also seems to be interested in those sites where one of the reservoirs is a natural lake since this would reduce social and environmental costs. The reason behind the interest in Syarpu Daha stems precisely from this reason[47].

One issue that needs to be thought through is whether PSH in Nepal would be developed keeping in mind Nepal's energy context and portfolios or for India's current or future energy needs. These may not be one and the same thing. For instance, in Nepal's case which is marked by excess energy generation during the rainy season and having to import electricity from India during the dry season, PSH development in Nepal could help in reducing electricity imports from India during the dry season. India's case is marked by massive growth in solar on the one hand and on the other hand, of it not being possible to develop electrical energy storage systems like PSH (to complement solar) due to the flat terrain in the Indo-Gangetic plains. In the years to come, should Nepal prioritize development of PSH for Nepal's own energy needs or also for India's energy growth trajectory? This question is important because of the astounding scales involved and the impact on type and scale of development. If Nepal's own needs are to be factored, it would suffice to build medium scale PSH schemes. However, if Nepal, taking advantage of its height, is to develop electrical energy storage

[47] KII with Mr. Nasib Man Pradhan (Project Development Department, NEA) and Ms. Anju Maharjan on July 24th, 2023. He further highlighted NEA's plans to integrate PSH development with existing Bluefield sites or natural lakes, a measure intended to reduce E&S costs associated with PSH projects.

systems for India's massive development of solar plants, then the PSH schemes that Nepal builds needs to be very large/big scale.

10.2 Exploring the Promising Potential of PSH in the Nepal Himalaya

The article "Nepal Himalya offers considerable potential for pumped storage hydropower" (Baniya et al, 2023) explores the suitability and potential of pumped storage hydropower (PSH) schemes in Nepal. Published in the journal of Sustainable energy technologies and assessments, volume 60 in 2023, the study aims to generate baseline characteristics of the energy potential in the Nepal Himalaya. It does so by seeking to address three major research questions (1) the theoretical, technical, and exploitable potential of PSH, (2) the preferred reservoir configurations, and (3) the impact of topography and hydroclimatic condition on the spatial distribution of PSH across the country.

The authors begin their discussion with a global need for a shift towards renewable energy sources to mitigate adverse effects of climate change and then underscore the importance of clean energy and PSH in providing reliable and flexible energy storage to support this transition. The authors point out that PSH acts as a giant battery for large-scale energy storage much more effectively than other competing storage technologies, and can be leveraged to balance energy demand and supply and contribute to grid stabilization. The article also links the contribution of PSH to various sustainable development goals (SDGs), including affordable and clean energy (SDG 7) and climate action (SDG 13).

The article refers to the global assessment estimating the need for at least 850 Giga Watt (GW) of hydropower to limit global warming to the target levels, thus focusing on the importance of assessing feasible locations and potential for PSH projects in the Nepal Himalaya. The authors point out that regional assessments in various countries, including Turkey, the United States, France, and Iran have shown promising prospects for PSH. The study, concentrating on Nepal Himalayas known for its abundant renewable hydropower potential, points out that while the country has to depend mainly upon run-of-river plants for its electricity demand, PSH could offer an efficient and cost-effective energy storage alternative.

The study employs a geospatial model using Geographic Information System (GIS) algorithm to identify viability of PSH in the region. It considers diverse topographic conditions, including natural lakes, flat lands, and rivers, for developing PSH. The research makes use of hydro-meteorological, monthly climate, and streamflow data for the past 40 years for the analysis, proposing four reservoir schemes: Lake to Lake (L2L), Lake to Flat Land (L2F), Lake to River (L2R), and Flat Land to River (F2R) and discusses methodologies for selecting three different energy storage capacities – theoretical, technical, and viable/exploitable. The criteria for each level of potential are carefully laid out, considering factors like topography, infrastructure, and efficiency. The exclusion of protected areas from the exploitable potential assessment as well as reservoir depth to minimize reservoir-induced seismicity reflects a commitment to environmental preservation and risk minimization. The findings, discussing the potential of PSH for all four reservoir configurations, notes that the F2R configurations have the largest and most widely distributed exploitable potential in Nepal.

Considering economic potential through cost-benefit analysis as well as theoretical and technical feasibility through integrated modeling framework, the study identifies 1,193 exploitable PSH locations, capable of generating 904.8 GWh annually, a significant increase from previous estimates. It also points to the challenges related to power market and regulatory frameworks, including grid infrastructure, and the presence of protected areas with water conservation serving as a tool to mitigate climate change impacts. New legal approaches and environmental guidelines are suggested for specific PSH location development, describing the role of regulatory bodies as pivotal in developing and operating PSH projects.

