Online training of SAARC Professionals on Small, Mini and Micro Hydro Power Generation
(Sept 13 - 17, 2021)

Introduction to Small, Medium and Micro Hydropower

Sept 13, 2021

Arun Kumar
Professor
Department of Hydro and Renewable Energy
Indian Institute of Technology, Roorkee
arun.kumar@hre.iitr.ac.in, aheciitr.ak@gmail.com

Contents and Learning Objective

Contents

- About Hydropower development including historical prospect
- Hydropower and Small hydropower potential in the SAARC region
- Status of SHP development
- Typology
- Classification of SHP
- Ultra Low Head SHP Development
- Barriers
- Risk and Challenges
- department of Hydro and Renewable energy

Learning Objective

To know about small hydro development status, barriers and risks

History of SHP Development

- Hydropower or water power is power that is derived from the force or energy of moving water from higher elevations to lower elevations harnessed for useful purposes.
- Prior to electric power, hydropower was used for irrigation and operation of water mills, textile machines and sawmills etc.
- Mechanical power of falling water was used by the Greeks to turn water wheels for grinding wheat more than 2,000 years ago.

- The first hydroelectric power plant installed in Cragside, Rothbury, England in 1870. Industrial use of hydropower started in 1880 in Grand Rapids, Michigan, when a dynamo driven by a water turbine was used to provide theatre and storefront lighting.
- In 1881, a brush dynamo connected to a turbine in a flour mill provided street lighting at Niagara Falls, New York.
- Lator electric generator was coupled to turbine and thus world's first hydroelectric station (of 12.5 kW) was commissioned on 30 Sept 1882 on Fox River in Appleton, Wisconsin, USA, lighting two paper mills and a residence.

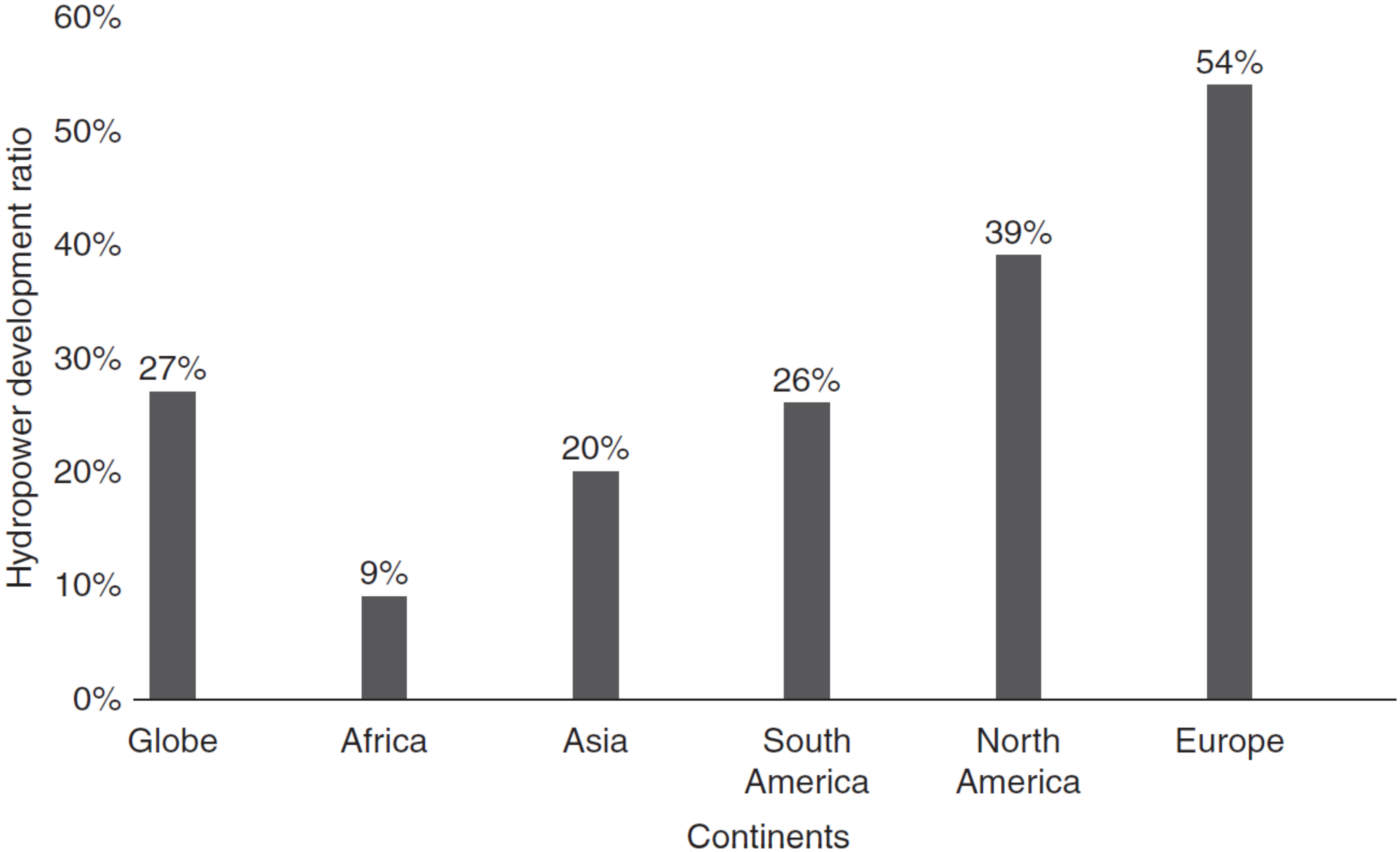
Hydropower

- Hydropower is a proven renewable, mature, predictable, highest conversion efficiency and cost competitive energy source.
- Hydropower requires relatively high initial investment, but has the advantage of very low operation costs and a long lifespan, Part of multipurpose river valley projects, Quick start, stop and peaking
- Life cycle analysis of hydropower shows as cleanest electricity technology with a low carbon footprint
- Has the highest energy payback ratio.

Hydropower

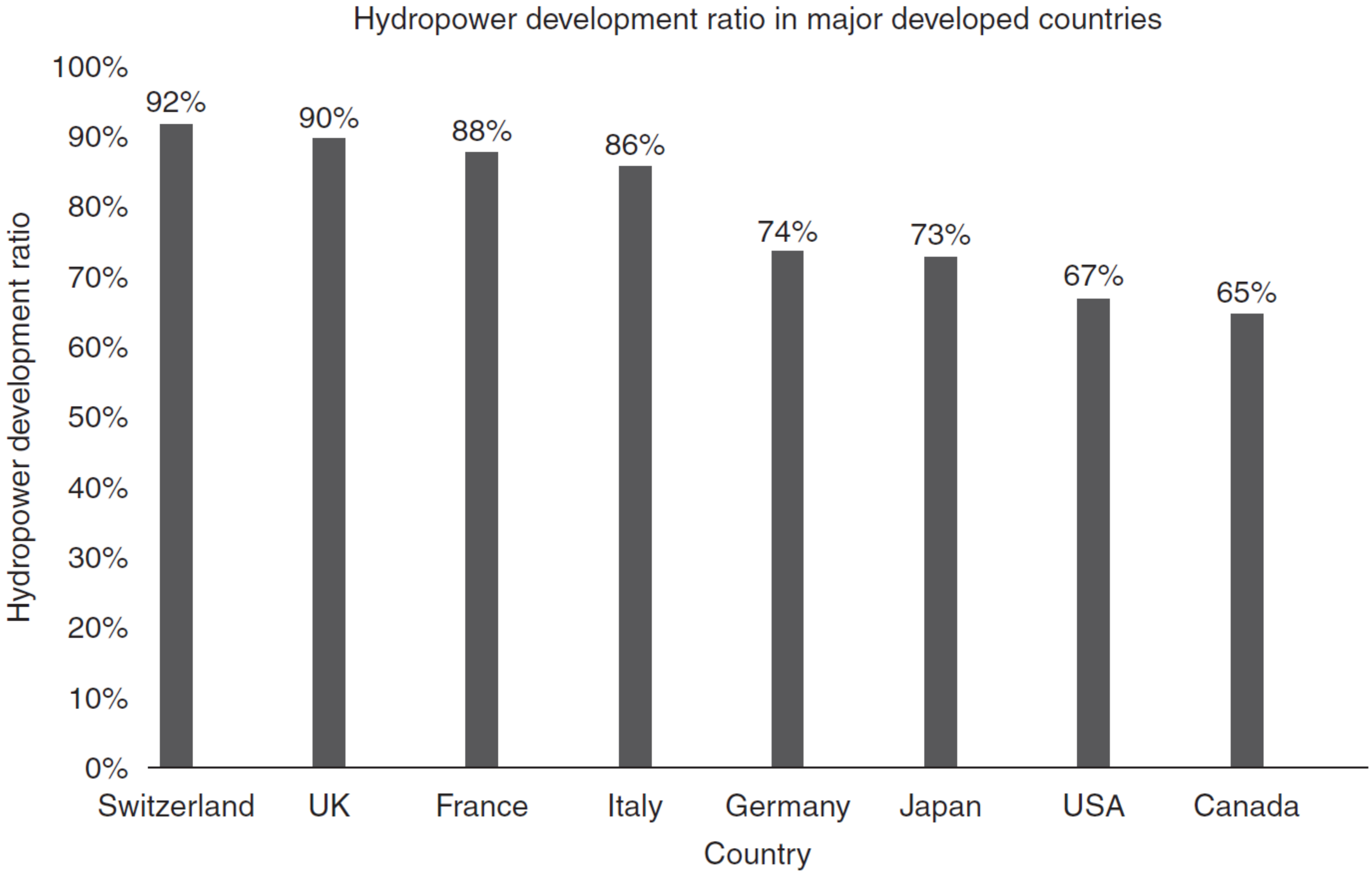
- HP can support the penetration of other renewables by providing the backup that variable technologies need
- HP, regardless of size can be an opportunity for local, national and regional development when social and environmental impacts are dealt with properly – new tools exists to increase environmental and sustainability performance
- Hydropower is too often overlooked in energy policies.
- Many tend to believe that hydropower plants are detrimental to environment or unsafe.

