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Hydropower in India
Key enablers for a better tomorrow

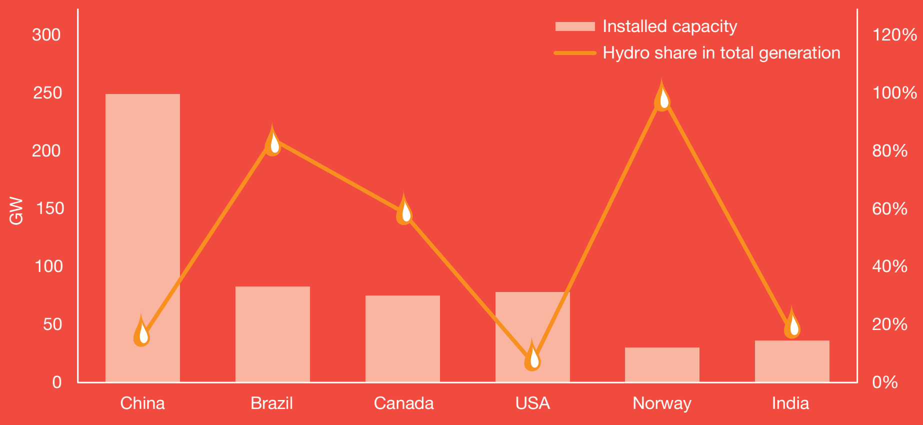
Introduction

Propelled by sustained economic growth and rise in income levels, India is poised to face significant increase in energy demand in the next few decades which also translates into higher demand for electricity. The gap in the electricity demand-supply situation is highlighted by the fact that the country experienced a peak deficit of 5.2% and energy deficit of 4.2% in FY 13-14[1], with the surplus western and eastern regions unable to compensate for the severely deficit northern, southern and north-eastern regions.

Considering an energy elasticity of 0.8[2], India is projected to require around 7% annual growth in electricity supply to sustain a GDP growth of around 8.5% p.a. over the next few years. This requires tapping all potential sources to address the deficit and meet the demand growth for accelerating economic development while taking into account considerations of long-term sustainability, environmental and social aspects.

Climate change and other negative effects of using fossil fuels for power generation along with growing concerns over energy security are driving the expansion of hydropower around the world. Though reservoir based hydropower projects have come under criticism due to CO_2 and methane emissions beyond acceptable limits, most hydro-rich countries have followed an integrated full life-cycle approach for the assessment of the benefits and impacts to ensure sustainability.

Installed hydropower generation capacity and share in total generation

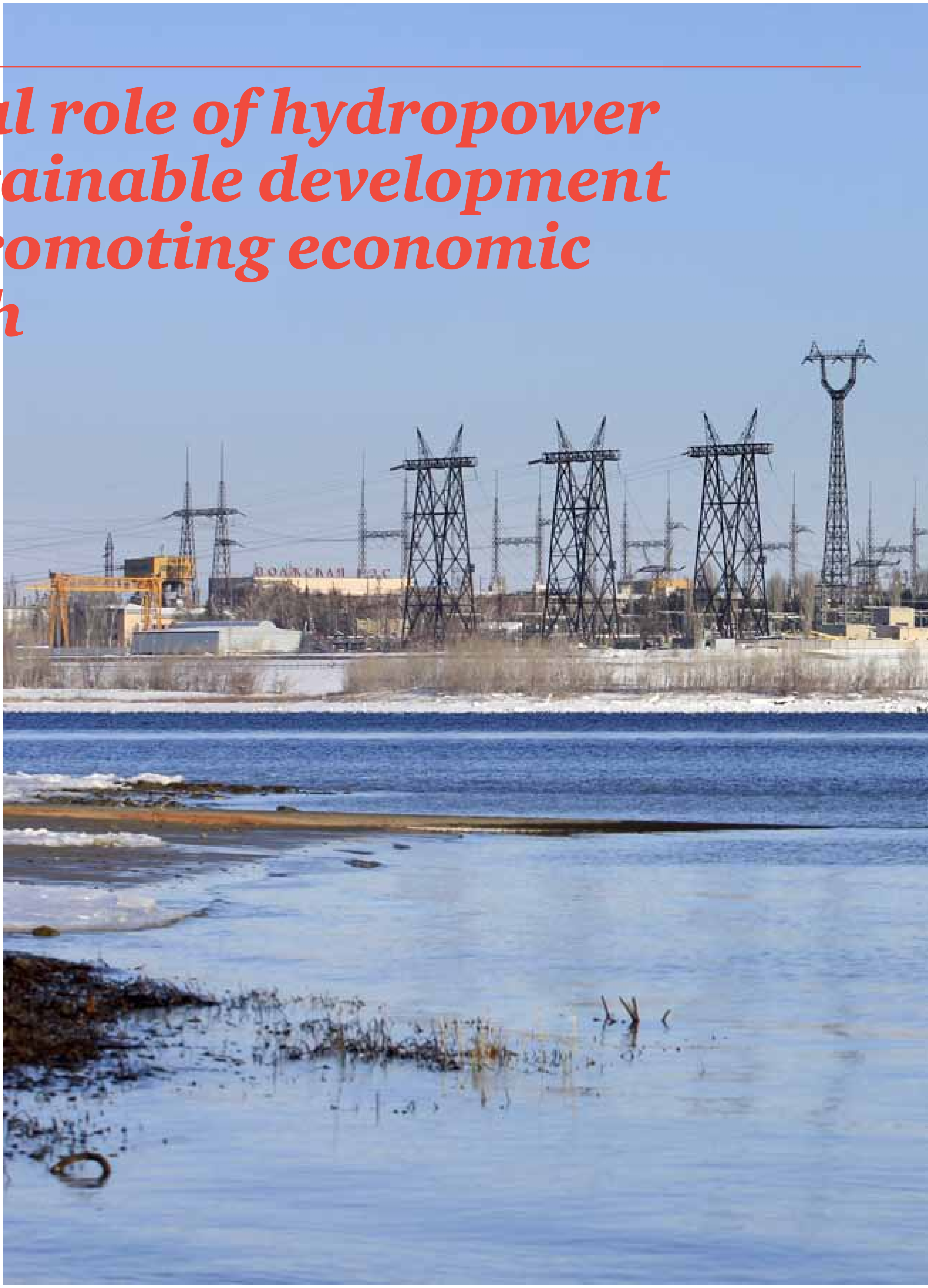


(Source: World Energy Council, CEA)

India is endowed with rich hydropower potential to the tune of 148 GW (which would be able to meet a demand of 84 GW at 60% load factor) which makes it one of the most important potential sources to meet the energy security needs of the country.

