CEDREN

Centre for Environmental Design of Renewable Energy

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

0.1.27
Renewable Energy Respecting Nature

Indo-Norwegian seminar
Mumbai, India, 7-8 May 2013

CEDREN - Centre for Environmental Design of Renewable Energy: Forskning for teknisk og miljøriktig utvikling av vannkraft, vindkraft, overføringslinjer og gjennomføring av miljø- og energipolitikk. SINTEF Energi (vertsinstitusjon), NINA og NTNU er hovedforskningspartnere, med en rekke energibedrifter, norske og internasjonale FoU-institutter og universiteter som partnere.

Finansieres av Forskningsrådet, energiselskaper og forvaltning gjennom ordningen med forskningssentre for miljøvennlig energi (FME).
FME-ordningen består av tidsbegrensede forskningssentre som har en konsentrert, fokusert og langsiktig forskningsinnsats på høyt internasjonalt nivå for å løse utpekte utfordringer på energi- og miljøområdet.

Trondheim, 7 June 2013

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Norges teknisk-naturvitenskapelige universitet (NTNU)

Laboratorium for ferskvannsøkologi, Universitetet i Oslo
Norsk institutt for vannforskning (NIVA)
Uni Research AS

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Energi Norge
International Centre for Hydropower (ICH)
Norsk Hydro Produksjon AS
Sira-Kvina kraftselskap
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Direktoratet for naturforvaltning (DN)
Norges vassdrags- og energidirektorat (NVE)

Content

CEDREN
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RENEWABLE ENERGY RESPECTING NATURE
Indo-Norwegian seminar, Mumbai, India 7-8 May 2013
Hotel Trident Bandra Kurla, C-56, G Block, Bandra Kurla Complex

Tuesday 7th May

09.30 – 10.00 Registration

Opening session:
10.00 – 10.15 Welcome and opening address
Ms. Ligia Noronha, Executive Director, TERI, India
10.15 – 10.30 Opening address
Prof. S. P. Gupta, Deputy Director IIT Roorkee, India
10.30 – 10.45 Opening address
Mr. Eivind S. Homme, Norwegian Ambassador to the Republic of India
10.45 – 11.15 Indo-Norwegian research collaboration
Mr. Bjørn Tore Kjellemo, Deputy Director / Ms. Tone Ibenholt, Special Advisor
The Research Council of Norway (RCN), Norway
11.15 – 11.30 Questions and discussions

11.30 – 12.30 Lunch

Technical session I: Renewables and their integration in the energy system
12.30 – 12.45 Enhancing renewable energy integration with hydropower
Prof. Ånund Killingtveit, NTNU and Deputy Director, CEDREN, Norway
12.45 – 13.00 Potential and challenges for wind power development in India
Dr. Jami Hussain, Chief Mentor and Co-founder, WinDForce Management Services, India
13.00 – 13.15 Offshore wind technology
Dr. Adil Rasheed, Research Scientist, Norwegian Research Centre for Offshore Wind Technology (Nowitech),
13.15 – 13.30 Environmental impacts of wind power and mitigation
Dr. Kjetil Bevanger, Senior Research Scientist, NINA and CEDREN, Norway
13.30 – 13.45 Smart Grid deployment opportunities and challenges in India
Mr. V. S. K. Murthy Balijepalli, Research Scholar, Indian Institute of Technology Bombay
13.45 – 14.00 Smart grid trends, opportunities, challenges and R&D efforts in Norway
Dr. Vijay Venu Vadlamudi, Postdoctoral Fellow, The Norwegian Smart Grid Centre

14.00 – 14.30 Tea/coffee break

14.30 – 14.45 The role of small hydro in the Indian energy system
Dr. Arun Kumar, Professor, Indian Institute of Technology, Roorkee, India
14.45 – 15.00 The Norwegian renewable industry
Mr. Geir Elsebutangen, Managing Director, Norwegian Renewable Energy Partners (INTPOW), Norway

teri
intpow
Norwegian Renewable Energy Partners
The Research Council of Norway
INNOVATION NORWAY
NORWEGIAN EMBASSY

15.00 – 15.15 Development of solar power in India
Mr. Shirish S. Garud, Senior Fellow, TERI, India
15.15 – 15.30 Renewable energy – Power exchange in India
Mr. Girish Rane, Regional Manager, Western Region, Indian Energy Exchange
15.30 – 15.45 Renewable energy respecting nature and people – addressing the acceptance challenge
Dr. Helene Egeland, Research Scientist, SINTEF and CEDREN, Norway
15.45 – 16.00 Renewable energy for energy access
Mr. Vivek Jah, Fellow, TERI, India
16.00 – 16.15 Tea/coffee break

16.15 – 17.45 Roundtable: R&D challenges in renewable energy
At the end of the discussion, important knowledge gaps would be defined.

18.00 Business event followed by dinner in collaboration with Innovation Norway/Norwegian Embassy/INTPOW/RCN

Wednesday 8th May

Technical session II: Hydropower
09.30 – 09.50 Hydropower development in India- Status and issues
Dr. Praveen Saxena, Advisor, Small Hydro Power, MNRE, India
09.50 – 10.10 Future hydropower development in India
Mr. Lars Ellegaard, Head, SN Power, India (tbc)
10.10 – 10.30 Hydropower in the Himalaya region
Ms. O. R. Lalitha , Vice President, GMR Consulting Services, India
10.30 – 10.50 Hydropower in the Himalaya region
Mr. M. M. Madan, Director and Head, Hydro Power, GVK Group, India
10.50 – 11.10 Environmental design of hydropower
Mr. Atle Harby, Director, CEDREN, Norway
11.10 – 11.30 IPP perspective of hydropower development
Mr. Amulya Charan, Chief Mentor, Tata Power Company Ltd., Mumbai, India
11.30 – 11.45 Climate change and hydropower
Prof. Ånund Killingtveit, NTNU and Deputy Director, CEDREN, Norway
11.45 – 12.00 Annual estimates of GHG emissions from a tropical reservoir in India: case study
Ms. Swati Kawade, PhD student, IIT Roorkee. India
12.00 – 12.15 Tea/coffee break

12.15 – 13.30 Roundtable: R&D challenges in hydropower development
At the end of the discussion, important knowledge gaps would be defined.

13.30 – 14.30 Lunch and end of seminar

Organized by Centre for Environmental Design of Renewable Energy (CEDREN) in collaboration with:	
TERI-The Energy and Resources Institute	Intpow - Norwegian Renewable Energy Partner
Indian Institute of Technology Roorkee	Innovation Norway
The Research Council of Norway	The Royal Norwegian Embassy in India

Forskningsrådet

INDIA – NORWEGIAN RESEARCH COLLABORATION
Renewable energy seminar
Mumbai, May 7 2013

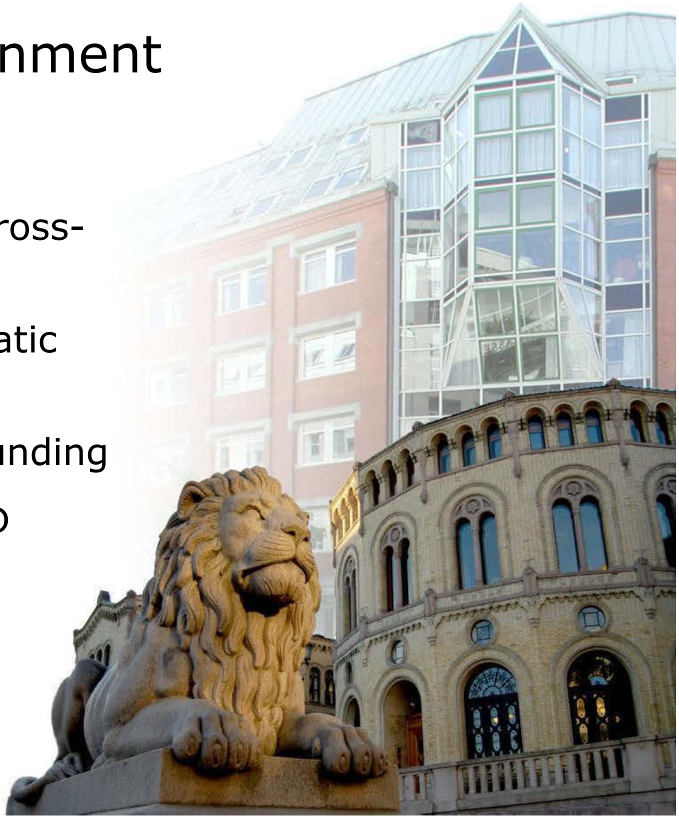
Director Bjorn T. Kjellemo
The Research Council of Norway

Norway is a significant energy provider

- The second largest exporter of natural gas in the world
- The sixth largest exporter of oil
- Europe's biggest producer of hydropower
  - 99% of electric power in Norway comes from hydropower
- Energy research

The Research Council of Norway

- Adviser to the government
- Funding agency
  - All disciplines as well as cross-disciplinary research
  - Implement national thematic priorities
  - 30 per cent of all public funding
  - Incentives for private R&D
- Networking
- Internationalization



The Research Council of Norway's international strategy 2010-2020

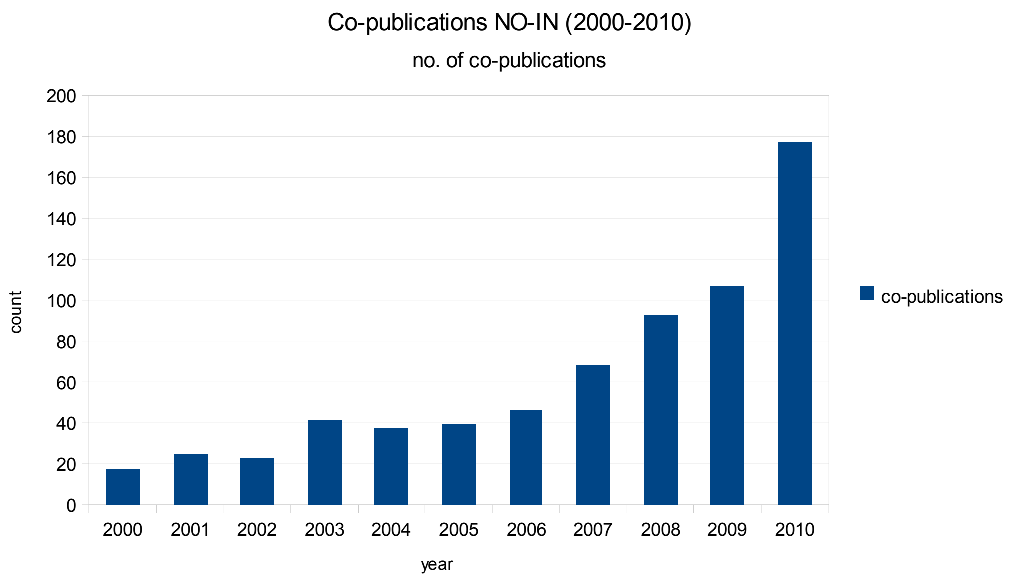
Why:
Quality and relevance
Global challenges
What:
Participation in FP7, Horizon 2020
Bilateral cooperation with a selected group of countries
Mainstreaming of international cooperation in thematic programmes

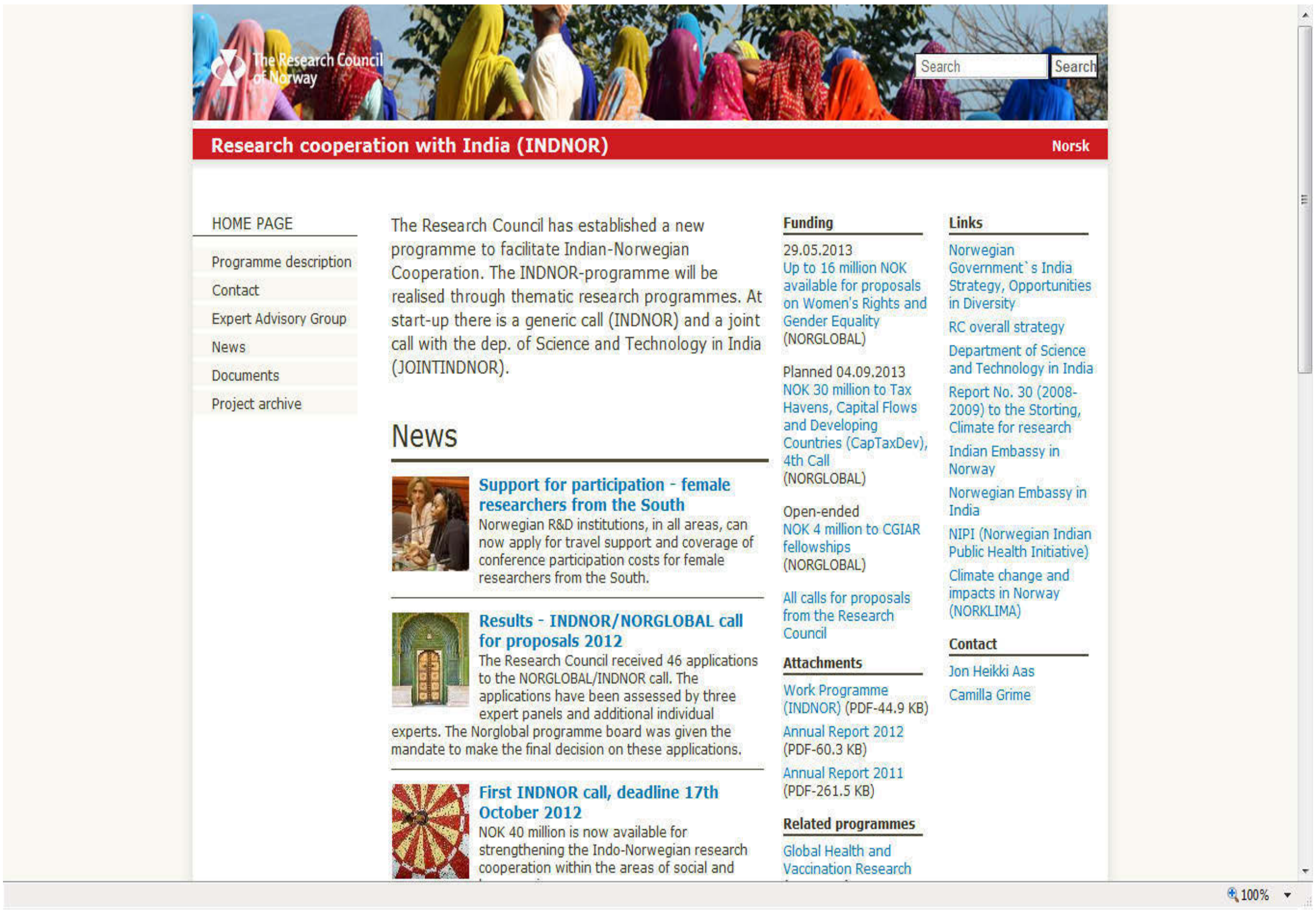
Research collaboration between India and Norway

- Science and Technology Agreement 2006
  - Joint Working Group – biannual meetings
  - Programme of Cooperation 2012-2014
- Funding bilateral collaboration
  - Indnor-programme from 2010
  - Cooperation with Norwegian embassy in India
- Participation in EU-India cooperation
  - New Indigo – multilateral calls
  - EU Strategic Forum on International Cooperation (SFIC)

(1) Total numbers

- Scientific co-publications with Norwegian and Indian participation between 2000 and 2010
- Overall: 672 co-publications





Forskningsrådet

Visit us at:

www.rcn.no

Contact us:

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The Research Council of Norway

Climate-friendly energy research in the Research Council of Norway

Tone Ibenholt
Special Adviser, The Research Council of Norway

Meeting the climate challenges – energy research in RCN

- Environment-friendly management of the country’s energy resources
- A highly reliable energy supply
- Internationally competitive industrial development related to the energy sector.

- Political attention has resulted in:
  - Increased R&D programme budgets
  - New Research Centers – FME

The Research Council of Norway

RCN's main instruments for energy R&D

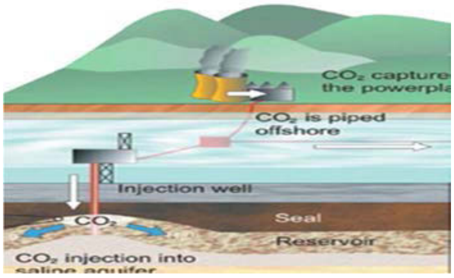
- **ENERGIX** (45 mill EUR annually)

  Renewable energy and energy efficiency

- **CLIMIT** (12 mill EUR annually)

  CO_2 Capture and Storage

- **Centres for Environmentally friendly Energy Research** (20 mill EUR annually)



Forskningsrådet

The ENERGIX-programme will generate new knowledge and solutions for:

Energy policy, society and economics

Renewable energy
- Hydropower
- Wind and marine energy
- Solar energy
- Bio energy

Energy systems
- Energy infrastructure
- Battery
- Hydrogen
- Bio fuel

Efficient use of energy
- Building
- Industry
- Transport

New concepts

Three types of projects

Innovation Projects for the industry

- Level of innovation and potential for value creation for industrial partners
- **Applicants industrial companies or groups of companies**
- Cofinancing from industry – minimum 50%

- Call to be announced in June with deadline16th October

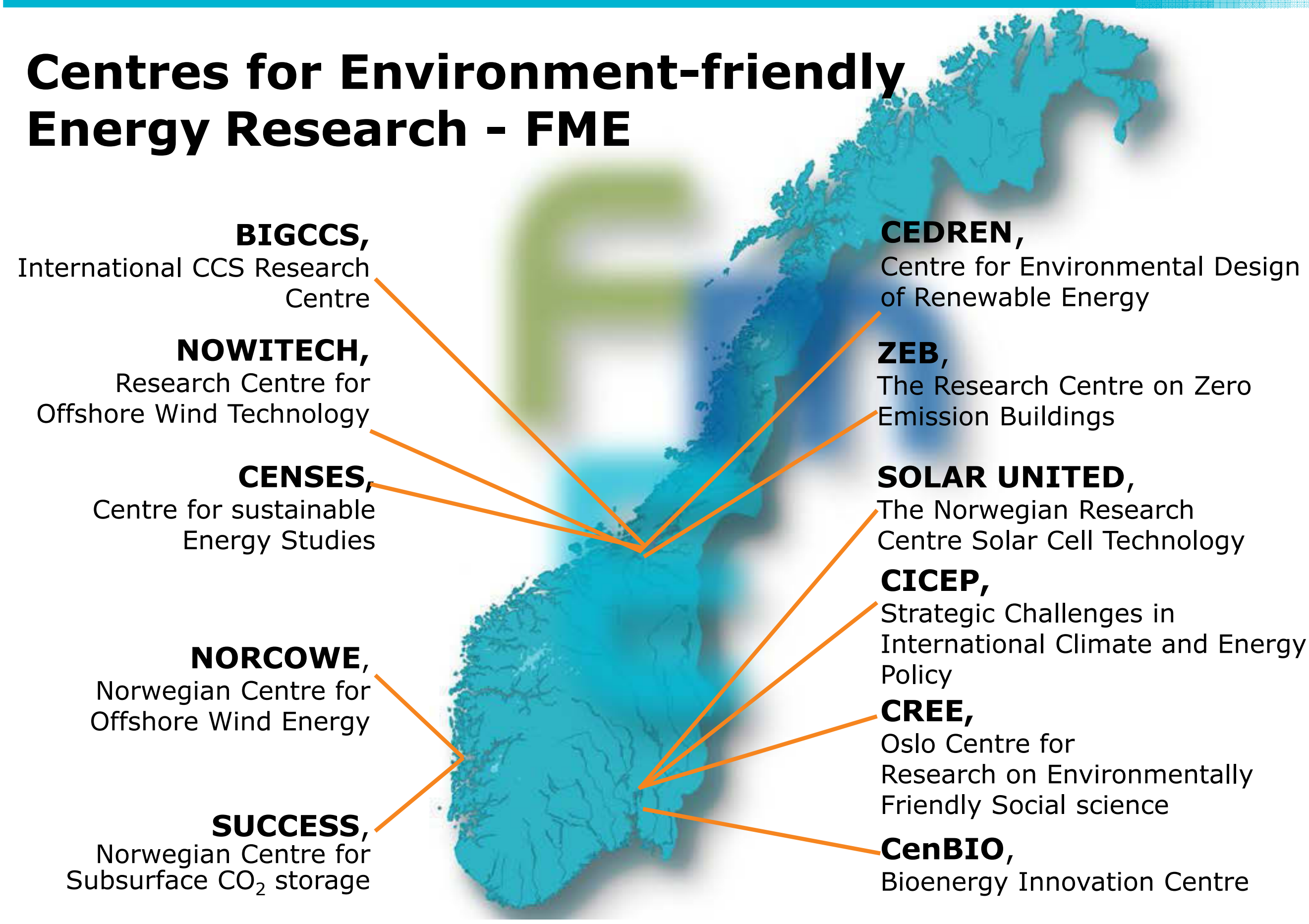
Knowledge-building projects for industry – (KPN)

- Level of research and relevanc and benefit to industry
- Applicants must be **research institution in binding cooperation with industry**
- Cofinancing from industry – minimum 50%

Research projects (RP)

- Scientific merit is the main evaluation criterium
- Applicants must be **research performing institutions**

Centres for Environment-friendly Energy Research - FME



International collaboration

- International collaboration a high priority
  - Strengthen research quality
  - Develop knowledge for solving global challenges
  - Value creation for industry
- Increased budgets for key energy R&D programs offer more opportunities to support projects with international collaboration

The Research Council of Norway

Collaboration with India

- The IndNor-programme: Call on clean energy and CO_2 capture and storage in 2011
- Three ongoing projects
  - Wave Energy: Converters for Combined CleanEnergy and Coastal Protection
  - Geothermal energy: Energy from the lava in Indian Himalayas
  - Geothermal energy and CO2-storage: Fracture and Flow in Porous Media

NewIndigo - ERA net

New INDIGO
Science brings Europe and India closer

New INDIGO is a consortium of European and Indian S&T organisations involved in promoting research cooperation between Europe and India.

- Next call will be on energy resarch, with the thematic areas **«Smart Energy Grids»** and **«New Energy Materials»**
- The call will be launched this week - 8th May, with deadline at 23rd August
- At least one Indian partner and two European partners in each project.

www.newindigo.eu

Enhancing Renewable Energy Integration With Hydropower

Ånund Killingtveit
Norwegian University of Science and Technology (NTNU)
Department of Hydraulic and Environmental Engineering

CEDREN
Centre for Environmental Design of Renewable Energy

Some of the main challenges for the future

- Stabilizing climate impact from fossil fuel use
- Meeting the energy demand of a growing global population
- Bringing electricity to the 1.6 B people without access
- Ensuring stable and secure energy access for all nations
-Transporting electricity long distances
  (from where it is generated to where it is used)

In figures, the challenge for the year 2050 is :
1) energy demand will increase by a factor of two,
2) simultaneously, CO_2 emissions must be reduced by a factor of two

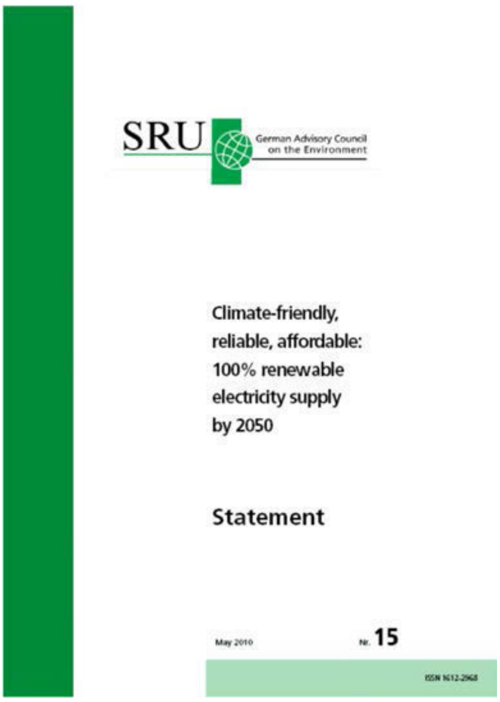
(International Electrotechnical Commission, 2010)

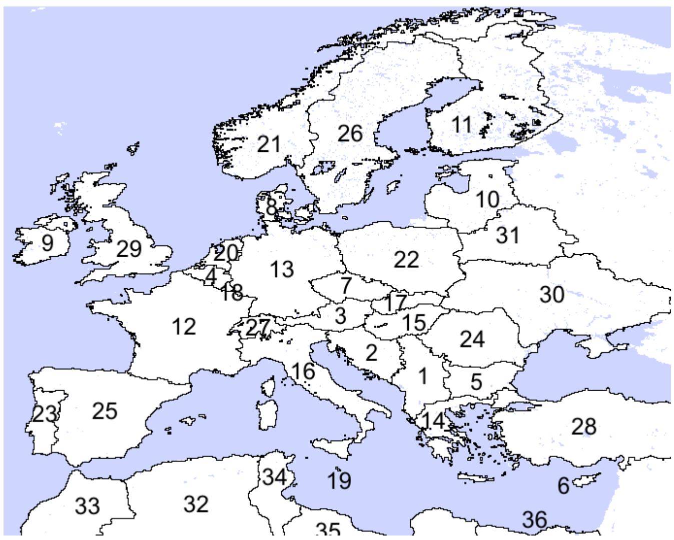
WE NEED TO MOVE FROM FOSSIL TO RENEWABLE ENERGY

Renewable energy may be the future
- But can RE really deliver

- The energy we need
- When we need it
- Where we need it
- With good enough quality??

Climate-friendly 100% renewable electricity supply for Europe by 2050 (SRU, 2010)

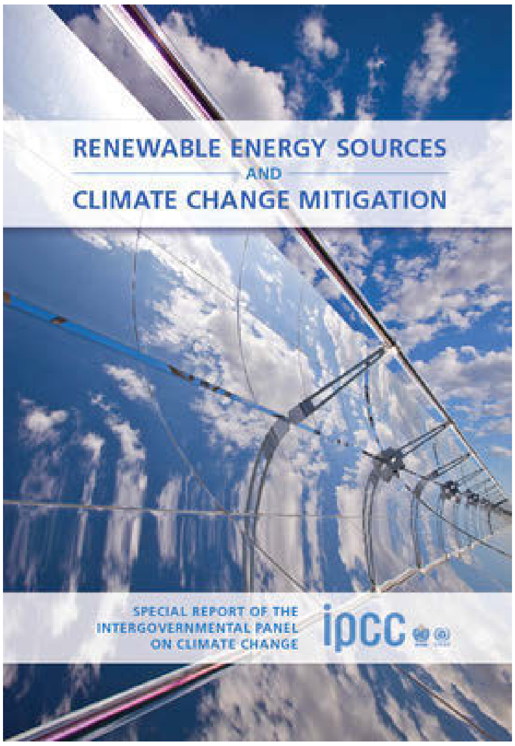




SRU German Advisory Council on the Environment

- **100%** renewable electricity supply for Germany and Europe is possible by 2050 (2030 if needed)
- **The system will mainly be based on wind and solar**
- **Storage and transmission will be crucial**
- **Pumped storage hydro will be in great demand**
- **Norway will become a unique swing provider for the European system due to its hydro resource**
- **We can start with bilateral cooperation**

IPPC Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN, 2011)



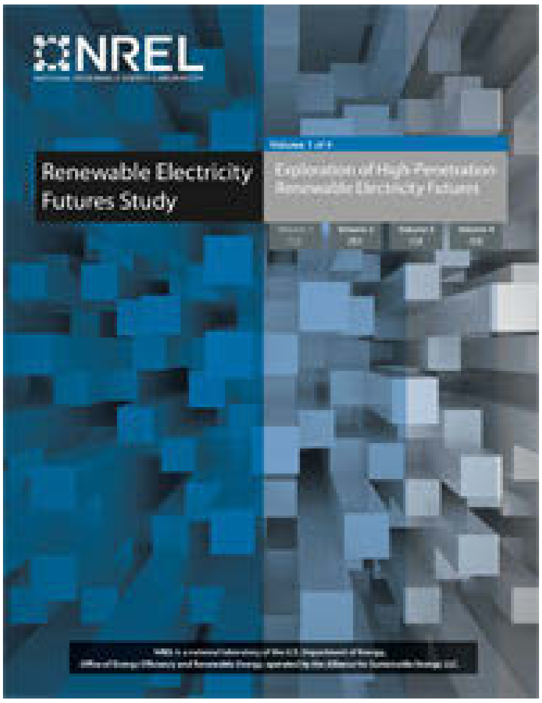
Up to 80% Renewable could be possible If backed by the right enabling policies

The global technical potential of RE sources will not limit continued growth in the use of RE

A wide range of estimates are provided in the literature, but studies have consistently found that the total global technical potential for RE is substantially higher than global energy demand

The technical potential for solar energy is the highest among the RE sources, but substantial technical potential exists for all six RE sources

Renewable Electricity Futures Study (For US) (NREL , 2012)



<u>Key Findings</u>

"Renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050 while meeting electricity demand on an hourly basis in every region of the country"

Conclusions in these and other studies are similar

Large scale RE development is possible with present technology

Three main sources: Wind and Solar + Hydro

Few, if any, fundamental technical limits exist to the integration of a majority share of RE, but advancements in several areas are needed:

- Transmission and distribution infrastructure
- Energy storage technologies
- Demand side management
- Improved forecasting of resource availability

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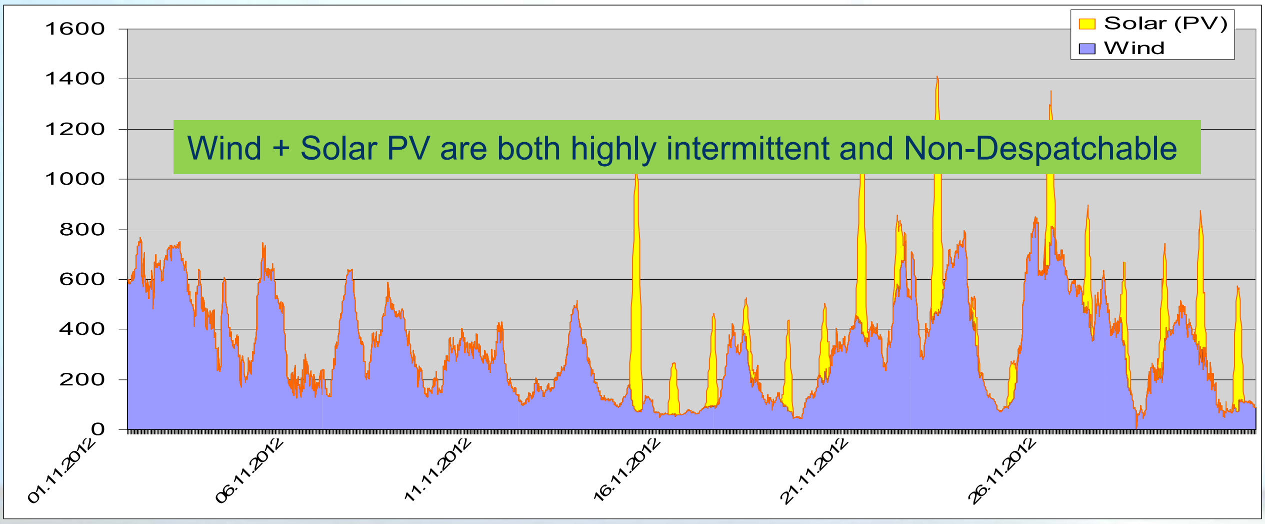
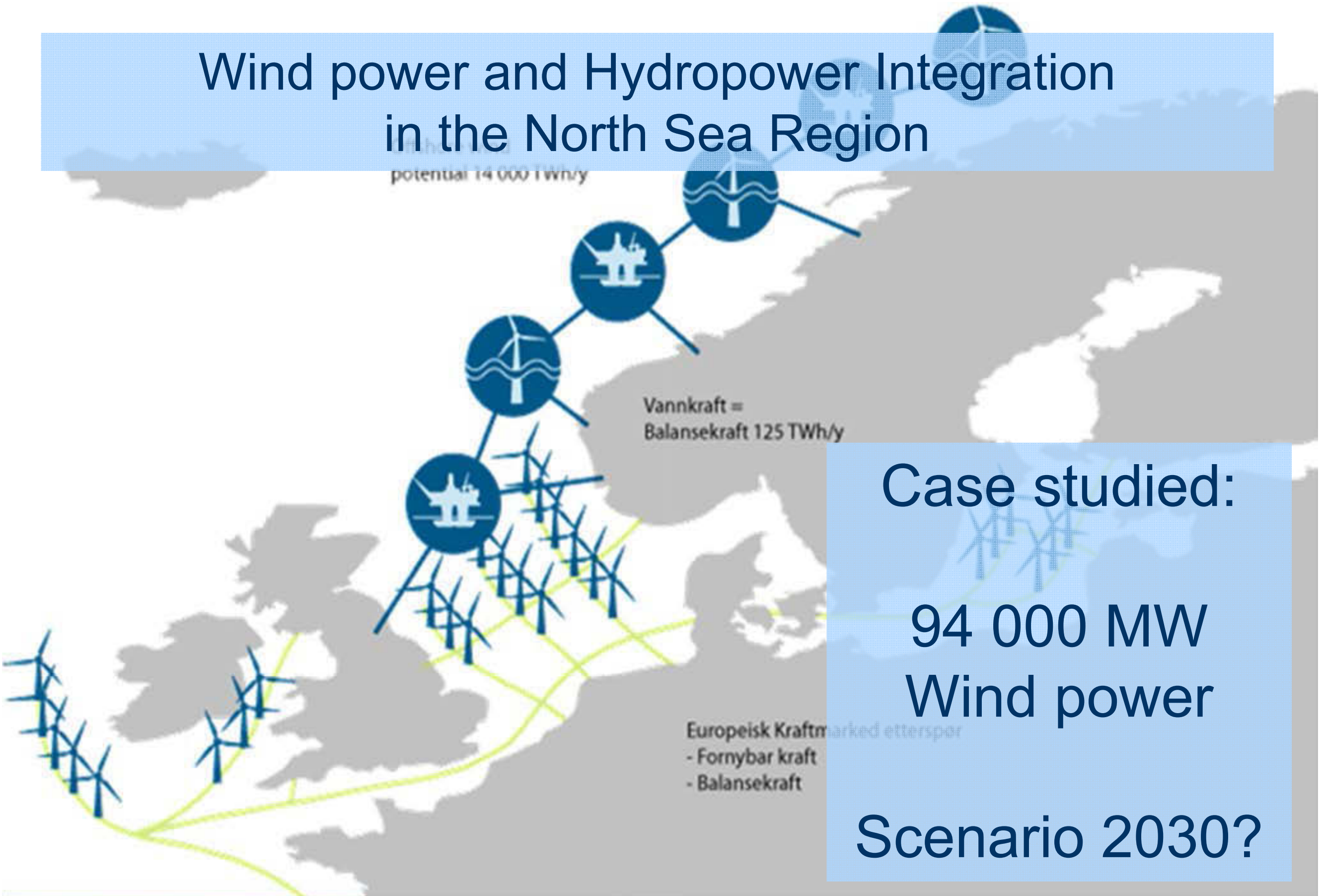
Main problem with
Wind and Solar Power:

- Intermittency
- Highly variable output
- Low predictability
- Non-Despatchable



Wind power and Hydropower Integration in the North Sea Region

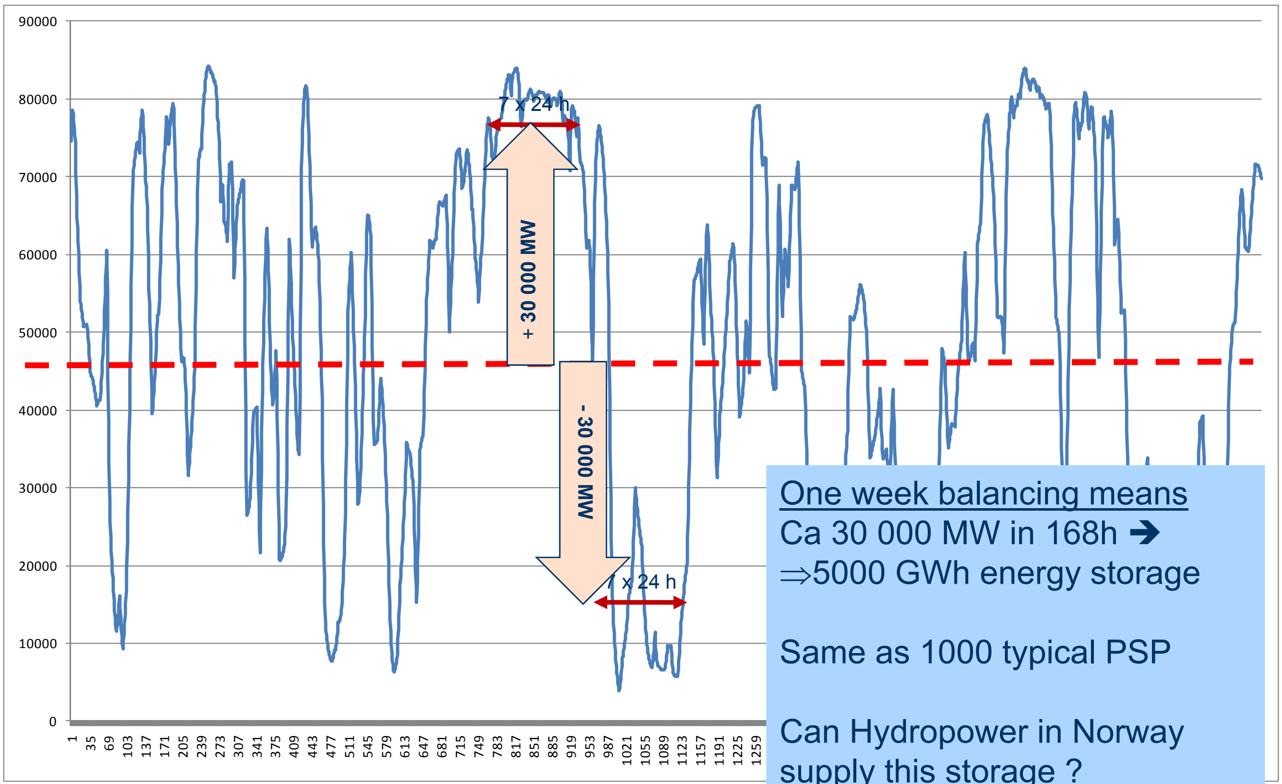


Case studied:

94 000 MW
Wind power

Scenario 2030?

Simulated Wind Power North-Sea Region Jan–Mar 2001

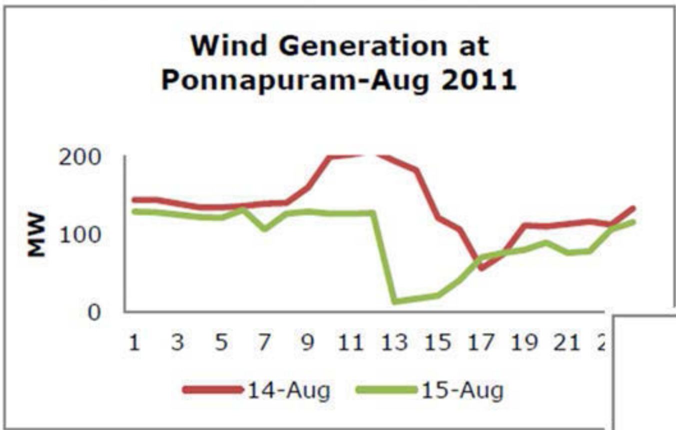


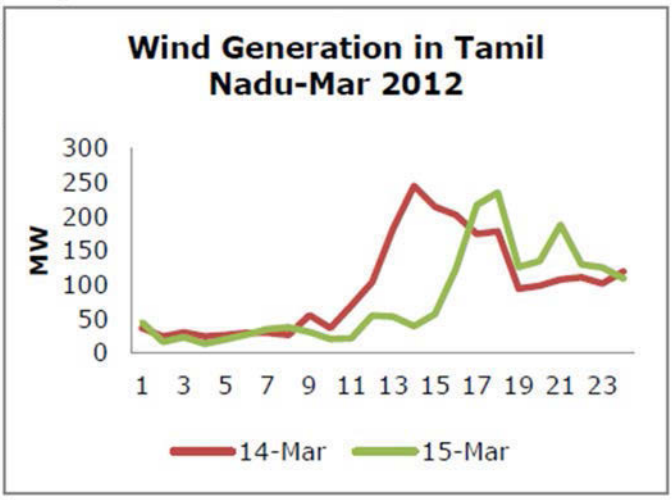
<u>One week balancing means</u>
Ca 30 000 MW in 168h ➔
⇒5000 GWh energy storage

Same as 1000 typical PSP

Can Hydropower in Norway supply this storage ?

Wind Power Output Ponnapuram and Tamil Nadu, India Aug 2011





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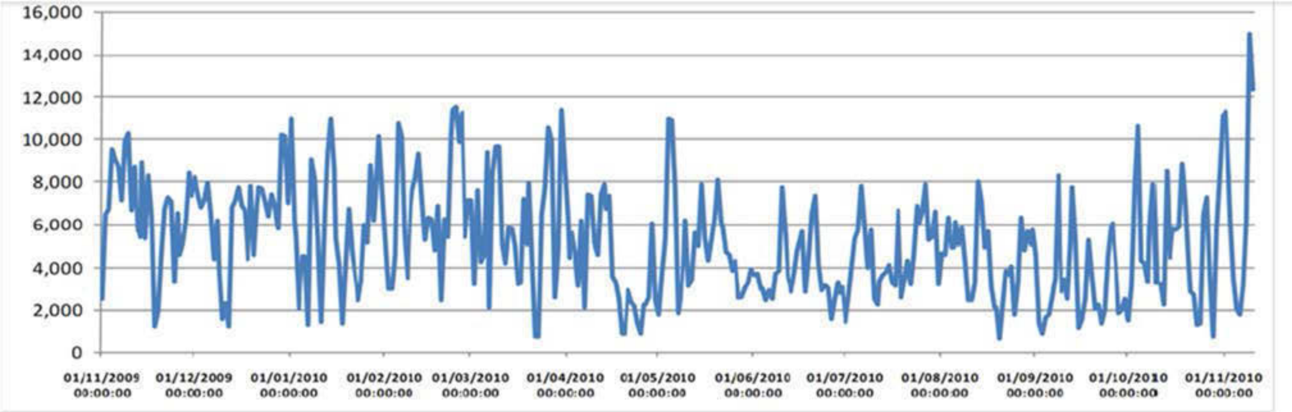
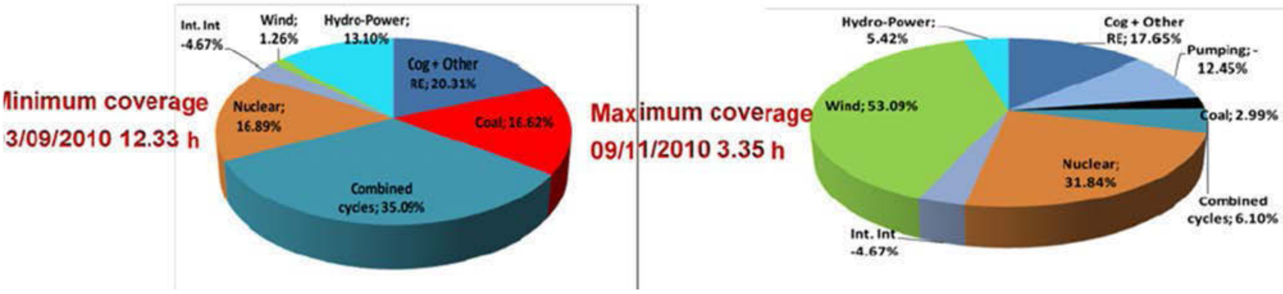
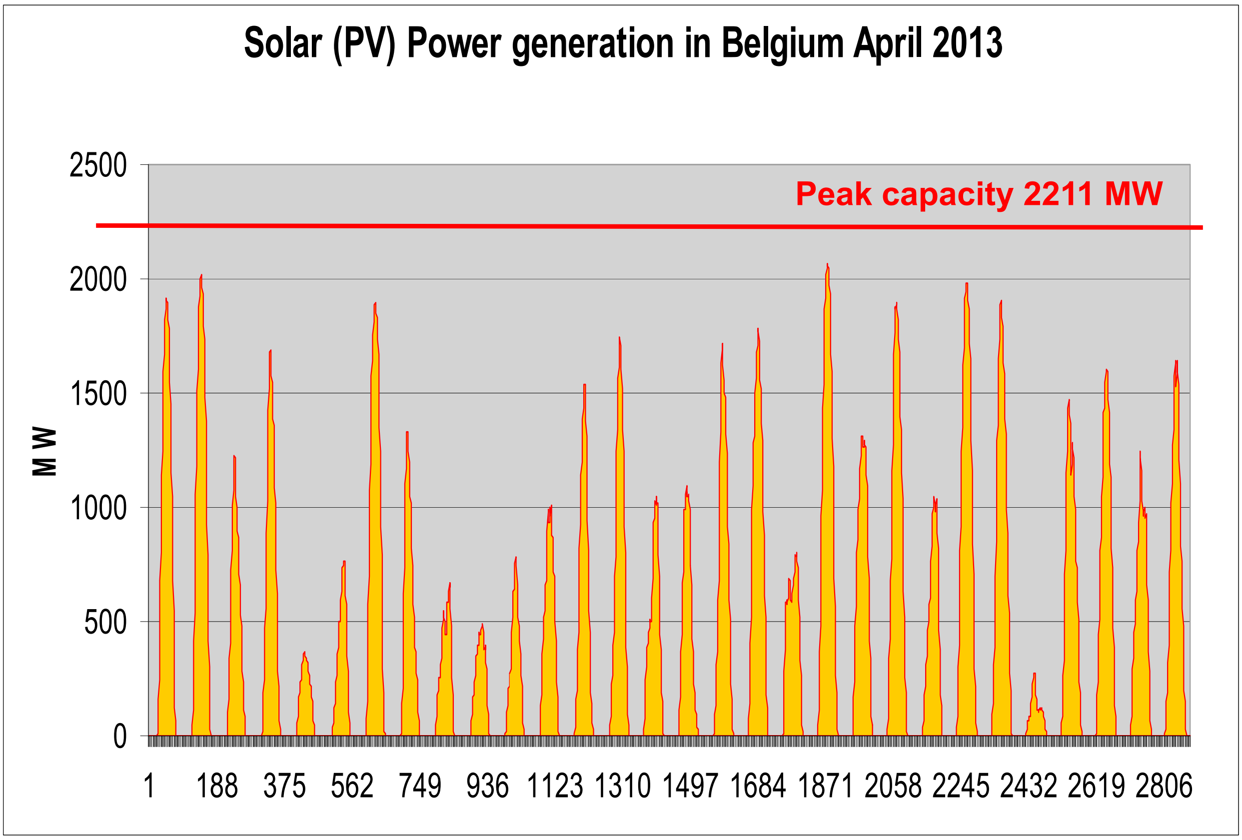
Wind power output (MW) in Spain 2009-2010

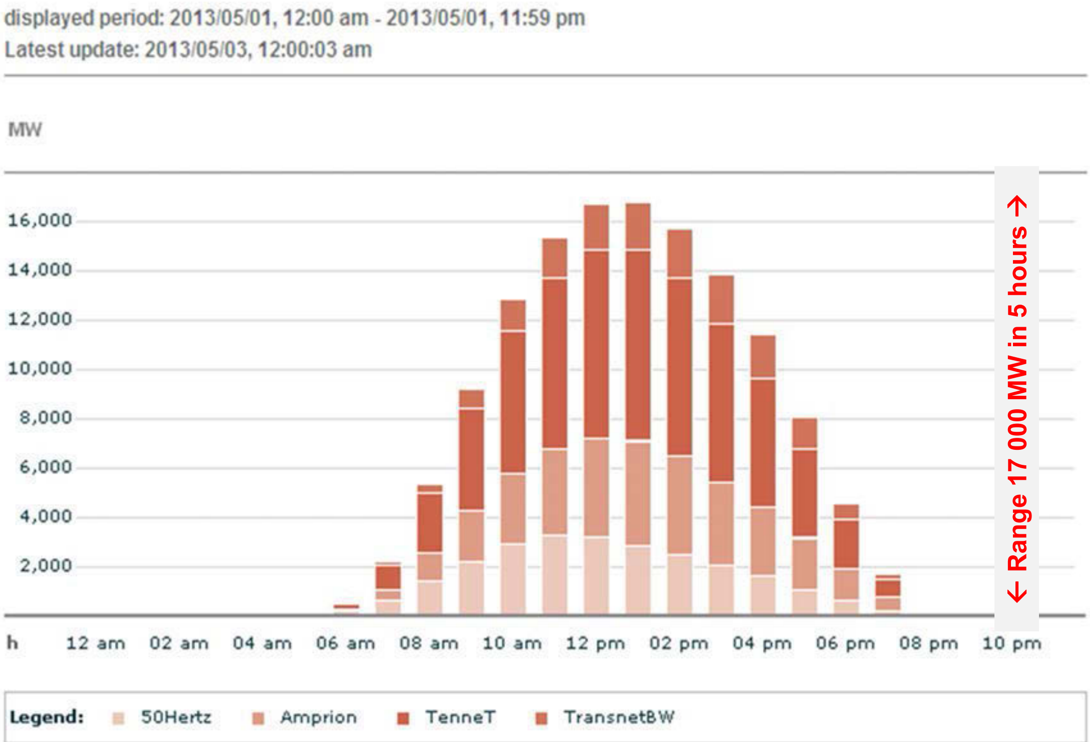




(In 2012: China 76 GW, USA 60 GW, Germany 31 GW, Spain 23 GW, India 19 GW)



Solar energy output (MW) in Germany May 5th 2013



Hydropower - supporting other Renewables

Storage of energy (as water)
- Seasonal
- Daily balancing (PSH)

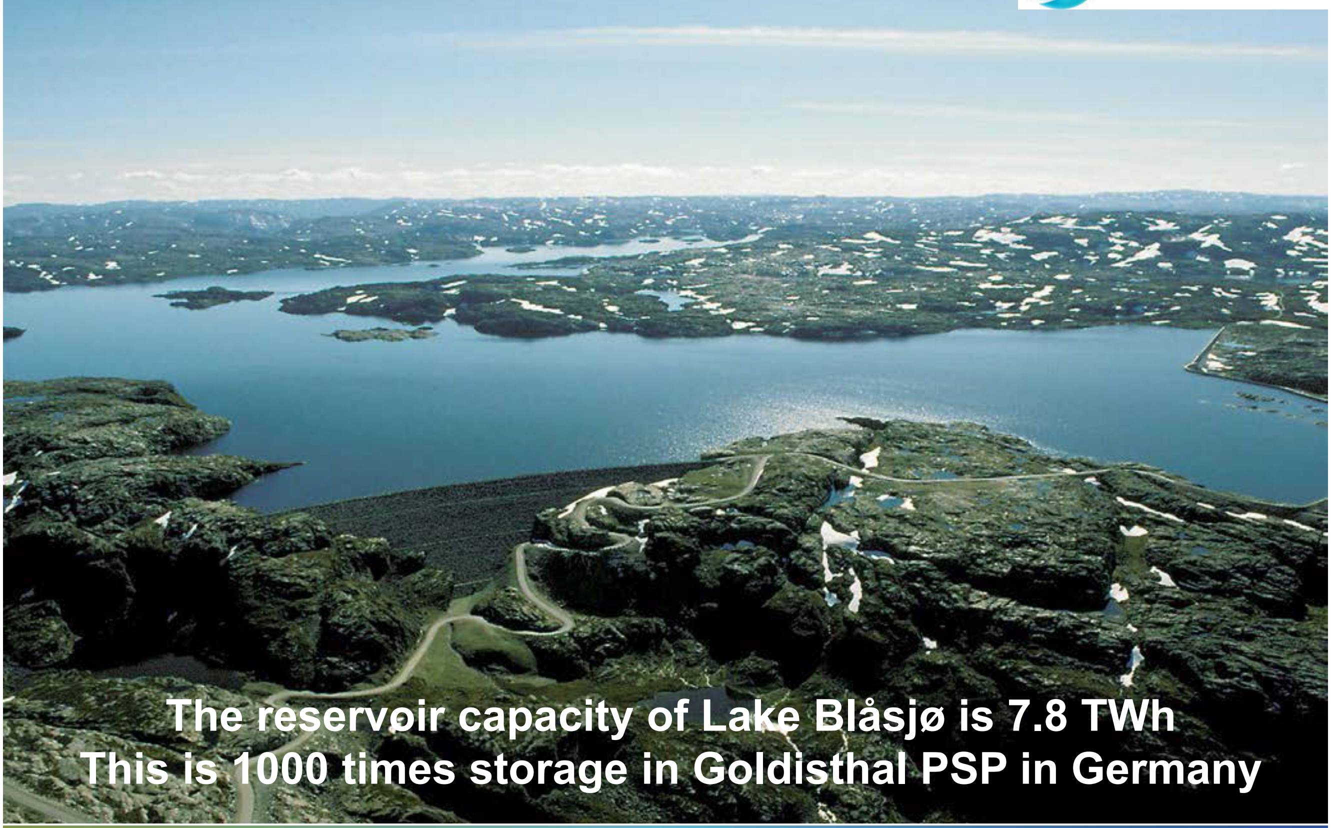
Very fast response time
- Frequency regulation
- Spinning reserves
- Non-spinning reserves
- Voltage support
- Black-start capacity

