Article

India's Energy Transition: The Case for Hydropower

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Abstract

In India, solar and wind have emerged as key components of the country's strategy for a clean energy future. Although hydropower has historically been the main source of clean and renewable energy in the country, it currently lags solar and wind in terms of deployment. Nonetheless, hydropower has a critical role in hastening India's clean energy transition and climate change mitigation efforts. Hydropower's ability to integrate large shares of variable and intermittent renewable energy sources, such as solar and wind, in the country's electricity system is increasingly important as their penetrations increase. Hydropower installations also provide crucial services like water supply, irrigation, flood protection, and drought mitigation, navigation, tourism, and recreation. Beyond this, it also serves strategic purposes. By alleviating the socio-economic conditions of border villages and communities in the India-Tibetan border regions such as Arunachal Pradesh, hydropower projects can help India consolidate its administration in the remote border regions, and strengthen its security and defence preparedness. However, such projects are inherently challenging and can have adverse environmental and social impacts. But these can be mitigated by adopting new social and environmental safeguards and more robust and cost-effective technological solutions.

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Although hydropower has historically been the main source of renewable energy in India, it currently lags that of solar power and wind power that has emerged as important components of the country's strategy for a clean energy future. This article argues that hydropower has a key role in India's clean energy transition and climate change mitigation efforts. Hydropower's flexibility and its ability to integrate large shares of variable and intermittent renewable energy sources such as solar power and wind power in the country's electricity systems is increasingly important as the penetration of renewable energy increases. In addition, hydropower also provides services like water supply, irrigation, flood protection, and drought mitigation, navigation, tourism, and recreation. Beyond this, it would serve a strategic purpose by helping India strengthen its administration in the contested Indian border areas such as those in Arunachal Pradesh. This aspect of hydropower has received less attention and remains poorly understood. Hydropower projects could help significantly improve the socio-economic conditions of remote border villages and communities. That, in turn could strengthen India's border security and its defence preparedness.

Global Hydropower Scenario

On 30 September 1882, the world's first hydropower plant, the 12.5 kilowatt (kW)/ 0.01 MW Vulcan Street Plant, began operation on the Fox River in the United States.[1] It provided electricity to two paper mills and one home. Since then, hydropower has supplied a significant portion of the world's electricity and helped spur economic development in many countries. Currently, hydropower is the lowest-cost source of electricity worldwide and it meets the majority of the electricity demand in 28 different emerging and developing economies with a combined population of 800 million.[2] As of 2020, global installed hydropower capacity reached 1,330,000 MW/1,330 GW and it generated a record 4,370 terawatt hours (TWh) of electricity.[3] That amounts to 16.8 percent of the world's total electricity generation, and is approximately equivalent to the entire annual electricity consumption of the United States. China has the world's largest installed hydropower capacity of 370,000 MW/370 GW, or 27.81 percent of the global total.[4] Brazil (109,000 MW/109 GW), the United States (102,000 MW/102 GW), Canada (82,000 MW/82 GW), and India (50,000 MW/50 GW) constituted the rest of the top five (see Table 1).

Table 1: Installed hydropower capacity of top 10 hydropower producers and the rest of the world in 2020

Country	Installed hydropower capacity
China	370,200 MW/370.2 GW
Brazil	109,300 MW/109.3 GW
United States	102,000 MW/102.0 GW
Canada	82,000 MW/82.0 GW
India	50,500 MW/50.5 GW
Japan	49,900 MW/49.9 GW
Russia	49,900 MW/49.9 GW
Norway	33,000 MW/33.0 GW
Turkey	31,000 MW/31.0 GW
France	25,500 MW/25.5 GW
Rest of the world	426,800 MW/426.8 GW
Total	**1,330,000 MW/1,330 GW**

Source: International Hydropower Association (IHA), 2021.

