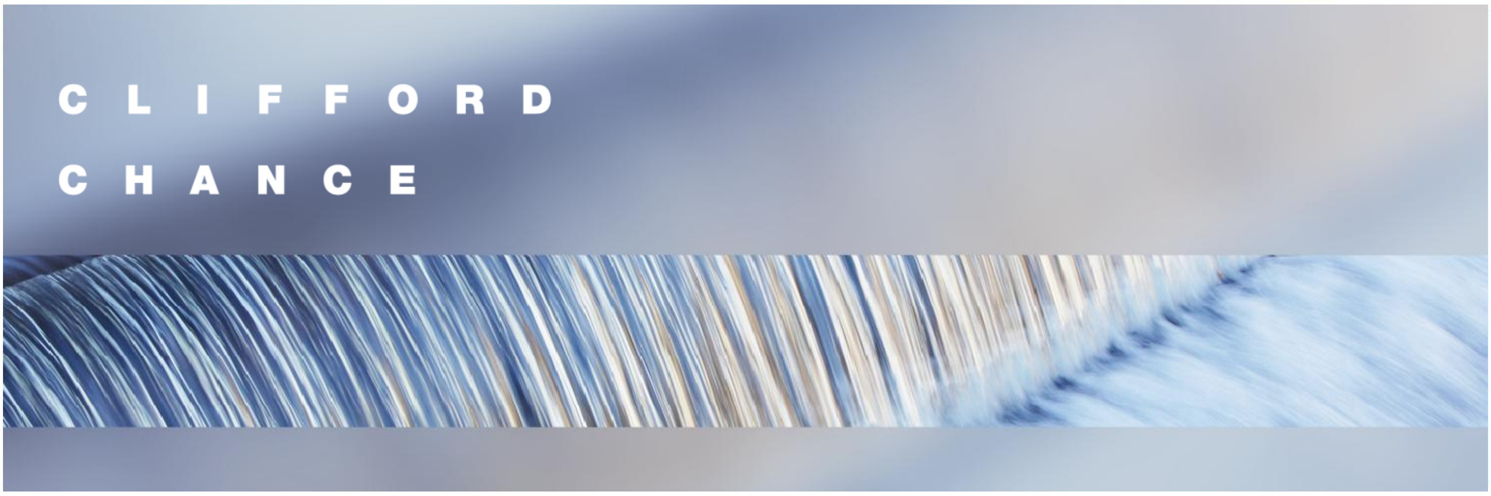

HYDROPOWER – OVERVIEW AND SELECTED KEY ISSUES

Hydropower is the production of electricity from the use of the gravitational potential energy of falling or flowing water. It is the most widely used and the oldest form of renewable energy produced around the world. It offers flexible technology that, at its smallest, can power a single home, and at its largest can supply industry and the public with renewable electricity on a national and even regional scale.

HYDROPOWER

Compared with thermal power, hydropower projects (**HPPs**) offer a wide range of benefits including:

- once they are functional the operational costs are much lower than those for thermal plants;
- they are a clean source of energy;
- they can last for up to a half century (even longer with rehabilitation).

HPPs do however also have some disadvantages compared to other technologies, including:

- the construction of an HPP can have a particularly wide ranging social and environmental impact – e.g. population displacement, deforestation;
- the upfront investment costs of HPPs are generally much higher than with thermal power, wind or solar projects of the same capacity;
- HPPs are exposed to climate risks such as prolonged drought and variable seasonal water flow in the absence of a dam providing water storage.

Key pros and cons of HPPs

Pros

- Clean energy source
- Low operating costs
- Reliable long term technology

Cons

- Environmental and social impacts
- High upfront cost
- Climate risks

TYPES AND BASIC FEATURES OF HPPS

There are four main types of HPP:

- **Run-of-the-river** - energy is generated according to the flow of the river. Typically, a run-of-the-river project will have little or no storage facility and this type of HPP relies on a continuous supply of electricity (base load) through water flow that is regulated by the plant. Waterfalls are ideal locations for run-of-the-river HPPs as they can take advantage of the steep drop in altitude. However, the limited capacity or lack of storage with this type of HPP means that power generation is less reliable compared to a conventional reservoir HPP, and the capacity of a run-of-river HPP is generally less than that for conventional reservoir HPPs.