The article provides a comprehensive but highly technical overview of the potential for pumped storage hydropower in the Nepal Himalayas that would be of immense value to agencies such as the NEA, WECS and DoED as they begin the task of inventory, screening and ranking of potential PHS schemes in Nepal. However, the technical challenges and limitations (as well as assumption) inherent in such modeling approaches must be examined further. For instance, an assumption of a uniform round-trip efficiency of 70-80 percent may oversimplify the complexities involved in the actual construction and operation of PSH systems. Similarly, assumptions limiting depth of reservoir to avoid reservoir-induced seismicity and totally excluding what the Forest Department would consider its domain need to be revisited in greater detail for overall resource management decisions. After all, hydropower projects will be built mostly on government lands that historically the Forest Department considers its domain and jurisdiction.

Detailed discussion on the economic feasibility and cost-benefit analyses of implementing PSH projects that may induce both positive and negative externalities are lacking as are social, legal and institutional difficulties, which this IDA report may provide some clues. Integrating components such as gender equality, disability, and social inclusion (GEDSI), as well as considering other socio-economic and political-economy concerns are necessary to reach a more holistic understanding of the challenges and opportunities associated with PSH development. While the positive externalities may stem from the multiple benefits of water usage like drinking-water, irrigation, flood control, and fisheries, the negative ones will stem from impacts of land acquisition, resettlement and loss of existing environmental services to the marginal communities, all of which have a bearing on practical decision making.

The key takeaway from this excellent study by Nepali scholars is that it provides the basic foundation for further exploration of potential PSH sites in Nepal from a technical perspective. There is a need to twin this approach with more thorough social, economic, environmental, legal and institutional explorations of challenges that this promising new pathway for hydropower development entails.

10.3 Challenges with PSH and Other Issues

As mentioned above, as one moves from more abstract to a nitty gritty operational level, there could be various challenges in promoting PSH in Nepal, especially in the context where the private sector could be involved. The first of these relates to policy issues.

Developers believe that because of the issues related to the current licensing policy, just like with hydropower projects, PSH will also face challenges. How is the licensing mechanism going to be? Who will look after this initially and who will have control over it? These are some of the pertinent questions that need to be addressed. Private developers are also skeptical of the intentions of the national utility – they believe that the national utility will probably keep the licenses for the best PSH sites for national itself. The IPPs believe that though IPPs possess more expertise and experience compared to the national utility, as PSH moves forward, NEA will probably get the licenses – at least for some of the best potential PSH sites. What this means is that IPPs will get licenses for those potential PSH sites that the national utility will not be interested in for various reasons.

Whether first a pilot scheme for PSH is to be developed or whether PSH policy is to be formulated (or PSH related policies are to be integrated into energy policies) is like a chicken and egg dilemma. While some are of the opinion that a small PSH scheme should be constructed, which will give an idea of the technical and financial issues involved, others are of the opinion that first a PSH policy needs to be prepared which will then help launch a pilot scheme. Stakeholders are also of the opinion that in developing the pilot scheme, due considerations need to be given to existing software such as the Brazilian WASP model, that among others could also undertake a cost benefit analysis.

Nevertheless, all are in agreement that PSH related policies or PSH-related policies integrated into energy policies, need to be developed. There are certain ambiguities in the current policy regime that need to be resolved before the private sector would be assured of investing in PSH. For instance, the current licensing period in Nepal is 30-35 years. If the private sector wanted to modify the current p-r-o-r scheme into PSH by building a reservoir above and using the p-r-o-r as a lower reservoir, this may provide policy challenges on a few fronts. If say, the project has already been in operation for 15 years, would the licensing period be for the remaining 20 years or would it be for 35 years? The policy provisions need to be clear on issues such as these before the private sector can invest.

The current flat-rate tariff system for power generation in Nepal stands out as one of the main constraints. Though NEA has announced different rates for dry season and wet season, IPPs do not get different prices for electricity produced during different times of the day – such as during the morning peak (5 am to 9 am), during day time (9 am to 5 pm), evening peak (5 pm to 10 pm) and during the night time. For there to be investment in PSH there needs to be differential tariff rate not only as per season but also as per the time of day. The rate should be such that it should encourage private sector investment in PSH while at the same time the cost of electricity should not be high for the end user i.e., ordinary citizens. Likewise, the royalty that the state gets from PSH should be just. It should not be too high to disincentivize investment in PSH, while simultaneously taking into consideration the interests of the consumers.

It needs to be kept in mind that though PSH is a new technology in the context of Nepal, other new technologies are making inroads, and in that context, PSH needs to compete with those technologies. One such technology is lithium batteries. The cost of lithium batteries is coming down. PSH in the days to come needs to be competitive or have other additional values – such as multipurpose benefits of water infrastructure development – for the state and private sector to be able to invest in PSH vis-à-vis lithium batteries. Though not directly related to PSH per se but related to the solar PV issues and thus indirectly related, is the Feed in Tariff (FiT). There is no provision for the Feed in Tariff. This lack of FiT does not justify or incentivize investment in PSH.