Large HP potential remains undeveloped



The development of hydropower on all continents

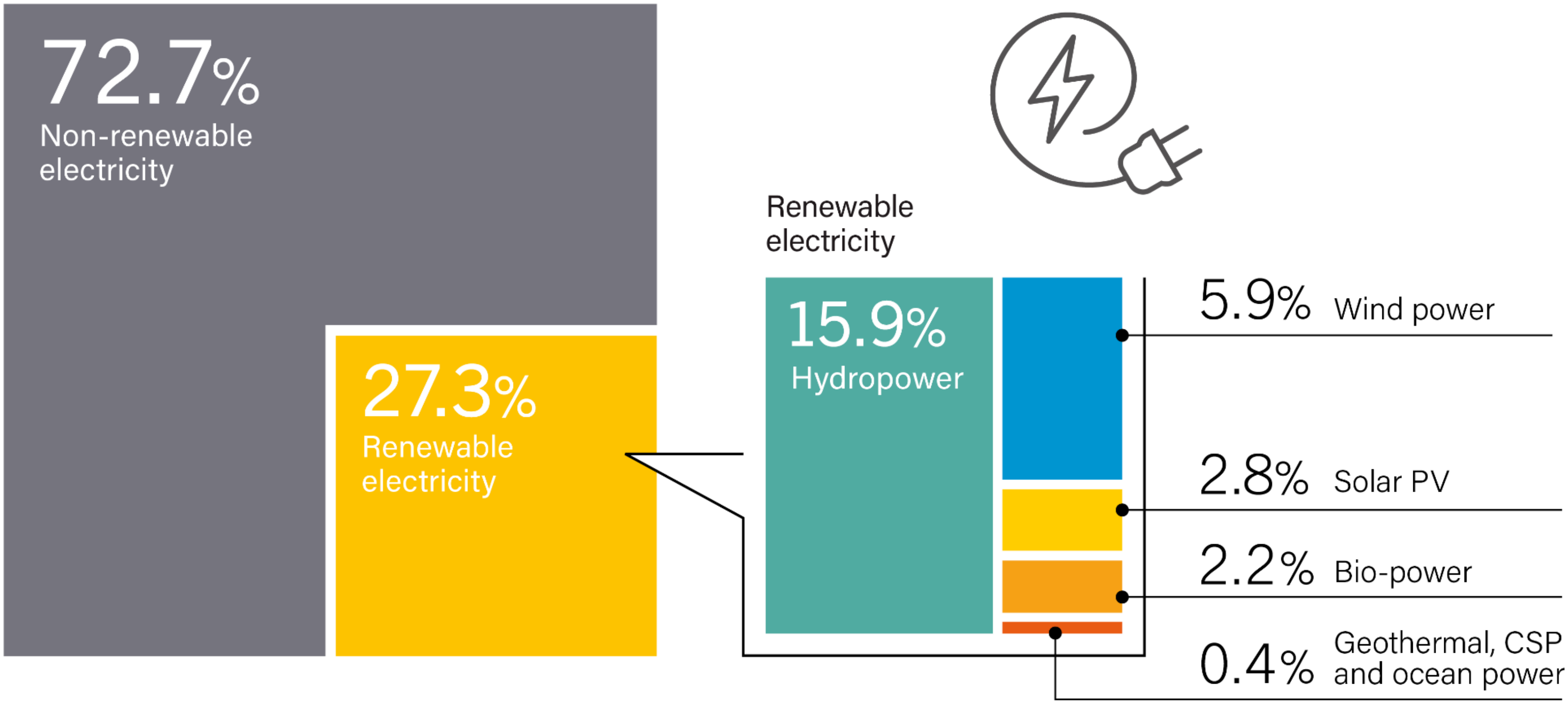
Bin Duan (2021), Discussion on the development direction of hydropower in China, Clean Energy, 2021, 10–18



Hydropower development in major developed countries

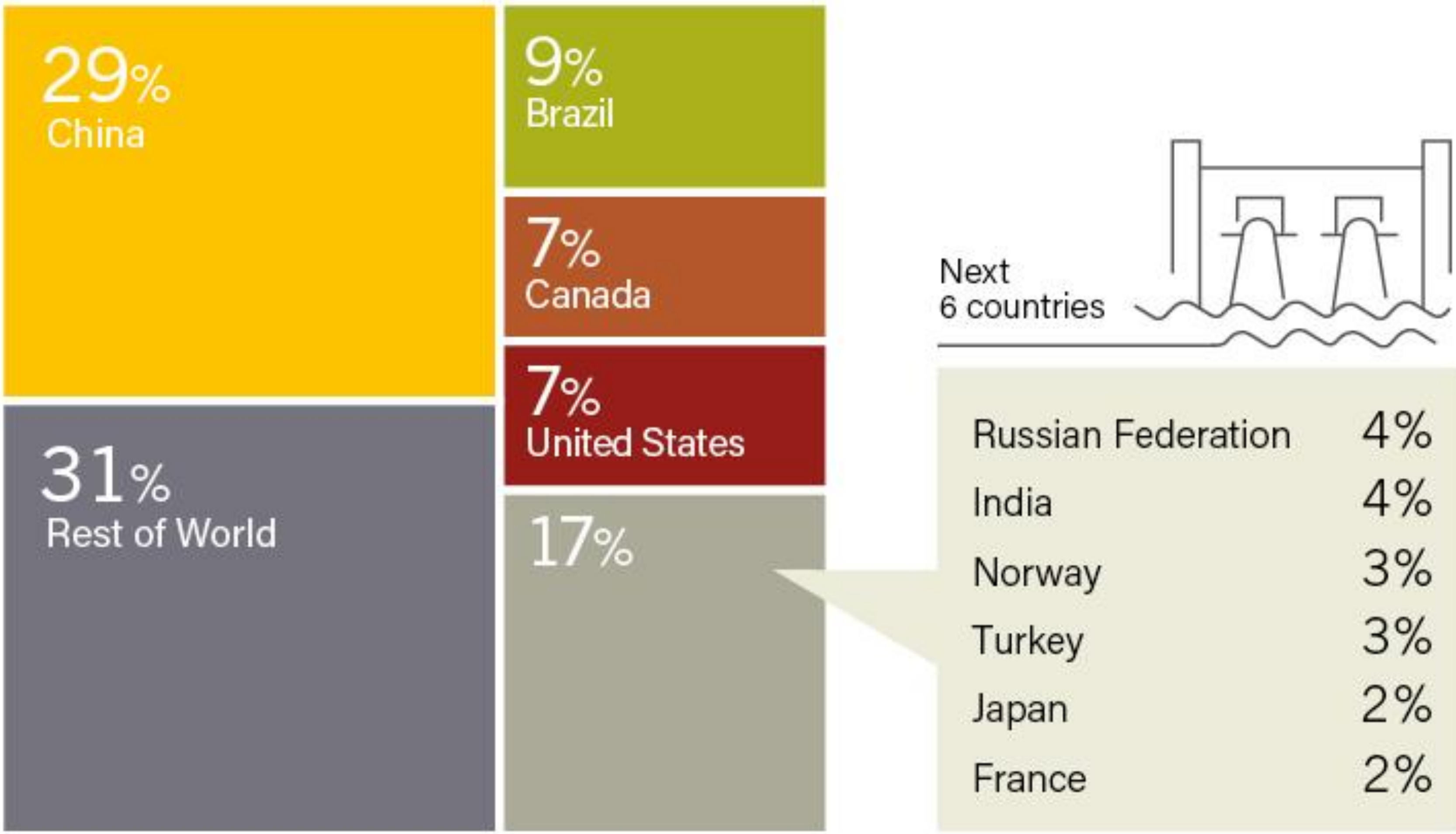
Bin Duan (2021), Discussion on the development direction of hydropower in China, Clean Energy, 2021, 10–18

Estimated Renewable Energy Share of Global Electricity Production, End-2019



Note: Data should not be compared with previous versions of this figure due to revisions in data and methodology.

Hydropower Global Capacity, Shares of Top 10 Countries and Rest of World, 2020



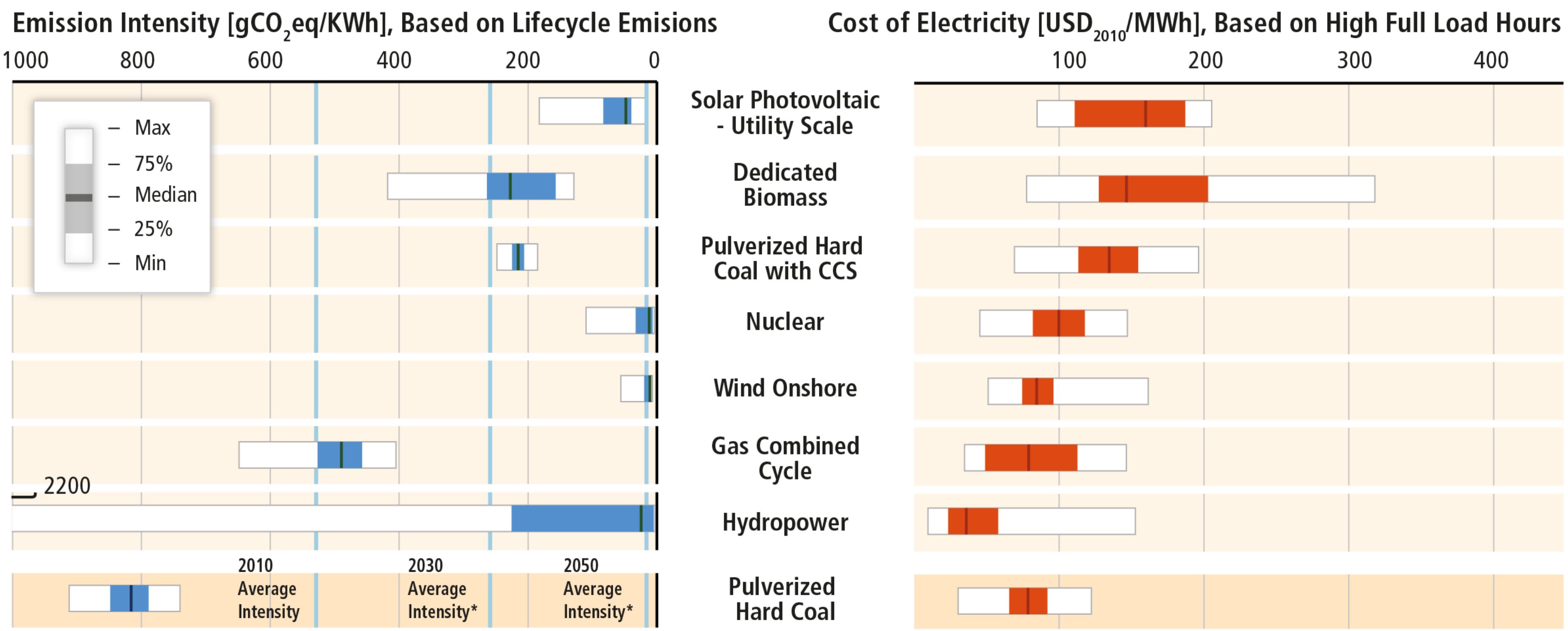
REN21 RENEWABLES 2021 GLOBAL STATUS REPORT

Hydropower Generation

County	Capacity (GW)	Country	% of hydro in total domestic electricity generation	Producers	TWh	% of world total
China	341	Norway	96	China	1,188	28
Brazil	101	Venezuela	68	Canada	380	9
USA	80	Brazil	63	Brazil	417	10
Canada	80	Canada	58	USA	300	7
Russia	48	China	18.7	Russia	177	4
India	49	Russia	16.7	Norway	143	3
Norway	32	France	12.2	India	134	3
Japan	22	India	10.2	Venezuela	81	2
France	25	Japan	8.4	Japan	78	2
Turkey	27	United States	6.5	France	53	1
Rest	376	Rest	15.6	Rest	1,223	29
World	1,181	World	16.7	World	4,174	100

Source: Key World Energy STATISTICS, IEA, 2016 / IJHD 2018

Costs of many power supply technologies decreased substantially, some can already compete with conventional technologies.
IPCC AR5-2014



* Median Value in Mitigation Scenarios (430-530 ppm CO_2eq by 2100)

- Southern Asia comprises eight countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.
- All countries of the region have hydropower potential, except Maldives.
- Wide diversity of resources in the region.
- India, Pakistan and Bangladesh account for major natural gas and coal reserves, whereas Afghanistan, Bhutan, Nepal and Sri Lanka have large hydropower resources.

- All the countries have vast renewable energy potential.
- Energy sector cooperation may focus on developing a regional power market, energy supply availability, energy trade infrastructure and harmonizing legal and regulatory frameworks.
- Access to electricity has been steadily increasing in the region, with all countries now having high electrification growth.

Typology

Classification based on different approach

(not mutually exclusive).

- By purpose (single or multi-purpose)
- Types: run-of-river, reservoirs, in-stream and pumped storage.
- By size (large, medium, small, mini, micro, pico)
- By head (high or low)
- By system - isolated or connected to grid
- Regulation performance,

- Run-of-river hydropower plant (daily/weekly regulating hydropower plants),
- Seasonal regulating hydropower plant and annual/multi-year regulating hydropower plant.

- Hydrological relation single or in cascade

No world wide definition on size classes

“Hydropower --- cover a continuum in project scale”.