Although hydropower is the leading source of renewable electricity, its growth has slowed considerably and is deemed to be "the forgotten giant of clean electricity."[5] A key reason for this is the increased availability and use of coal and natural gas, as well as faster deployment of solar and wind power. Several other factors have also hampered hydropower's growth. For example, hydropower projects often faced long lead times, lengthy permitting processes, high costs and risks from environmental assessments, and opposition from local communities facing displacement. These resulted in higher investment risks and financing costs compared with other sources of electricity and have discouraged investors. Although 21,000 MW/21 GW of new hydropower capacity were added in 2020, that represented an increase of just 1.6 percent over 2019 when 15,600 MW/15.6 GW capacity was added.[6] Furthermore, the average year-on-year growth in installed hydropower capacity in the five years between 2016 and 2020 was 1.8 percent. Also, despite the projected increase in global hydropower capacity by 17 percent between 2021 and 2030 – led by China, India, Turkey, and Ethiopia – it is still nearly 25 percent slower than hydropower's expansion in the previous decade.[7]

Despite these, hydropower has a critical role in accelerating the global transition towards clean energy and in achieving the countries' climate ambitions. Under the landmark Paris Agreement signed in 2015, a total of 197 countries committed to holding global temperature rises to "well below" 2°C above pre-industrial levels while "pursuing efforts" to limit it to 1.5°C. Limiting global warming to 1.5°C above pre-industrial levels by 2100 would require reducing carbon emissions by 45 percent by 2030, compared with the 2010 level, and from there to net-zero emissions by 2050. Reaching net-zero emissions entail first and foremost reducing human-caused emissions (such as those caused by fossil-fueled vehicles and factories) to as close to zero as possible. Any remaining greenhouse gases should then be balanced with an equivalent amount of carbon dioxide (CO_2) removal, which can happen through actions like restoring forests or using direct air capture and storage technology. As of November 2021, more than 140 countries, accounting for 90 percent of global emissions, have signed up to the net-zero goal. The dates voluntarily set for achieving the target are 2050 by developed countries, 2060 by China and 2070 by India.[8]

Achieving net-zero emissions requires deploying several clean and efficient energy technologies, including hydropower. Although solar power and wind power are currently at the forefront of the unprecedented global energy transition, questions remain about their reliability in meeting the rising energy demand in the same way that fossil fuel can. Intermittency of supply inherently affects solar power and wind power as they both depend on changes in climate and weather conditions. For example, the sun does not shine all the time, and the wind too does not blow all the time. As a result, their output is not perfectly controllable, and cannot be directly stored or stockpiled. That concern reinforces the importance of hydropower due to its unmatched capabilities in terms of flexibility. Hydropower plants can start up and shut down quickly and economically, giving the network operator the vital flexibility to respond to wide fluctuations in demand across seasons and at different times of the day. Most importantly, hydropower can allow more solar and wind to be added to the system by

Hydropower can allow more solar and wind to be added to the system by providing rapid-response power when intermittent sources are off-line.

providing rapid-response power when intermittent sources are off-line. That makes sustainable hydropower an attractive foundation for integrating wind and solar power in greater amounts.

In light of this, the International Hydropower Association (IHA) has estimated that around 850,000 MW/850 GW of new hydropower capacity will be required by 2050 to keep global warming to below 2°C by the end of 2100.[9] As for the more ambitious goal of limiting global warming to 1.5°C by the end of 2100, an additional 1,200,000 MW/1,200 GW of new hydropower capacity will be needed by 2050. Meanwhile, the International Energy Agency (IEA) projected that an additional 1,300,000 MW/1,300 GW of new hydropower capacity would be required by 2050 if the world is to realize the goal of reducing carbon emissions to zero and limit global warming to 1.5°C by the end of 2100.[10] In other words, the world needs significantly more hydropower to be built at a much faster rate. As such, hydropower's current annual growth rate of 1-2 percent is simply not enough. It must grow by at least 2.3 percent annually for the world to fully transition towards clean energy and in the process limit global warming to 1.5°C by the end of 2100.