1 *CEA, Load Generation Balance Report, 2014-15*
2 *Planning Commission, government of India*

Critical role of hydropower in sustainable development and promoting economic growth

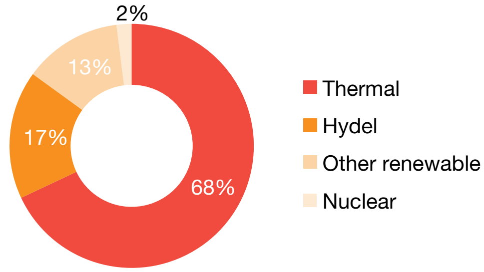


The current development profile and trends in generation capacity addition in India have resulted in the following aspects:

- ***Skewed development pattern between different generation technologies:*** The current portfolio of installed capacity of 233 GW is dominated by thermal power with around 68% share. Hydro, with an installed capacity of 36 GW, has a share of around 17% coming down from around 46% in 1966. Adequate diversity in generation asset base has not been maintained with growth in hydro assets not being concomitant with growth in the thermal asset base. This also impacts the long-term least cost development pattern with overt reliance on 25-year thermal plants vis-à-vis more than 40-year hydro assets.
- ***Inadequate peaking and quick response capability:*** While regional grids have been integrated and frequency regimes have been streamlined due to Availability Based Tariff (ABT) regime, the country faces lack of assets capable of meeting peaking deficits and with quick response characteristics. Peak shaver hydro assets will prove beneficial in meeting the current and projected energy and peak shortage in the Indian power market.
- ***Sustainable low carbon development:*** While India is considering a low carbon strategy and actively considering focusing on Energy Efficient Renovation & Modernization (EE R&M) to sweat existing assets, the low carbon strategy can be fostered further with a higher thrust on green capacity additions via hydropower development.

These factors necessitate renewed emphasis on 'responsible hydropower development' to promote economic growth. Hydro's critical role in sustainable development and energy security for the country is based on the elements of sustainability, availability and affordability.

India's generation mix

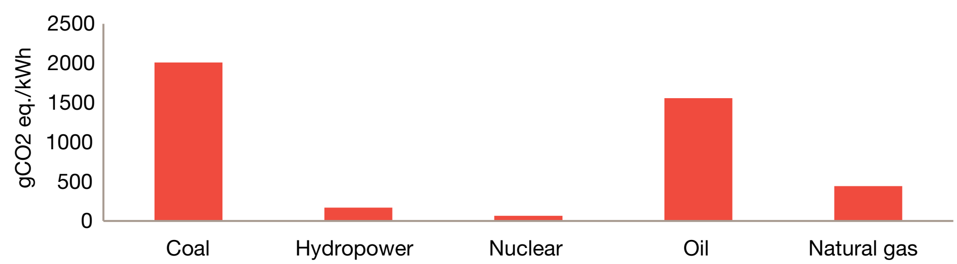


Estimated levelised cost of electricity (LCOE) for plants to be commissioned in 2019

Plant type	Total system LCOE (USD/ MWh)
Conventional coal fired	95.6
Conventional combine cycle gas fired	66.3
Integrated coal-gasification combined cycle (IGCC)	115.9
Nuclear	96.1
Wind	80.3
Wind - Offshore	204.1
Solar - PV	130
Solar thermal	243.1
Hydropower	84.5

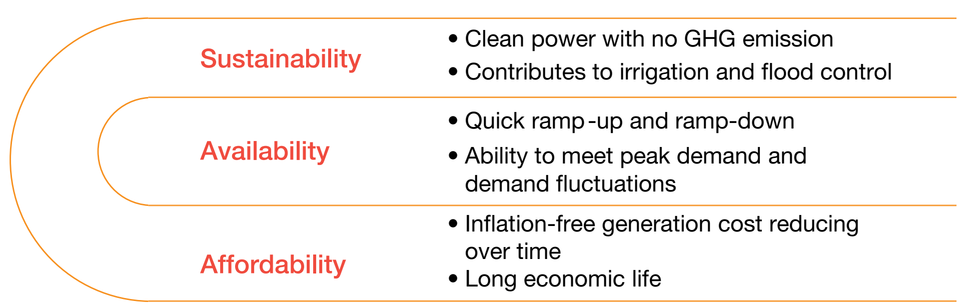
Source: US Energy Information Administration