“ - it may be more useful to evaluate a hydropower project on its sustainability or economic performance, thus setting out more realistic indicators.”

0.1 kW

22, 400 MW

MW

SHP Definitions

Country Name	SHP
Italy	≤ 3 MW
Dominican Republic, Guatemala, Macedonia	≤ 5 MW
Mauritius	≤0.05 MW
Marocco	≤8 MW
Afghanistan, Burundi, Iran, Malaysia, Mali, Nepal, Norway, Sri Lanka, Tunisia, Kenya, Uganda, Zambia, Madagascar, Armenia, Austria, Croatia, Montenegro, Nigeria, Turkey, Serbia, Slovenia, Switzerland, Azerbaijan, Cambodia, Philippines, Indonesia, Senegal	≤10 MW
Georgia	≤ 13 MW
Bangladesh, Laos, Lesotho, Thailand	≤15 MW
El Salvador, Peru	≤ 20 MW
Bhutan, India, Mozambique	≤25 MW
Argentina, Brazil, Mexico, Benin, United States	≤30 MW
Canada, China, Pakistan, New Zealand	≤ 50 MW

HYDROPOWER CLASSIFICATION

"Hydropower --- cover a continuum in project scale".

Like many countries in India it is classified further as:

Pico/village	5 kW & below
Micro	100 kW & below
Mini	2 MW & below
Small	25 MW & below
Medium	100 MW & below
Large	above 100 MW

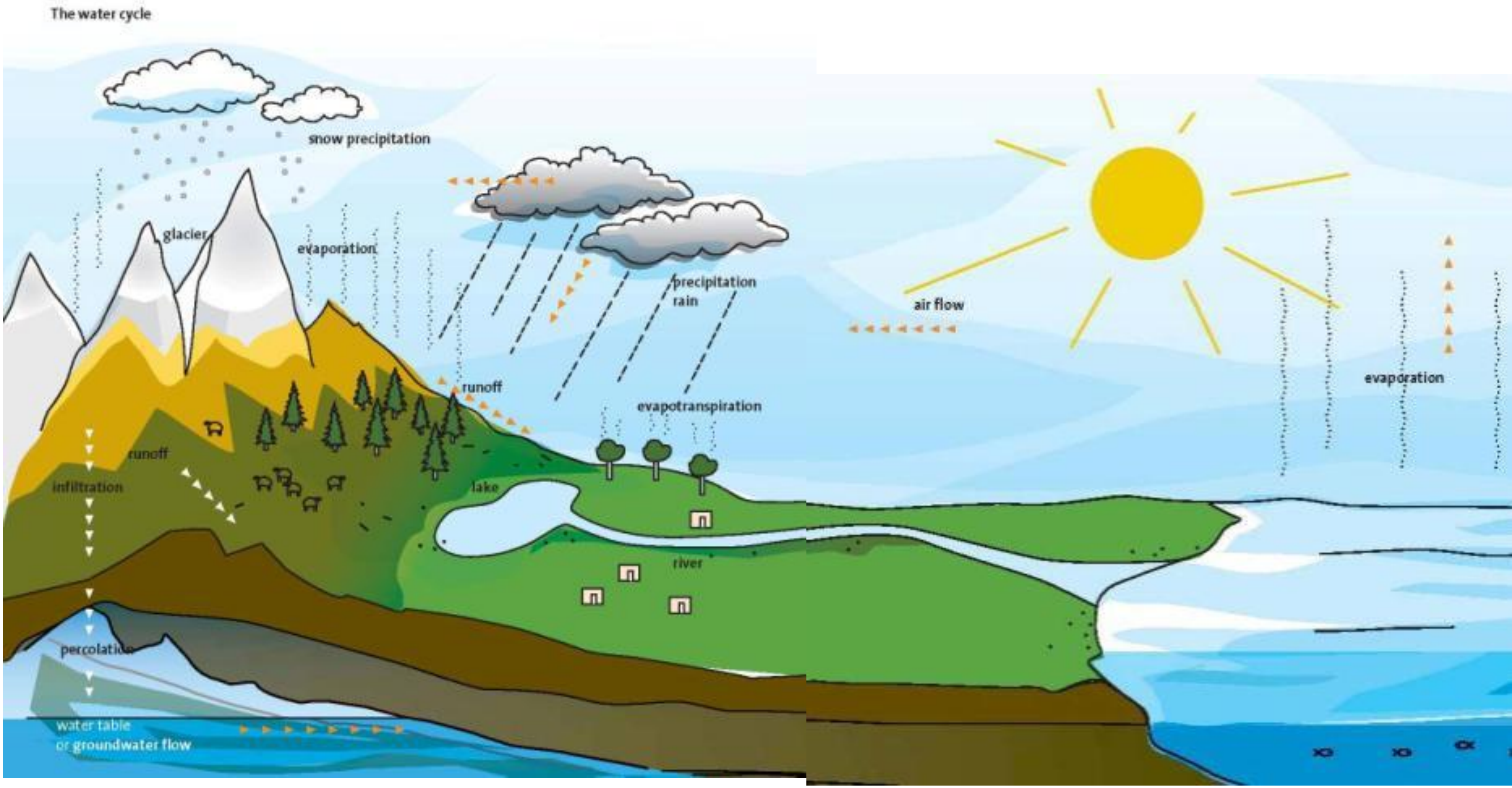
Efficiency of HP Station and Equipment

Overall Efficiency of hydropower plant = 75 – 80%

(A) Water Conductor system = 90 – 95%

(B) E&M Works = efficiency of turbine* generator* gearbox

- Turbine 88 to 94%
- Generator 96 to 98%
- Gearbox (if applicable for low head) 98%



Hydrological Cycle

Power Potential & Energy Generation

Basic Equation for Power Generation from potential energy

$$\text{Power in W} = \rho .\ Q.\ H.\ 9.81 .\ \eta$$

where,

ρ	Density in kg/m^3
Q	Discharge in cumecs
H	Head in meters
η	Overall efficiency of turbine, gear-box & generator

Power from Flowing water $P = (1/2).\rho.C_k.A.V^3$

C_k	Power coefficient
A	Turbine area (m^2)
V	Velocity of water (m/s)

Global SHP Identified Potential and Installed Capacity (Upto 10 MW)

Region	Potential	Installed	Region	Potential	Installed
Africa	10,241	596	Asia	138,275	51,069
Eastern	6833	276	Central	34358	266
Middle	1856	114	Eastern	75437	45723
Northern	520	112	Southern	4203	697
Southern	422	50	South-Eastern	16361	850
Western	610	44	Western	7916	3533
America	41,861	6,241	Europe	37,526	19,699
Caribbean	297	177	Eastern	4370	1903
Central	1202	524	Northern	10805	4401
Southern	28483	806	Southern	14716	6881
Northern	11879	4734	Western	7635	6514
Oceania	1,208	441			
Aust and NZ	795	327			
Pacific Islands	413	114			
			TOTAL	**229,111**	**78,046**

Source: *World SH Development Report 2019*

Small Hydropower Capacities in Southern Asia (Local and ICSHP definitions) (MW)

(WSHPD Report 2019)

Country	Local SHP definition	Installed capacity (local def.)	Potential capacity (local def.)	Installed (<10 MW)	Potential (<10 MW)
Afghanistan	up to 10	75.7	1,200.0	75.7	1,200.0
Bangladesh	-	0.06	1.4	0.06	1.4
Bhutan	up to 25	32.1	17,792.0	8.1	N/A
India	up to 25	4,485	21,134.0	N/A	N/A
Nepal	up to 25	446.8	4,196.2	236.2	1,959.5
Pakistan	up to 50	410.0	3,100.0	N/A	N/A
Sri Lanka	up to 10	357.0	873.0	357.0	873.0
Total		-	-	677.5	4,033.5

Hydro Potential Assessment is Required

Several opportunities where hydro power potential is yet to be assessed are

- Pipelines for drinking and industrial use.
- Effluent outfall at water treatment plants and sewage treatment plants
- Small scale pumped storage plants
- Hydro kinetics in flowing channels/streams

Purpose of SHP

Social Sector SHPs-

- Aims to supply electricity specially in stand alone mode,
- Characterized with poor load factor and of small capacity
- Often involved in distribution also
- Often are fully supported by government
- O&M is recovered through user charges collection

Commercial SHPs-

- Aims to sell electricity to power distributing or trading companies or for captive use,
- Are grid connected and are relatively larger capacity
- Have high load factor
- Financially sound

Both are required and different level of approach, subsidy, tariff etc are needed

Issue and Challenges

- Clearances by different departments
- Land acquisition
- Power evacuation
- Financial closure
- Power Purchase Agreement
- Local support
- Infrastructure Availability
- Accessibility
- Dull environment for developing hydropower

Indian Power Scenario

Installed Capacity and Energy Generation

Installed Capacity ~ 370 GW
(Renewables – @24%)