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The Case of India

Not long after the world's first hydropower plant began operation in the United States on 30 September 1882, India commissioned its first hydropower plant in Darjeeling on 10 November 1897. The 130 kW/0.13 MW Sidrapong hydropower plant provided electricity to Burdwan Palace, the Governor House, a police station, a hospital, tea gardens, etc. By 1947, India's installed hydropower capacity reached 508 MW/0.50 GW, and it accounted for 37.27 percent of the country's total installed electricity capacity of 1,363 MW/1.36 GW. As of 31 December 2021, India's total installed electricity capacity had reached 393,389.46 MW/393.38 GW, out of which 51,351.62 MW/51.35 GW or 13.05 percent was accounted for by hydropower--the largest of any renewable energy sources.[11] Large hydropower (installed capacity above 25 MW/0.02 GW) accounted for 46,512.22 MW/46.51 GW or 90.57 percent of India's total installed hydropower capacity and 11.82 percent of its total installed electricity capacity. Small hydropower (installed capacity below 25 MW/0.02 GW), on the other hand, accounted for 4,839.40 MW/4.83 GW or 9.42 percent of India's total installed hydropower capacity and 1.23 percent of its total installed electricity capacity, respectively. Overall, non-fossil fuel (renewable energy and nuclear) accounted for 158,170.75 MW/158.17 GW or 40.20 percent of India's total installed electricity capacity respectively. Of this, renewable energy accounted for 151,390.75 MW/151.39 GWor 38.48 percent, and nuclear accounted for 6,780.00 MW/ 6.78 GW or 1.72 percent of India's total installed electricity capacity (see Table 2).

Table 2: India's total installed electricity capacity as on 31 December 2021

	Energy sources	Installed capacity	Share in total installed electricity capacity
Thermal	Coal	203,189.50 MW/203.18 GW	51.65%
	Gas	24,899.51 MW/24.89 GW	6.32%
	Lignite	6,620.00 MW/6.62 GW	1.68%
	Diesel	509.71 MW/0.50 GW	0.12%
	Total	235,218.72 MW/235.21 GW	59.79%
Nuclear		6,780.00 MW/6.78 GW	1.72%
Renewable	Hydro	51,351.62 MW/51.35 GW	13.05%
	Solar	49,346.71 MW/49.34 GW	12.54%
	Wind	40,082.70 MW/40.08 GW	10.18%
	Bio	10,609.72 MW/10.60 GW	2.69%
	Total	151,390.75 MW/151.39 GW	38.48%
Total		393,389.46 MW/393.38 GW	

Source: Central Electricity Authority (CEA), 2021.

India's current installed hydropower capacity (capacity above 25 MW/0.02 GW) of 46,512.22 MW/46.51 GW is just 32 percent of its estimated total potential of 145,320 MW/145.32 GW.[12] In other words, India is yet to tap even half of its total hydropower potential. The Brahmaputra River basin accounted for 65,400 MW/65.4 GW or 45 percent of India's total hydropower potential. The Indus River basin on the other hand accounted for 22.72 percent, the Ganga River basin accounted for 13.93 percent, east-flowing rivers accounted for 9.47 percent, west-flowing rivers accounted for 6.19 percent, and central Indian rivers accounted for 2.66 percent respectively. Despite possessing the largest hydropower potential in India, the Brahmaputra River basin has a current installed hydropower capacity of just 4,687.0 MW/4.68 GW. This is only 7.16 percent of its total estimated potential, the lowest among India's river basins (see Table 3).

Among states, Arunachal Pradesh, located in the Brahmaputra River basin, accounted for 50,064 MW/50.06 GW or 34.45 percent of India's total hydropower potential, the largest in the country (see Table 4).[13] The state, however, has an installed hydropower capacity of 544.55 MW/0.54 GW or 1.08 percent of its estimated potential as of 31 December 2021.

