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Economic case for **clean energy** transition in Nepal

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Energy plays a crucial role in economic growth, as it is a key input in the production process and a driving force behind many economic activities. Increased access to clean and affordable energy can unlock Nepal's economic potential. With about 15 percent of the population living in extreme poverty[1] and more than one-fourth facing different kinds of extreme deprivation[2], achieving rapid and equitable economic growth is a critical priority for Nepal. To meet these objectives, Nepal has been attempting structural transformation to transition from a low-productivity economy to a higher value-added and higher-productive one. Such structural transformation—from an agrarian to an industrialized economy—is going to be energy intensive.

While economic growth is one of the significant agendas for Nepal, sustainable development is equally important given its social and ecological vulnerabilities, more so when the world is facing disastrous impacts of climate change. Any policy

interventions targeted at economic growth need to consider their environmental costs. Hence, reconciling their industrial ambitions while minimizing greenhouse gases emission is one of the severe challenges faced by developing countries. Countries like India and China have committed to go net-zero by 2070 and 2060, respectively. However, their dependence on fossil fuel to power homes, commercial centres, industries and transport, and their rate of industrial and urbanization expansion mean transitioning to renewable and cleaner sources of energy would require a policy overhaul and large-scale economic readjustments. Trade-off between economic and net-zero ambitions is an actual concern.[3]

However, Nepal may not face such a predicament. A low level of industrialization and an energy mix dominated by traditional fuel sources (e.g., firewood) coupled with good prospects of domestic clean energy sources may in fact make a clean energy transition desirable in an economic sense as well. At present, the industrial sector (including construction) makes up about 11 percent of Nepal's GDP (while Bangladesh and Bhutan—also least developed countries—have more than 33 percent of their GDP coming from industry).[4] Such low levels of industrial activities have limited Nepal's per capita energy consumption as well as emissions. Nepal ranks the second lowest among South Asian countries in these parameters (Table 1). Unlike more industrialized countries, Nepal has the advantage of not having to decouple its economic growth from fossil fuel-based energy consumption. Moreover, the challenge in Nepal's case is to improve the existing energy infrastructure—institutional and physical—so that the country's energy mix will be dominated by hydroelectricity, offering cleaner and more affordable energy.

Table 1 South Asia's emission and energy consumption (2019)

Country	Primary energy consumption (TWH)	Energy use per person (KWH)	CO2 emission per capita (MT)*
Afghanistan	35.97	952.46	0.2
Bangladesh	452.59	2734.37	0.5
Bhutan	22.39	29170.91	1.5
India	9485.63	6858.18	1.8
Maldives	9.29	18410.12	4.2
Nepal	43.76	1517.79	0.5
Pakistan	983.53	4404.67	1.4
Sri Lanka	108.17	4996.26	1.1
World	165,320.00	20,902.00	4.4

Source: https://ourworldindata.org/
**Climate Watch. 2020. GHG Emissions. Washington, DC: World Resources Institute.*
Note: 1 KWh is equivalent to the energy consumed or generated by a 1 kilowatt (kW) power source for a period of 1 hour; 1 TWh is equivalent to 1 million KWh.

Energy for economy

Nepal's latest development plan (The Fifteenth Plan, FY2019/20—2023/24) aims for an annual average GDP growth of 9.6 percent in the five-year period. The average growth in the agriculture, industry and service sectors is projected to be 5.4, 14.6, and 9.9 percent, respectively.[5] This target is in line with the government's aim to push Nepal to upper-middle-income country status by 2030 from its current lower-middle-income country status. Moreover, the Long-Term Vision for development aims for an annual economic growth of 10.5 percent over a 25-year period from 2018 to 2043.[6] This high growth is expected to come from a 5.5 percent average annual growth in agriculture, 13 percent in industry and 10.9 percent in the service sector. The plan is to increase the share of industry in the economy to 30 percent (which has remained less than 15 percent for the last 10 years) and the share of the service sector to 61 percent in order to transfer a large proportion of the workforce from agriculture to industry and services by 2043. Likewise, targets under Sustainable Development Goal 9 set by Nepal include increasing industry's share of GDP to 25 percent and manufacturing's share of GDP to 15 percent by 2030.[7] Over the past two decades, Nepal has been undergoing premature deindustrialization as the share of industry in GDP has been in a steady decline, driven by a falling share of manufacturing in GDP.[8]

