International Conference on
HYDROPOWER AND DAMS DEVELOPMENT FOR WATER AND ENERGY SECURITY – UNDER CHANGING CLIMATE

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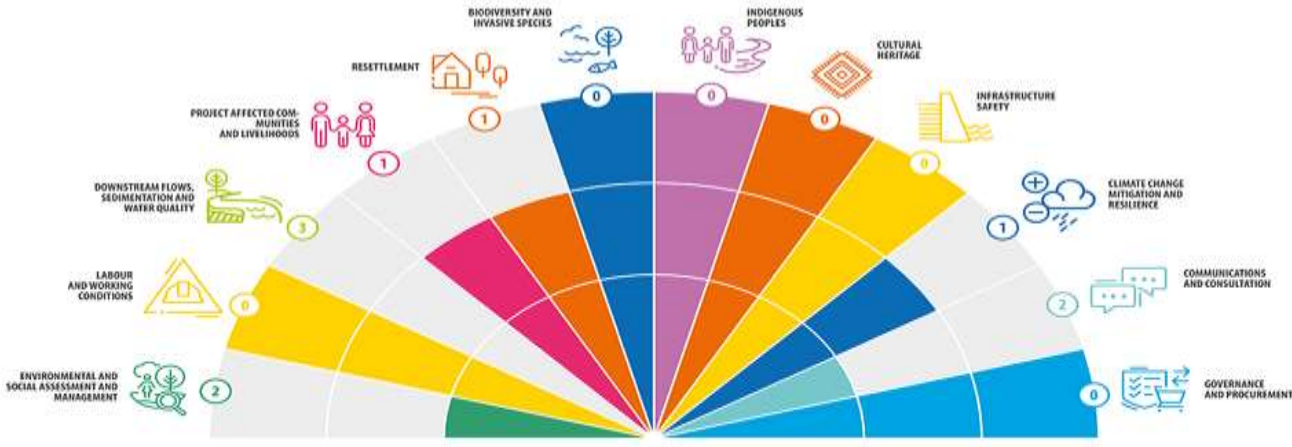

ECOLOGICAL AND CUMULATIVE ENVIRONMENTAL CONSIDERATIONS

FOR HYDROPOWER DEVELOPMENT IN CURRENT ENERGY TRANSITION SCENARIOS

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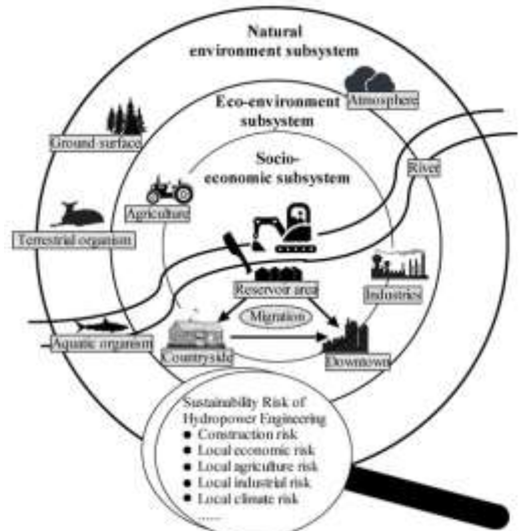
Energy – Key in Nation's Development

- Clean and affordable energy - (7th) of its 17 SDGs

- Global transition- towards renewable resources, such as solar, wind, hydropower, tidal, geothermal, biopower, and green hydrogen.

- Climate Change, Global warming and frequent extreme and irregular weather events - increasing environmental concerns

- India, a developing economy, is the world's third-largest energy consumer.



Contribution of Hydropower in Current Transition

- Hydropower is today the largest source of renewable electricity, with over 1,300 GW of installed capacity - more than 15% of the world's electricity.
- a step-change needed on global installed capacity of sustainable hydropower by 2050 to support clean energy transition away from fossil fuels and to tackle climate change.
- India's current installed capacity is about 387 GW, with thermal power occupying 61%, hydropower (above 25 MW) occupying 12%, nuclear 2%, and renewables such as solar, wind, small hydropower, biomass gasifier, biomass power, urban & industrial waste power occupying 25% of the share.
- Increased demand for sources of flexible low carbon generation.
- Consequently, the IEA and IREA both assess that in order to cost-effectively keep global warming to below 2°C at least 850 GW of new hydropower capacity is needed.