Table 3: Basin-wise estimates of India's hydropower potential

River basins	Potential capacity (for capacity above 25 MW/0.025 GW)
Brahmaputra	65,400 MW/65.4 GW
Indus	33,028 MW/33.02 GW
Ganga	20,252 MW/20.25 GW
East flowing rivers	13,775 MW/13.77 GW
West flowing rivers	8,997 MW/8.99 GW
Central Indian rivers	3,868 MW/3.86 GW
Total	**145,320 MW/145.32 GW**

Source: Central Electricity Authority (CEA), 2021.

The Decline of Hydropower

Despite hydropower being a reliable source of renewable electricity for decades, its share in India's overall installed electricity capacity has declined. At the time of independence in 1947, hydropower accounted for 37 percent of India's installed electricity capacity, and it reached a peak of 50.61 percent in 1963. It has declined ever since, and in 2021, it accounted for just 11.82 percent. A Lok Sabha Standing Committee on Energy report published in 2019 observed that hydropower "has not been paid due attention over the years" and highlighted the following issues that have hampered the sector's growth.[14]

- ***Land acquisition:*** Acquisition of land for dam, powerhouse, switchyard, etc., has often encountered procedural delays, unavailability/mismatch of land record, court cases, unreasonable demands by landowners, etc.

Table 4: State-wise estimates of India's hydropower potential

Rank	States	Estimated potential (for installed capacity above 25 MW/0.02 GW)
1	Arunachal Pradesh	50,064 MW/50.06 GW
2	Himachal Pradesh	18,470 MW/18.47 GW
3	Uttarakhand	17,998 MW/17.99 GW
4	Jammu & Kashmir	11,567 MW/11.56 GW
5	Karnataka	6,459 MW/6.45 GW
6	Sikkim	4,248 MW/4.24 GW
7	Kerala	3,378 MW/3.37 GW
8	Maharashtra	3,314 MW/3.31 GW
9	Andhra Pradesh	3,261 MW/3.26 GW
10	Odisha	2,981 MW/2.98 GW
11	West Bengal	2,829 MW/2.82 GW
12	Meghalaya	2,298 MW/2.29 GW
13	Chhattisgarh	2,202 MW/2.20 GW
14	Ladakh	2,046 MW/2.04 GW
15	Mizoram	2,131 MW/2.13 GW
16	Madhya Pradesh	1,970 GW/1.97 MW
17	Manipur	1,761 MW/1.76 GW
18	Tamil Nadu	1,693 MW/1.69 GW
19	Nagaland	1,452 MW/1.45 GW
20	Telangana	1,099 MW/1.09 GW
21	Punjab	971 MW/0.97 GW
22	Uttar Pradesh	664 MW/0.66 GW
23	Assam	650 MW/0.65 GW
24	Gujarat	590 MW/0.59 GW
25	Jharkhand	582 MW/0.58 GW
26	Rajasthan	483 MW/0.48 GW
27	Haryana	64 MW/0.06 GW
28	Goa	55 MW/0.05 GW
29	Bihar	40 MW/0.04 GW
30	Tripura	0
	Total	**145,320 MW/145.32 GW**

Source: Central Electricity Authority (CEA), 2021.