- **Conventional reservoir (or storage hydropower)** – this type of HPP uses a dam to store water in reservoirs; the electricity is produced by releasing water from the reservoirs through a turbine, which activates a generator. In this type of HPP, energy can be dispatched on demand and the plants can be shut down and restarted at short notice to meet peak loads. The storage capacity of reservoirs allows this type of HPP to operate independently of the hydrological inflow for many weeks or even months, providing the potential for reliable generation all year, even through dry seasons, unlike run-of-the river HPPs exposed to seasonal variations. Traditionally, this type of hydroelectric scheme offers the largest energy production capacity, but its environmental footprint is also more significant compared to the other types of HPP.
- **Pumped storage** – these HPPs incorporate pumps to cycle water from a lower reservoir or river into a higher reservoir from where it is released when required to generate electricity. Water is pumped into the higher reservoir at times of low demand (when electricity is abundant and less costly) and then is released back into the lower reservoir through the turbines to produce electricity at times of high demand. It is currently the technology offering the greatest potential for 'storage' of electrical energy at scale and its principal function is energy storage/rapid response and balancing load.
- **Offshore hydropower** – although less established, the offshore hydropower market is substantially gaining from the rising demand for clean energy. It uses tidal currents or the power of waves to generate electricity. This technology is currently unproven at scale and not cost-competitive without subsidy.

It is worth noting that the different types of HPP are not mutually exclusive as one type may adopt certain features from another, e.g. a conventional reservoir HPP could adopt the pumping technology used in pumped storage HPPs to augment water flow, and run-of-the-river HPPs can have reservoirs (although with limited capacity).

SOME KEY FEATURES OF HPP PROJECTS

In structuring the development and financing of HPPs, several project-specific issues need to be considered and set out below is an overview of some of the key features of HPP projects.

Hydrology risk

Risk of adverse hydrology

It is important to consider who will bear the risk of adverse hydrology affecting the ability of the project to meet its construction and operational objectives. In particular:

- whether and to what extent this risk will be assumed by the offtaker(s) under the power purchase agreement or the State under the concession agreement (e.g. under a compensation payment regime);
- the probability level and the agreed level below which the water level can be considered insufficient;
- whether this risk is a termination event and for how many years/seasons the available water must be below the "agreed level" before it becomes a termination event (i.e. 'drought years' exemptions).

There are various ways of structuring the allocation of hydrology risks in HPPs. For instance, if hydrology risk is allocated to the offtaker, this might be reflected by way of a fixed capacity payment based on technical availability of the plant only (as opposed to actual availability of the plant, which would include having sufficient water).

If hydrology risk is shared between the offtaker and the project company, the sharing may be by way of a tariff structure where the offtaker pays:

- a "firm energy tariff" at a level designed to allow the project company to derive a certain percentage (e.g. 90%) of its base case revenues (debt and equity) at a certain hydrology probability (e.g. P95 hydrology), and
- a "non firm energy tariff" sized to allow the project company to take the remaining percentage (e.g. 10%) at a designated hydrology probability (e.g. P50 hydrology).

Changes in hydrology risk profile

Changes in the expected hydrology risk profile can arise either from changes in the hydrology itself (for example, due to climate change or competing offtake) or by changes in the relationship between weather seasons and the construction schedule triggered by construction delays. In the construction phase, this risk may also impact performance testing at completion and/or excess flows during the construction process may impede or damage works under construction. This risk can be mitigated through appropriate insurance.

When a capacity payment structure is used, the manner in which the annual testing is carried out will need to be adjusted to take into account that the testing may need to occur at different heads and flows, and the relevant data may therefore only become available over the course of the year, rather than on a fixed testing date as it would be the case on a thermal plant.

Site issues

Associated infrastructure

Selected sites for HPPs are frequently remote so there may be a need to build significant associated infrastructure (such as workers camps, transmission lines from the project site to the grid). Where associated infrastructure is required, it will be necessary to ensure that there is a clear allocation of responsibilities between the project company, the offtaker and the State and potential project-on-project risk (e.g. where transmission lines are required to be built) will need to be taken into account.

Site selection

Among the many considerations in site selection is the risk of overlapping concession rights with developers of other HPPs or other industries (for example mining and timber) as well as the watershed management. For example, where HPPs are arranged in a cascade, the reservoir head water level of one HPP could materially affect the tailrace of another. It may be necessary to put in place protections against any HPPs being built up-stream and, separately, the impact on any known or anticipated downstream projects must be considered carefully (particularly during the inundation period).

Environmental and social issues

The environmental, social and health and safety implications of the project will be a key consideration for both equity investors and lenders. On an HPP, some of the particular areas to be considered include:

- dam design and safety issues;
- the role of responsible authorities for supervision and their ability to exert control over the project;
- the liability for remedying site and environmental contamination (whether historic and/or resulting from the project);
- population displacement – as HPPs typically cover a significant area, their development may require the displacement of a large number of people. In such cases, ensuring that any resettlement complies with internationally recognised environmental and social standards must be addressed early on in the project development. Compliance with these rules is often more difficult in practice than on paper, and NGOs and other activists will be monitoring this process closely.

