ASSOCHAM INDIA

Contents

Hydropower @ Crossroads

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Foreword

India is endowed with rich hydropower potential to the tune of 148 GW, which will be able to meet a demand of 84 GW at 60% load factor. Various factors have contributed to the slow pace of hydropower development, resulting in the declining share of hydropower in India's energy mix. The issues have been exacerbated as hydropower development has largely remained under the ambit of state governments (water being a state-specific subject) with varying policies.

Hydropower's critical role in our nation's energy security is based on the elements of sustainability, availability and affordability. I believe this conference will highlight the industry's collective concerns and issues impacting the development of the hydropower sector.

I sincerely thank PwC, our knowledge partner, for their efforts in preparing this paper to suggest a roadmap to accelerate hydropower development in the country.

We also acknowledge the support provided for publishing this report by the National Hydropower Corporation (NHPC), Arunachal Pradesh Power Companies Association (APPCA), CESC (RP-Sanjiv Goenka Group), Damodar Valley Corporation (DVC), India Power Corporation (IPC), Normet India, Jindal Steel, Satluj Jal Vidyut Nigam Limited (SJVNL), Statkraft India, Voith Hydro, AF Consult and Omega Icehill.

I hope the recommendations in this paper will merit the consideration of policymakers. I wish the conference all success.

D S Rawat
Secretary General
ASSOCHAM

Introduction

India added 108 GW of new generation capacity in the last five years, which has led to power deficits declining from 12.2% of peak demand in FY02 to 2.6% in FY16.

In energy terms, the change is more evident. Plant load factors (PLFs) have dropped to 65%, which is a historic low for the Indian power sector. With respect to power exchange, traded power has declined to 2,826 INR per MWh, which is 33% below the bid rate for a new long-term coal-based thermal power plant.

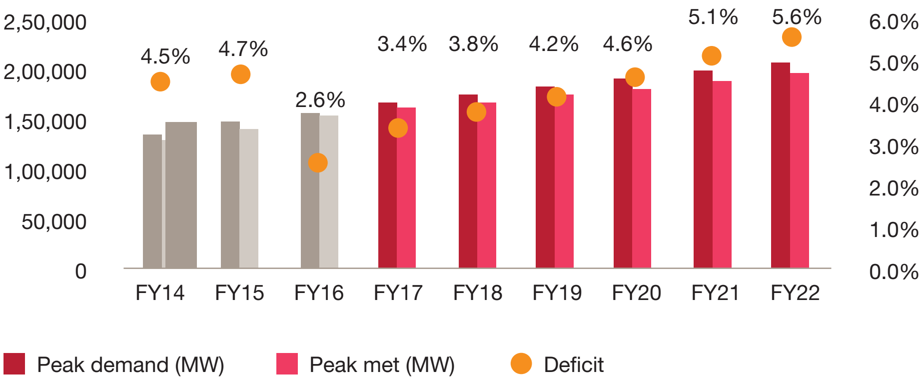
However, medium-term forecasts suggest that the trend may soon reverse as demand starts to overtake supply, resulting in growing deficits. Our forecast until 2022 suggests that demand will continue to outpace supply. In fact, new project initiation has tapered off.

Further, considering an energy elasticity of 0.8, India is estimated to require around 7% annual growth in electricity supply to sustain a GDP growth of around 8–9% per annum. Our analysis also suggests that for the country to achieve its target of 1,800 kWh per capita consumption and electricity access for 300 million people by 2034, it will require an additional power supply capacity of 450 GW.

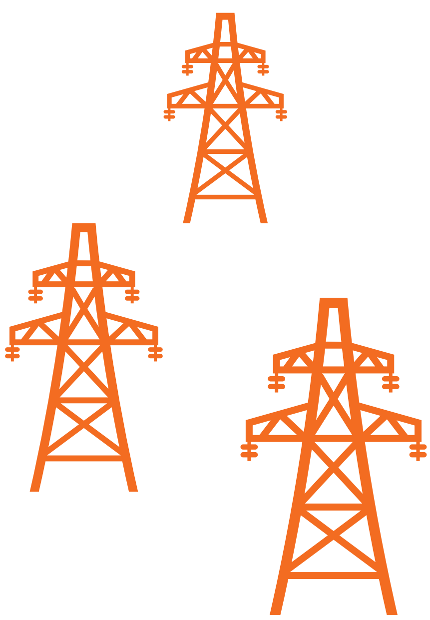
Currently, India's power generation landscape has largely been dominated by coal-based generation, accounting for approximately 70% of the total installed capacity and over 80% of the total units generated in the country. This higher dependency on thermal generation sources pose a serious threat to energy security in terms of fuel availability, long-run economic viability and environmental sustainability.

Thus, availability of reliable, affordable and sustainable electricity is an essential requirement for propelling the India growth story and all potential sources of energy will need to be tapped to meet the envisaged demand and ensure its energy security. Hydropower, with an abundant potential of around 148 GW, can substantially contribute towards meeting the energy needs of the country.