Important for achieving
- Grid stabilization
- Load balancing
- Storage of intermittent energy (Solar and Wind)

➔ Permitting higher penetration levels for RE

Energy Storage in Seasonal Reservoirs

Statkraft



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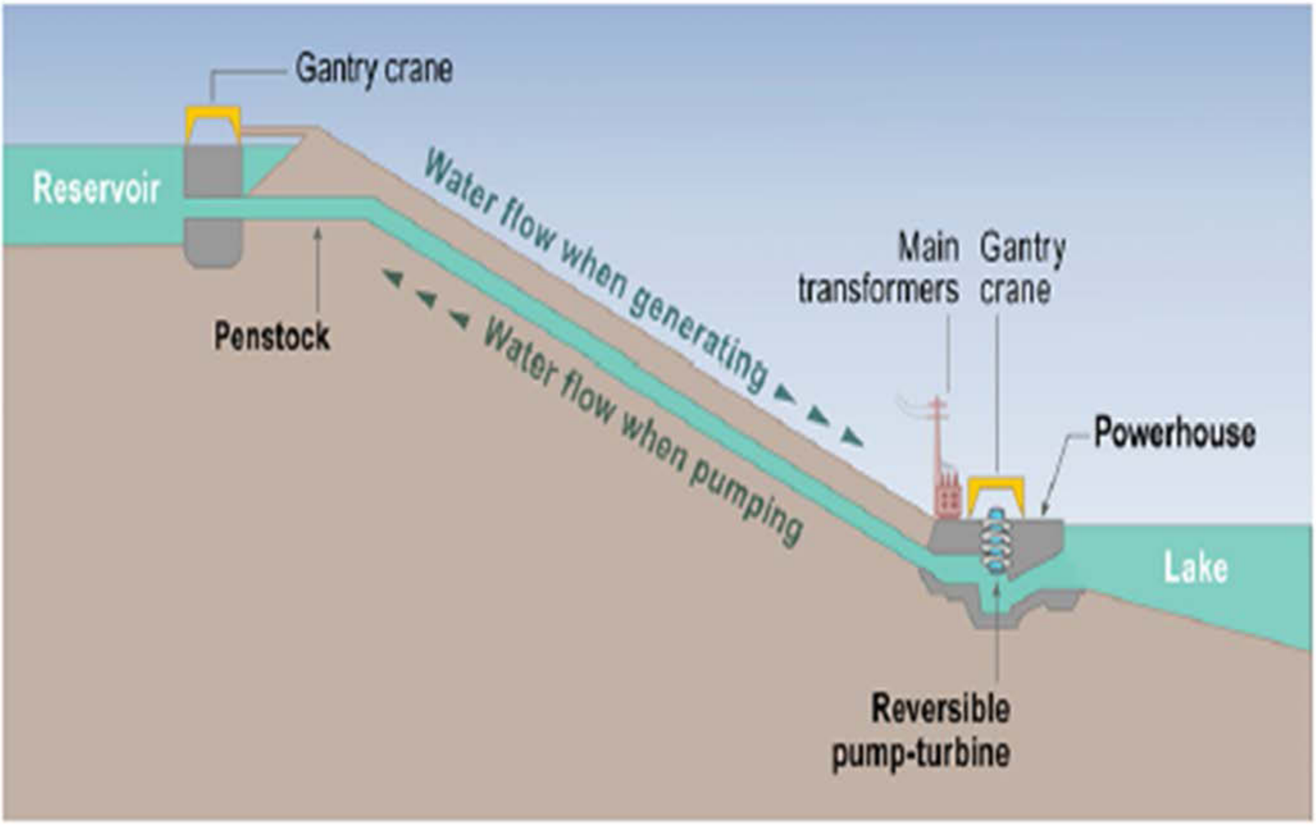
Pumped Storage Hydropower (PSH)

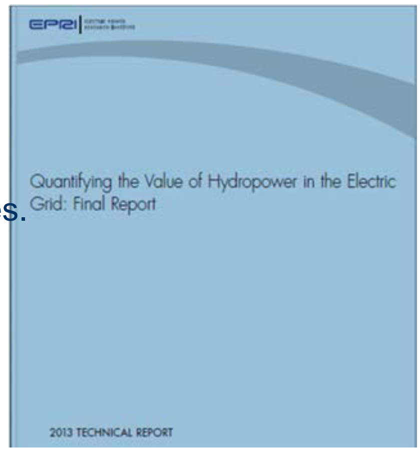


Ten ways to increase the value of Hydropower Assets (EPRI, 2013)

1) Improve plant efficiency while respecting the river system
2) Use Hydro more to address variability and improve other generation
3) Recognize hydro for enhancing energy security and power supply reliability
4) Expand effective operation range for hydro to higher/lower head etc
5) Apply adjustable speed drive electronics in new or existing PSH
6) Design new PSH that minimizes environmental impacts
7) Increase hydro storage energy arbitrage with grid demand load levelling
8) Co-optimize energy and ancilliary services
9) Treat pumped storage as a new storage asset class
10) Credit hydro for its very fast regulation response

Future work should be done on

- Quantify the full value stream of hydropower resources.
- Modelling on shorter time-scales (minutes, secs)
- Better understanding of Hydro's role in supporting a reliable grid
- Preparing the power system for an uncertain energy market future



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For more information –
visit CEDREN at or our web-site

http://www.cedren.no/

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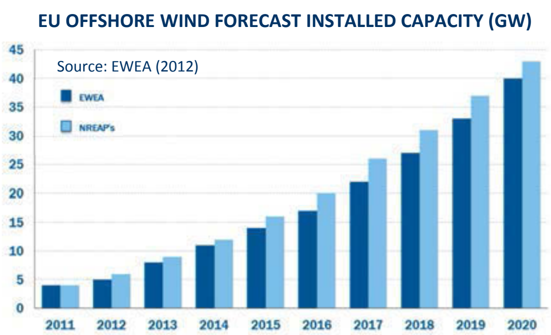
NOWITECH

(Norwegian Research for Offshore Wind Technology)

7th May 2013
www.nowitech.no
Adil RASHEED
Trond KVAMSDAL
John TANDE
SINTEF, Norway

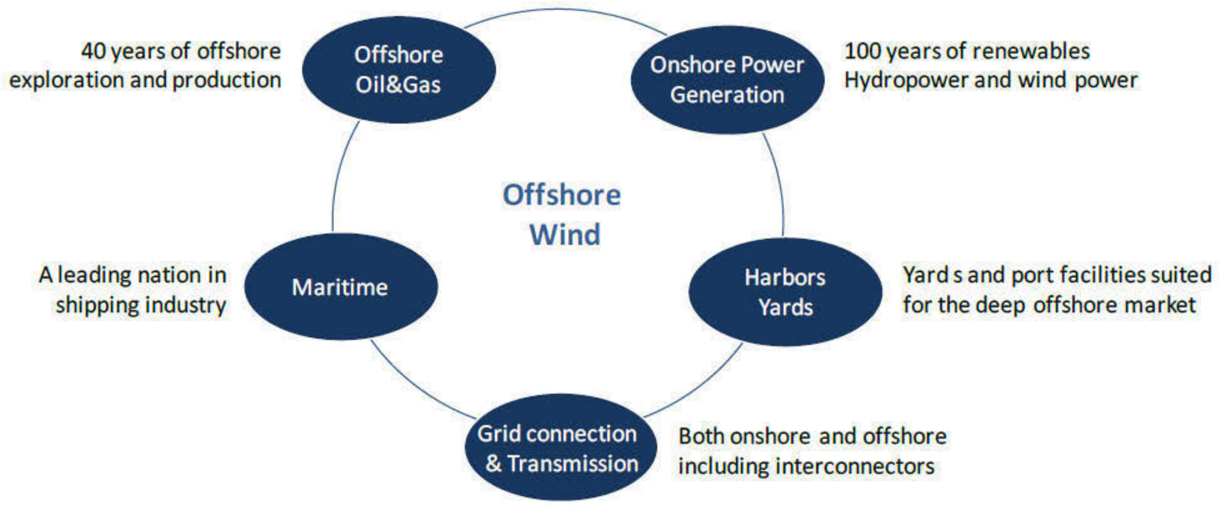
Motivation

- Firm EU commitment to develop offshore wind
- EU offshore wind forecast 2020:
  - Total installed capacity 40 GW
  - Total investments EUR 65.9 billions
- EU offshore wind forecast 2030:
  - Total installed capacity 150 GW
  - Total investments EUR 145.2 billions
- Significant developments also in China, Japan, Korea and USA
- The near-term large commercial market is mainly for bottom-fixed wind farms at shallow to intermediate water depths (50 m)
- Significant interest in developing floating concepts expecting large volume after 2020
- Threat: financial crisis / economic recession

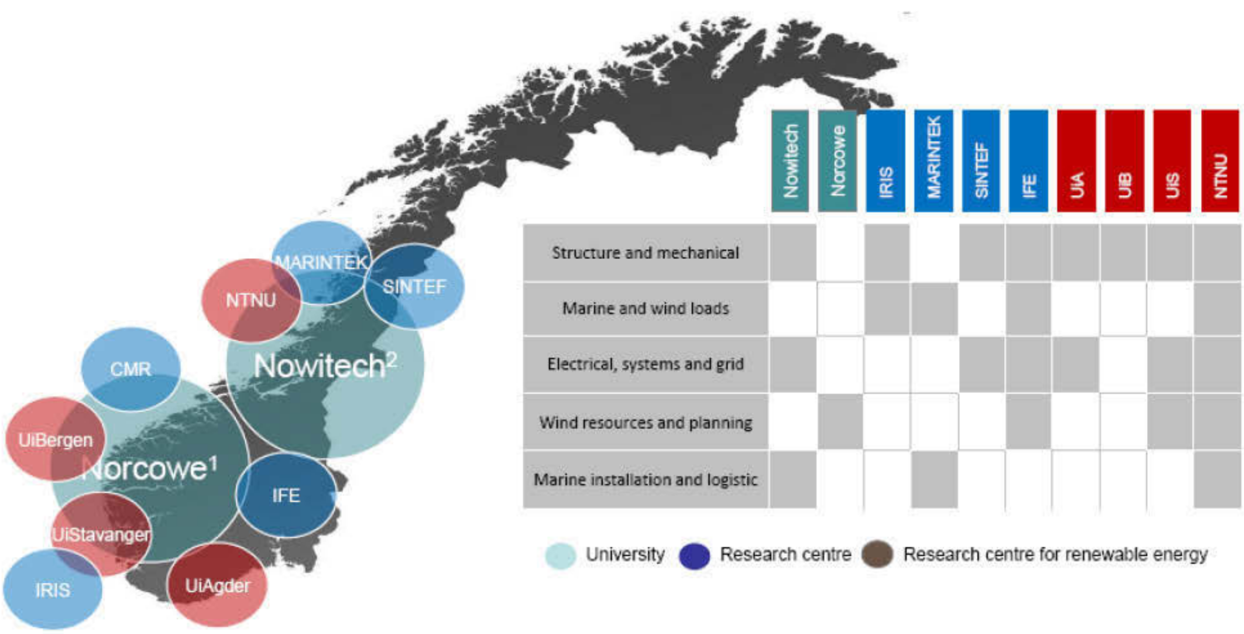


A large growing global market for offshore wind

Norwegian Expertise in Offshore



R&D Projects: NOWITECH & NORCOWE



NORCOWE

- Met / Ocean Data
- Design, installation and operation of offshore wind turbines
- Wind Energy Estimation

**Basically Meteorological Aspect
of
Wind Engineering**

NOWITECH in brief

- **A joint research effort**
- **Focus on deep offshore wind technology (+30 m)**
- **Budget (2009-2017) EUR 40 millions**
- **Co-financed by the Research Council of Norway (50%), industry (25 %) and research partners (25%)**
- **25 PhD/post doc grants**
- **Key target: Reducing cost of offshore wind energy through innovations**
- **Vision:**
  - **large scale deployment**
  - **internationally leading**

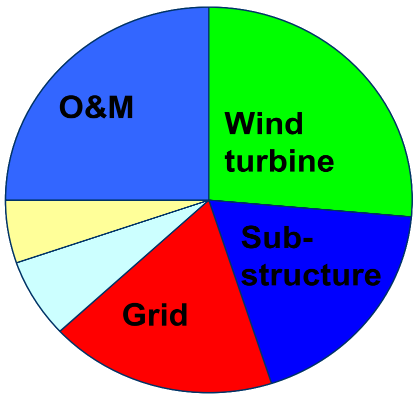
Benefits of Industries involvement

- ► Commercial exploitation of the research findings
- ► More industry driven activities
- ► First access to detailed results for business development
- ► Recruitments, spinoffs
- ► Reduced cost

► NOWITECH brings forward relevant research results to a certain maturity at which further development is typically industry based towards more competitive and commercial application.

Research Challenges

NOWITECH focus area

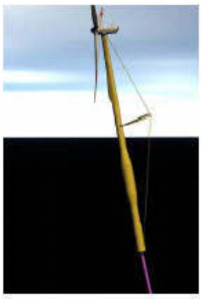


LPC distribution of offshore wind farm (example)

Key issue: Innovations reducing cost of energy from offshore wind

Wind Turbine: Exciting floating concepts

Hywind, with its 2.3 MW, was the world's first full scale fully operated floating turbine. It was installed 2009.

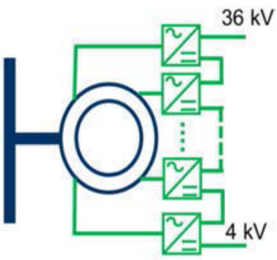


SWAY is developing a downwind floating wind turbine concept. A 1:6 floating prototype was installed in 2011.

Force Technology and NLI develop Windsea - a floating concept with three turbines. Tank tests are done.

The University of Stavanger is developing a Floating Vertical Axis Wind Turbine. It is in early phase and seeks developing partners.

NOWITECH 10 MW reference turbine



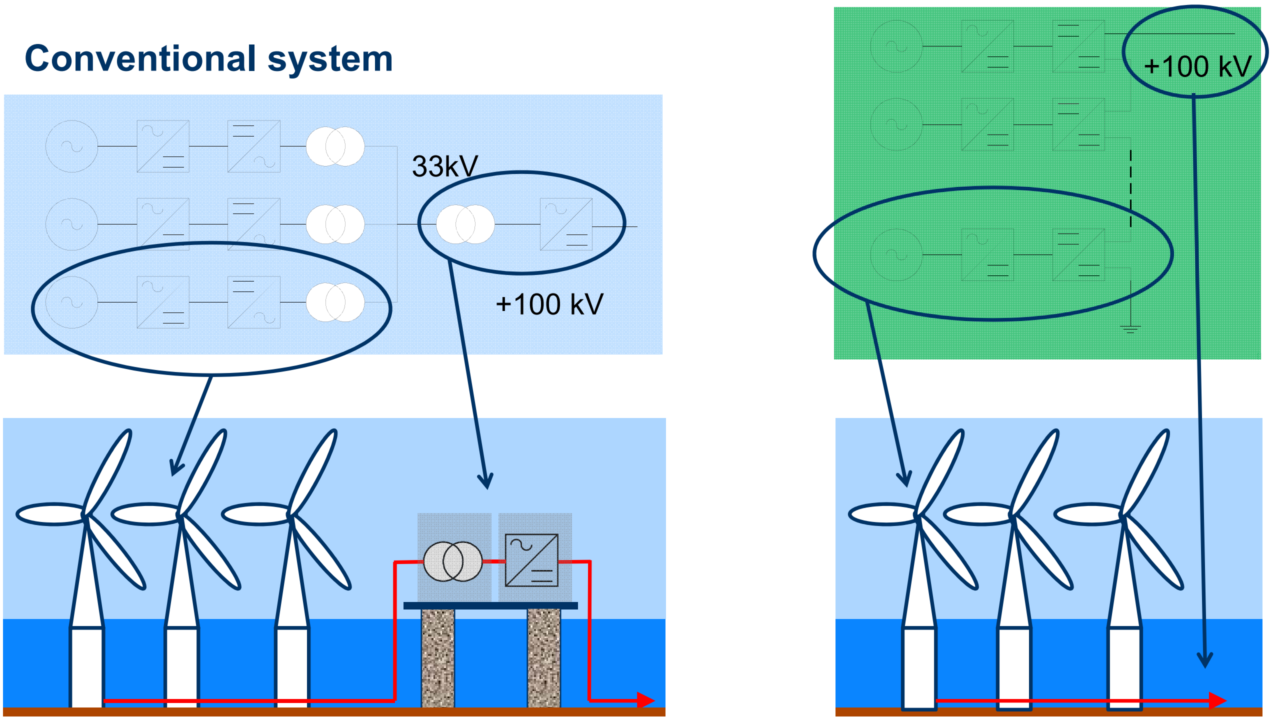
Initial design parameters

- Nominal power output 10.0 MW
- Design wind velocity 13.0 m/s
- Tip speed ratio 7.7
- Hub height 93.5 m
- Turbine diameter 141.0 m
- Design water depth 60.0 m
- Wind & waves ala Doggerbank
- **(work in progress!)**

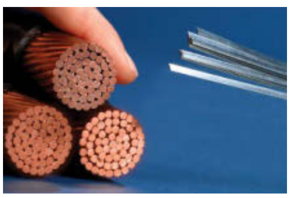
The NOWITECH 10 MW reference turbine introduces a new generator and support structure concept

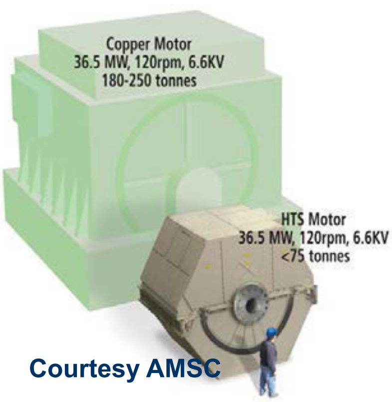
Innovative DC grid solutions for offshore wind farms avoiding need for large sub-station

Conventional system



Superconducting generators reduce weight



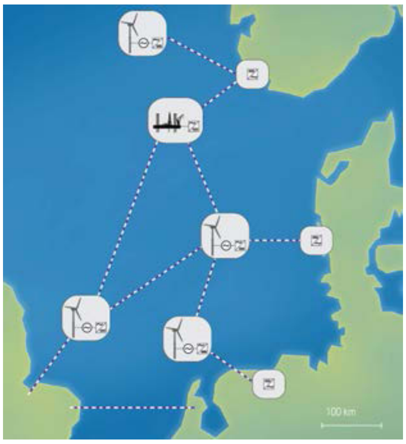


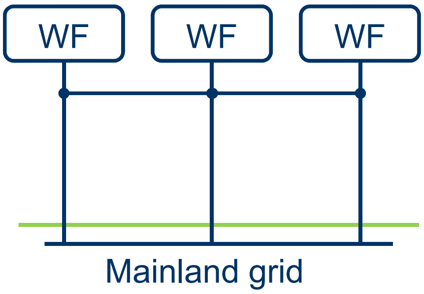
Courtesy AMSC

- 100 times the current density compared to copper
- More than doubles the achievable magnetic field
- Eliminates rotor losses
- Operating at 20-50 K

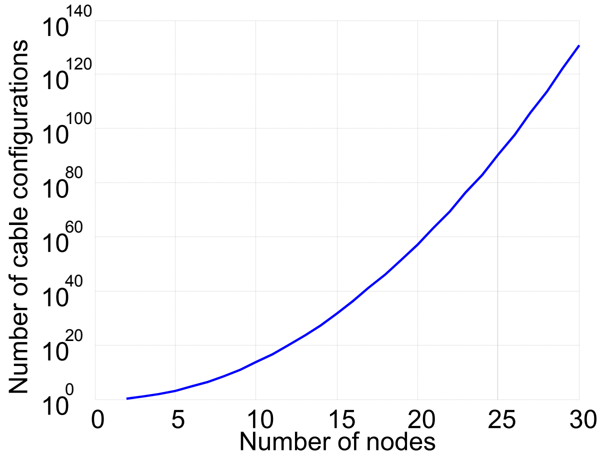
- New materials give new electromagnetic designs
- Possible step-changing technology
- Activity in new FP7 project application: **InnWind**

Optimization of the offshore grid





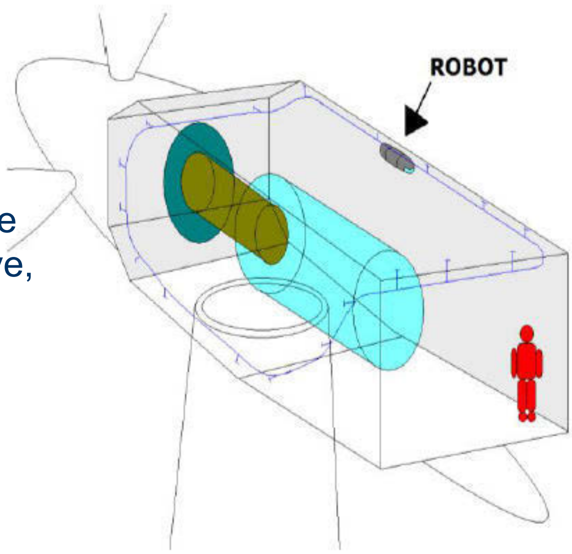
- ► **Inside and between wind farms**
- ► **New market solutions are required**
- ► **New technology (HVDC VSC, multi-terminal, hybrid HVDC/HVAC, ..)**
- ► **Protection, Fault handling, Operation, Control, Cost, Security of Supply**



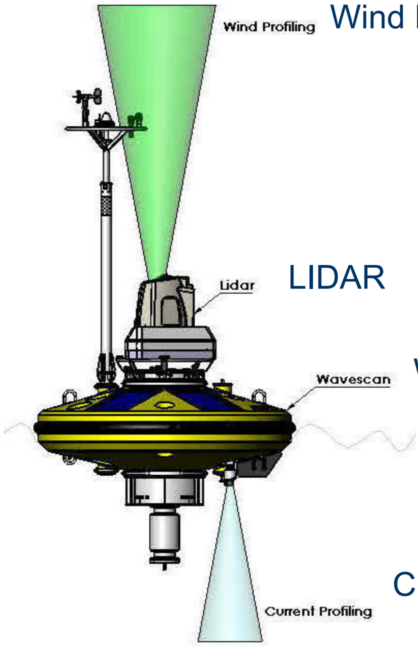
O&M: Remote presence

- ► It is costly and sometimes impossible to have maintenance staff visiting offshore turbines

- ► Remote presence:
  - Remote inspection through a small robot on a track in the nacelle equipped with camera / heat sensitive, various probes, microphone etc.
  - Remote maintenance through robotized maintenance actions



SEAWATCH Wind Lidar Buoy: 4 in 1



Wind Profiling

LIDAR

Wavescan

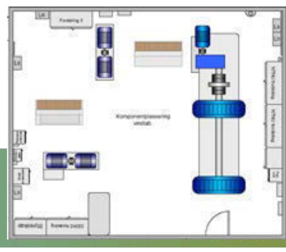
Current Profiling

Lab Activities

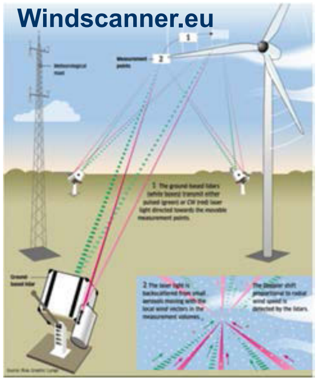
Wind tunnel

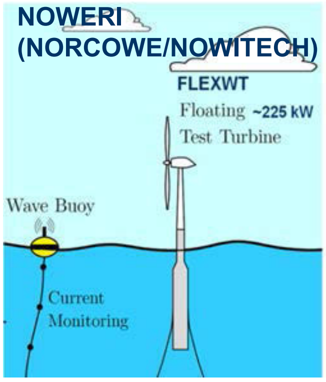
Material testing

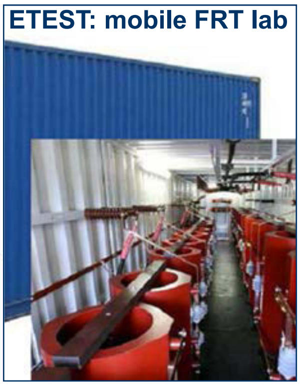
SmartGrids lab



Field Activities







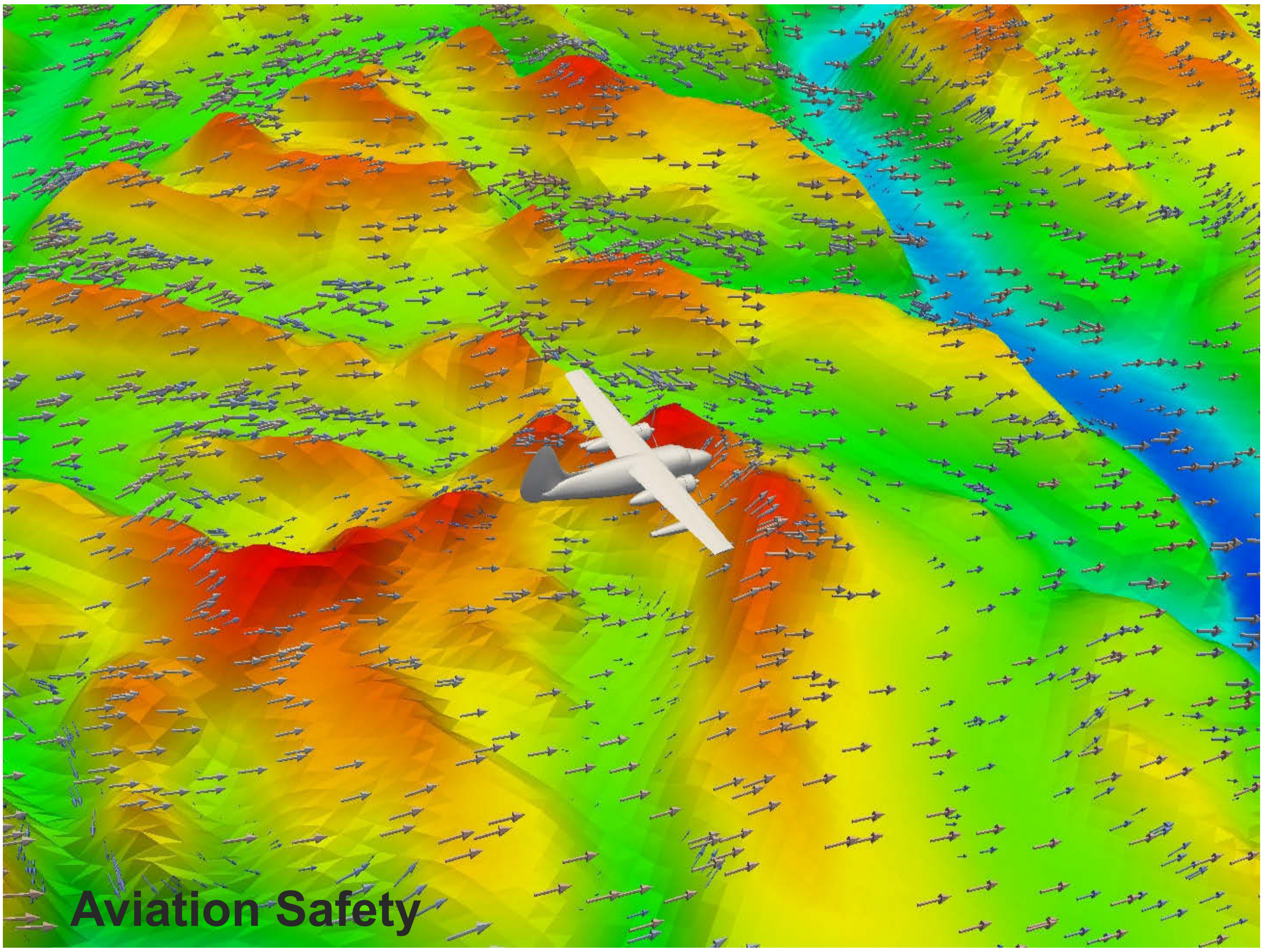
Recruitment and education

- Recruitment and education is a key activity for NOWITECH SC
- 25 PhD and post doc students are granted by NOWITECH to be finished in 2014-2015
- Some +30 PhD students are funded through other projects and some hundred MSc have specialized within wind energy
- A proposal for a next PhD programme is in development

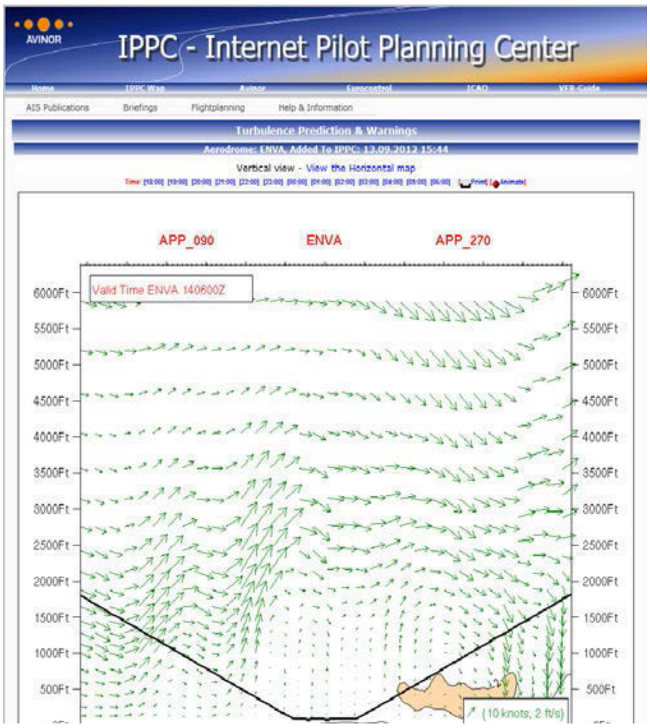
Rounding up

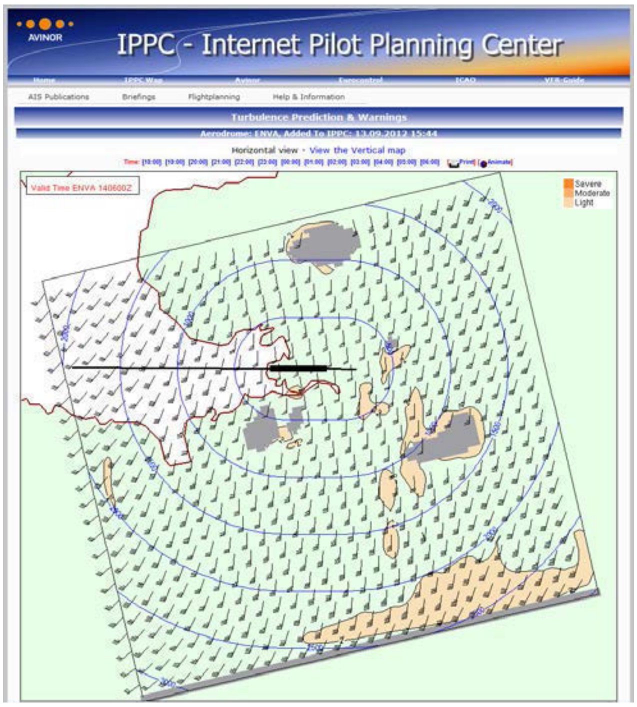
- **NOWITECH is about education, competence building and innovations reducing cost of energy from offshore wind**
- Significant budget and duration: EUR 40 millions (2009-2017)
- Strong consortium with leading research and industry parties
- Excellent master and PhD programme: 25 PhD & post doc grants
- Strong scientific results: good number of peer-reviewed publications
- R&D results give value creation and cost reductions
- Innovation process is enhanced through TRL
- Two new business developments (Remote Presence + SiC coatings)
- Strong infrastructure in development: NOWERI, WindScanner, ++
- A high number of spin-off projects: total volume EUR 125 millions

- **Vision: large scale deployment & internationally leading**

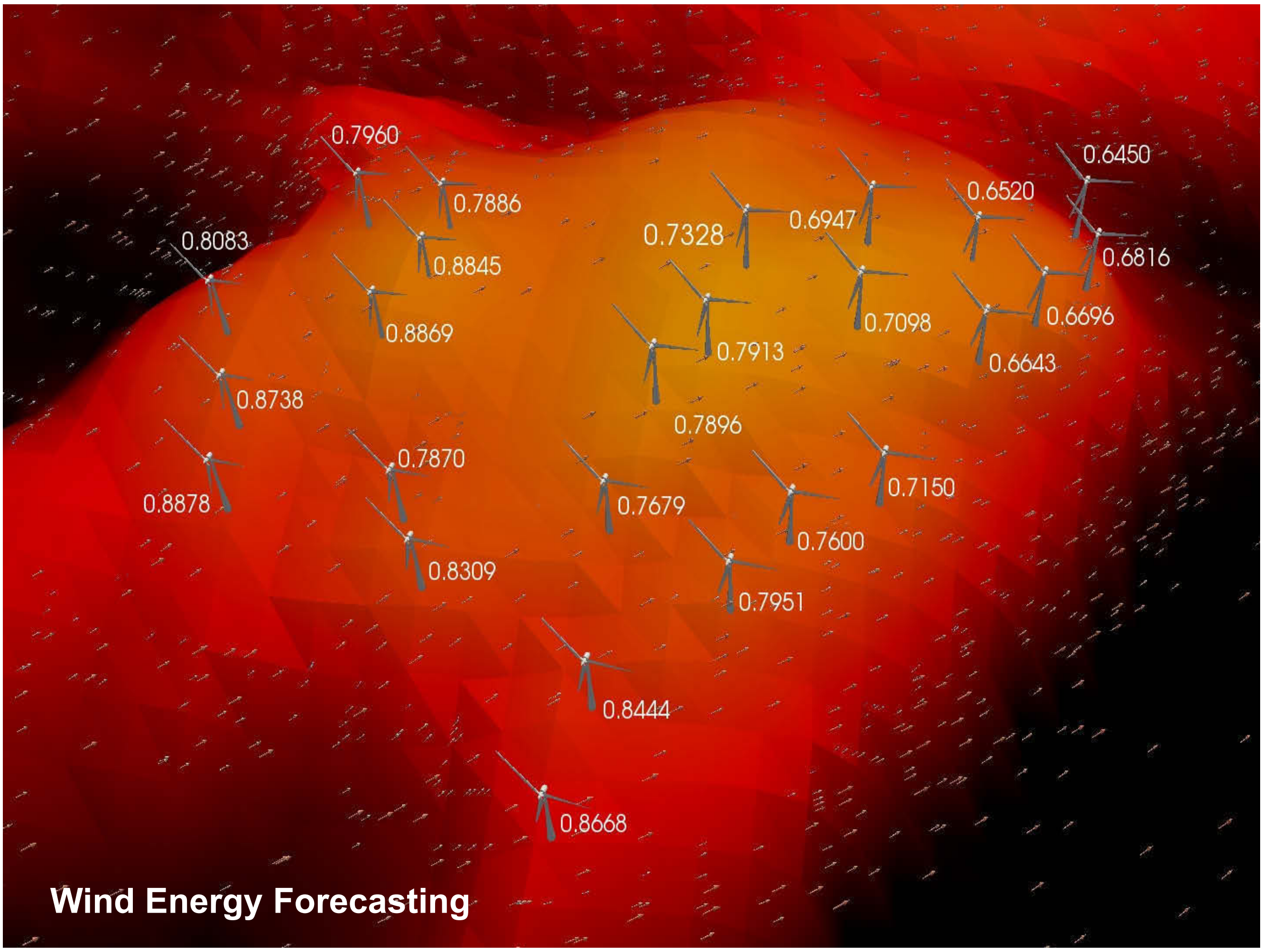


www.ippc.no

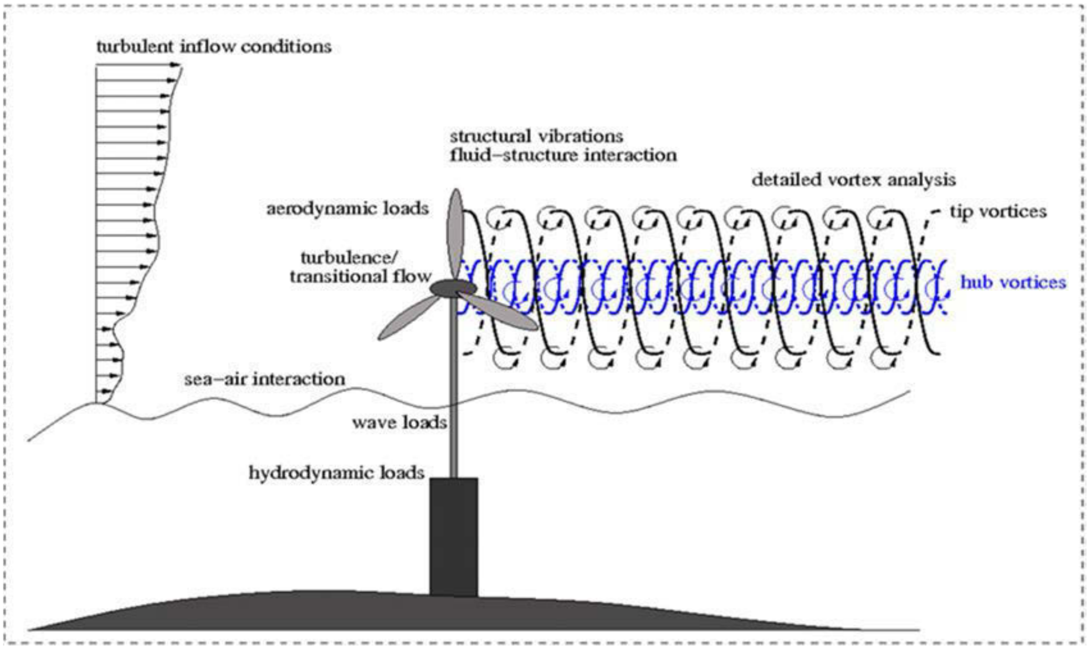




NOWITECH Norwegian Research Centre for Offshore Wind Technology



FSI-WT



We make it possible

NOWITECH is a joint 40M€ research effort on offshore wind technology.

- Integrated numerical design tools
- New materials for blades and generators.
- Novel substructures (bottom-fixed and floaters)
- Grid connection and system integration
- Operation and maintenance
- Assessment of novel concepts

www.NOWITECH.no

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Wind energy generation and power transmission – environmental impacts

Kjetil Bevanger, CEDREN

Indo-Norwegian seminar, Mumbai, India 7-8 May 2013

Environmental impacts

Land use/habitat fragmentation and splitting, Barrier effects, Visual (and noise) "pollution", EMF/health, Bird mortality,

Land use/habitat fragmentation and splitting, Barrier effects, Visual and noise "pollution", Bird mortality

Birds – a focal topic both for wind power production and power transmission

BirdWind – a CEDREN project

"Obtain an improved information base and tools for the energy industry and environmental and energy authorities to use in determining siting and conflict reduction of new wind power plants"

- **Mortality studies (weekly monitoring of dead birds)**
- **Impact studies – the endemic Smøla Willow Ptarmigan (behaviour, habitat selection, reproduction, survival)**
- **Impact studies - waders and small passerines (avoidance of breeding birds)**
- **Impact studies - White-tailed Eagle (behavioural response, monitoring of breeding success/population development, migration, population model (PhD study)**
- **Tools and technology (satellite tracking, avian radar lab, video camera monitoring – close turbine behavioural responses, GIS and terrain modelling)**

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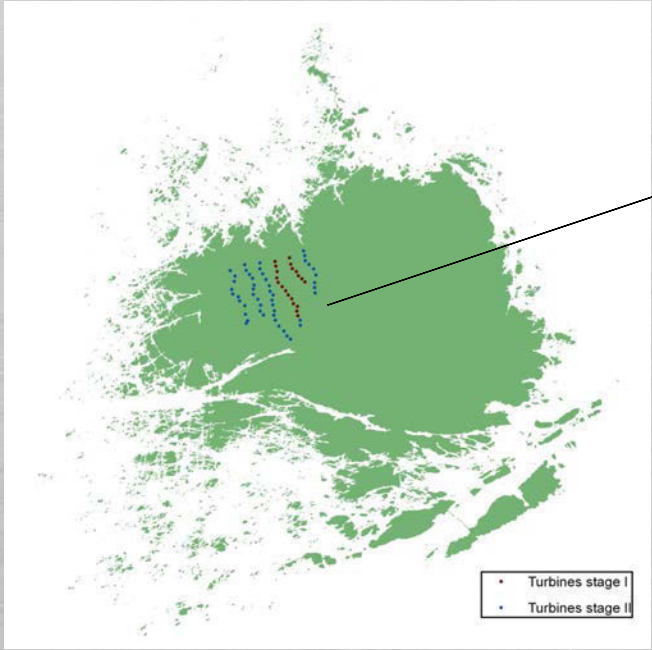
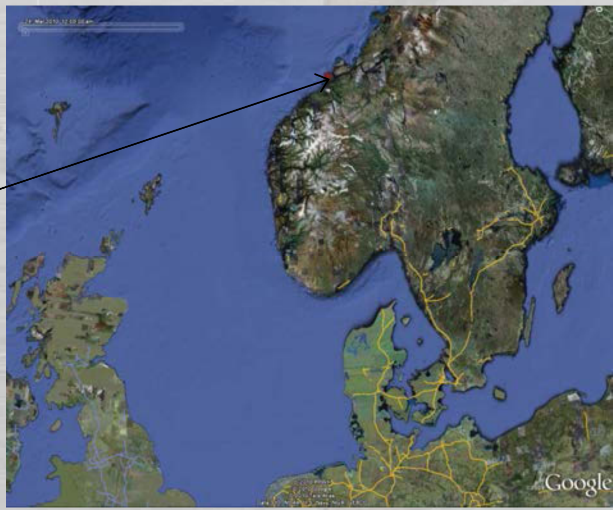
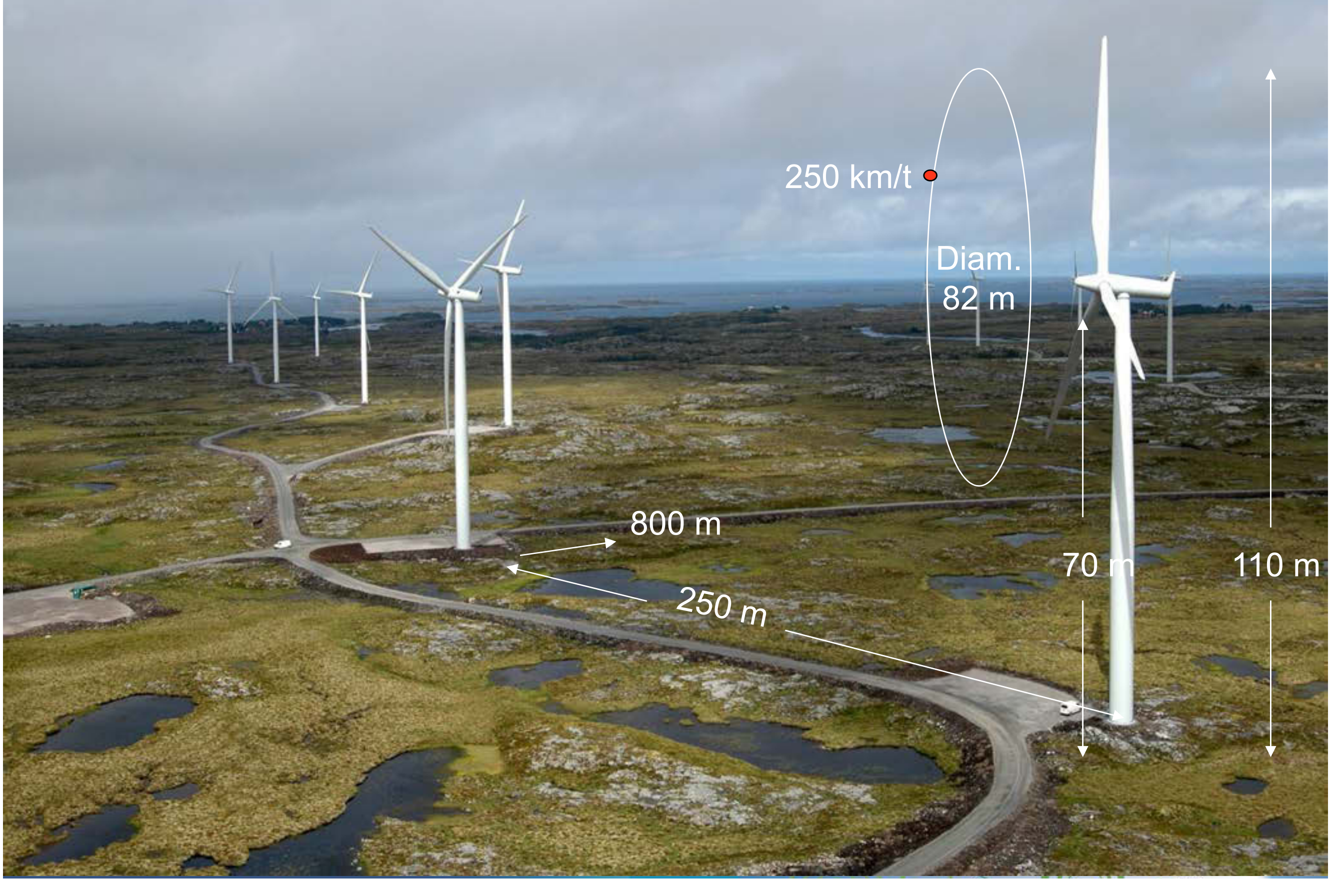
The Smøla Wind-Power Plant





68 turbines, 450 GWh/year capacity



Main challenge - species-specific bird vulnerability and population impacts

Tools, methods and technology

The white-tailed eagle

- The largest raptor in Norway
- Territorial, monogamous
- 30+ years, adult: 5 year
- 1900-2200 pair in Norway (estimate of 2000)
- Approximately 40% of the European population (Norway has an international responsibility for the species)

The white-tailed eagle mortality experienced on Smøla was reported to the Bern Convention Secretariat by Birdlife International (6-7 fatalities annually – more than 50 in total to date)

On-the-spot visit on Smøla June 2009 - representatives from the Bern Convention Secretariat and Statkraft

Smøla is a case-file and Norwegian authorities (i.e. the Ministry of Environment and the Ministry of Petroleum and Energy has to report regularly (next time in 2014) at the Bern Convention Standing Committee Meetings in Strasbourg on actions taken to improve the situation on Smøla

Energy companies and grid owners world-wide have to focus single species like the white-tailed eagle – and particularly red-listed species - due to international obligations through e.g.