Peak Demand ~ 177 GW

Consumption ~ 1366 BU

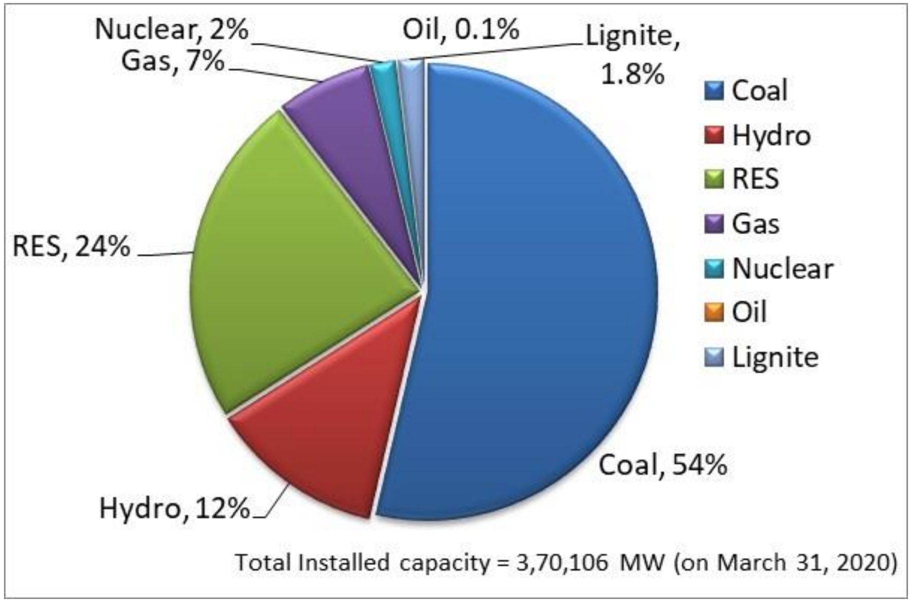
Electricity consumers ~ 300 Million

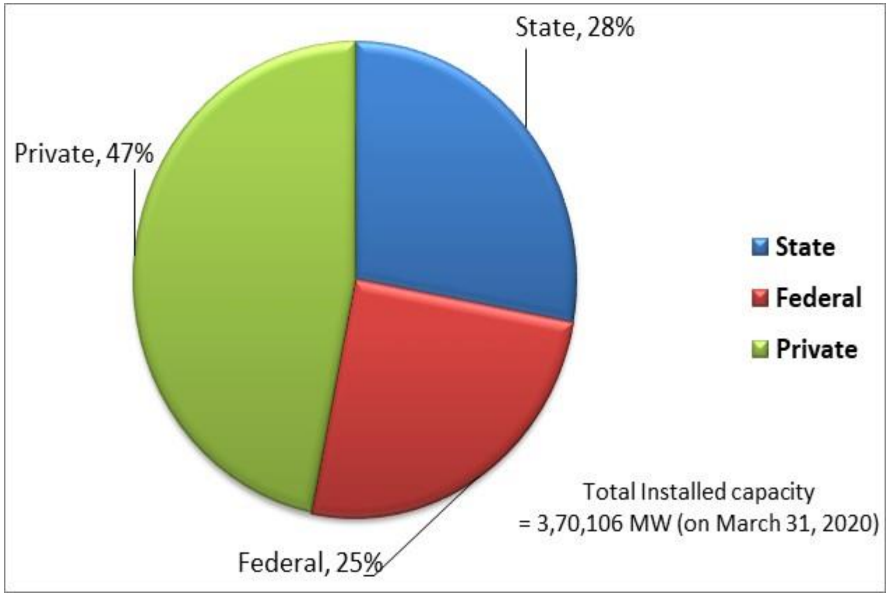
Per capita . ~ 1200 kWh

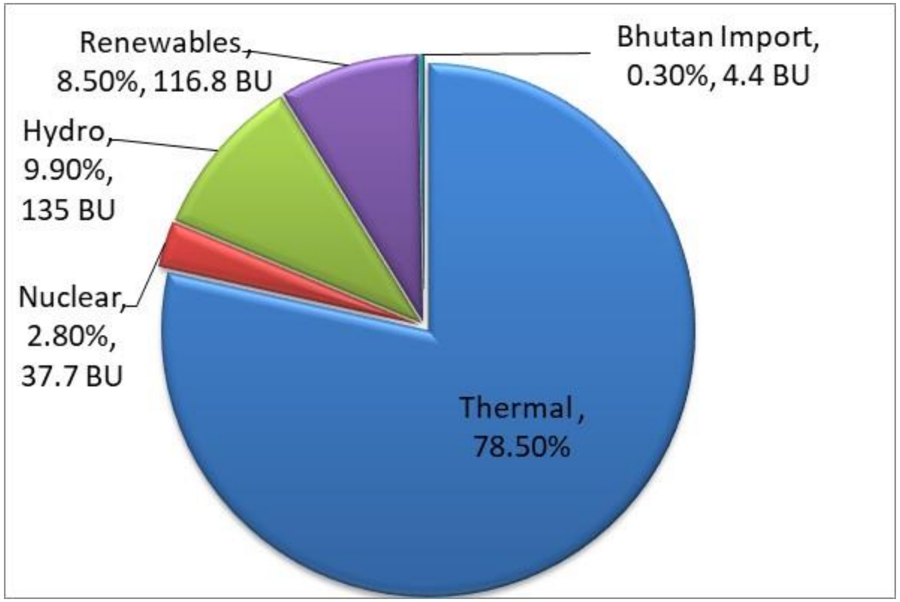
Distribution Companies ~ 100

Transmission lines ~ 425,000 ckms

T&D Losses ~ 21%







Low head power plant (4.5MW)
Madhavmantri, (head 4.5 m) Kaveri River, India

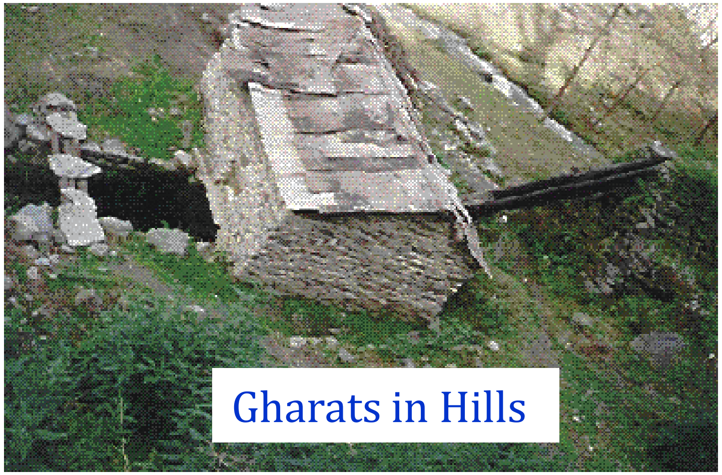
Low head power plant (90 MW)
BIRSFELDEN, (head 3 to 9 m) Rhine river, Switzerland

Examples

Three Gorges

OLD WATER DRIVEN MILLS- Low Head Application

For cereal grinding in Norway



For Textile use in Braine_le_Chateau Belgium

Villager made water wheel for electricity generation- Indonesia

Water mills in Bosnia

Hydropower for Grinding Flour and Generating Electricity (INDIA)

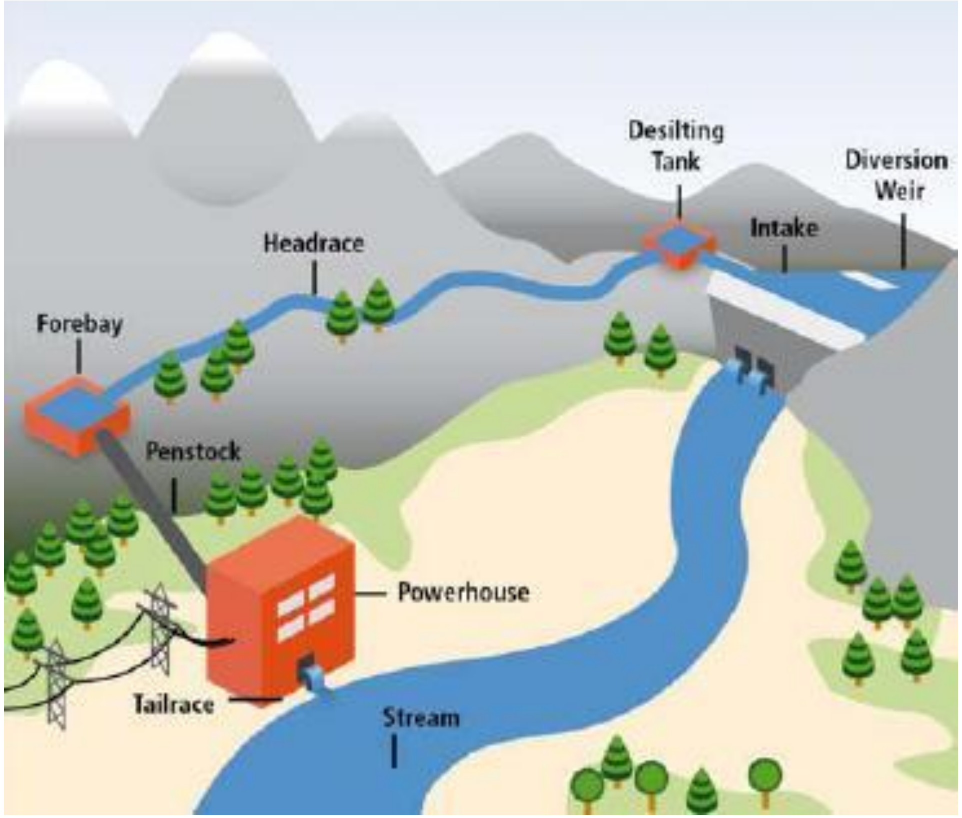
Calverton Water-Pumping station, UK

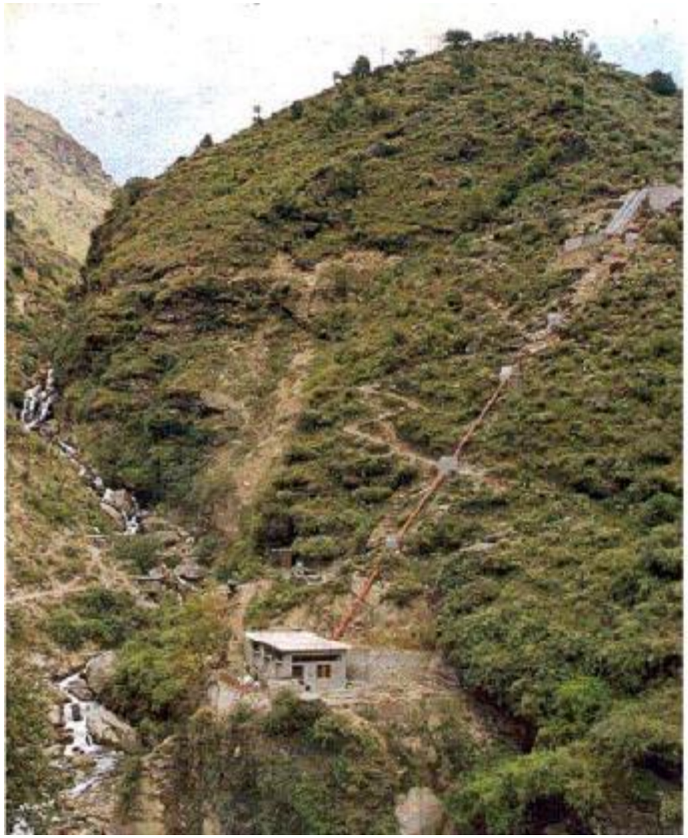

Local hydropower on Nam Ngouang
Transmission line
Rotating unit
Guiding water

Small Hydro owned by individuals

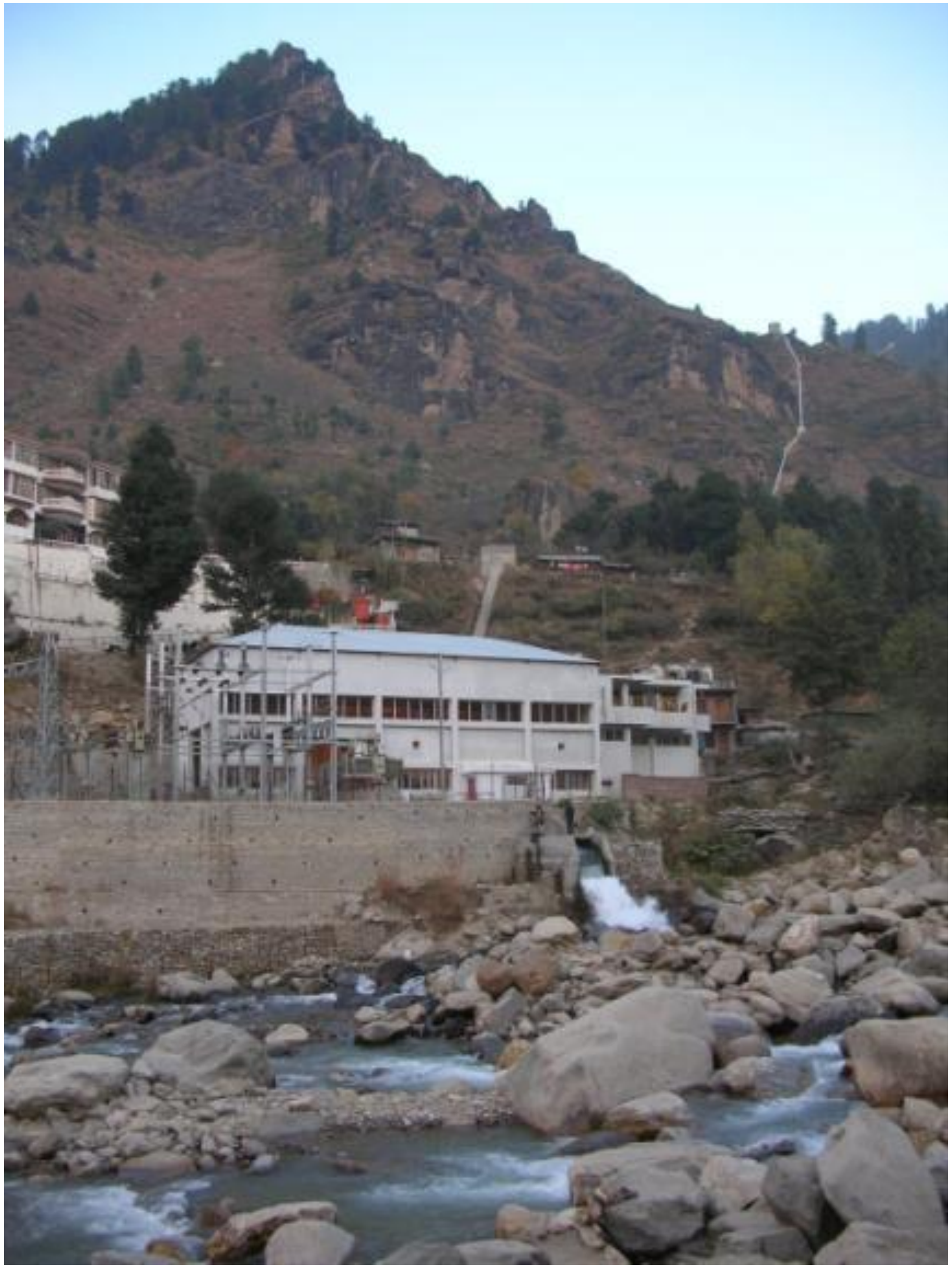
Types of Hydropower

Run of River:



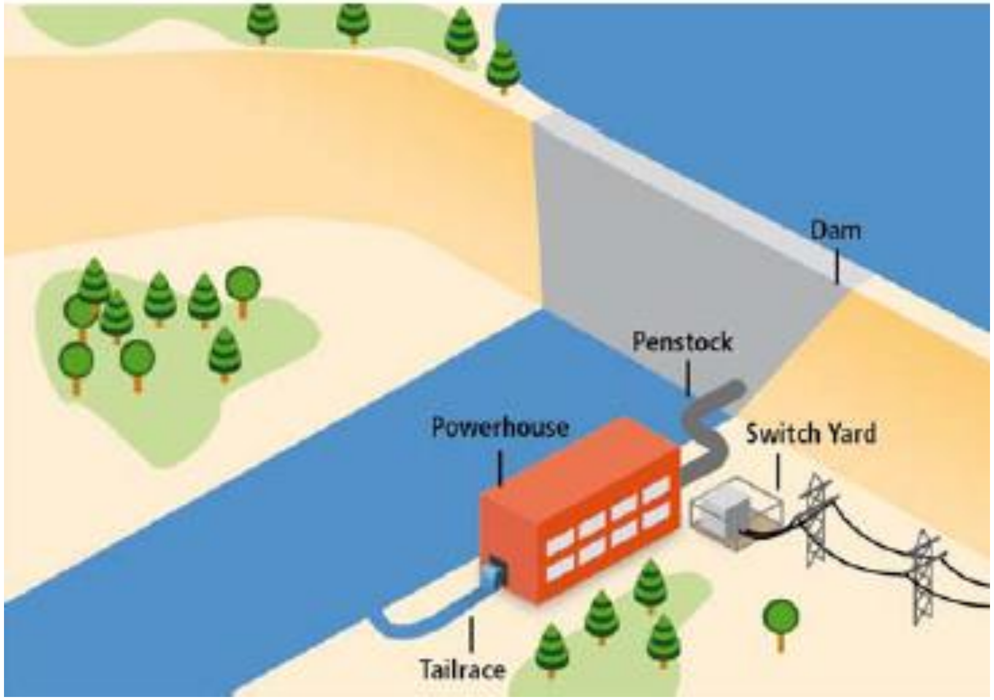


Run of river hydropower development



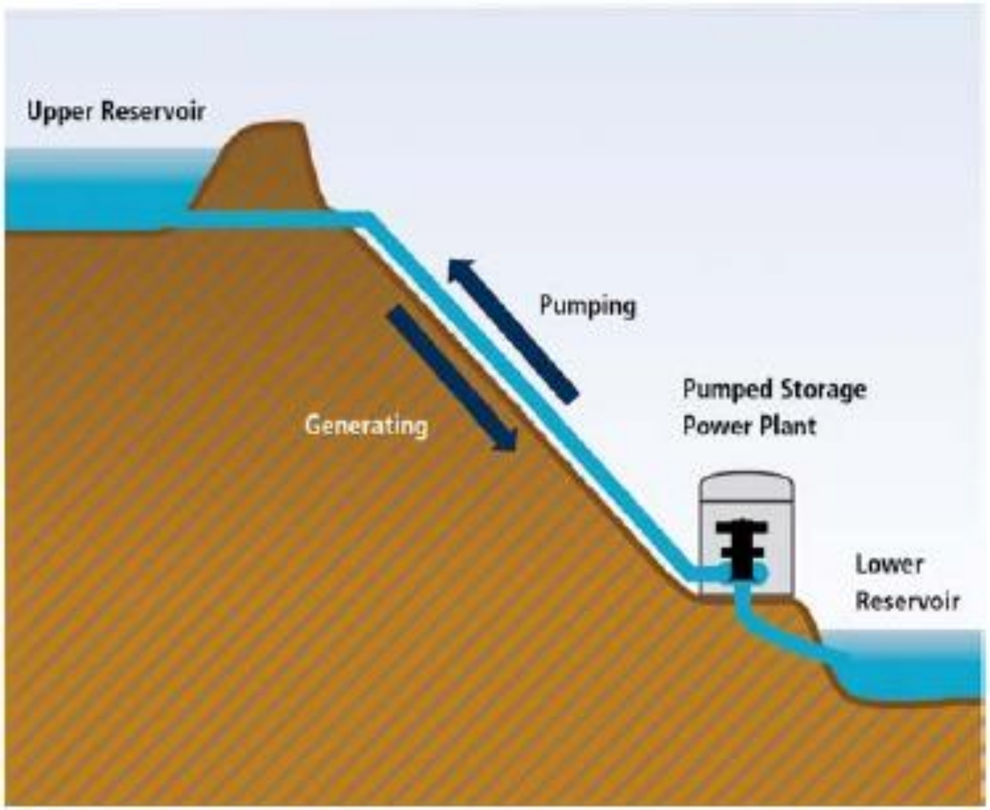
Using existing facilities:

Typical Arrangement of canal fall small hydropower development



Reservoir Based Hydropower Development

Pumped-storage:



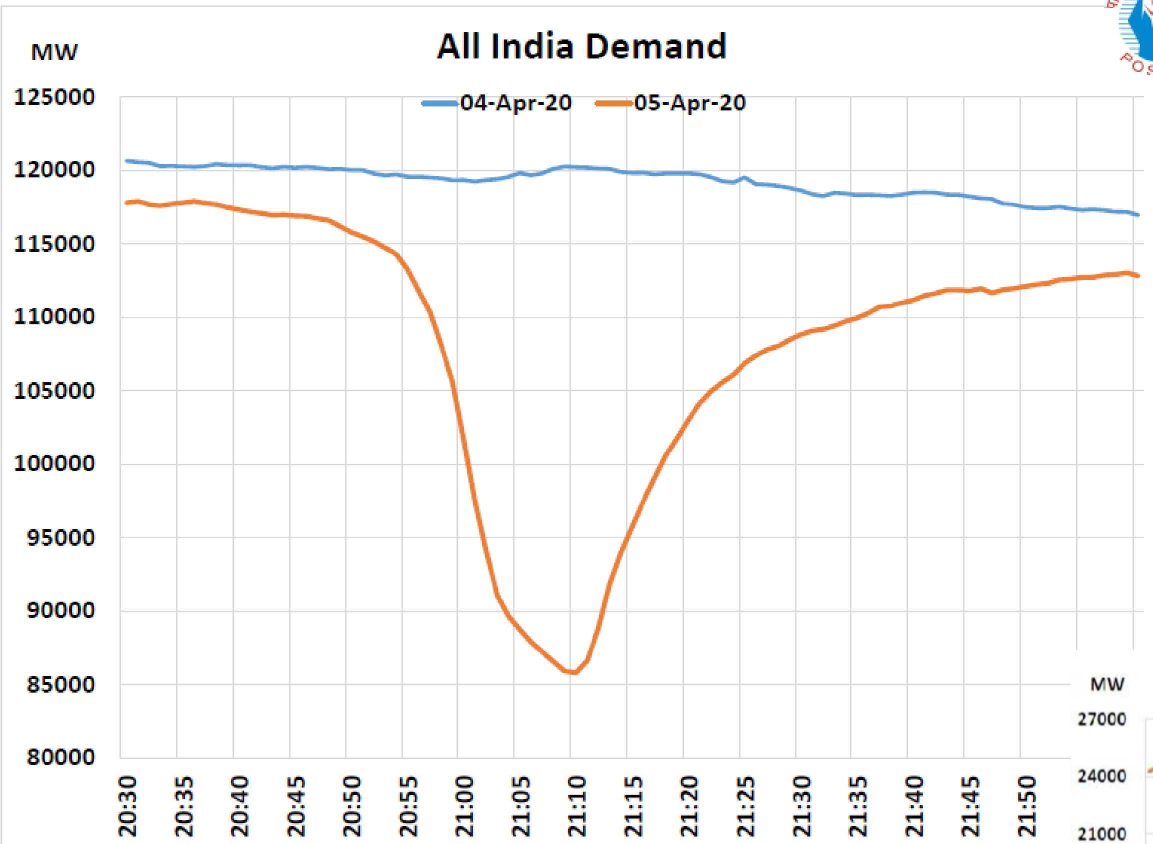
(Source: IEA)

Pump Storage Development

PUMP STORAGE PLANT – 1000 MW

CROSS SECTION THROUGH WATER WAY

Hydro storage – support on April 05, 2020 for 31 GW drop and ramping

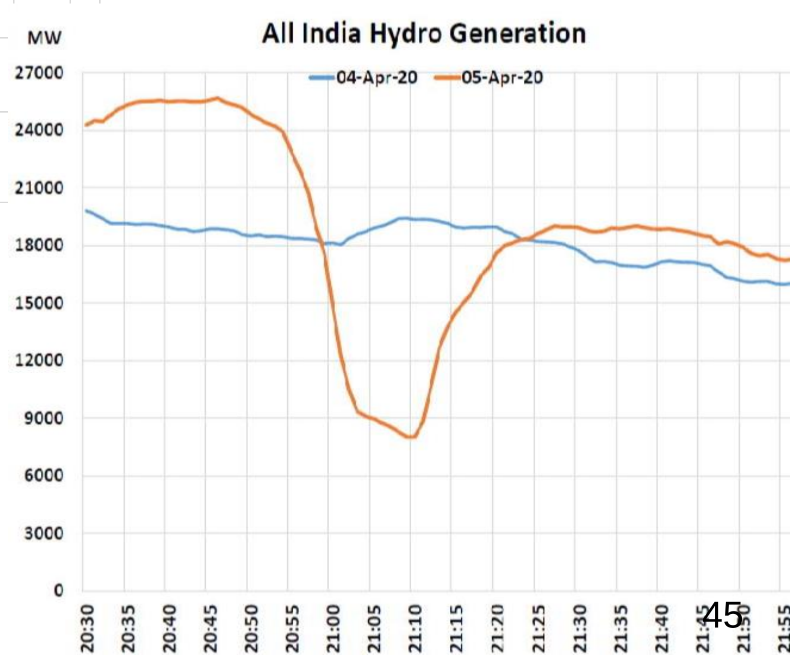


POSOCO

Residential lighting load to go off suddenly at 9:00 pm and come back at 9:09 pm as per PM call

Hydro alone supported a reduction of 18 GW (20:45- 2110) out 31 GW reduction

Ramped up by 11 GW (21:10-21:27) to meet rising power demand



Andhra Pradesh IRESP: Layout

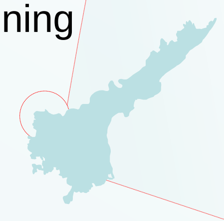
Project details and illustrative site layout (Andhra Pradesh)