The ambitious growth and industrialization targets require enhanced energy consumption in order to power the expansion of economic activities. Construction of physical infrastructure, powering industrial activities and an overall increase in the production of goods and services would require increased use of energy. Moreover, as the economy grows and more jobs are created resulting in increased incomes for households, there will be higher consumption demand at the household level, and to meet increased household demand for goods and services, there will be more production at the firm level, creating a multiplier effect on energy consumption. Additionally, in Nepal's case, electrical energy is not only the catalyst of economic growth but a conduit too. Increased energy generation—harnessed from the countries' significant hydroelectricity generation potential—could power industries in a cost-effective manner, enhancing industrial competitiveness. Although the cost of hydroelectricity is highly project specific, depending on the installed capacity and other geographical (and political) factors, hydroelectricity is considered the most cost-effective dispatchable low-carbon electricity. The globally weighted average of levelized cost of electricity (lcoe) from hydropower in 2019 was US$0.047 per kWh while fossil-fired power generation lcoe was between US$0.05/kWh and 0.177/kWh.[9]

Existing consumption

According to the World Bank, in 2019, Nepal's total primary energy consumption was around 6.9 million tons of oil equivalent (MTOE), relatively low compared to India (707 MTOE) and China (3,170 MTOE). Among South Asian countries, Nepal ranks second lowest in terms of per capita energy consumption (see Table 1). Nepal's energy mix is heavily reliant on burning firewood, petroleum products and coal, the worst emitters of greenhouse gases (GHGs). Use of firewood, agriculture residue and animal waste account for around two-thirds of the country's total energy consumption.[10] Similarly, 27 percent of the energy consumption includes coal and petroleum products while relatively clean energy sources such as electricity and renewables account for less than 7 percent (see Table 2).

Electricity makes up a tiny part of Nepal's overall energy mix. Between 2009 and 2021, Nepal's installed hydroelectricity capacity increased from 636 MW to 2,023 MW (including those from the state-owned Nepal Electricity Authority's power plants and those from independent power producers).[11] Despite a more than three-fold increase in installed hydropower capacity, the share of electricity in Nepal's energy mix increased from 2 percent to 4 percent during 2009-2021. Meanwhile, firewood consumption declined to 66 percent from 78 percent in the same period. This reduction in firewood is due to a growing use of LPG and a rising electrification rate. Moreover, LPG use is increasing at a rate of more than 25 percent annually, replacing kerosene, firewood and electricity.[12]

In terms of the sectoral composition of consumption, the residential sector still dominates consumption, followed by the industrial and transport sectors (Figure 1). As Nepal's economy expanded, the share of the residential sector in consumption declined while that of the industrial sector rose. In 2009, residential consumption accounted for 89 percent of total consumption while the industrial sector accounted for only 3.3 percent. By 2021, the share of residential consumption had dropped to 63 percent while that of industrial consumption had increased to 18 percent.

By 2021, 93 percent of Nepal's population had access to electricity. While most households use electricity for lighting, residential energy consumption is still heavily concentrated in firewood as 85 percent of household energy needs are met by firewood.[13] The industrial sector consumes coal, firewood, diesel and electricity while the transport sector is predominantly diesel and petrol dependent. Nearly half of the industrial sector's fuel consumption is in the form of coal, followed by firewood at 17 percent, which is used for furnaces and boilers. Agriculture residues and diesel are used for thermal purposes while electricity use makes up less than 9 percent of total consumption by the industrial sector. These figures indicate that there is enough space for energy use from GHG-emitting sources to cleaner resources transition such as hydroelectricity and renewables. Moreover, dependence on coal and petroleum products is also contributing to increased pressure on foreign exchange reserves as 29 percent of Nepal's energy mix is made up of imported fuel sources.[14]

As the Nepali economy industrializes and grows, energy demand for industrial and commercial use will also grow. To achieve rapid economic growth, Nepal needs to make efficient and optimum use of the energy sources that are least damaging to the environment, and add to mitigation co-benefits while being affordable. According to the government-prepared Vision 2050 for the energy sector,[15] if Nepal's economy grew by 4.4 percent, the share of total energy consumed by the industrial and

Table 2 Energy Consumption in 2021

Category	Fuel type	Energy ('000 GJ)	GWh	% of national total
Traditional	Fuelwood	377,790.36	104,941.77	60.38%
	Agricultural residue	18,782.36	5,217.32	3.00%
	Animal waste	17,967.02	4,990.84	2.87%
		414,539.75	**115,149.93**	66.26%
Commercial	Kerosene	831.03	230.84	0.13%
	Petrol	19,560.86	5,433.57	3.13%
	Diesel	63,465.44	17,629.29	10.14%
	Aviation turbine fuel (ATF)	2,218.29	616.19	0.35%
	Liquid petroleum gas (LPG)	21,802.75	6,056.32	3.48%
	Furnace oil	3,399.09	944.19	0.54%
	Coal	58,445.58	16,234.88	9.34%
	Hydro electricity	26,373.39	7,325.94	4.22%
		196,096.43	**54,471.23**	**31.34%**
Renewable	Biogas	9,756.95	2,710.26	1.56%
	Solar	4,759.67	1,322.13	0.76%
	Wind	1.87	0.52	0.00%
	Micro/Pico hydro	514.96	143.05	0.08%
		15,033.46	**4,175.96**	**2.40%**
Total		**625,669.64**	**173,797.12**	**100.00%**