- **The Convention on Biological Diversity (CBD)**
- **The Bern Convention - Convention on the Conservation of European Wildlife and Natural Habitats**
- **The Bonn Convention (CBS) - Convention on the Conservation of Migratory Species of Wild Animals**

- but also due to the consumer attitudes and demands for ethical, "green" and environmental friendly production

Wind turbines and wind-power plants will never be "bird friendly" – however the problem can be minimized by

- conducing high quality pre-construction studies (EIA)
- avoiding siting close to bird protection areas and nesting areas of species known as frequent collision victims
- avoiding siting close to bird migrating routes (locale, regional and national)
- arranging the wind turbines in rows parallel to known migrating routes
- avoiding siting of turbines between important key areas for birds (e.g. nesting and feeding localities)
- avoiding areas with seasonal high bird densities; get data on peak densities, and assess temporary close down during such periods
- avoiding siting in areas with frequent foggy conditions
- avoiding areas with frequent thermal and hang-wind generation (relates to soaring species like several raptors)

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The "Smøla fallacy"

- lack of solid data for a species-specific risk assessment and insight into the species-specific vulnerability to wind turbines (particularly relating to the white-tailed eagle and willow ptarmigan)
- a poor EIA and pre-construction study

The consenting authorities were (are?) reluctant to see escalating EIA studies in connection to wind power-plant construction, making the project economy poorer than it already is. A main lesson learned from the Smøla case is that one should never be penny-pinching regarding the EIA and pre-construction study

POWER LINES

The Norwegian power-line grid (km air wires)

- ***Distribusjon grid (0,2-24 kV)*** **165 789**
- ***Regional grid (33-145 kV)*** **17 182**
- ***Central grid (132-420 kV)*** **10 685**

Tied up land area in connection to power-line corridors in Norway: approx. 1800 km^2

The world-wide power-line grid (km medium-high voltage air wires 2008) is 65 million (5% annual growth)

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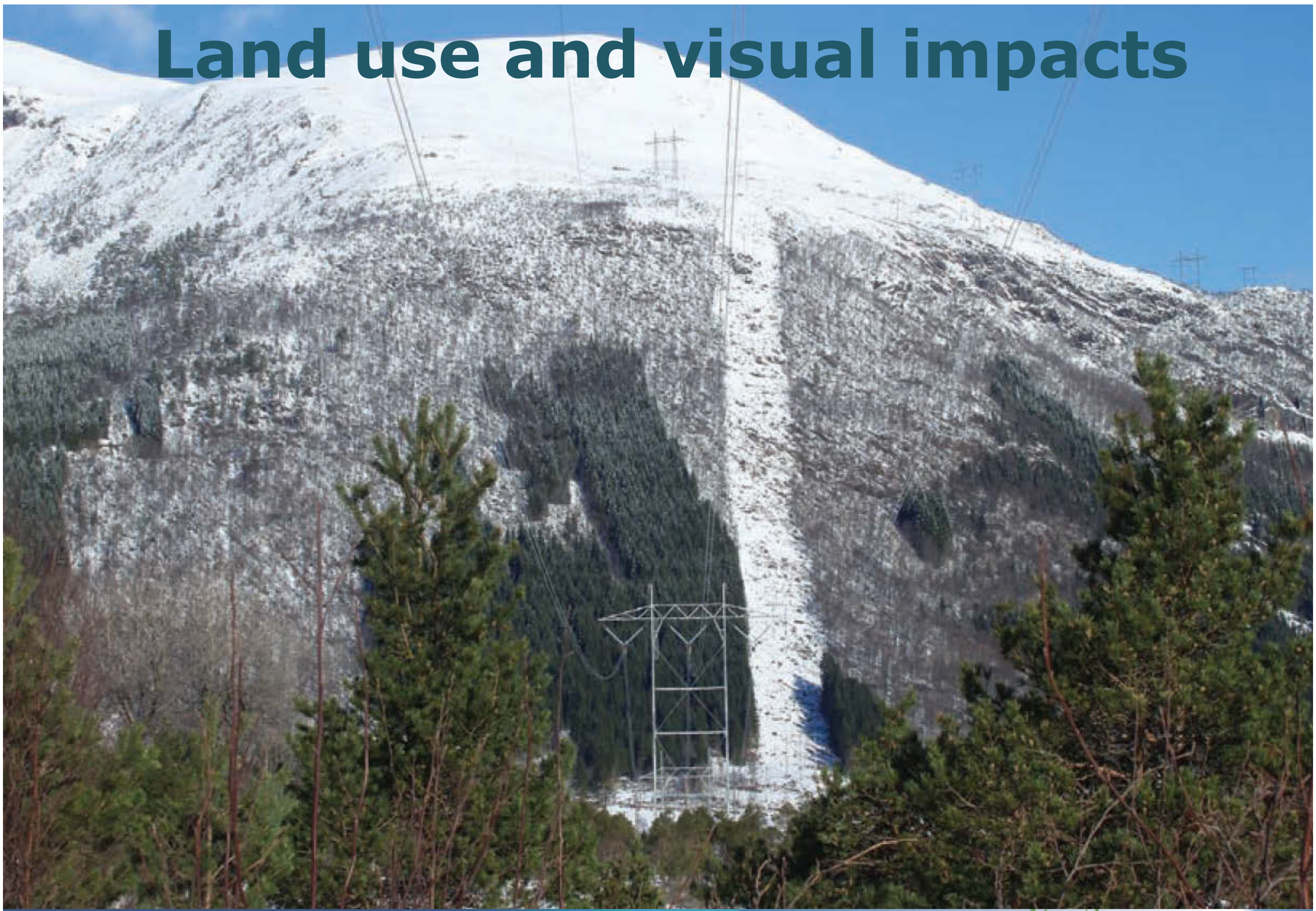
Land use and visual impacts

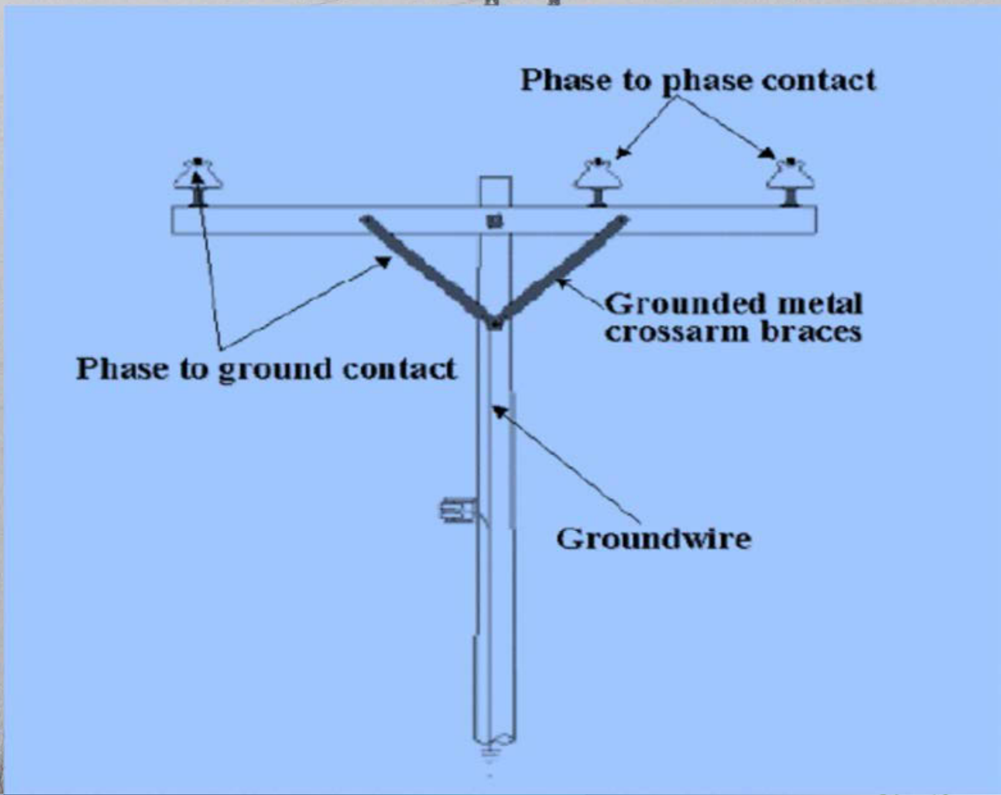


Estimated annual bird death world-wide: 1 billion – including several red-listed species

Collisions

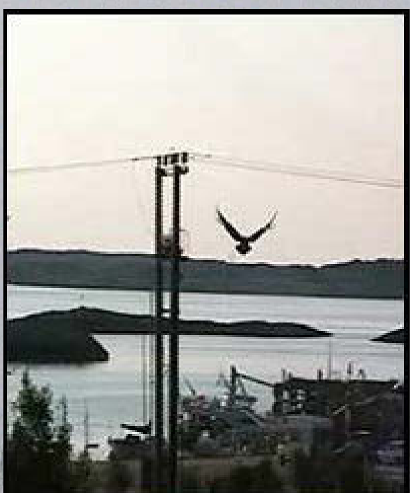
Electrocution

Bird electrocution (distribution lines only)



White-tailed eagle electrocution

Compensating actions – electrocuting trap removal

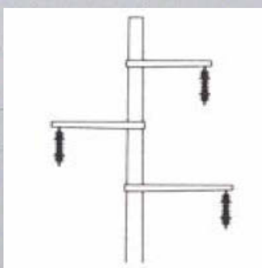
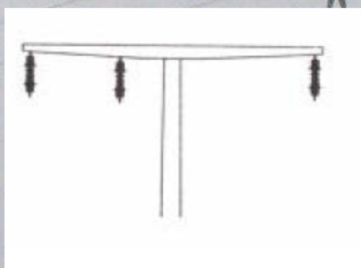


Typical electrocuted-bird remains



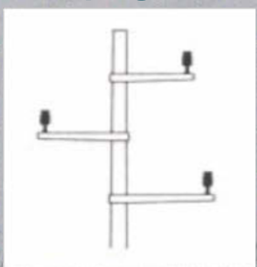
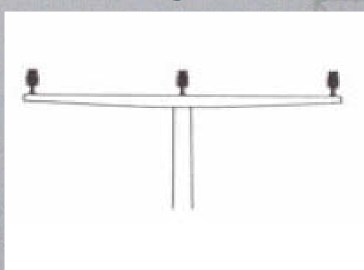

Electrocution mitigation

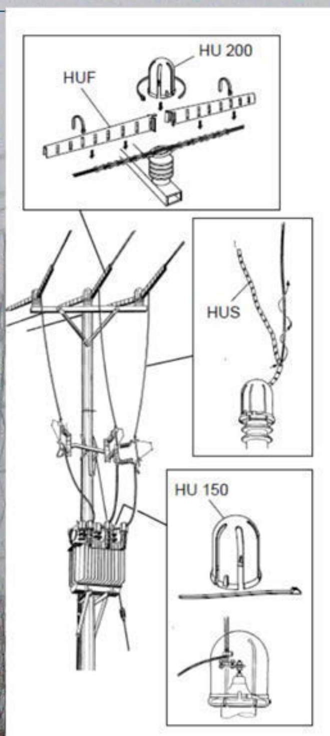
Pole design– solution tailoring

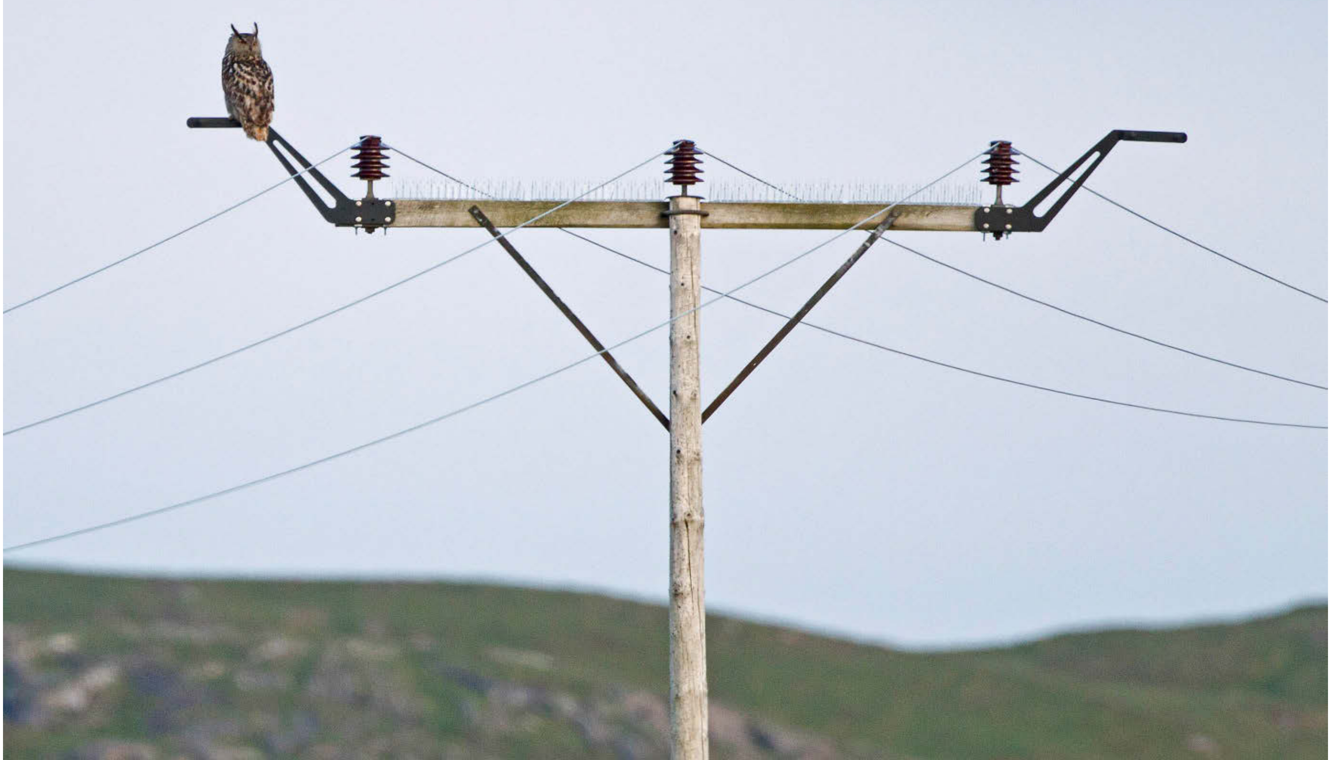
Suspended insulators – low risk

Upright insulators – high risk

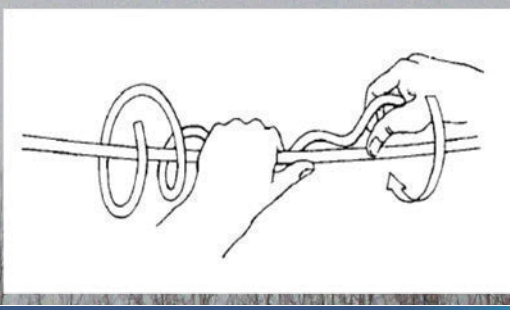





Eagle owl elevated perch - a CEDREN innovation product from the OPTIPOL Project



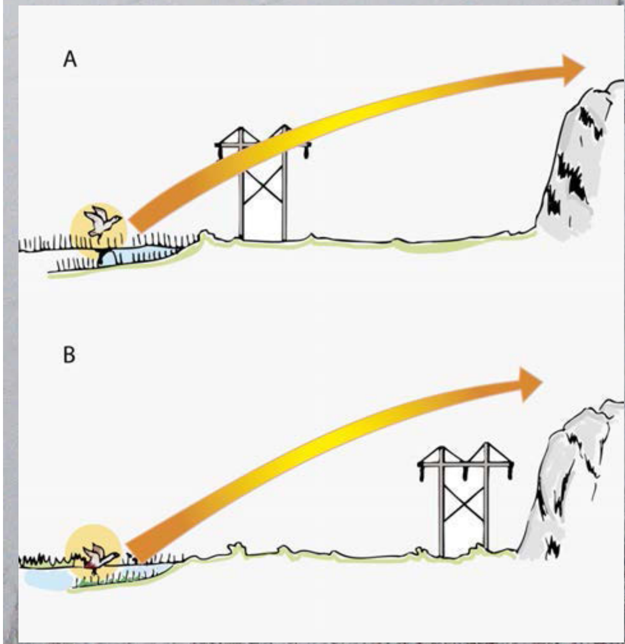
Mitigation by increased wire visibility

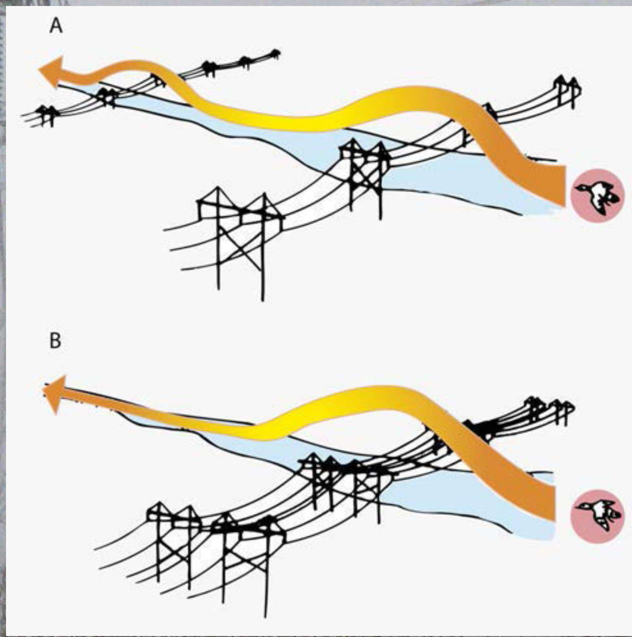


E0668347
Fågelavvisare Firefly för linmontage.
Hammarprodukter

E0668349
Fågelavvisare för linmontage.
Hammarprodukter

Mitigation by routing practice and common corridors





Underground cable - the “final solution”?

Wire-related mortality in the globally threatened Sarus Crane

K. S. Gopi Sundar, Principal Coordinator, the Indian Cranes and Wetlands Working Group (Sundar K.S.G. & Choudhury, B.C. 2005. Mortality of Sarus cranes (*Grus antigone*) due to electricity wires in Uttar Pradesh, India. - Environmental Conservation 32: 260–269.)

- **Globally threatened with Indian population estimated to be <10,000 individuals**
- **>95% of population present outside protected areas in shallow wetlands (maintained by village panchayats) or private agriculture fields**
- **Population presently estimated to be 5% of that present in early 1880s**
- **Etawah and Mainpuri districts in Uttar Pradesh most important globally – nearly 15% of estimated global population present here**

Threats to the Sarus Cranes in India

- **Wetland loss and degradation: biggest threat to breeding pairs and non-breeding flocks**
- **Pesticide-related mortality: increasing and less understood**
- **Chick mortality by domestic and feral dogs: biggest threat to pre-fledged young**
- **Power lines: biggest source of mortality to breeding and non-breeding adults and post-fledged young**

Thank you for your attention!

CEDREN Centre for Environmental Design of Renewable Energy

Smart Grid deployment opportunities and challenges in India

Speaker: **V S K Murthy Balijepalli, IIT Bombay**

CEDREN
Centre for Environmental Design of Renewable Energy

The Research Council of Norway

teri
The Energy and Resources Institute

NORWEGIAN EMBASSY

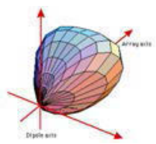
INNOVATION NORWAY

Indian Institute of Technology - Roorkee

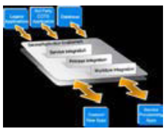
Indo-Norwegian seminar, Mumbai, India 7-8 May 2013

Smart Grid Environment

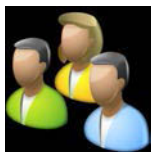
Multi-directional 'flows'



Seamless integration of new applications



End-consumer real time Information & participation



Central & dispersed sources

Central & dispersed intelligence

PHEV usage

Smart materials and power electronics

Smart Grid bodies in India

- Union Power Minister Launched India Smart Grid Forum on May 26, 2010

India Smart Grid Forum

- A non-profit voluntary consortium of public and private stakeholders with the prime objective of accelerating development of Smart Grid technologies in the Indian Power Sector
- Ten different working groups been constituted for Smart Grid study
  - Advanced Transmission, Advanced Distribution, Communications for Smart Grids, Metering, Consumption and Load Control, Policy and Regulations (incl. Tariffs, Finance etc.), Architecture and Design, Pilots and Business Models (incl. planning and implementation, Capacity Building), Renewables and Microgrids, and Cyber Security

Smart Grid bodies in India

India Smart Grid Task Force

- An inter ministerial group and will serve as Government's focal point for activities related to "Smart Grid".
- Five different working groups been constituted for Smart Grid study
  - Trials/Pilot on new technologies, Loss reduction and theft, data gathering and analysis, Power to rural areas and reliability & quality of power to urban areas, Dist Generation & renewable, and Physical cyber security- Standards & Spectrum.

Visit - http://www.desismartgrid.com/2012/07/india-smart-grid-forum-and-india-smart-grid-task-force/

Smart Grid for India –Stakeholder Expectations

- Expand access to electricity – "Power for All"
- Improve reliability of supply to all customers – no power cuts, no more DG sets and inverters!
- Improve quality of supply – no more voltage stabilizers!
- User friendly and transparent interface with utilities

Customers

- Reduction of T&D losses in all utilities to 15% or below
- Peak load management
- Reduction in power purchase cost
- Better asset management
- Increased grid visibility
- Self healing
- Renewable integration

Utilities

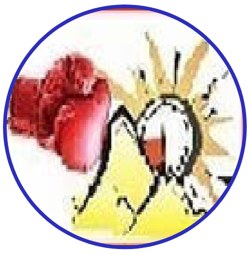
- Satisfied customers
- Financially sound utilities
- Tariff neutral system upgrade and modernization
- Reduction in emission intensity

Government & Regulators

Smart Grid Priorities for India

No more power cuts, *Prosumer* enablement

Reduce T&D losses, improve QoS



Manage peak power, DR, EV proliferation

Integrate renewables/ DG efficiently

National Smart Grid Mission

"Quality Power on Demand for All by 2027"

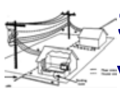
Smart Grid Vision for India

Transform the Indian power sector into a secure, adaptive, sustainable and digitally enabled ecosystem by 2027 that provides reliable and quality energy for all with active participation of stakeholders.

*National Smart Grid Mission is a proposal made by ISGF to Ministry of Power (budget- **INR 31416 Cr** for 2012- 2017)*

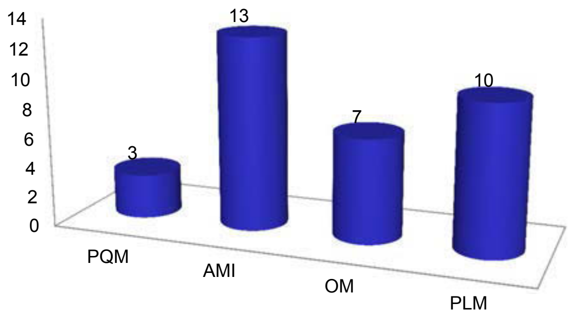
http://173.201.177.176/isgf/Download_files/Roadmap.pdf

Smart Grid Pilots in India

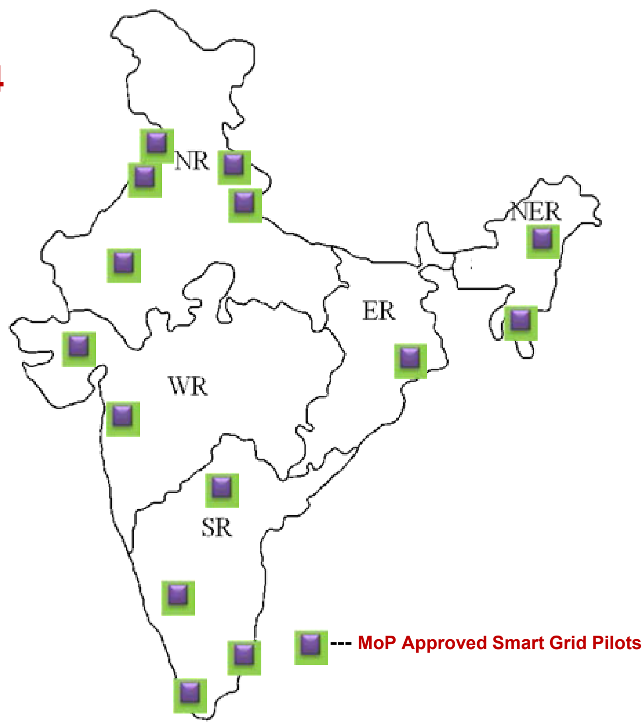


- Smart Grid initiatives started at various Energy Distribution Utilities
  - Smart Grid pilots sanctioned (MoP)- **14**

- AMI is the functionality opted by most of the utilities

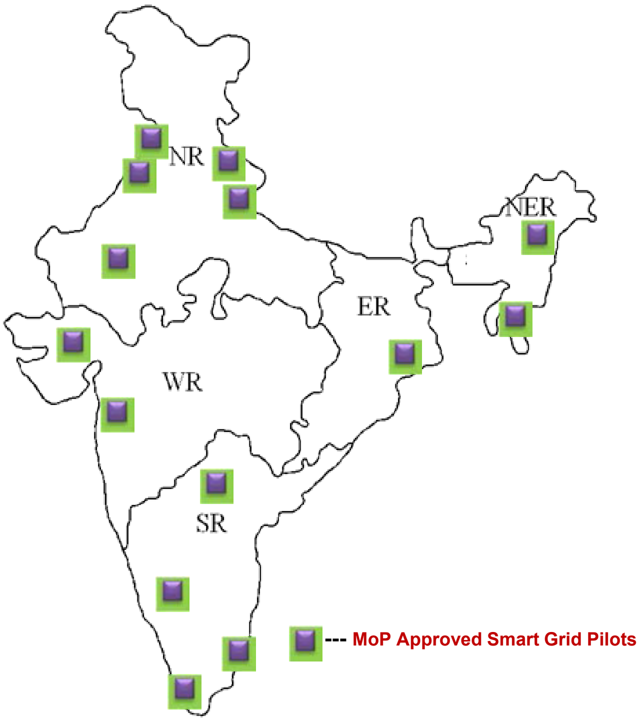


PQM- Power quality management
AMI- Advanced metering infrastructure
OM- Outage management
PLM- Peak load management



Smart Grid Pilots in India

- Investment is around Rs 4 billion (US $ 80 million) with 50% funding from Govt. of India.
- Pilots aim at integrating the consumer, operations and asset management domains of Distribution Sector to bring in efficiency and enhance reliability.
- Build business cases, policy and regulatory recommendations



A Biggest Challenge!

Advanced Transmission, Advanced Distribution, Communications for Smart Grids, Metering, Consumption and Load Control, Policy and Regulations (incl. Tariffs, Finance etc.), Architecture and Design, Pilots ar
Capacit

? ? ?

? **Smart Grid Education and Standards** ?

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tion and theft,
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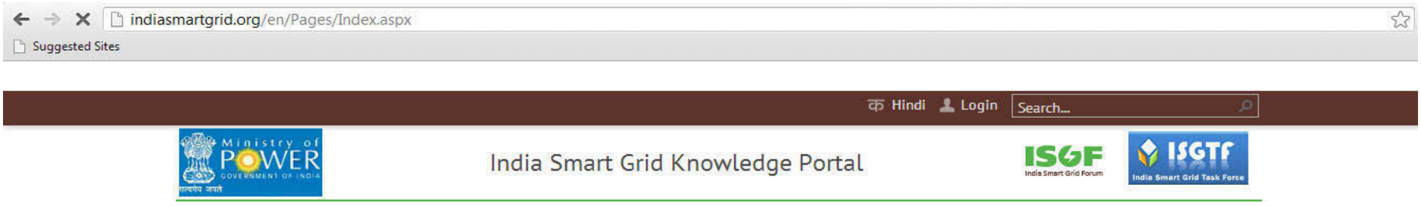
Dist
security-

*National Smart Grid Mission is a proposal made by ISGF to Ministry of Power (budget- **INR 31416 Cr** for 2012- 2017)*

India Smart Grid Knowledge Portal

- India Smart Grid Knowledge portal
  - Launched on 16th January, 2013 by Shri. Sam Pitroda (Advisor to Prime Minister of India)



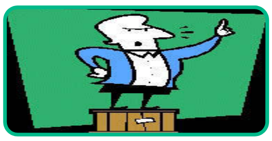
A Way Forward!

Formulation of effective customer outreach and communication programmes for active involvement of consumers in the smart grid implementation.

Development of utility specific strategic roadmap. Required business process reengineering, change management and capacity building programmes to be initiated by 2014.

Development of microgrids, storage options, virtual power plants (VPP), vehicle to grid (V2G), solar to grid (PV2G), and building to grid (B2G) technologies in order to manage peak demand, optimal use of installed capacity and reduce load shedding and black outs.

Investment in research and development, training and capacity building programmes for creation of adequate resource pools for developing and implementing smart grid technologies in India as well as export of smart grid know-how, products and services.



Development of appropriate standards for smart grid development in India

Thank You!

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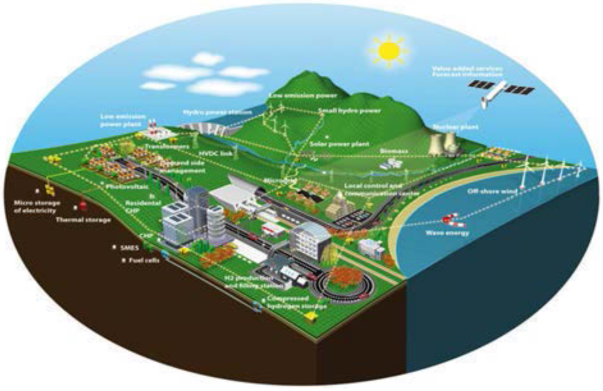
Smart Grid Challenges and Opportunities – the Norwegian Perspective



Vijay Venu Vadlamudi, Postdoctoral Fellow, NTNU
Kjell Sand, Sintef Energy Research
The Norwegian Smart Grid Centre

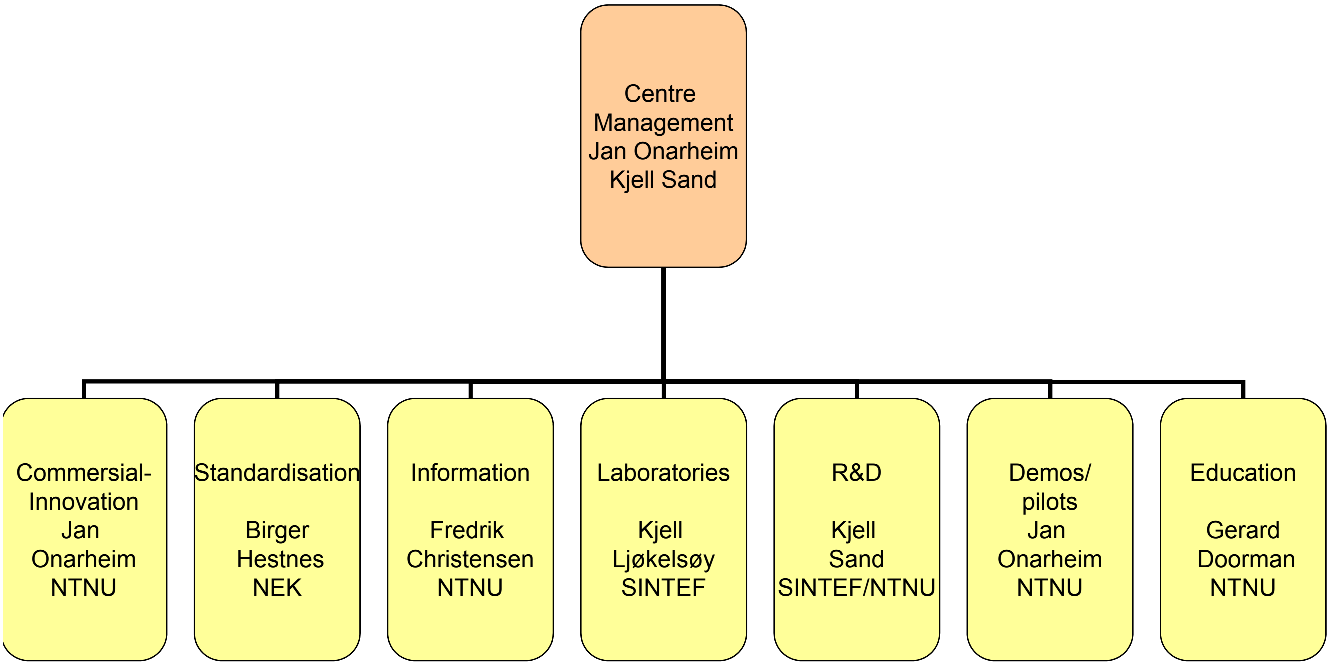
Smart grid – as we see it:

- A term for the future electric power system (2020-2050)
- A giant leap on ICT integration
- A merger of power systems and internet
- A system where all components and apparatuses have an "IP- address" (Internet Protocol address) – accessible from the "internet"
- A contribution to Internet of Energy and Internet of Things

The Norwegian Smartgrid Centre

www.smartgrids.no

- a national competence building centre open for all



smartgrid The Norwegian Smartgrid Centre

Project list @ NTNU

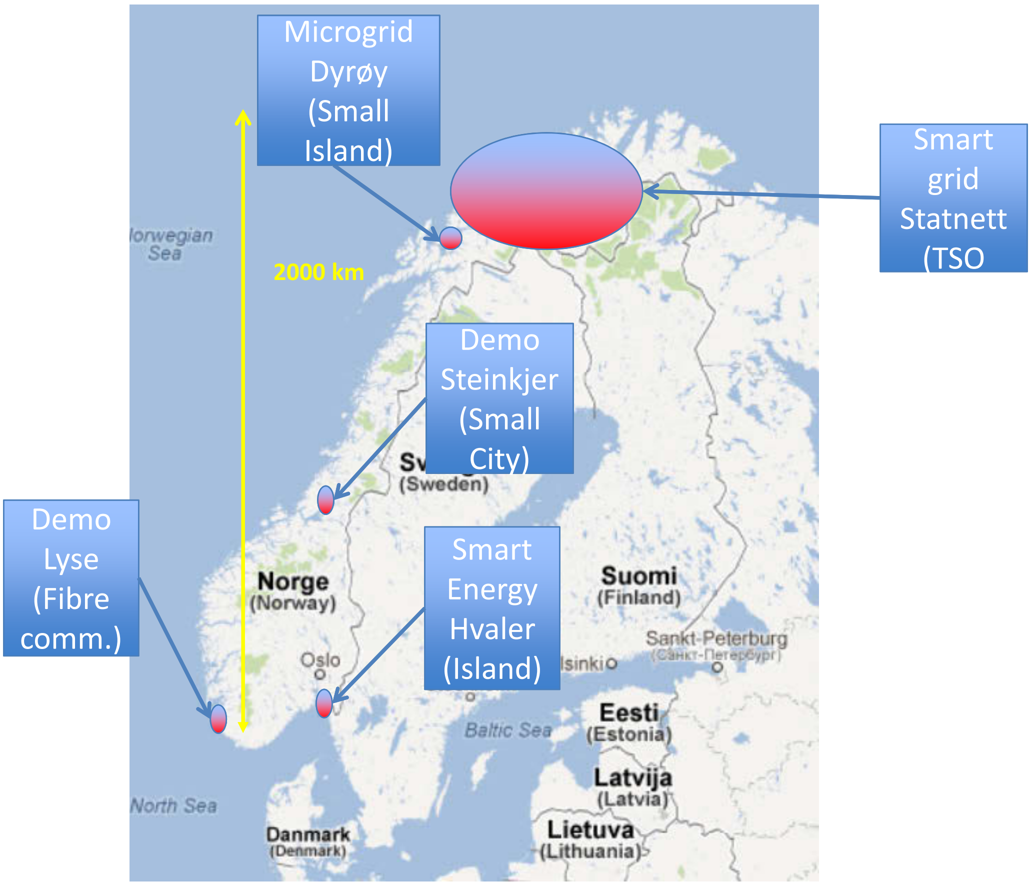
IME (Information Technology, Mathematics and Electrical Engineering)

- A: Smart operation and control in power transmission network
- B: Identification of potential instability in AC distributed multi-converter system under non-ideal electrical conditions
- C: SmartGrids as a critical infrastructure
- D: Reliability Analysis of Wind Energy Systems
- E: Integrated communications and control
- F: Improved Management of Software Evolution for SmartGrids applications
- G: Energy Efficient Parallelization of SmartGrid Computations on Novel Multicore Processors
- H: The next generation control centres for Smart Grids
- I: Optimal Power Network Design and Operation
- J: Architecture and functionality for future active distribution network
- K: Reliability Perspective
- L: Identifying electrical instability in grids dominated by power electronics

CenSES (Centre for Sustainable Energy Studies)

- M: Utviklingen av smartgridteknologier i et STS-perspektiv
- N: Flexible network and market design

NTNU Det skapende universitet



Smart Grid Status Norway

Transmission/sub-transmission

"Smart"

MV Distribution

Not so "smart"

LV distribution/ supply terminal

Becoming "smarter"

Smart metering by 2019-01-01

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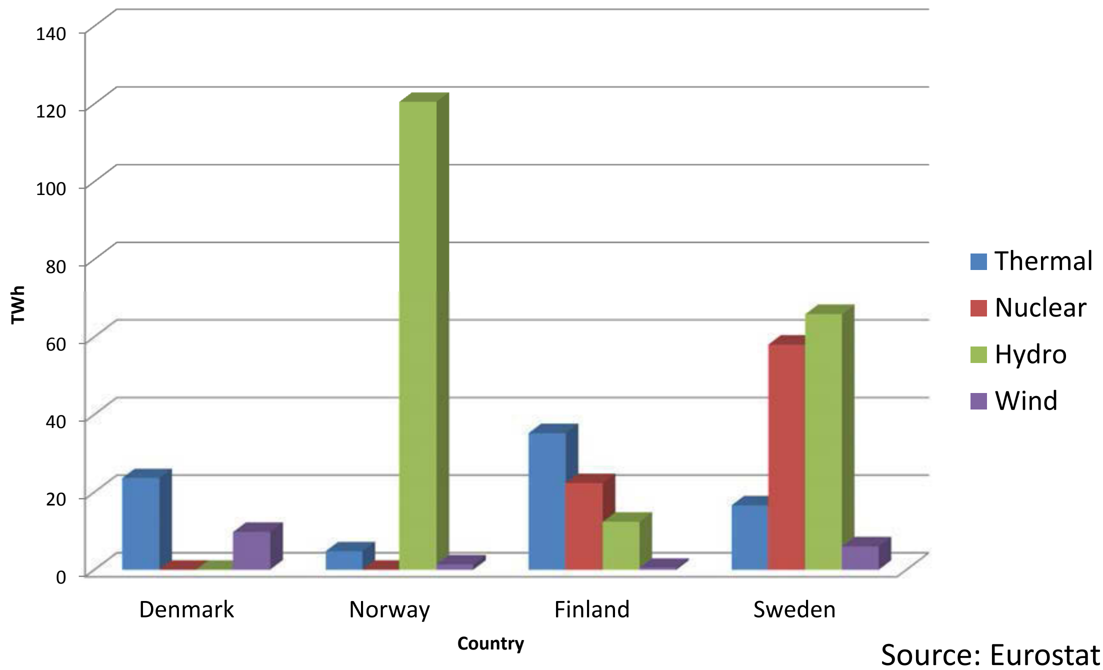
2,8 millions computers in the "fuse boxes" –
Estimated costs 10-12 billion NOK.

Electricity Generation in the Nordic system 2011 (TWh)



Source: Eurostat

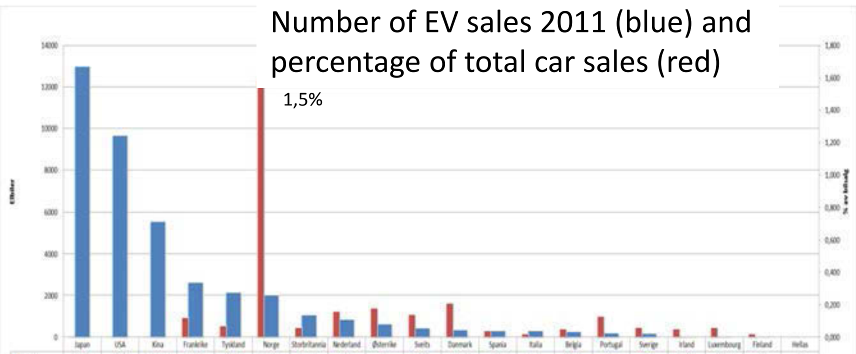
Largest CO_2 emission sectors

- Transport
- Industry
- Offshore oil and gas industry

To reduce emissions in these sectors are on the agenda and involves the use of more electricity e.g electrical cars.

Electrification of transport – Norway

- 19 % of Norway's GHG emissions are due to road transport (2009, ssb)
- Expected surplus of electric energy towards 2020



	Japan	USA	Kina	Frankrike	Tyskland	Norge	Storbritannia	Nederland	Østerrike	Sveits	Danmark	Spania	Italia	Belgia	Portugal	Sverige	Irland	Luxembourg	Finland	Hellas
Elbiler	13000	9674	5579	2630	2154	2038	1082	862	631	433	362	319	302	263	203	178	46	31	29	0
% av total bilsalg	0,004	0,0007	0,0004	0,12	0,07	1,6	0,06	0,16	0,18	0,14	0,21	0,04	0,02	0,05	0,13	0,06	0,05	0,06	0,02	0

Ambition:
•10 % chargeable vehicles by 2020

Currently

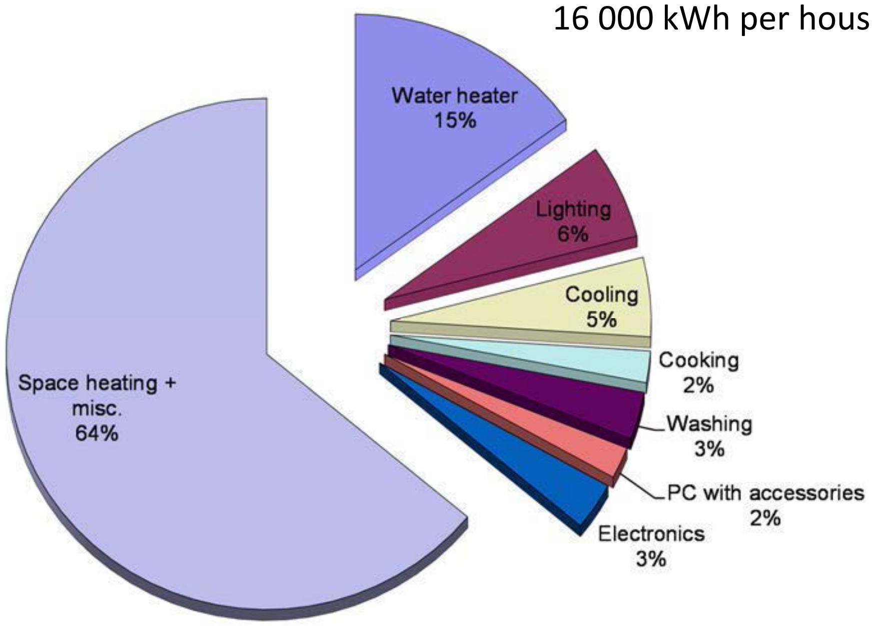
- Fifth largest market in the world in total sales for 2011
- Largest market in the world, compared to total number of vehicles sold
- High sales due to good incentives

smartgrid The Norwegian Smartgrid Centre

Electric Energy Usage in Norwegian Households.

(Much space and water heating, large flexibility potential)

16 000 kWh per household (average)



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Sustainability contribution from the Norwegian Electricity System

- Export of renewables
- Improve European utilisation of renewables (balancing power)
- National fossil energy substitution
  - Electricity demand flexibility by customer participation is thus also a Norwegian issue

DSO SG issues

- DG – especially small hydro power (typically < 10MW)
- Integration of wind

- Automation, efficiency in manual processes

- Improve reliability
  - Reduce cost of energy not supplied and penalties

DSO SG issues (cont)

- Prepare for el. vehicles
- Improve power system monitoring and documentation
- Voltage quality management

- Harbour electricity supply to ships
- End of life monitoring – information for maintenance and renewal management

DSO SG issues (cont)

- Improve customer service
- Customer interruption notification
- Power losses management
- Congestion management (to reduced the need for new lines…)

Conclusion:

- We don’t know where we are going,
- …but we know we are on our way

Indo-Norwegian seminar on

Renewable Energy Respecting Nature

(May 07 – 08, 2013)

The Role of Small Hydro in the Indian Energy System

May 07, 2013

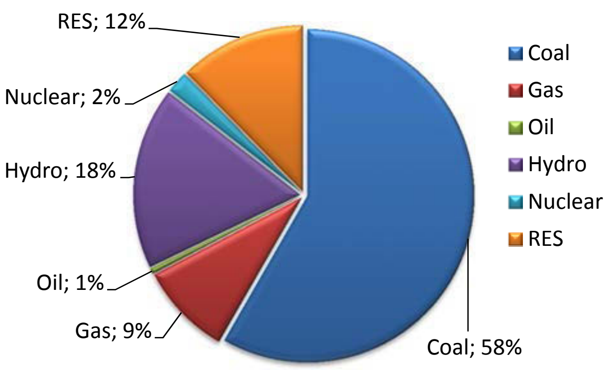
ARUN KUMAR Ph.D.
Alternate Hydro Energy Centre,
Indian Institute of Technology, Roorkee
E-mail : aheciitr.ak@gmail.com, akumafah@iitr.ernet.in

Introduction

- Renewable Sources of Energy attracted worldwide focus including the developing world.
- Large scale hydropower projects provide an excellent electricity base
- Small scale hydro power projects) – grid as well as to isolated is one of the proven option as a business as well as rural electrification
- Water in the most of the countries is government subject and hence for hydropower development permission from government is required.

STATUS OF ELECTRICITY IN INDIA

(RES include SHP, BG, BP, U&I and Wind Energy)



Total Installed capacity = 2,23,348 MW (on March 2013)

Peak Deficit : -9.0 %

Energy Deficit: -8.7 %

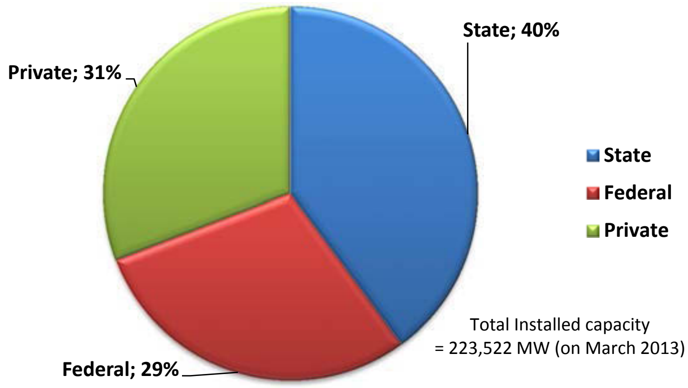
Un-electrified Villages: 33,883 (6.0)%

Un-electrified households:

about 40%

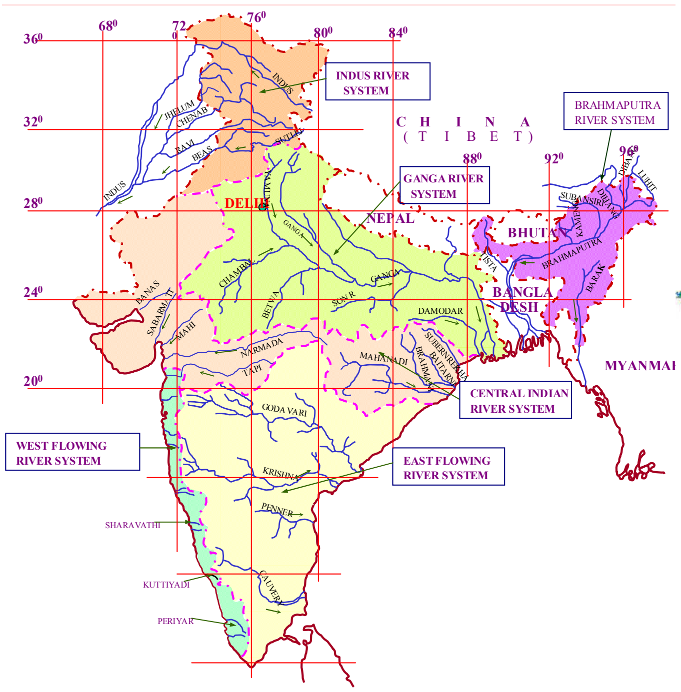
Electricity Generation Capacity (MOP March, 2013)

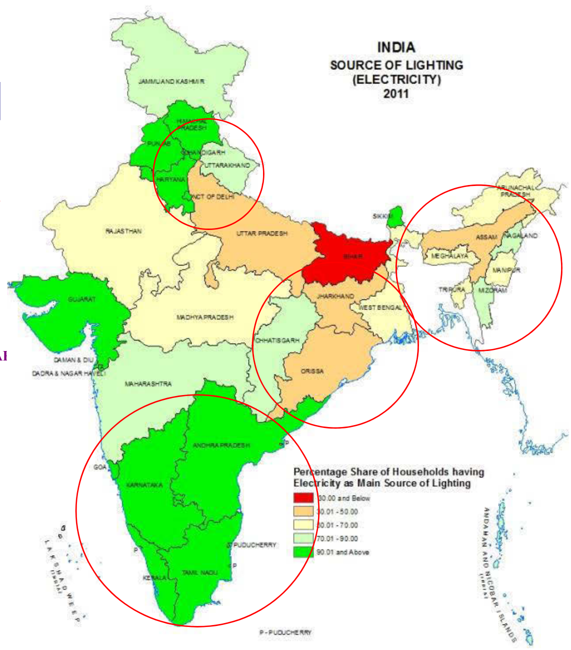
Total:	223,348 MW
Thermal:	**151,530** MW
Hydro:	***39,491 MW***
Nuclear	4,780 MW
RES	27,541 MW



Total Installed capacity = 223,522 MW (on March 2013)

Households using Electricity as Source of Lighting





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

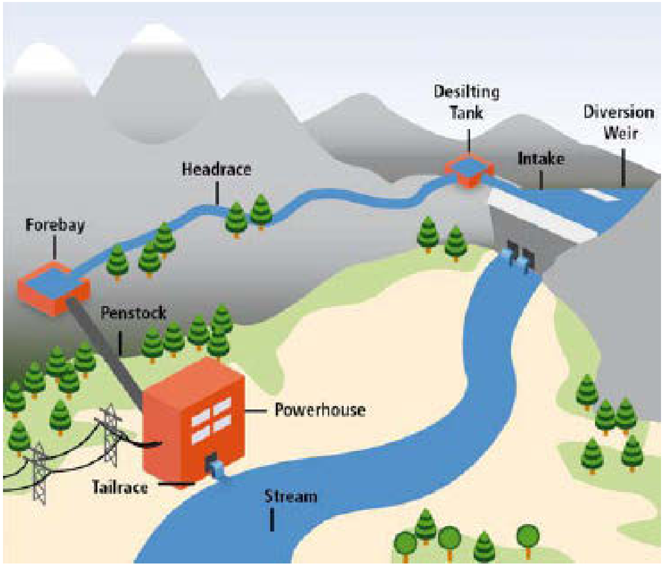
Both are required and different level of approach, subsidy, tariff etc are needed

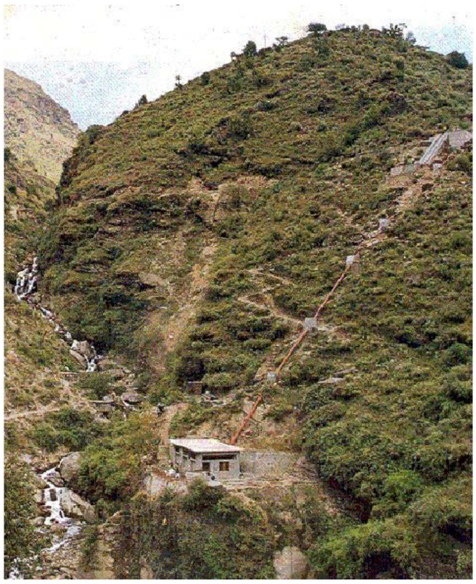
Types of SHP schemes

- Run-of-river
- Canal fall based
- Dam Toe based
- In stream
- Pumped Storage

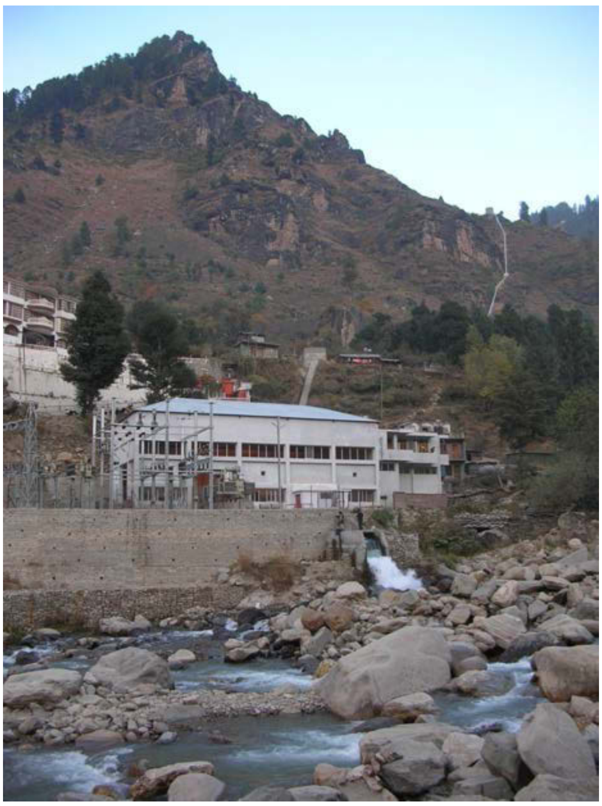
Types of Hydropower

Run of River:





Run of river hydropower development

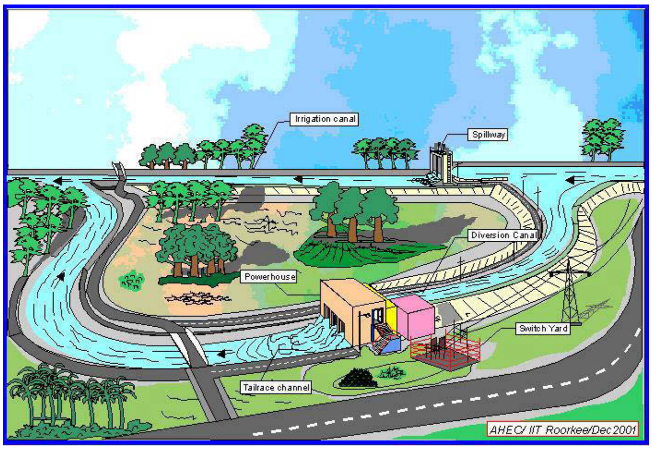


Low head power plant (4.5MW)
Madhavmantri, (head 4.5 m) Kaveri River, India

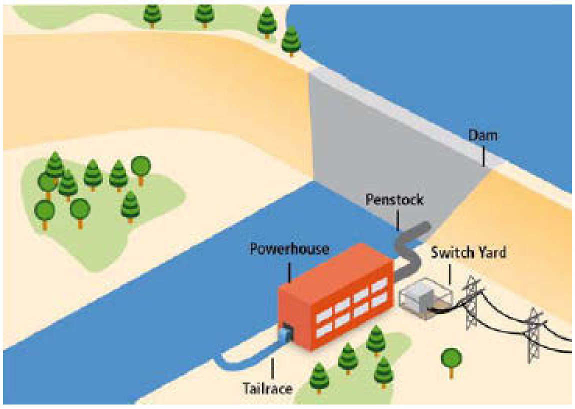
Low head power plant (90 MW)
BIRSFELDEN, (head 3 to 9 m) Rhine river, Switzerland

Examples

Using existing facilities:



Typical Arrangement of canal fall small hydropower development



Reservoir Based Hydropower Development

WATER MILL- Gharat

Wheel used for converting water energy into mechanical energy by passing flowing water through a wheel and are Known as water mills or gharat.

Used in ancient times in India, China, Egypt and later in Europe. These Water Mills being used mainly for grinding cereals in hilly regions.