Though PSH is generally tied up with solar, in Nepal's context, even though the overall cost of solar panels is coming down, the PPA rates for energy generated from solar plants is not encouraging. If the buyback rate was NPR 7.30 earlier, it has now been reduced by NEA to NPR 5.94. Solar developers in Nepal say that this rate is economically not viable. This has watered down the urge to invest in solar plants. Even if the PPA were to be the same i.e., NPR 5.94 it could be viable to solar developers if the state, as in the case of India, promotes 'solar park' which are basically a well-constructed areas designated for the development of solar energy projects, that offers proper infrastructures, convenient services and greatly reduces the paper work requirements necessary for implementation of the project. Or if, solar developers receive subsidies i.e., low long term interest rates. For instance, in India ADB and WB have given grants and soft loans to certain banks such as SBI under green finance scheme. A private solar developer could then get a loan from the SBI for developing solar at low interest rates. If and when solar development proceeds forward, it will have to be thought about how solar PV is to achieve synergy within the larger national electricity context, including with grid electricity.

Other issues

PHS Atlas – improvements needed

Further improvements in the PSH Atlas could enhance its relevance utility. The following are the tentative suggestions for further improving the PSH Atlas:

1. The google map and the data it is tied up with, is from 2009. A lot of things already underway in the ground e.g., roads, etc., which are not shown in the current PSH Atlas. It is important to tie-up the PSH Atlas with a more updated google map.
2. There is a need to take into account population density. If the population density in the upper and lower reservoir could be shown, this could help in screening out dense population areas from potential PSH sites.
3. If there is a way to do some initial screening of the geology, even if at a very rudimentary level, that would be very helpful. Some preliminary costing, even if very rudimentary, would also be good.
4. Partners such as IDA should also be given access to undertake further analysis. This will help the IDA team in showing where the reservoirs in the pipeline such as Budhi Gandaki, Tamor, West Seti, etc., are planned. If there is a need to show the various run of river schemes that have been built or are planned to be built, then these can also be shown in the PSH Atlas.
5. PSH Atlas shows only the Greenfield sites. It should also show the Bluefield sites. This is also important for IPPs to be able to identify potential PSH development next to their existing projects. PSH Atlas should have high resolution[48].

Transmission and distribution

If PSH were to be developed in Nepal, it is important for transmission lines to be upgraded. Likewise, in context where the distribution system had been developed mainly for lighting purposes, the distribution system too needs to be ramped up taking into account, consumption of energy for cooking purposes as well as for charging electric vehicles. Thus, a study has to be underway that examines the transmission network and how these could be upgraded.

Accurate calculation of power generated from PSH schemes

An accurate calculation needs to be done of the power that could be generated from PSH schemes. For instance, the ANU team had examined a B and an C class option as the upper reservoir and Kulekhani reservoir as the lower reservoir and taking into account the volume of water and the head, and other factors, had assumed that 250 MW would be generated. This was questioned by the private sector developers who were of the opinion that much less energy would be generated. Thus, even at

[48] Instead of a 90-meter grid, 30-meter grid could be used for higher resolution (Suggestion given by Nasib Pradhan, NEA during KII on 24th of July, 2023).

an initial scale it is important to have a better estimate of the power that would be generated and make explicit, how the process was calculated.

10.4 PSH Roll-Out

As the study progresses towards the next phase of the PSH project, there are three key areas that need to be addressed for the successful implementation of PSH in Nepal. Firstly, a comprehensive inventory, screening, and ranking process needs to be undertaken, – a rigorous process that will identify the 10 best PSH sites. Secondly, to roll out PSH in Nepal, a 'second- generation' master planning exercise must be carried out, carefully considering the licenses that have already been granted, as well as the associated existing legal and water rights. Given that the feasibility and construction licenses have already been awarded for most sites, it is essential to acknowledge that undoing these is not possible. And lastly, there is a need to foster and further deepen the existing collaboration between Nepal, Sikkim (India) and Bhutan on the research on PSH, and between the three countries and ANU/Australia. The following sections further elaborate on these three points.

Inventory, screening and ranking

A rigorous process of preparing an inventory, screening and ranking could lead the 10 best PSH sites to be identified. This could first begin with the inventory phase.