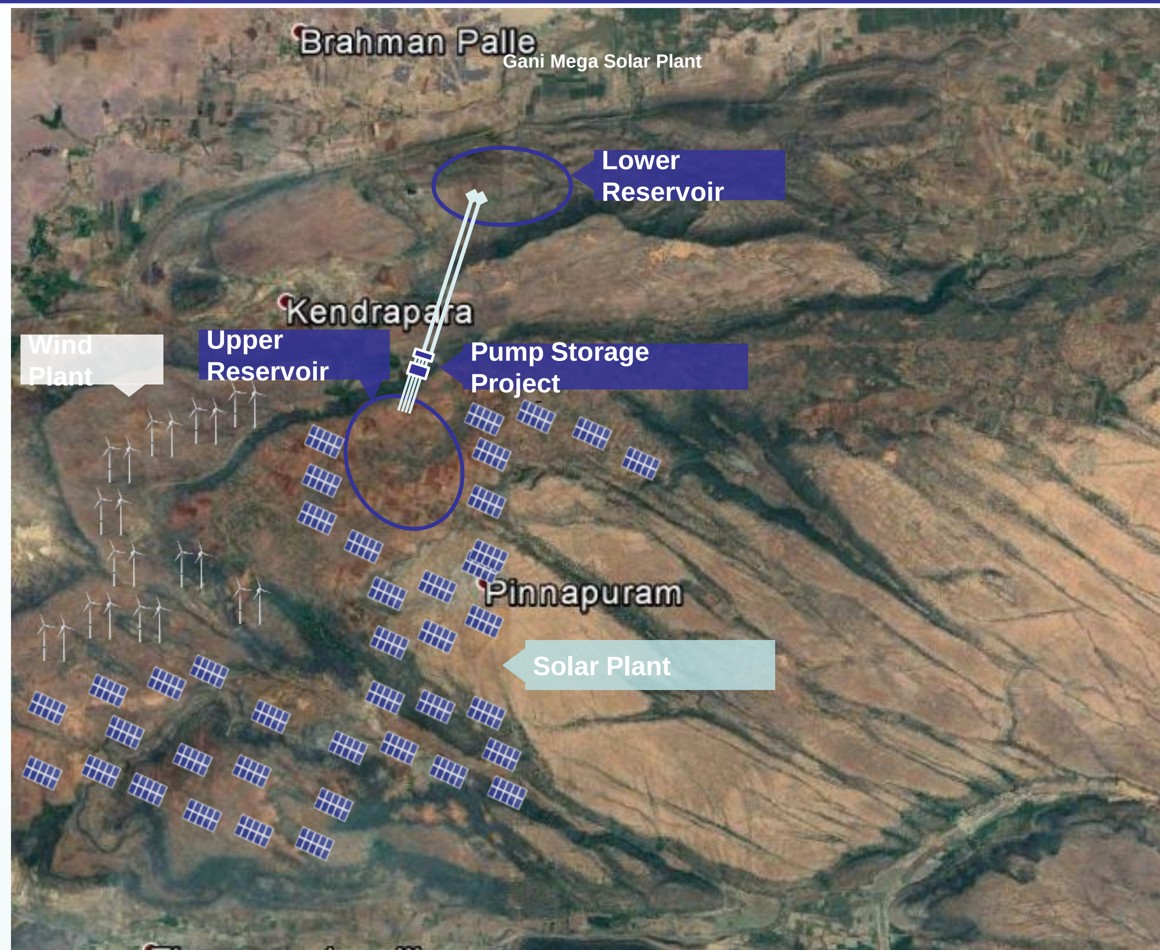
Location

1200 MW PSP in near Kurnool, Andhra Pradesh

Details for Round the clock (RTC) project

- Solar + Wind: 3500MW
- Storage: 1200 MW
- Key Features:
  - Caters to RTC, Fixed and Peak Power requirements
  - Commissioning by 2022





Source: Greenco

Ultra Low Head (Below 3 m)

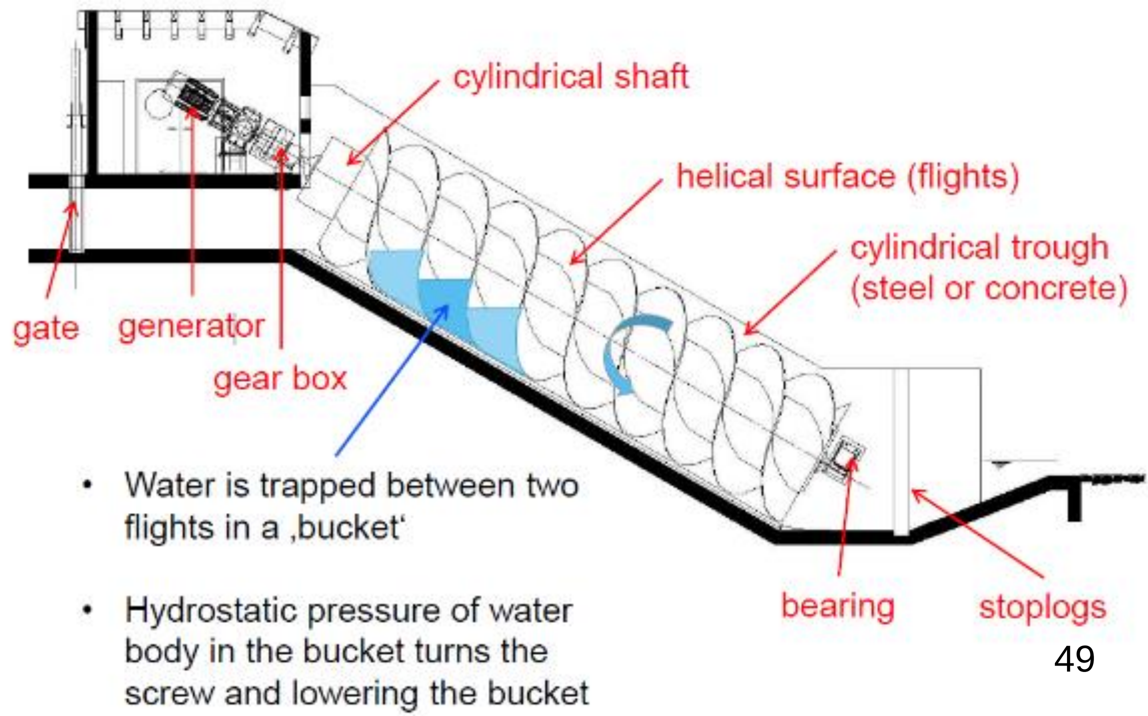
- Abundant potential of ultra low head available
- Not much work done on survey of ultra low head sites
- Dearth of economic viable low head turbines.

(archmedies screw, vortex, cross flow, very low head, belt, kinetic and steam etc are available)

- Ultra low head hydro power in micro range has large number of sites in the country on irrigation canal falls, outfalls of sewage/drainage, industrial channels etc.
- Water mills/Gharats with ultra low head micro range size available in the hilly state are suitable for such installation

Archimedes screw

18.5 kW using 50 MLD of Kabitkhedi STP Indore Municipal Corporation (IMC) on BOOT basis for 25 years



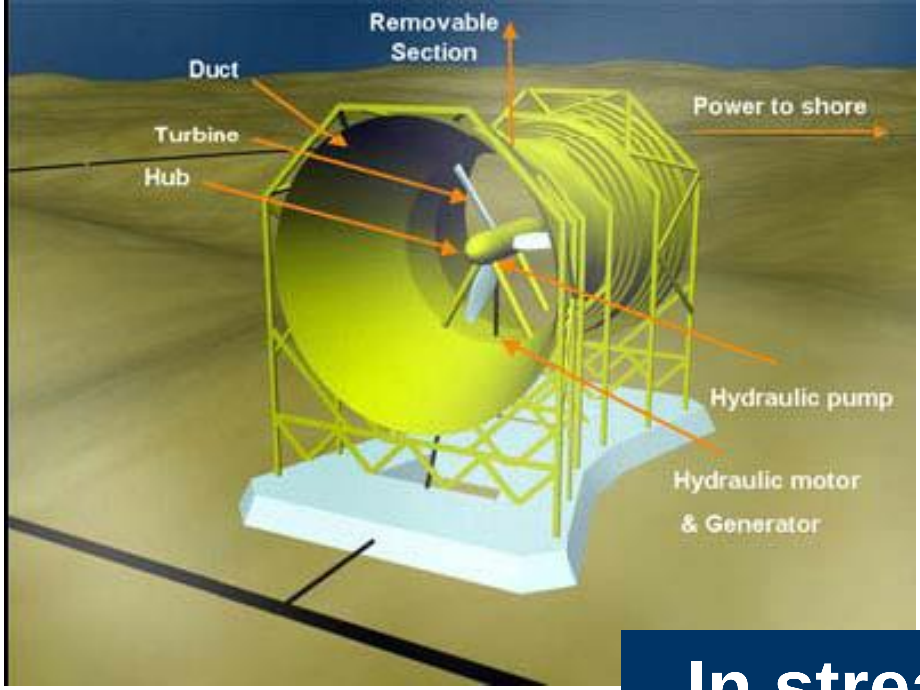
Stream Diver

Steff turbine Turbines

- Head: 2.5 m and above
- Discharge: 0.2-0.8 m^3/s
- Power Output: 5-20 kW
- Efficiency: ~80 %

Chilla Power Channel 2 x 25 kW installed in 2011 and withdrawn in 2012 for new design

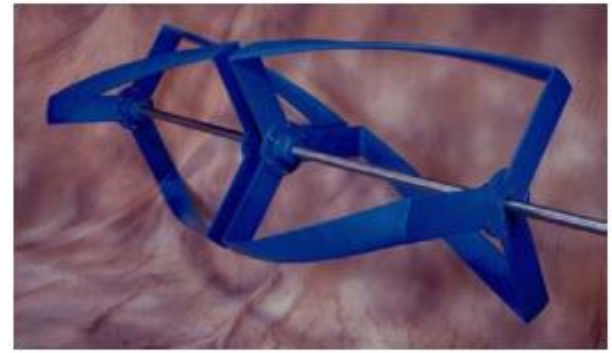
Vortex Turbine



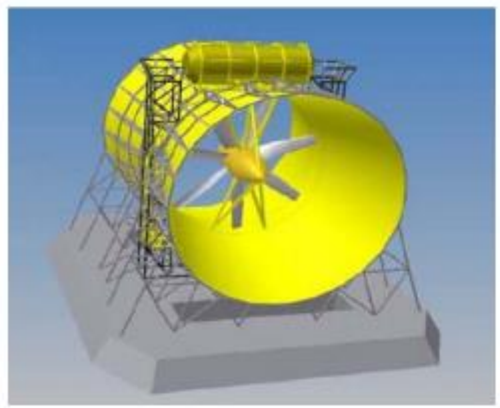
In stream hydro

Different Devices

Open Hydro Rim Drive Turbine

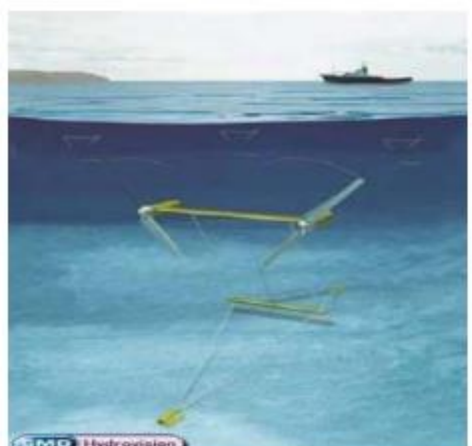


Gorlov Helical Turbine



Lunar Energy RTT Turbine

MCT Experimental SeaFlow



SMART HYDRO POWER

Low Maintenance Hydrokinetic River Turbine Design

WHY SHP In Developing Countries

- The majority SHP have been used to mini grids and remote (often mountainous) areas as well as for grid-based power generation
- Village-scale mini grids can serve hundreds of households in settings where there are sufficiently clustered end-users

Most village-scale mini grids have been developed in Asia on the basis of small hydro, particularly in China, Nepal, India, Vietnam and Sri Lanka where they are often also powering small industries that provide substantial local income and jobs.