Recently these are also being used for electricity generation for isolated individual or group need

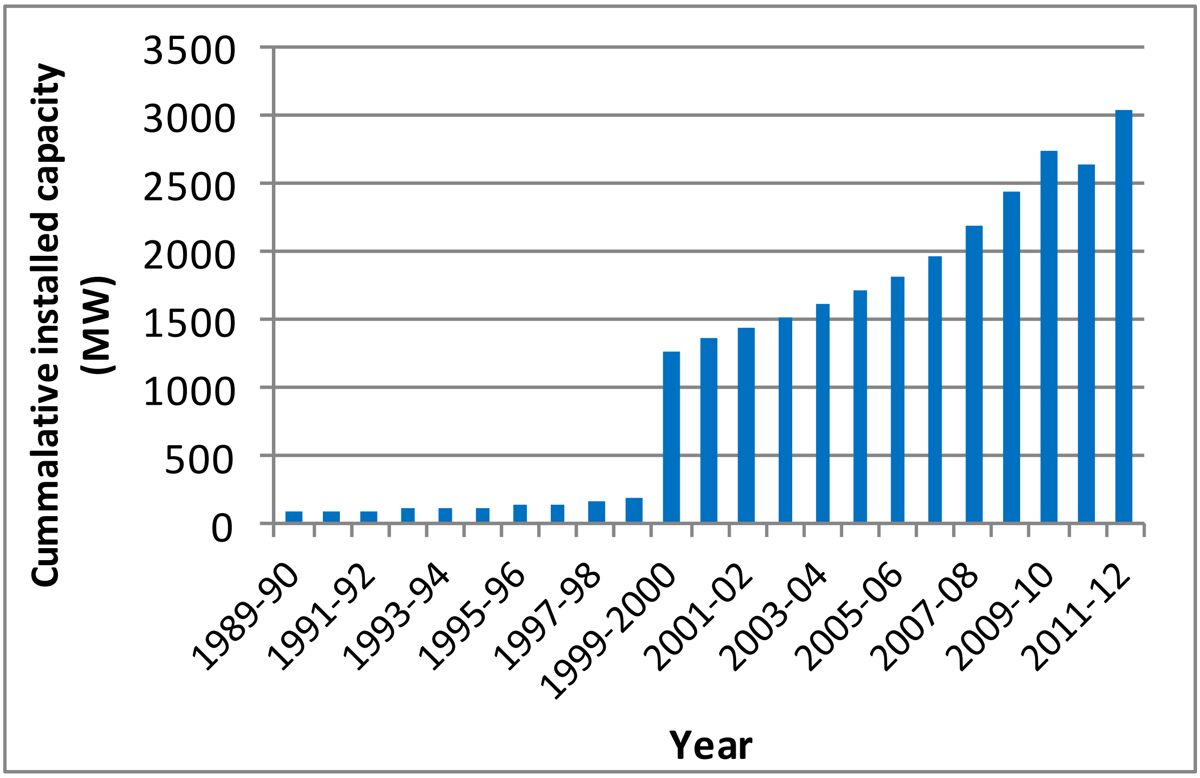
Over 40,000 gharats are reported to be in India

Flour Grinding

Water Mills in Uttarakhand (India)

In stream- Japan

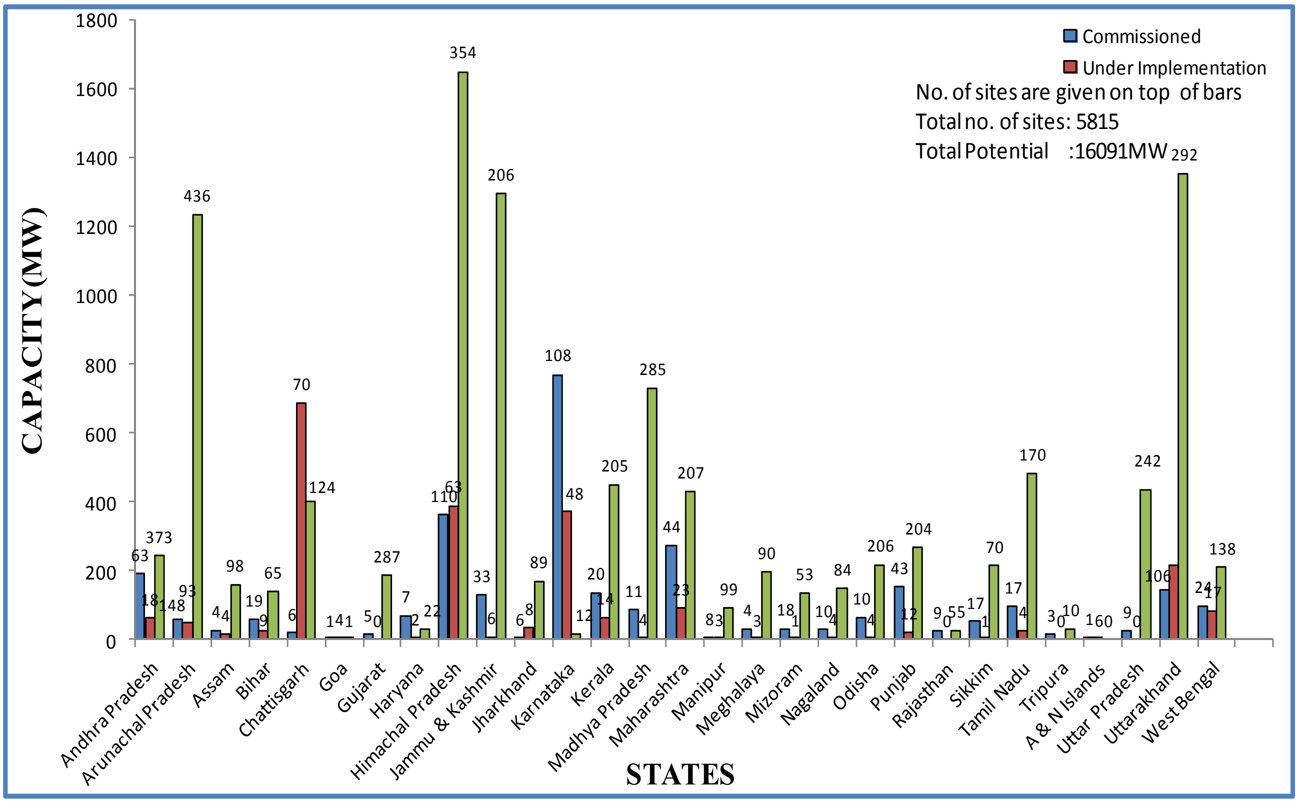
Year wise capacity addition for SHP in India



Small Hydro Potential Assessment

Scheme	CEA (1997 June) Upto 15 MW		PFC/AHEC (Mar 2003) Upto 15 MW		MNRE/AHEC Mar-2010 Upto 25 MW	
	No. of Scheme	Potential (MW)	No. of Scheme	Potential (MW)	Scheme	Potential (MW)
Small streams (ROR)	977	6154	2396	6172	3484	11492
Dam Toe	99	64	175	599	379	1645
Canal Falls	436	564	1407	1565	1952	2953
Total	**1,512**	**6,782**	**3,978**	**8,337**	**5,815**	**16,090**

Small Hydro Potential in India

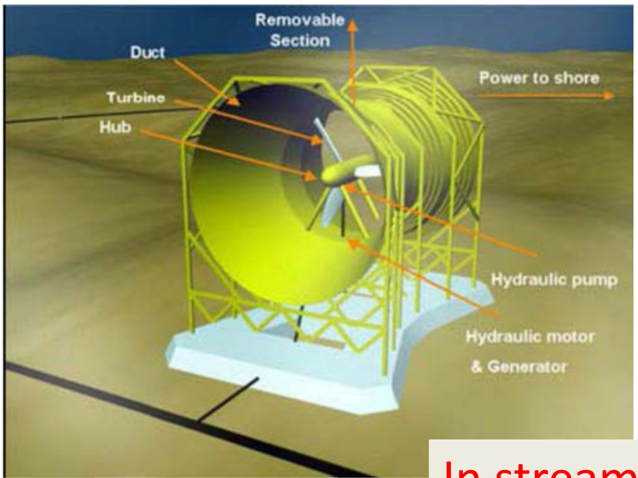


Small Hydro Potential Assessment is Required

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

MNRE, GOI is contemplating a small scale hydropower assessment programme during the 12th plan period.



In stream hydro

Tariff for SHP by different Regulators

Plant capacity (MW)	Tariff (US cents/kWh)			
	Uttrakhand state	Federal	Maharastra st	Punjab State
Up to 5	7.5	7.8 (Hilly) 9.24 (Others)	8.56	8.52
5 to 10	7.3	6.7(Hilly) 8.0(Others)	7.3	7.3
10 to 15	7.0			
15 to 20	6.8			
20 to 25	**6.5**			

Assumed 1 UD $ = 50 Indian Rupees

Barriers to SHP Development

Technical Barriers

- Absence of basic data like ***Hydrological data***
- To carry out detailed designs and drawings
- To increase plant load factor ***integration*** with other development and livelihood activities like irrigation, rural industries, education, health etc specially in hilly areas
- ***Absence of adequate coverage*** of transmission and distribution

Barriers to SHP Development…. contd

Policy Barriers

- Undecided about the development priority of the area
- Hidden subsidies to other energy sources not taken into consideration
- Absence of integration of different sector development

Social barriers

- Lack of visualization for enhancing livelihood and development activities
- Environmental and sustainability concept not explained and understood

Difficulty in Getting Clearances from Government – time schedule is regular issue of concern.

GOI POLICY ON HYDRO DEVELOPMENT

- In Aug 1998, the Government of India announced a Policy on 'Hydro Power Development' and revised in Nov.2008.
- Hydro is used to supplement the base load provided by thermal power plants.
- Central Electricity Authority has issued various hydro related reports and guidelines:
  - **the best practices in Hydroelectric Generation;**
  - **Preliminary ranking study of hydroelectric scheme;**
  - **Guidelines for accord of concurrence of HE Scheme;**
  - **Guidelines for formulation of DPRs for HE scheme;**
  - **Draft model contract document for hydro projects;**
  - **Project monitoring status reports;**
  - **Project clearance status reports**
  - **Status of 50,000 MW Hydroelectric Initiative reports .**

SMALL SCALE HYDRO POWER- new Issues

- Mostly run of river type and don’t provide adequate power during lean season
- Mostly new private developers
- Several new turbine manufactures and don’t provide reliable quality equipment
- Automation is not provided as normal choice
- New consultant for engineering not having experience to handle hydraulics and sediment
- Not much regulations available for releasing environmental flows at diversions causing great concern at several places

SMALL SCALE HYDRO POWER- Areas for collaboration

- Silt erosion measurements, assessment and silt resistive material for turbines
- Efficiency evaluation and development of variable-speed operation (Optimal use of low and variable heads sites) using the hydraulic turbine testing laboratory
- Environmental Management of rivers for hydropower development- e-flows
- Sediment management and handling hydropower development during snow and ice conditions
- Development of standardized control and monitoring hardware and software package

SMALL SCALE HYDROPOWER- Areas for collaboration

- Diagnostic analysis and solutions on the performance and behavior of the hydro turbine under control conditions.
- Cost effective development of very low head technology (0.5 to 2 m)
- Adaptation of high pole permanent magnet excitation generators to small hydro
- Optimizing Water Resources for Multiple Uses
- Integrating Renewable and Distributed Energy Technologies

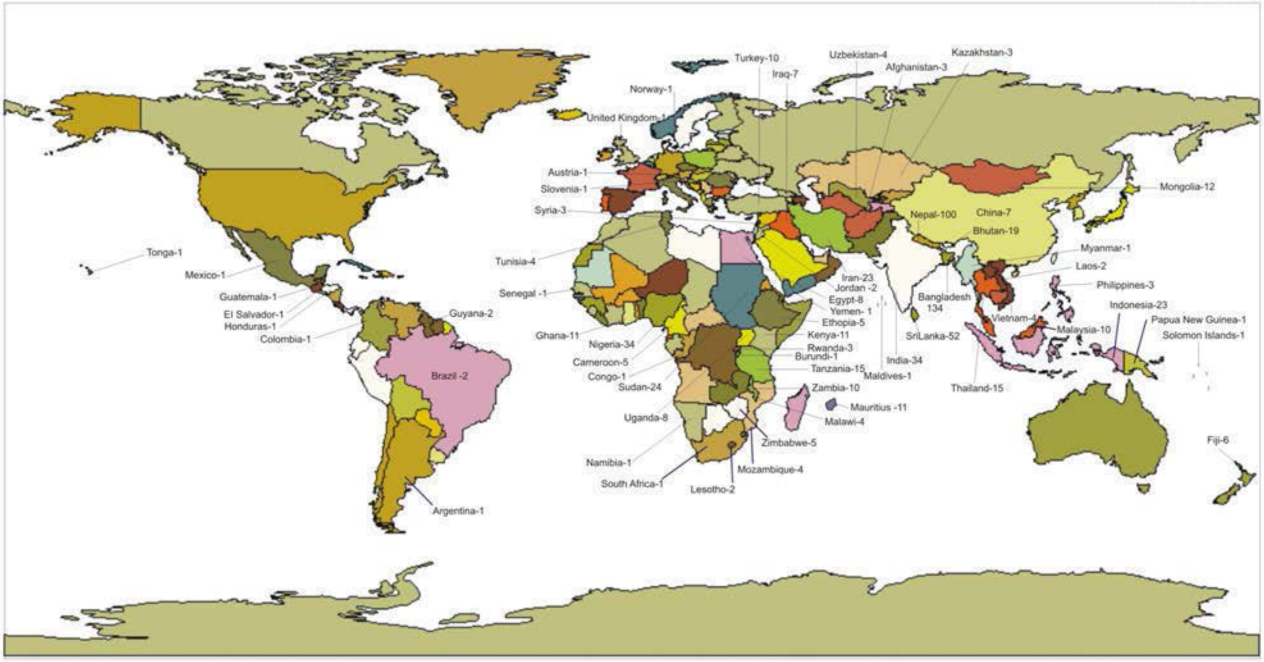
AHEC, IIT Roorkee

- **Set up initially by MNRE government of India in 1982**
- **Exclusive academic center of IIT Roorkee, 165 years the oldest technical institution, working with focus on SHP development and recognized as National Resource Centre for Small Hydropower.**
- **Large national database and resource assessment for shp development and rural electrification.**
- **Preparing the National Standards/ Code of Practices for SHP development.**
- **Systematic state master plans for shp and remote village electrification**
- **Training and education in shp at all levels and related field as per requirement. Two Masters of Techonlogy and PhD programmes are offered to national and international students**
- **Independent performance and efficiency testing and evaluation of shp stations**

Real-Time Digital Simulator (RTDS) for Small Hydropower Plant
at Alternate Hydro Energy Centre IIT Roorkee

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

1999 Onwards



AHEC/Feb. 2013

Thank You

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Norwegian Renewable Energy Partners

CEDREN
Centre for Environmental Design of Renewable Energy

The Research Council of Norway

teri
The Energy and Resources Institute

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NORWEGIAN EMBASSY

INNOVATION NORWAY

Indian Institute of Technology - Roorkee

Norwegian Renewable Energy Partners – INTPOW

Your Networking Arena

Norwegian Renewable Energy Sector

Mr. Geir Elsebutangen, Managing Director

intpow
Norwegian Renewable Energy Partners

Norwegian Renewable Energy Partners – INTPOW

Promoting Norwegian renewable energy capabilities internationally

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Norwegian Renewable Energy Partners

Long history and strong competence

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Norwegian Renewable Energy Partners

Norwegian Renewable & Environment Industry

Segment	No. of companies*	Turnover (NOK 1000)	Value added (NOK 1000)	Labor costs (NOK 1000)	No. of employees
RENEWABLE ENERGY					
Hydro-production	594	54 823 101	30 850 973	5 500 040	7 513
Hydro - technology	33	3 454 327	979 364	746 570	1 149
Bioenergy	155	4 572 891	1 304 638	622 741	936
Wind - production	15	49 471	24 700	26 919	21
Wind - manufactoring and technology	33	2 099 078	567 218	551 229	811
Solar	30	9 768 223	711 383	1 849 720	2 386
Other clean energy	22	2 261 260	797 734	156 949	172
Subtotal	882	77 028 351	35 236 010	9 454 167	12 989
ENVIRONMENTAL TECHNOLOGY AND SERVICES					
Consulting, R&D, ICT	102	7 630 486	4 200 825	3 801 077	5 211
Energy efficiency	96	4 150 006	1 080 668	904 741	1 532
Industrial/transport emission management, CCS	27	2 140 308	525 094	229 633	260
Environmental monitoring	11	326 709	147 385	126 872	180
Subtotal	236	14 247 509	5 953 972	5 062 323	7 183
TRADITIONAL ENVIRONMENTAL SERVICES					
Waste management, treatment and recycling	475	27 812 318	8 204 113	4 977 931	8 871
POWER DISTRIBUTION AND TRADING					
Power distribution and trading	193	61 768 503	14 870 543	5 850 933	9 574
Total	**1 786**	**180 856 682**	**64 264 638**	**25 345 355**	**38 616**

Renewable Energy Supply Chain

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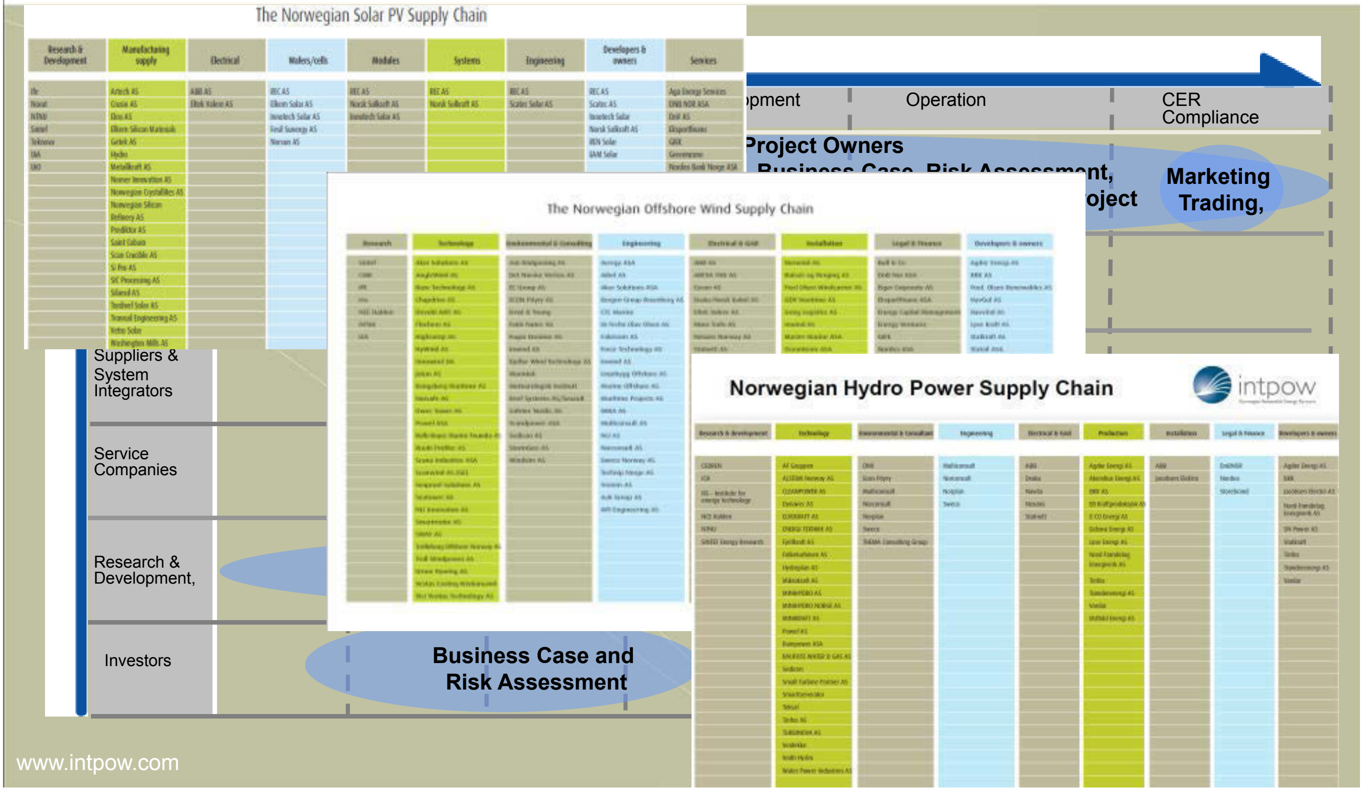
Norwegian Renewable Energy Partners



www.intpow.com

We believe..

intpow
Norwegian Renewable Energy Partners

- That combining PV and hydro power already is a cost competitive solution in solar rich regions
  - With little or no subsidies
- That this combination facilitates better water management
  - (More water can be used for irrigation)
- That this solution counteracts seasonal fluctuations in power generation
- That the market is huge

Hydro Power and Floating PV

- The PV-panels can be mounted on the shore or on a floating structure in the dam
- PV-modules mounted on water will be cooler and have higher efficiency
- Evaporation losses can be reduced by 70 %

Floatovoltaic™

The Idea

- Most people have observed that sunshine and rain at the same time is fairly rare..
- Thus, PV and hydro power should be a perfect match for power generation
- Several theoretical studies of these type of systems are described in the scientific literature, but none have been built…(?)

The Main Objectives

intpow
Norwegian Renewable Energy Partners

- Demonstrate a successful combination of hydro and solar power
  - Norway first, then internationally
- Enhance the existing power production
  - Save cost on using the existing infrastructure
- Develop solutions for efficient power control for this type of systems
- To gain experience for future projects

Photo: Small Turbine Partner

Partners in the Rekåa project

intpow
Norwegian Renewable Energy Partners

Together we have more than 200 years of experience in hydro power
+
more than 30 years of PV experience

intpow ITS INNOTECH SOLAR TINFOS MULTICONSULT

Timothy C. Lommasson and more …..

Rekåa Hydro Power Plant - Facts

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Norwegian Renewable Energy Partners

- Rekåa Hydro Power Plant is situated close to the Tinfos' main office in Notodden, Norway
- Capacity: 500 kW
- Average flow: 373 l/s
- Height difference: 90 m
- Average power production: 1,5GWh/y
- Run-off-river (no reservoir)

The PV-plant - I

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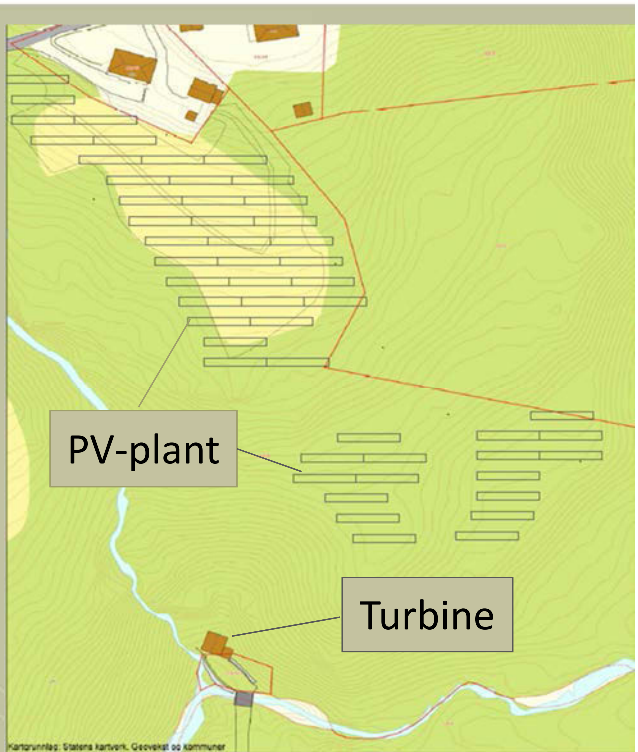
Norwegian Renewable Energy Partners

- The PV-plant will be built in the hillside, facing the south
  - Above the water pipe
- Capacity: 500 kWp
  - This will increase the existing capacity with 100 %
- Yield: 0,48 GWh/y
  - This will increase the power production with ~ 30 %



The PV-plant - II

- We expect very low power production during the winter (snow)
- Power production in spring will be high, due to cold weather and reflection on the snow
  - When the snow melts, the peak flow is during night

Financial Viability

- Cost is a challenge, but we believe that we have come down to a level which is acceptable
- Yet, there is a need for governmental support today
- We believe that
  - The next project will be cheaper
  - Constructing the PV- and Hydro power plant at the same time is even cheaper

Conclusions

- PV and hydro power makes a perfect match
    - Especially in those regions of the world which needs more electrical power
- We believe that the world market for combined PV and hydro power production is huge
- This is a cost efficient and competitive solution

Foto: Marit Lystad Johansen

Development of Solar Power in India

Shirish Garud,

Senior Fellow,

The Energy and Resources Institute

Renewables Respecting Nature,

IndoNorwegian Seminar,

Mumbai

Outline

- Changing scenario
- National Solar Mission
- Solar PV sector in India
- Opportunities for Indo- Norwegian Collaborations

Changing scenario

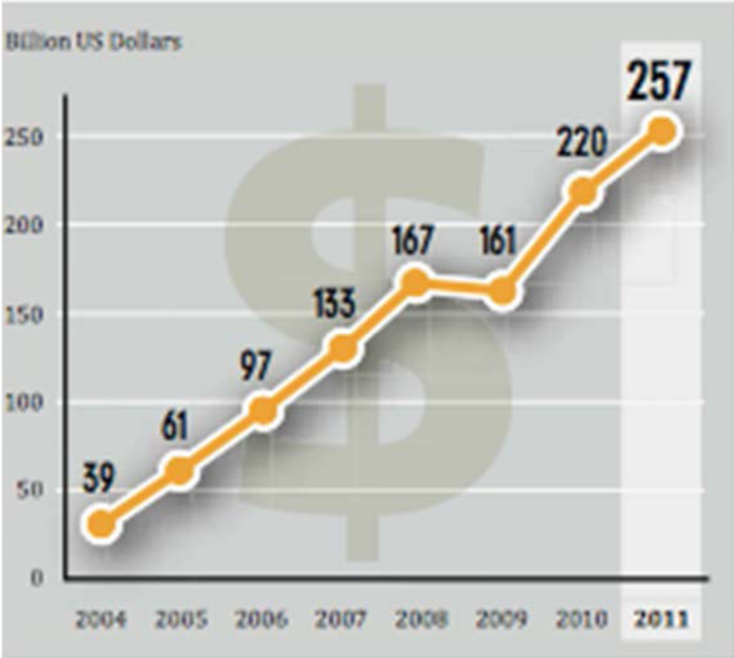
- Drivers for renewables
  - **Conventional fuels are increasingly becoming expensive and supplies are becoming irregular**
  - **Climate Change impacts are visible**
  - **India's concern for energy security and access to energy**

Annual RE Capacity Addition 2011

Sl. No.	New Capacity	Hydro-power capacity	Solar PV capacity	Wind power capacity	Solar hot water / heating capacity	Bio-diesel produc-tion	Ethanol produc-tion
1	China	China	Italy	China	China	United States	United States
2	United States	Vietnam	Germany	United States	Turkey	Germany	Brazil
3	Germany	Brazil	China	India	Germany	Argentina	China
4	Italy	India	United States	Germany	India	Brazil	Canada
5	India	Canada	France	U.K. / Canada	Italy	France	France

Source – REN 21, GSR 2012

Investments



- **RE investments are increasing**
- **Investments in India crossed US$ 10 billion**

Source - REN21, GSR 2012

Energy sector related ministries/ departments

Government of India

- **Planning Commi- -ssion**
- **Ministry of Coal**
- **Ministry of Power**
  - **CEA**
  - **Generation companies**
    - •NTPC
    - •NHPC
  - **T&D company**
    - •POWERGRID
  - **Power finance**
    - •PFC
    - •REC
  - **Power trading**
    - •PTC
  - **Regulatory organizations**
    - •CERC
    - •STATE ERCs
  - **Energy Conservation**
    - •BEE
  - **Research and training**
    - •CPRI
    - •NPTI
- **Ministry of Petroleum & Natural Gas**
- **Ministry of New & Renewable Energy**
  - **Financial Institution**
    - •IREDA
  - **R & D, testing, Certifying institutions**
    - •SEC
    - •C-WET
    - •AHEC
  - **Supervisory Organizations Regional offices**
- **Dept. of Atomic Energy**

Renewable energy sector development in India

Creating Innovative Solutions for a Sustainable Future

1970s

- R&D programs initiated
- Focus on developing RE technologies and products
- Demonstration projects

1980s

- Fiscal & financial incentives introduced (subsidy, tax incentives, etc)
- Increased role of Public Sector Undertakings
- Infrastructure development

1990s

- More emphasis on fiscal incentives
- Increased Private Sector Participation

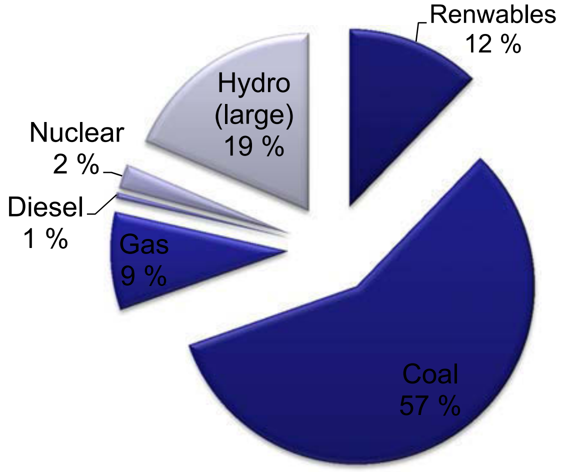
2000 Onwards

- EA 2003, NEP 2005, NTP 2006
  - Quota/Obligation system introduced
  - Preferential tariffs for RE
- Integrated Energy Policy 2006
- Generation based incentive for Solar PV/ Thermal
- NAPCC

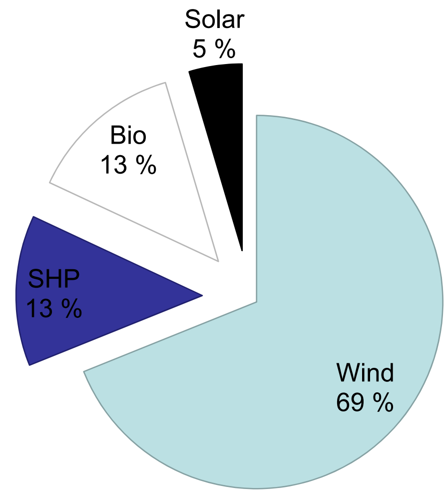
Installed Power Generation Capacity

Creating Innovative Solutions for a Sustainable Future

Installed capacity as on Jan 31, 2013



Total installed 213 GW



Total installed RE 26.7GW

National Solar Mission

- The objective of the National Solar Mission is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible.
- Mission aims to achieve grid tariff parity by 2022 through
  - **Large scale utilization, rapid diffusion and deployment at a scale which leads to cost reduction**
  - **R&D, Pilot Projects and Technology Demonstration**
  - **Local manufacturing and support infrastructure**

Strategy

- Enabling policy and regulatory frame work
- Supporting Utility scale power generation
- Emphasis equally on grid & off-grid applications
- Accelerating Research and Development
- Enhancing Domestic manufacturing base

JNNSM Targets

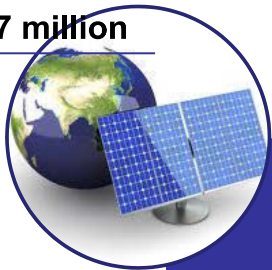
	2010-13	2013-17	2017-22
Utility grid power, including roof top (MW)	1100	4000-10000	20000
Off grid solar applications (MW)	200	1000	2000
Solar Collectors (sq. meters)	7 million	15 million	20 million

2017-22

To create favorable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.

2013-17

Capacity will be aggressively ramped up to create conditions for up-scaled and competitive solar energy penetration in the country after taking into account the experience of the initial years.



2010-13

Main focus on capturing the easily available options in solar-thermal and on promoting off-grid systems to serve populations without access to commercial energy and modest capacity addition in grid-based systems.

Launched in Jan 200

State solar policies summary

State Policy	Year of announcement	Period	Major initiatives	Key points
Gujarat 'Solar Power policy-2009'	2009	till March 31, 2014	Max 500MW in five years	• Two part tariff (first twelve year and next 13 year) • Min capacity for both SPV and ST is 5 MW
Rajasthan Solar Policy 2011	2011	Until supersede d by another policy	10-12GW in next 10-12 years	100MW (50MW each for PV& CSP) projects under tariff bidding with bundling 600MW under direct sale by 2017 Special allocation quota for manufacturing units, R & D projects, solar park establishment
Madhya Pradesh Solar Policy 2012	2012	Not mentioned	Encourage participation of Private Sector to set up Solar Power based projects in the State.	• Promoting both the technologies within strict timelines adherence for category II and III projects, • Guidelines for SPG mentioned under four categories belonging to registration under SERC, Open access and captive consumption, REC, JNNSM; • promotes off-grid solar projects too; • Support to solar park development

State solar policies summary (contd.)

State Policy	Year of announcement	Period	Major initiatives	Key points
Tamil Nadu Solar Energy Policy 2012	2012	2015	3GW installed capacity by 2015 and thereby achieve grid parity	• 3% solar RPO requirement till December 2013 & 6% solar RPO requirement from 2014 • Program breakup of target achievements source wise • Rooftop solar program development through domestic, government installations • Promoting SWHS • Encouragement of solar parks • Promote indigenous manufacturing of solar panels and other related equipment with identified land for solar manufacturing . • 1 lakh street lights through solar energy by 2015-16 and water supply installations in local bodies will be energized through solar power phase wise
Andhra Pradesh Solar Policy 2012 & First Amendment	2012	Till 2017	Promote SPG through REC mechanism	• Incentives in force for a period of seven years from the date of implementation. • All the projects developed under this scheme will be eligible for REC benefits. • Policy will be reviewed after 2 years

State solar policies summary (contd.)

State Policy	Year of announcement	Period	Major initiatives	Key points
Chhattisgarh Solar Policy 2012-17	2012	Till 2017	SPG target between 500MW to 1,000MW by March 2017.	• Incentives to developers under Industrial Policy of Chhattisgarh uptill 2017 • The policy will promote grid connected solar generation, rooftop solar power projects, solar parks.
Karnataka Solar policy 2011-16	2011	Till 2016	200 MW by 2015-2016	• For solar PV min. and max. capacity shall be 3 MW and 10 MW, resp. For Solar thermal projects min. capacity is 5 MW. • In addition to 200 MW, 50 MW from the central or state owned undertaking for setting up solar projects for bundling with thermal power. • 100 MW capacity to be installed under the Renewable Energy Certificate mechanism. • CPP and OA do not form part of the proposed 200 MW capacity.

State solar policies summary (contd.)

State Policy	Year of announcement	Period	Major initiatives	Key points
Draft Uttar Pradesh Solar Policy 2012	2012	Till 2017	target of 500 MW	• Min. 5 MW capacity SPP to be allotted • PPA span of 10 years
Kerela rooftop solar policy	2012	2013	10 MW rooftop SPV power plants	• Applicant can register for only 1kW non-grid connected system • FA from ANERT @ Rs. 39,000/kWh • Additionally, 30% capital subsidy or support @ Rs.81,000/kWh from MNRE, whichever is lower.

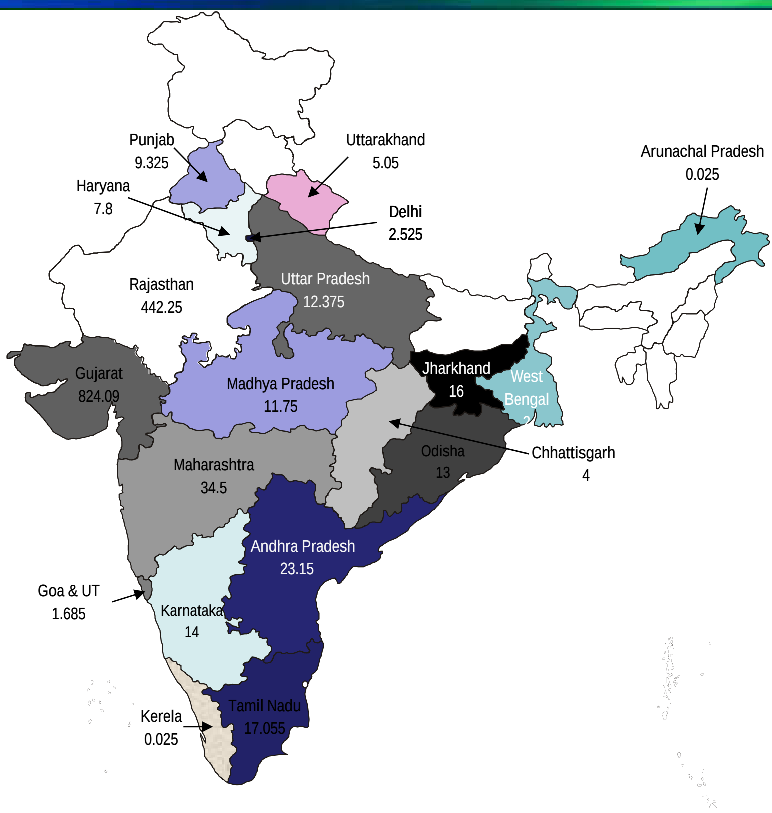
Current status: JNNSM

- Phase I
  - Under implementation 1000MW grid connected project
  - 1686.44 MW SPV grid connected power projects installed (including state mission targets)
- Phase II
  - Draft for first round of 750MW PV grid connected power project
  - SECI to play an important role
  - Viability gap funding proposed

JNNSM Solar PV

- Solar PV is rapidly becoming cheaper and implementable
- Investors and bankers showing confidence
- Emerged as most preferred option for grid connected plants

Current status of solar project



Total installed capacity 1440 MW

as on March 09, 2013

Key research areas-Solar PV

- Development of large area anti-dust, self-cleaning coatings for glass surfaces.
- Improvement of commercial efficiencies of silicon solar cells greater than 20%.
- Development of CZTS solar cells with efficiency target of 15% on one cm^2 area
- Development of Solar Cells with peak efficiencies at 30°C – 40°C ambient temperature
- CPV and PV/T technologies

Indo-Norwegian Collaborations

- Solar PV research collaboration
- Project on developing implementable road map for solar PV research and development
- Joint research center for SPV development
- Development of trained manpower
- Policy studies

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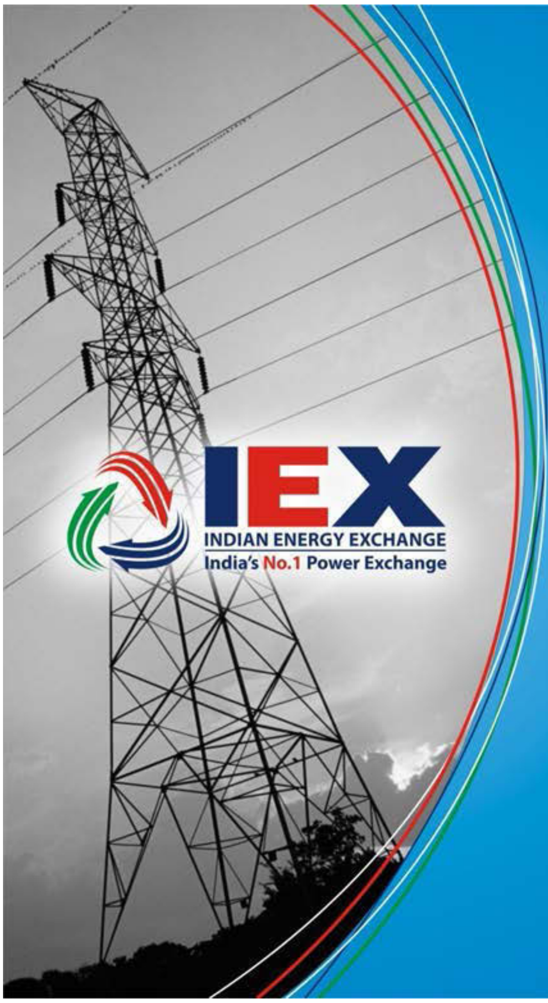
Thanks!

Contact: shirishg@teri.res.in

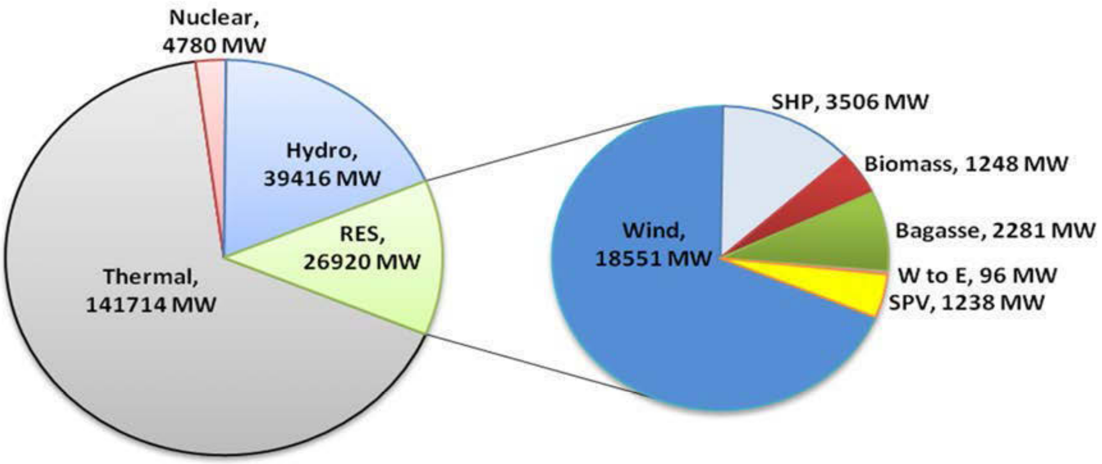


Renewable Energy Certificate Mechanism

- **April’2013**
- **Email: info@iexindia.com**
- **Website: www.iexindia.com**

Status of Installed Renewable Generation Capacity

Total Installed Capacity



2,16,067 MW Capacity as on 28th February 2013

26,920 MW Capacity as on 28th February 2013

Renewable Energy Certificates … Genesis

- **In-firm nature**
  - Scheduling for sale within State – can be only on monthly basis
  - Scheduling in MW outside State – very difficult
- **Difficulty in fixing preferential tariffs for each technology, vintage etc.**
- **Disparities among States**
  - Surplus States (having abundant Renewable resource) - cannot absorb renewable power at preferential tariff
  - Deficit States - Only through scheduling , no other manner for procuring renewable energy
- **Solution**
  - Convert (Renewable) Green Energy = Electricity + Green Attribute
  - Sell Electricity @normal prices
  - Sell Green Attributes @ some premium

Overview of Legal Framework

- **2008 : National Action Plan on Climate Change (NAPCC)**
  - **Suggests RPO at 5% in year 2010, increasing 1% every year for 10 years.**
  - **Appropriate authorities may issue certificates that procure RE power in excess of the national standard**
  - **Such certificates may be tradable, to enable utilities falling short to meet their RPS.**
  - **Penalties as may be levied, falling short in RPS**
- **January,2010 : CERC issues REC Regulation on 14th Jan,2010**
  - **CERC(Terms and Conditions for recognition and issuance of Renewable Energy Certificate For Renewable Energy Generation) Regulations, 2010**
  - **CERC designated National Load Despatch Centre (NLDC) as Central Agency: Notification dated 29.01.2010**
- **June,2010 : CERC approved Procedures for Accreditation, Registration & Issuance**
- **June,2010 : CERC Order on determination of forbearance price and floor price**
- **Sep,10 : First amendment of REC Regulation**

Renewable Energy Certificate

Bundled Green Power

Seller (RE power) → Buyer (RPO Compliance)

Issues
- Schedulability
- Uncertainty
- Transmission Loss & Charge

Un-bundled Green Power

Seller (RE power) → Electricity; REC(Green Attributes)

REC(Green Attributes) + Electricity → Buyer (RPO Compliance)

Why REC a better option than 'buying renewable power' ?

Schedulability
- Less predictable
- Less controllable
- Require better prediction tools over one-day
- Scheduling changes till one-hour before

High Overheads
- More System imbalances
- Discoms to spend on more reserves to avoid UI
- More reserves required to balance

Open Access costly
- Payment of Transmission, Wheeling Charges, Losses and Scheduling Charges to LDCs(50-100p/kWh) vis-à-vis 7p/kWh in RECs

RECs are better way to transfer green premium than green energy

REC Sellers : Approved Sources

Wind

Biomass,
Bio – fuel
co - generation

Solar

Municipal Wastes

Small Hydro

Any type/source approved by MNRE

Black Liquor : MNRE consider Black Liquor as a Biomass Source

REC Buyers

- Obligated Entities
  - Distribution Companies
  - Open Access Consumers
  - Industries consuming Captive Power
- Voluntary Entities
  - Corporates under CSR
  - Individuals

Eligibility Criteria

- **Self Consumption / Captive Use**
  - No Promotional Wheeling*
  - No Promotional Banking**
  - No Electricity Duty Exempt
  - **Eligible if all three condition mentioned above are met**
- **Third Party Sale / Open Access**
  - Sale at Mutually Agreed Price
  - **Eligible**
- **Sale Through Bilateral Contracts**
  - Sale at Mutually Agreed Price
  - **Eligible**
- **PPAs with Distribution Licensee**
  - PPA at Average Power Purchase Cost → **Eligible**
  - PPA at State Regulated Tariff → **Not Eligible**

Important Provisions

- Eligibility for REC :

  A Generating company is eligible for obtaining accreditation from the State Agency if :

  - It does not have any PPA at a preferential tariff.
  - Sells to distribution licensee at a price not exceeding the pooled cost of power purchase,
  - Sells to open access consumer at mutually agreed price.
  - Sells through power exchange at market determined price.

- Non-compliance of RPO :

  If the obligated entity does not fulfill the RPO as per the regulations, The Commission may direct the obligated entity to deposit into a separate fund, to be created and maintained by the State Agency (SLDC), such amount as the Commission may determine on the basis of the shortfall in units of RPO and the forbearance price decided by the Central Commission (NLDC).

- The penal charges will be equivalent to the forbearance price multiplied by shortfall in units of RPO.

Summary of REC Regulations

- REC Regulations
  - All States except Sikkim
- RPO Regulations
  - All States except Sikkim
- RPO for OA /CPPs
  - All States except WB and Sikkim
- State Agency Regulations
  - All States Sikkim

Salient Features of REC Mechanism

Participation	Voluntary
REC Denomination	1 MWh
Validity	730 Days after issuance **(As per CERC order dated 11th Feb'2013)**
Categories	1. Solar REC 2. Non-Solar REC
Trading Platform	Power Exchanges only
Banking	Not Allowed
Borrowing	Not Allowed
Transfer Type	Single transfer only , repeated trade of the same certificate is not possible
Penalty for Non-compliance	'Forbearance' Price (Maximum Price)
Price Guarantee	Through 'Floor' Price (Minimum Price)

RECs Floor/Forbearance Price

2012-2017	Floor Price	Forbearance Price
Solar	9300/REC	13400/REC
Non Solar	1500/REC	3300/REC

1 REC is equivalent to1 MWh

Reference : CERC Order in matter of Petition no. 99/2010, dated March 23, 2010

REC Mechanism

Procedure for ACCREDITION (Through State nodal Agency)

Procedure for REGISTRATION (Through Central Agency NLDC)

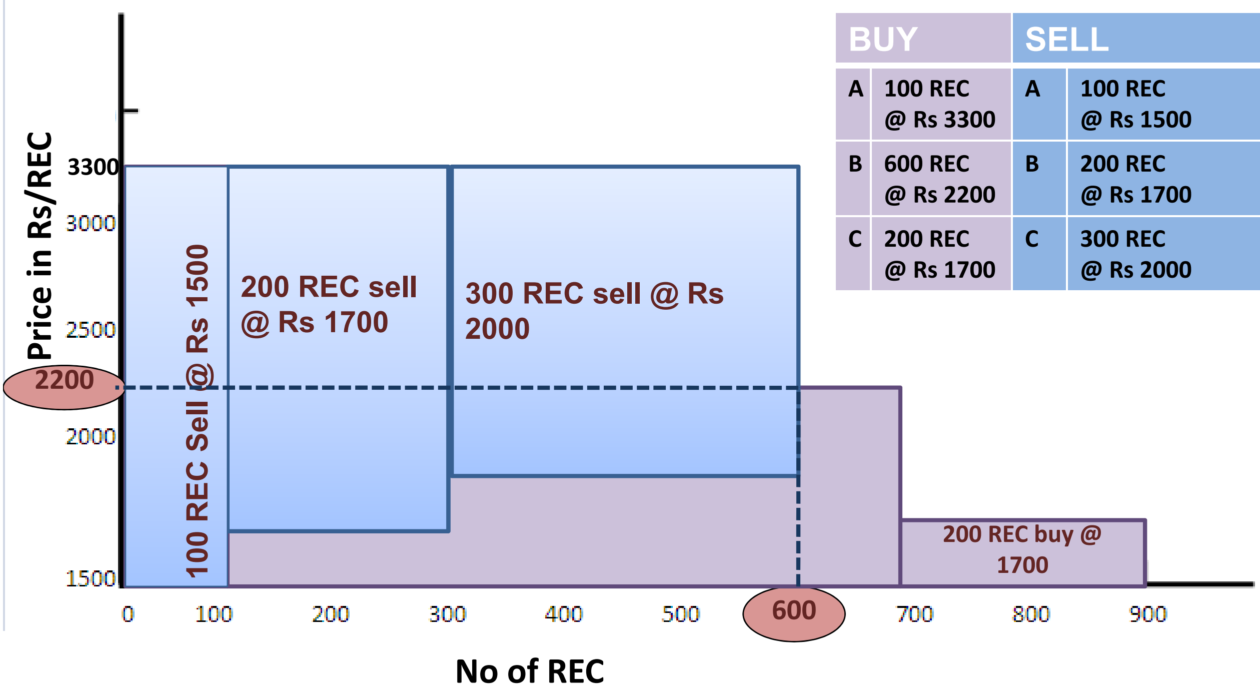
Procedure for ISSUANCE (Through Central Agency NLDC)

Procedure for TRADING & REDEMPTION(Through PXs)

Trading at IEX

Trading Day	Last Wednesday of every Month
Market Clearing	Closed Double sided auction
Trading Time	1300-1500 Hrs
By 1530 Hrs	Verification by Central agency for Valid REC by cleared seller at IEX
By 1600 Hrs	Central agency confirms REC
By 1630 Hrs	IEX finalizes trade
By 1700 Hrs	Buyer & Sellers informed to Central Agency
By 1800 Hrs	Invoice raised *(proof of REC trade)*

Cleared volume : 600 RECs **MCP:** Rs 2200/REC



BUY		SELL	
A	100 REC @ Rs 3300	A	100 REC @ Rs 1500
B	600 REC @ Rs 2200	B	200 REC @ Rs 1700
C	200 REC @ Rs 1700	C	300 REC @ Rs 2000

REC - Fee & Charges

State Nodal Agency

Accreditation	Fee & Charges
Application Processing Fee	Rs. 5000
Accreditation Charges (One Time – for 5 Years)	Rs. 30,000
Annual Charges	Rs. 10,000
Re-Validation Fees (After 5 Years	Rs. 15000

Central Agency

Registration	Fee & Charges
Application Processing Fee	Rs. 1000
Registration Charges (One Time – for 5 Years)	Rs. 5000
Annual Charges	Rs. 1000
Re-Validation Fees (After 5 Years	Rs. 5000

Central Agency

Issuance	Fee & Charges
Fees Per REC issued	Rs. 10

IEX

Redemption	Fee & Charges
Fees Per REC traded	Rs. 20

REC - Fee & Charges Impact

Cost Impact of Fee and charges in First Year

Assumptions:

- Project of Capacity = 1 MW
- Capacity Utilisation Factor = 22%
- No. of Units Generated = 19.27 MU
- No. of REC Issued = 1927

Cost Head	REC @ 1500	REC @ 2600	REC@3600
Accreditation	45000	45000	45000
Registration	7000	7000	7000
Issuance	19270	19270	19270
TOTAL COST	**71720**	**71720**	**71720**
Revenue from REC	2890500	5010200	6937200
% Cost Incurred	2.48%	1.43%	1.03%
Paise Impact Per Unit	**3.7 Paise**	**3.7 Paise**	**3.7 Paise**

Similarly the cost impact (in Paise / Unit) for:

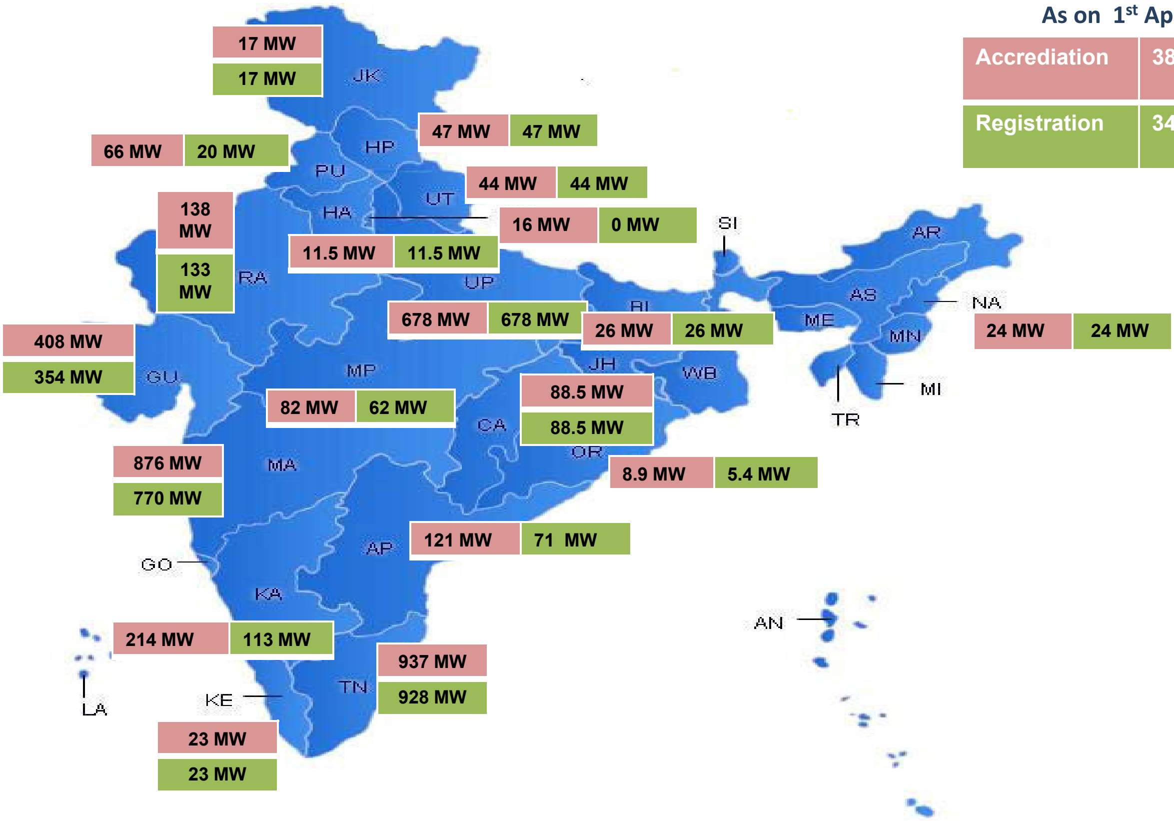
TWO Year	THREE Year	FOUR Year	FIVE Year
2.15 Paise	**1.65 Paise**	**1.32 Paise**	**1.20 Paise**