Inventory phase

1. This will mainly involve deskwork i.e., mainly going through the PSH Atlas. From all the potential PSH sites, on the basis of PSH Atlas, will be initially screened and the number brought down to 100 from the potential 200+ sites on PSH Atlas. This will be done taking into account population density, whether the site is in conservation area or is a sacred site. It is envisaged that it will take around 3-4 months of intensively going through PSH Atlas.
2. Then "ground truthing" will be done for the 100 or so sites. This will entail going to the location and observing things like (1) Number of houses and farm or other areas that would be submerged (2) Road access – till which point (3) Transmission line – till which point (4) priorities of the local people. Through this process, the possible PSH sites will be brought down to 50. It is envisaged that this process will take 7-8 months.

Screening phase

3. A more thorough investigation will be undertaken of these 50 sites. This will entail (1) a quick social and environmental study (2) socio economic household survey in affected areas (3) initial geological study (4) initial economic study including internal rate of return (5) initial civil engineering study. It is envisaged that this process will take 7-8 months.

Ranking phase

4. Based on these a total of 10 potential PSH sites will be identified. A ranking will be undertaken of these 10 PSH sites. Will take into account existing Brazilian software, the WASP model. It is envisaged that it will take 3-4 months to complete.
5. At the end of the second year, there will be 10 PSH sites in ranked order – from the best to the least good. Thus, inventory, screening and ranking are expected to take around 2 years.

Engagement with policy issues and Master Planning Exercises

1. Policy reform in the hydropower sector needs to take into account PSH. There is a need to take into account the Master Planning exercise underway at WECS.
2. Second generation master planning will have to take into account the licenses that have already been awarded (and the ensuing existing legal and water rights). It would not be possible to undo the feasibility or construction licenses that have already been awarded. It would be a second-generation Master Plan that accepts the existing arrangements and legal rights and then not only seeks to optimize the government-initiated developments but also opens up possibilities for the private sector IPPs to upgrade their existing developments by adding the PSH component.

Further Deepening International Collaboration

3. Deepen the existing collaboration between Nepal, Sikkim (India) and Bhutan on the research on PSH and between the three countries and ANU/Australia. Significant possibilities exist for mutual learning as each country engages with PSH. Visit to multipurpose projects that combine PSH with solar and wind (such as the one in Andhra Pradesh by Green-co or elsewhere in India), and visit by the study team members from the three countries along with key government and private developers to PSH sites in Australia.

Support in developing a pilot or a demonstration PSH site in Clean Energy House at the Institute of Engineering, Pulchowk Campus where a small demonstration microhydro exists for educational purposes. An upgrading of this to a PSH will help policy makers in understanding how the concept works in practice as well as in training a new generation of BE and ME students on PSH.

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Annex 1: Meeting with Private Hydropower and Solar Developers - Summary of Issues and Suggestions

May 24, 2023 (8:30 am to 11:30 am)
Inter Disciplinary Analysts' Office

1. **Suggestions for improvement of PSH atlas:**

   - The atlas needs to have a better resolution and resolution scales need to be specified to allow for evaluating potential size of reservoirs.
   - Nepal's Himalayan geology is considered to be young and fragile, and it would entail significant risks on this count for reservoirs up in the hills. Hence, the PSH atlas could maybe incorporate information about geological risks.

2. **Challenges that private developers see for PSH roll-out:**

   - "The fruits of all this investment seems to be small":

     Regarding the upper reservoir of the Kulekhani, one participant did a quick calculation in his mind (taking into account volume of water and head) and suggested that it would be able to generate only 3 MW (contrary to the Atlas's mentioning a size order of magnitude higher). This participant was of the opinion that this is too small a scale and would not be able to make a lasting impact on the system. To achieve a noticeable result, a substantial number of such projects would need to be constructed, which would require a considerably higher investment but the return on the other hand, would be modest. (This remark presses the case for a pilot demonstration PSH development to prove the contrary.)

   - What this observation points to is the need by the ANU PSH team to make explicit on the power generated from such upper reservoir. While ANU's calculation was that around 250 MW would be generated, the private developer's calculation was that only 3 MW would be generated. This points to the need to make explicit the basis for the calculation.

   - Submergence area:

     Nepal is a small country. When constructing one reservoir, the submergence area has the potential to span across 1-2 municipalities, especially since administrative boundaries are generally demarcated by rivers. Thus, caution and early sensitivity need to be exercised.

- Policy development:

  PSH related policy needs to be developed first. Without a separate policy dedicated to PSH, this project cannot take off. Besides, government agencies and the national utility tend to take any new idea as a conceptual threat to their comfortable hegemony.

- Licensing period remains the same for a new project:

  Even though the environmental and social (and even financial) costs are low for PSH in the Nepal Himalaya, if the issues with "development policy, profit, license, cost, tariff" are not cleared beforehand, it will be difficult for the private sector to risk investing. This example was provided: "If a private developer think of upgrading or adding a new PSH project to his or her existing 30–35-year-old project, the situation is such that this new addition is lumped together with the old one. If the old project has run for 15 years and now only 15 years of licensed ownership remain, new PSH project will get the benefit of only remaining 15 years." Hence, policy intervention is necessary to revise the licensing system to encourage private investments.