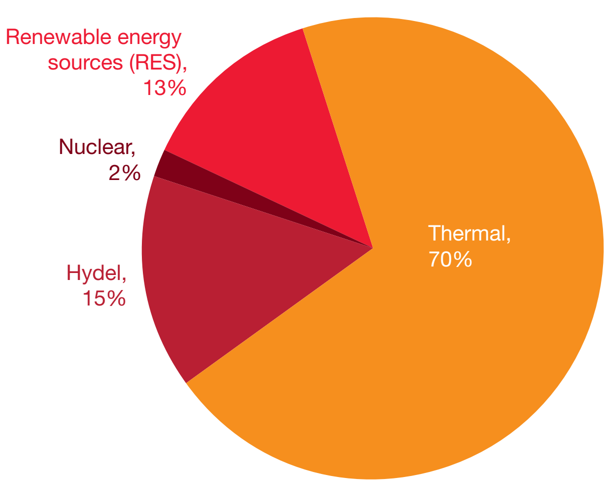
India medium-term forecast: Moderate growth scenario (MW)



Source: PwC analysis



India's generation mix



Source: Ministry of Power, Coal, New & Renewable Energy

Hydropower as a sustainable energy source

Hydropower can play a crucial role in India's sustainable development and energy security given that it meets the criteria of sustainability, availability, reliability and affordability.

Advantages of hydropower

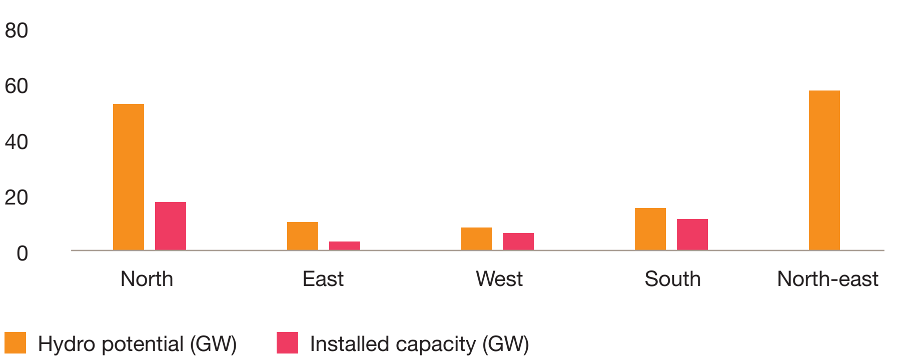
Sustainability	Clean source of energy	Hydropower uses a clean source of fuel and does not contribute significantly to carbon emission (storage projects). Hydropower projects emit 169 gCO2 equivalent compared to the 2,010 gCO2 equivalent and 443 gCO2 equivalent released by coal-based and gas-based power plants respectively.
	Irrigation and flood control	Hydropower projects have the ability to control flood and irrigation by regulating the downstream flow of water.
Availability	Black start capability	Hydropower plants do not need any outside source of power to start. This allows system operators to provide auxiliary power to other generation sources that could take hours or even days to start.
	Peak shaver asset	The ability of hydropower plants to quickly change their output helps them to serve peak demand.
Affordability	Low operating cost	Hydropower plants have a low operating cost—almost half that of thermal power plants.
	Long economic life	The plant life of hydropower projects is normally in the range of 40–50 years. In fact, their operating life can be increased to 100 years through timely renovation, which also helps in higher revenue generation for investors.
Reliability	Reliable grid support	Given its large inertia, hydropower provides transient stability to the grid.
	Support for variable generation of renewable energy sources (RES)	The storage capabilities of many hydropower plants make them a perfect instrument for optimising the use of variable RES over both shorter and longer periods.

Status of hydropower development

India is blessed with significant hydropower potential and can meet a demand of around 85 GW at 60% load factor. However, till date, only 41 GW of hydropower capacity has been installed, which is only 28% of the total potential. Countries like Canada and Brazil had harnessed around 69% and 48% of the economically feasible potential back in 2009.

In order to increase the hydropower capacity, the Government of India has

Status of hydropower development in India



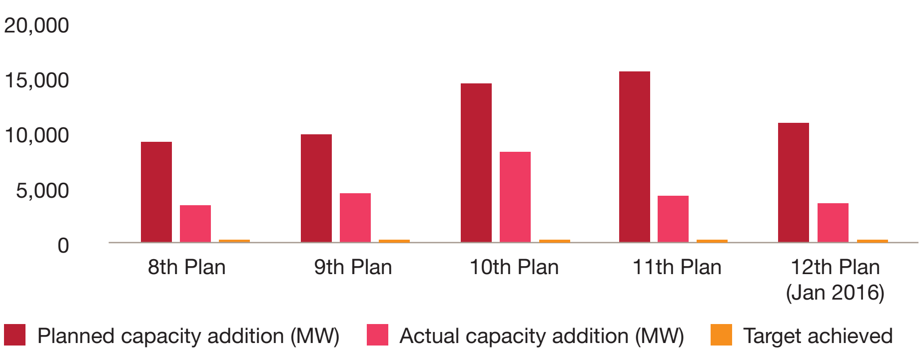
Source: Central Electricity Authority (CEA)

planned to add capacity of 10,897 MW in the 12th Five Year Plan, which is almost 25% of the total hydro installed capacity. However, the actual capacity added was around 3,673 MW (till January 2016), which means that only one-third of the target has been achieved during the first two-thirds of the period. The same trend may be observed in the previous five year plan periods—for example, in the 11th Five Year Plan, only 40% of the target was met.