gCO2 equivalent emission

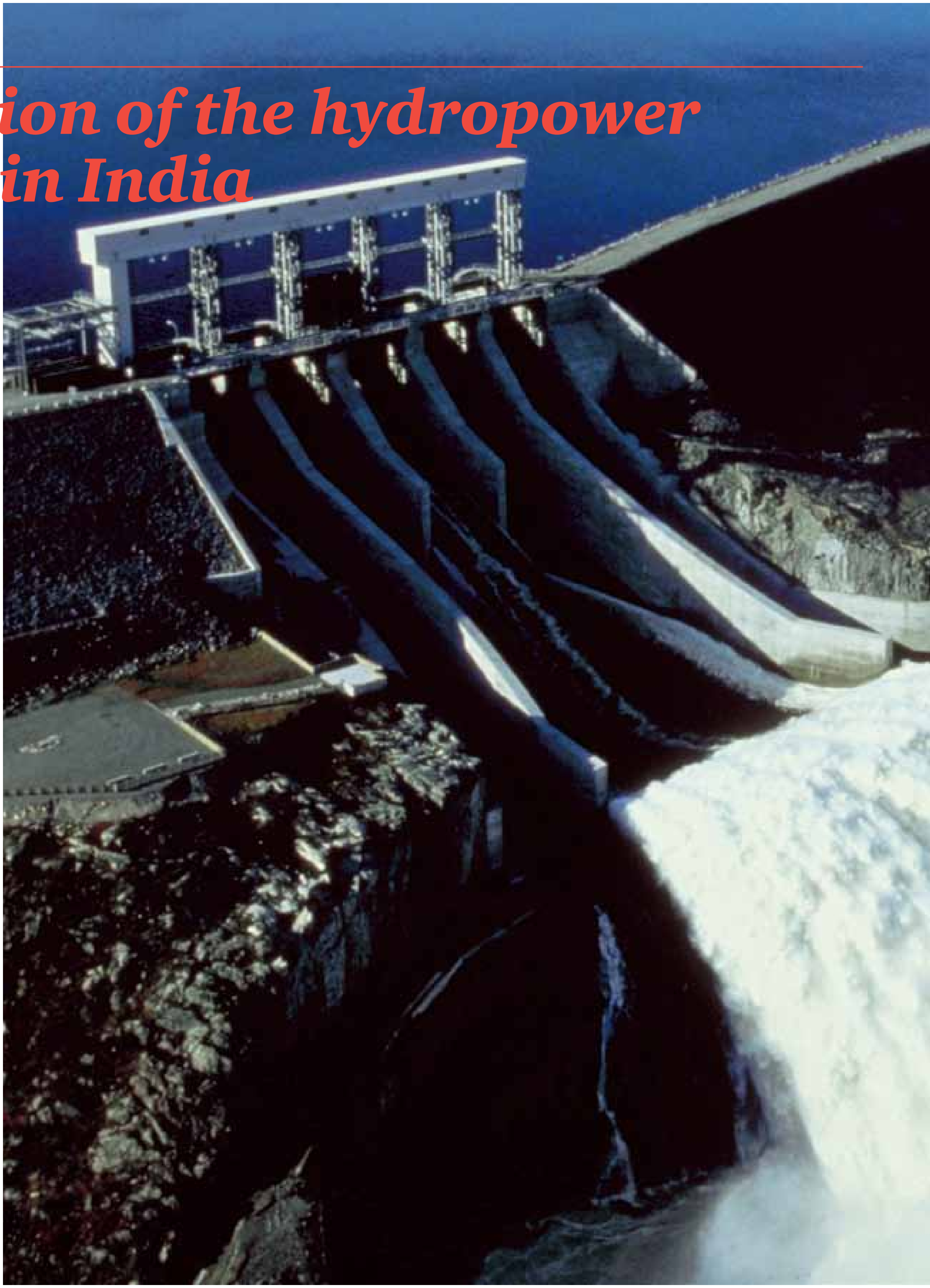


Source: IJSTR, Vol 2, Issue 12, Dec'13

Critical role of hydropower



Evolution of the hydropower sector in India



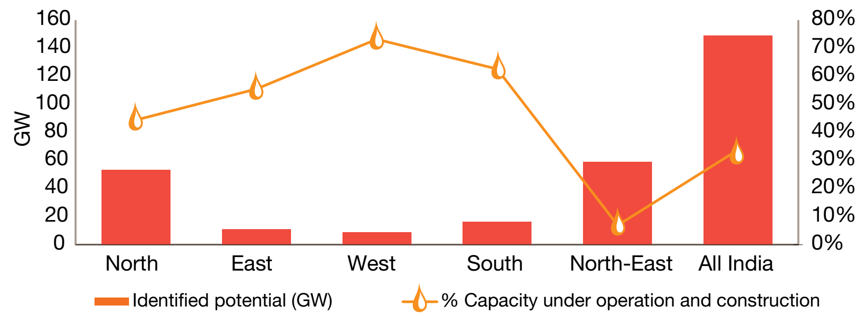
Untapped potential

India is endowed with significant hydroelectric potential and ranks fifth in the world in terms of usable potential. As per the latest available data, India has around 36 GW of installed hydropower capacity whereas an additional 13 GW is under construction. This puts the total capacity which is yet to be tapped at around 67% of the potential. Countries such as Canada and Brazil had harnessed around 69 and 48% of the economically feasible potential back in 2009.

From a regional perspective, over 93% of the total potential in the north eastern region is yet to be tapped, primarily in parts of the Brahmaputra river basin. The scenario is in sharp contrast to the southern and the western regions where more than 65% of the potential has already been harnessed.

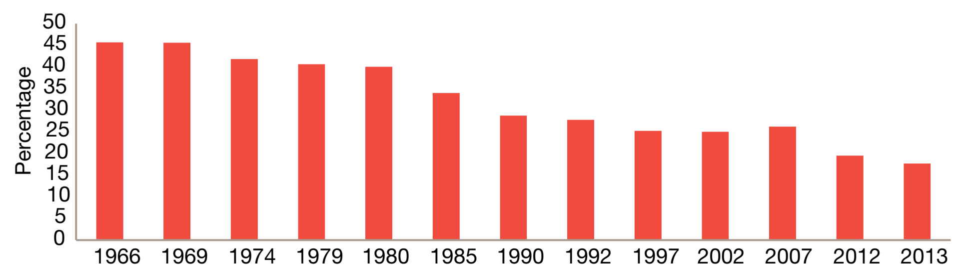
The government of India has, over the years, taken a number of initiatives to prioritise hydropower development and to attract investments in the sector. Key measures include the preparation of a shelf of well investigated projects, which could substantially reduce risk perceptions, streamlining clearance procedures, the provisions of open access and trading as per the Electricity Act 2003, etc. However, issues in implementation of such policy initiatives and regulations still plague the sector resulting in the declining share of hydropower in India's energy mix since 1966.

Status of hydropower potential development in India



(Source: CEA)

Hydro as a percentage of total installed capacity



(Source: CEA)

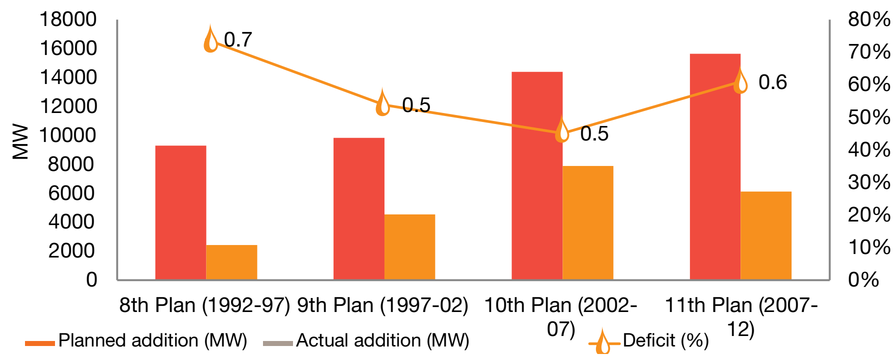
Electricity Act, 2003	National Electricity Policy, 2005	National Tariff Policy, 2006	National R&R Policy, 2007	Mega Power Projects Policy, 2008	Hydro Power Policy, 2008	Land Acquisition Act, 2014
Changed the industry structure and laid the foundation for open access, which suits hydropower projects that are naturally best suited to meet peak power requirements in the country.	Emphasised on full development of feasible hydropower potential. Issues of long-term financing, centre and state participation, etc. were addressed.	Differential rates for peak and non-peak power and uniform guidelines for SERC. Aimed to bring greater transparency in the power sector.	Emphasises a need for a more transparent and participative rehabilitation and resettlement process in improvement in the quality of life of PAPs.	Hydropower projects with capacity over 500 MW are given mega power project status. Such projects get several benefits including a 10-year tax holiday, no customs duty on import of equipment, etc.	Emphasised the development of hydropower capacity and increasing private sector participation.	Replaced archaic act of 1894. Greater clarity in acquisition and R&R policies.

Recent trends

The government of India has increased financial allocation, along with other non-financial support, to prioritise hydropower development and increase capacity addition. Accordingly, in the 11th Five Year Plan, the target for hydropower capacity addition was placed at 16.5 GW, which was almost half of the total installed capacity then. However, the achievement, at around 5400 MW, was well short of the target. The same trend of achievement falling short of target by far can be observed in the previous plan periods too.

Various factors such as environmental concerns, R&R issues, land acquisition problems, long clearance and approval procedures, capability of developers, etc. have contributed to the slow pace of hydropower development in the past. These issues have been compounded as hydropower development has largely remained under the ambit of state governments (water being a state-specific subject) with varying policies (e.g. upfront premium, royalty power, land acquisition policy, etc.) adopted by the states.