Status of Accredited & Registered Project

State wise Accrediation & Registration Capacity

As on 1st April'13

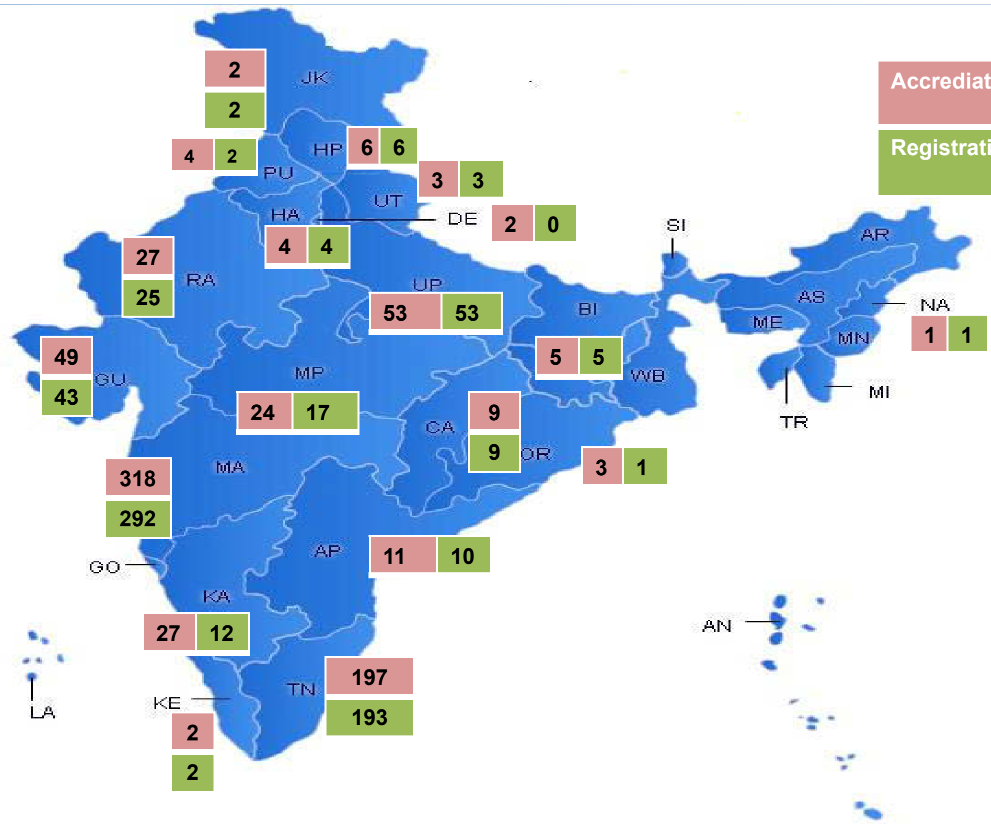
Accrediation	3831 MW
Registration	3420 MW



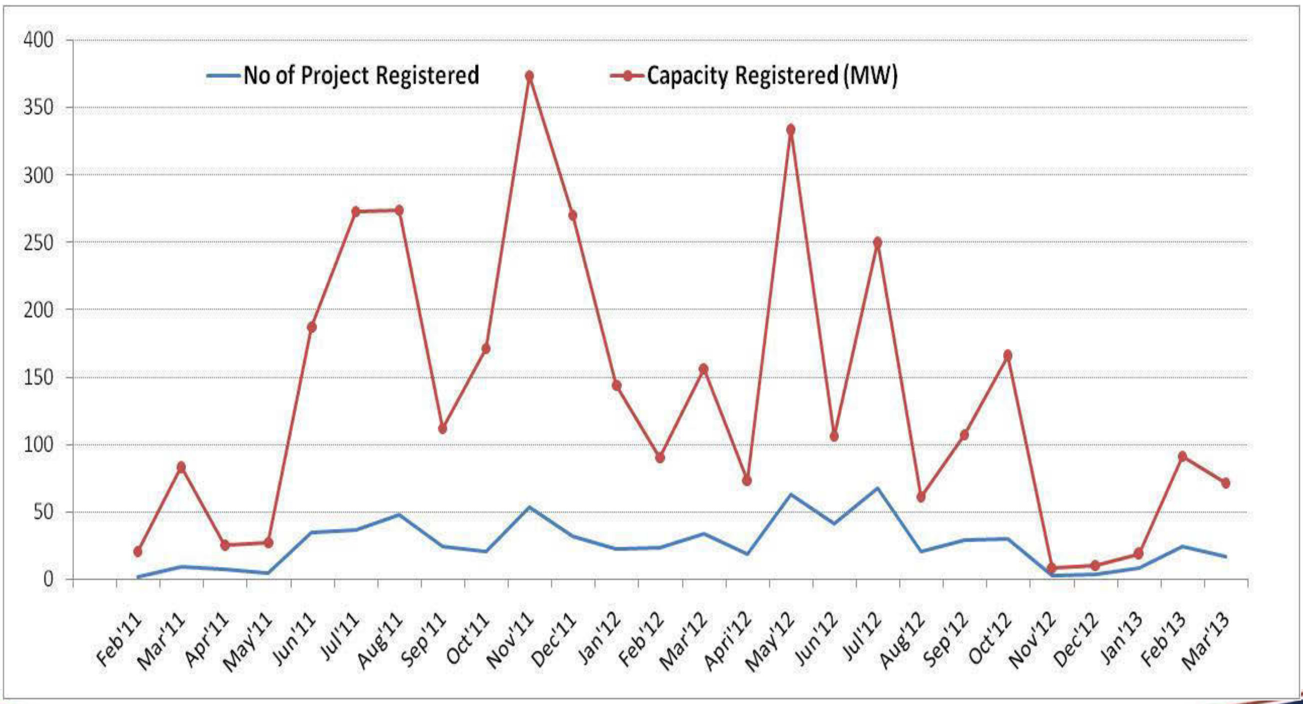
State wise Accredited & Registered No. of Projects

As on 1st April'13

Accrediation	727 No
Registration	669 No



Project registered Vs Capacity registered



Performance so far

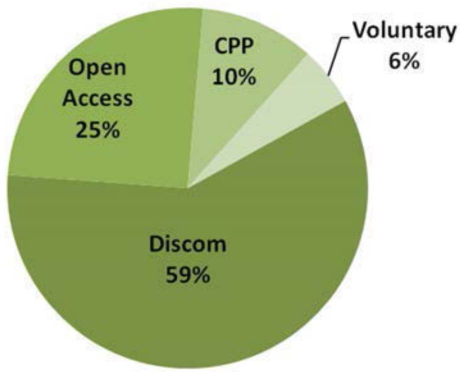
Adequate Liquidity in REC

- ✓ 1100+ Participation in a single trading sessior (March'13)
- ✓ 1500+ portfolio
- ✓ Cleared Volume = 29,42,147 RECs
- ✓ Average Monthly Volume = 1,17,685 REC
- ✓ Record 3,09,892 REC traded in a single tradir session (March'13 trading session)

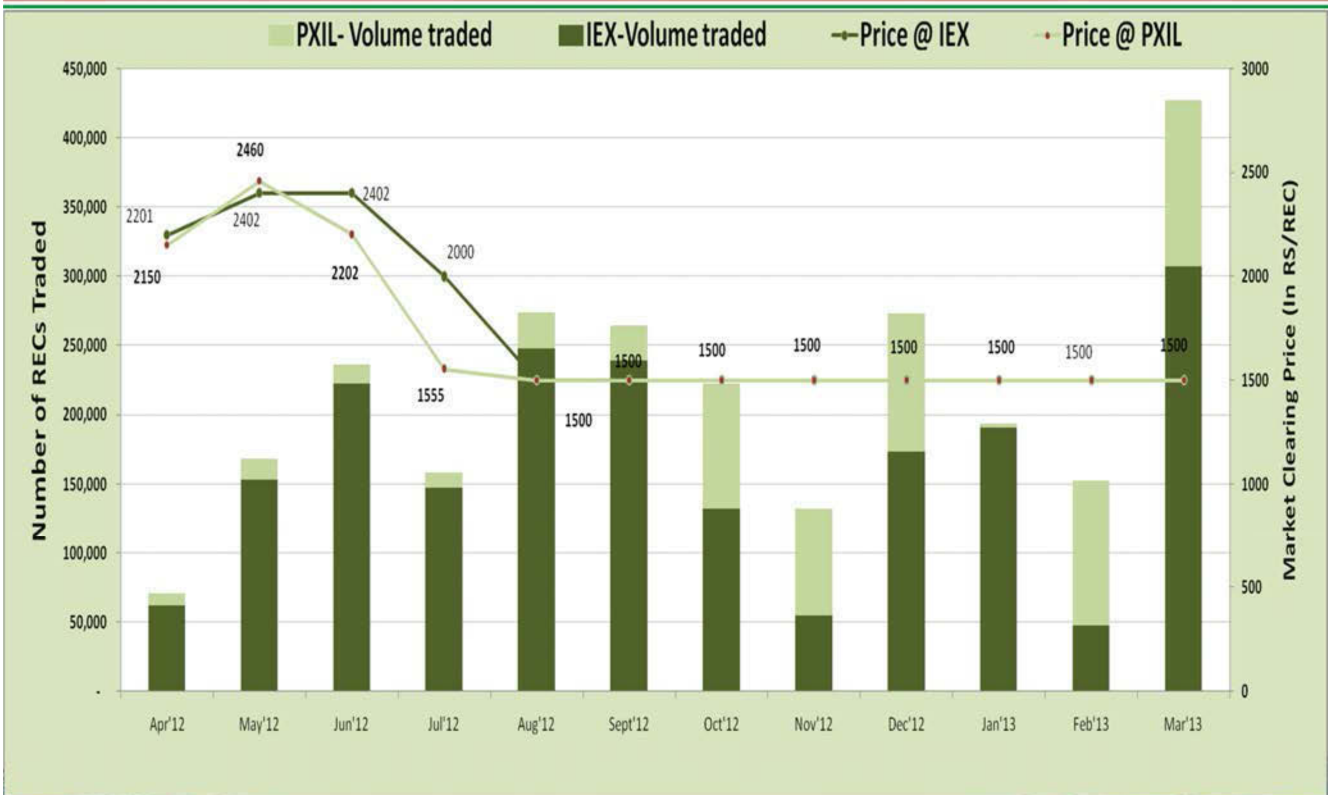
Participation Details

Registered Participants	1690
Obligated Entity	1153
DISCOMs	26
OA consumers	1075
Captive Consumer	52
Voluntary	13
Eligible Entity (Sellers)	524
Highest participation in an Auction(March'13)	1135

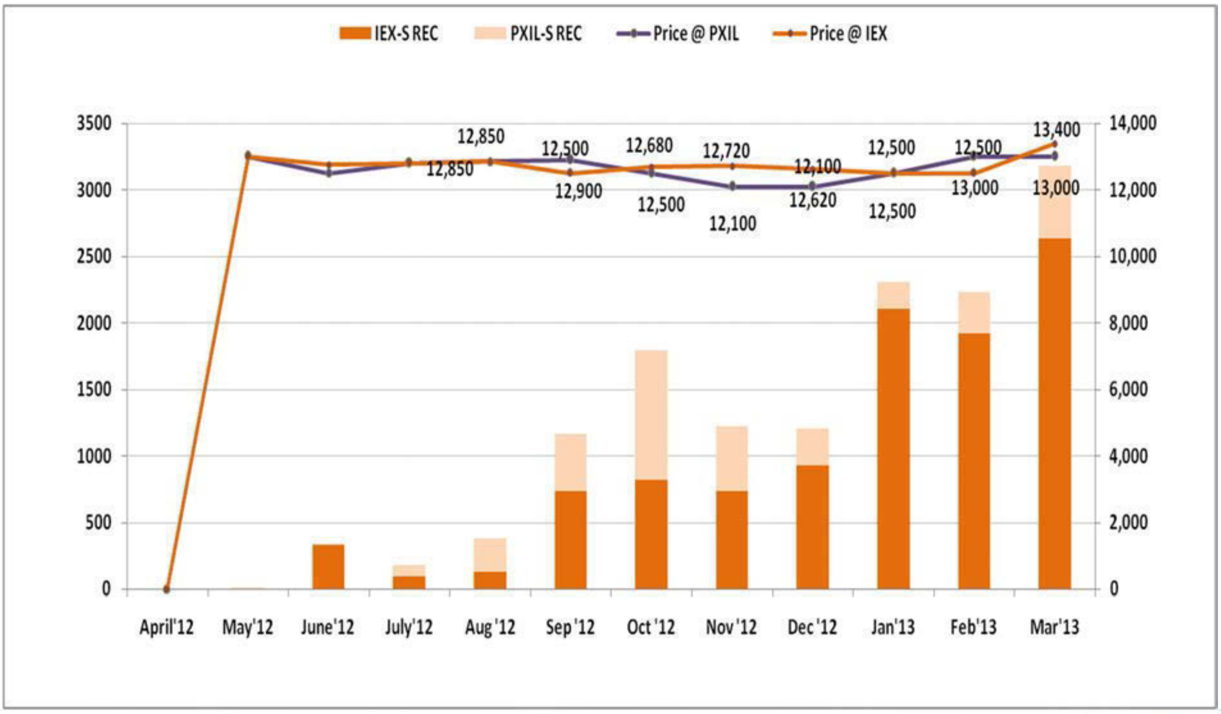
Buyer Participation Share



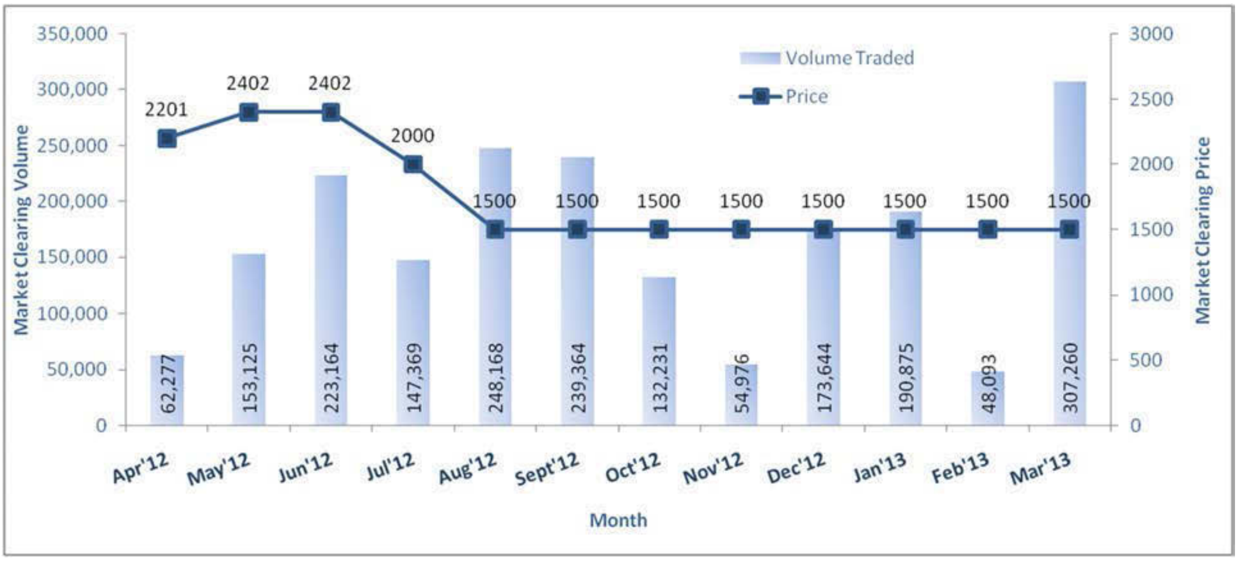
N-Solar REC trade detail



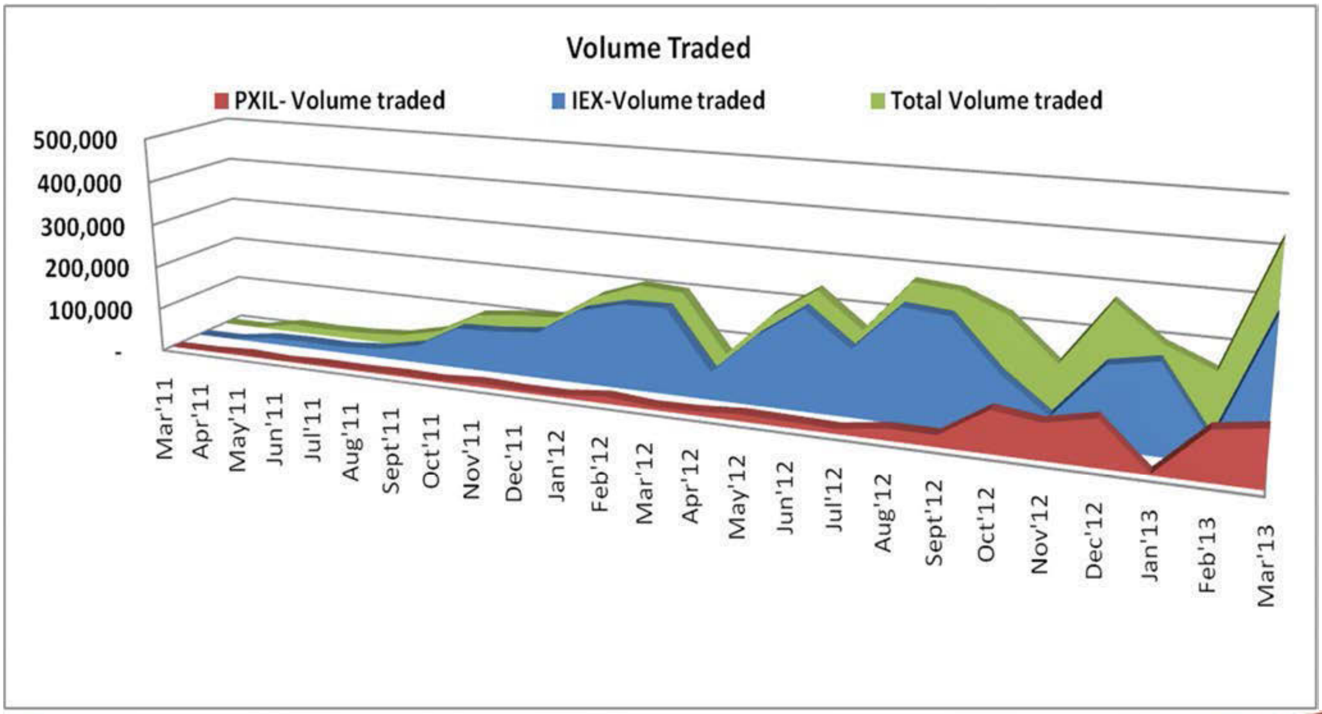
Solar REC trade detail



Price volume trend for NS-REC



REC volume cleared



IEX Initiatives
Continuous communication with Users

IEX Daily SMS Service for Trade Details

Email
sms@iexindia.com

IEX Monthly Bulletin

Email
bulletin@iexindia.com

IEX hourly Trade Prices displayed on its website

Email
info@iexindia.com

Thank You

www.iexindia.com

Renewable energy respecting nature and *people*

- addressing the acceptance challenge

Helene Egeland
CEDREN

The future of renewable energy and the issues of acceptance

- Report written on behalf of **European Commission DG ENERGY (2011)**:

*"Although the use of renewable energy sources (RES) is broadly supported, the huge growth of renewable projects is leading to increasing **acceptance issues** at a community level."*

- ***project developers***
- ***Governments***

*Calls for a need to address the **acceptance** challenge – a common challenge in order to realize ambitious renewable targets in the EU as well as in India*

Acceptance and renewable energy in India

The Electricity Act, 2003, emphasize on a transparent public participation in the regulatory process

- Report by Electricity Governance Initiative (EGI): public opposition to clean energy among civil society organizations

Lack of accurate and transparent data on the renewable energy potential has lead to resistance towards high renewable energy tariffs

Key challenges

- Social and environmental impacts
- Lack of awareness about the role and process of regulatory decision making – spaces for CSO intervention
- Need for capacity building in order to participate in the regulatory processes
- Need to acknowledge the role of CSOs in the regulatory process

Acceptance and energy (hydropower development) in a historical perspective

- Hydropower production's strong position in the development of Norway as a welfare state
- The bonds to the local municipalities:
  - Focus on how to minimize the negative impacts on the local municipalities
  - Economically compensated
- The social contract:
  - the legitimacy of hydropower development to a large extent was founded on the degree stakeholders were offered articulation and representation within the governance regime (Angell & Brekke 2011).
- From the 1960s and onward: the balancing of opposing interest
  - Through the institutionalization of the environmental concerns (the establishment of the Ministry of the Environment and the Directorate of Nature Management), the earlier regulatory authority of the Norwegian Water Recourses and Energy Directorate was challenged.
  - The role of 'knowledge' in order to minimize resistance against large

The trade-off between competing concerns and the role of knowledge

- 1960s and 1970s
  - Conflicts related to development of large scale hydropower
    - Impacts on the environment, landscape, recreational interests and indigenous concerns (the Sámi people)
  - ➢ *Assumption: knowledge based management of the water resources would moderate the level of conflicts between competing interests*

- Institutionalization of environmental impacts
  - 1990: statutory though the Planning and Building Act

Involvement in the concession process in Norway

Legal framework: The Energy Act as well as The Plan and Building Act 2008, chapter 14 including the guidelines for impact assessments (1.7.2009) regarding impacts on the environment, natural resources as well as on society

The Norwegian Water Resources and Energy Directorate (NVE) arranges public hearings and assess the comments received from the consultative bodies (organizations as well as private individuals)

- Two stages: Notification (input to the Environmental Impact Assessment Program) and the application (Possibilities for additional impact assessments)

➢ *In addition: voluntarily measures:*
- ➢ *Early involvement and 'open door' policy – high voltage grid development*
- ➢ *Dialogue between hydro power companies and stakeholders at the local and regional level*

CEDREN Centre for Environmental Design of Renewable Energy

The role of knowledge in order to tackle social acceptance – some results from GOVREP

- The role of knowledge in balancing environmental and energy concerns:

  » The focus on 'knowledge' as a common basis in order to balance competing concerns is not sufficient – the importance of getting acceptance, ensuring transparence

  » The question of legitimacy is related the aim of the impact assessments, the communication of the results, and how the results are balanced in the final assessments (made by the regulatory authorities)

  » The need to include local experience as part of the assessment process

Beyond a NIMBY understanding of acceptance

Some preliminary results from the SusGrid project (Sustainable Grid Development)

- Survey on peoples knowledge about grids
  - *The importance of understanding situational dependent factors*

- Conduct case studies (UK and Norway)

Some key challenges

The 'need' – important, however the question of routing, local benefits and involvement are crucial

Trust – degrees of involvement, at what stages in the process, how concerns are taken into account (by the TSO, NVE and MPE)

Choice of technology (overhead lines vs undergrounding)

The role of knowledge – the assessment of impacts

Towards a sustainable future

Understanding and addressing public acceptance is of crucial importance in order to realize a future based on renewable energy

Thank you for your attention!

CEDREN Centre for Environmental Design of Renewable Energy

Centre for environmental design of renewable energy - CEDREN

Name, title

www.cedren.no

Contact:
helene.egeland@sintef.no

Norsk institutt for naturforskning

Renewable energy for Energy Access

- Vivek Jha

teri

Centralized or Decentralized

teri

Demand has three facets

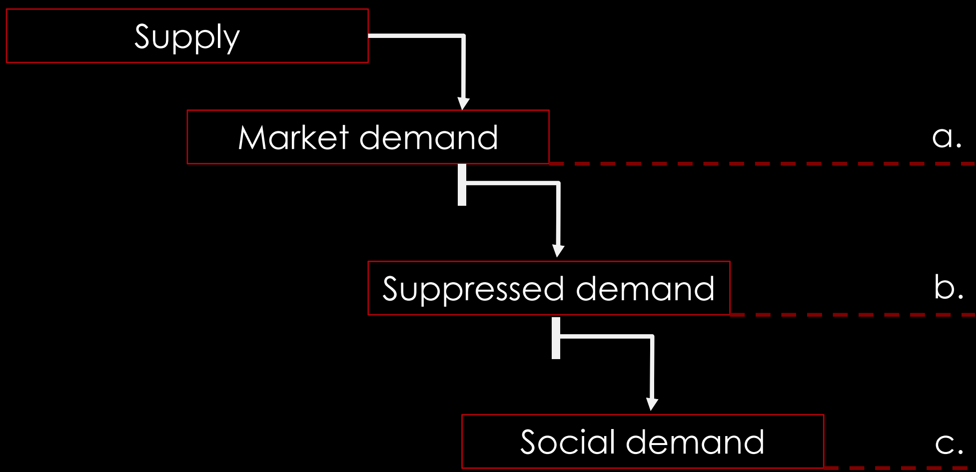
i. Market demand - *associated with different levels of economic growth, structural change, and population growth*
ii. Suppressed demand - *created by frequent blackouts and the ubiquitous power rationing*
iii. Social demand - *based on political targets for increased access to electricity*

Centralized or Decentralized

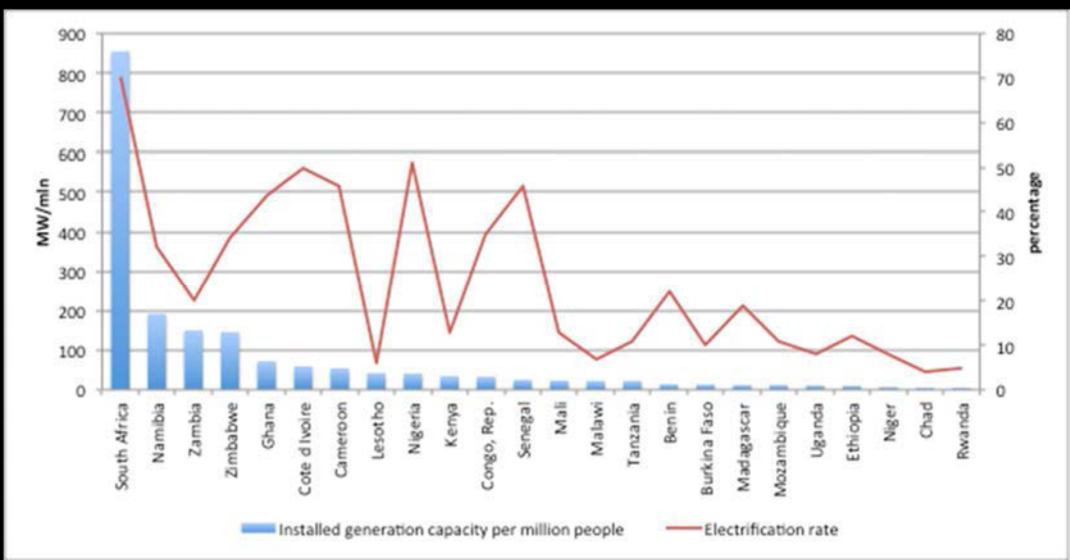
In developing countries

✓ Notional demand > Supply

✓ Notional demand – Supply = suppressed demand



Capacity expansion

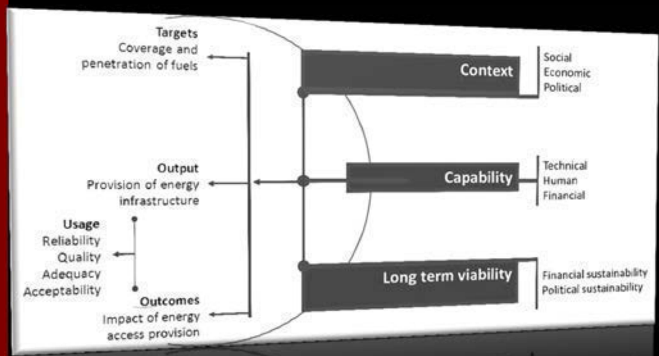


Bottom line

✓ 23 GW each and every year through 2030

Small is beautiful

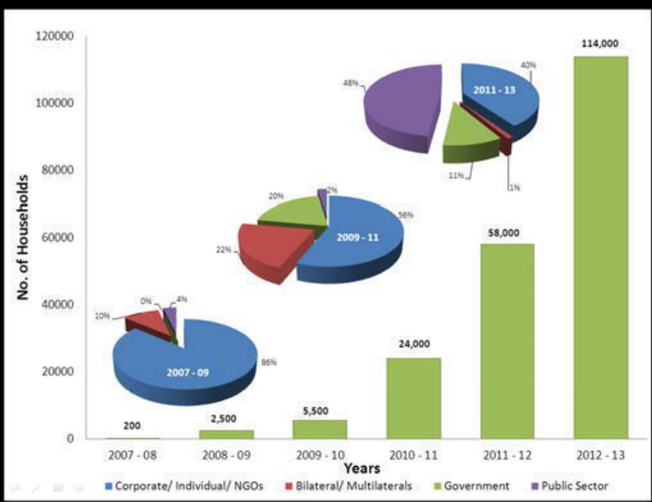
- ✓ Current structures focus largely on supply and are not geared to be outcome oriented



SE4ALL postulates 'distributed electricity solutions' as an action area for the initiative's energy access objective

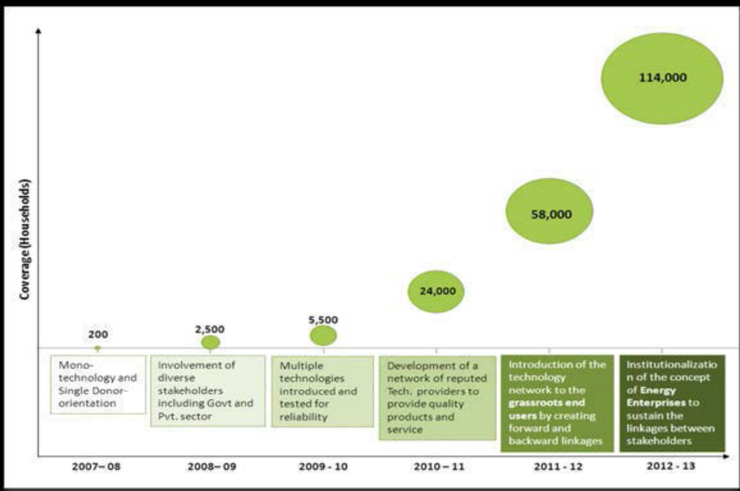
Almost 55% of the additional connections needed for universal access will come from micro-grids and off-grid solutions - IEA (2012)

Key features...



a shift from solely corporate/ individual donors to a mix of stakeholders that now include collaborative efforts of governments, multilateral/ bilateral agencies, individuals and corporates.

Sustainability at grassroots



Provisioning of lighting contributes towards the **UN MDGs**, which are comprehensive and concrete goals adopted by the international community.

Key features…

catalyze the dissemination of solar lighting technology for multiple uses by strengthening the market based value chain for rural energy access.

Key features…

Combined ownership: Selected entrepreneurs have invested 45% of the hardware cost.

Local Energy Entrepreneurs, operators and technicians have been trained to provide after sales service support ensuring reliable and sustainable service

Energy Plus ++

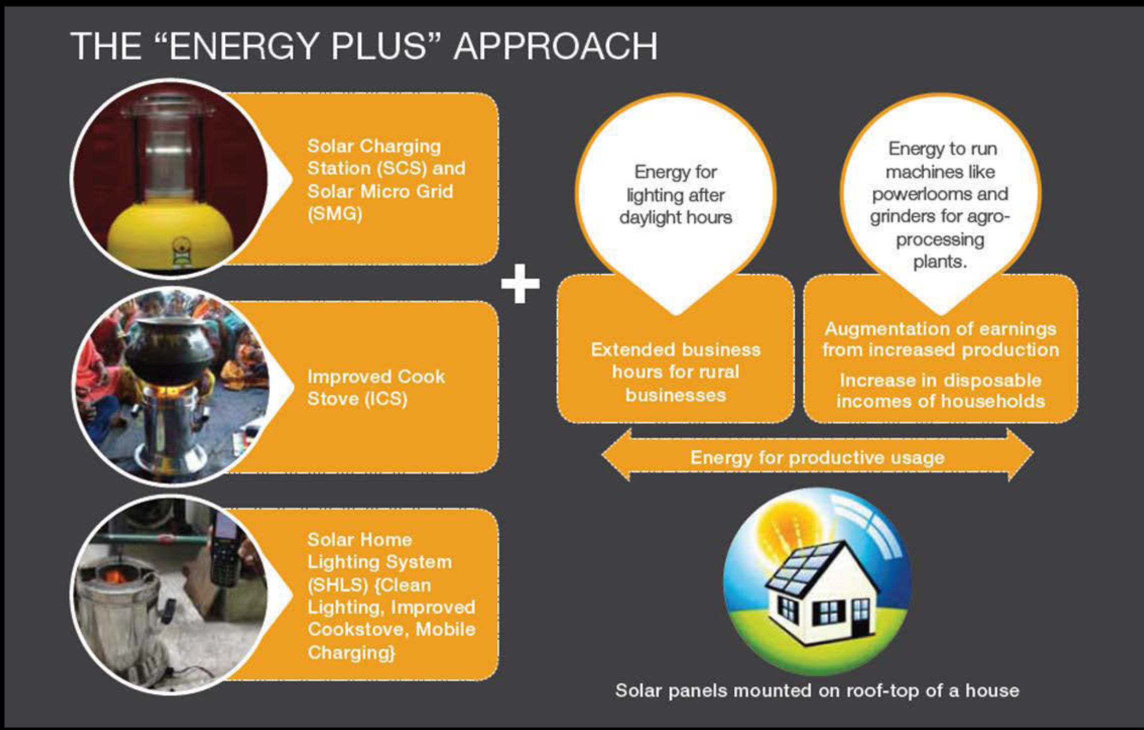
Provision of a robust technology solution

Facilitation of access to easy finance

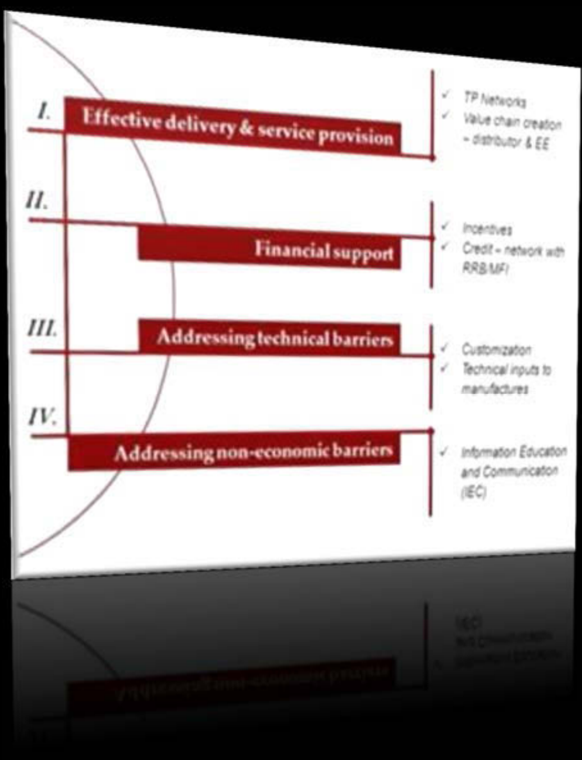
Development of technical and business skills to entrepreneurs

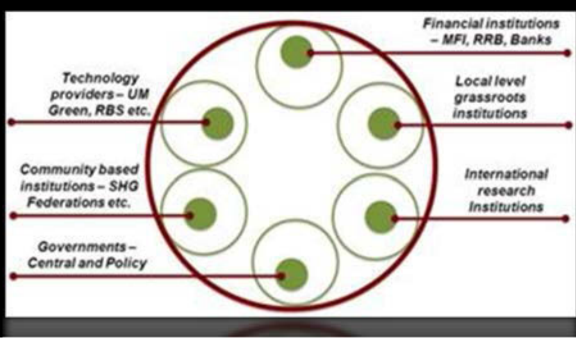
Dovetailing of interventions in line with state and national development policies

Addressing barriers!!



Addressing barriers!!





Thank you!!

- vivekjha@teri.res.in

Renewable Energy Respecting Nature
Indo-Norwegian Seminar- Mumbai
7-8 May 2013

Hydro Power Development in India

Dr. P. Saxena
Adviser
Ministry of New and Renewable Energy
Government of India

Out Line of Presentation

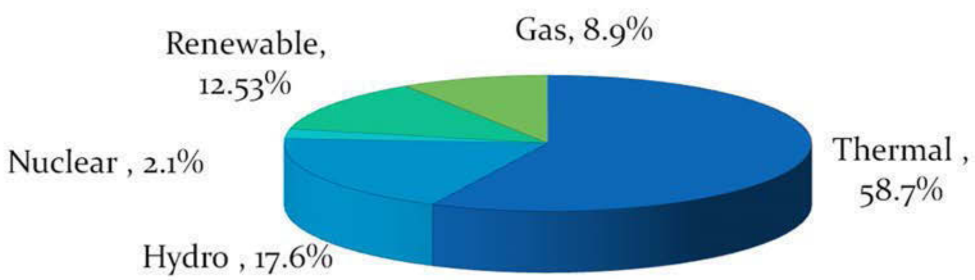
- Power Sector Capacity Status
- Over all Renewable Power Potential in the Country
- Over all Renewable Power Growth and 12th Plan Projections
- Hydro and Small Hydro Development

INDIAN POWER SCENARIO

TOTAL INSTALLED CAPACITY	2,23,868 MW (March, 2013)
GROSS GENERATION	911.65 BUs
PER CAPITA CONSUMPTION	879 kWh / Annum (2011-12)
ENERGY SHORTAGE	about 8.6 % (June 2012)
PEAKING SHORTAGE	about 11.1 %

Indian Power Sector at a Glance

Total installed capacity : 2,23,868 MW



Thermal	Hydro	Gas	Renewable	Nuclear
1,31,421	39,491	20,109	28,067	4780

- Renewable contributes 28,067 MW – 12.53%
- If we take large hydro under RE – 31%

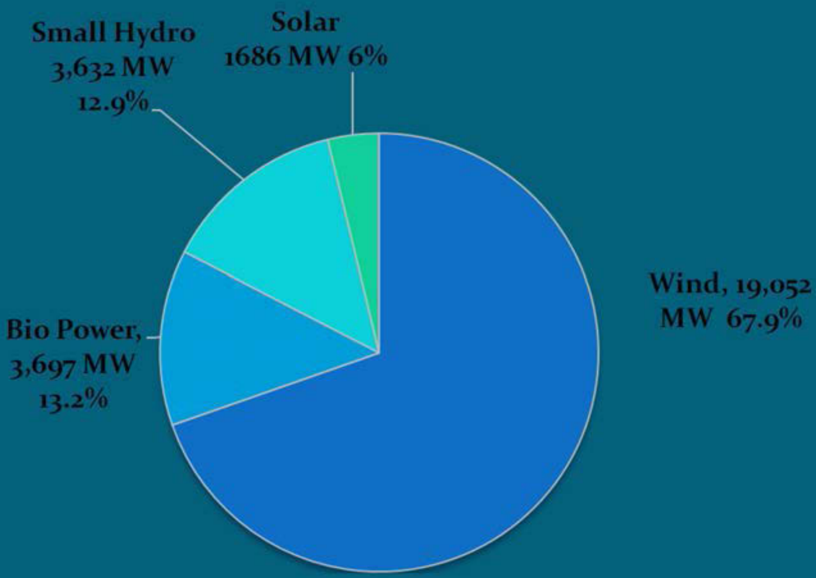
Renewable Power Potential

S. No.	Resource	Estimated Potential (In $MW_{eq.}$)
1.	Wind Power (as per C-WET estimates at 80 m hub height)	~ 100,000
2.	Solar Energy	> 100,000 30-50 MW/ sq. km.
3.	Small Hydro Power (up to 25 MW)	20,000
4.	Bio-Power:	
	Agro-Residues	17,000
	Cogeneration - Bagasse	5,000
	Waste to Energy: - Municipal Solid Waste to Energy - Industrial Waste to Energy	 2,600 1,280
	Total	>2,45,880

Plan wise Renewable Power Growth

	Beginning of 10th Plan 1.4.2002 (MW)	Beginning of 11th Plan 1.4.2007 (MW	Achievements during 11th Plan 2007-2012 (MW)	Cumulative Achievements up to 31.3.2012 (MW)
Wind	1,628	7,092	10,260	17,352
Small Hydro	1,434	1,976	1,419	3,395
Bio power	389	1,184	2041	3,225
Solar	2	3	939	941
Total	3,453	10,255	14,660	24,914

Indian Renewable Energy at a Glance
Total Installed capacity 28,067 MW



Renewables constitute about 12.53 % of the total power generation installed capacity in the country

12th Plan Projections

Installed Capacities in MW

Source	Installed capacity by end of 11th Plan 31.3.2012	Capacity addition Target for 12th Plan (2012-17)	Target installed capacity at the end of 12th Plan
Wind power	17,352	15,000	32,500
Small Hydro	3,395	2,100	5,500
Biomass Power	1,150	500	1,700
Bagasse Cogeneration	1,985	1,400	3,300
Waste to Power	90	500	600
Solar Power	941	10,000	10,200
TOTAL	24,914	29,500	53,800

Contribution of renewables after 12^{th} Plan (2017)

At the end of 12^{th} Plan,

the total power generation capacity of the country is expected to be 318,800 MW

Renewables are expected to contribute about 17% in this capacity (55,000 MW)

and

Over 9% in the electricity mix

The Year 2012-13 and 2013-14

Installed Capacities in MW

Source	2012-13 Targets (MW)	2012-13 Achievements (MW)	2013-14 Targets (MW)
Wind power	*2500*	1698	*2500*
Small Hydro	*350*	236	*300*
Biomass Power	*105*	114	*100*
Bagasse Cogeneration	*350*	352	*300*
Waste to Power	*40*	*20*	*30*
Solar Power	800	*754*	1100
TOTAL	4125	3163	4330

HYDROPOWER DEVELOPMENT IN INDIA

STATUS OF ELECTRICITY

- Electricity a concurrent subject – both Central (Federal) Government and State Governments have responsibility
- Country is divided in Five power regions and planning is done on a regional concept.
- Access to electricity is low in the rural areas.
- Hydro potential 1,48,701 MW and SHP 20,000MW
- Potential Tapped so far: 26.5% and 18%

Reforms in the Electricity Sector in India

- A conducive policy environment has been created by modifying the Electricity Act.
- Electricity Act-2003 deals with the laws relating to generation, transmission, distribution, trading and use of electricity.
- The Electricity Act and Tariff Policy are favorably tilted towards power generation from renewable.
- Aiming per capita availability of electricity to 1000 kWh by 2012 (879 kWh in 2012)
- Capacity addition of 100,000 MW during 2012-17 is planned.

Reforms in the Electricity Sector in India

- Ministry of Power is responsible for large Hydro above 25 MW
- Ministry of New & Renewable Energy, Government of India is the nodal ministry for small hydropower development in India.
- Central Electricity Regulatory Commission announced the tariff calculation guidelines for renewable technologies including SHP.
- Small hydro is the focus area of MNRE and the programme is mainly private sector driven.
- For remote rural electrification micro hydel projects are considered as one of the options for electrification.

GOI POLICY ON HYDRO DEVELOPMENT

- In Aug 1998, the Government of India announced a Policy on 'Hydro Power Development' and revised in Nov.2008.
- Hydro is used to supplement the base load provided by thermal power plants.
- Central Electricity Authority has issued various hydro related reports and guidelines

GOI POLICY ON HYDROPOWER DEVELOPMENT

- Projects held up for environment and forest clearance, concerned State Govt./developer to get the timely E&F clearances.
- 1% of free power with a matching 1% support from State government for local area development to the affected local population.
- Problems such as local agitation (law & order), land acquisition etc. need be resolved by concerned State Government.

HYDROPOWER DEVELOPMENT

12th Plan Target for Hydro Power Generation

Sl. No.	States	Central Sector		State Sector		Private sector		Total	
		No.	MW	No	MW	No.	MW	No.	MW
1.	Himachal Pradesh	2	816	7	892	6	749	15	2457
2.	Jammu & Kashmir	4	2450	4	1473	0	0	8	3923
3.	Uttarakhand	12	4374	7	1655	5	829	24	6858
4.	Punjab	0	0	1	168	1	75	2	243
5.	Madhya Pradesh	3	166	0	0	0	0	3	166
6.	Andhra Pradesh	0	0	3	1560	0	0	3	1560
7.	Kerala	0	0	6	373	0	0	6	373
8.	Karnataka	0	0	2	400	0	0	2	400
9.	West Bengal	1	120	2	66	0	0	3	186
10.	Sikkim	1	520	0	0	10	1935	11	2455
11.	Arunachal Pradesh	3	1610	0	0	23	7969	26	9579
12.	Assam	0	0	1	150	0	0	1	150
13.	Manipur	2	1566	0	0	0	0	2	1566
14.	Tamil Nadu	0	0	1	500	0	0	1	500
15.	Meghalaya	0	0	1	54	1	450	2	504
16.	Total	28	11,622	35	7291	46	12,007	109	30,920

Hydro Capacity addition

- 2011-12: Target 2080 MW
- Achievement: 1423 MW

- 2012-13: Target 802 MW
- Achievement: 501 MW

- 12th Plan Expected: 9204 MW

SMALL HYDRO POWER

- It is recognized that small hydro power projects can play a significant role in meeting energy requirements in remote and hilly areas where extension of grid is uneconomical.

- Small hydro can contribute in capacity addition of hydropower in relatively short time frame.

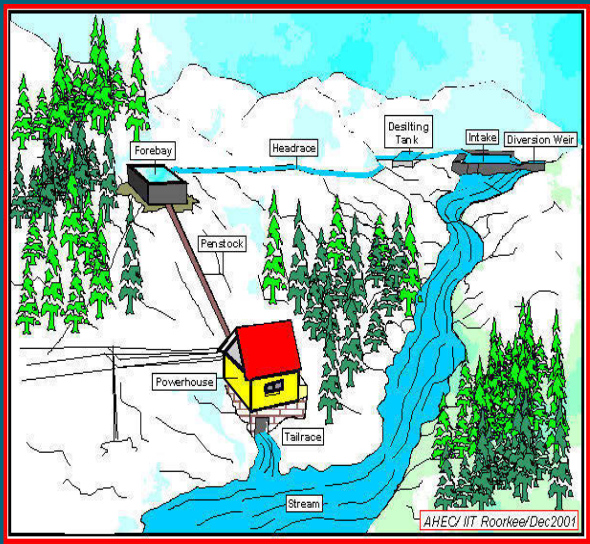
Small Hydro Projects

Small Hydro Power (SHP) is generated from flowing or falling water from rivers, rivulets, storage dams or canal drops.

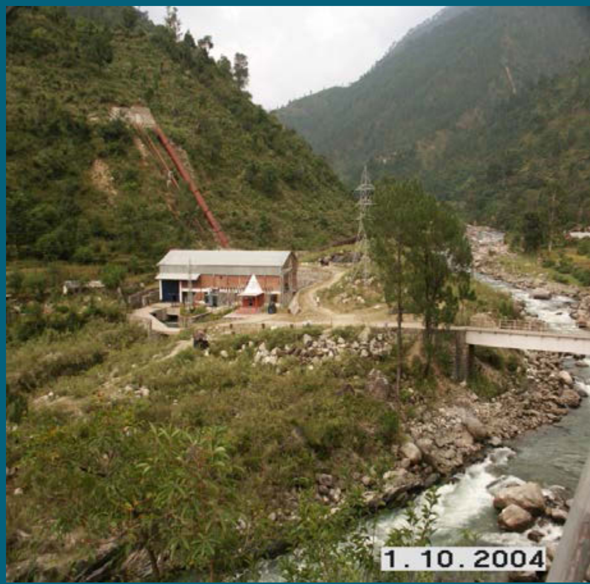
MNRE responsible for SHP upto 25 MW capacity.

Type	Use	Capacity
Water Mills	For local use	Up to 5 KW
Micro	Village electrification	Up to 100 kW
Mini	Village Electrification & Grid	101 kW to 2000 kW
Small	Grid	2001 kW to 25000 kW

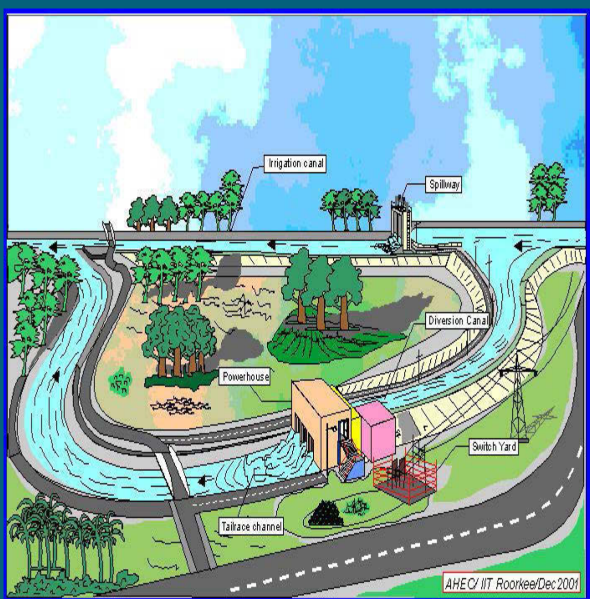
Typical Arrangement of Small Hydro project



Typical Arrangement of Small Hydro Power Station

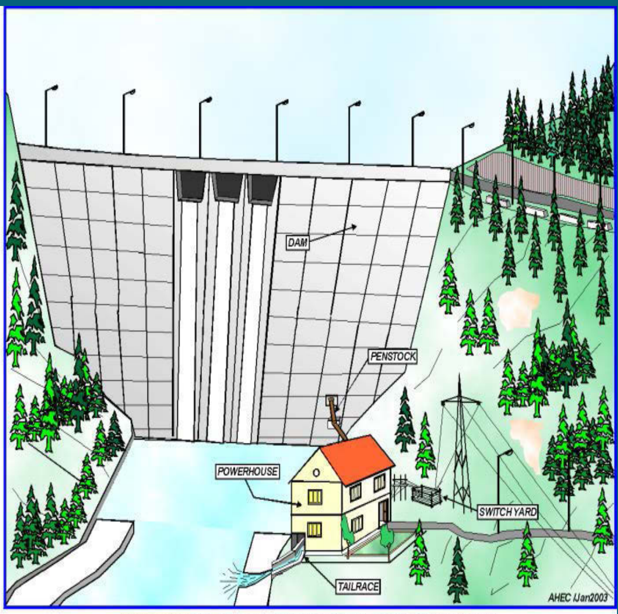


Typical Arrangement of Small Hydro project



Typical Arrangement of Canal Fall Small Hydro Power Station

Typical Arrangement of Small Hydro project



Typical Arrangement of Dam toe Small Hydro Power Station

SMALL HYDRO POWER PROGRAMME

- **Potential - about 20,000 MW**
- **Identified potential - 19,749 MW (6,474 sites)**
- **Installed Capacity - 3,632 MW (967projects) (18%)**
- **Under implementation - 1061 MW (281 projects)**
- **2007-2012 Target - 1400 MW**
- **11th Plan Achievements so far - 1419 MW**
- **Average capacity addition per year - 300 MW**

Plan-wise Target / Achievement

Plan	Physical		Financial	
	Target (MW)	Achievement (MW)	Target	Achievement (Rs. in crore)
9th Plan	130	269	123.00	127.59
10th Plan	550	537	199.49	205.93
11th Plan	**1400**		**700.00**	
2007-08	200	204.75	50.00	49.95
2008-09	250	248.93	82.50	82.49
2009-10	300	305.27	107.00	106.79
2010-11	300	307.21	152.00	151.99
2011-12	350	352.68	140.00	154.85
2012-13	350	236.93	159.00	158.92

SMALL HYDRO POWER PROGRAMME

- **The Ministry's aim is that about 50% of the potential should be harnessed by the end of 13th Plan.**
- **About 50% of the potential lies in Himalayan States, Karnataka, Andhra Pradesh and Maharashtra.**
- **A large part of capacity addition is now coming through private sector participation.**

State-wise Potential and Achievement

State	Sites (Nos.)	Potential (MW)	Achievement (MW)
Andhra Pradesh	387	978	219.03
Arunachal Pradesh	677	1341	103.90
Assam	119	238	31.11
Bihar	93	223	70.70
Chhattisgarh	200	1107	52.00
Goa	6	6.5	0.05
Gujarat	292	202	15.60
Haryana	33	110	70.10
Himachal Pradesh	531	2397	587.90

State-wise Potential and Achievement

State	Sites (Nos.)	Potential (MW)	Achievement (MW)
Jammu & Kashmir	245	1430	130.53
Jharkhand	103	208	4.05
Karnataka	834	4141	963.75
Kerala	245	704	158.42
Madhya Pradesh	2 99	820	86.16
Maharashtra	274	794	299.92
Manipur	114	109	5.45
Meghalaya	97	230	31.03
Mizoram	72	168	36.47
Nagaland	99	196	28.67

State-wise Potential and Achievement

State	Sites (Nos.)	Potential (MW)	Achievement (MW)
Orissa	222	295	64.30
Punjab	259	441	154.50
Rajasthan	66	57	23.85
Sikkim	88	266	52.11
Tamil Nadu	197	659	123.05
Tripura	13	46	16.01
Uttar Pradesh	251	460	25.10
Uttaranchal	448	1707	174.82
West Bengal	203	396	98.40
A&N Island	7	8	5.25
Total	6474	19,749	3632.25

Focus States

- Karnataka
- Himachal Pradesh
- Andhra Pradesh
- Uttarakhand
- Kerala
- Maharashtra
- Chattisgarh
- Arunachal Pradesh

SHP Programme

- The MNRE has been providing financial support / subsidy for following activities to develop the SHP sector :
  - Resource Assessment, Detailed Survey & Investigation, DPR Preparation and perspective plan for States
  - Capital Subsidy to State Sector Projects
  - Subsidy for Commercial Projects
  - Renovation & Modernization of old SHP projects (State Sector)
  - Micro Hydel &Water Mills
  - Capacity building

PRIVATE SECTOR INITIATIVES

World's largest SHP development programme through private sector participation

Policies for private sector participation for SHP development announced by 23 States

Over 8500 MW capacity SHP sites offered/ allotted to private sector for their development

PRIVATE SECTOR INITIATIVES

328 SHP projects aggregating 1748 MW commissioned by the private sector.

Karnataka	826.50 MW
Andhra Pradesh	131.53 MW
Himachal Pradesh	361.30 MW
Maharashtra	101.70 MW
Uttaranchal	107.95 MW
Punjab	26.70 MW
West Bangal	6.45 MW
Orissa	57.00 MW

Constraints in faster Growth

- **Difficult locations where SHP projects are set up**
- **Short working season in hilly areas**
- **Involvement of private and forest land**
- **The risks due to natural calamities**
- **Time taken in allotment of sites and obtaining statutory clearances in the Stat**
- **Lack of Hydrological data and monitoring system**
- **Inadequate evacuation and transmission facilities**
- **Resistance by the Local people**

MNRE Scheme

Support to new SHP project in private / co-operative / joint sector

Category	Up to 1000 KW	Above 1 MW – 25 MW
Special category and NE States	Rs. 20,000 / KW	Rs. 2.00 crore + Rs. 30 lakh / MW
Other States	Rs. 12,000 / KW	Rs. 1.20 crore + Rs. 20 lakh / MW

Technical Centre

- Alternate Hydro Energy Centre (AHEC) at IIT Roorkee is the lead technical centre for small hydro
- It provides technical backup to the Ministry on all aspects of small hydro
- Provides consultancy on design and development of SHP projects
- Offers M.Tech course on SHP
- Organises regular training courses for International and National participants
- Have facilities for research and testing of SHP projects

SHP Digital Simulator at AHEC

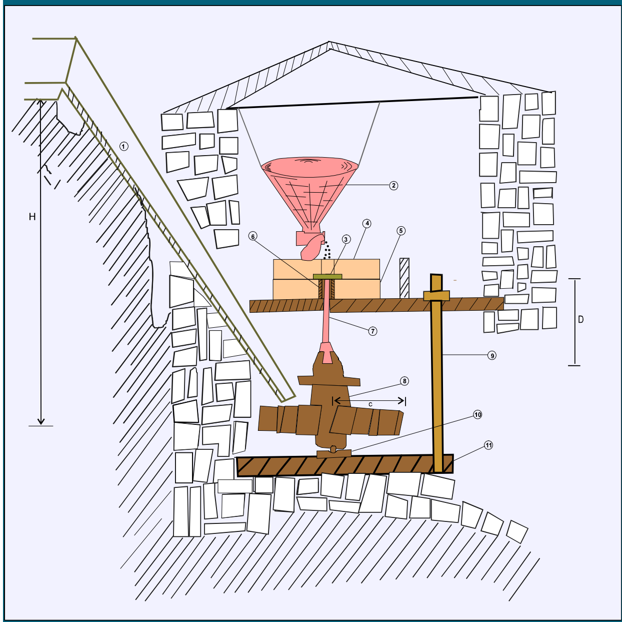
ESTABLISHMENT OF R&D HYDRAULIC TURBINE LABORATORY

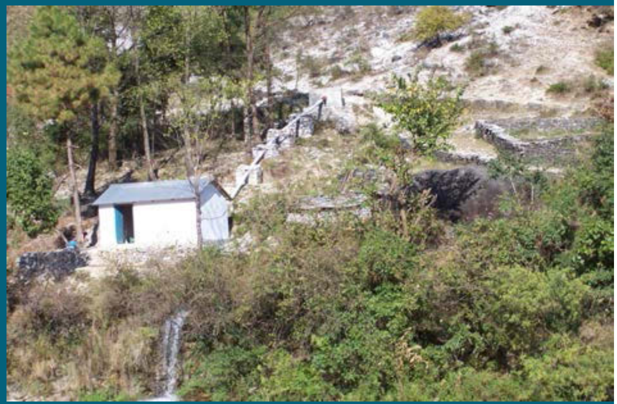
- R&D hydro turbine Laboratory of International level being established at AHEC IIT Roorkee
  - turbine-model testing,
  - research & development (R&D),
  - human resource development (HRD)
  - verification of designs,
  - generation of design data,
  - design validation through CFD analysis,
  - Witnessing tests on turbines/pumps in field
- Laboratory is expected to be fully functional by the end of year 2012.