Source: Nepal Energy Sector Synopsis Report – 2022, Water and Energy Commission Secretariat.

commercial sectors is expected to increase to 19 percent and 11 percent, respectively, in a business-as-usual scenario without major policy and technological shifts. In the case of a medium growth scenario, of 5.6 percent, average growth in total energy consumption will be 3 percent with the share of industrial and commercial sectors increasing to 23.2 percent and 14 percent, respectively. These projections indicate that if Nepal does not adopt major policy shifts in shuffling the energy mix in favour of renewable/clean energy resources, the country will still be dependent on inefficient and polluting sources. Policy interventions promoting the use of electric boilers in factories, an impetus to the use of electric vehicles, promotion of electricity for groundwater pumping and electrification of cooking can lead to a significant reduction in the use of firewood and petroleum products. Thus, the share of electricity would grow to 32 percent of the total consumption even in a low-growth business-as-usual scenario. Moreover, if domestic energy security-related policies were to be implemented as envisioned, per capita CO2 equivalent emission in 2030 would be 50 percent less than in the business-as-usual scenario. This makes a case for making concerted efforts towards transitioning to a high degree of use of hydroelectricity.

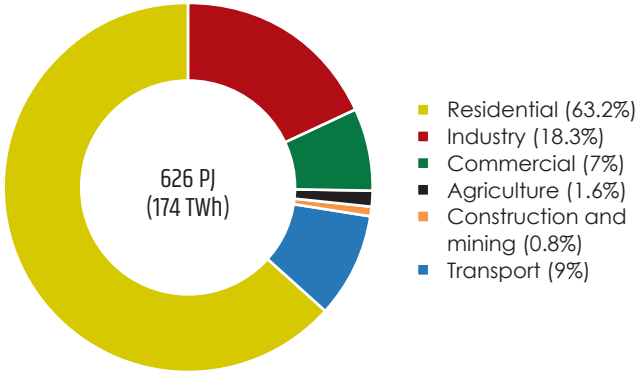
Climate commitment

The role of clean sources energy is important in propelling a country's economic growth, making the lives of people comfortable, and in mitigating GHG emissions. The Agenda 2030 for Sustainable Development (SDG) has dedicated Goal 7 to enhancing access to clean and affordable energy. Considering the global urgency to fight climate change impacts that have threatened the lives and livelihoods of people around the globe, Nepal has also pledged to work towards minimizing GHG emissions. In 2020, Nepal submitted its second Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC). The Second NDC has proposed to reduce GHG emissions from both energy and non-energy sectors to meet the net-zero emission target by 2045. Achieving net zero emissions requires reducing GHG emissions to as close to zero as possible through decarbonization of the economy and then using various methods to remove any remaining emissions from the atmosphere, such as afforestation, reforestation, and carbon capture and storage (see Box 1). To achieve that, Nepal needs to transition from its dependence on traditional energy sources to clean energy sources. Meeting the targets of generating 10,000 MW by 2028 and ensuring 100 percent electricity access by 2023 will aid the clean energy transition. Similarly, there are also plans to increase the share of solar energy generation through the involvement of the private sector with a target of generating about 550 MW by 2024 and adding 2,100 MW of solar energy to the national grid by 2030.[16]

Given the size of the economy and population, it is quite evident that Nepal's GHG emissions are negligible in the global carbon budget. Nepal's per capita GHG emission stood at 1.69 tonnes CO2eq while the global per capita emission was 6.45 tonnes CO2eq. Similarly, the annual emission of Nepal was 48.37 million tonne of CO2eq while the total emissions of the world were 49.76 billion CO2eq. Although Nepal is not one of the biggest polluters, its geographical location, monsoon-dependent climate, high social vulnerability and limited capacity make the country susceptible to weather disasters made extreme by climate change, particularly through unpredictable heavy rains causing secondary hazards like flooding, landslides, and other disasters that cause significant losses of life and damage to infrastructure. The rising global average temperature due to increasing GHG is leading to the melting of glaciers. The country's agriculture-dependent economy gets adversely affected by changes in temperature and precipitation patterns.