Regional assessment of hydropower development shows that almost 75% of the total potential for hydropower development is concentrated in the north-eastern and northern regions. However, only 34% of the total potential in the northern and 2% of the potential in the north-eastern region has been developed till now.

Exploitation of the large hydro potential in the north-east region would contribute significantly in meeting the country's peaking needs in the future. The region would also benefit from the development of associated infrastructure such as roads, schools and electricity supply to remote areas, which would further improve the quality of life. However, until now, only 7% of the total potential of the region has been tapped (installed capacity and capacity under development) and this provides enormous opportunities to the state governments and hydro developers to harness the rest of the potential.

Planned vs actual capacity addition



Source: Central Electricity Authority (CEA)

States	Identified potential (MW)	Percentage of capacity under operation and construction
Arunachal Pradesh	50,328	6%
Meghalaya	2,394	13%
Mizoram	2,196	3%
Manipur	1,784	6%
Nagaland	1,574	5%
Assam	680	55%
Tripura	15	Nil

Policy and regulatory initiatives to facilitate hydropower development

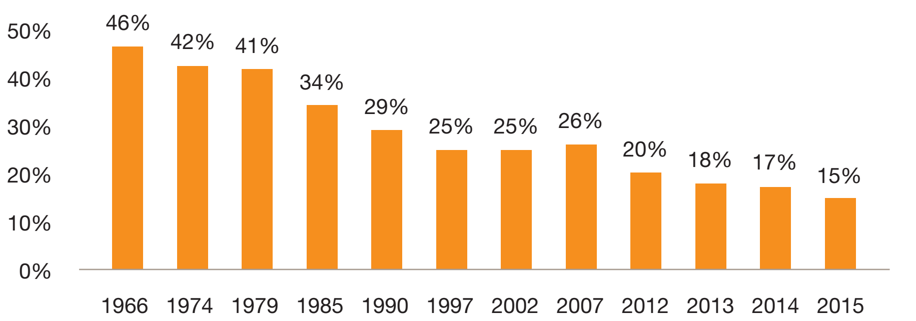
Acknowledging the need of the hour, the Government of India has undertaken a number of initiatives in the recent past, supported by various policy-level changes to promote hydropower development and facilitate investment in the sector. As a part of these initiatives, the government has increased financial allocation, along with other non-financial support, and is also in the process of establishing a dedicated hydropower development fund to improve the investment attractiveness of the sector. Some key policy-level changes introduced by the government to facilitate hydropower development in the past are discussed in brief below:

Legislation/act/initiatives	Key features
Hydropower Development Policy, 1998	• Established a power development fund by levy of cess on electricity consumed • Transferred the subject of hydropower development up to 25 MW from the Ministry of Power to the Ministry of New & Renewable Energy
50,000-MW initiative	• Preparation of a preliminary feasibility report and detailed project report of hydroelectric schemes in 16 states
National Electricity Policy, 2005	• Addressed the issues of long-term financing of hydel projects and provided guidelines for centre-state participation in development of hydel projects • Emphasised large-scale development of feasible hydropower potential
Mega Power Projects Policy, 2008	• Awarded all hydel projects with capacity above 500 MW the status of a 'mega power project' (qualification relaxed to 350 MW for projects in the north-east region) • Extension of the benefit of a 10-year tax holiday, no customs duty on imports of equipment, etc., to identified projects
National Hydro Power Policy, 2008	• Provided great impetus to hydropower development and emphasised increasing private sector participation in hydropower development • Aimed at quickly harnessing India's balance of hydroelectric potential by ensuring improved financial viability of hydel projects
Central Electricity Regulatory Commission (CERC) (Ancillary Services Operation) Regulations, 2015	• To restore and maintain frequency of electric supply at desired levels by providing commercial incentives for both ramp-up and back-down ancillary services
National Tariff Policy, 2016	• Underlines the norms for ancillary services and also gives right to the CERC to introduce the norms and framework for ancillary services necessary to support the grid operation, including the method of sharing of charges • Provides exemption from competitive bidding till 2022

In addition, in 2014, the Government of India has also introduced a significant transformation in the institutional structure by merging the Ministry of Power, the Ministry of New & Renewable Energy and the Ministry of Coal under a single ministry (Ministry of Power, Coal, New & Renewable Energy), which will ensure closer coordination in the decision-making procedure.