Target vs achieved capacity addition (Source: CEA)



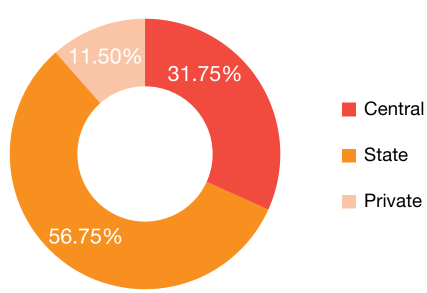
(Source: CEA)

Major slippage reasons for 10th Plan projects

Major reasons for slippage	Hydro capacity slipped (MW)
Geological surprises	510
Natural calamity	450
Delay in award of works	823
Delay in MoEF clearance	400
Delay in clearance/investment decision/funds tie-up constraints/delay in financial closure	1400
Delay in preparation of DPR and sign of MoU between HP & SJVNL	400
CR & R issues	400
Court cases	675
Total	**5058***

** This does not include 3009 MW dropped from 10th Plan*
Source: Working Committee on Power for 11th Plan

Percentage contribution in hydro capacity addition from 1992-2012

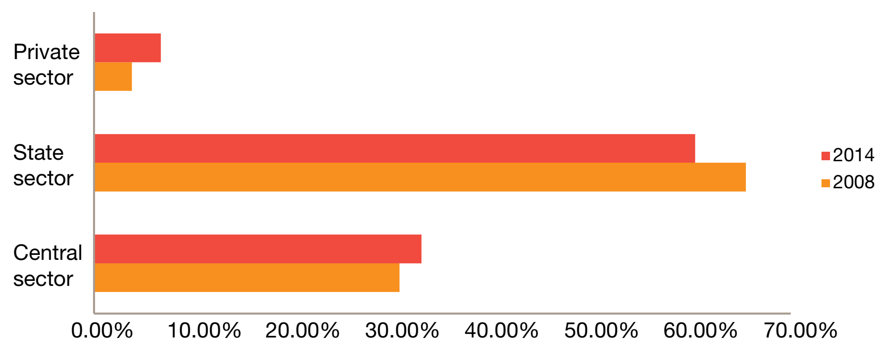


(Source: CEA)

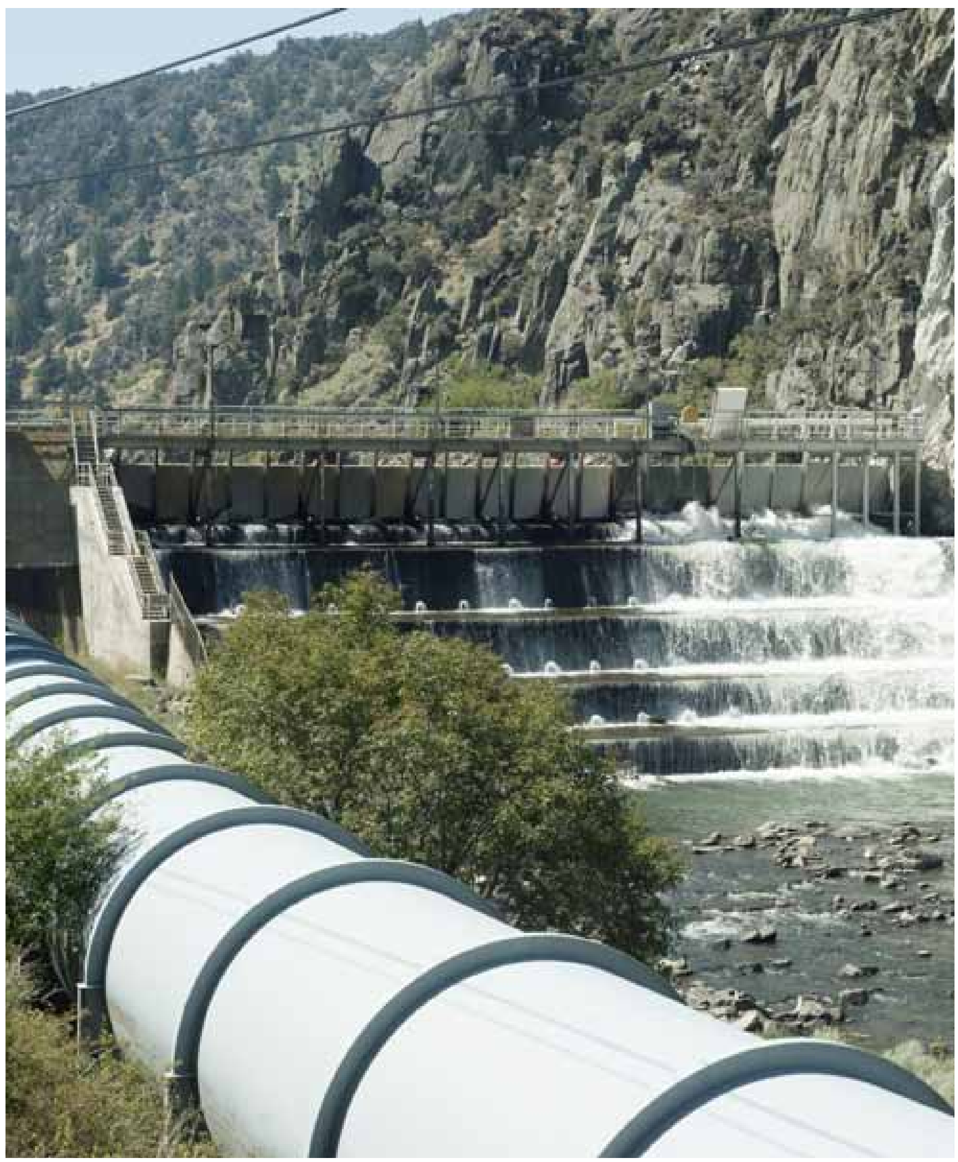
To accelerate growth in the hydropower sector and to bridge the gap between the actual and planned capacity addition, the private sector is being seen as an important stakeholder. The hydropower sector was opened up for private sector participation in 1991. Subsequently over the years, to facilitate projects through PPP/ JV mode, some states have nominated a state nodal agency with an option of equity investment by the state government. However, from 1991 to 2012, the private sector has contributed to about 11.5% of the hydropower capacity addition. So far only about 2700 MW has been commissioned through the private route, which constitutes less than 7% of the total installed hydropower capacity.

Though private participation in the hydropower sector has gained momentum in the recent past, it still faces impediments in the execution of projects across various stages of the project implementation cycle. The central and state governments need to create an enabling investment climate for increasing private participation by addressing issues related to safeguards, land acquisition, evacuation, law and order problems, technical challenges and non-appreciation of the risks involved in project development.