- *Environment:* Hydropower projects often affect river flow regimes and water quality, hinder fish migration, and lead to loss of biological diversity. As such, clearances are required from three different wings of the Ministry of Environment, Forest and Climate Change (MoEFCC)-environmental clearance from the Expert Appraisal Committee (EAC), forest clearance from the Forest Advisory Committee (FAC) and wildlife clearances from the National Board of Wildlife (NBWL). This makes the process of acquiring clearances cumbersome and time consuming.
- *Rehabilitation and resettlement:* Hydropower projects often lead to population displacement. Their rehabilitation and resettlement can be expensive and time consuming and often lead to court cases.
- *Law and order problems:* Protests by the local people who demand employment, extra compensation, etc., often create problems and delay the completion of project work.
- *Culture/religion:* Religious sentiments attached to rivers and the cultural importance of rivers often hamper hydropower development.
- *Technical/geological:* Hydropower projects, especially in the Himalayan region, are susceptible to geological surprises, especially during underground tunneling. Besides, natural calamities like landslides, hill slope collapses, roadblocks, floods, cloud bursts, etc., often cause delay in construction and completion.
- *Difficult terrain and poor accessibility:* Hydropower project sites are often located in inaccessible and remote locations, and the absence of approach roads for transporting large and heavy equipment to the project sites often cause delay.
- *Finance:* While hydropower is a low-cost source of power with low operational costs, it is capital intensive and requires a great deal of investment upfront. Besides, there is a lot of uncertainty over the final costs and completion time of hydropower projects.
- *Water cess:* States like Jammu and Kashmir have levied water cess, and that has affected the viability of hydropower projects in the state as it increases the tariff by about 50p-Rs 1/unit.

The phenomenal growth of renewable energy sources such as solar has further contributed to hydropower's slow decline in India (see Table 5).

Table 5: Charting the decline of hydropower's share in India's total electricity capacity, 1947-2021

Year	Total installed electricity capacity	Total installed hydropower capacity	Hydropower's share total installed electricity capacity
1947	1,363 MW/1.36 GW	508 MW/0.50 GW	37.27%
1950	1,713 MW/1.71 GW	560 MW/0.56 GW	32.69%
1963	5,801 MW/5.80 GW	2,936 MW/2.93 GW	50.61%
1969	12,957 MW/12.95 GW	5,907 MW/5.90 GW	45.58%
1974	16,664 MW/16.66 GW	6,966 MW/6.96 GW	41.80%
1980	28,448 MW/28.44 GW	11,384 MW/11.38 GW	40.01%
1985	42,585 MW/42.58 GW	14,460 MW/14.46 GW	33.95%
1990	63,636 MW/63.63 GW	18,307 MW/18.30 GW	28.76%
1997	85,795 MW/85.79 GW	21,658 MW/21.65 GW	25.24%
2000	97,837 MW/97.83 GW	23,857 MW/23.85 GW	24.38%
2005	118,419 MW/118.41 GW	30,936 MW/30.93 GW	26.12%
2010	159,398 MW/159.39 GW	36,863 MW/36.86 GW	23.12%
2015	267,637 MW/267.63 GW	41,267 MW/41.26 GW	15.41%
2020	375,323 MW/375.32 GW	45,798 MW/45.79 GW	12.20%
2021	393,389 MW/393.38 GW	46,512 MW/46.51 GW	11.82%

Source: Central Electricity Authority (CEA), 2019.

Solar power has certain inherent advantages over hydropower. Whereas building a hydropower plant costs Rs 7-9 crore (1 crore=10 million) per MW, it only costs Rs. 3.5-4 crore per MW to build a solar power plant. Also, it takes about eight years to build a hydropower project, while a solar power plant takes only 1.5-2 years. Not surprisingly, solar power is seen as the driver of India's renewable energy push, and it is projected to surpass hydropower in the coming years. Whereas solar power accounted for 49,346.71 MW/49.34 GW or 12.54 percent of India's total installed electricity capacity in 2021, it was projected to account for 280,155 MW/280.15 GW or 34.28 percent of India's total installed electricity capacity of 817,254 MW/817.25 GW by 2030.[15] Hydropower (both large and small), however, will account for just 65,977 MW or 8.07 percent of India's total installed electricity capacity.

The Case for Faster Deployment of Hydropower

Facilitating India's Clean Energy Transition

On 2 October 2015, India outlined its post-2020 climate actions that it intends to take under the Paris Agreement on climate change. It included a commitment to increase the share of non-fossil-based energy resources to 40 percent of the country's total electricity capacity by 2030. As part of this effort, India aimed to install a renewable capacity of 175,000 MW/175 GW by March 2022, including 100,000 MW/100 GW from solar power, 60,000 MW/60 GW from wind power, 10,000 MW/10 GW from biomass power, and 5,000 MW/5 GW from small hydropower respectively. This target is on track to be achieved with India's renewable energy capacity having reached 151,390.75 MW/151.39 GW in 2021, or 38.48 percent of its total installed electricity capacity.