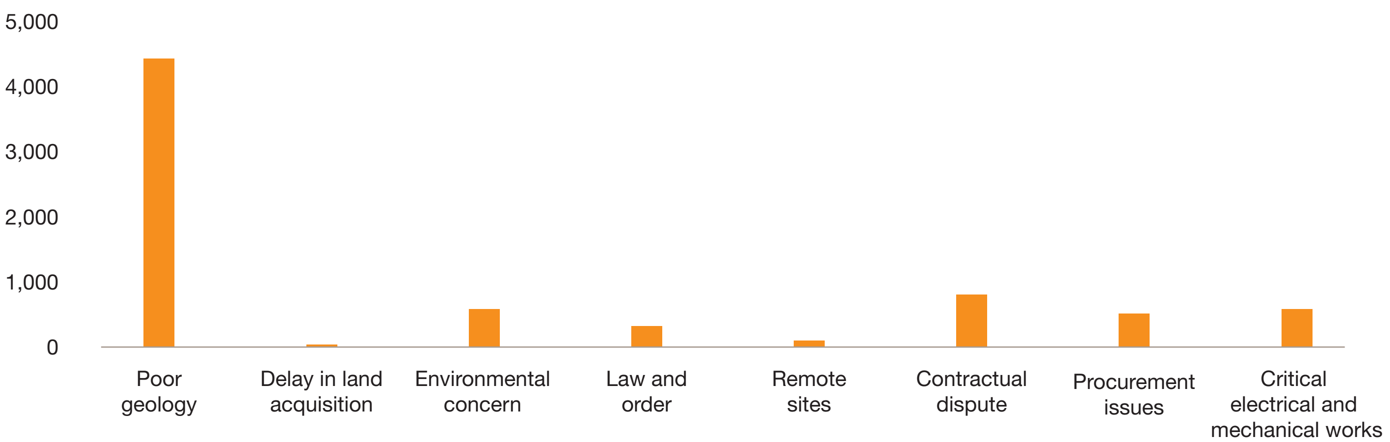
However, various issues still remain: water-sharing disputes, environmental concerns, rehabilitation and resettlement (R&R) issues, land acquisition problems, delays in procuring clearance and approvals, inadequate technical and financial capability of developers, etc. These issues result in a declining share of hydropower in India's electricity mix—e.g. the share of hydropower has decreased by almost 30% in the last 40 years. For example, in Arunachal Pradesh, out of 120 MoUs (40,141 MW), most of the projects were at a standstill due to various issues such as local agitations, R&R, forest clearance and inadequate power evacuation infrastructure.

Proportion of hydropower in total installed capacity



Source: Central Electricity Authority (CEA)

Major reasons for slippage for 10th Plan projects (MW)



Source: Working Committee on Power for 12th Plan

Hydropower development roadblocks

The figure below provides a summary of the major factors hindering the growth of the hydropower sector in the country. We have also discussed these issues in detail.

Hydropower planning

Hydropower planning and development in India are generally project oriented and not based on any basin development plan. Non-sequential development of a hydropower project may make it unviable and inefficient.

Developing multiple projects on the same river often compromises the capacity of a project to meet peak demand due to other peak load projects subsequently developed.

Unexpected costs may emerge due to the development of new projects on the same river, e.g. by increasing or reducing the level of silt in the water.

Impacts of social and environmental assessment may emerge in a more severe form when the development of multiple projects in a basin is considered.

Concerns such as vulnerability of the river basin and related ecosystems to climate change may arise due to absence of long-term planning.

In India, water is a state subject and requires the consent of states that are impacted by a project. This is a time-consuming process that hinders integrated river basin development for hydropower projects. A large number of hydropower projects with common river systems between adjoining states are held up due to a lack of interstate agreements and disputes on water sharing. The Sutlej-Beas dispute between Punjab and Haryana and the Mullaperiyar Dam conflict between Kerala and Tamil Nadu are well-reported examples of water-sharing disputes between states. The conflicts in Assam and Arunachal Pradesh on the division and utilisation patterns of the Brahmaputra are another case in point.

Land acquisition

Land acquisition is one of the key reasons for delay when it comes to the implementation of major infrastructural projects like hydropower. Previously, under the 120-year-old prevailing act, most of the land was acquired in the name of development and little stake or benefits were given to the people affected by a project. Not only were they not given adequate compensation or rehabilitation, but they also did not get enough employment opportunities. For example, in the case of the Hirakud Dam project, there was hardly any rehabilitation or compensation given to the project affected people.

The Land Acquisition Act, which came into effect from January 2014, attempts to address some of the social inequities in the existing framework of land acquisition. However, certain amendments were proposed in the New Land Acquisition Bill, 2015, with respect to various clauses, such as those on consent of landowner and social impact assessment (SIA), in order to address the land acquisition problem from the perspective of both landowners and developers.

But some issues need to be addressed to smoothen the process of hydropower (and other infrastructure) development.

- R&R provisions are not mandatory in the case of private purchase of land of less than 100 acres in rural areas and 50 acres in urban areas. These provisions enable the developer to buy land in multiple parcels of less than 100 acres and also allows for no R&R in case of acquisition of agricultural land.
- Instead of addressing issues related to responsible development and benefit sharing, the SIA processes sometimes cause delays. However, the New Land Acquisition Bill has sought the exemption of SIA for critical infrastructure projects which may benefit the developer. However, this may on the other hand cause delays due to protests from NGOs, locals and other concerned organisations.
- Public sector companies do not require any public consent for acquiring land. This deters private investors and may also lead to protests, causing delays for projects undertaken by the public sector.

The New Land Acquisition Bill tried to address this issue by allowing exemption for both public and private developers. However, the acquisition process needs to be strengthened to prevent misuse of land by private entities.

Safeguard issues

Hydropower projects are site specific and may impact the environment in a variety of ways, such as affecting the natural river system and changing the river course, thereby impacting the flora and fauna. Furthermore, large storage-based hydropower projects involve

The Tehri Dam project met with mass protests and public outcry on the issues of safety, environment and rehabilitation, resulting in unusual delays (the Tehri Dam was commissioned more than 25 years after the R&R was started).