SHP plays a very important role in hydro power development, especially in remote off-grid communities

Prospects for technology improvement and innovation

- Variable speed technology
- Fish-friendly turbines
- Hydrokinetic turbines
- Abrasive resistant turbines
- Tunnelling technology
- Dam technology
- Optimization of operation
- Resource Assessment, Planning & Design
- Good controls

Barriers to SHP Development

- Technical Barriers
- Institutional Barriers
- Financing Barriers
- Financing Barriers
- Social barriers
- Difficulty in Getting Clearances from Different Departments

Possible solutions to Barriers to SHP Development

- **Capacity development is the key to success for scaling up of SHP programme** *for planning, oversight, and monitoring; training to all project developers, facilitators, financial institutions and community members; adopting the standard equipments and designs*
- Upfront public financing
- Encouraging higher participation of private sector
- Continued support R& D in several areas
- Clarity in Policies and regulations
- Setting up and enhancing institutions capacity

Barriers to small hydropower development in SAARC countries

- **Afghanistan** micro- to small hydropower is mostly used in rural areas.

  Absence of important data, limited technical human resources capacity and limitations of the grid in terms of geographic coverage and operational synchronization. Lack of funding, instable political situation.

- In **Bangladesh**, high installation costs, the lack of interest from the private sector in hydropower due to flat terrain.

- In **Bhutan**, costly compared to larger hydropower projects and, hence, have not been prioritized. The lack of an enabling environment, feed-in tariffs.
- **India** vary from state to state, depending on the availability of discharge data, site, feasibility reports and clearances. These barriers include the long process of obtaining project licences, clearances, permissions and finances; the lack of awareness and legal tools with state governments to regulate minimum flows in the streams; the lack of power evacuation infrastructure; the continuous increase in capital costs of SHP projects.
- **Nepal** lacks clear and supportive policies and a regulatory framework limitations on bank financing, poor access to infrastructure or power evacuation lines, young geology and high sedimentation rate.

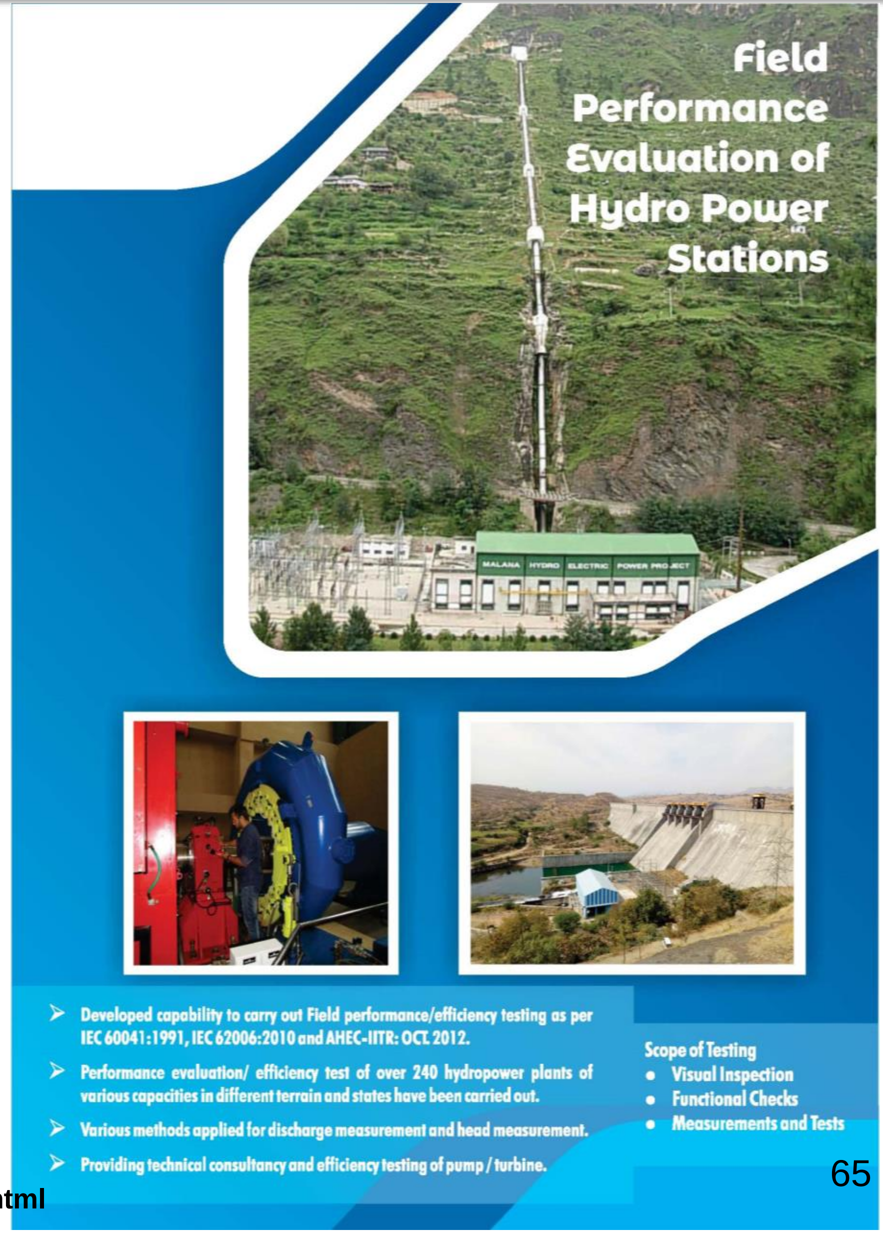
- **Pakistan** is promising but have some barriers due to the limited interest from local manufacturers to develop low cost electrical and mechanical equipment for SHP, limited availability of financing taking longer for clearance.
- **Sri Lanka** legal issues in power purchase agreements, the absence of a dedicated transmission, limitations for adding more SHP to the grid; and the absence of a well-equipped monitoring system to ensure environmental compliance by operational plants.
- **Myanmar** has total potential is 231 MW for SHP plants up to 10 MW with over 300 potential sites and has installed capacity in SHP as 36.4 MW.

About HRED, IIT Roorkee

- IIT Roorkee established in 1847 has 8000+ students and 500 faculty.
- An academic department of Indian Institute of Technology Roorkee, set up in 1982.
- Imparts education, training and research and development related to small hydro, other renewable energy sources and environmental management of water bodies
- Research Projects/assignments sponsored by different governments/ institutions including Ministry of New and Renewable Energy, Ministry of Environment and Forests and National Mission for Clean Ganga

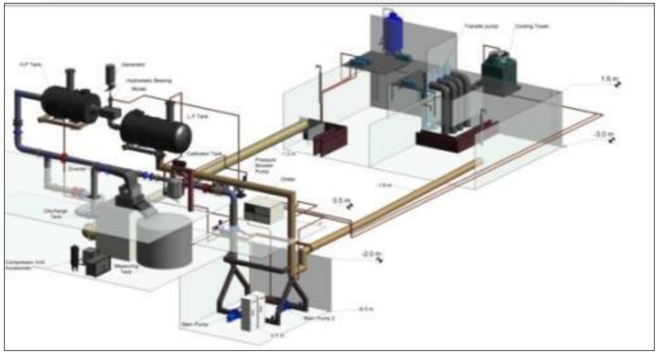
Performance Evaluation of Hydro plants Since 2004 onwards

- Field measurement of flow in penstocks, channel, rivers
- Efficiency measurement for hydro turbine
- Performance testing of control and protection equipment
- Performance evaluation/ efficiency test of over 240 hydropower stations of different capacities in different terrain and states using different methods of discharge measurement and head measurement.



https://hre.iitr.ac.in/departments/HRE/pages/Labs+Instrumentation_Lab.html

R&D HYDRAULIC TURBINE LAB at HRED



- IEC-60193 and ISO 17025
- NABL accredited
- research & development
- turbine-model testing,
- human resource development (HRD)
- generation of design data
- design validation through CFD analysis
- Third party evaluation

First independent facility in the region

- Head 15-60 m and discharge upto 950 lps
- Building 15 x 24 m height +13.5 to – 6.5 m
- Water storage 300 cubic m

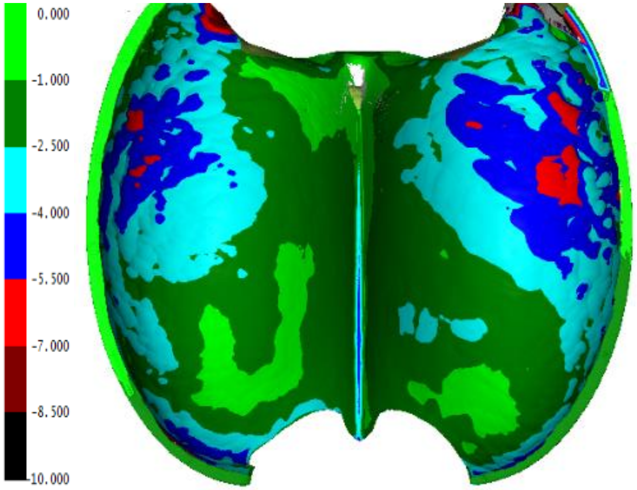
- Laboratory was inaugurated in April 2018
- Turbine Manufacturers and project developers are taking benefits of the lab.

https://hre.iitr.ac.in/departments/HRE/uploads/brochures/Hydraulic_Turbine_Lab_Brochure_Nov_2020.pdf

Sediment Monitoring and Impact Analysis Laboratory

- Laboratory for sediment monitoring and impact analysis studies in hydropower plant is under establishment.