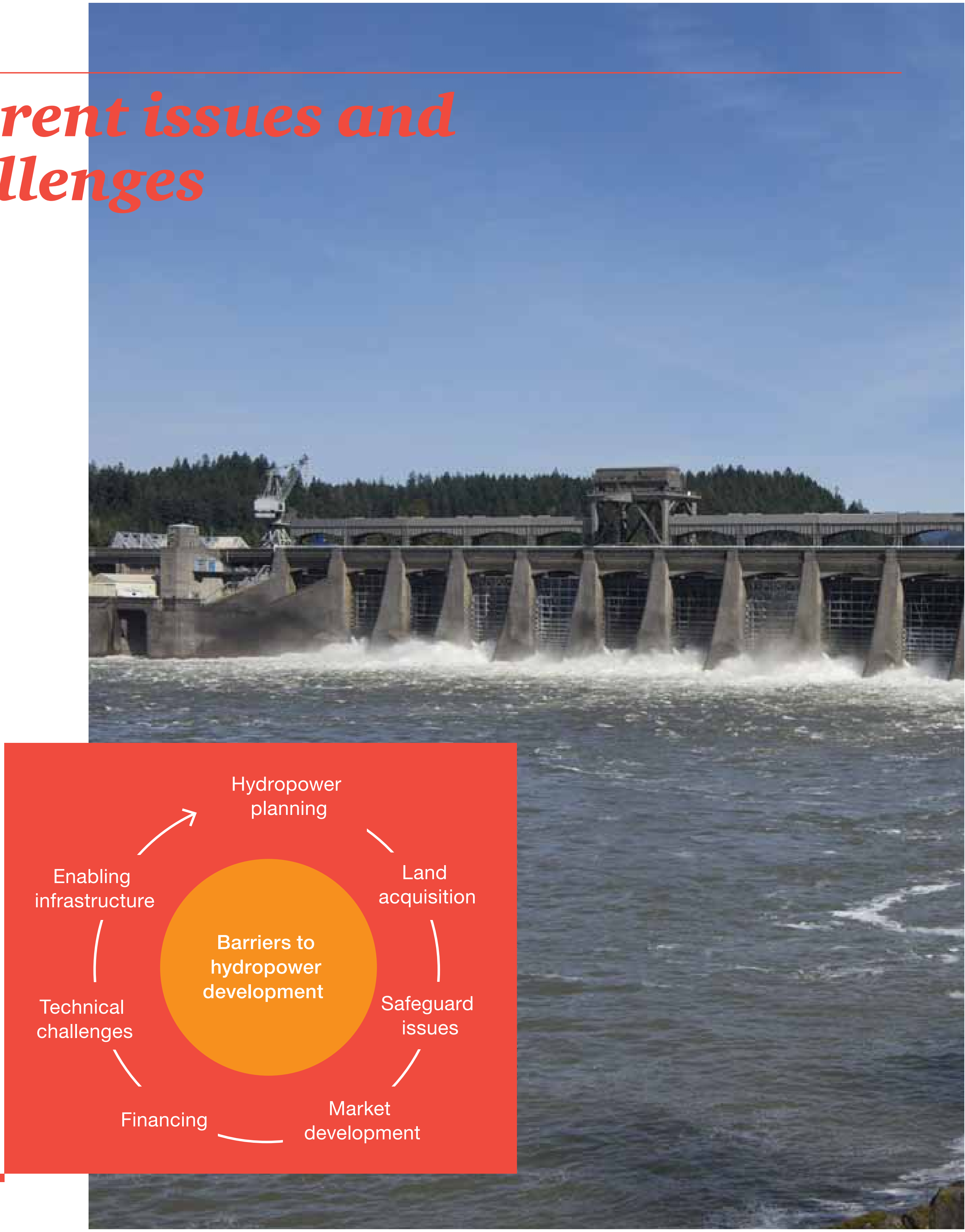
Share of central, state and private sector in hydropower capacity in 2008 and 2014



(Source: CEA)



Current issues and challenges



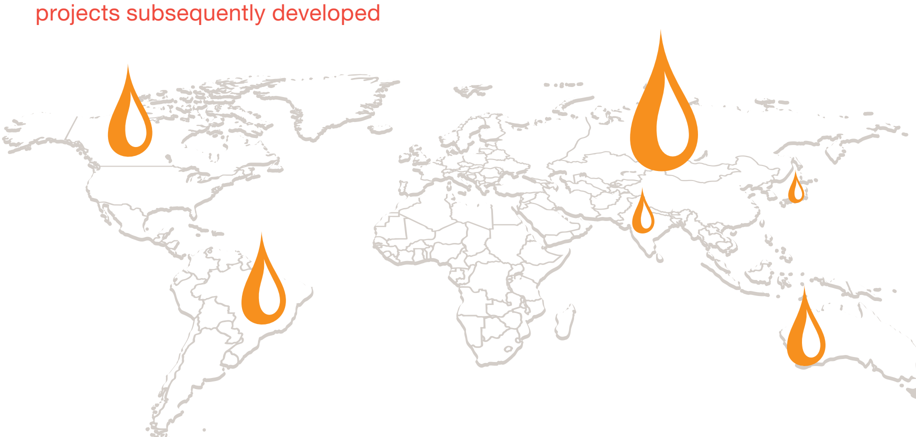
Hydropower planning

Planning for hydropower development in India has generally been oriented toward individual projects. However, this approach has several limitations for sustainable development of an entire river basin.

Inter-state disputes are another aspect which 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 inter-state 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 division and utilisation patterns of the Brahmaputra are also emerging.

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 development of multiple projects in a basin is considered

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

Land acquisition

Land availability and acquisition are among the core structural issues that impact almost all infrastructure sectors. Problems arising in the acquisition of land for hydropower projects are causing suspension and delay in construction activities.

Till recently, under the 120-year-old prevailing Act, land acquisition for public purpose had been beset by several issues surrounding processes, procedures and compensation, as the term 'public purpose' was never clearly defined. The new law, which came into effect from January 2014, attempts to address the social inequities in the existing framework of land acquisition. However, there are still serious issues which need to be addressed to remove constraints in infrastructure development. The government had already identified the following issues and is working towards finding an optimum solution between addressing the land-loser's concerns and the developer's perspectives:

- Consent of 50% landowners in PPP projects even if the ownership vests with the government
- Compensation amount for acquisition in rural areas and urban regions
- The Social Impact Assessment (SIA) processes which, instead of addressing issues related to responsible development and benefit sharing, cause delays
- Legal definitions which increase complexity and cost for developers without adequately benefitting the affected population

Safeguard issues

Construction and operation of hydropower dams can significantly affect natural river systems as well as fish and wildlife populations. Furthermore, hydropower projects involve submergence causing the displacement of project area people. The rehabilitation of project affected people is also a major issue which is more pronounced in the case of storage-based hydropower projects, as was evident during the development of the Tehri dam. The project met with mass protests and public outcry on the issue of safety, environment and rehabilitation, resulting in unusual delays (e.g. the Tehri dam was commissioned more than 25 years after R&R was started).

Hydropower projects often require forest areas for their implementation and compensatory afforestation on non-forest lands. Progress of many projects has been affected on account of delay and non-clearance on environment and forest aspects.

These factors have resulted in negative public perception about hydropower projects resulting in sustained opposition to project construction in many cases often resulting in time and cost over-runs.

Rehabilitation of Project Affected People (PAP)

Deforestation

Protection of flora, fauna, forests, and wildlife

Disaster potential in the event of earthquakes, reservoir induced seismicity, surplusing of reservoirs, etc.

