PROMOTION & FINANCING OF INNOVATIVE GREEN TECHNOLOGIES

“HYDRO POWER GENERATION”

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Agenda

1. Overview of Hydro – what is it, how does it work?

2. Risks & Contractual Aspects

3. Project Finance Aspects

4. Barriers to Delivery

5. Case Studies
1. Overview of Hydroelectricity;
What is it and how does it work?
Overview of Hydro – Facts (1)

- Hydroelectricity is the production of electrical power through the use of the gravitational force of falling water
- Circa 20% of global electricity is generated using hydro
- World’s largest renewable / sustainable source of electricity
- Largest plants are situated in China, Americas, Brazil, India and Russia
- Success Factors - supply of rivers; available technology; investment in renewable energy; government subsidies for hydro scheme development – bankable projects
- Africa & SE Asia low levels; lack of available funding and technology
Overview of Hydro – Facts (2)

- 25 countries depend on hydropower for 90% of their electricity
- Norway produces almost all its electricity from hydro
- Austria produces 70% of its electricity from hydro
- Circa 2/3rds of economically viable schemes are undeveloped
- Hydro’s payback ratio is 10 times better than an oil fired plant
- The only renewable technology that can be used to store large energy quantities
Global hydroelectric output grew by a below-average 1.6%. Strong growth in North America (+13.9%) was offset by drought-related declines in Europe & Eurasia and Asia Pacific.
How Does Hydro Work?

1. Hydropower is derived from the kinetic energy in flowing water

2. Flowing water – rivers or man made systems

3. Turbines convert the water’s kinetic energy to mechanical energy

4. Turbines turn generators converting the mechanical energy into electrical
Characteristics of a Hydro Scheme

1. “Head” and “Flow” determine how much electricity can be generated

2. “Head” – vertical distance that the water falls

3. “Flow” – the quantity of water flowing through the turbine per second

4. Three classification of hydro schemes; Impoundment / Storage
   Pumped Storage
   Diversion / “Run of River”
1. **Dam**
A barrier built across a watercourse to hold back the flow of water and create a reservoir. The reservoir that is formed is, in effect, stored energy.

2. **Penstock**
A pipeline used to convey water, under pressure, from the reservoir to the turbines of a hydropower plant.

3. **Turbine**
A machine that is turned by the force of the fast moving water pushing against its blades. Turbines convert the kinetic energy of the water to mechanical energy.

4. **Generator**
Connects to the turbine and rotates to produce the electrical energy.

5. **Transformer**
Converts electricity from the generator to usable voltage levels.

6. **Transmission Lines**
Conduct electricity from the hydropower plant to the electric distribution system. Transmission line voltages are normally 115 kV or larger.
Pumped Storage Scheme

- Variation of the impoundment scheme
- A means of keeping water in reserve for peak period power demands.
- Water is stored in a high level reservoir. At times of peak demand, water flows downhill through pipes to the turbines below, generating electricity.
- After passing through the turbines, the water is stored in a second, lower, reservoir.
- At times of low electricity demand, the water is pumped back up to the storage pool, to be used again when demand for electricity is high. Sustainable energy source.
- “Dinorwig” scheme in Wales is the largest pumped storage scheme in Europe. Manages peak demands on National Grid and can go from zero to a maximum 1800MW output in 12 seconds.
Diversion / Run of River Scheme

- Schemes harness the flow of a river, and do not require a large reservoir.
- Tend to be smaller scale.
- These are Diversionary
- Water is diverted from a river by the building of a weir / small pond.
- The diverted water is channelled into a penstock.
- The intake passes the water downhill to a powerhouse.
- At the powerhouse, the water is passed through a turbine, which is connected to a generator which converts the energy into electricity.
- The water is then returned to the river through a channel known as the “Tailrace”.
2. Risks & Contractual Aspects
Issues to be Addressed in Hydro Schemes

- High Investment Costs – long Return on Investment
- Hydrology Dependent – guaranteed long term water supply?
- Environmental Impact – fish migration, flooding of habitats
- Population Displacement – relocation of people (1.3m for “3 Gorges”)
- Sediment – slow water, impoundment shallows - needs periodic flushing
- Erosion – landslides, increased migration, ecosystems destroyed
Advantages of Hydro