- The above point is very pertinent especially taking into account new PSH design into existing p-r-o-r or reservoir sites. According to current provisions after 30-35 years, the scheme would revert back to the government. Say, 10 years have already gone by in a p-r-o-r scheme. If with design modification, a PSH is constructed, it will be only 20 years more before the scheme reverts back to the government. If this were to be the case, it would not be economically viable for the private sector to invest in the construction of a PSH.

- Feed in Tariff (FiT):

  One of the biggest hurdles in policy level is the Feed in Tariff (FiT). The present FiT does not justify or incentivize investment in PSH.

- Present licensing policy as a bottleneck:

  Developers believe that because of the issues related to present licensing policy, just like with hydropower projects, PSH will also face challenges. "How is the licensing mechanism going to be? Who will look after this initially and who will have control over it?" are some of the pertinent questions that need to be addressed. Developers believe that IPPS undoubtedly possess more expertise and experience compared to the national utility, but if NEA gets priority in the licensing process, IPPs will be handicapped.

- 'Solar Park' Policy in India:

  "The solar park is a concentrated zone of development of solar power generation projects and provides developers an area that is well constructed, with proper infrastructure, access to amenities and by minimizing paper works for project implementation" (Indianeconomy.net, 2016).

Developers in India have the benefit of such a promotional policy. They have also accessed huge funding from ADB and WB, whereas in Nepal, the private sector needs to take care of everything on their own with no infrastructural support from the government, thus providing little incentive to invest in new energy ventures such as solar or PSH. WB and ADB in India have also given grants and soft loans to certain banks such as SBI under green finance scheme. When a private developer then gets loan from the SBI, the interest rate is low.

- Solar in India is at a large scale with developers developing 500 MW or more giving them large economies of scale benefits. In Nepal, small scale solar plants will not be viable and the country too needs to go for economy of scale with 100-200 MW solar plants.

- Solar buy- back rate:

  A maximum price of NRs 5.94 per unit offered by the NEA is not profitable for investors who have made huge investments in the expectation of getting Rs7.30 per unit, the rate fixed by the government earlier.

  The cost of solar maybe coming down but the construction cost is rather high. Developers reasoned that even 6.60 rupees instead of 5.94 would have been more viable.

- Department of Energy Development (DoED) and permission:

  One of the participants raised a question that if private developers expressed their intention to build a PSH project, would the DoED grant permission? The participant stated that it is necessary for DoED to explicitly include "permission for PSH" in the DoED document.

- Batteries:

  The price of lithium batteries is also coming down. Therefore, there is a need to look at the advantages and disadvantages of lithium batteries in place of PSH for mini-grids and other off-grid or small enterprises. Our grid is synchronized to the Indian grid which raises problems of instability in the Nepali system which can be solved with just a few 1-2 MW batteries *in situ* where it is required to solve this problem.

- Green Certificate: A green certificate is a financing tool but In Nepal, developers do not receive green certificates for hydropower projects, unlike in India and Bhutan. Green certificates are also traded for solar in India.

3. Specific questions that private sector has for the government:

- Solar power is a new energy in Nepal in the sense that the official thinking has long been dominated by conventional hydropower. There is a policy regarding net metering but PPA is only for 2 years, although this has been improving in the last year. However, a more incentivizing policy is needed.

4. Suggestions from Private Developers

- There is a need for experts to write popular articles related to PSH, since many (including politicians, social and environmental activists and even public opinion makers do not know how grid stability can be achieved cheaply and effectively via PSH.
- There is a need for a small pilot project with a 10-15 KW reversible pump that can convincingly demonstrate its viability to government institutions and decision makers. Upgrading the centrally located small demonstration hydropower lab-scale plant at the Institute of Engineering Pulchowk Campus will educate students and young engineers as well about PSH.
- IDA and the PSH Australia/Bhutan/Sikkim team should think about developing a PSH manual that covers all the issues of policy, cost, profit, license, opportunities, challenges and such.
- There is a need to have clarity about the market we would be developing PSH for. Which market are we looking at? Domestic Nepali or even cross- border market in India? Given the scale at which India is developing its solar, when planning for PSH in Nepal, we also need to consider the solar market in India given that Nepali and Indian grid systems are interconnected at several places. The approach to developing PSH for the Nepali market is dwarfed by the scale of the problem as well as benefits if done for the Indian market; and given past and ongoing transboundary issues between Nepal and India, it is doubtful if the Nepali side is prepared to handle that scale of challenge.
- Policy-making or the process of policy reform needs to be informed by a constructively engaged discourse between stakeholders with varying perceptions of the nature of the problem. Academics, market players, civic voices as well as local government need to be involved in such a dialogue to convince society at large. They need to conduct and then publish studies that demonstrate through facts and figures the advantages of PSH over conventional PROR.
- Potential benefits of PSH and the encouragement to both private and state developers need to be codified and guaranteed by the proposed new Electricity Act.
- Technical feasibility study and the commercial/financial viability needs to go hand in hand. Given that this is relatively new for Nepal, much public awareness and education is required for its takeoff. If possible, reversible turbine manufacturers should be invited to Nepal to conduct a seminar for officials, private developers as well as academics.

