Power Sector and Hydropower Development in Nepal

Rabindra Bahadur Shrestha

Abstract: This paper is prepared on the answer to the valuable comments made by late Jeewan P. Thanju on my article 'Water Resources of Nepal: Misconception and Reality' published in The Rising Nepal on January 23 & 24, 2014.The rivers of Nepal possess sufficient hydropower potentiality to enhance the country's socio-economic development. However, some spurious expert and vested interest group exaggerated the hydro potentiality and distorted the fact of water resources development prospective in Nepal. This has created confusion among the policymakers, politician and multilateral agencies. As a result, hydropower development in Nepal has headed for wrong course, and now the power sector, the vital impetus for socio-economic development is in dire strait. This paper highlights the uniqueness and distinct technical features of Nepalese Power Sector.

In this paper important component like Integrated National Power System/Grid (INPS), Power Generation Modality (Hydropower, Thermal/Nuclear Plants and Diesel Plants) are well described and Master Plan, Project Selection, Construction Schedules and Hydropower potentiality of Nepal are discussed in detail. In a severe power and energy crisis situation in the country, power export is not recommended.

Nepal needs 3000 MW to reach the level of other south Asian nations. INPS is owned and operated by NEA; therefore NEA also has the responsibility to prepare master plan for power generation, transmission and distribution. But, the Department Electricity Development a regulatory body of Ministry of Energy of is undertaking / carrying out feasibility study without taking care of INPS/country's power requirement. This has created duplication of work and confusion; as such the Ministry of Energy deviated from its responsibility of preparing sound policy, regulation and monitoring them strictly. The Ministry shouldn't indulge in feasibility study, construction and operational activities, which come under the responsibility of concerned technical department /authority.

Keywords: INPS, hydropower, LDC, IPP, Run-of-River, Nepal

Introduction

The power sector consists of mainly three components or activities i.e. electricity generation, transmission and distribution. All these activities are carried out simultaneously in parallel operation and can't be separated. But currently the Nepal's power sector is in disarray due to alienation of generation from transmission and distribution activities. Why such ambiguity in the country's power sector? Is this the outcome of mismanagement, rampant corruption or just a case of ignorance? If it's ignorance, the way out is straight forward. Therefore, all the stakeholders including the foreign donor agencies should understand the uniqueness and distinct technical features of Nepalese Power Sector.

Integrated National Power System/Grid (INPS)

Most nations have their own independent Integrated National Power System/Grid (INPS) under the control of a central load dispatch center (LDC), which is the apex body to ensure integrated operation of the power system. An INPS consists of power generation, a transmission and distribution network and its primary function is for smooth evacuation of power from generating stations to consumers. In other words, the INPS is responsible for the overall reliability, security, economy and efficiency of the power system. Power generation in INPS is mostly done by thermal, hydro, and nuclear power, depending on the availability of the resources in each nation. Long distance transmission of power is carried through high voltage transmission lines and distribution is conducted through voltage distribution lines and sub-station networks.

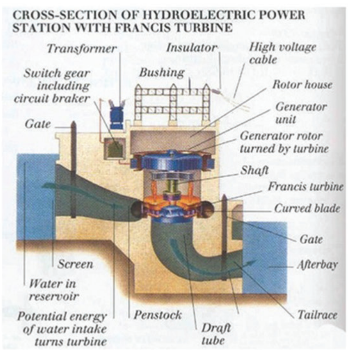
Nepal also has its own Integrated Nepal Power System (INPS) and its generation is mainly based on hydropower plants. In a hydro-based INPS, the three components (generation, transmission and distribution) cannot be separated and the generated electricity is utilized simultaneously through transmission and distribution lines. In other industrial sectors, production (generation), transportation, storage, and distribution/marketing activities can be separated and carried out independently. In 1985, the government authorized the Nepal Electricity Authority (NEA) to plan, develop, operate, and maintain the Integrated Nepal Power System (INPS), with the mandate of hydropower project construction as well. Meanwhile, under a more liberal economic policy, government also encouraged the private sector to invest in generation, transmission, and distribution. But the private investors have opted for the more profitable hydro generation only. The distribution sector, where private sector's management skill is required, was left to Nepal Electricity Authority. In such a scenario, if the private sector does not invest and development the transmission and distribution sector, NEA will only be able to sustain power purchases up to 20 % of total INPS. Beyond 20%, power purchases will bankrupt NEA, which would also bring independent power production to an end, since there wouldn't be any organization left (i.e., NEA) to disburse the IPP bills. Therefore, it will be an act of wisdom for IPPs to keep 'The Duck That Lays Golden Eggs' alive and healthy.