Similarly, the construction of the 200-MW Subansiri Lower Dam has been stopped since December 2011 due to safeguard issues such as impact on downstream states like Assam and vulnerability of the dam to seismic activity. This results in a daily loss 10 crore INR.

submergence of villages, causing relocation of people, disruption of community networks and loss of biodiversity. They also affect the downstream irrigation activity by altering the volume of water flow.

Hydropower projects often require forest areas for their implementation and compensatory afforestation on non-forest lands. The progress of many projects has been affected on account of delays and non-clearance on environment and forest aspects. The availability of large land areas required for compensatory afforestation also poses a threat to project implementation as this is a mandatory precondition for the execution of construction work.

These factors have resulted in negative public perception of hydropower projects, resulting in sustained opposition to project constructions in many cases as well as time and cost overruns.

Market development

According to the new Tariff Policy, 2016, competitive bidding for hydropower projects is exempted under a sunset clause till 2022. The deferment is based on the recommendation of the power ministry's task force, which cited high construction risks and geological uncertainties inherent in these projects as some of the reasons that make it difficult for hydro projects to be cost competitive in the bidding process.

Moreover, the Indian power market is at a nascent stage and the current market structure does not allow the differential pricing of peak and off-peak power. The volume of the short-term market, which allows different instruments for peak and off-peak supply, is also very low. Although the new tariff policy has allowed differential pricing, the implementation impact is yet to be tested.

With the introduction of a huge capacity of RES in the system, stability in terms of voltage regulation, reactive power control, etc., needs to be tightened, owing to the intermittent nature of RE sources. Although ancillary services have been introduced through the new tariff policy, an appropriate regulatory mechanism for the implementation is yet to be put in place. Besides, separate policy guidelines for the development of pumped storage schemes has to be charted, considering the integration of large-scale renewable capacity.

The Polish Zarnowiec hydropower plant's contribution to system stability

The flexible units of Zarnowiec, Poland's largest hydropower plant with 716 MW capacity, play an important role in ensuring stability in the national electricity system, where coal-fired thermal power plants dominate electricity generation. The plant is located in a very sensitive area, with huge amounts of wind energy coming from Germany, but also soon from Polish sites. Thus, there is a need for balancing. The Zarnowiec hydropower plant fulfils several essential functions for the Polish national electricity system:

- Flexibility to cope with the fast activation and disconnection of units, and covering a sudden power drop or increase in the system
- Control of reactive power flow in the system (voltage regulation and reactive power control)
- Establishment of rotating reserve by means of second power controlling (primary control) and minute power controlling (secondary control)

Zarnowiec therefore played an important role in managing the European blackout of 4 November 2006. Activating pumps helped to stabilise the frequency and voltage and restore the system after power failure.

Source: Hydro in Europe: Powering renewables (Eurelectric)

Financing

Hydropower projects are capital-intensive and require higher upfront costs to address greater complexities in design, engineering, environmental and social impact mitigation, etc. These complexities and technical challenges often lead to time and cost overruns and increase the uncertainty of cash inflows, thereby resulting in higher risk premiums on financing charges.

Limited financing avenues

Non-availability of long-term debt in the Indian capital market necessitates higher provision for depreciation to generate revenues required to meet repayment obligations.

Inadequate incentives

Owing to the withdrawal of the Mega Power Policy, hydro projects are deprived of incentives like export benefits, custom duty exemption and local tax exemption.

Moreover, the provision of free power to the state, irrespective of the technical parameters, affects the financial viability of projects, especially of those with a low load factor. This makes projects even more costly and tariff becomes almost unsustainable.

Technical challenges

Technical challenges are the most critical bottleneck for the commissioning of hydropower projects, as demonstrated by projects scheduled to be commissioned within the 12th Five Year Plan. The features of hydro projects are site specific and depend on the geology, topography and hydrology of a site. Construction time is highly influenced by the unpredictable nature of geological and climatic conditions, which impact the accessibility and favourable working condition of the site. These unpredictable geological conditions are more pronounced in the young fold mountains of the Himalayas, where most of the Indian hydropower potential is located. Moreover, a matter of concern while executing complex hydro projects in India is the limited availability of experienced engineering, procurement and construction (EPC) contractors and proper equipment to tackle certain geological surprises.

The construction of the 4,432-MW hydro projects planned during the 10th Five Year Plan has been delayed due to poor geology. For example, the Kameng (600 MW) and Pare (110 MW) projects of Arunachal Pradesh have been delayed due to unforeseen geological features.

Enabling infrastructure

Most of the hydropower projects are located in remote areas which do not have adequate transmission infrastructure for power evacuation due to various reasons, such as site inaccessibility, absence of integrated generation and transmission plans, and lack of demand. For example, in the case of north-east India, construction of a transmission line is very expensive and time-consuming due to the difficult terrain, especially when the transmission line has to be built through the Chicken's Neck corridor between India and Bangladesh.

There are certain other challenges for the coordinated development of a transmission network:

- Identification of beneficiaries well in advance
- Optimisation of transmission capacity development, considering the planned projects to address the right of way (RoW) issues (high cost of RoW, land acquisition, etc.)
- Furthermore, the PLF for hydropower projects is typically less than 50%, as a result of which significant transmission capacity is underutilised if sufficient projects are not developed.