Market development

The power market development in India is still at a nascent stage. Though section 63 of the Electricity Act makes competitive bidding mandatory for all power procurement, hydropower projects are exempted under a sunset clause which expires by end 2015 (as per the June 2011 amendment to the Tariff Policy 2006). The deferment for hydro power is based on the recommendation of a Power Ministry taskforce, which cited high risks and uncertainties inherent to these projects as among the reasons why it is difficult for hydro projects to compete with thermal generation on long-term basis.

Furthermore, the current market structure does not allow hydropower developers to realise the potential benefit of meeting peak demand as the tariffs for both peak load and off-peak load are undifferentiated.

Though the Enquiry Committee constituted after the two major grid failures in the country on 30 and 31 July 2012 opined that “a review of UI mechanism should be carried out in view of its impact on recent grid disturbances. Frequency control through UI may be phased out in a timebound manner and generation reserves and ancillary services may be used for frequency control”, an appropriate regulatory mechanism for implementation is yet to be set in place.

Financing

Hydropower projects are capital-intensive and financing them, by finding an optimum balance between bankability and affordability, is often a challenge. Although the operating cost of hydro projects are minimal and the project life longer than thermal, there are multiple other factors that make hydropower difficult to finance.

High capital costs

- Capital cost of hydro projects ranges between 60 mn to 80 mn INR/ MW compared to 30 mn to 50 mn INR/ MW for thermal plants.
- Hydro projects require higher upfront costs to address greater complexities in design, engineering, environmental and social impact mitigation, etc.

Long construction period

- Most hydroprojects takes at least five to six years to construct which increases the interest during construction.
- Delay in cash inflows increase uncertainty and risks, resulting in higher risk premium on financing charges.

Additionally, hydropower development needs long tenure debt (20 years or more) availability which is limited in Indian capital markets. The constrained financial situation of the distribution sector which is the end user of the power generated also often poses counterparty risks for developers and lenders. Furthermore, the technical challenges in hydropower development often results in time and cost overrun, posing additional risks for financiers.

Hydropower plays an important role in all mature power markets. For example, hydro is the cheapest power source in the Nordic market. A low level in hydro reservoirs will mean producers use more expensive sources which will result in higher production costs. In the same manner, production costs will fall with more water in the reservoirs. Hence, Nordic power prices are highly dependent on both rainfall levels and access to nuclear power and the price of other sources, establishing the critical role of hydropower in power markets.

(Source: http://www.nordpoolspot.com)

Technical challenges

Techno economic viability of hydropower projects depends on the geology, topography, hydrology and accessibility of the project site. Even if extensive investigations using state-of-the-art investigation and construction techniques are adopted, an element of uncertainty remains in the sub-surface geology. Geological surprises during actual construction cannot be ruled out. This unpredictable geology is more pronounced in the young fold Himalayas where most of the Indian hydropower potential resides. Such technical challenges add to construction risks.

During the 11th Plan capacity addition, multiple projects such as Tapovan Vishnugad (520 MW) in Uttarakhand, and Parbati St. II (800 MW) and Rampur (412 MW) in Himachal Pradesh have been delayed due to adverse technical challenges.

Enabling infrastructure

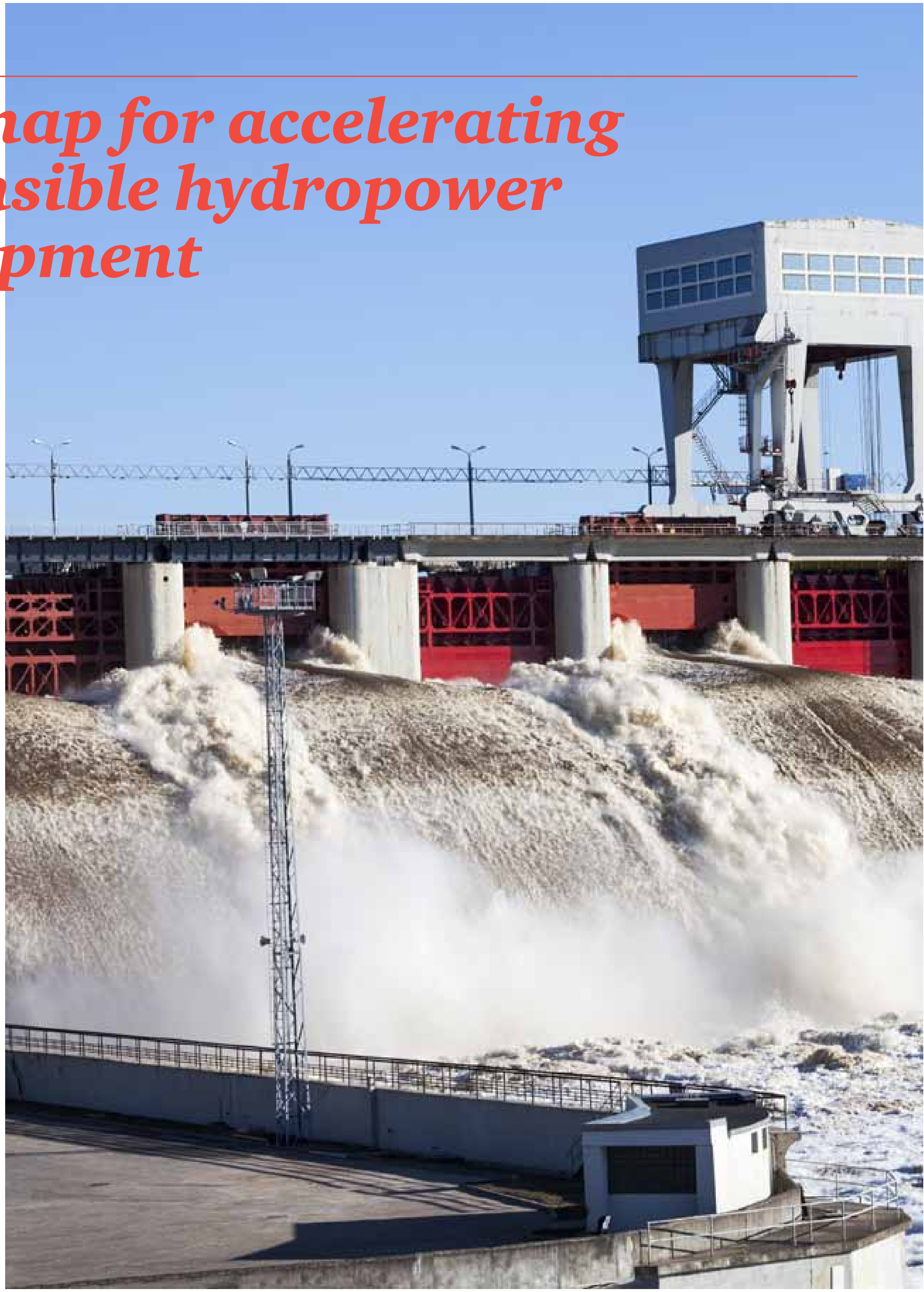
A number of hydropower projects are located in remote sites in states which do not have adequate demand for electricity. This creates the requirement for developing enabling infrastructure for power evacuation. The 'chicken neck' presents geographical constraints in developing requisite transmission infrastructure for hydropower evacuation from the north east.