STANDARDS FOR SMALL HYDRO

- SHP needs to be made profitable and a long-term investment opportunity, while ensuring quality and reliability of the power.
- To make SHP cost effective and reliable, standards, guidelines and manuals are required covering entire range of SHP activities.
- Necessity of the standards/guidelines and manuals strongly felt by developers, manufactures, consultants, regulators and others.
- Government of India has initiated preparation of about 30 standards for SHP and are expected to be ready by the year 2011.

Water Mills





Thank you

Hydropower in Himalayan Region

O. R. Lalitha
GMR Hydro

GMR

CHALLENGES IN HYDRO PROJECTS

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Challenges	Project
PLANNING/CONSTRUCTION STAGE CHALLENGES	
Dam Foundation on Soft Rock	Subansiri HEP (2000 MW), Arunachal Pradesh
Restriction in Use of TBM because of changing rock strata	Parbati II HEP (800 MW), Himachal Pradesh
Rock Slope Analysis and Support Design with limited input parameter	Parbati II HEP
Liquefaction potential of foundation	Alakananda HEP
Steep River gradient	River in Higher Himalayan reaches like Alaknanda, Bhagirathi…
Excessive overburden in side abutments	Upper Marsyangdi-2 HEP (600 MW), Nepal
O & M STAGE CHALLENGES	
Damages caused by silt in undersluices, glacis, spillway bucket, runner in O&M HEPs	Chamera HEP, Salal HEP and Bairasul HEP.

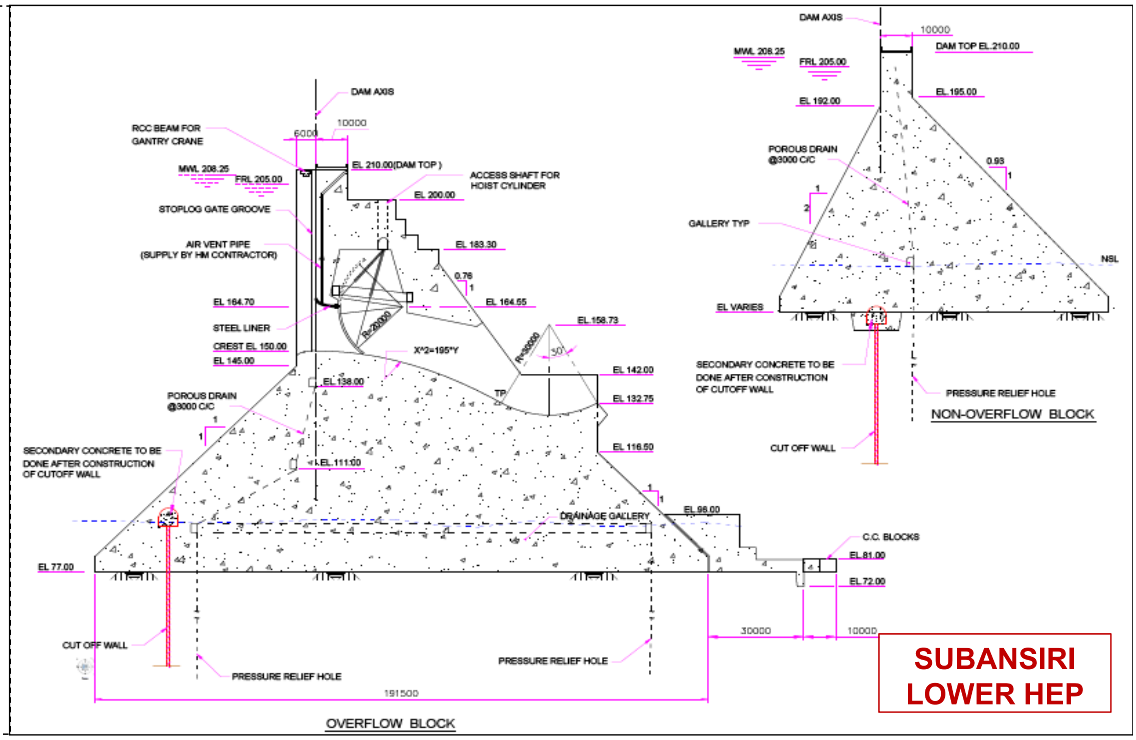
DAM FOUNDATION ON SOFT ROCK

TYPE	: CONCRETE GRAVITY	TOP ELEV	: EL 210 M
HEIGHT	: 116 m (ABOVE RIVER BED LEVEL) 133 m (ABOVE DEEPEST FONDATION LEVEL)	DESIGN FLOOD	: 37,500 M^3/ Sec

DAM Foundation on Soft Rock results in increase of base width to keep the stresses within limit

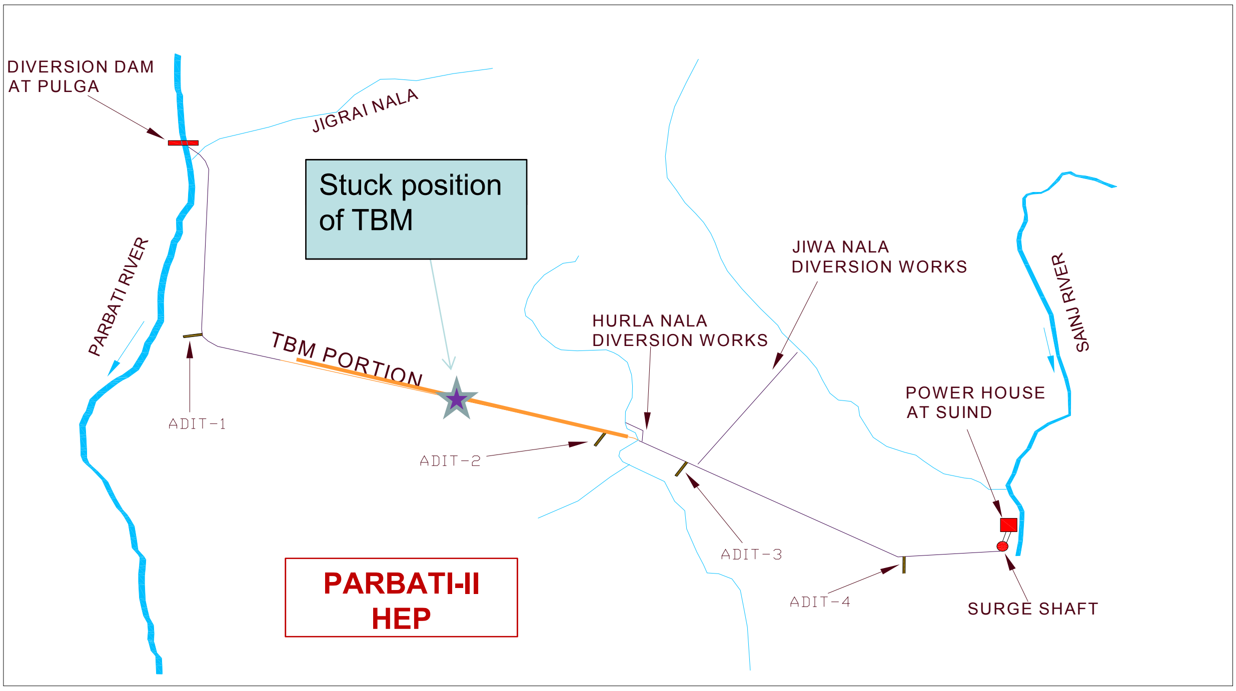
Properties of Rock

UCS in dry condition is 12 to 20 Mpa but in wet condition it is 1.24 to 7.21 Mpa



RESTRICTION IN USE OF TBM

Total Length of HRT 31.5 km, 9.05 km targeted by TBM dia 6m (circular), balance by DBM dia 6m (horseshoe) (Completed by TBM – 4123m)



Atlas Copco Jarva MK-27 Tunnel Boring Machine

RESTRICTION IN USE OF TBM

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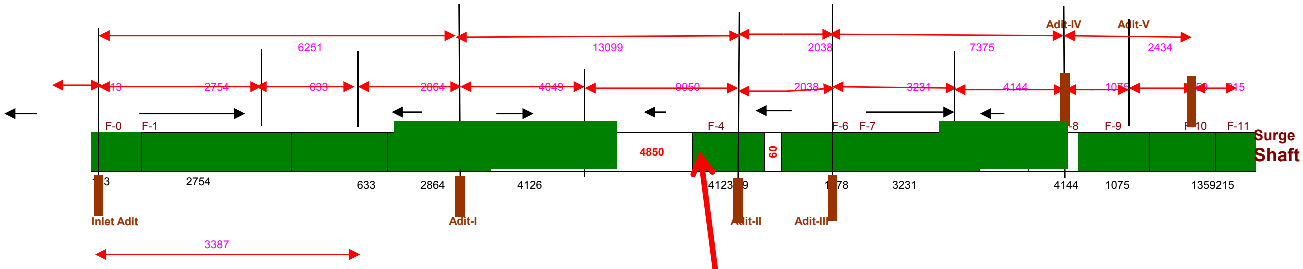
HRT Excavation



PARBATI-II HEP

TBM got buried at RD 4056m

DULHASTI HE PROJECT

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Muck Deposit due to High Ingress of Water in HRT

Humility | Entrepreneurship | Teamwork and Relationships | Deliver the Promise | Learning | Social Responsibility | Respect for Individual

ROCK SLOPE ANALYSIS AND SUPPORT DESIGN

To study the behaviour of the Rock slope we need the data in respect of

- Geology
- Rock Strength and
- Ground water

Investigations we carry out are

- such as surface mapping, drilling and laboratory testing

Thus we get following parameters

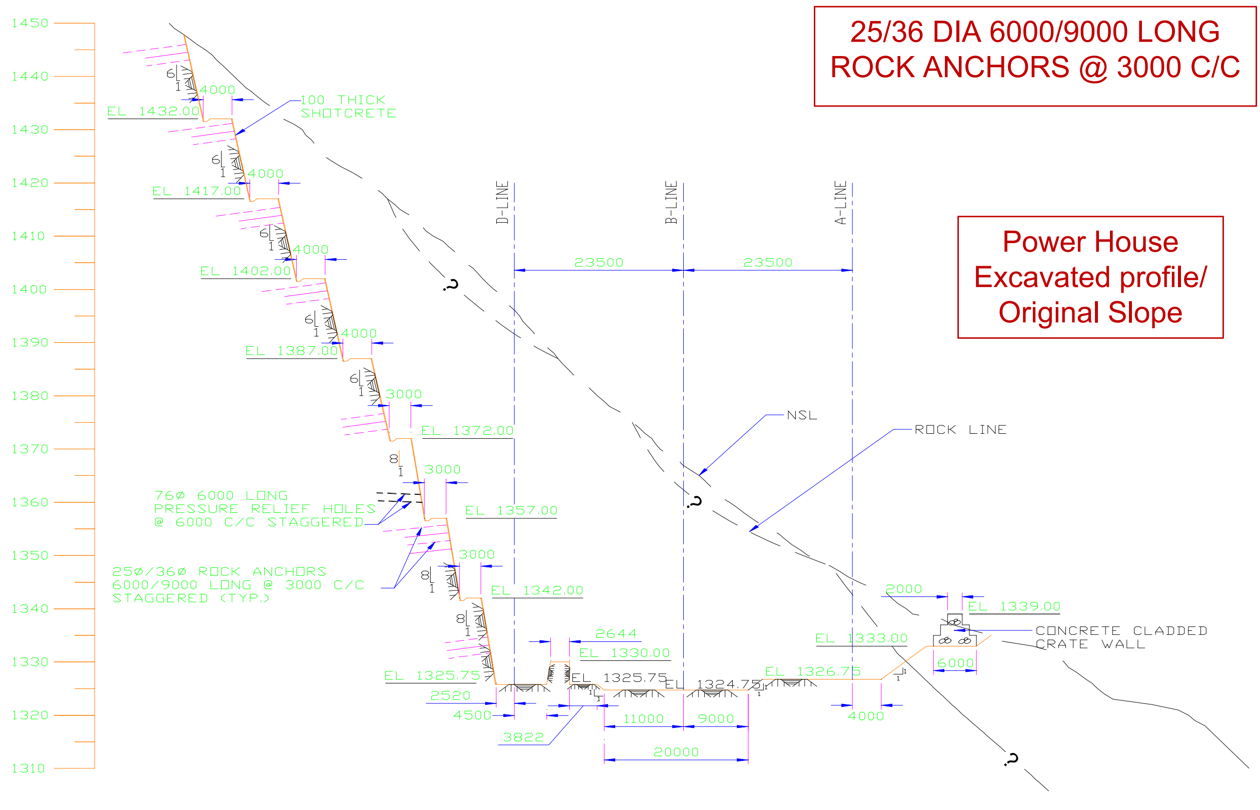
- joint orientation and dip, persistence, spacing of joints etc.,
- quality of rock, RQD, Permeability of strata, Overburden thickness etc.,
- shear strength parameters like cohesion and friction, Modulus of Deformation.

But it is quite difficult to get the joint properties

- such as Normal stiffness of joints , Shear Stiffness of joints, Basic friction angle etc.

Hence in spite of having powerful numerical tools it becomes highly difficult to conduct true rock slope analysis representing actual joint pattern. What we do is a continuum analysis with approximate equivalent rock mass properties which is in most cases a 2D analysis. For want of parameters 3D analysis becomes less attractive and less useful.

ROCK SLOPE ANALYSIS AND SUPPORT DESIGN



ROCK SLOPE ANALYSIS AND SUPPORT DESIGN

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Wedge Analysis performed based upon the available design parameters. Slope and support system provided as shown in last slide

Corner of excavated slope failed in Feb 2007, slip circle failure pattern observed.

Lower level slope flattened, support system improved

Some movement in main power house back slope observed

Lower level slope further flattened, cable anchor and drift anchor suggested

Instruments showed early alerts but preventive measures couldn't be taken by deploying equipment, because of narrow bench width

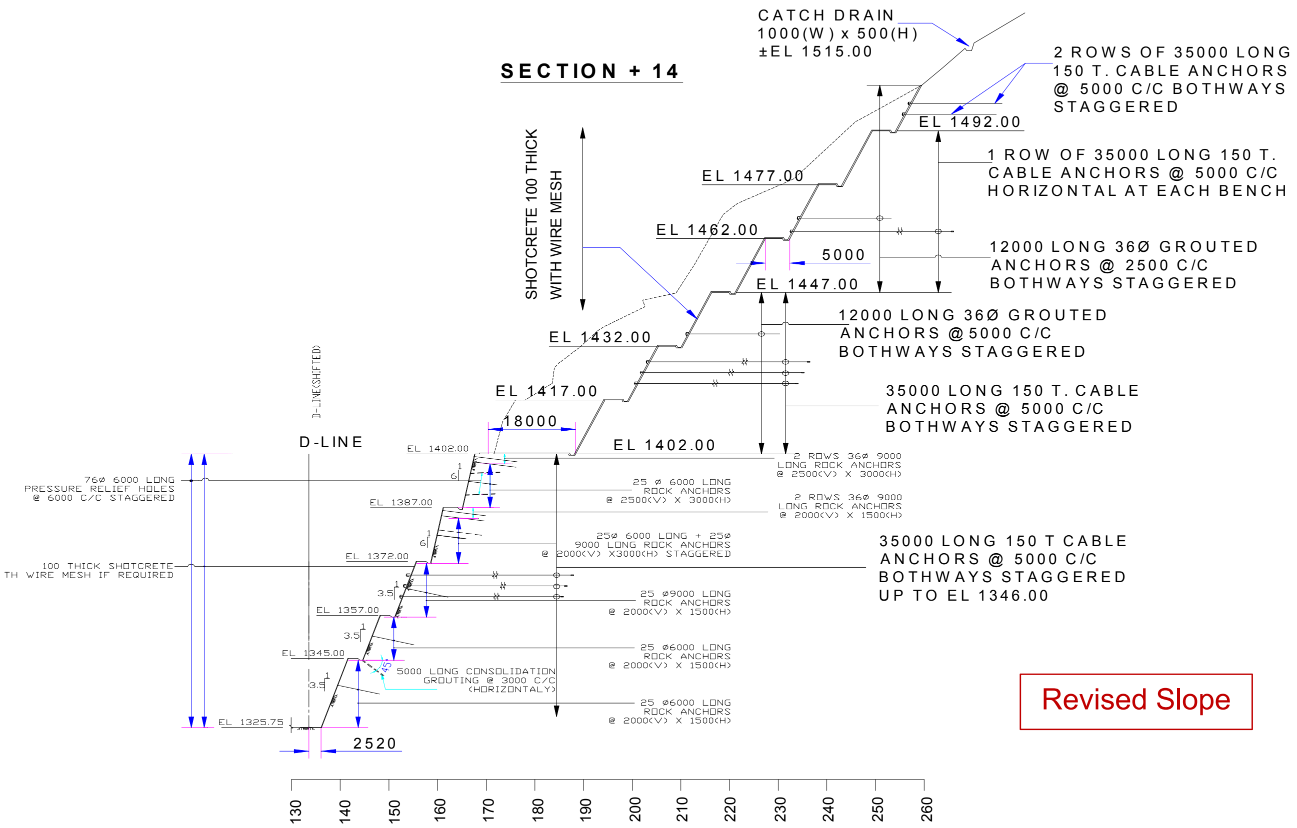
High cut slope forms slip circle which goes beyond normal support hence cable anchors are provided through ADIT/ Drift/ Tunnels

STAGES OF SLOPE ANALYSIS

ROCK SLOPE ANALYSIS AND SUPPORT DESIGN

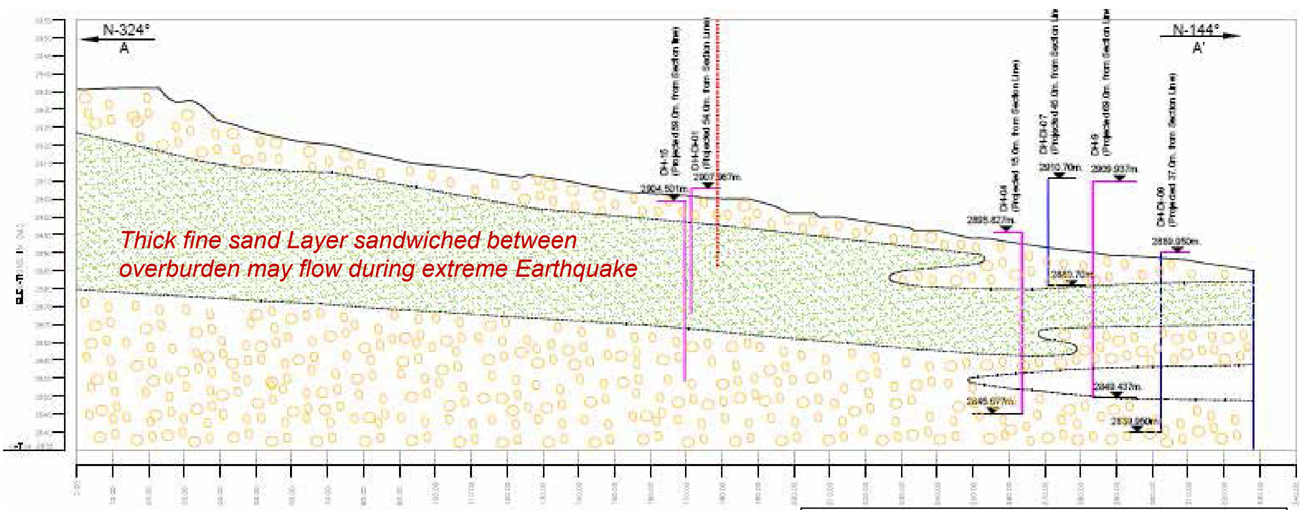
GMR

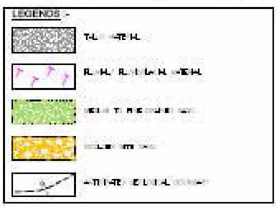
ROCK SLOPE ANALYSIS AND SUPPORT DESIGN



LIQUEFACTION POTENTIAL OF FOUNDATION

It is more likely to occur in loose to moderately saturated granular soils with poor drainage, such as silty sands or sands and gravels capped or containing seams of impermeable sediments.





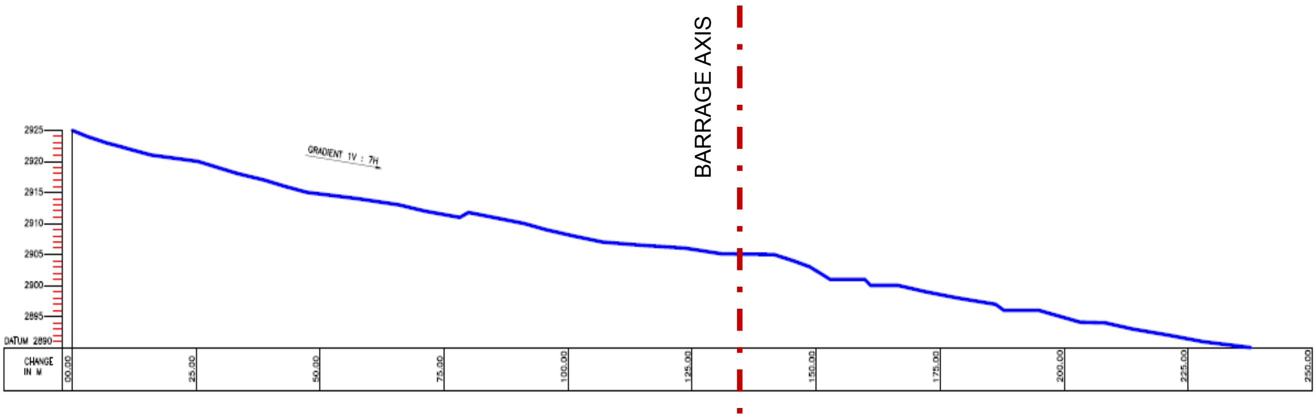
GEOLOGICAL L-SECTION NEAR HEAD WORKS ALAKNANDA HEP

Mitigation (By Densification of the soil)

- ✓Grouting
- ✓Soil Compaction Techniques
  - ❖Vibro Compaction
  - ❖Dynamic Compaction
  - ❖**Vibro Stone Columns**

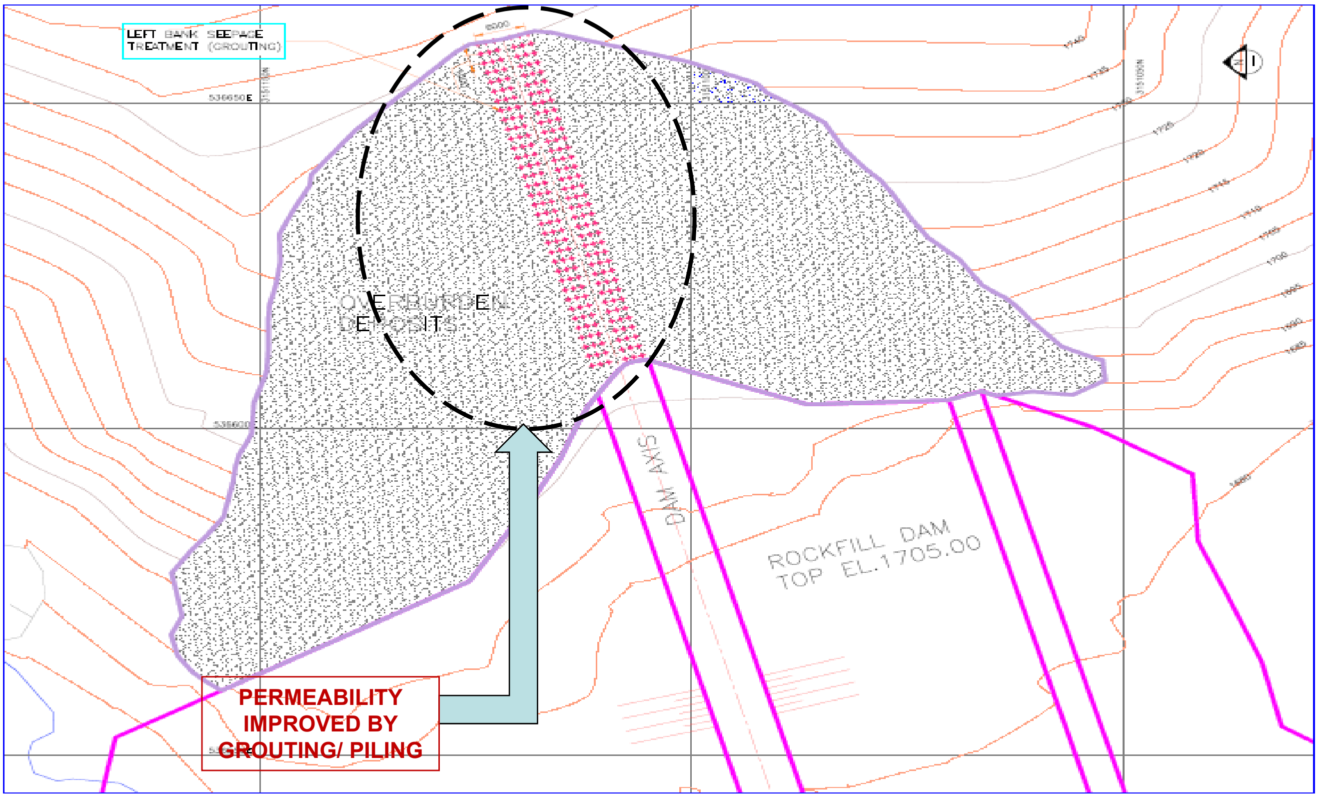
STEEP RIVER GRADIENT

- ✓ The tributaries viz. Alaknanda and Bhagirathi at the higher Himalayas pass through very steep (say 1V to 7H) slope.
- ✓ Design of a stable diversion structure in such a steep slope is a challenge and moreover an effective energy dissipation arrangement cannot be provided.



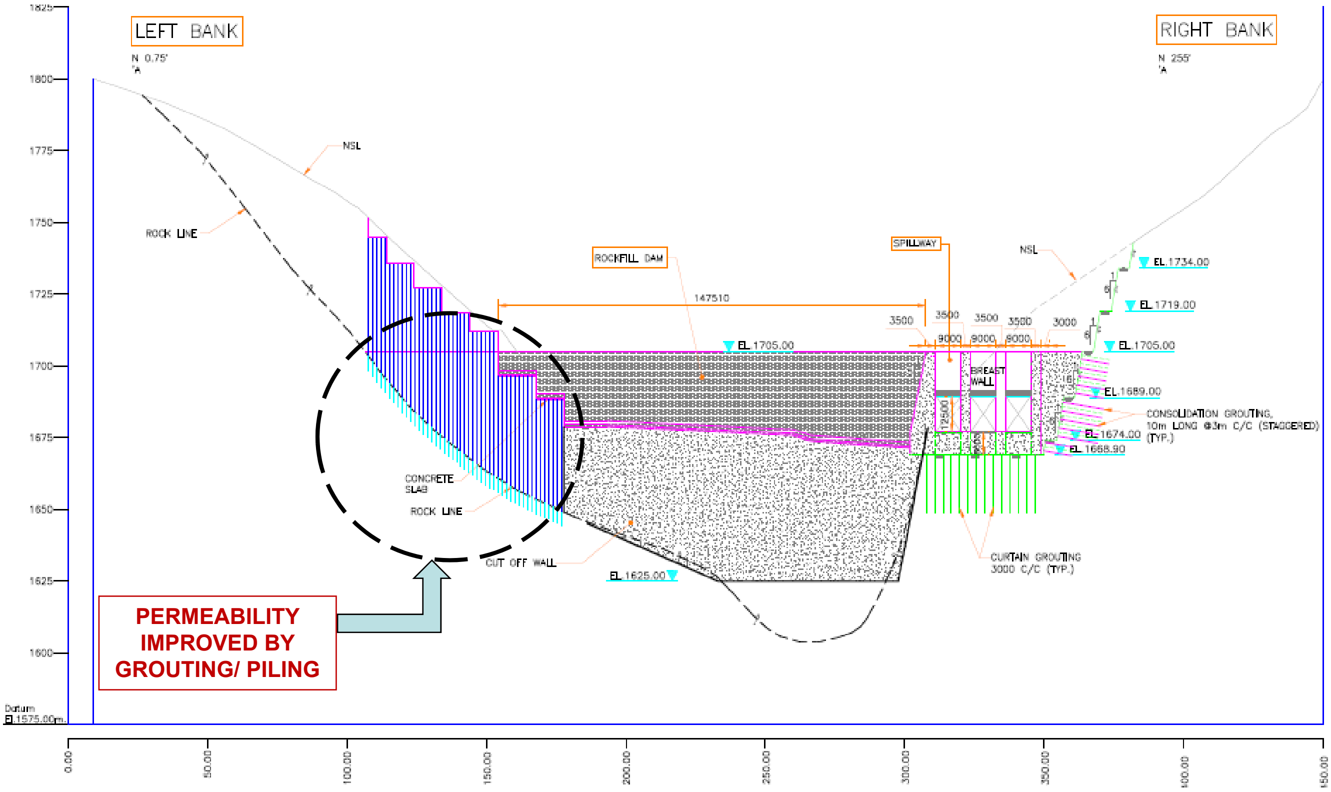
L-SECTION OF ALAKNANDA RIVER (SLOPE 1 IN 7)

OVERBURDEN IN SIDE OF DAM



Marsyangdi 2 HEP : DAM-SPILLWAY PLAN (LEFT BANK)

OVERBURDEN IN SIDE OF DAM



Marsyangdi 2 HEP : DAM-SPILLWAY X SECTION

Humility | Entrepreneurship | Teamwork and Relationships | Deliver the Promise | Learning | Social Responsibility | Respect for Individual

O & M STAGE CHALLENGES

DAM LAYOUT- CHAMERA H.E. PROJECT

Humility | Entrepreneurship | Teamwork and Relationships | Deliver the Promise | Learning | Social Responsibility | Respect for Individual

DAMAGED UNDERSLUICES IN CHAMERA DAM

O & M STAGE CHALLENGES

Solution to the Problem :

Earlier steel liner was used, but this liner got damaged by back water.

Nowadays High performa-nce concrete with Epoxy mortar is used.

DAMAGED UNDERSLUICES

Humility | Entrepreneurship | Teamwork and Relationships | Deliver the Promise | Learning | Social Responsibility | Respect for Individual

O & M STAGE CHALLENGES

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AERIAL VIEW OF DAM
SALAL HE PROJECT

O & M STAGE CHALLENGES

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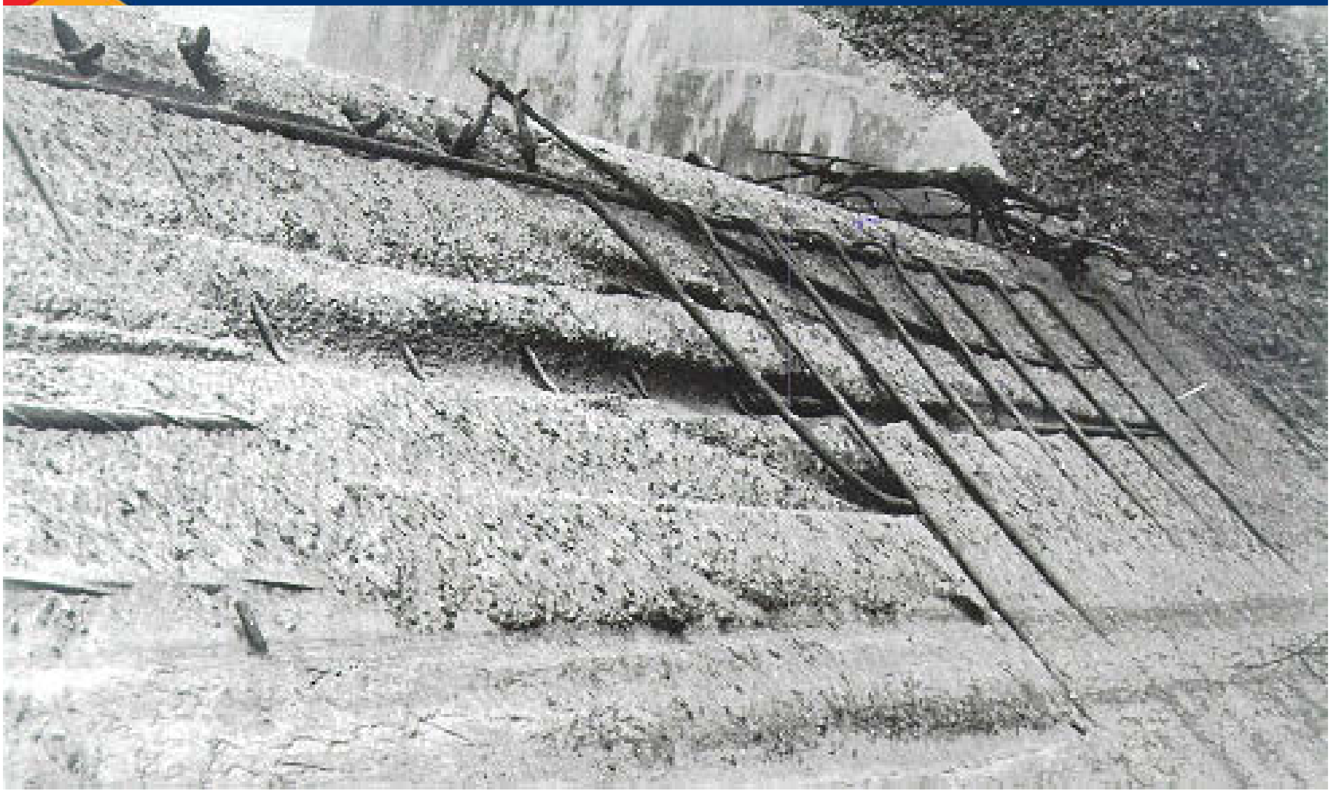
EROSION IN SPILLWAY GLACIS-1996
SALAL HE PROJECT

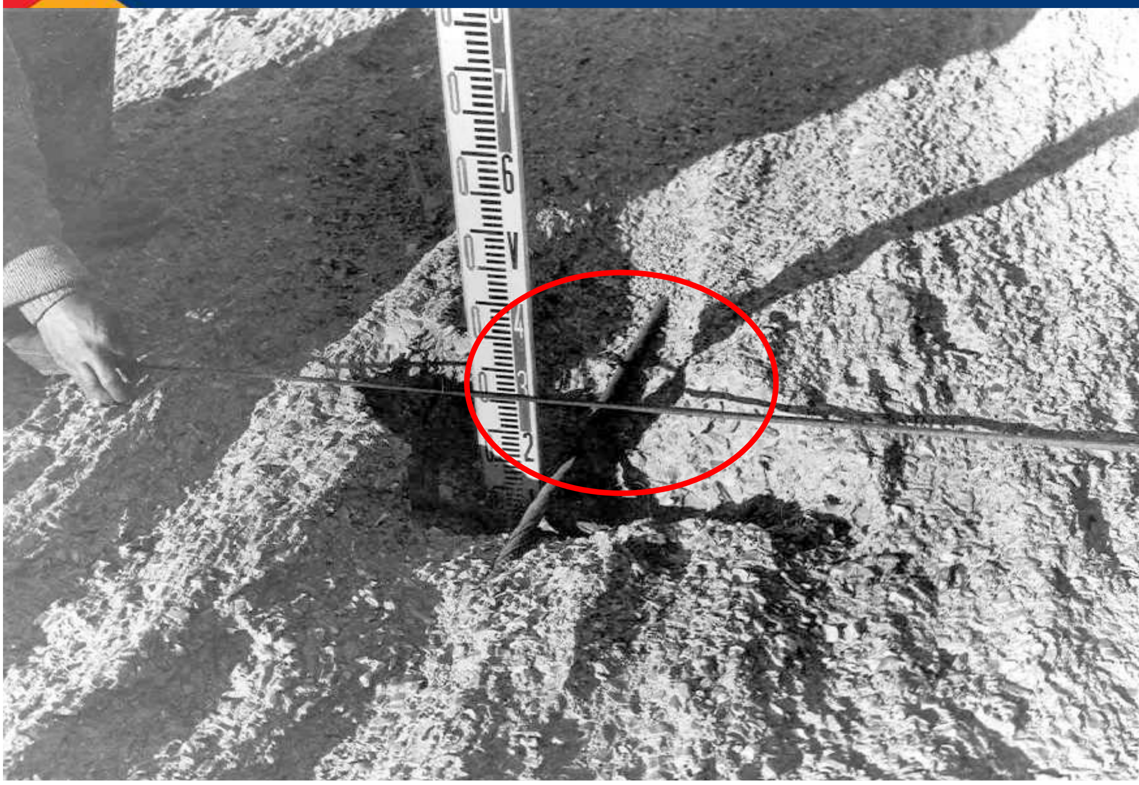
Humility | Entrepreneurship | Teamwork and Relationships | Deliver the Promise | Learning | Social Responsibility | Respect for Individual

O & M STAGE CHALLENGES



EROSION IN THE SPILLWAY BUCKET-1996
SALAL HE PROJECT

O & M STAGE CHALLENGES



Solution to the Problem :

Proper Anchorage with High Strength Concrete (M60)

PITS IN THE SPILLWAY BUCKET –1996
SALAL HE PROJECT

O & M STAGE CHALLENGES

Solution to the Problem :

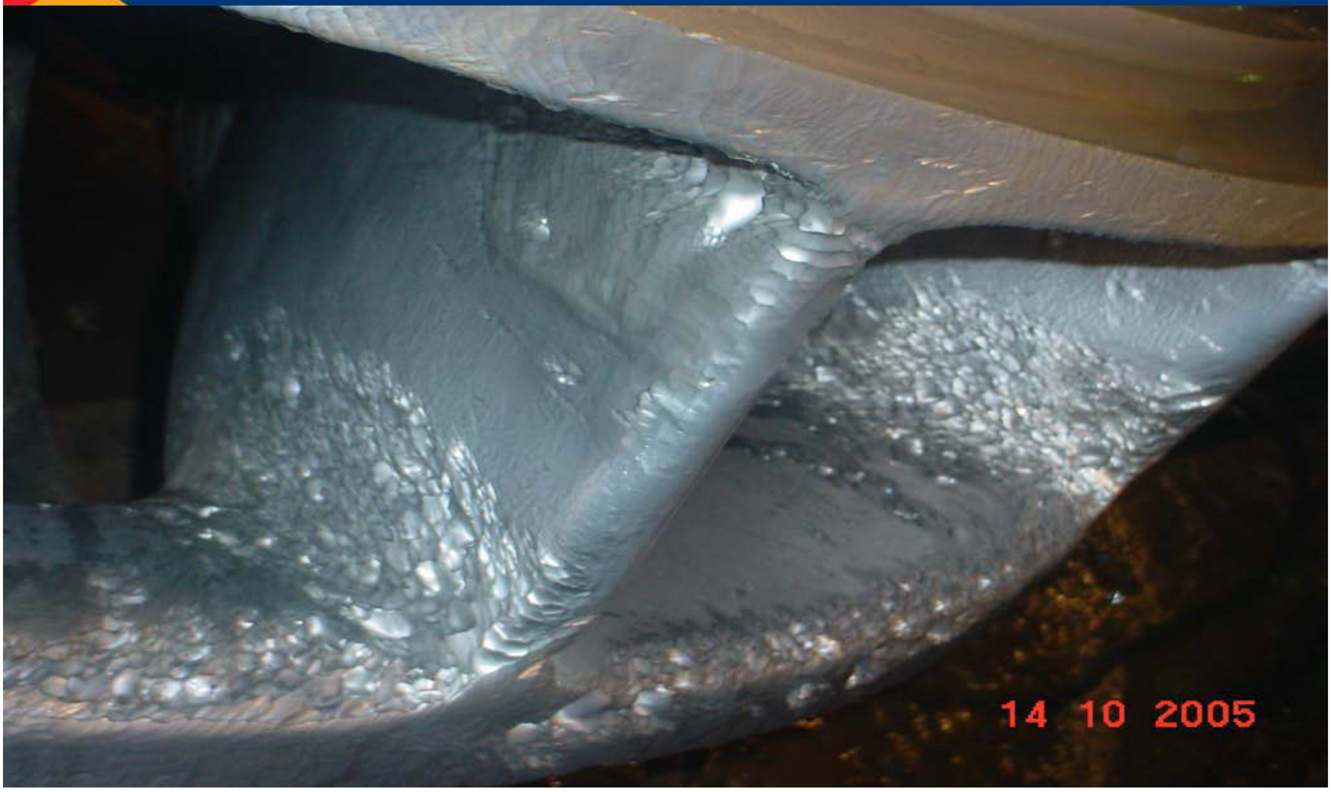
Soft/Hard Coating and periodic replace of Runner.

DAMAGES IN RUNNER UNIT NO.6 (NOV-2003)
SALAL H.E. PROJECT

O & M STAGE CHALLENGES

DAMAGES IN RUNNER UNIT NO.6 (MAR-2006)
SALAL H.E. PROJECT

O & M STAGE CHALLENGES



Damaged Runner photographs of Unit #1 taken out during 2005-06 maintenance
BAIRA SIUL H.E. PROJECT

Thank you

GVK

Hydro Power in India

Issues & Government Action

M M MADAN
Director (Hydel)-GVK

Indian Power Sector

GVK

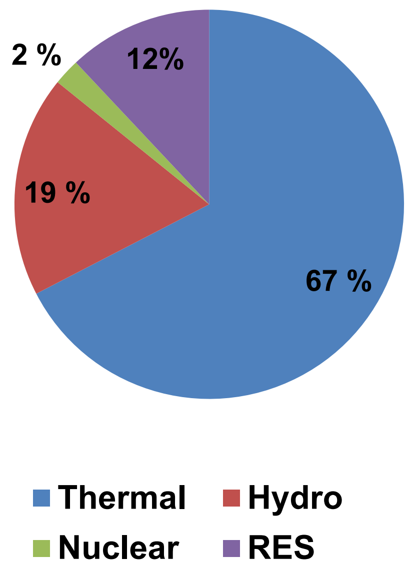
- Electricity is a concurrent subject, meaning thereby that, both the Central Government and the State Governments have responsibility to promote this sector and authority to make necessary laws, regulations, formulate and implement policies and programs.

- At the time of independence, in the year 1947 only 1,362 MW of electricity was produced in India.

- India paid considerable attention to the generation of power as a result of which the installed capacity of power generation has presently grown to 2,23,343MW.

Installed Generation of Power Capacity

Sources	Installed Capacity (MW)	%
Thermal	1,51,530.49	67 %
Hydro	39,491.4	19 %
Nuclear	4,780	2 %
RES	27,541.71	12 %
TOTAL	**2,23,343.6**	



AS ON 31.03.2013

Indian Power Demand & Consumption

- The access to electricity in the rural areas is vital. Out of about 608,000 villages 85% villages are electrified and 85 % of the irrigation pump sets are energized. But above figures does not mean that all village house hold have full access to electricity.
- Consumption of electricity per person has increased from 631.4 kWh in 2005-06 to 879.22 in 2011-12.
- On the whole, India face shortage of electricity of 11 % in peak demand and 10 % overall Energy Shortage.

Anticipated Power Supply Position in India (2012-2013)

GVK

STATE / REGION	ENERGY				Peak			
	Requirement	Availability	Surplus (+) / Deficit (-)		Demand	Met	Surplus (+) / Deficit (-)	
	(MU)	(MU)	(MU)	(%)	(MW)	(MW)	(MW)	(%)
Northern	299,166	267,495	-31,672	-10.6	44,953	39,429	-5,524	-12.3
Western	285,541	286,497	956	0.3	40,659	39,352	-1,307	-3.2
Southern	277,480	223,271	-54,209	-19.5	39,614	29,178	-10,436	-26.3
Eastern	111,159	105,831	-5,328	-4.8	17,922	17,966	44	0.3
North-Eastern	11,970	10,277	-1,692	-14.1	2,314	1,807	-507	-21.9
All India	985,316	893,371	-91,946	**-9.3**	145,462	127,732	-14,856	**-10.6**

Per Capita Power Consumption In India

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Year	Per Capita Consumption (kWh)
2005-2006	631.4
2006-2007	671.9
2007-2008	717.1
2008-2009	733.5
2009-2010	778.6
2010-2011	818.8
2011-2012	879.22

India has to harness every available source of power generation and in this context, Hydropower has acquired priority and Small Hydropower has a special place.

Hydro Power

- India has a history of about 110 years of hydropower.
- India's experience with Hydro dates back to 1897 with a Small Hydro Project of 165 KW at Sidrapong, in Darjeeling.
- First Medium size Hydro Project, was set up at Sivasamudram (4,320KW) in Karnataka in 1902.
-
- First Private sector Hydro Project was set up at Khopoli by M/S Tata Power(32 MW) in in 1915.
- At the time of independence, the installed capacity stood at 1362 MW with share of hydro as 532 MW.

Hydro Electric Power Potential in India

- India is blessed with many rivers. As many as 12 of them are classified as major rivers whose total catchment area is 258.2 million ha.
- India has an enormous hydro electric power potential of around 1,48,700 MW (84,044MW at 60% load factor).
- Utilization of Hydropower potential is only 39,491 MW out of the 1,48,700 MW (27%).

Basin - wise Hydropower Potential in India

BASIN / RIVER	Potential @ 60% Load Factor	Probable Installed Capacity (MW)
Indus	19,988	33,832
Ganga	10,715	20,711
Central Indian Rivers	2,740	4,152
West Flowing Rivers	6,149	9,430
East Flowing Rivers	9,532	14,511
Brahmaputra	34,920	66,065
TOTAL	**84,044**	**148,701**

Total Hydro Capacity – Region Wise

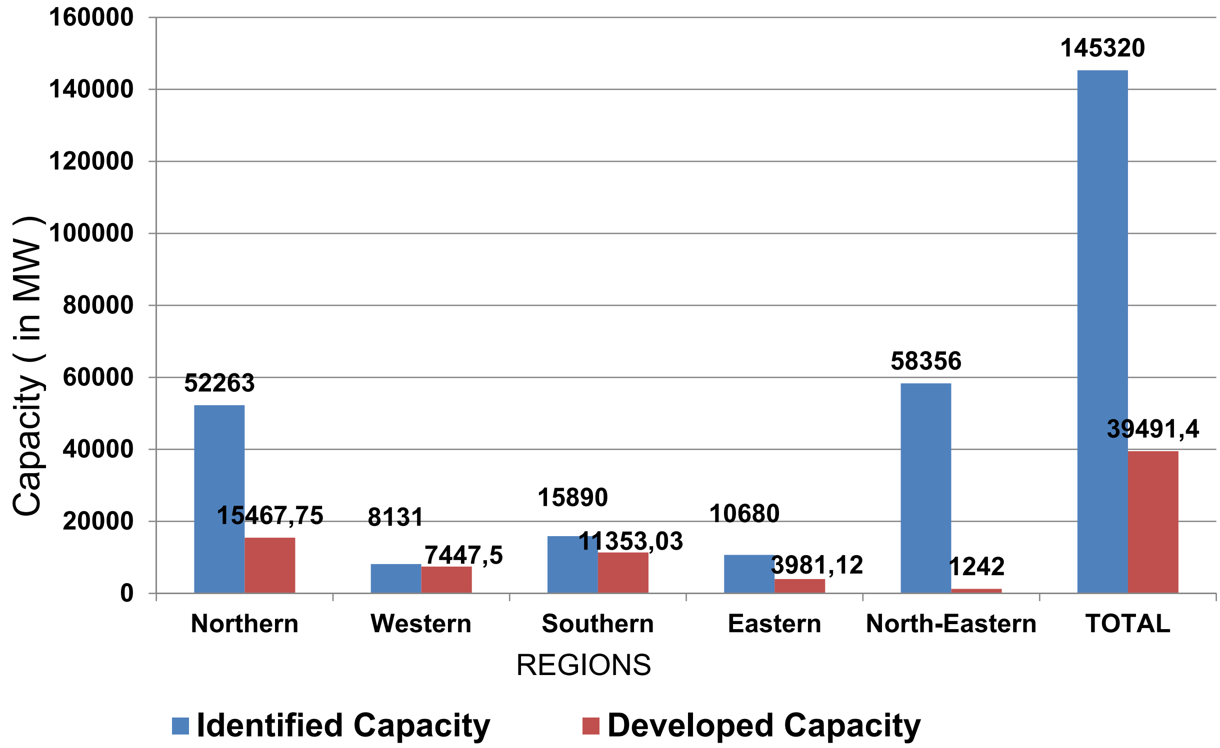
Region	Identified Capacity	Developed Capacity	% Developed
Northern	52,263	15,467.75	29 %
Western	8,131	7,447.5	91 %
Southern	15,890	11,353.03	71 %
Eastern	10,680	3,981.12	37 %
North-Eastern	58,356	1,242	2 %
TOTAL	**145,320**	**39,491.4**	**27 %**

AS ON 31.03.2013

There is huge untapped potential in North-Eastern States like Arunachal Pradesh - around 4,460 MW capacity is under construction in the State.