Construction – key features

Procurement structure

There is no single norm in relation to the procurement structure for HPPs. Some projects adopt the single-point EPC structure typical of thermal plants, while a significant proportion of HPPs are procured under disaggregated structures involving separate contract packages for (at least) the civil and electromechanical works. Both structures can be made to work and selection depends on a number of variables such as size, location, PPA terms, perceived extent of unforeseen condition risk and financing structure. Even where a single-point EPC structure is adopted, rejection remedies of the kind often encountered in PPA-based thermal IPPs are unlikely to be feasible in an HPP context, given the high proportion of immoveable civil works embedded in the scope.

Significance of civil works

A high proportion of construction costs (typically 30-60%) will go towards the civil works. Civil works will include the construction of major structures such as dams, significant tunnelling and excavation (e.g. for temporary river flow diversion during construction or for penstock tunnels) and temporary works such as coffer dams to protect the construction area from water flow.

Unforeseen ground conditions

The risk of unforeseen ground conditions (for example, from excavation and rock support requirements) is typically higher in HPPs than other categories of power projects. It is customary for the project company to share such risk under the construction contracts and seek to allocate all or some of its retained risk to the offtaker (assuming that there is a PPA structure). Risk-sharing techniques include the use of unit rate pricing and the granting of time and cost relief to the project company.

HPP turbine technology risk

Whereas the civil works may be complex and subject to unforeseeable risks, HPP turbine technology is generally well proven. HPPs arguably therefore present the opposite risk profile to a typical thermal plant, where civil work risks may be low but complex/prototype turbine technology may be involved.

Environmental and social requirements

Typical requirements for an HPP will include:

- Environmental and social impact assessment and management plan
- Emergency/disaster management plan
- Mandatory environmental and social provisions
- Clear allocation of responsibility for supervision and remedying of contamination
- Provisions for closure and rehabilitation of the project site

These project plans and contractual provisions will commonly make reference to the IFC Performance Standards and the World Bank Environmental and Social Guidelines.

Turbine overhauls

Over time, accumulated sedimentation in the reservoir may reduce generation capacity, lead to turbine deterioration and it may also separately affect soil fertility downstream of the dam. Preventive maintenance programs will be necessary and it is typical for turbines to require overhauls after approximately 10 years (compared to the typical 3-year major inspection intervals for gas turbines). Protected areas are sometimes established in upper catchment areas in order to reduce sediment flows into the reservoir.

Operation – key features

Operating costs

Generally, operating costs for HPPs are low and largely fixed – there is no associated fuel price risk – except in relation to high value replacements or refurbishments. These are sometimes not priced into the O&M package because the requirement for replacement is assumed to be infrequent as the equipment is considered to be highly reliable. Long term O&M agreements of the kind commonly encountered on thermal projects are thus not a standard feature of HPPs.

Compensation for peak demand

There is often potential operational flexibility through reservoir storage (be it conventional reservoir or pumped storage HPPs) to compensate for peak demand or variability in other renewable sources. This will not be available for run-of-river HPPs, which do not have (or have limited) capacity reservoirs.

Right to 'make up' energy

Although specific to each project, some projects may impose requirements on the amount of water that must be retained in the reservoir – this results in restrictions on the release or spillage from the reservoir. In such a case, the availability payment portion of the PPA tariff may be linked to the level of water contained in the reservoir and therefore where the offtaker has made an availability payment, but has failed to dispatch to the plant, the PPA may contain a right for the offtaker to 'make up' energy, i.e. a right to dispatch electrical energy without incurring any additional payment obligation. This in turn may be linked to a requirement on the project company to store sufficient water in the reservoir to service this 'make up' right.

Financing considerations

Reserve accounts

There may be a requirement for the project company or the sponsors to start funding a reserve account where the water flow rate is less than an agreed limit over a specified period of time (hydrology probability) prior to a repayment date.

Loan tenor

As development costs are high and frontloaded, long tenor financing would most likely be required in order to keep the tariff low and make the project economically viable. This could mean that projects would need to involve more development financial institutions and export credit agencies than commercial banks, as commercial banks have more stringent tenor restrictions. Bond financing may also be considered (and we are aware of a number of instances of refinancing into bonds being considered for HPPs in South East Asia).

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