RUN-OF-THE-RIVER HYDROELECTRICITY

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ABSTRACT

The identification of the capacity of a run-of-river plant which allows for the optimal utilization of the available water resources is a challenging task, mainly because of the inherent temporal variability of river flows. This paper proposes an analytical framework to describe the energy production and the economic profitability of small run-of-river power plants on the basis of the underlying stream flow regime. We provide analytical expressions for the capacity which maximize the produced energy as a function of the underlying flow duration curve and minimum environmental flow requirements downstream of the plant intake. Similar analytical expressions are derived for the capacity which maximize the economic return deriving from construction and operation of a new plant. The analytical approach is applied to a minihydro plant recently proposed in a small Alpine catchment in northeastern Italy, evidencing the potential of the method as a flexible and simple design tool for practical application. The analytical model provides useful insight on the major hydrologic and economic controls (e.g., stream flow variability, energy price, costs) on the optimal plant capacity and helps in identifying policy strategies to reduce the current gap between the economic and energy optimizations of run-of-river plants.

Keywords- Analytical methods, Economic evaluation, Flow duration curve, Run-of-river hydropower, Water resources.

I INTRODUCTION

Run-of-the-river hydroelectricity (ROR) is a type of hydroelectric generation whereby a considerably smaller water storage called pondage or none is used to supply a power station. Run-of-the-river power plants are classified as with or without pondage. A plant without pondage has no storage and is, therefore, subjected to seasonal river flows and serves as a peaking power plant while a plant with pondage can regulate water flow and serve either as a peaking or base load power plant. ROR projects are dramatically different in design appearance from conventional hydroelectric projects. Traditional hydro dams store enormous quantities of water in reservoirs, necessitating the flooding of large tracts of land. In contrast, most of run-of-river projects do not require a large impoundment of water, which is a key reason why such projects are often referred to as environmentally-friendly, or “green power”. Hydropower, hydraulic power, hydrokinetic power or water power is power that is derived from the force or energy of falling water, which may be harnessed for useful purposes. Since ancient times, hydropower has been used for irrigation and the operation of various mechanical devices, such as watermills, sawmills textile mills, dock cranes, and domestic lifts. Since the early 20th century, the term

is used almost exclusively in conjunction with the modern development of hydro-electric power, the energy of which could be transmitted considerable distance between where it was created to where it was consumed.
Another previous method used to transmit energy had employed a trompe, which produces compressed air from falling water, that could then be piped to power other machinery at a distance from the energy source.

II CONCEPT

Run-of-river hydroelectricity is ideal for streams or rivers with a minimum dry weather flow or those regulated by a much larger dam and reservoir upstream. A dam, smaller than that used for traditional hydro, is required to ensure that there is enough water to enter the "penstock" pipes that lead to the lower-elevation turbines. Projects with pondage, as opposed to those without pondage, can store water for peak load demand or continuously for base load, especially during wet seasons. In general, projects divert some or most of a river's flows through a pipe and/or tunnel leading to electricity-generating turbines, then return the water back to the river downstream.
The use of the term "run-of-river" for river projects varies around the world and is dependent on different definitions. Some may consider a project ROR if power is produced with no storage is considered by others. Developers may mislabel a project ROR to sooth public image about its environmentally or social effects.
Water's power is manifested in hydrology, by the forces of water on the riverbed and banks of a river. When a river in is flood, it is at its most powerful, and moves the greatest amount of sediment. This higher force results in the removal of sediment and other material from the riverbed and banks of the river, locally causing erosion, transport and, with lower flow, sedimentation downstream.
The Bureau of Indian Standards describes run-of-river hydroelectricity as:
A power station utilizing the run of river flows for generation of power with sufficient pondage for supplying water for meeting weekly fluctuations of demand. In such stations. The normal course of the river is not materially altered.

2.1 Advantages

When developed with care to footprint size and location, ROR hydro projects can create sustainable energy minimizing impacts to the surrounding environment and nearly communities. Advantages include:

i. **Cleaner flooding, fewer greenhouse gases:**
Like all hydro-electric power, run-of-river hydro harness the natural energy of water and gravity, eliminating the need to burn coal or natural gas to generate the electricity needed by consumers and industry.

ii. **Less flooding/reservoirs:**
Substantial flooding of the upper part of the river is not required for smaller-scale run-of-river projects as a large reservoir is not required. As a result, people living at a near the river don't need to be located and natural habitats and productive farmlands are not wiped out.

2.2 Disadvantages

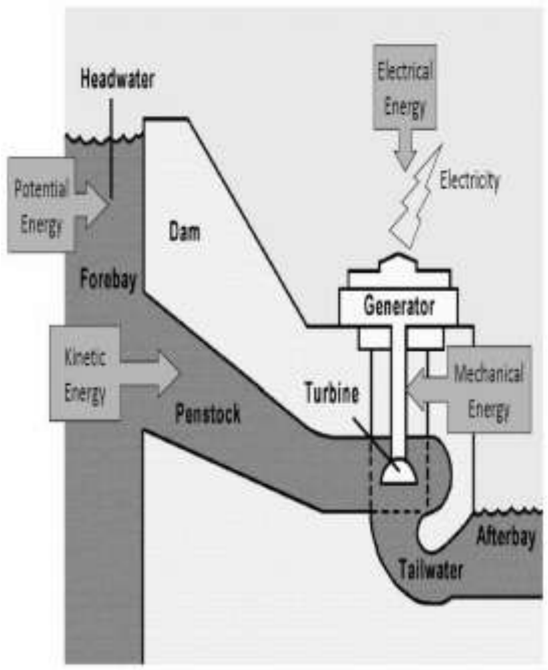
i. **Unfirm power:**
Run-of-river power is considered an "unfirm" source of power: a run-of-river project has little or no capacity for energy storage and hence can't co-ordinate the output of electricity generation to match consumer demand. It thus generates much more power during times when seasonal river flows are high, and much less during drier summer months. However, it is more predictable than solar PV or wind.

ii. **Availability of site:**
The potential power at a site is a result of the head and flow of water. By damming a river, the head is a available to generate power at the face of the dam. Where a dam may create a reservoir hundreds of kilometers long, in run of the river the head is usually delivered by a canal, pipe or tunnel constructed upstream of the power house. Due to the cost of upstream construction, a pipe steep drop in the river is desirable.