How will Pump Storage add value?

- By 2050 hydropower will be the dominant source of system flexibility. No low carbon options are available today that can deploy at the scale needed.
- The IHA study shows that there is at least 500 GW of projects in the pipeline i.e. future hydropower capacity. However, only 156 GW of this is under construction. 165 GW has been regulator approved but awaiting construction, 138 GW is pending approval and 89 GW has been announced.
- Moving these projects into construction is crucial if we are to cost-effectively tackle climate change.
- Analysis shows clear trends for future hydropower, such as the regional disparities in development and the growth of pumped storage.
- larger future growth in capacity in East Asia and Pacific, Africa, and South and Central Asia, with 240 GW, 118 GW and 91 GW in the pipeline respectively.
- The analysis also confirms the growing importance of pumped storage hydropower, and if all projects in the pipeline were completed, pumped storage capacity would almost double in future.

PSP : Emerging Trends

- New approaches for PSH span three board categories:
  - furthering PSH potential (such as seawater PSH),
  - retrofitting and upgrading PSH systems (such as utilizing abandoned mines), and
  - developing hybrid systems (such as combined with thermal storage).

- There is emerging research on retrofitting PSH at disused mines, underground caverns, non-powered dams and conventional hydro plants, representing vast untapped PSH potential.

- Enhanced by latest technological advancements, such as the use of variable speed pump-turbines or hydraulic short circuit, it is possible to enhance the performance and flexibility services provided by existing PSH with viable costs.

- Hybrid solutions such as PSH coupled with other energy storage technologies (e.g. batteries) and solar PV have to potential to provide a one-stop solution and enable access to revenue streams in electricity markets.

- Location agnostic systems are made possible by modern tunnel boring machines to create underground water ways and power houses or convert an existing abandoned mine.

Options of Hydro Bundling

- **Hydropower is clean energy & highly flexible**
  - Capable of providing flexibility and storage capacity that will be needed by an increasingly dynamic Indian power grid
  - Requiring a substantial amount of power from generation sources
  - Have quick start and stop capability and can offer grid balancing services.
  - Such resources come online within a short span of time to bridge the gap on supply side arising due to variable renewable energy generation.
  - Ability to effectively store energy in its reservoirs and respond quickly to system requirements
  - Even greater value within the future Indian power system.