Buoyed by the rapid progress of its renewable energy deployment, solar and wind in particular, India announced a more ambitious climate plan during the United Nations Climate Change Conference (COP26) in Glasgow, 2021, that included having 50 percent of the country's power generated from renewable energy by 2030; increasing non-fossil energy capacity to 500,000 MW/500 GW by 2030; and reaching net-zero emissions by 2070. The pledge to achieve net-zero emissions is highly ambitious because India is yet to emit the majority of its potential emissions and is far away from its peak in terms of economic growth and energy consumption. Going forward, therefore, India is unlikely to achieve its increasingly ambitious climate goals and clean energy transition plans on the back of solar and wind power alone. As has already been discussed, concerns remain about the reliability of these sources of electricity. Hydropower, on the other hand, provides unmatched capabilities in terms of flexibility - it can supply electricity or store it to meet real-time needs. This flexibility makes hydropower an attractive foundation for integrating wind and solar power into the grid. Thus, even when the sun is not shining or the wind is not blowing, hydropower can ensure that electricity supplies stay constant. These qualities make hydropower the ultimate "guardian of the grid."[16] Besides, hydropower also delivers services beyond clean electricity, including water supply, irrigation, flood protection and drought mitigation, navigation, tourism, and recreation. It is a vital pillar of economic and social development. Some 38 large hydropower projects were under construction with a total installed capacity of 12,973.5 MW/12.97 GW as of November 2020. Furthermore, it has been reported that India is committed to installing an additional hydropower capacity of 70,000 MW/70 GW by 2030.[17]

Consolidating India's Position in the India-China Border Areas

Hydropower projects could also play a vital security role by helping India consolidate its position in the Indian border regions such as Arunachal Pradesh that face encroachments and territorial claims by China. This aspect of hydropower has not received due attention and is poorly understood. Increased deployment of hydropower especially in the border regions of Arunachal Pradesh could help India address the potential hydrological and strategic implications of Chinese dams on Tibet's rivers.

China has increasingly set its eyes on Tibet's rivers, the Yarlung Tsangpo or Brahmaputra, in particular. According to one estimate, China has planned to build "more than 28 dams" on the river.[18] Of these, five are known to have been constructed or approved for construction on the middle reaches of the Yarlung Tsangpo River. They are Zangmu, Jiacha, Zhongda, Jiexu, and Langzhen.[19] Construction of the 510 MW/0.51 GW Zangmu Hydropower Project began in 2009 and was completed in 2015. Construction of a second dam, the 360 MW/0.36 GW Jiacha Hydropower Project, soon followed in 2015, and was completed in 2020.[20] The remaining three dams are believed to be in various stages of planning, engineering, and construction. China also aims to build more hydropower projects on the lower reaches of the Yarlung Tsangpo River that includes a 60,000 MW/60 GW hydropower project close to the Indian border. The plan for the construction of this "super dam" was announced on 29 November 2020.[22] India fears that hydropower projects on the Yarlung Tsangpo could adversely impact the country as China may withhold, block or restrict water flows during the dry seasons. That could lead to reduced water flow in the Brahmaputra River. Conversely, excess water released from the reservoirs during the wet or rainy season may trigger deadly floods in Arunachal Pradesh and Assam. Beyond this, Chinese dams on the Yarlung Tsangpo River could also advance China's territorial ambitions on Arunachal Pradesh by facilitating the development of more roads, border villages, and mining close to, and even inside, Arunachal Pradesh and help consolidate the country's encroachments there.