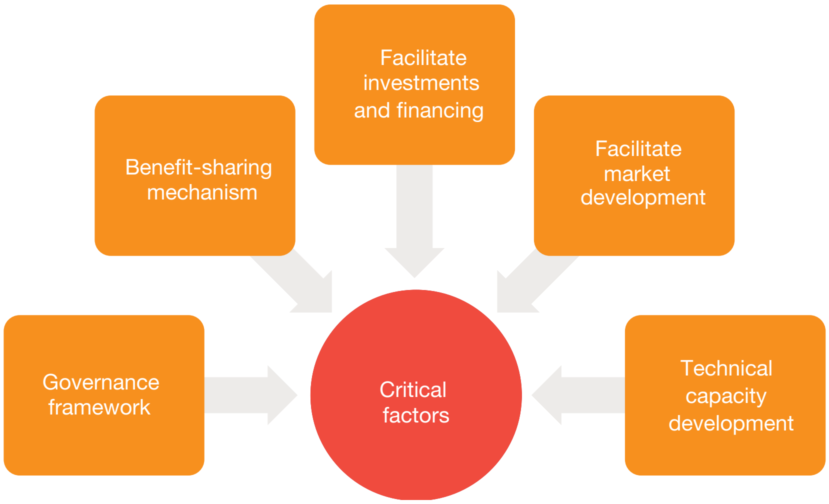
There are certain other challenges for the coordinated development of the transmission network, e.g. identifying beneficiaries well in advance, developing excess evacuation capacity keeping in mind the future development of projects (especially where there are Right of Way (RoW) issues). Furthermore, the Plant Load Factor (PLF) for hydropower projects is typically less than 50%, as a result of which significant transmission capacity is under-utilised. All these result in higher transmission costs.

Hydropower projects also require the development of associated infrastructure such as roads and bridges in the area. Inclusion of the cost of development of such associated infrastructure increases the cost of power generated affecting project viability and sustainability. Lack of infrastructure such as schools, hospitals and difficult access to sites often become blocks to moving skilled manpower to difficult project sites.

The associated transmission system for evacuation of Kameng (600 MW) power is estimated at Rs 11,000 million, about 50% of the cost of the generation project.

Roadmap for accelerating responsible hydropower development





Governance framework

Strengthening of governance in the natural resource sector is a key determinant for sustainable and inclusive growth. Thus, a nation needs to have an overarching policy framework, specific sector strategies, and clear and transparent processes for accelerating hydropower development. Standardised processes and efficient inter agency governmental coordination reduces unpredictability to create a better climate for potential investors.

Action plan

Key enablers	Action plan
Efficient coordination for implementation of policy goals and targets	Ministries, departments and state governments need to work together collaboratively and efficiently, in a coordinated manner, to achieve policy goals and capacity addition targets. Alignment of processes, structures and institutional framework is necessary to achieve this. For example, the National Solar Mission with a clearly articulated goal of 20 GW by 2020 helped get commitment from all stakeholders and ensured efficient inter departmental coordination for achievement of the well laid down goal.
Planning for integrated river basin development	• The government of India needs to ensure that inter-state agreements for water sharing must be in place to avoid disputes. A National River Authority of India may be constituted to improve river management, address inter-state disputes and for integrated river basin development. • A basin wide hydrological simulation model needs to be developed under the guidance of Central Electricity Authority (CEA)/Central Water Commission (CWC) to understand the effects of one project on another in a cascade. This will reduce project risks, encourage planning and operation on a broader scale, and allow planners and developers to understand how changes to one project might affect others in the system. • An appropriate planning forum needs to be constituted to bring all stakeholders (developers, state governments, etc.) together to discuss infrastructure needs and reach a consensus on how to proceed. Greater coordination in developing infrastructure such as access roads, transmission lines, etc. can help lower overall costs by allowing developers to pool costs. It will also reduce environmental impact. Using mathematical modelling, a case study shows that optimising the operation of two adjacent projects on the Alaknanda as a cascade (rather than the planned individual operation) will be likely to increase annual energy output by 230 gWh, currently valued at around 15 million USD.
Project allocation procedures	• Allocation of hydro sites to developers needs to be done in a fair and transparent manner, keeping in mind the optimal development of the river basin. Specifically, the state government needs to ensure project allocation on inter-state rivers in line with the CEA's/CWC's optimal development plan of the river basin. • A comprehensive cost-benefit analysis between different project allocation models (e.g. MoU vs competitive bidding) needs to be carried out on a case-to-case basis based on project specific issues. Further, the project allocation model needs to give due weightage to the financial capacity, technical capacity as well as credibility of developers.

Key enablers	Action plan
Institutional framework	The current institutional framework and organisation of concerned institutions for hydropower development at the state level needs to be reviewed. The objective will be to ensure that the government plays a key role in planning, procuring and regulating the assets created. Also, whenever necessary, based on project-specific circumstances, the government needs to fully or partially own the asset and play a role in project development. Private players, however, should also be provided requisite freedom to develop, finance, build and operate the assets.

Benefit-sharing framework

Mitigation of social and environmental risks also plays a critical role in the development of hydropower projects. Since the benefits and negative effects of natural resource development are often unevenly distributed, benefit-sharing mechanisms and mitigation measures are crucial for sustainability and stability in development. Benefit-sharing is a commitment by the government and the developer to share the monetary and non-monetary returns with stakeholders. An appropriate benefit-sharing mechanism ensures social stability and also aligns a country's national strategy with the local needs.

Action plan

Key enablers	Action plan
Focus on responsible development	Social and environmental impact assessments need to be given due importance, instead of treating them as mere legal formalities. The process needs to be participatory and transparent. The overarching principle for socially and environmentally responsible hydropower development needs to be that the project affected population be the first beneficiary of the project.
Public private people participation	• Involvement of project affected persons (PAPs), and joint consultation processes between developer, government and PAPs need to be carried out to smoothen out differences and get legal and social consent. Such involvement and joint consultation processes are necessary to address immediate problems and legitimise decisions. • Project developers need to be mandated to open technical training centres in the neighbourhood of the project. This will help developers gain public acceptance and get skilled labour while local residents get employment opportunities. Similarly, developers can open clinics and health centres, schools, etc. for local residents with minor impact on project cost.

Key enablers	Action plan
Benefit-sharing with PAPs	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. The mechanism should find an optimal balance, to the consensus and benefit of all stakeholder, between modalities: • Revenue sharing • Local development funds • Ownership structure • Taxation levels • Preferential electricity rates, etc.

Facilitating investments and financing

In order to attract investments for capital-intensive hydropower projects, it is necessary to address the concerns of developers, consumers as well as PAPs. To broaden investment avenues, the government needs to facilitate optimum risk allocation and often, on a case-specific basis, better upside to developers. Furthermore, the PPP framework needs to be designed considering key factors needed to develop commercial hydropower projects such as capital, capability and credibility.