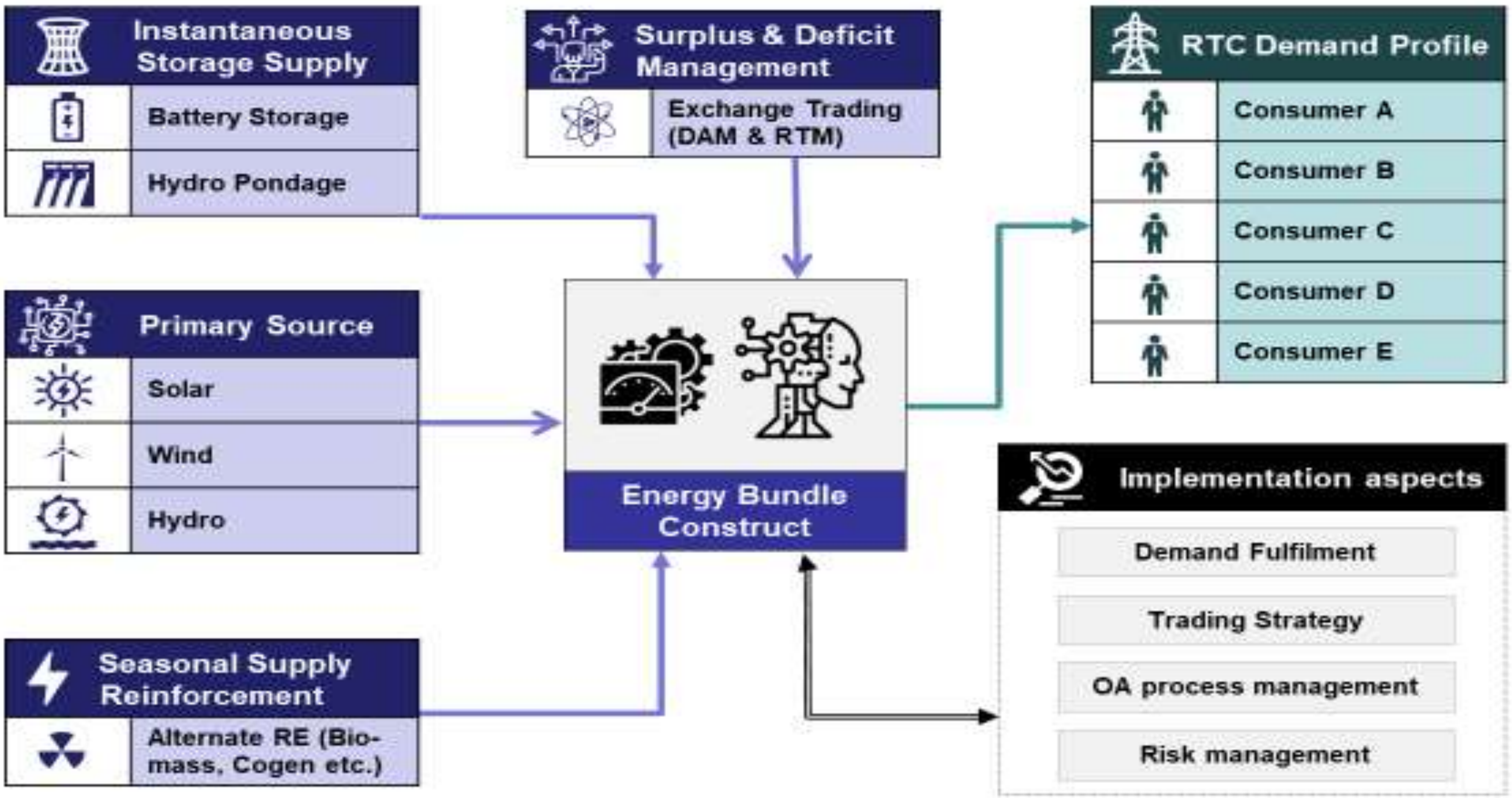
- **One option to utilize the surplus of hydropower is:**

Support integration of renewable energy sources is to create a bundled product, comprising large hydropower, solar and wind plants. Such a bundled product would create multiple benefits

- Provision of round-the-clock power supply to electricity consumers,
- Decrease in overall offtake price supporting less competitive hydropower generation assets,
- Increased grid stability,
- Higher competitiveness in the Indian power market, and others.

How will System Work?

A bundle of hydro and solar / wind with seasonal support from alternate RE and supplemented by storage / exchange power has been envisaged.



Process flow for bundling of sources

Planning	Scheduling	Supply Reinforcement	Surplus / Deficit Mgmt.
Alternate RE (Bio-mass, Cogen)	Solar Wind Hydro	Battery Hydro Pondage	Day Ahead Market (DAM) Real Time Market (RTM)

1 Seasonal supply

- Seasonal RE tie-up basis quarter / month ahead solar, wind profiles & demand

2 Day-ahead RE supply

- Hydro varied basis solar and wind day ahead schedules

3 Instantaneous supply

- Battery / hydro pondage charged with surplus in prior blocks as instantaneous sources

4 Residual power mgmt.

- Surplus (in peak season) and deficit met through IEX trading in run time as last resort

Operationalizing Bundle Structure

- **Trading strategy** for market engagement with vendors
- **Bundle customization** basis stakeholder requirement
- **Demand management** through block wise mapping
- **Incremental value addition** by secondary objective fulfilment
- **Exchange trading automation** workflow streamlining
- **Risk mitigation** strategy to limit potential downside