In addition, the development of associated infrastructure—for example, roads and bridges for improving accessibility to the project site—increases the cost of development and thereby affects a project's viability. Furthermore, lack of infrastructure such as schools and hospitals and inaccessibility to the sites often become roadblocks in moving skilled manpower to such out of reach project sites.

The cost of the associated transmission system for the evacuation of electricity from Kameng Hydroelectric Project (600 MW) is estimated at 11,000 million INR, which is about 50% of the project's cost of generation. Similarly, in the case of Lower Subansiri, the transmission cost is estimated at 100 billion INR.

Critical success factors

Governance enablers → Investment facilitators → Benefit-sharing framework → Technical capacity augmentation

Governance enablers

Hydropower development is challenged by varying risks and uncertainties, and needs government support in terms of data availability, financing, market development, etc., for efficient development. Sustainable growth in the sector can be channelised through an efficient governance framework by adopting a suitable policy framework, sector-specific strategies, and simple and transparent processes.

Efficient coordination and institutional framework for policy goals implementation

- Ministries, state governments and departments must be on the same page to approach sustainable development of hydropower in an efficient and coordinated manner. The processes, structures and institutional frameworks are all required to be well aligned with the development goals and targeted capacity addition.
- The present state-level institutional framework and organisations of concerned institutions need to be reviewed for hydropower development. Both government and private parties are required to play a key role in the process to ensure quality planning, procurement, and development and operation of the assets.

The National Solar Mission with a clearly articulated goal of 20 GW by 2020 helped secure commitment from all stakeholders and ensured efficient interdepartmental coordination to achieve this goal.

Integrated river basin development and project allocation procedure

- The central government can constitute an authoritative body to improve river management, address interstate water-sharing disputes and conduct integrated river basin development. A proper planning forum must be in place to bring all the stakeholders together to reach a consensus on the way forward.
- A basin-wide study needs to be conducted under the guidance of the Central Electricity Authority (CEA)/Central Water Commission (CWC) to understand the effect of one project on another and to ensure efficient project allocation in a river basin. Moreover, the Ministry of Environment and Forest (MoEF) is expected to conduct a basin-wise, cumulative impact assessment study and identify clear go/no-go areas to eliminate uncertainty.
- The allocation of hydropower sites must be done keeping in mind the financial and technical capacity and credibility of developers. Also, cost-benefit analysis should be carried out with different project allocation models.

Brazil: Change of policy to facilitate private investment

In the 1990s, Brazil moved to a free-market model by awarding hydropower generation concessions on a highest rent basis. However, to encourage improved security of supply and attract more private investment from 2004, hydro concessions began to be awarded based on the lowest tariff offered. Brazil has used this system even for some very large (>3,000 MW) sites. The Brazilian authority emphasised limiting risks substantially for developers in order to make this model attractive to them. Some of the key initiatives towards achieving this objective included pre-specifying projects in great detail, providing payment surety for developers and arranging finance from the Brazilian Development Bank.

Power evacuation and associated infrastructure

- The Ministry of Power and the Ministry of Finance, Government of India, may allocate funds for the construction of a dedicated transmission corridor for hydropower (e.g. Green Energy Corridor) to evacuate the hydropower generated from remote areas.
- The state governments should make provisions for building pooling substations in locations having a large concentration of hydro resources to help developers reduce the project cost on account of last-mile connectivity.
- Other associated infrastructure needs to be developed to facilitate project implementation in a cost-effective manner. The development of such associated infrastructure has spurred economic activities, and the state government must partially bear the costs of development. The state governments must effectively channelise local development funds, upfront premium, etc., received from developers to invest in such associated infrastructure.

The integrated river basin plan, along with a transmission system master plan, can help in the optimum utilisation of transmission infrastructure and prohibit delays in commissioning of plants.

Investment facilitators

As hydropower projects are capital-intensive and are faced with various risks and uncertainties, optimum risk allocation mechanisms between the developers, government and project affected people need to be in place. Moreover, new financing avenues need to be developed along with sufficient funding support from the government in order to attract investment in the sector. The key focus areas are mentioned below:

Streamlining of the land acquisition process and other approvals

- The state government, in consultation with the central government, may develop appropriate procedures to expedite various clearances, such as those for the environment, forest and land. It can also form a specialised institution for facilitating large infrastructure projects in terms of clearances and approvals, thereby minimising the time taken for these processes. In addition, specific timelines for all statutory and non-statutory clearances for a project at both the central and state levels need to be fixed, along with accountability for delays.
- The government on the other hand can also complete all pre-development activities (e.g. land acquisition) and statutory clearances (e.g. environment and forest) for identified priority projects which are in line with the procedure for Ultra Mega Power Projects (UMPP) developed through the Power Finance Corporation (PFC) before allocating them to developers.
- The government should also provide all available data for the land records in advance, which will help the developer with project preparation and also facilitate the project financing process. In addition, the government can form a lender consortium to validate the available data of different hydropower sites and review the financial viability of a project at the detailed project report (DPR) preparation stage. This will assist in better preparation of bankable DPRs to be shared with financial institutions, as, once prepared, it is very time-consuming to collect and present raw data again to satisfy the financier.

