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PROMOTION & FINANCING OF INNOVATIVE GREEN TECHNOLOGIES

“HYDRO POWER GENERATION”

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Bishkek, 08 November 2012

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)

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- 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)

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- 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

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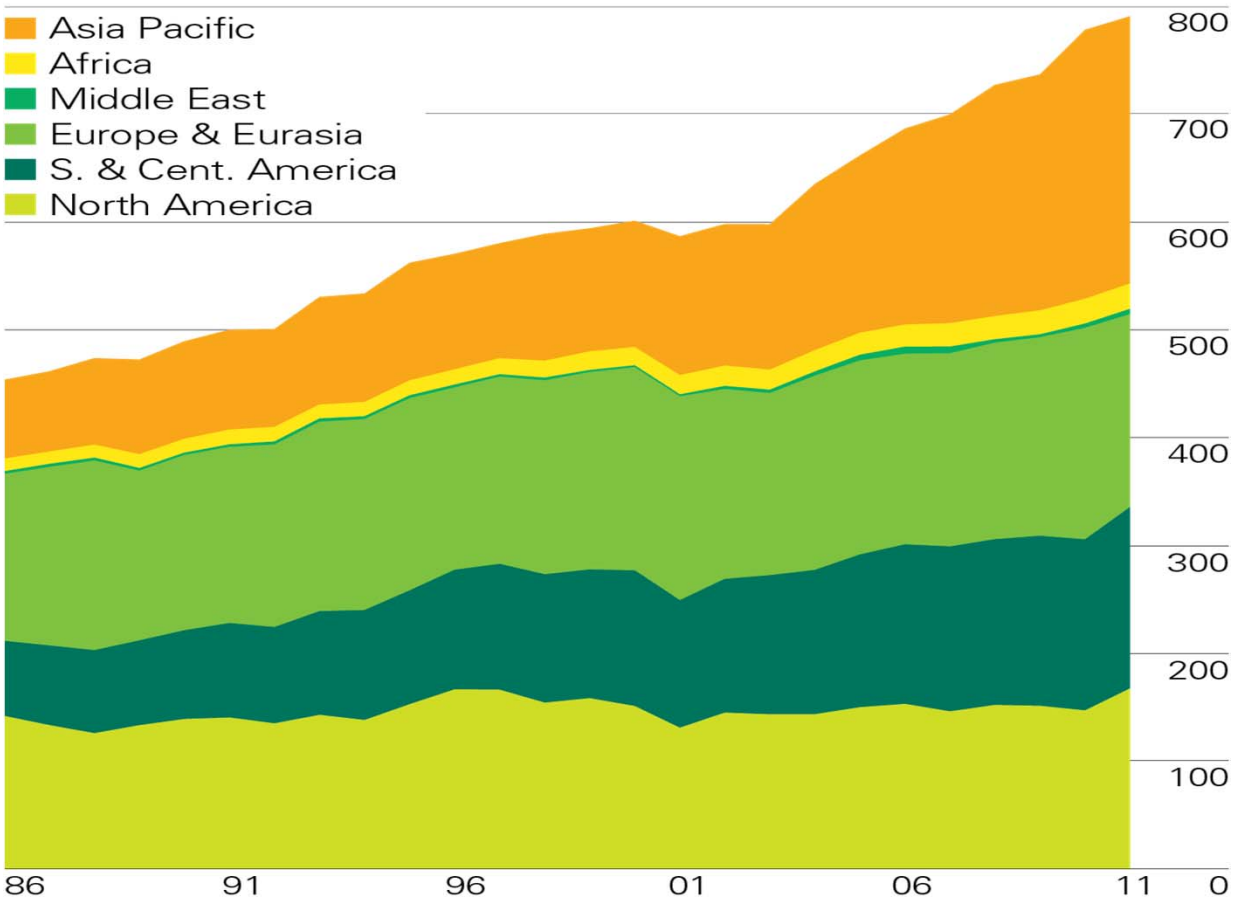
Hydroelectricity consumption by region

Million tonnes oil equivalent



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?