Annex 2: Meeting with State Actors and Related Individuals - Summary of Issues and Suggestions

June 5, 2023 (8:40 am to 11:40 am)
Inter Disciplinary Analysts Office

1. **Suggestions for the improvement of PSH Atlas:**

- PSH Atlas needs to be adaptive, and an ongoing improvement process by concerned agencies and utilities.
- It was pointed out that the google map and the data it is tied up with, was from 2009. A lot of changes already underway in the ground e.g., roads, etc., are not shown in the current PSH Atlas. Therefore, it is important to tie-up the PSH Atlas with a more updated google map, which might be an ongoing process.
- There is a need to take into account the population density. If the population density in the upper and lower reservoir could be shown, this could help in screening out dense population areas from potential PSH sites.
- The Atlas also needs to keep in mind the geological feasibility as, given the complexity of Himalayan geology, finding an actual viable site might not be so easy.

2. **Upper Reservoir and Multiple Benefits of Water:**

- There was general agreement that constructing an upper reservoir has multiple benefit. The water in the upper ponds of PSH can be used for small-scale drip-irrigated vegetable farming, for forest fire- fighting, and for drinking water. Moreover, water that percolates from the upper reservoir can help recharge springs, and increase soil moisture in the vicinity, thus assist in maintaining forest health. However, while the multiple usage of water means positive news, it is also imperative to consider the cost of water loss from the point of view of one who develops/constructs this project. A plan is necessary on how to compensate the project developers (or share costs with them) for their losses enjoyed as public, private or common pool benefits by others.

3. **Floating solar panels in reservoirs:**

- Placing floating solar panels on the reservoir was seen as a good idea because of its dual benefits: the generation of solar energy from a surface without issues of land acquisition; and reduction in the amount of water evaporation which is a problem faced by many reservoirs in the sub-tropical regions. But on the other hand, the cost of installing such floating solar panels is more than that for normal solar panels. Additionally, covering the reservoirs/waterbodies with floating solar panels can also ruin the picturesque view that tourist resorts around the water body sell as their primary good.

4. **Issues related to licensing period and tariff:**

- Government agencies hold the view that developers of the PSH project should provide the government with substantial royalties in exchange for utilizing the water resources which is a national property. How that pricing is to be done is not a settled issue.
- Everyone agreed that the implementation of a differential tariff is necessary for the roll- out of PSH projects.
- A proper analysis of licensing period is imperative. Once granted, licenses cannot be revoked or altered without inviting costly court cases. One view was that reform of the licensing policies be done only for newer projects, while not tampering with the licensing policy for already allocated ones to r-o-r projects.
- If the licensing period of an existing r-o-r plant was extended to cover adjacent development of PSH by the same developer, it would mean good news for the developers. However, as most developers will have already recovered their costs, it is not going to be fair on the consumers. As government representatives, it is their duty to negotiate with the IPPs by keeping in mind the good of the consumers too.
- Critical in such negotiations is that one should be well-versed about the electricity prices when working on granting permission for PSH projects.

5. **Policy development and Policy Recommendation:**

- There was firm opinion among agency representatives that first, substantial research on PSH should be carried out and, second, a small pilot PSH scheme constructed (2-3 small pilot studies through NEA itself), which can give an idea of the technical, financial and socio-environmental issues involved with the PSH project development. It is only then that a more comprehensive PSH policy can be formulated. Most important of these is the cost benefit analysis.
- It was stressed that, given the multipurpose nature of water storing reservoirs, the dam, tunnel and the powerhouse should be developed by a separate entity, and the reservoir should be developed by a separate public entity. Currently, there is no policy to construct a vertically separate PSH agency and that it is necessary to raise this issue in the policy recommendation. Although this is a matter that rightly belongs in the drafting of the new Electricity Act, that has not been possible because the Electricity Bill-2020 aimed at amending the Electricity Act (1992). It was under consideration in the National Assembly (upper house) but was withdrawn on 16th of September, 2022 by the then Energy Minister Pampha Bhusal. It is currently under consideration of the parliamentary committee on infrastructure development chaired by RPP MP Deepak Bahadur Singh.
- There was agreement that now it is high time for Nepal to move towards a policy on hydropower development within the framework of multiple usage of stored water in reservoirs. This would allow better cost sharing among beneficiaries and thus reduce the cost of electricity than if all the development costs were to be borne by the power component making others free-riders. They further added that there is a possibility of installing floating

solar panels in 60% of the reservoirs. If this is done (as the Green Co company model in India's Andhra Pradesh shows), Nepal can be well on its way to a net carbon zero country.