The Investment Board in Nepal has the mandate to assist developers with interdepartmental coordination, clearances and approvals for hydro projects greater than 500 MW.

Fiscal incentives

- Adequate fiscal incentives in terms of tax holiday, Value Added Tax (VAT) exemption, and exemption of custom duty should be allowed by the government to help in reducing the project cost and securing a cheaper source of finance.
- The lender consortium may also provide interest rebates on long-term loans during the construction and early years of operation to help developers in generating sufficient revenue for meeting their repayment obligations. Similarly, a provision of higher depreciation in the early years of operation can also be allowed for hydro developers to serve their requirement of higher upfront cost efficiently.

New financing avenues

- Capital markets need to be deepened to help provide long-term debt financing given the capital-intensive nature and high gestation periods of hydropower projects. Initiatives such as the setting up of the India Infrastructure Finance Company Limited (IIFCL) for infrastructure lending have been taken. The government of India also needs to encourage suitable innovative products (e.g. tax-exempt bonds focussed on the hydropower sector).
- Viability gap funding (VGF) can also be a viable proposal to make hydropower projects price competitive. For new projects, the government may consider floating tenders and allocating projects to developers with the lowest VGF proposal.
- Considering the importance of hydropower in the country's energy basket and its capital-intensive nature, hydropower projects need specialised and dedicated funds to secure their long-term financing. The Government of India may create a special hydropower development fund or can use the clean energy fund to provide loans to hydro projects at a lower rate of interest.
- Hydropower developers can also opt for multilateral funding and financing from green funds provided there is a viable business case and an appropriate risk mitigation plan.

The 345-MW San Roque Multipurpose Project in the Philippines was to be financed by public funds. However, it was eventually developed through the public private partnership (PPP) route with the 'split ownership model'. The dam was built at a cost of 610 million USD and was financed by the Government of Philippines using a bilateral soft loan and domestic funds. On the other side, the power complex costing 580 million USD was financed on a 75:25 debt-equity ratio, with 52% of the total cost derived from export credits and the rest of the debt as loans from the Japanese government and commercial banks. The utility payment obligations were backed by sovereign guarantees. The construction was the responsibility of the private partner to mitigate conflicts during the development stage. This model allowed burden sharing between the private and public sectors, and also allowed the Government of Philippines to operate the dam according to its irrigation requirements.

The Indian Renewable Energy Development Agency (IREDA), National Clean Energy Fund (NCEF) launched a refinancing scheme by providing loans at 2% for the revival of operational small hydro projects (SHP) and biomass projects which have been affected by low tariff, low PLF levels or force majeure conditions.

Market instruments

- With its strong regulatory oversight, CERC should facilitate market-based instruments like hydropower purchase obligations (HPOs), which have an underlying principle of mandatory purchase of hydropower by distribution utilities. Such HPOs provide assurance to developers by guaranteeing the purchase of electricity and make projects much more financially viable.
- Tariff comparison needs to be done on the basis of the quality of the energy supplied, reflected by the position hydropower occupies in the load duration curve. CERC needs to come up with a differentiated peak and off-peak tariff to incentivise hydropower, given its potential to meet peak demand.
- Hydropower plants are generally better placed to provide ancillary services to the grid and offer better system reliability. The implementation of the ancillary service market must be guided by an efficient commercial mechanism based on an enabling regulatory framework to encourage the generation of plants for maintaining grid reliability. It will also help hydropower plants to monetise their capabilities to provide reactive power compensation, voltage stabilisation, etc., given a plant's ability to ramp-up and ramp-down in a very short time.

Ancillary services: Emerging regulation in India (CERC Regulations, May '15)

Objectives	• Maintain grid frequency within limits by balancing generation and load • Reduce dependence on deviation settlement mechanism (DSM)/unscheduled interchange (UI) mechanism
Eligible participants	• All generators that are regional entities and whose tariff is determined/adopted by CERC for their full capacity
Agencies involved	• Interstate generating stations (service providers) • National Load Dispatch Centre (scheduling and dispatch) • Regional Power Committee (energy accounting)
Services provided	• Regulation up service (ramping-up generation) • Regulation down service (backing down generation)
Tariff structure	• Fixed cost (refunded to original beneficiaries) • Variable cost • Markup on fixed cost (commitment charge) as decided by CERC

Ancillary service offerings from storage hydropower

Quick start

- Quick-start capability, taking just a few minutes—compared to 30 minutes for other turbines, and hours for steam generation
- Savings in start-up and shutdown costs of thermal plants and steadier operations

Black start

- Capability to run at a zero load—when loads increase, additional power can be loaded rapidly into the system to meet the demand
- Systems with available hydroelectric generation are able to restore service more rapidly than those solely dependent on thermal generation

Regulation and frequency response

- Contributes to maintaining the frequency within the given margins by continuous modulation of active power and meeting moment-to-moment fluctuations in the system's power requirements

Voltage support

- Ability to control reactive power, thereby ensuring that power will flow from generation to load

Spinning reserve

- Provide spinning reserve—additional power supply that can be made available to the transmission system within a few seconds in case of blackout
- Support in maintaining stability in case of unexpected load changes in the grid