Challenges of Hydro Power Development

- **Feasibility Stage**
  - Late identification of environmental, social or geotechnical constraints
  - Fixed installed capacities at early stages
- **DPR Stage**
  - Lack of access to project site conduct adequate survey & investigations
  - Obtaining basic hydrological data in geo-political conflict zones, real consultant project experience in DPR stage, evaluation stage and implementation stage.
- **Evaluation & Appraisal Stage**
  - Implementation of modern software tools and skill development
- **Implementation Stage**
  - Slow financial closure of projects
  - Restricted access to modern construction techniques and equipment
  - High-interest rate for debt funding
  - Lack of financiers due to comparison with other renewable energy investments

Addressing these common barriers can help accelerate the development of large hydropower in India.

Cumulative and Ecological Challenges in Bundled Products of Hydro & PSP

- Hydropower's high flexibility
- Such a bundled product would create multiple benefits
  - round-the-clock power supply to electricity consumers, decrease in overall offtake price supporting less competitive hydropower generation assets, increased grid stability, higher competitiveness in the Indian power market, and others.
- However, such arrangements will also foresee a change in the operation of hydro power.
- The operation of hydro will take shape as per the protocol of bundling of power which to honor peaking requirement or use of other source and thus may operate at different time of hour than is practiced currently.

Cumulative and Ecological Challenges in Bundled Products of Hydro & PSP

- This will have environmental and social concerns due to changed operation in the existing hydropower facility .
- **Key areas of concern could be** : (a) Environmental flow downstream and upstream (b) impacts on upstream and downstream projects, (c) bio-diversity impacts including aquatic resources and (d) floods/ inundation impacts for downstream communities/ water usages.
- The environmental barriers to off-river pumped hydro are much lower than conventional river based hydro reservoirs that include new dams on rivers.
- The schemes are not designed to capture water beyond the initial reservoir fill so there is minimal impact on natural stream flows.

What are suggestive Environmental and Social Sustainability Pathways

Ecological and Environmental Considerations for Power Sector are key to Success :

Use of tools: These tools will help ensure the achievement of a balanced approach to energy development and poverty reduction while mitigating the negative social and environmental impacts of reservoir and dam construction.

- *Strategic Environmental and Social Impact Assessment (SESIA).*
- *Cumulative Impact Assessment (CIA).*
- *Project-Level Environmental and Social Impact Assessment (ESIA)*
- *Management of Biodiversity*
- *Catchment Area Treatments*
- *Livelihood Development Planning is a Critical Part of a Resettlement Program*
- *Resettlement Programs as a Development Platform.*
- *Consultative and stakeholder involvement*
- *Use of Independent Panels of Experts*

Environmental Best Practices

Low Impact Hydropower Institute (LIHI, U.S.)	Total eight categories: Flows, water quality, fish passage and protection, watershed protection, threatened and endangered species, cultural resource protection, recreation and facilities recommended for removal.
Hydropower Sustainability Assessment Protocol (IHA, U.K.)	IHA Hydropower Sustainability Assessment Protocol (HSAP) offers a way to assess the performance of a hydropower project across twenty four sustainability topics that include: communications and consultation, governance, demonstrated need and strategic fit, sitting and design, environmental and social impact assessment and management, integrated project management, hydrological resources, infrastructure safety, financial viability, project benefits, economic viability, procurement, project affected communities and livelihood, resettlement, indigenous people, labour and working conditions, cultural heritage, public health, biodiversity and invasive species, erosion and sedimentation, water quality, reservoir planning, downstream flow regimes, and climate change

In 2014, the World Bank endorsed the Hydropower Sustainability Assessment Protocol (HSAP) as a tool for guiding hydroelectric development in client countries