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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

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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”

Impoundment / Storage Scheme

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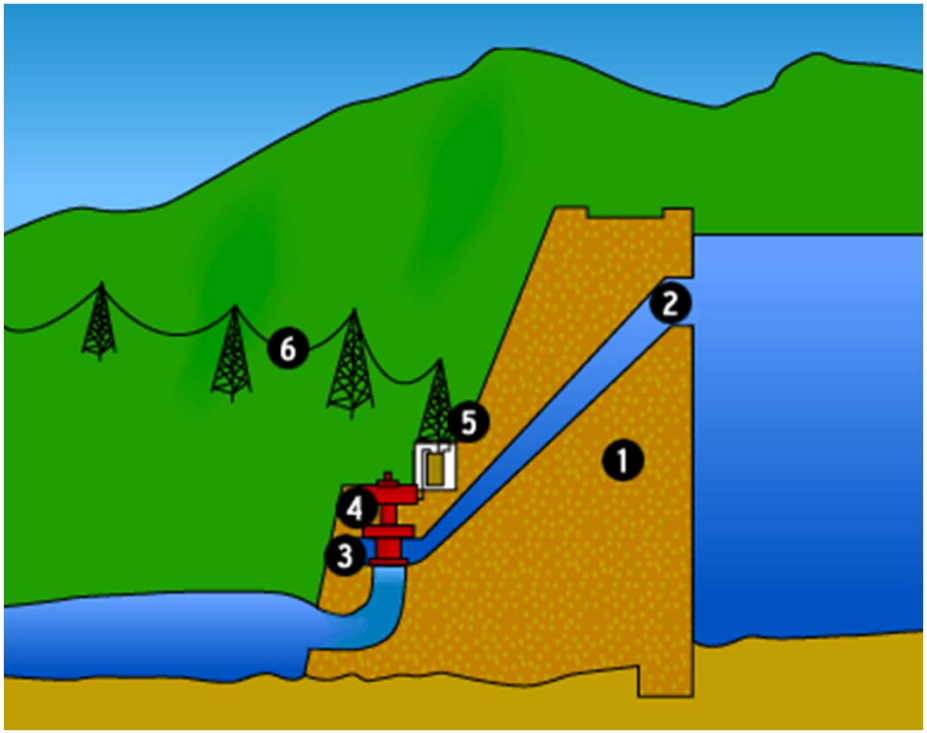
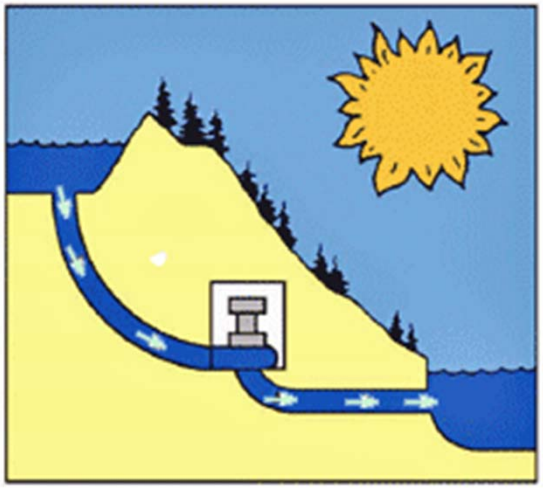


1. Dam
A barrier built across a watercourse to hold back the flow of water and create a reservoir. The reservoir that is formed is, in effect, stored energy.
2. Penstock
A pipeline used to convey water, under pressure, from the reservoir to the turbines of a hydropower plant.
3. Turbine
A machine that 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