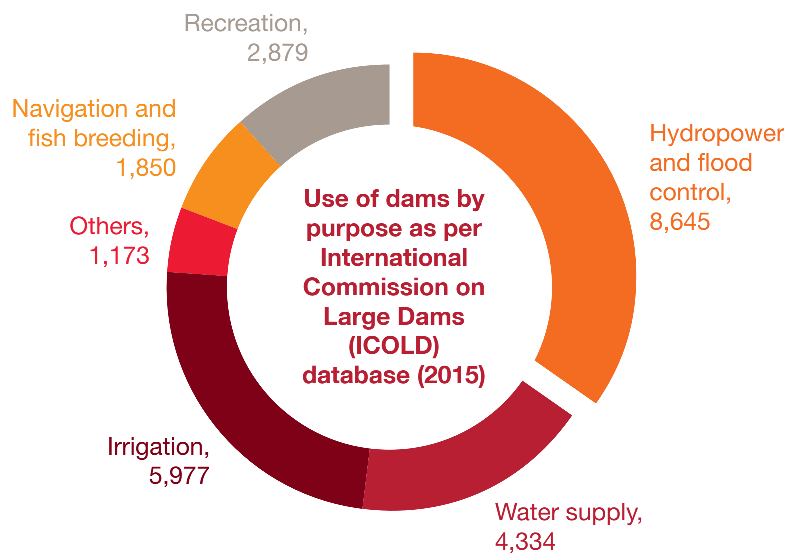
Benefit sharing framework

The benefits of a hydropower development project come at the cost of negative impacts on natural resource developments. Hence, benefit-sharing mechanisms and mitigation measures play a key role in addressing the social and environmental risks associated with hydropower development. An appropriate benefit sharing mechanism leads to social stability and helps a country's national strategy to meet various local needs.

- Social and environmental impact assessments need to be given due importance instead of treating them as mere legal formalities. Involvement of project affected persons (PAPs) and joint consultation processes between the developer, government and PAPs need to be carried out to eradicate differences and get legal and social consent. Such involvement and joint consultation processes are necessary to address immediate problems and legitimise decisions.
- As a part of economic and social development of the area, developers need to be mandated to open technical training centres, clinics and health centres, schools, etc., in the project affected area. This will help developers gain public acceptance and get skilled labour, while local residents get employment opportunities.
- A structured mechanism needs to be developed for balancing benefits from hydropower projects and transferring economic rents from projects to the government, which should ultimately be passed on to affected stakeholders.

Benefits of hydroelectric dams

Hydropower dams often help regulate river flows and operate by storing volumes of floodwater and controlling the timing of discharge. However, there is a need to set storage rule curves to balance the drawdown levels prior to the flood season, prevent or minimise spill and maintain maximum hydraulic head for hydro generation for more effective use of dams for flood control. Other uses of hydropower dams, which provides social and environmental benefits, are indicated below:



Technical capacity augmentation

As mentioned earlier, geological issues are the biggest problem area here and have delayed the timely completion of hydropower projects in recent years. Technological capacity augmentation thus emerges as a priority area which requires urgent intervention. As hydropower projects are more likely to be developed in difficult terrains, it is imperative to build capacity for the developers and contractors involved in this sector, in terms of knowledge, technology and up-to-date techniques for successful and timely implementation.

- As most of the hydro projects in the country are constructed in the Himalayan region, which is still developing geologically, incidents of geological surprises are common, thus affecting the project cost and timeline. Therefore, hydropower developers are required to opt for modern machinery and techniques to enhance their capability to deal with contingencies. Hand-holding by developers from other territories with successful experience of similar projects may prove beneficial in this regard. However, developing the knowledge and experience of working in this region is crucial as, unlike most areas, usage of a higher level of technology alone cannot be considered beneficial in Himalayan terrain, which possesses young fold mountains and a weak rock structure.

Flexibility, technical knowledge and expertise proved crucial in the successful implementation of the 53-MW Mtkvari hydropower project in Georgia. Initially, the developers decided to adopt the conventional method and a 400-m tunnel was excavated. However, the low efficiency of the method prompted the decision makers to engage a 6-m diameter tunnel boring machine (TBM), which can excavate at a rate of 400 m/month.

- The central government agencies should be notified about probable project sites well in advance and adequate geological data, including seismic mapping and hydrological data, should be collected by these agencies prior to handing over the project to the developer. The developers can thus be better prepared as data collection not only involves a cost but also significant time, thereby resulting in delays at the project preparation stage.
- The hydropower plant operators also require technical capacity upgradation, especially for older plants. Most of the plants with more than 30 years of operational life work on a lower automation level which hampers plant productivity. Thus, renovation and modernisation of older hydel plants is of critical importance to ensure that they operate at optimum levels and with better capacity utilisation.

The Nseke Hydroelectric Power Plant, the Democratic Republic of the Congo, was commissioned in the 1950s and has been operating at reduced capacities. The utility decided to rehabilitate four 65-MW Francis turbines with challenges associated with its control system. A new control system, a supervisory control and data acquisition (SCADA) product with a modern automation level, replaced the old system based on the electromechanical relays logic with control panels, thus improving plant control and performance monitoring with more real-time decision-making enablers.

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