6. **Hydropower Masterplan:**

- It was learnt that WECS is working on a new Hydropower Development Masterplan. However, representatives from other related government agencies were completely unaware about this development. The primary goal of WECS formulating a new Hydropower Masterplan was to prioritize overall national benefits but not necessarily that of the IPPs.
- It was acknowledged, nonetheless, that there is a need for a meeting between the government and the private sector so that both parties can find a common ground and figure out mutually beneficial solutions.
- It was also clarified that this master planning exercise at this stage, does not have any plans and policies laid out for PSH development in Nepal. However, it was highlighted that if proper study/ research is conducted on PSH, there is still a chance to include PSH in this version of the master plan.

7. **Areas where further clarity is imperative before the state could prioritize PSH project:**

- Government agency representatives sought clarification on whether the private developers are interested to invest in PSH project or if the responsibility for investment rests solely with the government. An issue was also raised whether a separate EIA needs to be formulated for PSH projects; and it was also felt that transmission lines in the hills need to be upgraded to facilitate the development of PSH. The need to collect a data inventory of PSH project is critical so that it can help with the total cost and profit calculation before decisions can be made. A proper viable tariff structure study is also necessary to figure out how it can support the development of PSH in Nepal.
- An opinion was expressed that private research organizations like IDA should take the responsibility of generating ideas for PSH development, including conducting independent studies on energy and electricity demand forecasting, since government agencies like NEA and DoED are all preoccupied with other issues.
- It was also emphasized that the organization or individual responsible for conducting a detailed study on PSH should not be made the project manager. There will be biasness on the part of such a person to show that the projects he/she has been involved in screening/ranking is indeed the most feasible one.

8. **Suggestions given by government stakeholders:**

- The participants believed an easy site for pilot study should not be chosen. Instead, a relevant site that has complications but at the same time where multiple usage of water can also be studied should be chosen so that potential mistakes could be avoided for "normal" project sites.
- An accurate reflection of cost is a must. The developer – whether it be national utility or IPP – should get a good rate for the upper reservoir stored water since this would be for peaking

purposes – because such a rate would incentivize investment. However, it should not be too high since this cost will ultimately fall on the consumer. The PPA rate should realistically reflect the investment cost.

- Government stakeholders were also of the opinion that in developing the pilot scheme, due considerations need to be given to existing software such as the Brazilian WASP model, that among others could also undertake a cost benefit analysis.
- The conflict of both government and IPP hydropower developers with the forest ministry has shackled the sector's development and has driven up costs. Environment protection is important and is an accepted value even with hydro developers. However, much of the potential future hydro development is in what would be considered forest lands. Given that hydropower is as much as resource of the country as is forest, a win-win compromise should be found for both. We need to understand this and should go through a proper "denotification process" for forest lands converted to hydropower development with compensatory safeguards for wildlife and environment. Forests have been conserved in Nepal for all the good reasons all these years, now it is time to move to "sustainable forest utilization" from "forest conservation" ("ban semrakchan bata ban sadupayog").

It was also proposed that we need a different concept of government royalty for different PSH and hydro development projects, in that, while the tariff regulations may be slightly strict for the developers, the royalty and tax benefits for the public should be maximized.

Annex 3 - Nepali participants who attended one on more interactions around PSH organized by IDA