- to be a depository of silt data and online monitoring of silt flow for all hydropower stations experience gained by different power utilities and manufacturers
  - Online Turbidity Sensor and Suspended Solids
  - Laser Diffraction sediment sensor,
  - Acoustic based sediment measurement,
  - Digitizer for quantifying shape and size
  - High speed camera system



https://hre.iitr.ac.in/departments/HRE/uploads/brochures/Sediment_Lab_Brochure_Nov_2020.pdf

Real-Time Digital Simulator (RTDS) for Hydropower Plant

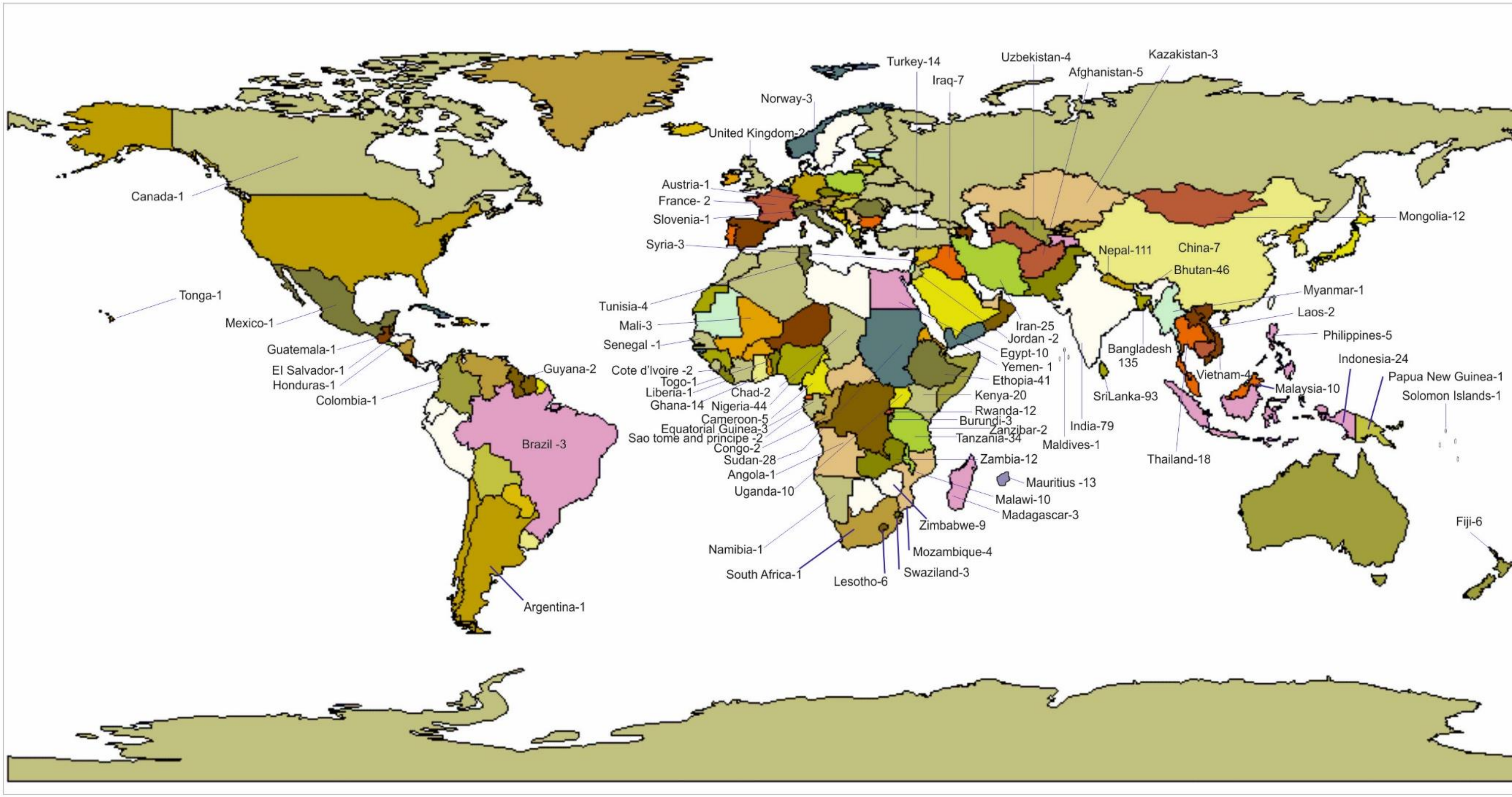
Department of Hydro and Renewable Energy

Commissioned in 2007

https://hre.iitr.ac.in/departments/HRE/pages/Labs+Real_Time_Digital_Simulator_Lab.html

Number of Participants attended the International Training Courses on SHP Development Organised by AHEC,IIT Roorkee

1999 Onwards



AHEC/Oct. 2018

ENVIRONMENTAL MANAGEMENT OF RIVERS AND LAKES

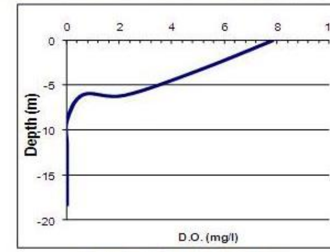
MAJOR ADVISORY SUPPORT PROVIDED IN UTTARAKHAND

- Conservation and Management Plan for Nainital Lake, Bhimtal, Naukuchia Tal, Sat Tal and Khurpa Tal in Nainital District.
- Conservation Measures: Planned and designed, vetted
- Plan and Design of Artificial Lake at Champawat
- Status Paper on River Ganga: State of Environment and Water Quality
- Review of proposals for River Pollution abatement through sewage treatment and sewer network of Muni ki Reti and Chamoli -Gopeshwar.

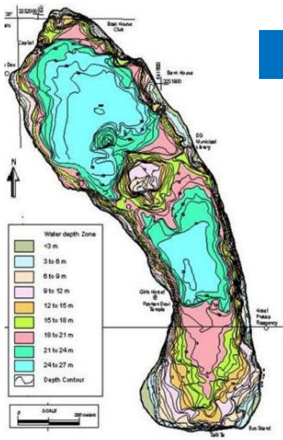
NAINITAL LAKE 2011

NAINITAL LAKE 2007

Variation in dissolve Oxygen with depth with controlled aeration

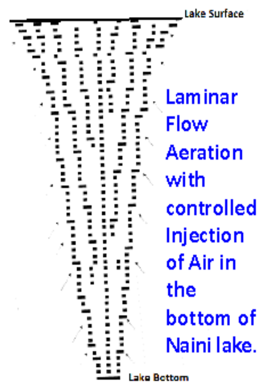


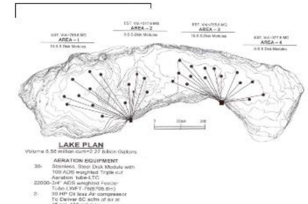
2007 Before Aeration

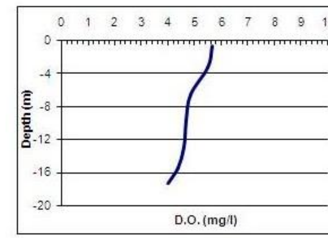


Interventions outside Lake

- Slope stabilisation
- Drainage line treatment
- Strengthening and protection the outlet / nallah from lake
- Sanitation around the lake
- Shoreline development
- Institutional development
- Management of Sewage
- Management of Municipal Solid wastes







Oct 22, 2007 After Aeration

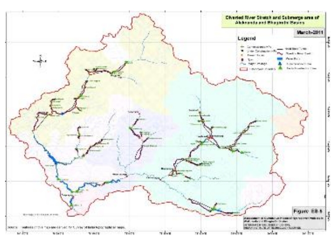
Interventions within Lake

- Oxidation at the bottom of the lake without disturbing thermal stratification through controlled aeration.
- Control fish Gambusia affinis by putting minnow traps.
- Renovation of outflow slucies.
- Regular monitoring of water quality.

Status Paper on River Ganga

- Cumulative Impacts of Hydropower Projects on River Alaknanda and Bhagirathi

HP Type	TOTAL No. of HP	Installed Capacity (MW)	Generating Units (MU)
COMMISSIONED			
Large	4	1,794	7,542
Small	9	57	319
Total	**13**	**1,851**	**7,860**
ONGOING CONSTRUCTION			
Large	7	2,469	10,273
Small	7	69	454
Total	**14**	**2,538**	**10,727**
UNDER PREPARATION			
Large	16	3,843	15,310
Small	26	801	3,206
Total	**42**	**4,644**	**18,516**
TOTAL			
Large	27	8,106	33,125
Small	42	927	3,978
Total	**69**	**9,033**	**37,103**



Main Recommendations:

- Variable Environmental Flow (EF) to be released.
- Regular flushing of beds at barrages
- Sufficient gap between two consecutive projects for river recuperation
- Construction of fish passes at barrages
- Regular collection of data on Valued Ecosystem Components to ensure sustainability
- Adaptive management and regular monitoring

A two year M.Tech Programme on "Environmental Management of Rivers and Lakes" and organizes training programmes

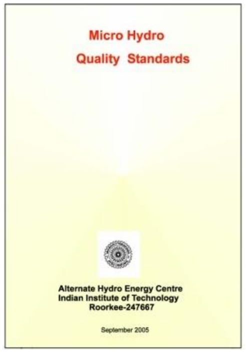
SUPPORT PROVIDED TO ENVIRONMENTAL MANAGEMENT OF OTHERS RIVERS AND LAKES INCLUDING PREPARING GUIDELINES

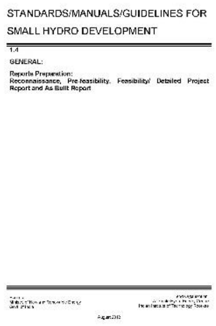
- Conservation and Management Plan for Dal and Nagin Lakes in J&K
- Conservation and management Plan for Kailana Lake (Jodhpur) and Gadisar Lake (Jaisalmer) Rajasthan
- Mangement Plan for Daya and Kuakhai River in Bhubneshwar, Orrisa and River Kshipra, Ujjain, Madhya Pradesh
- Reviewed Project Proposals of lakes of Hussain Sagar (Hyderabad), Kodaikanal (TN), Sukna (Chandigarh), Pushkar, Gapsagar, Goverdhann Sagar, Gundovlav Talab, Jaisagar, Kushal, Rajasamand, Sambhar, Sujan Ganga and Udai Sagar of Rajasthan

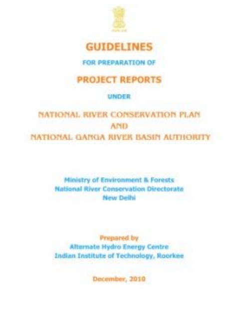
- Prepared Guidelines for Ministry of Environment & Forests, GoI
- Preparation of project reports under National River Conservation Plan and National Ganga River Basin Authority
- Guidelines for National Plan for Conservation of Aquatic Ecosystems

STANDARDS/GUIDELINES FOR SMALL HYDRO

- Standards/Guidelines and manuals are useful for developers, manufactures, consultants, regulators etc.
- AHEC prepared 27 standards to boost the development of this sector. Also available on website.
- Also prepared standard for environmental management of rivers and lakes


Micro Hydro
Quality Standards
Alternate Hydro Energy Centre
Indian Institute of Technology
Roorkee-247667
September 2005


STANDARDS/MANUALS/GUIDELINES FOR
SMALL HYDRO DEVELOPMENT
GENERAL:
Reports Preparation:
Reconnaissance, Pre-feasibility, Feasibility/ Detailed Project Report and As Built Report


GUIDELINES
FOR PREPARATION OF
PROJECT REPORTS
UNDER
NATIONAL RIVER CONSERVATION PLAN
AND
NATIONAL GANGA RIVER BASIN AUTHORITY
Ministry of Environment & Forests
National River Conservation Directorate
New Delhi
Prepared by
Alternate Hydro Energy Centre
Indian Institute of Technology, Roorkee
December, 2010


GUIDELINES
NATIONAL PLAN FOR CONSERVATION OF AQUATIC ECOSYSTEMS (NPCA)
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE
NATIONAL RIVER CONSERVATION DIRECTORATE
GOVERNMENT OF INDIA
February, 2015

Indian Parliament Commends AHEC'S Contribution

- *Extract from 16th Report of the Standing Committee on Energy (2010-2011) on Small and Mini Hydel Projects Presented to Lok Sabha as well as Rajya Sabha on 18th March 2011.*

Recommendation no. 12: "Committee would therefore recommend that AHEC, IIT Roorkee should work as a premier institution in the development of small hydro technology in the country paving the way for economic and efficient development of the technology and be a torch bearer for other technological institutes. The Committee also recommend that the **Ministry should strengthen the AHEC and provide all support in encouraging it to boost the research and development activities in the small hydro sector**".

- *Extract from 13th Report of the Standing Committee on Energy (2015-2016) on Development and Status of Small Hydro Sector Presented to Lok Sabha as well as Rajya Sabha on 14th March 2016.*

Recommendation no. 15: "The Committee feel that AHEC, IIT Roorkee, is a premier institution in the development of small hydro technology in the country paving the way for economic and efficient development of the technology and hence should be provided all support in encouraging it to boost research and development activities in the small hydro sector. The Committee, therefore, **recommend that the Institution may be strengthened with regard to their capacities and resources, both human and financial, and it should be made a guiding star for the sector with sufficient technical, financial and functional support and autonomy**".

Thank you