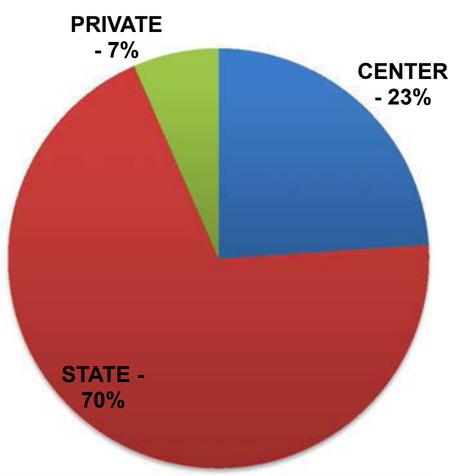
HYDRO POWER - Identified Capacity Vs. Developed Capacity

GVK



Hydro Power Capacity by Sector

GVK



SECTOR	Installed Capacity MW	Percentage
Center	9,459.4	23 %
State	27,437	70 %
Private	2,595	7 %
TOTAL	**39,491.4**	

AS ON 31.03.2013

GVK

Hydro - 11th Five Year Plan

SECTOR	TARGET	ACHIEVED	% ACHIEVED
CENTRAL	8,654	1,550	18%
STATE	3,482	2,702	78%
PRIVATE	3,491	1,292	37%
TOTAL	**15,627**	**5,544**	**35%**

GVK

12th & 13th Five Year Plans

SECTORS	12th Five Year Plan	13th Five Year Plan
Hydro	10,897	12,000
Nuclear	5,300	18,000
Thermal	72,340	49,200
TOTAL	**88,537**	**79,200**
Wind	15,000	11,000
Solar	10,000	16,000
Other RES	5,000	3,500
RES - TOTAL	**30,000**	**30,500**

Advantages of Hydro Power

GVK

- **Renewable source** of energy
- Relatively **Environmentally benign**
- **Ability for instantaneous starting**, stopping and load variation thereby ideally suited for peaking operation
- Long useful **life span well over 50 years**
- **No fuel cost during the life** of the station

Advantages of Hydro Power

GVK

- Emerges to be most **economical source of power** in long run
- **Because of Hydro Projects, there is Development & Up Gradation of infrastructure and communication systems** in the remote locations
- Storage projects provide flood moderation, irrigation, drinking water supply, recreation facilities etc. and thus help in the maximum utilization of our scare water resources

Hydro Power Development in India - Some Facts

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First Hydro Power Station	1897, Sidrapong (130 kW) in Darjeeling.
First Major Hydro Station	1902, Sivasamudram (4500 kW) in Mysore
First Private Hydro Station	1915, Tata-Khopoli (32 MW) in Maharashtra
Largest tunnel Diameter	15m, Srisailam (770 MW) in Andhra Pradesh
Longest Tunnel	27 km, Nathpa Jhakri (1500 MW) in H.P.
Highest Dam	260m, Tehri (1000 MW), Uttaranchal
Hydro Capacity in 1947	508 MW
Present Hydro Capacity	39,491.4 MW (As on 30.03.2013)

Some of the Major Completed HEPs in India

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Station	State	Operator	Capacity (MW)
Uri Hydroelectric Dam	Jammu & Kashmir	NHPC	480
Tehri Dam	Uttarakhand	THDC India Ltd.	1000
Teesta-V	Sikkim	NHPC	510
Sardar Sarovar	Gujarat	SSNNL	1,450
Salal	Jammu & Kashmir	NHPC	690
Omkareshwar	Madhya Pradesh	NHPC	520
Nathpa Jhakri	Himachal Pradesh	SJVNL	1,500
Nagarjunasagar	Andhra Pradesh	APGenco	965
Koyna	Maharashtra	MahaGenco	1,960
Kalinadi	Karnataka	KPCL	1,240
Indira Sagar	Madhya Pradesh	NHPC	1,000
Idukki	Kerala	KSEB	780
Dulhasti	Jammu & Kashmir	NHPC	390
BSL	Himachal Pradesh	BBMB	990
Chamera-I	Himachal Pradesh	NHPC	540
Bhakra Dam	Punjab	BBMB	1,325

Nathpa Jhakri Power Station (1500 MW)

GVK

GVK

Double Curvature Arch Dam, Idukki.

Nagarjuna Sagar Dam across Krishna River.

Hydro Power Classification

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- ❖ Classification of hydropower varies differently in various countries.
- ❖ In India based on installed capacity of hydropower projects a general classification has been made:

Mini	20 MW & below
Small	25 MW & below
Medium	100 MW & below
Large	above 100 MW

Issues involved in Hydropower Development

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1. Land acquisition, Rehabilitation & Re-settlement issues.
2. Environment & Forest Clearance issues - Green tribunal cases .
3. Geological Challenges.
4. Law & Order issues in Border areas.
5. Power transmission challenges through forest and thickly populated areas and infrastructure related issues.

Land acquisition and Rehabilitation & Re-settlement problem.

GVK

- Hydro electric projects involve submergence of large areas of land, leading to R&R issues.
- The problems arising in acquisition of land for hydro electric projects construction are causing suspension and delay in the construction activities.
- The new Land Acquisition Rehabilitation and Resettlement bill strengthens the land owners rights during acquisition, but for development projects it will pose many hurdles to the industry.

Issues related to New Land Acquisition, Rehabilitation & Re-settlement Bill

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The Land Acquisition, Rehabilitation and Resettlement Bill, 2011 was introduced in the Lok Sabha on September 7, 2011. The Highlights of the bill are as follows:

- Consent required from at least 80% of "Project Affected People" in case of private companies & 70% in case public private partnership projects.
- Differential treatment of public and private enterprises: no consent of project affected people in case of PSUs.
- The new act will be applicable to all land acquisitions where either the money has not been paid or where the possession of land is still pending, for a period equal to or exceeding 5 years prior to commencement of this Act.
- For every acquisition of whatever size, SIA (Social Impact Assessment) will have to be conducted :

Environmental & Forest & Wildlife Issues

GVK

- Hydro electric projects involves submergence of adjoining areas which often requires forest land/ wildlife areas.
- The progress of some of the projects has been affected on account of delay in clearance of Land.
- Besides Comprehensive EIA Report and EMP there are new requirements which keep coming during the clearance process.

Geological Challenges

GVK

- Projects located in Himalayan zone suffer from adverse geological conditions and natural calamities.
- Slippages from 11th Plan around 1900MW has been attributed to poor geological conditions.
- Due to geological uncertainties the contractors quotes additional cost to cover this risk.
- It is therefore essential that state–of-the-art investigation and construction techniques and proper planning are adopted to minimize geological risks.

Power Transmission Challenges

- Delay in Forest clearance, cutting of forest area trees, private land acquisition, cutting of trees in private land & non cooperation by land owners.
- Long distances, unapproachable areas in Himalayas
- Charging of High cost for Private Land and Right of Way issues

Other Supporting Infrastructure

- Location of HEPs in remote areas needs upgraded supporting infrastructure such as Roads & Bridges.
- Projects located in the same valley by various developers suffers because every developer wants the other party to develop the supporting infrastructure.
- Sometimes the developer who starts first has to bear the burden of maximum cost. The cost is unpredictable if the ownership is with state or BRO.

Hydro performance during 11th Five Year Plan- low achievement of 10083 MW

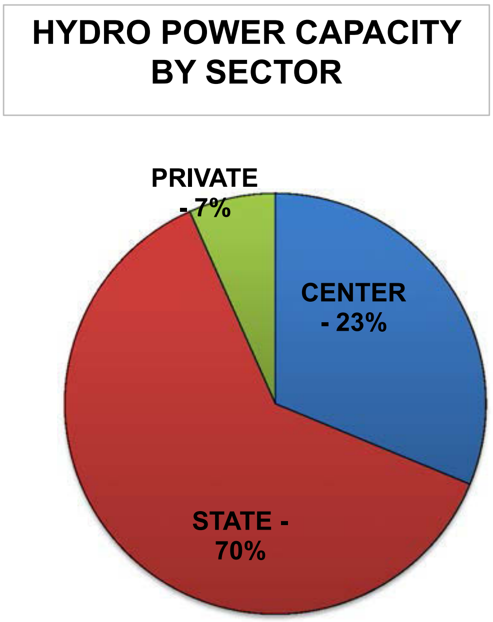
SECTOR	TARGET	ACHIEVED	% ACHIEVED
CENTRAL	8,654	1,550	18%
STATE	3,482	2,702	78%
PRIVATE	**3,491**	**1,292**	**37%**
TOTAL	**15,627**	**5,544**	**35%**

Slow development of Hydro Power by Private Developers by the end of 11th Plan

The total installed Hydro Power Capacity by the end of 11th Five Year Plan, sector vice is as follows:

Sector	Capacity (MW)	Percentage
Center	9,085.40	23 %
State	27,380.00	70 %
Private	2,525.00	7 %
Total	38,990.40	

The main reasons for the slow development of Hydro power by private developers are discussed in next slides.



Reasons for Slow development of Hydro Power by Private Developers :

1. Land Acquisition issues. The recent bill of Land Acquisition "The LA, R&R Bill 2011" will further complicate the issues.

2. Withdrawal of benefits of Mega Power status which has additional impact on the project cost.

3. MoEF insisting of release of 30% of Monsoon flow in the river at the Dam Toe, that reduces the generation capacity of many project.

Reasons for Slow development of Hydro Power by Private Developers :

4. Non availability of finances (equity or loan).

5. Poor Infrastructure availability in interior areas specially in Arunachal Pradesh.

6. Interference by local leaders/student leaders.

7. Recent norms of Net Present Value and its upfront payment for assessing the cost of forest diversion have added huge financial burden on the storage hydro schemes making them unviable.

Reasons for Slow development of Hydro Power by Private Developers :

8. Non-existence of Political will to execute Hydro power projects.

9. Forest & Environment clearance, Wild life area and National park clearances and post project award declarations.

10. Interference by NGOs on small issues in already cleared projects - in one of the project a small issue of shifting of temple is lingering on for years.

11. Non-identification of Private/state/forest/community land and its ownership specially in Arunachal Pradesh.

Expectations form Government

- Problems related to local issues, law & order, land acquisition, R&R etc. need to be resolved by the concerned State Government.
- Single window clearance from Government- State or Central
- Up-gradation of infrastructure in a valley where number of projects are being developed so as to share the cost of infrastructure up-gradation by all developers.
- The associated transmission system needs to be firmed up well in time so that completion of the transmission lines matches the commissioning schedule of concerned projects.

Expectations form Government

- The procedure for obtaining available hydrological data and survey sheets needs to be streamlined.
- Projects held up due to E&F problems, efforts may be made by the concerned state Govt. / Central Govt to get the timely E&F clearances.
- Tendency of converting storage projects to Run-of-River projects should be discouraged.
- Recent norms of Net Present Value and its upfront payment for assessing the cost of forest diversion need to be reviewed as the same have added huge financial burden on the storage hydro schemes making them unviable.

THANK YOU

Environmental design of hydropower

Atle Harby, CEDREN

Indo-Norwegian seminar, Mumbai, 7-8 May 2013

Dams

- Migration barrier
- Loss of connectivity
- Less access
- Loss of biodiversity

CEDREN Centre for Environmental Design of Renewable Energy


Degraded habitat in bypassed sections


Change in downstream flow regime

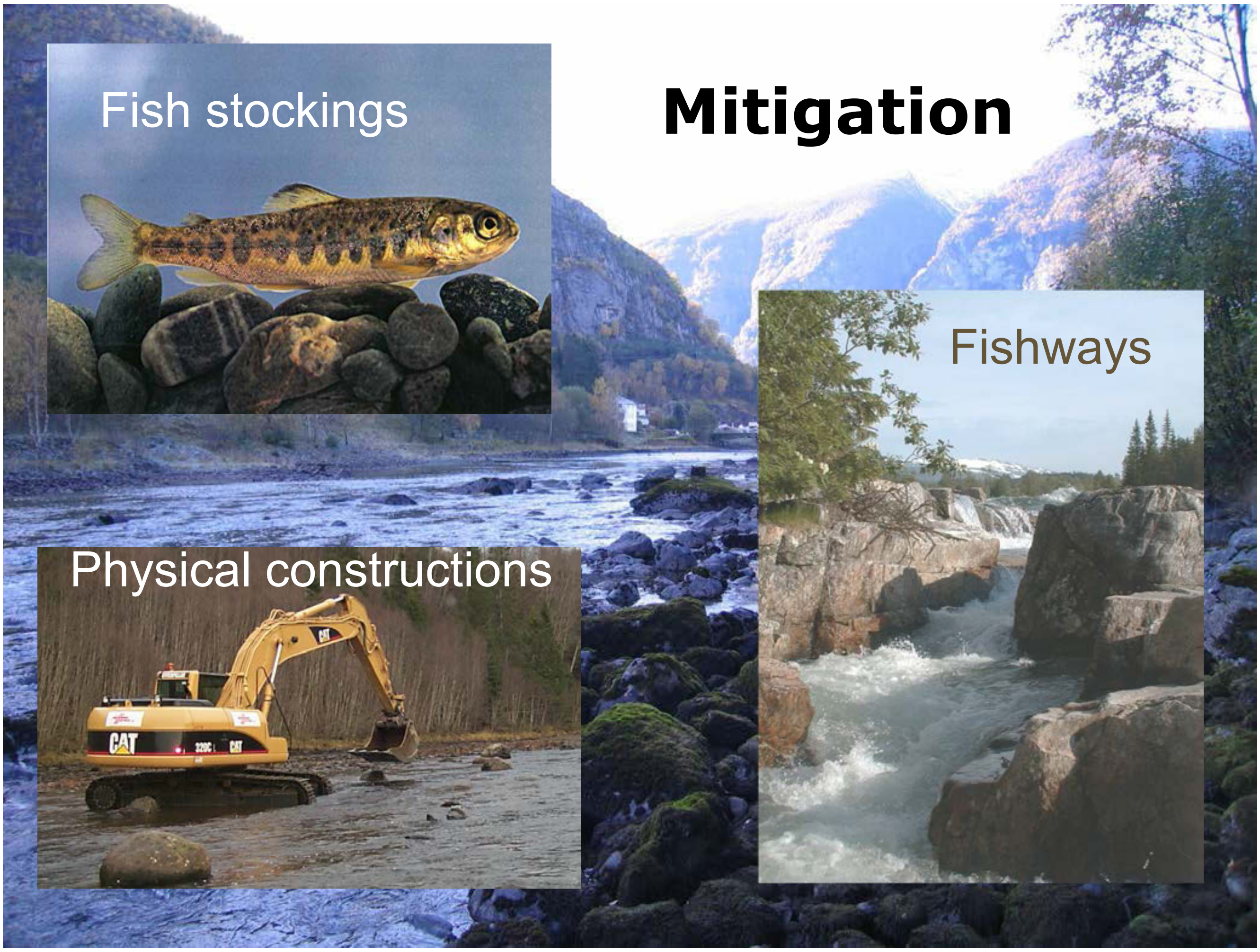

Barrier for sediments and fish

Landscape effect
Impacts on wildlife
Foto: NINA

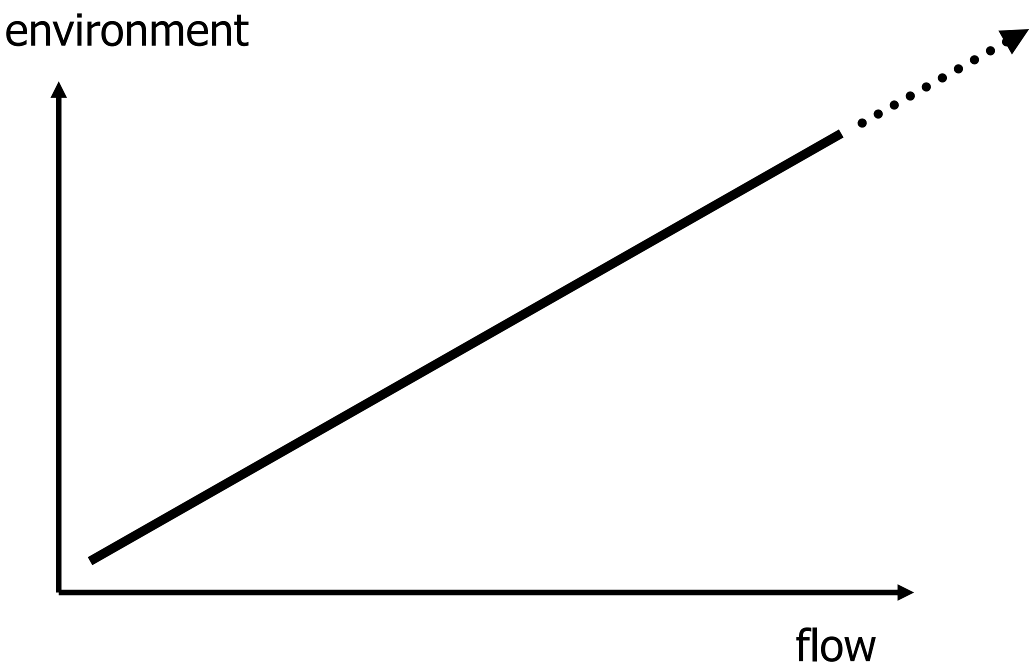

Greenhouse gas
emission control


Resettlement

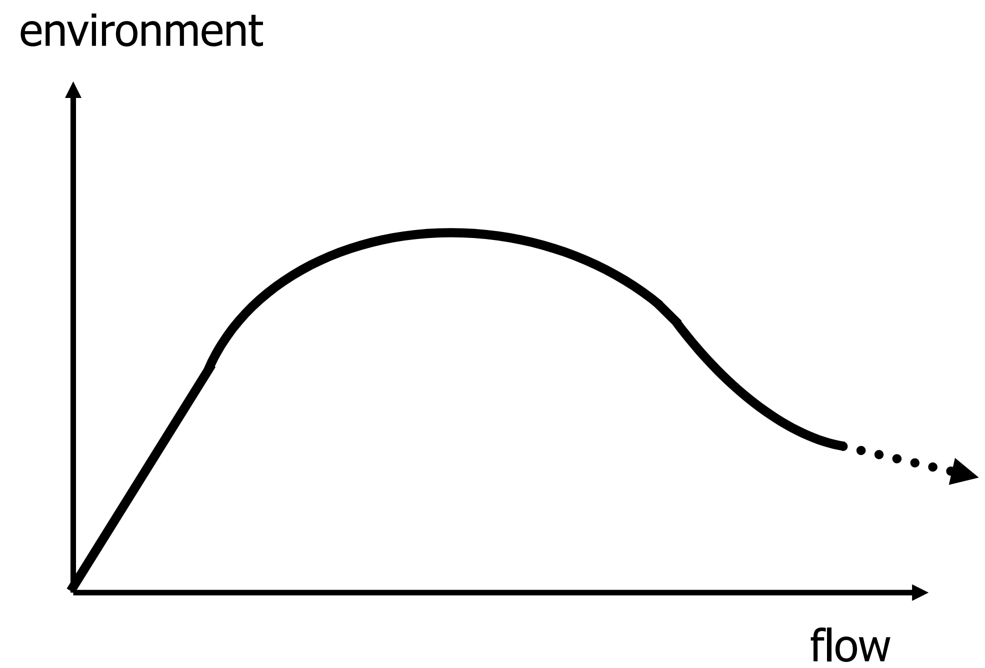

Mitigation



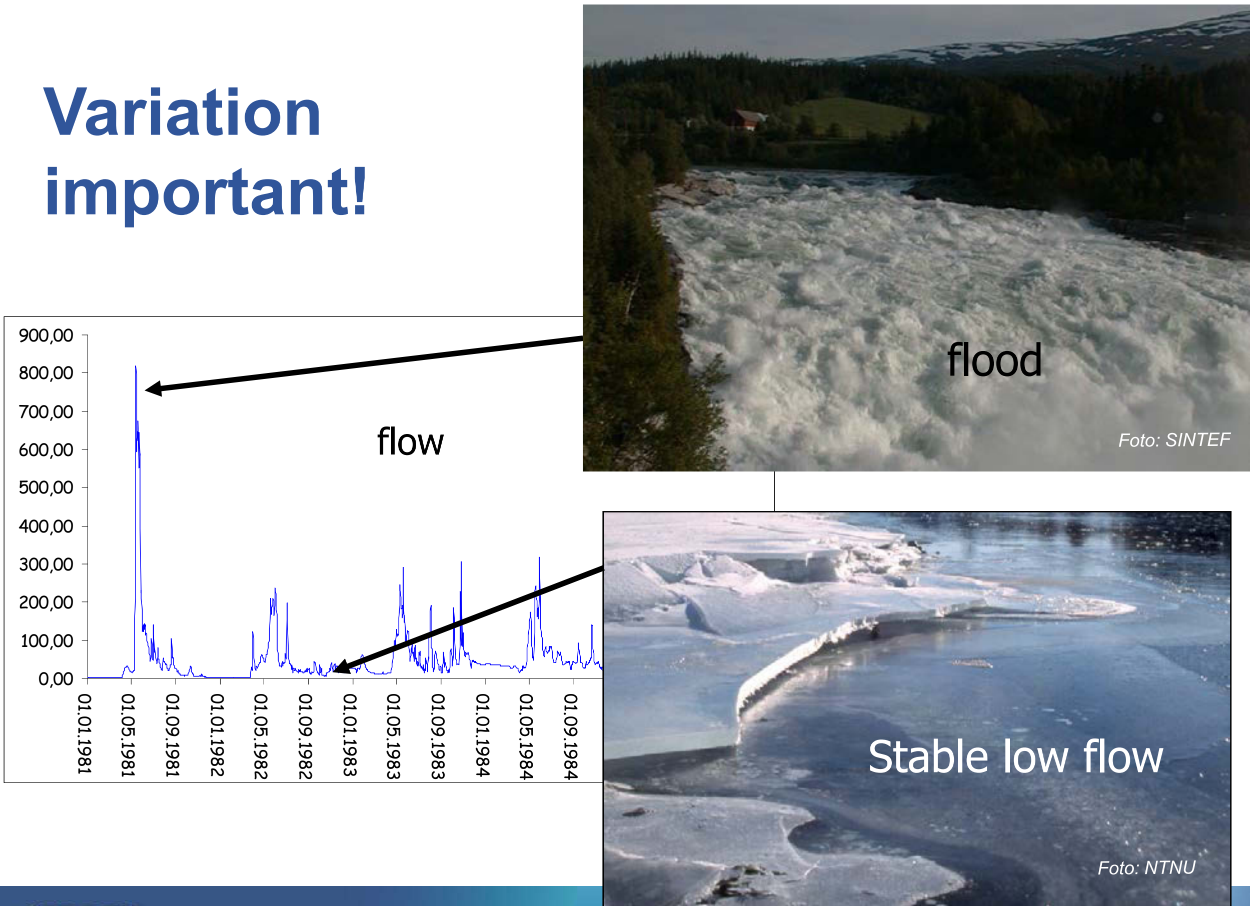
Flow and the environment



Flow and the environment



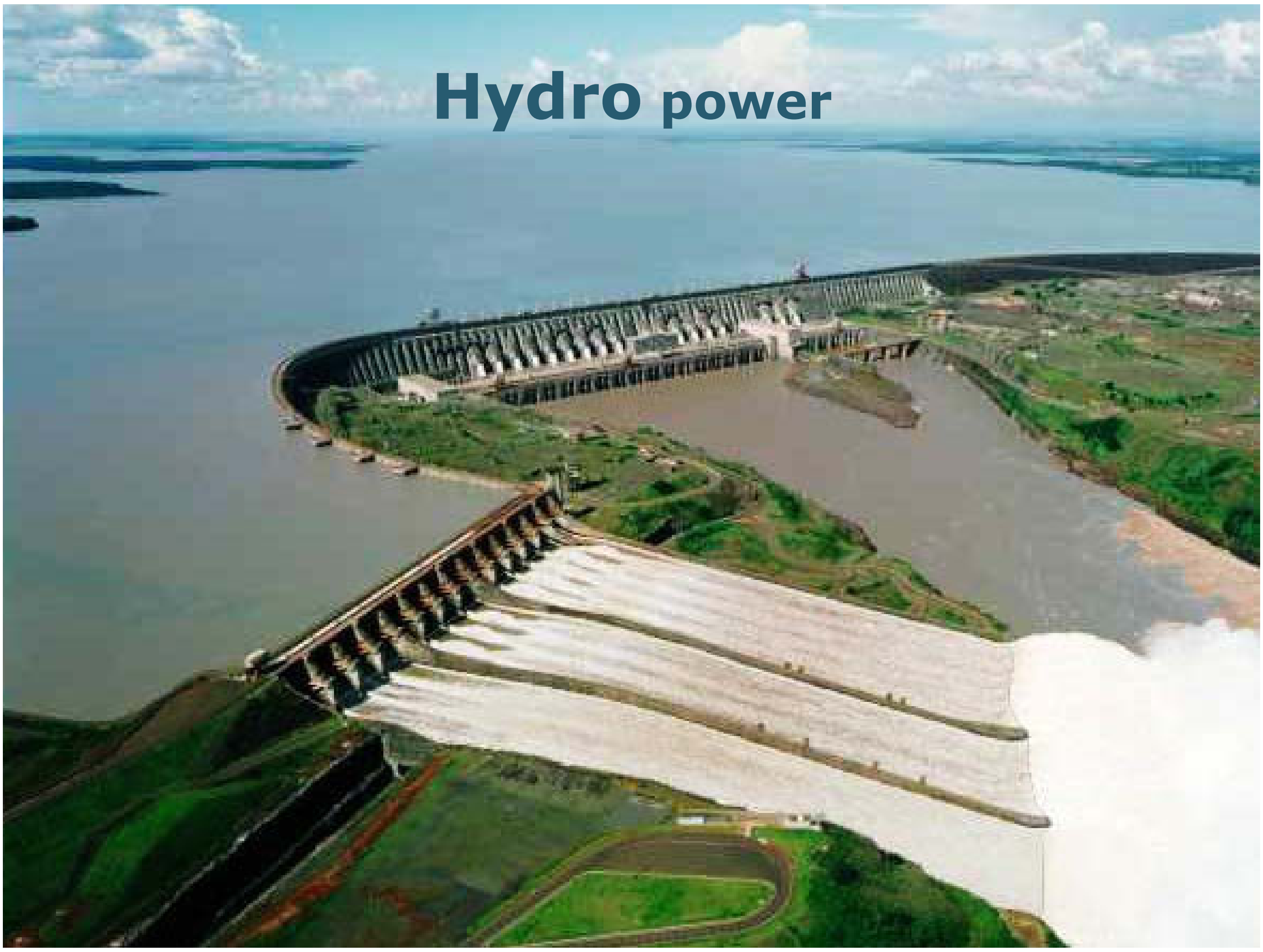
Variation important!



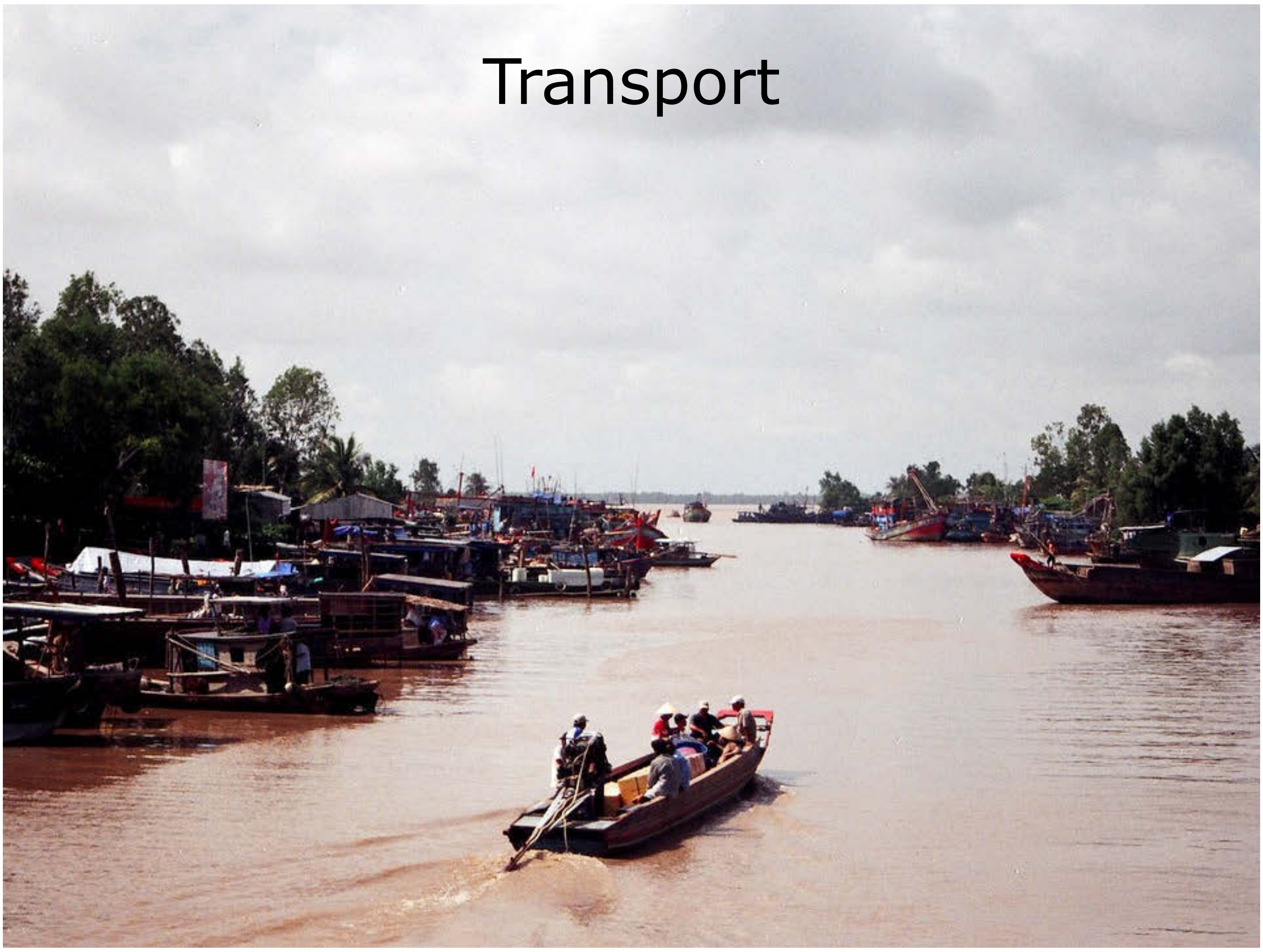
How much water is needed?

for hydropower
and ecology

CEDREN Centre for Environmental Design of Renewable Energy




Irrigation


Transport

Domestic use (drinking water)

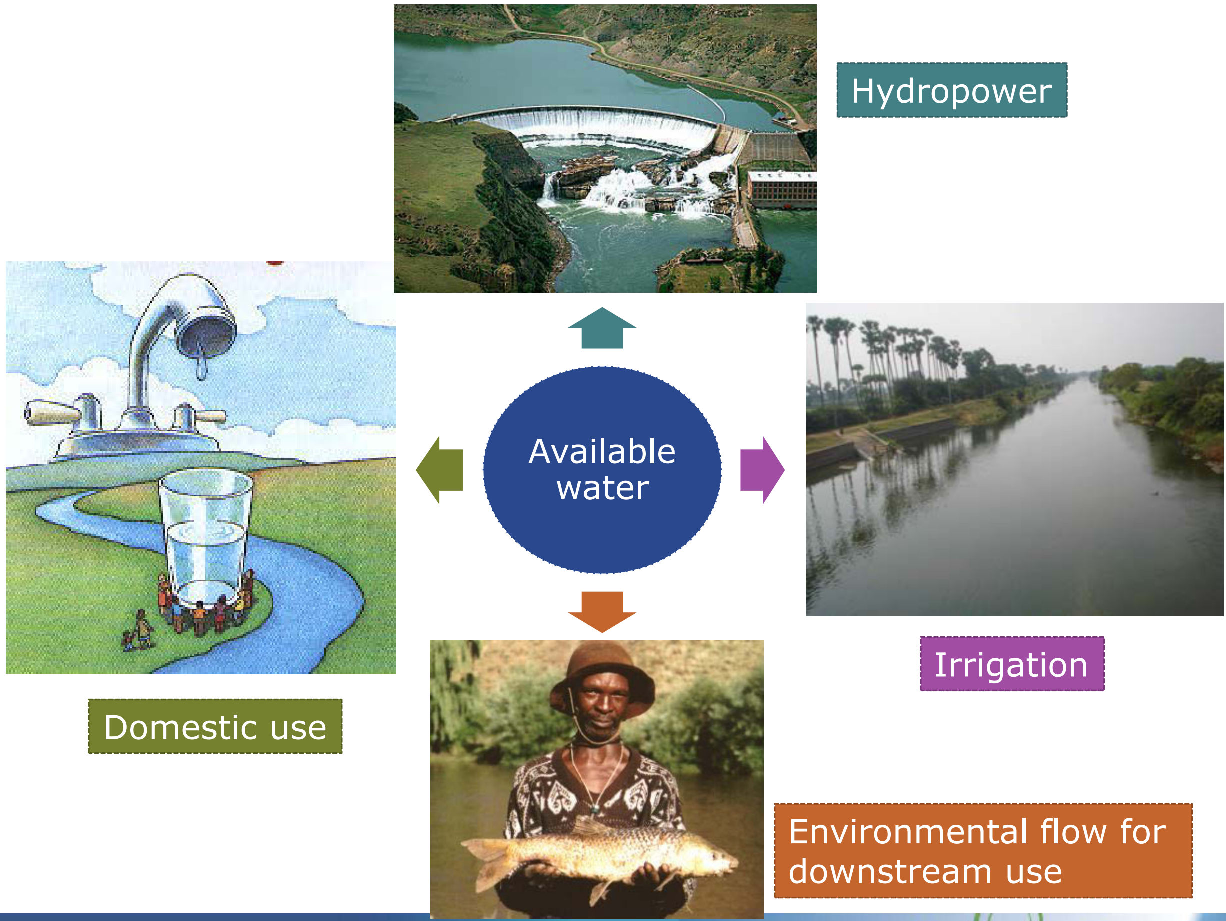
Food

CEDREN Centre for Environmental Design of Renewable Energy

Floods

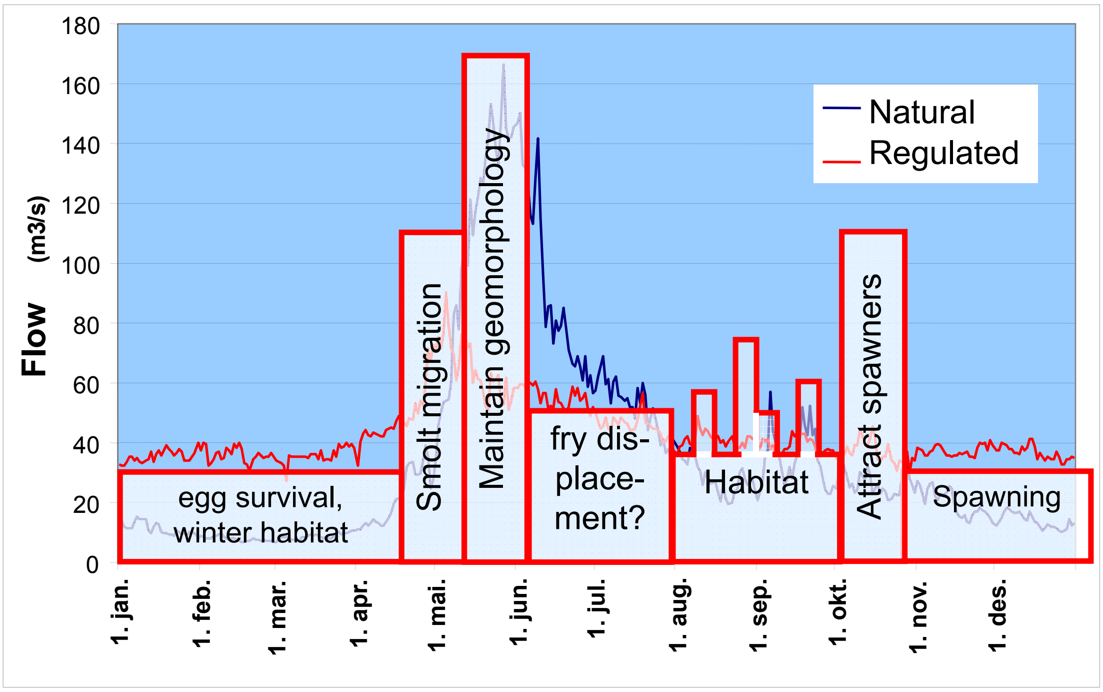
CEDREN Centre for Environmental Design of Renewable Energy

Draught

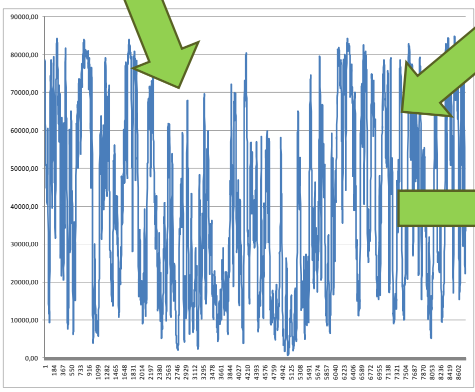


CEDREN Centre for Environmental Design of Renewable Energy

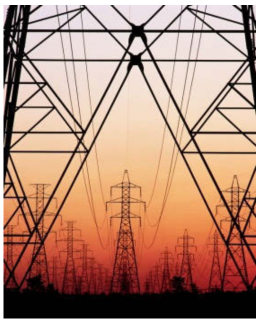
Seasonal requirements – salmon



Integrating intermittent renewables



Variable production



Strong and smart grid

+

Energy storage

Need for storage and flexibility

Tom Sauk PSP - USA

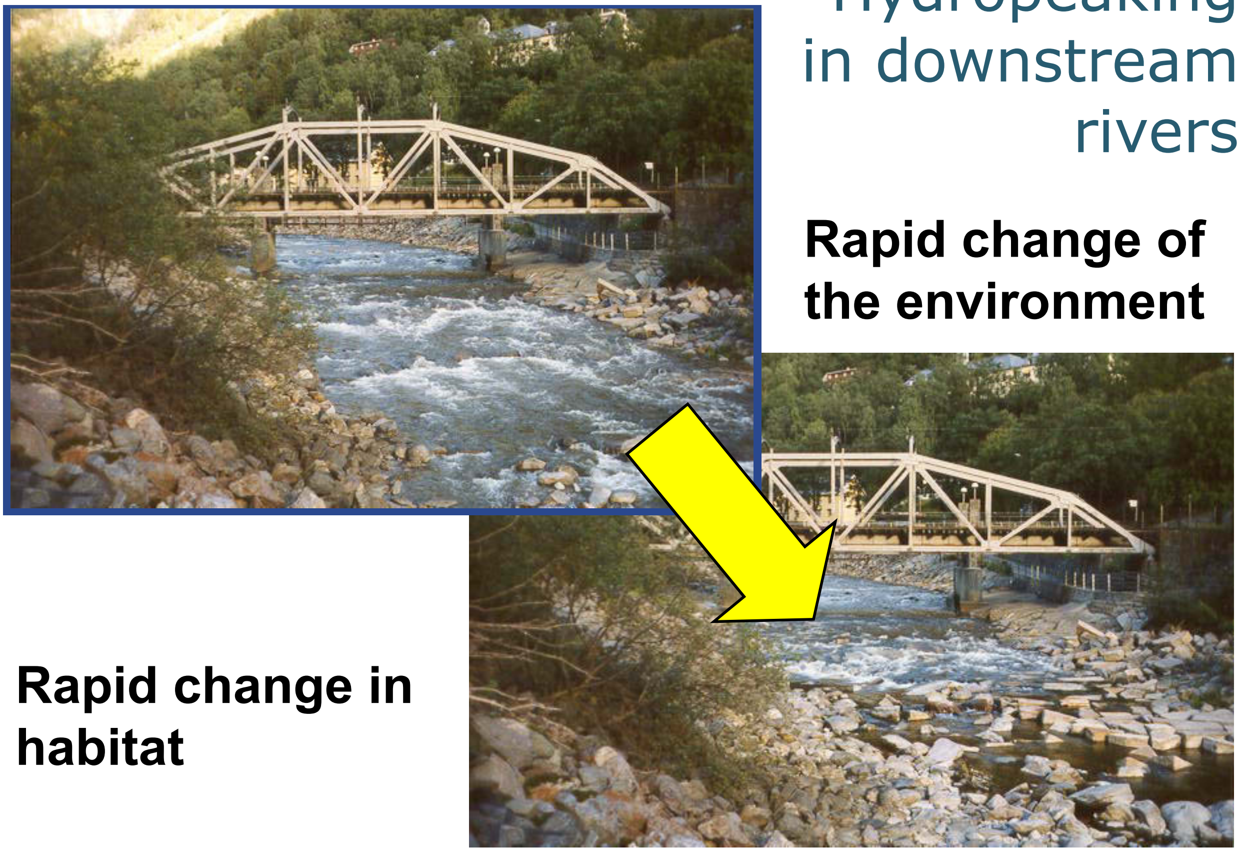
Tehri PSP Project - India

Blåsjø reservoir - Norway

Reservoir water level fluctuations

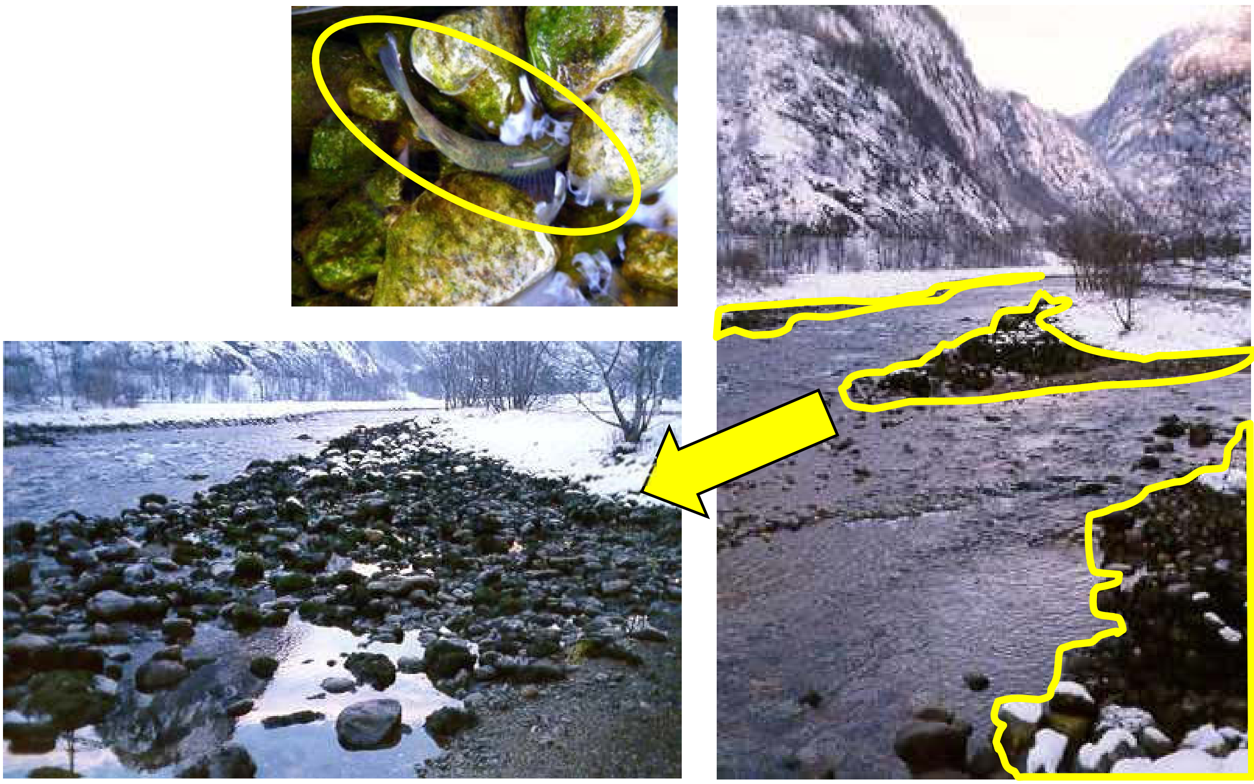
Hydropeaking in downstream rivers

Rapid change of the environment



Rapid change in habitat

Stranding risk - dry river beds



CEDREN Centre for Environmental Design of Renewable Energy

Environmental impacts of rapid and frequent flow changes

Knowledge about how, when and where rapid variations in power production may be done with acceptable impacts on the ecosystem.

Physical processes

Biological processes

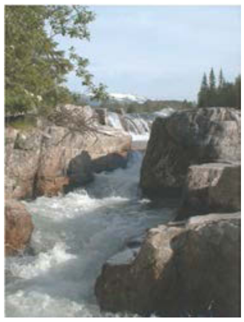
Mitigation

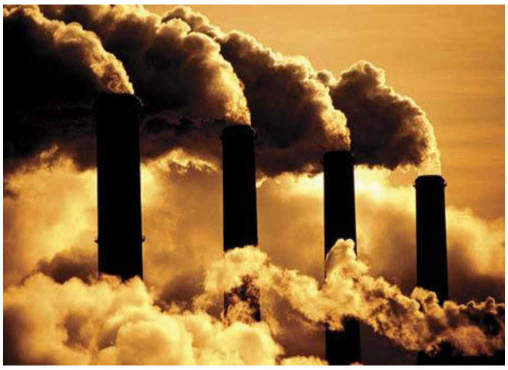
Conclusions

- Rivers are smaller, shallower and narrower at the upstream end compared to the downstream end – most of the times
- Rivers are wet – if they are not dry
- Bullet points are boring….

Research challenges

- Habitat improvements
- Downstream flows
- Environmental flows
- Fish migration
- Sediment "migration"
- Net greenhouse gas emissions
- Water consumption
- Energy storage
- Hydropeaking impacts
- Water for all needs → Building Block Method



….thank you for your attention!

Agility Care
Integrity
Excellence
Collaboration
Trust Respect

Hydro Power –Issues, Opportunities & Challenges

Amulya Charan
08th May 2013

Indian Power Sector – A Snapshot

- **Size & Scope**
  - Electricity Generation 831 TWh p.a. (ex-Renewables & Captive)
  - Per Capita per Year under 879 KWh p.a.
  - Installed Capacity: 211 GW
  - Private Sector constitutes of over 20%
  - Distribution Sector still State owned
  - Large AT&C Losses of over 25%
- **Fuel & Energy Sources**
  - Coal is primary fuel nearly 60% power generation
  - Gas constitutes of under 10% of capacity & generation
  - Imported Coal, Gas dependence increasing
- **Deficit Scenario**
  - 8.8% Energy Deficit, 9% Peak Power Deficit*
  - Latent Demand (15% villages to be electrified)
  - Load Shedding, DG Sets, Captive Power Plants

TATA POWER
Lighting up Lives!

* Source: CEA Review of Power Sector

Fuel Options

TATA

- **Coal:**
  - Coal is the dominant fuel in India's Power Generation mix
  - Domestic coal productions has been stagnant for last 3 years at around 530 MT, with Coal India failing to ramp up the production to meet the increasing demand
  - With 75% capacity addition in XIIth plan being coal based, we are headed towards a shortfall of more than 250 MT by 2017
- **Natural Gas:**
  - By 2015 expected demand of gas is around 380 mmscmd against an expected supply of 200 mmscmd
  - Fall in domestic production has resulted in stranding of generation capacities
- **Nuclear Power**
  - Insignificant contribution and expected to remain so for next 10 years

Fuel Options

TATA

- **Hydro**
  - Huge potential
  - In North and North Eastern region projects worth 50000 MW has been allocated
  - However slow progress towards developing these projects
- **Renewable**
  - Fast growth
  - Wind is the dominant source in this category
  - Characterized by seasonal variations and unpredictable daily generation

TATA POWER
Lighting up Lives!

Hydro Power – How can it help

TATA

- **Fuel Shortage**
  - India facing shortage of coal and gas
  - Abundant hydro resources make the issue of fuel availability redundant
- **Energy Security**
  - Falling domestic production of coal and gas will increase the import dependence
  - Hydro Projects will help in cutting short this dependence
- **Peak deficit**
  - India suffering from peak deficit of around 9% which will continue in near future
  - Hydro is the best choice for meeting the peak demand
- **Network security**
  - Indian Power Market is characterised by considerable variability in demand for electricity during the year, month, and week and even during the day
  - Inherent ability of hydro of quick starting, stopping and load variations offering operational flexibility

Peak deficit and Hydro power

TATA

- India currently has peak deficit of around 9%
- Out of 75,785 MW of capacity addition planned for the 12th plan, 83% (62695) is from coal based projects and only 12% (9,204 MW) from hydro and 1.4% (1086 MW) from gas based projects
- Focus on coal based projects will ensure that India continues to have significant peak deficit
- Working Group has recommended that peaking power demand could be supplemented by storage type hydro generating station including pumped storage schemes, open cycle gas turbine station, and gas based reciprocating engines
- Gas based peaking power faces the severe issue of availability and pricing of gas
- **Peaking power can ideally be provided by pondage/ reservoir based hydro plants and these must be encouraged**

TATA POWER
Lighting up Lives!

Why Pumped Storage Units Score Over Other Alternatives

- **Cost of peaking power:** As compared to gas based peaking power a pumped storage unit would generate power at much affordable rates as the fixed cost recovery will be spread over much longer period of time and higher PLFs.
- **Nature of Operation:** Pumped storage system is essentially an energy storage system and helps in optimising generation assets and balancing the power grid
- **Efficiency of operation:** Pump storage system operates with high efficiency of 80%-90% as compared to 30-42% for an open cycle gas turbine power plant with added impact of environmental pollution
- **Availability of fuel:** Availability of natural gas at acceptable price is an issue and will always be an issue for India. On the other hand, the country has significant hydro potential which is still untapped and some of these potential sites could be developed as pump storage systems

Hydro Power – Present Scenario

- Hydro constitutes approx 18% of the installed generation capacity
- Thermal to hydro ratio has been falling over the years
  - 65% thermal to 35% hydro at the end of 6th five year plan to a ratio of 77% thermal to 23% hydro at the end of 11th five year plan
- During 11th Plan only 4336 MW (27% of the targeted capacity) was added
- Key hydro states are J&K, Himachal Pradesh, Uttrakhand, Sikkim and Arunachal Pradesh
- Memorandum of Understanding (MOU)/ Implementation Agreement (IA) for a capacity of 50000 MW has been signed with private sector developers and CPSUs
- Slow progress of projects which have signed MoUs/IA

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Challenges for Hydro Development

- Non-availability of hydrological data recorded with CWC/Brahmaputra Board and other Govt. agencies resulting in delay in preparation of DPRs to Private developers
- Lack of infrastructure facilities like roads, construction power, reliable telecommunication system
- Delay in Environmental & Forest Clearance
- High interest rates and tighter credit availability
- Lack of technical and financial capabilities which are essential for hydro project development
- Conversion of storage schemes to ROR schemes on the insistence of State Govt
- Development of transmission system matching with commissioning of hydro projects located in remote areas
- High transmission open access charges

Measures to accelerate Hydro Power Development

- The States should be encouraged to either disinvest old and less efficient Hydro plants. This will bring modern technology, better efficiency and best utilisation of resources
- Hydro Projects irrespective of size should be treated as renewable projects and should be given incentives which are available to other renewable projects
- Government should encourage and support private players for projects in North East and adjoining region like Bhutan and Nepal
- Lack of long term finance for hydro projects should be resolved
- Upfront Payment and additional free energy to State Government, should be recognized as a part of project cost

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Any observations, comments ? We may have an open discussion on what is needed and how to achieve the same jointly !

"Journey Continues..
We value your inputs, suggestions and critique."

We take pride in Lighting up Lives!