S.N	Name	Designation
1.	Mr. Ajoy Karki	Director, Sanima Hydro
2.	Ms. Anagha Pandey	Environmentalist, NHPC
3.	Mr. Aniruddha Poudel	Director, Social and Environment Department, NEA
4.	Ms. Anju Maharjan	Assistant Manager, NEA
5.	Mr. Anup Kumar Upadhayay	Former Secretary, MoEWRI
6.	Dr. Bikram Acharya	Research Fellow, PRI
7.	Mr. Chandra KC	Statistician, IDA
8.	Dr. Debendra Raut	Deputy Head, Department of Automobile and Mechanical Engineering, Institute of Engineering, TU
9.	Ms. Dilasa Shrestha	Research Associate, IDA
10.	Mr. Dipak Gyawali	Chairman, IDA; Former Minister of Water Resources
11.	Mr. Gajendra Budathoki	Chief Editor, Taksar News; Person with Disability
12.	Ms. Geeta Bhatta	PhD Scholar - Renewable and Sustainable Energy Laboratory, KU
13.	Mr. Govinda Chalise	Project Manager, Sahas Urja
14.	Mr. Hitendra Dev Shakya	Former Managing Director NEA
15.	Ms. Ishani Rijal	Engineer, NHPC
16.	Dr. Jagan Nath Shrestha	Emiritus Professor - Solar and PV, Former Director IOE TU
17.	Dr. Kapil Gewali	Senior Hydrologist, WECS
18.	Mr. Kumar Pandey	CEO NHPC; Private Sector Hydropower Developer; MCC Board Member
19.	Mr. Laxman Biyogi	Editor, Urja Khabar
20.	Mr. Madhav Belbase	Member, Public Service Commission; Former Secretary, MoWS
21.	Mr. Madhu Prasad Bhetuwal	Joint Secretary - Spokesperson, MoEWRI; Former DG DoED
22.	Dr. Minendra Rijal	Former Minister and MP, Nepali Congress
23.	Mr. Nasib Man Pradhan	Director, Project Development Department, NEA
24.	Mr. Padam Bahadur Thapa	Engineer, Nalgad Hydropower, MoEWRI
25.	Mr. Prabin Dhakal	Masters' Thesis Student, KU
26.	Mr. Pradeep Gangol	CEO PTEEL
27.	Mr. Pushpa Jyoti Dhungana	Secretary, Department of Energy Water Resource, CPN UML

28.	Dr. Rabin Shrestha	Former Advisor at World Bank
29.	Mr. Rabindra Bahadur Thapa	Joint Secretary, MoEWRI
30.	Mr. Raj Kumar Thapa	Private Sector Solar Developer
31.	Mr. Ram Gopal Lageju	Senior Division Engineer, Program and Budget Branch (Energy), MoEWRI
32.	Dr. Ram Prasad Dhital	Former Member, Electricity Regulatory Commission, Nepal
33.	Mr. Ramesh Sah	Globalmatics Renewable Energy
34.	Mr. Ratan Bhandari	Activist; Public Interest Litigation Lawyer
35.	Mr. Ratna Sansar Shrestha	Chartered Accountant
36.	Dr. Sagar Prasai	Advisor, DFAT; Former Country Representative for TAF, India
37.	Mr. Sagar Raj Gautam	Officer, Investment Board of Nepal (IBN)
38.	Dr. Sandip Shah	CEO Pashupati Renewables, President SOPPAN; Former President IPPAN
39.	Mr. Sanjay Dhungel	DDG DOED
40.	Mr. Satish Joshi	Director, VRock and Company
41.	Dr. Sudhindra Sharma	Executive Director, IDA
42.	Mr. Suman Prasad Sharma	Former Secretary, Ministry of Finance and MoEWRI
43.	Mr. Sunil Poudel	Joint Secretary, MoEWRI
44.	Dr. Sunil Prasad Lohani	Associate Professor, KU
45.	Mr. Tika Ram Basnet	Research Associate, IDA
46.	Mr. Utsab S. Rajbhandari	Department of Mechanical Engineering, Institute of Engineering, TU
47.	Mr. Uttar Kumar Shrestha	CEO Butwal Power Company
48.	Mr. Vijaya Sharma	Hydro Engineer, IBN

Note: Out of the total 48 participants who attended different meetings and workshop related to Nepal PSH study, 5 of them were females and the rest were males.

Annex 4: Events in the Nepal PSH Study Cycle

S.N.	Events	Date
1.	Stakeholders Consultation - Orientation and Feedback on workplan	Dec 19, 2022
2.	Zoom Meeting with key Nepali stakeholders	Feb 28, 2023
3.	Zoom Meeting with key Nepali stakeholders	April 3, 2023
4.	KII with Mr. Sanjay Dhungel, DoED	April 12, 2023
5.	Nepal team travelled to Sikkim State (India) and Bhutan for field visits and workshops related to PSH	April 21 - May 6, 2023
6.	Arrival of Australian, Sikkim state (India) and Bhutan teams in Kathmandu	May 6, 2023
7.	Team meeting of all three country teams at IDA Office, Chabahil	May 7, 2023
8.	PSH site visit to Kulekhani with all three country teams	May 8, 9, 10, 2023
9.	PSH National Workshop at Hotel Royal Singi	May 11, 2023
10.	Meeting with World Bank and DFAT	May 12, 2023
11.	Departure of country teams from Kathmandu, Nepal	May 13, 2023
12.	Group Meeting conducted by IDA with the Private Developers	May 24, 2023
13.	Group Meeting conducted by IDA with the Government Agencies	June 5, 2023
14.	KII with Mr. Nasib Man Pradhan, NEA	July 24, 2023
15.	Participation of SOK – Nepal Draft Report	August 4, 2023
16.	Preparation of SOK – Nepal Final Report	December 2023

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