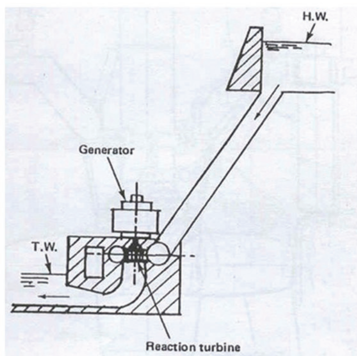
Power Generation Modality

The modalities, process and cost for various types of power generation in INPS are presented below.

Hydropower

The head (water pressure) created by the construction of a hydraulic structure in the river will rotate the turbine and generator to produce electricity (Figure 1). The process of electricity generation from river water is simple and clean. Most developed nations have already utilized their feasible hydropower potentiality. A hydropower plant can supply or take out large amount of power to or from INPS in a very short amount of time, whereas, in a thermal or nuclear plant, the switching on and off process takes hours or days. Due to its flexibility of providing peaking and emergency power supply, hydropower plants have very important role in balancing power, energy, voltage, and frequency within an INPS.





Schematic Drawings of Hydro, Thermal & Diesel Plants

The topography and hydrology of Nepal both are suitable for the construction of cost effective (3 to 5 Rs per kWh) hydropower projects. The construction cost of a hydropower project is about 1000 to 2000 US $ per kW and the annual operation and maintenance cost is about 2 to 3 percent of total construction cost. Due to the multipurpose (electricity, irrigation, water supply) use of rivers, most major hydropower projects are undertaken by the public sector.

Hydropower generation is generally divided into two categories: run-of-river (RoR) and high dam storage. RoR projects come in two forms: one with daily pondage and the other without. All of Nepal's public sector hydropower projects are RoR and most have daily storage to supply maximum power during evening peak hours. RoR storage projects developed by the private sector, however, do not have daily pondage. And the reason for this is mostly financial: the cost of a RoR project with daily storage runs about 20% higher than those without storage, on average.

High dam storage/reservoir projects can be divided into two categories: seasonal storage for power generation (e.g., Kulekhani); and year-round, multi-purpose storage for electricity, irrigation, and water supply. The potential benefit and utility of storage projects are higher than RoR dams, but they pose higher capital costs and incur more substantial environmental consequences with construction and operation.

Thermal Plants and Nuclear Plants

In a conventional thermal plant, coal and other fossil fuels are used to heat the water, whereas in a nuclear plant, heat is produced by nuclear reaction. The heated water produces large quantities of steam and the steam pressure rotates the turbine and generator to produce electricity in both thermal and nuclear plants (Figure 2). The cost of producing electricity from a thermal plant varies from 5 to 10 Rs per kWh, depending on availability of raw materials (coal and other fuel). Compared to a hydropower plant, the operation cost of a thermal plant is very high. Hence, a competitive management skill is required to control the cost. As such, thermal plants are built and operated by private sector in most nations. However, due to security and safety concerns, nuclear plants are still under the control of the host nation governments.

If our policy makers or energy experts are thinking of using thermal plants to solve Nepal's load shedding problem, here are some facts and figures to consider. To operate/generate power from a 300 MW (100 x 3) thermal plant, about 4000 tons (or 200 railway wagons) of coal are required daily. To fulfill this requirement, a 'coal corporation' just like ever-losing Nepal Oil Corporation would need to be established. With no access to sea, Nepal would have to depend on India for the supply of coal; but experience with oil imported from India tells us this will be very difficult. Therefore, even with the high cost power supplied from a thermal plant established in Nepal will not be regular and reliable. If ever build, the thermal plant should be managed and operated by the private sector.