There are now growing calls for India to accelerate the construction of hydropower projects in Arunachal Pradesh to offset both the potential hydrological as well as strategic impacts of Chinese hydropower projects on the Yarlung Tsangpo River. Hydropower, in turn, could help India achieve its strategic objectives along the Indian-China border by promoting development and improving the socio-economic conditions of the border villages and communities in Arunachal Pradesh among others. Thriving border villages are essential for India's security. In the absence of basic infrastructure and economic opportunities, border communities often feel insecure and neglected. This prompts them to migrate out of border villages, leaving behind gaping holes in India's border security and defence preparedness. Maximizing the development outcomes of hydropower projects in Arunachal Pradesh and elsewhere, therefore, could increase the incentives for border communities to continue living in border villages and contribute to the protection of the Indian border from Chinese territorial expansionism.

Policy Initiatives for Faster Deployment of Hydropower

To facilitate faster deployment of hydropower, India has announced a number of policy initiatives and measures over the past several years. These include the *National Rehabilitation and Resettlement Policy 2007*; the *Hydro Power Policy 2008;* the *Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013* and various other measures. The *National Rehabilitation and Resettlement Policy 2007* provides for benefits and compensation to people displaced by land acquisition purchases or any other involuntary displacement.[22] Benefits include land, house, monetary compensation, training in skills, and preference for jobs. The policy also established the post of Ombudsman to address grievances that may arise from the process of rehabilitation and resettlement. The *Hydro Power Policy 2008* sets out the broad policy objectives for accelerating the pace of hydropower development, such as inducing private investment in hydropower development, harnessing India's full hydropower potential, improving resettlement and rehabilitation, and facilitating the financial viability of hydropower projects.[23]

Furthermore, the *Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013,* sets out procedures for land acquisition that is "humane, participative, informed and transparent."[24] It observed that land can only be acquired for projects with a "public purpose". Whereas no consent is required from landowners for government projects, 70 percent consent is required for Public-Private Partnership (PPP) projects and 80 percent for private projects. Norms for compensation, rehabilitation and resettlement of affected persons have been prescribed. The Act also requires Social Impact Assessment (SIA) to be carried out to determine the potential positive/negative and intended/unintended consequences of large development projects, including hydropower. On 8 March 2019, India announced a slew of measures that included the following:[25]

a) Declaring large hydropower as a renewable energy source;

b) Hydro Purchase Obligation (HPO) as a separate entity within Non-Solar Renewable Purchase Obligation (RPO);

c) Tariff rationalization measures for bringing down hydropower tariff;

d) Budgetary support for flood moderation/storage hydropower projects; and

e) Budgetary support for enabling infrastructure, i.e., roads and bridges.

These policy initiatives and measures could potentially transform hydropower into an attractive and competitive source of electricity and spur its rapid deployment. Most importantly, budgetary support for building infrastructure such as roads and bridges could facilitate the development of hydropower in hilly regions/states where the bulk of India's hydropower potential is located. The lack of infrastructure, including roads and bridges for transporting heavy equipment and machinery to project sites, have for long hobbled faster deployment of hydropower projects in those regions. Taken together, the aforementioned policy initiatives and measures, coupled with lessons learnt from India's long history of hydropower development could help expand the country's hydropower capacity sustainably in the years ahead.

Conclusion

This article discusses the role of hydropower in India's energy transition. It argues that despite the phenomenal growth of solar power and wind power, hydropower has a critical role in accelerating India's clean energy transition and achieving the country's climate ambitions securely. Its unmatched flexibility offers an attractive foundation for integrating greater amounts of wind and solar power into the grid. That, in turn, could facilitate constant and stable electricity supply. Besides, hydropower projects also deliver multiple other services vital for development, especially in remote, neglected and often sensitive border regions.

Hydropower projects, however, are inherently challenging and can have adverse environmental and social impacts. But these can be mitigated. Towards this end, India has created an enabling environment for faster and sustainable deployment of hydropower through several policy initiatives and measures. Going forward, India needs to continue to adopt new social and environmental norms and develop more robust and cost-effective technological solutions so that hydropower projects can be deployed sustainably.

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