Daytime: Water flows downhill through turbines, producing electricity

Nightime: Water pumped uphill to reservoir for tomorrow's use

- 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

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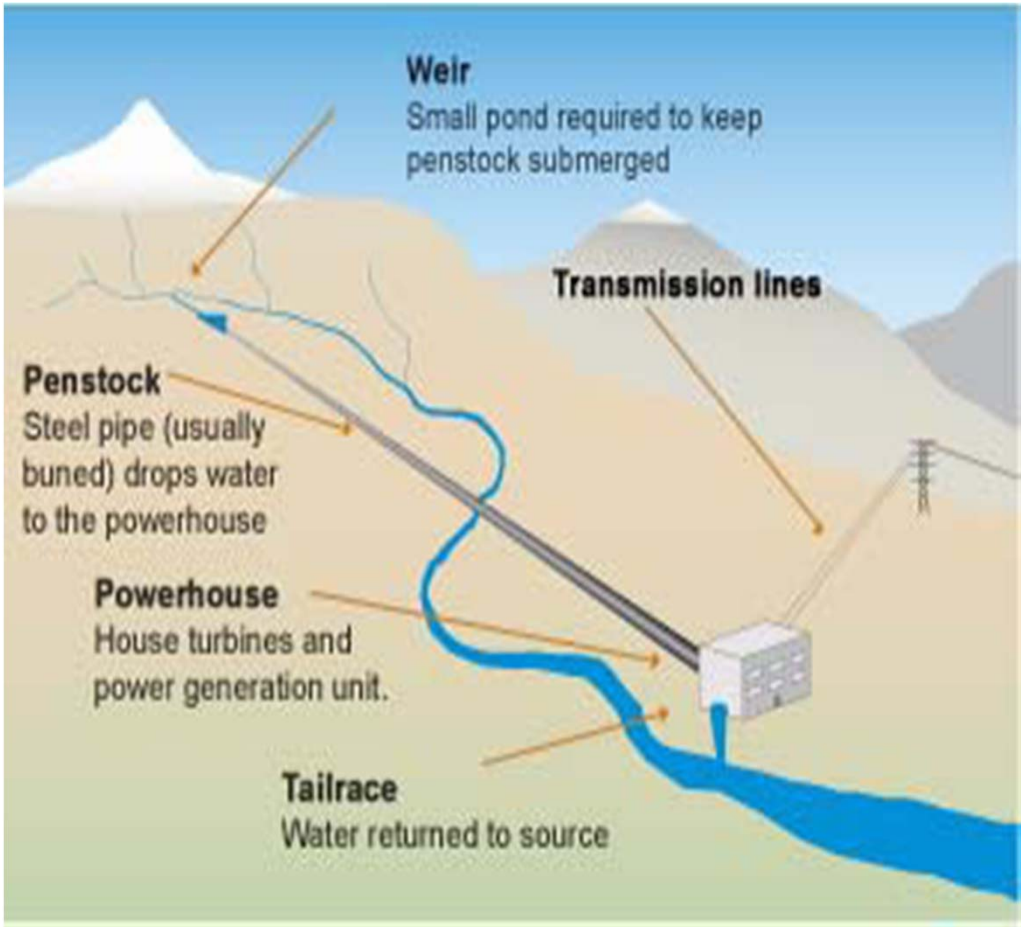

- Schemes harness the flow of a river, and do not require a large reservoir.
- Tend to be smaller scale.
- These are Diversionary
- Water is diverted from a river by the building of a weir / small pond.
- The diverted water is channelled into a penstock.
- The intake passes the water downhill to a powerhouse.
- 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

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- 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