Environmental Best Practices

International Energy Agency	Fourteen different categories: Biophysical Impacts (Biological Diversity, Hydrological Regimes, Fish Migration, and River Navigation, Reservoir Sedimentation, Water Quality, Reservoir Impoundment); Socioeconomic Impacts (Resettlements, Minority Groups, Public Health, Landscape, and Cultural Heritages); Sharing development benefits (Benefits due to Power Generation, Benefits due to Dam Function, Improvement of Infrastructure, Development of Regional Industries)
European Bank for Reconstruction and Development (EBRD)	Ten criteria under EBRD: Assessment and Management of Environmental and Social Risks and Impacts; Labour and Working Conditions; Resource Efficiency and Pollution Prevention and Control; Health, Safety, and Security; Land Acquisition, Restrictions on Land Use and Involuntary Resettlement; Biodiversity Conservation and Sustainable Management of Living Natural Resources; Indigenous Peoples; Cultural Heritage; Financial Intermediaries; Information Disclosure and Stakeholder Engagement

https://www.sciencedirect.com/science/article/pii/S2211467X21000626

Environmental Best Practices - Sustainable hydropower throughout the Western Balkans

- Across Europe's Western Balkans region, demand is growing for the reliable, renewable energy that hydropower can provide.
- Yet, local communities are divided over hydro's merits, with some campaigners seeking to bring a halt to new projects.
- To support authorities, investors and developers to implement international good practices in hydropower development, the IHA, the Albanian Power Corporation (KESH) and the Swiss government's State Secretariat for Economic Affairs (SECO) have launched a new initiative in the Western Balkans.

The aim of this project is to

- demonstrate that hydropower is not only renewable but sustainable and
- manage the environmental and social impacts of development responsibly.

https://www.waterpowermagazine.com/features/featurealigning-with-good-practice-9185613/

Environmental Best Practices – Biodiversity and invasive species: Itaipu, Brazil–Paraguay

Itaipu is located in the Atlantic Forests, a highly biodiverse but critically endangered ecological region. Recognised by WWF as one of the Global 200 priority eco-regions. The **Upper Paraná river** is recognised by WWF as a Global 200 freshwater eco-region, including over 300 species of fish, a variety of aquatic vertebrates and invertebrates, and a high degree of endemism.

The Itaipu project partners with upstream and downstream hydropower projects to monitor fish migration.

Contributions to habitat protection and ecological restoration can continue many years after project development

Brazil Itaipu established two Itaipu-owned biological refuges, the Bela Vista Biological Reserve (1,908 ha, established in 1984), and the Santa Helena Biological Reserve (1,483 ha), contributed to the establishment of an ecological corridor, planted a total of 23.2 million trees since 1979 through reforestation programmes.

Paraguay Itaipu established eight Itaipu-owned areas to protect primary and secondary forest, totalling 50,096 ha, launched the Itaipu Preserva programme to reforest a protection zone along the reservoir margin using native species.

Itaipu's protected areas and zones are important for linking the Atlantic Forest eco-region with the wetland ecosystems of Ilha Grande National Park. The Paraguay Biodiversity Project would be impossible without Itaipu's involvement, and it also contributes to the country's Plan 2030 for Sustainable Development.

Itaipu is located in a globally important eco-region, where many species are at risk. Demonstrates how a project can make a vital contribution to protecting biodiversity in the surrounding area.

Environmental Best Practices – Downstream flow regimes: Walchensee, Germany

The combination of various intakes enables the establishment of a continuous minimum flow regime

Nature and innovation combine to minimise downstream flow impacts

Older plants with minimal or no downstream flow commitments can build stakeholder support by restoring minimum flow

Uniper has completed a project to re-establish flow on the Obernach stream.

Flow regulation has enabled the lake trout population to spawn

This case study is based on an official assessment of Walchensee using the operation stage tool of the Hydropower Sustainability Assessment Protocol. The assessment was conducted in 2012, with an on-site assessment in March 2012.

The Walchensee project has implemented two important mitigation initiatives to address downstream flows, a concept that was unheard of at the time of project construction. This case study demonstrates how downstream flow measures can support local activities and wildlife.

Extensive studies provide a scientific basis for minimum flow determination

THANK YOU

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