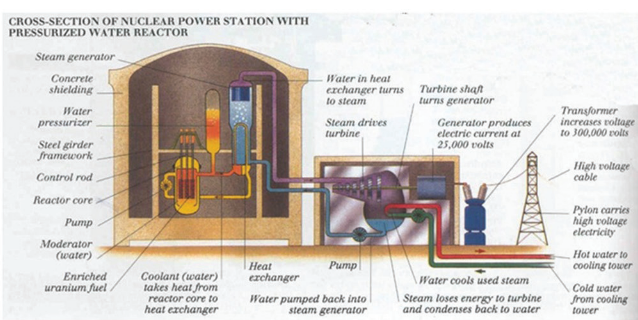


Figure 2a: Nuclear Plant

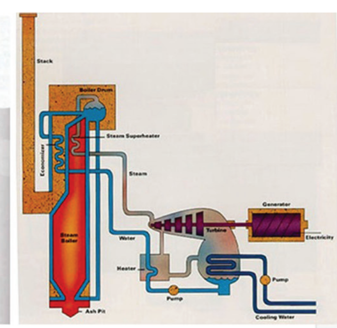
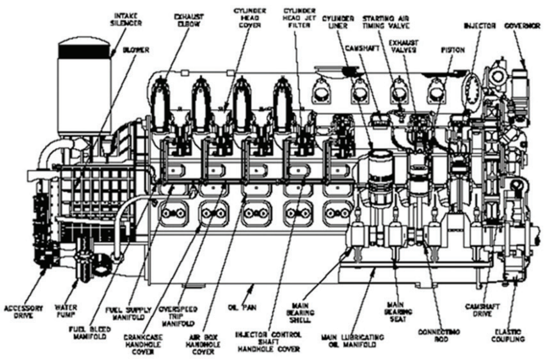


Figure 2b: Thermal Plant

Diesel Plants

In this process, diesel or petrol is used in an internal combustion machine (ICM) to run a generator (Figure 3). The ICM in a diesel plant is similar to the engine of a car; the difference is that in a car the combustion pressure turns a wheel, whereas in diesel plant it rotates the generator. With no turbine to rotate the generator, electricity generated from diesel plants is very expensive (30 to 40 Rs per kWh). Therefore, diesel plants can only be used for short periods as a captive power by individuals and private companies. Due to very high running costs, diesel plants are not used in INPS even by oil rich Gulf countries.



Fiigure 3: Diesel Plant

Construction Component/Cost			
	Civil	Mechanical	Electrical
Hydro Plant	60%	20%	20%
Thermal Plant	40%	35%	25%
Diesel Plant	10%	70%	20%

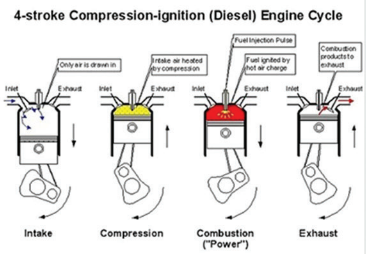
	Operation (Fuel)	Maintenance Cost
Hydro Plant	Water	Low
Thermal Plant	Coal, Oil, Uranium	Medium
Diesel Plant	Diesel	High

Table 1:Construction and O/M Cost Distribution

But in 1990s, some corrupt Nepali bureaucrats and commission agents created confusion by naming a diesel plant as ‘multi fuel plant’ or thermal plant and the government imported 6 units of 6.5 MW diesel plants manufactured in Finland. As a result, NEA is incurring about Rs 300,000,000 in losses every year just to generate 13 GWh (about 0.36 per cent of total annual energy). Therefore, if the government is thinking of solving the load shedding problem by installing fifty 6.5 MW unit (325 MW) diesel plants, the government should also be prepared to bear an additional annual loss of about Rs. 20,000,000,000. Therefore, government not only stop adding new diesel plants in INPS, but the existing so called Multifuel (Diesel) Plants should also be handed over to the private sector.

Master Plan, Project Selection and Construction

Master plan, project selection and construction time and schedule; a) At first Power (kW) and Energy (kWh) requirement of the Integrated Nepal Power System (INPS) should be ascertained. b) Desk study is carried out utilizing available topographic map, geological map, hydrological data, road maps and transmission line network maps. c) Reconnaissance study is done by site/field visit of project selected from desk study to collect hydrological, geological, construction material and other environment related data. Preliminary economic analysis is also done at this stage (6 months). d) Feasibility and Environmental study of the selected best project is carried out. During feasibility study hydrological gauging station is established, detailed geological study is carried out preliminary design and detail economic analysis is prepared. Physical, biological and socio-economic data collected and report prepared with public hearing (1 to 2 years). e) Detail engineering design financial closure and tendering (6 months). f) Construction and commissioning (3 to 4 years). Each and every hydropower project has to be built tailor made as per the site condition; there is no room for cut and paste like other industry/sector. So, it’s amazing how the political parties have declare to generate 10,000 MW in 10 years or 40,000 MW in 40 years without naming/listing the prospective hydro projects



Ministry and Nepal Electricity Authority

The important socio-economic development indicator, annual per capita electricity consumption in Nepal (170 kWh) is one of the lowest in this region (Pakistan 410, Sri Lanka 450, India 550, China 4000). Nepal needs 3000 MW to reach the level of other south Asian nations.