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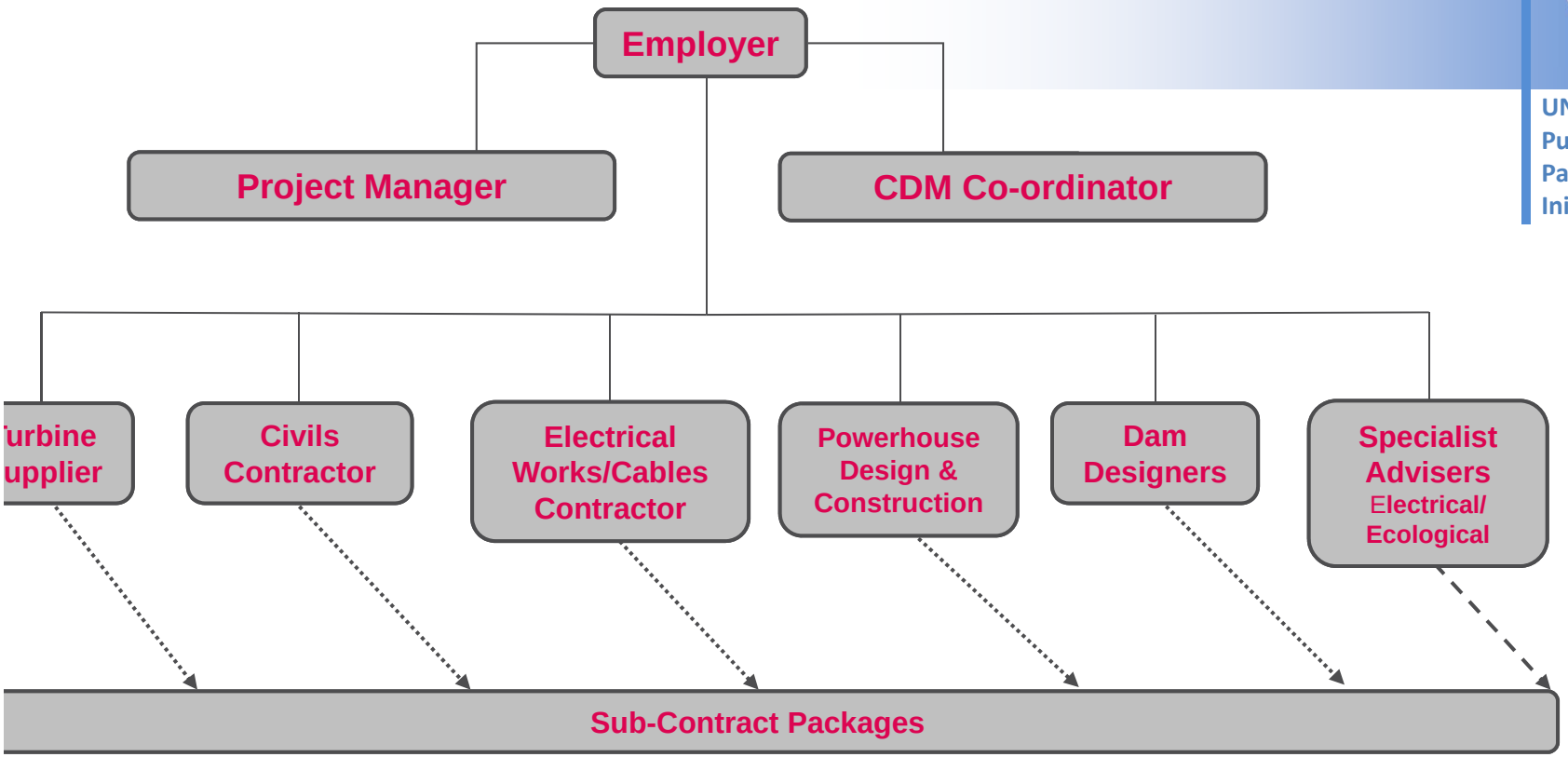

Multi Package Contracting

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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