2.3 Environmental impacts:

Small, well-suited ROR projects can be developed with minimal environmental impacts. Larger projects have more environmental concerns.

I. FIGURES



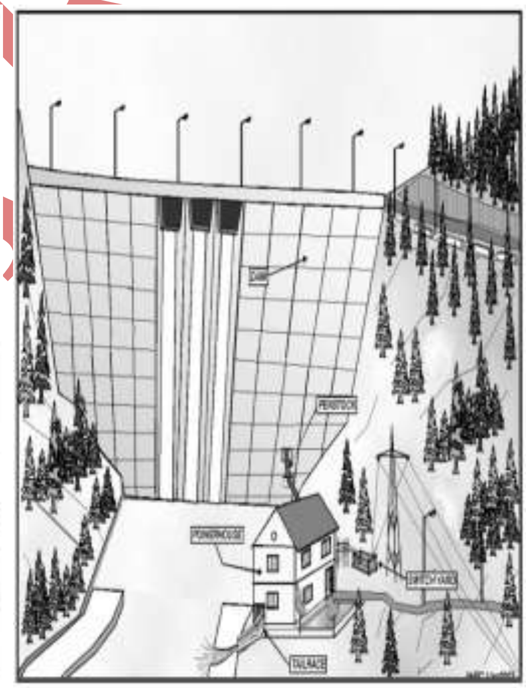


Fig.1: Working Of A Hydropower Plant **Fig 2: Typical Storage Dam Scheme**

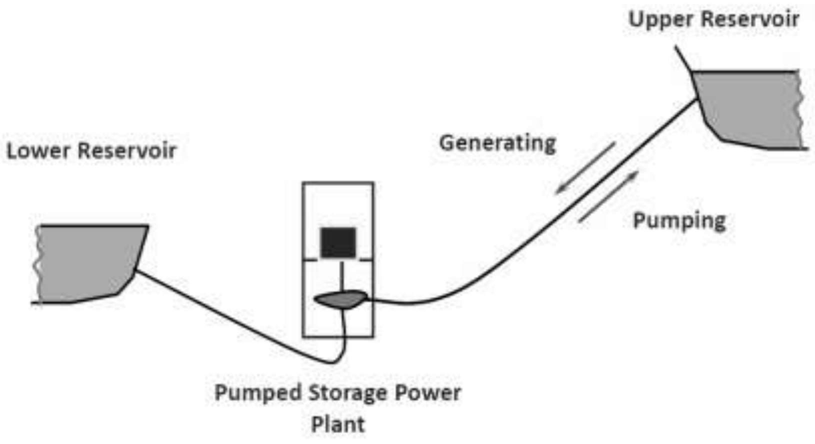


Fig 3: Typical Pumped Storage Scheme

2.4 Major examples:

List of run-of-river hydroelectric power stations:-

1. Chief Joseph Dam, 2,620 MW
2. Satluj Jal Vidyut Nigam Ltd., Satluj River Shimla, India, 1,500 MW
3. La Grande-1 generating station, 1,436 MW
4. Bute Inlet Hydroelectric Project, British Columbia, Canada, 1,026 MW
5. Upper Toba Valley, British Columbia, Canada, 123 MW

III CONCLUSION

The concept of run-of-river is very useful. As it has many advantages as cleaner power, fewer greenhouse gases, less flooding/reservoirs. We know that every system has some advantages and disadvantages. So. Some of the disadvantages are "unfirm" power, availability of sites and environmental impacts. Many of the impacts of this technology are still not understood or well-considered, including the following:

Diverting large amounts of river water reduces flows, affecting water velocity and depth, minimizing habitat quality for fish and aquatic organisms; reduced flows can lead to excessively warm water for salmon and other fish in summer. As planned, the Bute Inlet project in BC could divert 95 percent for the mean annual flow in at least three of the rivers.

New access roads and transmission lines can cause extensive habitat fragmentation for many species, making inevitable the introduction of invasive species and in undesirable human activities, like illegal hunting.

Cumulative impacts-the sum of impacts caused not only by the project, but by the roads, transmission lines and all other nearby developments-are difficult to measure. Cumulative impacts are an especially important consideration in areas where projects are clustered in high densities close to sources of electricity demand: for example, of the 628 pending water license applications for hydropower development in British Columbia, roughly one third are located in the southwestern quarter of the province, where human population density and associated environmental impacts are highest.

Water licenses issued by the BC Ministry of Environment, enabling developers to legally divert rivers, have not included clauses that specify changing water entitlements in response to altered conditions; this fact means conflicts will arise over the water needed to sustain aquatic life and generate power when river flow becomes more variable or decreases in the future. However, it should also be noted that under section 101 of the BC Water Act, regulations regarding a water licenses can be changed by the government at any time, including the amount of water that a power plant is required to protect aquatic life.

References

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