Transitioning to cleaner fuel and energy resources such as hydroelectricity and other renewable sources will help achieve the net-zero goal. In addition to the energy transition, given its high vulnerability, Nepal needs to develop adaptation actions and take measures to reduce its GHG emissions. Adaptation strategies for Nepal include replicating early flood warning systems to alert people to impending extreme weather events and promoting the use of drought-resistant seeds, among others. The cost-effectiveness of cleaner energy and its multiplier effect on economic activities could yield resources to implement adaptation strategies too.

Figure **Energy consumption composition**



Source: Nepal Energy Sector Synopsis Report – 2022, Water and Energy Commission Secretariat.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Nepal is on the frontline of battling climate change impacts but lacks resources to build resilience to disasters and support adaptive actions. A strategy focused on the generation and adoption of cleaner sources of energy, while improving the lives of people, will also contribute to economic growth and sustainable development. Nepal's Long-term Strategy for Net-zero Emissions shows that the country's carbon emissions reduction potential is high on the back of carbon capture in the forestry sector and future emissions reduction through aggressive promotion of clean energy sources.[17] In addition, the report also points out that Nepal has significant sources of clean energy that can be exported to offset emissions in neighbouring countries. This, however, depends on increasing power plant capacity to 34 GW in hydropower, 2.1 GW in grid-connected Solar PV power plants, and 1.1 GW in off-grid and isolated renewable energy power systems. Similarly, interventions are also required to promote electrification and shift to clean energy uses in the residential, transportation, industrial and commercial sectors. The expansion in electricity capacity will require substantial investment. For hydropower alone, according to some estimates, the required investment would be as much as US$5.34 billion in 2030, US$6.69 billion in 2040 and US$15.05 billion in 2050.[18] At the same time, the replacement of petroleum products such as petrol and diesel is one of the major co-benefits that could save as much as 6.7 percent of the national GDP in 2030, 11.5 percent in 2040, and 19.6 percent in 2050.[19]

Pathways to green structural transformation

For Nepal, the low electricity consumption level at present is a blessing in disguise as an effective energy transition strategy can succeed in replacing the biomass- and fossil-fuel-dominated energy mix with cleaner energy sources.

Generation alone, however, cannot magically support the transition to cleaner energy sources. Data show that a more than three-fold increase in hydropower generation barely helped double the share of electricity in Nepal's energy mix in the past decade. Not only should power be available, but the connection also needs to be reliable, accessible and affordable. Replacing firewood and animal waste as the main fuel source is imperative and attempts are being made towards that end. However, a better understanding of the socio-economic dimensions of fuel preferences is required to encourage replacement. According to an estimate, electricity is the most efficient and cost-effective cooking fuel in Nepal while firewood is the least efficient and petrol the most

Box **Major highlights from Second Nationally Determined Contribution submitted by Nepal in December 2020**

- By 2030, expand clean energy generation from approximately 1,400 MW to 15,000 MW, of which 5-10 % will be generated from mini and micro-hydro power, solar, wind and bio-energy. Of this, 5,000 MW is an unconditional target. The remainder is dependent upon the provision of funding by the international community.
- By 2030, ensure 15% of the total energy demand is supplied from clean energy sources.
- Sales of electric vehicles (e-vehicles) in 2025 will be 25% of all private passenger vehicles sales, including two-wheelers and 20% of all four-wheeler public passenger vehicle sales (this public passenger target does not take into account electric rickshaws and electric-tempos) in 2025.
- By 2030, ensure 25% of households use electric stoves as their primary mode of cooking.
- By 2030, adopt low emission technologies in brick and cement industries to reduce coal consumption and air pollution, including through the development and/or enactment of emission standards.
- By 2025, formulate guidelines and establish mechanisms to monitor emissions from large industries.

Source: Second Nationally Determined Contribution.

expensive.[20] Besides environmental benefits, the clean energy transition will accrue social benefits as clean sources will improve the health of those doing the cooking (mostly women) and the family. It will free up time for family members (mostly women) responsible for collecting firewood.

In the industrial sector, the use of coal and diesel dominates manufacturing as the production process requires high-intensity and reliable energy sources with a steady supply. Since the electricity supply in Nepal is unreliable, coal and diesel remain the main energy source in the industry. In some production processes, coal and firewood are better suited due to their thermal characteristics, and switching to electricity would require better technology adoption. Not all firms are open to or capable of making such investments. In these scenarios, incentivizing the adoption of electricity through a subsidy on the purchase of cooking stoves or reducing electricity tariffs for household consumption may work. Similarly, subsidizing electricity-efficient technology purchases through customs duty reduction or providing tax credits to industries adopting cleaner technology could be beneficial. Moreover, a detailed analysis of the cost of energy source switching needs to be undertaken to make a case for clean energy transition for industries.

Notes

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