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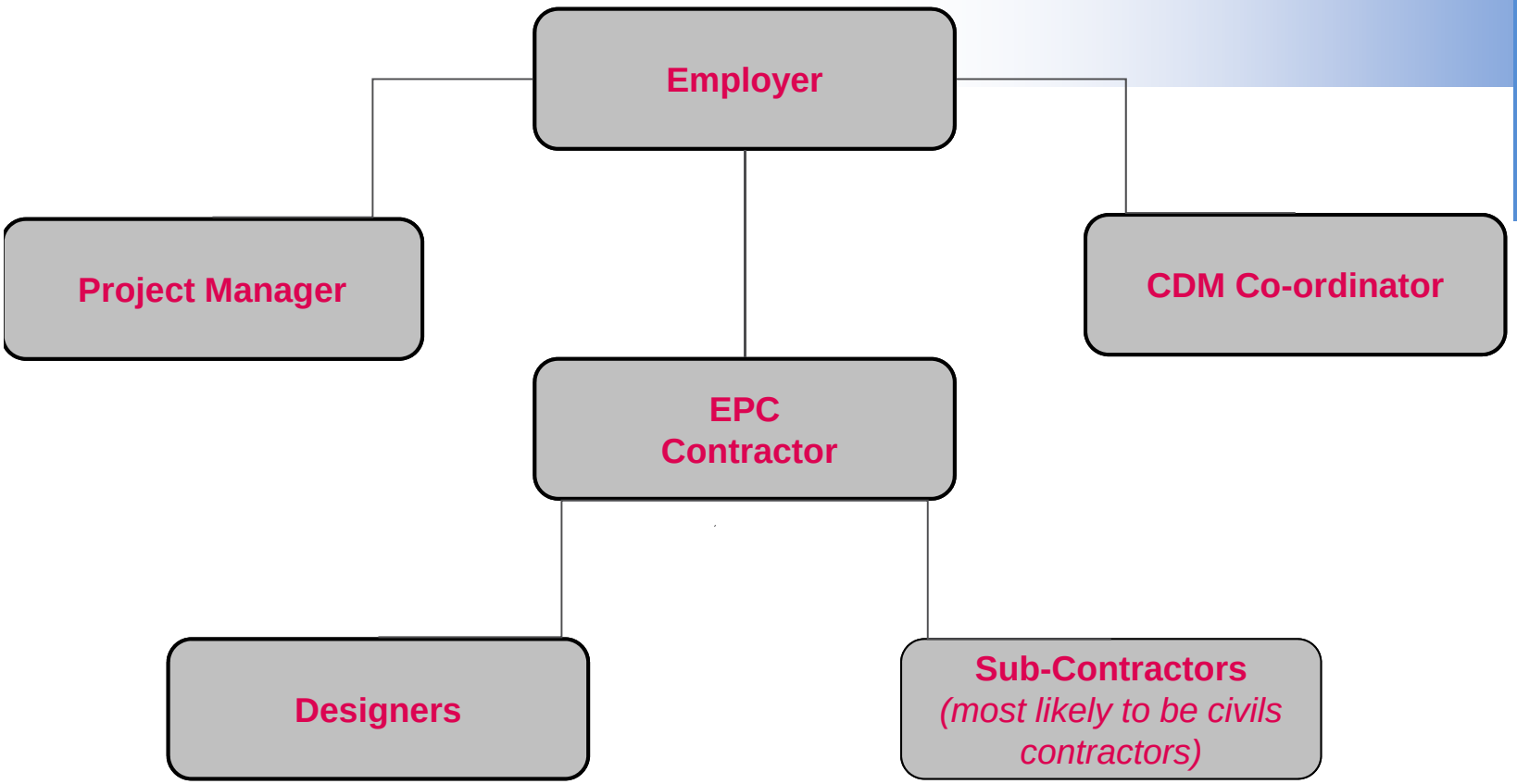

EPC Contracting

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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)

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- 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

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- Project needs to be financially viable and sustainable
- Hydro gen 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

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Yangtze Three Gorges Dam,

Hubei Province, China


CTGPC


CTGPC

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.

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Itaipu – Brazil / Paraguay

Itaipu - Facts

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- 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.

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THANK YOU FOR LISTENING

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