- Process 90% efficient
- Zero waste or pollution
- More reliable than wind, solar or wave power
- Water can be stored ready for periods of peak electricity demand
- Hydro generating stations can be increased to max capacity quickly
- Fuel is renewable and immune from price rises
- Very low opex, lifecycle and maintenance costs – highly automated
- Long life 50-100 years
Disadvantages of Hydro

- High construction cost; can be offset for flood defence or irrigation
- High social and environmental impact
- Few suitable sites due to population and ecology
- Downstream water quantity and quality can be affected
- Initial CO2 release from rotting trees and plants
- Dissolved methane released when water passes turbines
- Depends on amounts of precipitation
- Earthquake vulnerability – run!!!
Hydro Contracting Structure

Two types normally used:

- Multi Package Contracting
- Engineer, Procure and Construct (EPC)
Multi Contracting

Employer

Project Manager

CDM Co-ordinator

- Turbine Supplier
- Civils Contractor
- Electrical Works/Cables Contractor
- Powerhouse Design & Construction
- Dam Designers
- Specialist Advisers Electrical/Ecological

Sub-Contract Packages
Multi Package Contracting

Used for the development of the majority of hydro schemes

Benefits:
• Less expensive,
• Developer more “hands on”
• Flexible Works Schedule – individual phases of work can begin
• Flexible budget management

Disbenefits:
• Minimal Risk Transfer
• Significant “Interface” issues
• Unattractive to funders (debt providers) due to increased developer risk
• Very time consuming
• Over runs likely
EPC Contracting

- Employer
  - Project Manager
  - EPC Contractor
    - Designers
    - Sub-Contractors (most likely to be civils contractors)
  - CDM Co-ordinator
EPC Contracting

**Benefits:**
- Time and cost certainty
- Clear Risk Transfer to contractor
- Minimal interface issues to manage
- Developer less involved
- More attractive to funders – single point of responsibility

**Disbenefits:**
- More expensive
- Potential programming delays – FC before any work starts
- Less Developer input at detailed design stage
3. Project Finance Aspects
What Banks need to see before lending (1)

- Planning consents
- Grid connection offer
- Future power purchase agreement
- All of the construction contracts
- Certainty – time and costs, fixed price contracts with “milestone” completion dates
- Payment profile of contracts – debt drawdown certainty
What Banks need to see before lending (2)

• Contractors’ performance bonds (10-20% of contract value)
• Parent Company Guarantee – if contractor is subsidiary
• Advance Payment Bond from Turbine Supplier
• Collateral Warranties – from contractors to bank for recovery and Step In
• Interface matrix – prepared by all contractors together
• An experienced Developer’s Project Manager
• Design risk accepted
• Acceptable contractors’ liability caps
4. Barriers to Delivery
Barriers to Successful Delivery of Hydro Schemes

- Project needs to be financially viable and sustainable
- Hydrogen plant is expensive to develop compared to fossil fuel plant
- Government Subsidy – sufficiently high Feed in Tariff
- Otherwise “unbankable”
- Kyrgyzstan – Renewable Energy can attract up to 6 times normal
- Longer term debt unavailability
- Time taken to obtain planning, environmental and other licences – public sector support
5. Case Studies
Yangtze Three Gorges Dam,
Hubei Province, China
Three Gorges Dam - Facts

• Construction began in 1994 and was completed in 2006.
• Began operating in July 2003.
• 600km-long reservoir reached its full height in 2010, submerging 13 cities, 140 towns and 1,350 villages.
• Estimated Capex of US$40bn (4 x original estimate).
• Dam incorporates 32 turbo-generator units, each of 700MW capacity
• Combined generating capacity of 22.5GW, amounting to 11% of China's total hydropower capacity.
• Over 50% larger than the world’s 2nd largest hydro power station, Itaipu
• 1.3 million people displaced to facilitate the project.
Itaipu – Brazil / Paraguay
Itaipu - Facts

- Jointly developed on the Parana River, Itaipu by Brazil and Paraguay
- Construction began in 1974 and was completed in 1991
- First began operations in May 1984
- It is said to have cost US$20bn
- 20 generating units, each of 700MW capacity
- Combined generating capacity of 14GW capacity
- In 2000 it produced 20% of the energy supply in Brazil and 94% of the energy supply in Paraguay.
THANK YOU FOR LISTENING

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