Action plan

Key enablers	Action plan
Streamlining clearance processes	Appropriate institutional mechanisms need to be set up by each state with a clear mandate to speed up clearances and eliminate duplicity of clearances. Specific timelines to award all statutory and non-statutory clearances to a project at both central and state levels need to be fixed, along with accountability for delays. Specific timelines for the concessionaire to initiate, execute and commission the project must also be decided. State governments may set up ’investment boards’ to facilitate private investments across multiple infrastructure sectors including hydropower. These boards will be expected to address issues related to inter-departmental coordination and avoidable delays in according approvals and clearances.
Streamlining land acquisition process and modalities	Consultation between central and state governments needs to be taken up to bring in required changes in the new land acquisition law in order to enable speedier project implementation by addressing the issues and concerns of developers while ensuring that the rights and interests of the land-losers are protected.

<table>
<tr><th>Key enablers</th><th>Action plan</th></tr>
<tr><td>Evacuation infrastructure</td><td>

Dedicated transmission infrastructure may be created for evacuation of power from the north east. For example, Green Energy corridor for the evacuation of renewable energy projects from states such as Rajasthan and Tamil Nadu is being constructed.
Building pooling sub-stations in locations having large concentration of hydro resources is an efficient option which help developers reduce the project cost on account of last mile connectivity
For evacuation of energy from the plant bus-bar to the Central Transmission Utility (CTU)/ State Transmission Utility (STU) interface, multiple options can be evaluated, based on the specific circumstances of the project:

<table>
<tr><th>Options</th><th>Underlying risks/issues</th></tr>
<tr><td>Cost entirely borne by the developer but recovered through generation revenue</td><td>• Increase in project cost
• Regulatory risk for developers – approval on total investment, connectivity with CTU/STU network</td></tr>
<tr><td>Developer and concerned utility shares the cost in a specified ratio</td><td>• Increase in project cost
• Basis for arriving at an acceptable ratio
• Regulatory risk on account of approval on investment</td></tr>
<tr><td>Cost entirely borne by the utility but recovered / socialised through revenue</td><td>• Impact on the overall transmission tariff
• Regulatory risk on account of approval on investment</td></tr>
<tr><td>Financing through a ’hydropower development fund’</td><td>• Availability of funds, as part of the cost needs to be re-financed through interest-free loan or concessional debt support from such fund</td></tr>
</table>
</td></tr>
<tr><td>Other associated infrastructure</td><td>Other associated infrastructure needs to be developed to facilitate project implementation in a cost-effective manner. Since development of such associated infrastructure spurs economic activities, 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.</td></tr>
<tr><td>Fiscal incentives</td><td>Favourable tax treatment, especially at the early stage of projects, reduces project cost and helps projects secure cheaper financing. This is also important for projects that have predominant local supply, as cascading taxes only lead to higher tariffs. In addition, the government may offer tax credits (as in the US) or tax holiday (as in Laos) to facilitate investments. Thus the government of India needs to continue with tax holidays and the exemption of import tariffs for projects greater than 500 MW capacity.</td></tr>
<tr><td>Innovative financial products</td><td>

Capital markets need to be deepened to help provide long-term debt financing for the capital-intensive nature and high gestation periods of hydropower projects. Initiatives such as India Infrastructure Finance Company Ltd. (IIFCL) for infrastructure lending have been taken. The government of India needs to also encourage suitable innovative products. E.g. tax-exempt bonds focussed on the hydropower sector
Given the large-scale requirements of infrastructure and hydropower development, many more initiatives are required to channelise long tenure funding (from pension funds, banks, etc.) to these sectors. The government of India may create a special hydropower financing scheme (e.g. the Accelerated Generation and Supply Programme to state utilities) providing loans to power utilities at a subsidised rate of interest.
Multi-lateral institutions and green funds have, in recent times, shown some appetite to fund both public and private sector hydropower investments and can be a good source for investors if a sound business case and risk mitigation mechanism can be demonstrated.

</td></tr>
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Facilitate market development

Policies targetted at market development play a crucial role in channelising investments and private sector participation in hydropower development like any other sector. The private sector recognises the enormous potential of the hydropower sector in India. Yet, more substantive and enabling changes by the government in the policy and regulatory framework are needed to expedite the initiative.

Action plan

Key enablers	Action plan
Development models and ownership structures	A unified framework needs to be adopted with instruments standardising the fiscal and revenue-sharing policies for the selection of technically and financially qualified private developers with sound corporate governance practices. Minimisation or optimum allocation of risks and associated costs between all stakeholders involved is one of the critical success factors for all successful infrastructure projects across the world. Thus, the options for ownership structures need to take into account risk allocations and ensure that the risk burden does not get shifted heavily towards any of the major stakeholders involved, i.e. the government, the developer, the off-taker, or the project affected population.
Hydropower purchase obligations	The government needs to consider making it mandatory for power distribution utilities to purchase a fixed amount of hydropower. Such hydropower purchase obligations or HPOs provide assurance to developers by guaranteeing the purchase of electricity and make projects much more bankable. Such a move will, however, require amendments in the Electricity Act 2003 and subsequent changes in the National Tariff Policy.
Differential tariff structure	Tariff comparison needs to be done on the basis of the quality of energy supplied, reflected by the position hydropower occupies in the load duration curve. Currently the tariffs for both peak and off-peak loads are the same. Regulators need to differentiate between them and set differential tariffs which benefit hydropower developers. Most hydro plants are intended to operate in the medium to upper range of the load curve while thermal plants operate near the base load. This makes it misleading to compare generation costs between the two as the value of peak generation is significantly higher than the base load generation.
Developing market for ancillary services	A robust commercial mechanism based on an enabling regulatory framework need to be developed to encourage ancillary services support across the national grid. This will help maintain power quality, reliability and security of the grid. Hydropower operators will play a key role in providing such ancillary services given their black start characteristics.

Technical capacity development

Hydropower development involves significant challenges on account of terrain and geology. The solution to such challenges requires capacity-building of the agencies involved as well as the introduction of modern techniques and technologies. The capacity-building initiative will need to appreciate the technical challenges specific to hydropower and equip the concerned institutions with tools, training and systems to help address them.

Action plan

Key enablers	Action plan
State-of-the-art investigation and construction techniques	• Detailed geological and seismic mapping of specific potential areas needs to be carried out involving the Geological Survey of India. Similarly reliable hydrological data mapping needs to be done involving the National Hydrological Institute. • Hydrological yield estimation can be vastly improved through the coordinated collection of hydrological and meteorological data and dissemination of that data to developers. Similarly, centrally conducted studies can estimate the effects of climate change, an important aspect that individual developers are likely to ignore. • An upstream storage facility in each river basin can, by regulating overall flow, reduce silt loads downstream as well as lead to greater energy output. • Flood forecasting and warning system will be useful to ensure that all downstream power projects and local towns and villages receive adequate warning in the event of a flood or upstream dam break. Developing such a system is beyond the capacity of any individual developer and needs to be coordinated by state and central agencies.

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