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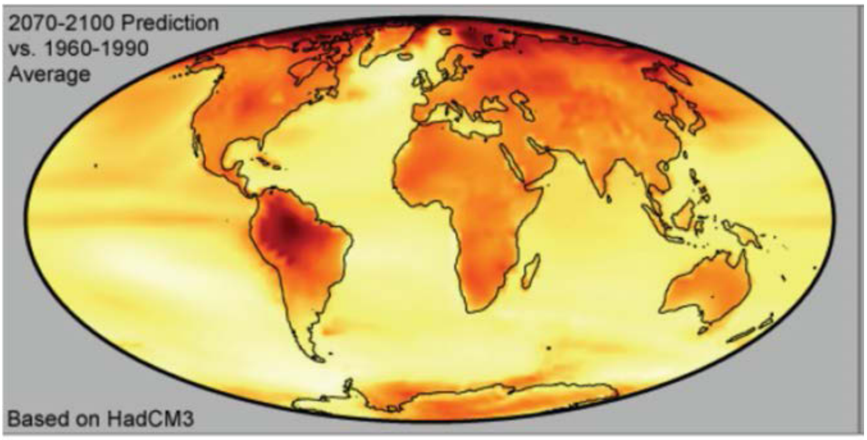
Climate Change and its effect on Hydropower



Ånund Killingtveit
Norwegian University of Science and Technology (NTNU)
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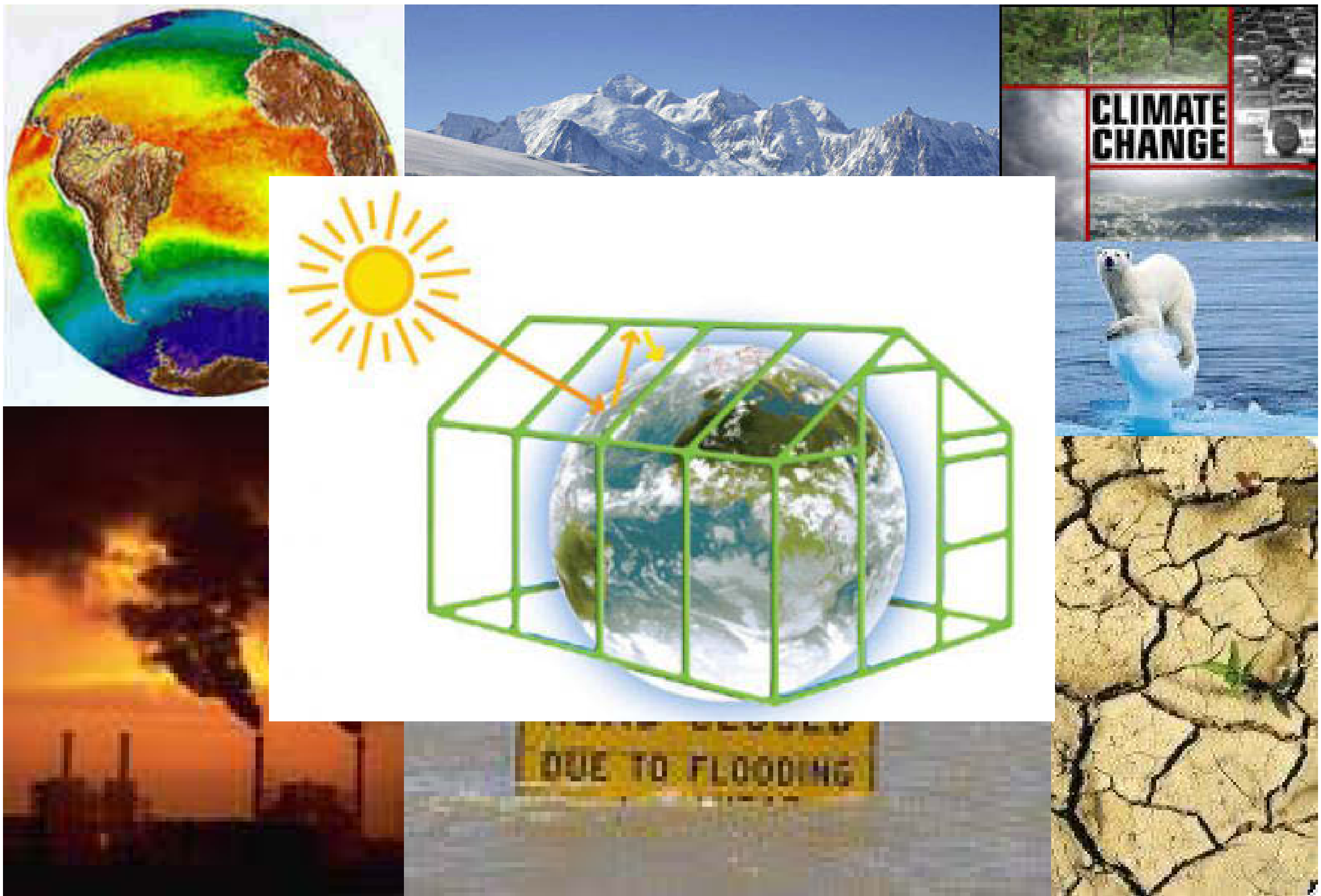

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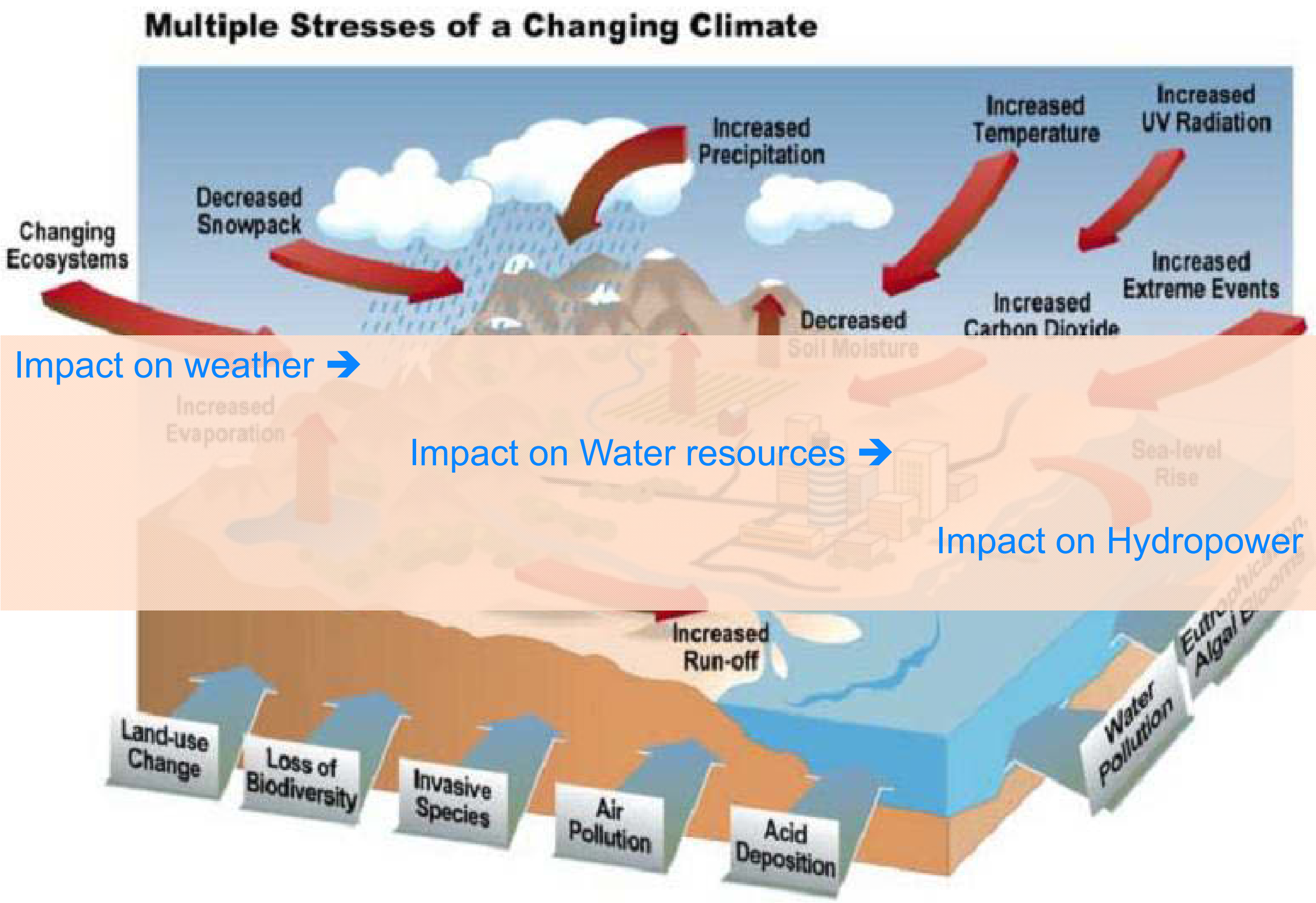
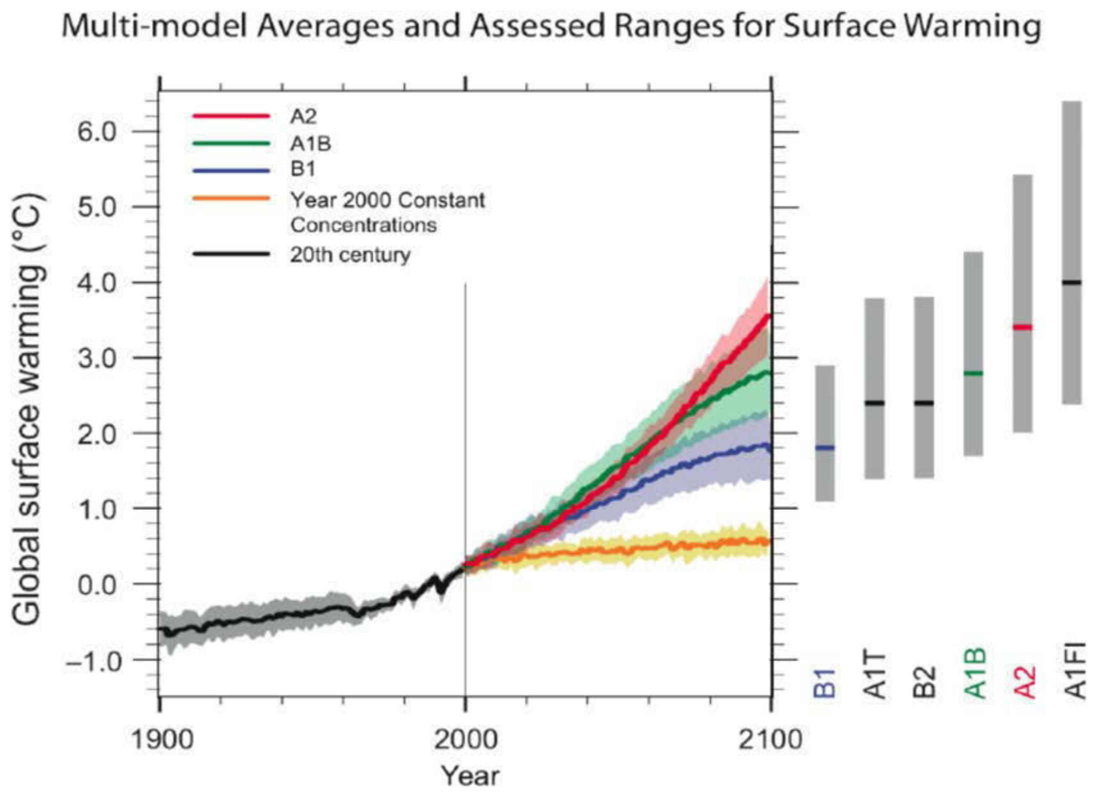


Impact on weather ➔

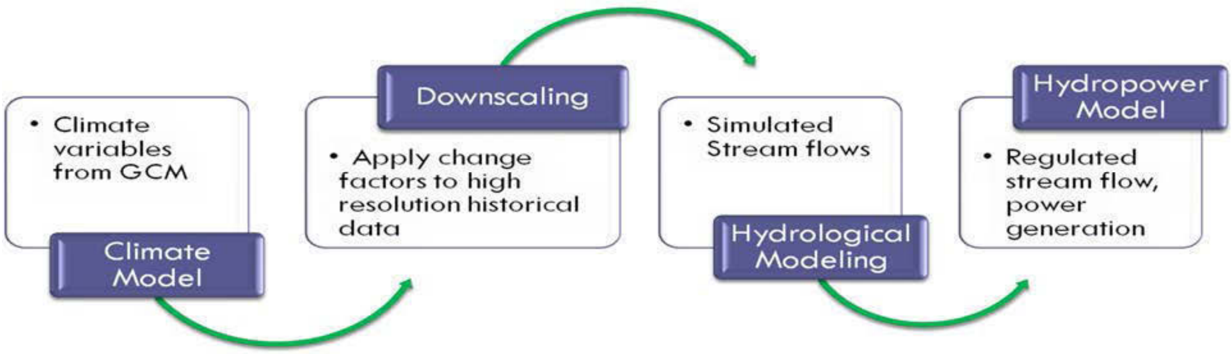
Impact on Water resources ➔

Impact on Hydropower

Emission Scenarios



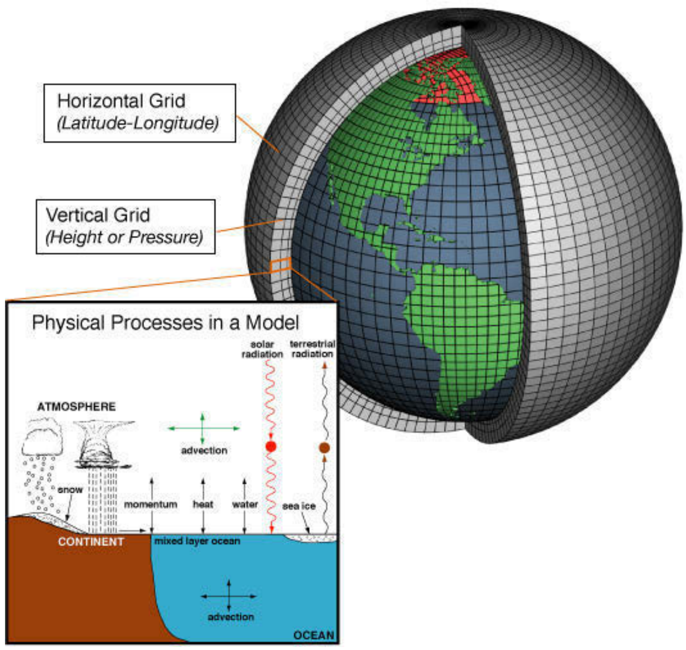
What about Hydropower - Main steps in the analysis process



- **Data sources**
  - Observed data (GHCN, GRDC, met offs)
  - Reanalysis data (NCEP, ERA 40/15)
  - GCMs data (PCMDI, CERA)

Changes in stream flow, power generation and revenues

Global Climate Models



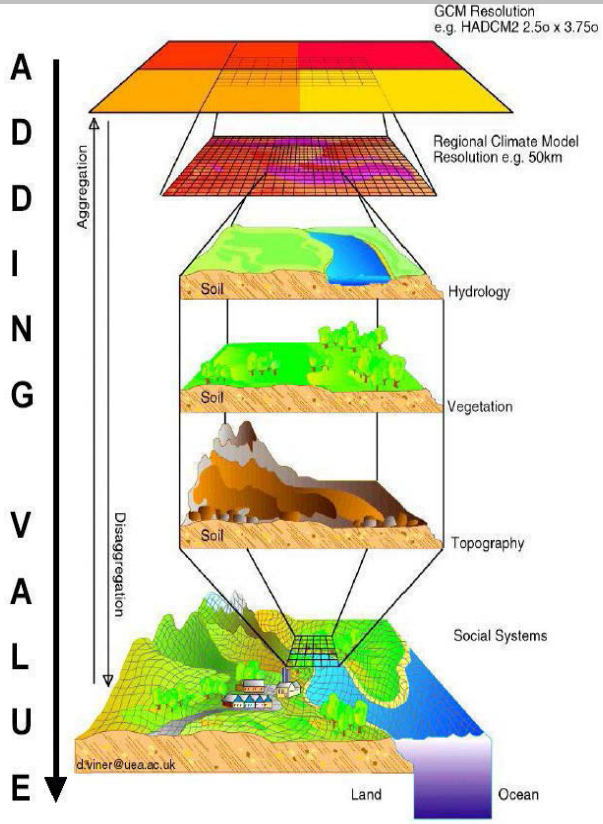
- Complex-climate components representation in 3D
- Perform climate change based on varying forcing (Emission scenarios)
- Simulates how climate evolves with different forcings
- Large grid size 200 x 200 km

Downscaling from GCM data

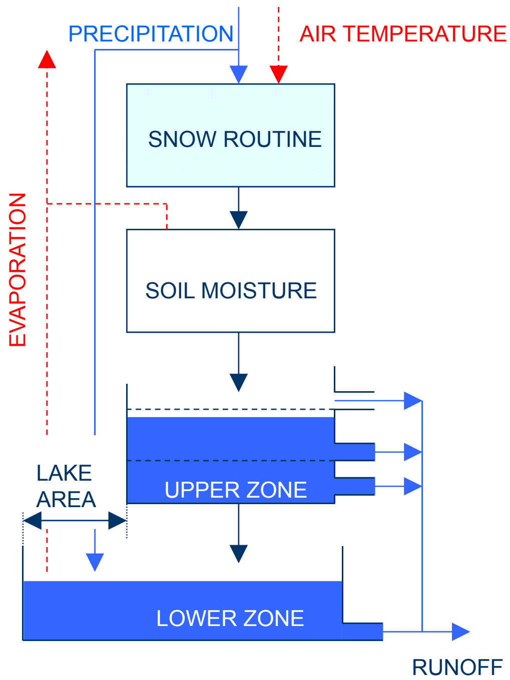
Gap (eliminate scale mismatch) between what GCMs can provide and what is needed in impact studies

Downscaling is used to generate more reliable climate change scenarios at a spatial scale much finer than that provided by GCMs

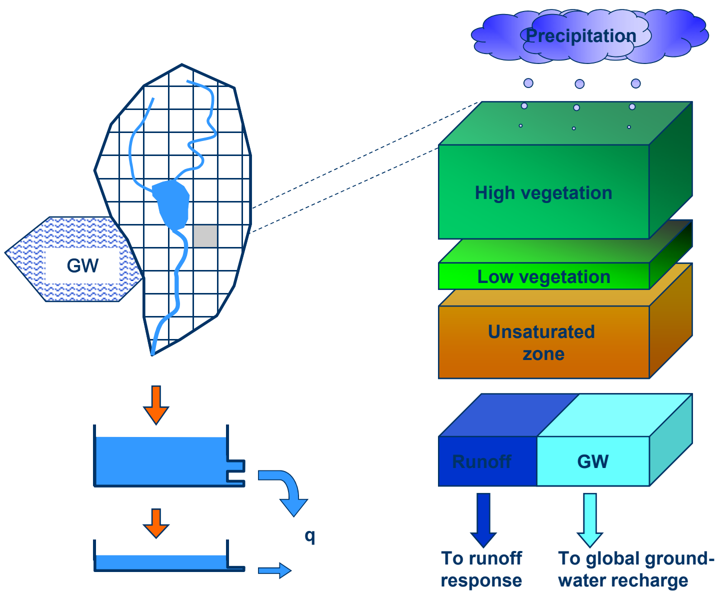
Downscaling is based on the fact that the smaller-scale climate is the outcome of the interaction of larger-scale circulation and smaller-scale physiographic details



Hydrological Models in Climate Change Impacts studies



HBV-model



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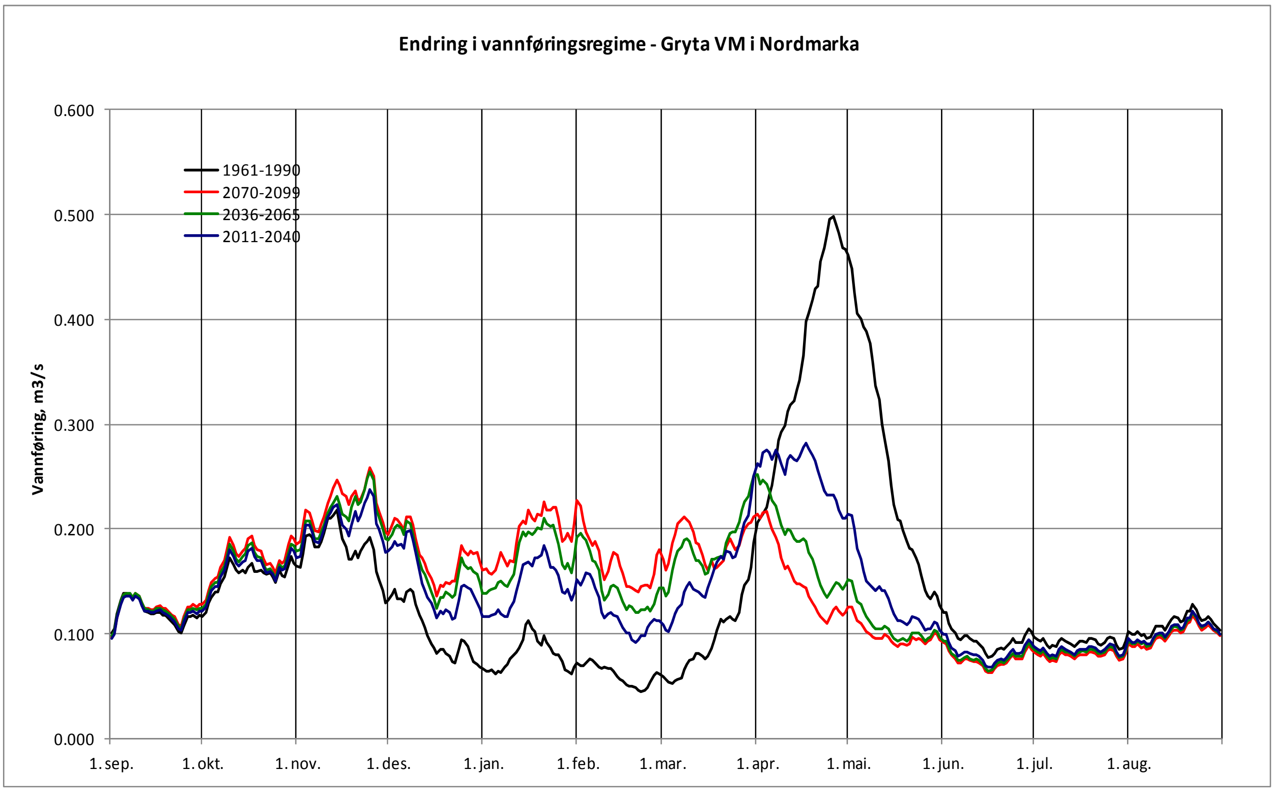
3. Hydropower Modeling – from river flow to energy

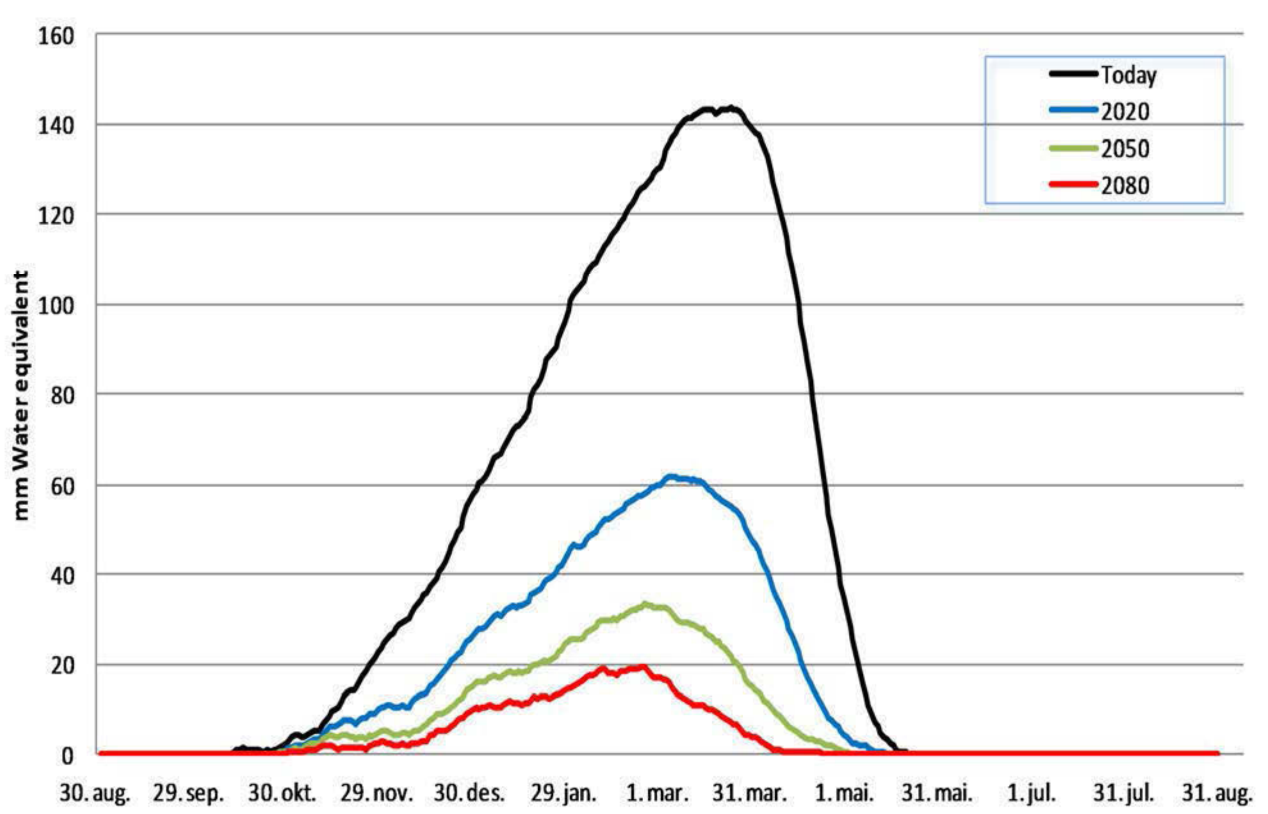
Changes in hydrology can have impact on hydropower by

- **Changes in volume/amount of water**
- **Changes in timing of flow (summer/winter)**
- **Changes in extremes (floods/droughts)**
- **Changes in sediment transport and deposition**
- **Changes in power demand profile**

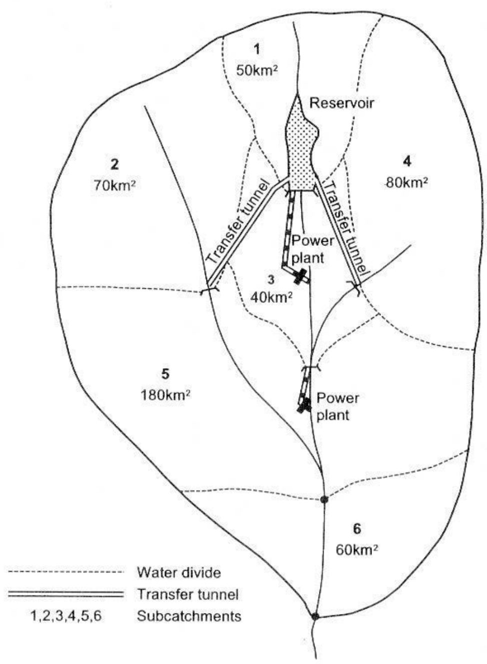
Climate change impact on runoff in Akerselva near Oslo



Climate change impact on snow storage in Akerselva



Hydropower system simulation model - Example



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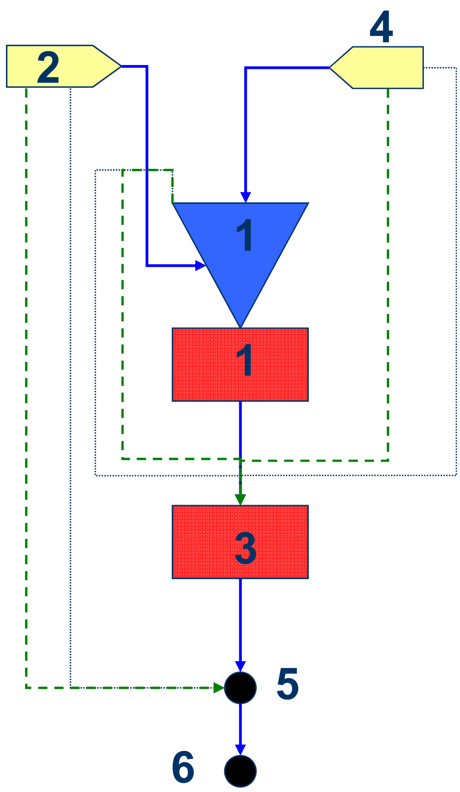
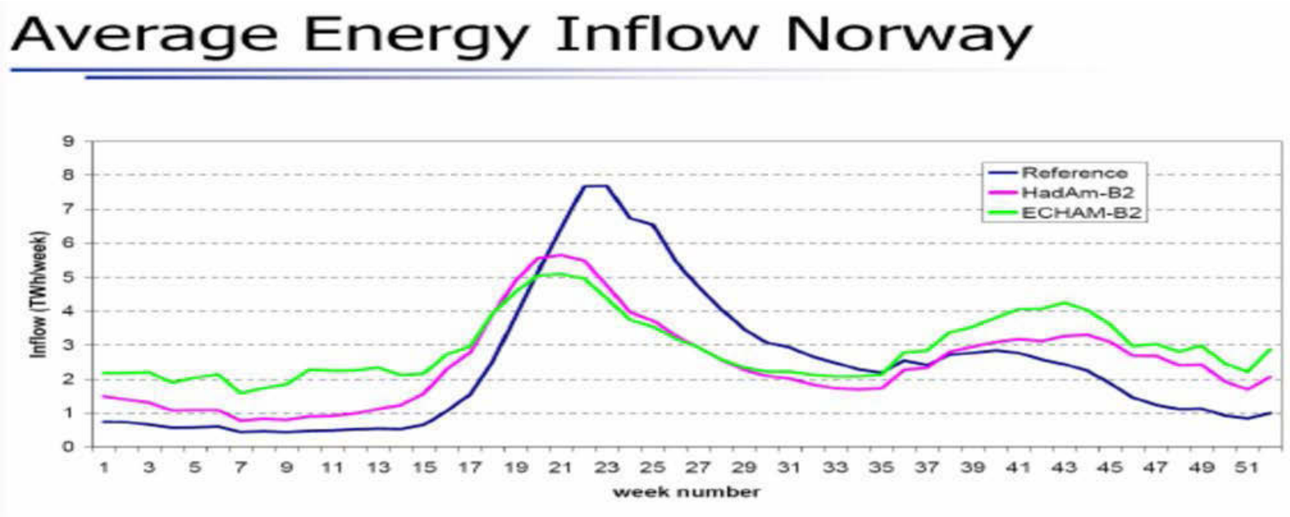


Effects on Hydropower system – Norway



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Effects on Hydropower system and Energy Production - Norway

Increasing runoff gives more water in total

More water leads to higher energy production

Milder winters, more rain, less snow

More winter runoff (but less in spring and summer)

Less need for storage

Milder winters also means less consumption

=> Generally improved conditions – less water spill

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Global effect of Climate Change on Hydropower Potential

Energies **2012**, *5*, 305-322; doi:10.3390/en5020305

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Article

Assessing Climate Change Impacts on Global Hydropower

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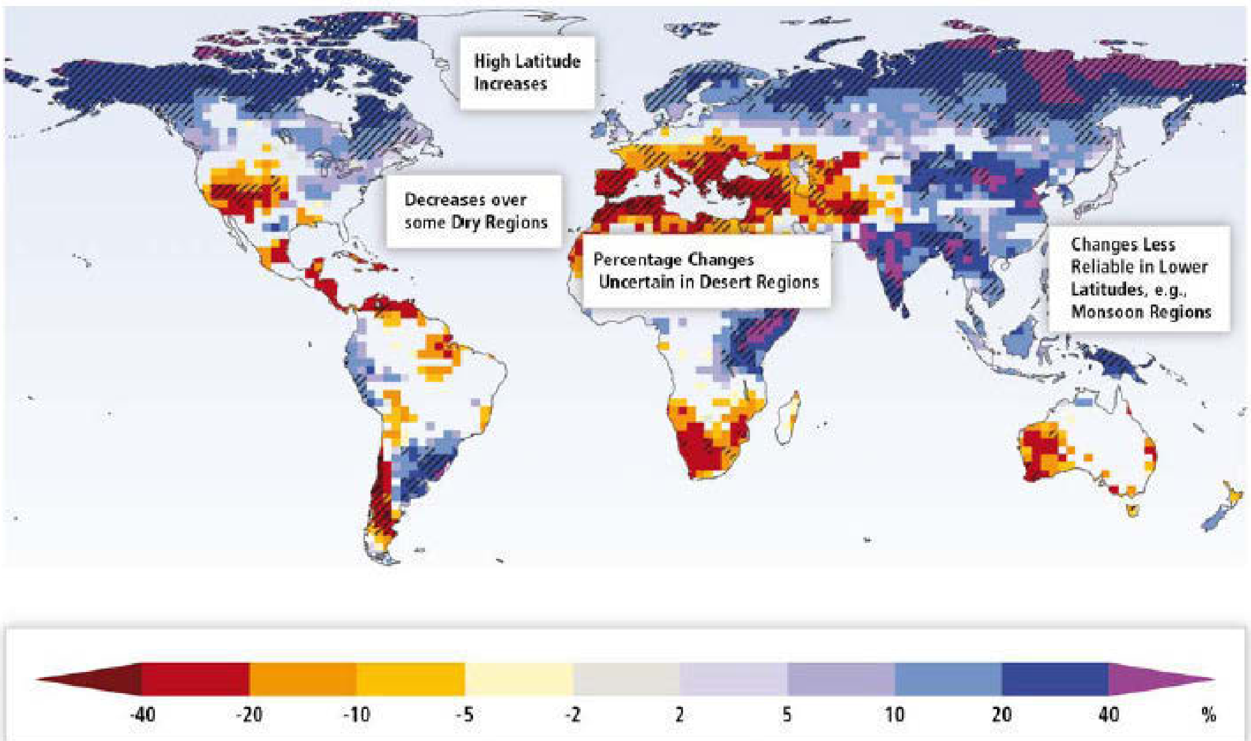
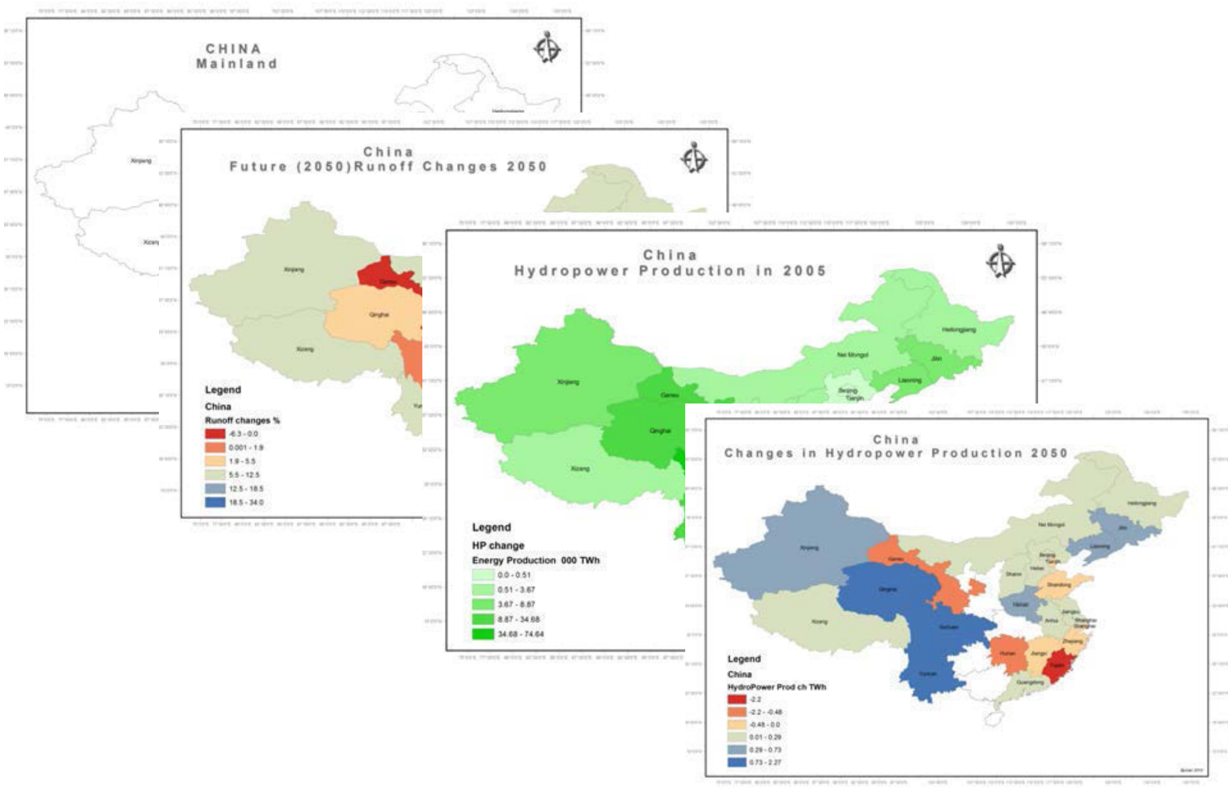
Global effect on Water Resources (Milly & al 2008)



Global effect on Hydropower Potential



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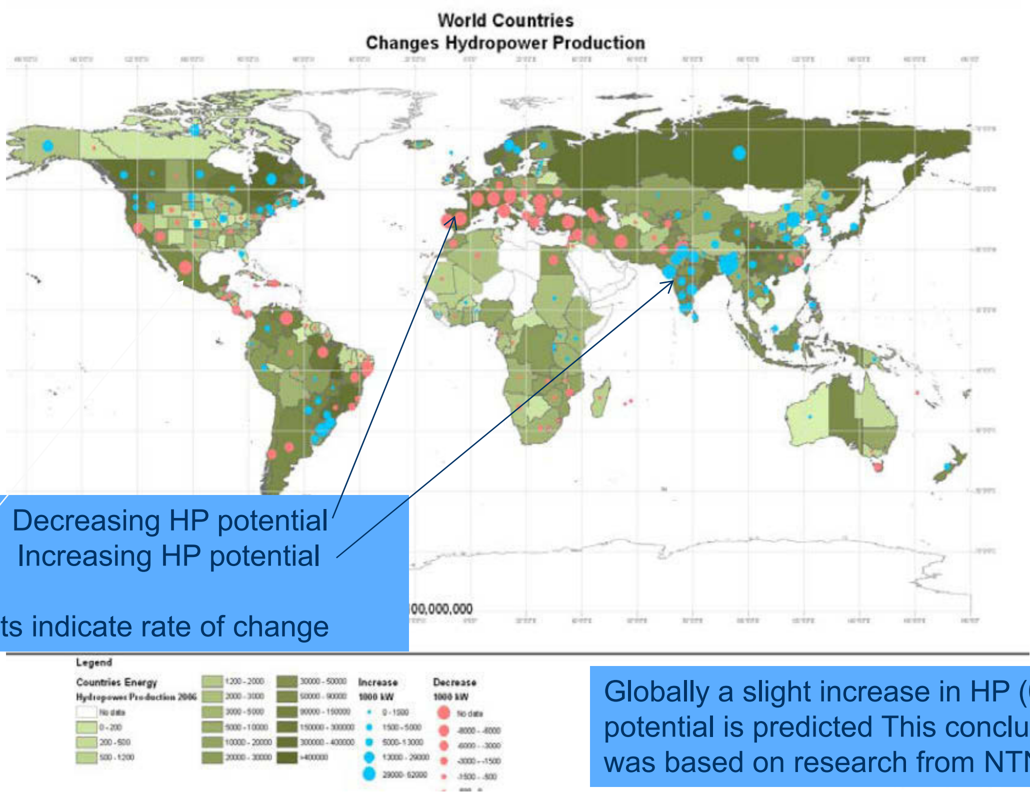
Computed Global effect on Hydropower Potential



Red dots: Decreasing HP potential
Blue dots: Increasing HP potential

Size of dots indicate rate of change

Globally a slight increase in HP (0.5%) potential is predicted This conclusion was based on research from NTNU

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Some renewable energy sources depends on the climate (IPCC, 2011)

- Hydropower (Rainfall, evaporation, snowmelt, runoff, sediments ...)
- Bio-energy (Precipitation, soil moisture, Biomass production,...)
- Wind (wind conditions)
- Solar energy (cloud amount and distribution)

No significant effect expected on

- Geothermal energy
- Ocean energy

"Climate change will have impacts on the size and geographic distribution of the technical potential for RE sources, but research into the magnitude of these possible effects is nascent"

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"Annual Estimates of Green-House Gases emission (GHG) from a Tropical Reservoir in India"

By

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Introduction

- Freshwater reservoirs are used to regulate flow for many purposes
  - water supply,
  - irrigation,
  - flood mitigation,
  - drought protection,
  - tourism and
  - hydropower.

- The conversion of land surface areas to create these water bodies indicated the changes in the emission of CO_2, CH_4 and N_2O which are relevant to inventories of greenhouse gas (GHG) exchanges.

GHG emission

- **Carbon dioxide (CO_2)** - due to aerobic decomposition of organic matter from soil, phytoplankton, algae etc.
  - CO_2 emission account for the largest share of GHGs (equivalent to 80-85% of the emissions) over 100 years

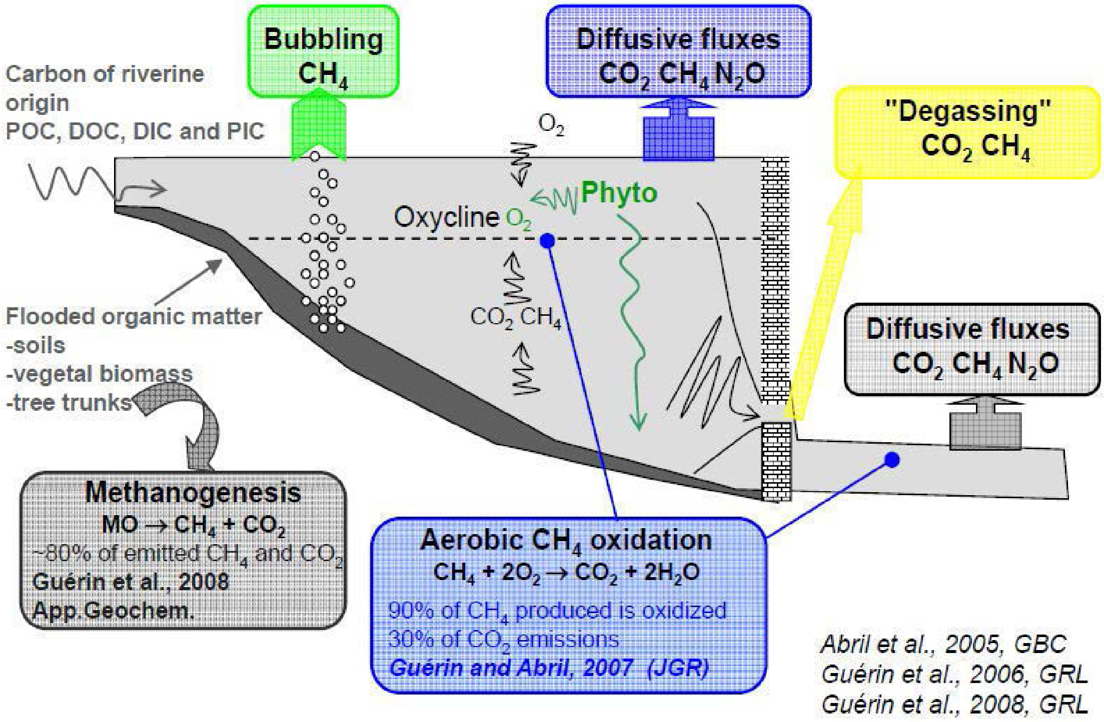
- **Methane (CH_4)** – due to anaerobic decomposition particularly in shallow and worm bodies
  - The GWP of CH_4 is 23 times stronger than CO_2 over 100 years

- **Nitrous oxide (N_2O)** – due to anaerobic denitrification and aerobic nitrification
  - The GWP of N_2O is 298 stronger than CO_2 over 100 years

Primary sources of GHG emission in reservoirs

- Availability / deposition of biomass (organic matter) during reservoir filling / flooding
- Continuous production of biomass (aquatic plant) through photosynthetic activity in the reservoir
- Decomposition of organic and inorganic soil components under aerobic and anaerobic conditions in reservoirs /lakes
- The dam related activities like the use of fossil fuels and building materials during construction, land clearing for resettlement, laying of transmission lines, laying of access roads etc.

Emission pathways



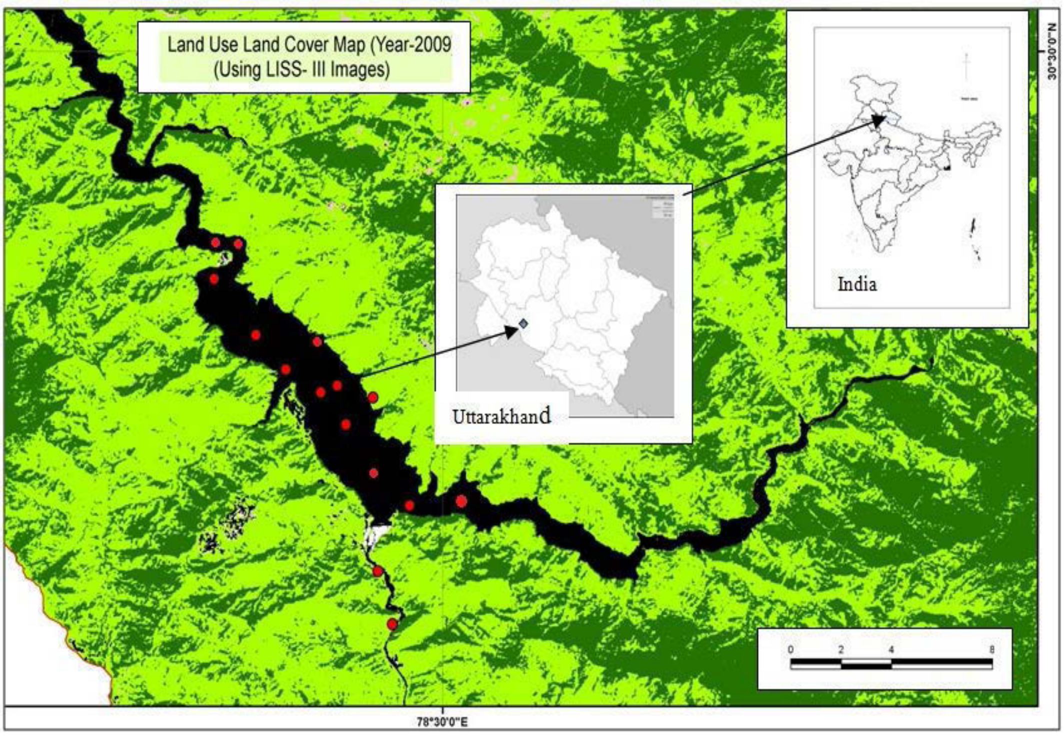
Factors affecting GHG emissions

- **Water depth**
- **Age of reservoirs**
- **Dissolved oxygen in water**
- **Concentration of OM**
- **Water pH**
- **Water temperature**
- **Residence time**
- **Wind speed and direction**
- **Water current speed**

Tehri Reservoir

Feature	Data
Eco-region	Tropical
Average air temperature, ^{0} C	28
Annual Precipitation, mm	1000-2000 mm
Year of impoundment	2005
Watershed area (km^2)	7208
Reservoir surface (km^2)	52
Volume, km^3	2.6
Residence Time, month	4-5
Mean depth (m)	260

Sampling Location on Reservoir Area



Measurement Techniques

- Water Quality
  - In-situ analysis (using multiparametric hydro lab Sundae)
  - Ex-situ (by collecting water sample and analyzing in Lab)
- Gases sample

  - Surface fluxes by Surface Chamber

  - Bubbling by Funnel

  - Degassing by Collecting the water sample and analysis by Head-space Technology

Water and Gaseous Sampling

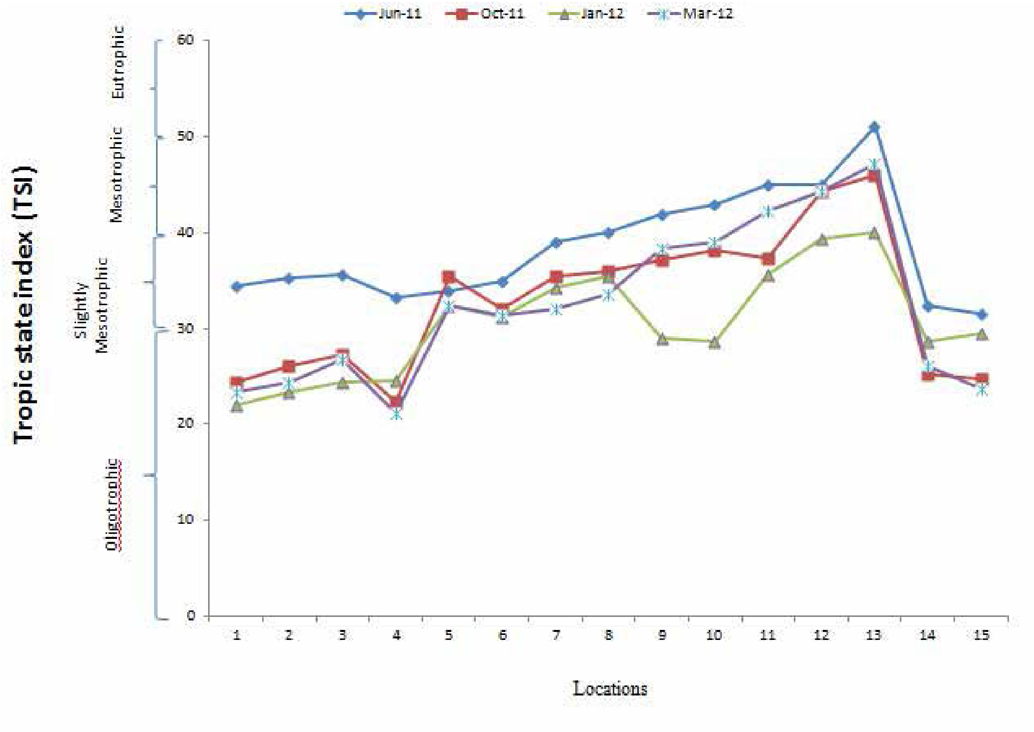
During year 2011 and 2012 measurements were carried out four times as follows:

1. Jun 2011 (Pre-monsoon)
2. Oct 2011 (Post- monsoon)
3. Jan 2012 (Winter)
4. Apr 2012 (Summer)

Water quality parameters in Reservoir

Parameters	Wet season	Dry season
Water Temp (^{0}C)	8-12	17-21
pH	7.63	8.64
DO (mg l^{-1})	8.8	8.7
COD (mg l^{-1})	107.2	138.5
Conductivity	131.6	111.47
TDS (mg l^{-1})	113.8	94.23
Doc (mg l^{-1})	6.34	2.17
Turbidity (NTU)	8.38	7
Nitrate-N	5.28	2.26
TP (mg l^{-1})	1.25	1.05
BOD (mg $l^{-1)}$	3.27	2.82
Fecal Coliform (MPN/100l)	141.6	98.6

Water Quality analysis



Average GHG Emission during year 2011-12

	Wet Season				Dry Season			
Gaseous Emission	Surface Flux	Bubbling Emission	Degassing	Total	Surface Flux	Bubbling Emission	Degassing	Total
CO_2 Flux ($mg\ m^{-2}\ d^{-1}$)	**628.5 (-102)**	**4.5**	**8.9**	**641.9**	**752.4 (-129)**	**6.3**	**7.3**	**766**
CH_4 Flux ($mg\ m^{-2}\ d^{-1}$)	**6.46**	**6.36**	**3.5**	**16.32**	**8.66**	**10.27**	**5.2**	**24.13**

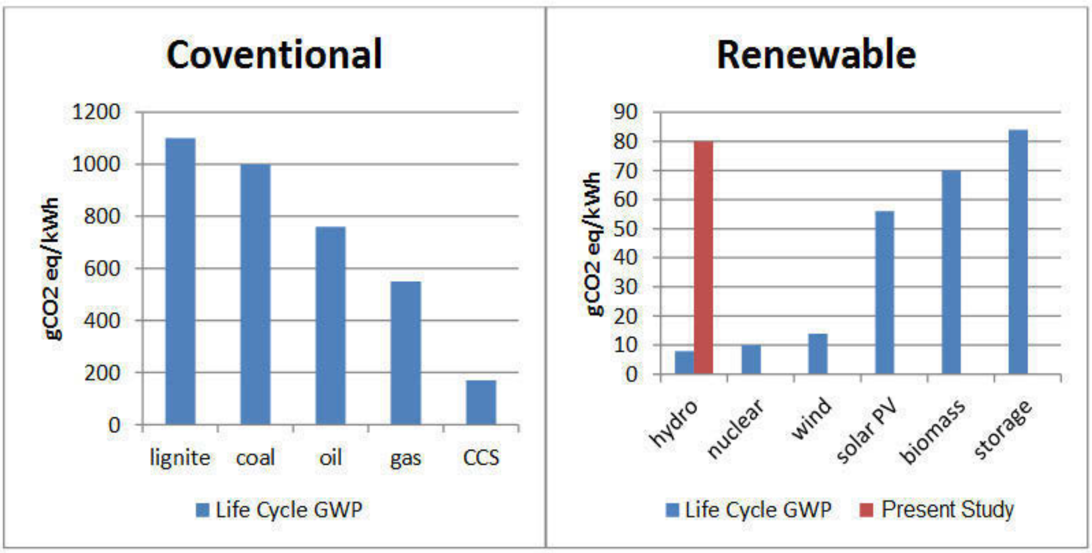
Comparison of GHG emission with other tropical reservoirs

	Tehri (8 years)	Tucurui (15 years)	Miranda (3 years)	Balbina (20 years)	Xingó (10 years)
CO_2 Flux	1407.9	9395	1229	8894	9094
CH_4 Flux	40.45	162.92	126	12.56	257

Life Cycle Assessment

CO_2 and CH_4 emission (gCO_2 eq/kWh)	
Construction phase	4+0.5
Operation phase	61±5
Decommissioning phase	1±0.5
Total CO_2 and CH_4 emissions per kWh (g CO_2 eq/kWh), 100 years	66±6

Life Cycle GHG Emissions for hydro and other sources of power Power Plant (reservoirs in Laos)



Conclusion

- GHG emissions were found more during dry season compared to wet season.
- Diffusive fluxes at the air-water interface are the main source of CO_2 emission which contributes
  - 63 to 90 % of total emission at the reservoir surface,
  - 20-25 % by bubbling and
  - 6-8 % at the outlet by degassing
- GHG Emissions are found more during operation phase, which are much more less than the conventional sources
- Global warming potential (GWP) is computed as 2.1+0.5 gCO_2 eq/kWh per year

Thank You

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