As mentioned earlier, INPS is owned and operated by NEA; therefore NEA also has the responsibility to prepare master plan for power generation, transmission and distribution. But, the Department Electricity Development, a regulatory body of Ministry of Energy, obtained the generation master plan from NEA and commenced the feasibility study of hydro projects without taking into account the INPS or the country’s power requirement. Currently its main focus is on providing license to foreign companies to build hydro projects to export power. The master plan never anticipated leasing country’s precious rivers to foreign company. The DoED/Ministry is promoting this strange concept of leasing rivers practiced nowhere in the world.

Now it’s also involved in construction of a hydropower project. This has created duplication of work and confusion; as such the Ministry of Energy deviated from its responsibility of preparing sound policy, regulation and monitoring them strictly. The Ministry shouldn't indulge in feasibility study, construction and operational activities, which come under the responsibility of concerned technical department /authority.

Therefore, all feasibility study and construction work undertaken by Investment Board/ Department Electricity Development should be handed over to the NEA, and the Ministry of Energy should focus on regulating and monitoring job. It is surprising that the World Bank and the ADB, the creators of Nepal Electricity Authority, have so far been tight-lipped on the mismanagement of power sector in Nepal.

Hydropower potentiality of Nepal

The first systematic technical analysis of hydropower potential in Nepal was carried out by Dr. Hariman Shrestha, a colleague of mine. I fully agree with his conclusion of a theoretical 83,000 MW and economic 42,000 MW for Nepal. But, some so-called experts without name or detailed analysis have said that Nepal has 200,000 MW of hydropower potentiality.

In recent times, no one has performed a systematic analysis of Nepal's hydropower potentiality. Therefore, I still support to Dr. Shrestha's 42,000 MW figure. I would only say that in this period of crisis, we should give priority to cost effective RoR projects, which can be developed much faster than high dam storage projects. The collective potential of Nepal's current RoR (at 1,500 US$ per kW) is approximately 12,000 MW. Because these projects are less expensive to construct, they should be offered out to Nepali firms and not to foreign interests. No one can deny the multipurpose benefit of a storage project. But those should be planned and built as per the long term requirements of the power system.

As for estimating hydropower potential, it's mostly conducted through desk studies, using available topographical and geological maps and hydrological data. The figures will vary with different assumptions made by each analyst. However, there is a long process of field investigation, detailed design, and economic analysis that is required before one can confirm the actual capacity of a hydropower site. With regard to Q40 of exeedence flow, it cannot be generalized. Each project must be subject to optimization studies, considering INPS requirements and value of energy in different seasons before determining an exeedence flow. Therefore, papers published vis-à-vis hydropower potentials should not be considered scientific. They are more appropriately termed as technical papers since they include external conditions that are unique to each site. Nevertheless, these calculations are less important at the moment as Nepal has only developed a fraction of its hydropower potential.

Export of Electricity During Energy Crisis

In a severe power and energy crisis, how have so many hydropower professionals come to believe that exporting power to India is a good idea?

Most developing nations are finding it hard to fulfill ever-growing demands for electricity for meeting the requirements of industry and other economic activities. As electrical energy is the back bone of the economic development, most nations have subsidies for electricity prices. Furthermore, establishing large electricity plants also has serious environmental consequences. So, no nation in the world should take on these risks to build an electricity plant to export power. However, I do acknowledge that a few countries have power exchange activities for the sake of balancing the power and energy of neighboring INPSs. But that is not the case in Nepal at present.

Each nation has its own independent INPS, and, due to differences in size, voltage, frequency and need for independent operation, INPSs are not directly synchronized. For power exchange, most nations use asynchronous high voltage direct current (HVDC) back to back interconnection mode. This allows each nation to retain independent control and operation over its own national grid, while ensuring complete control on the power transfer between the two nations. I have visited a HVDC back to back station in Finland, from where they exchange a large amount of power with Russia. Each country maintains independent control and operation over their own national grid. Recently, Bangladesh and India have also used HVDC back to back interconnection modality for a 500 MW power exchange between the two countries.

But strangely enough, the current power import from India is done through isolated, radial mode. For example, the power supplied to Biratnagar and Nepalgunj area will be isolated from the Nepali INPS and under direct control of the Indian INPS during the power supply period. In the future, if same mode of exchange is applied for power export to India, the hydropower plants, switching stations and transmission lines developed in Nepali territories will be under the control of Indian INPS. This will be a blatant violation of security and independence of a sovereign nation. So, in the future, if Nepal is thinking of power export to India, it has to be in HVDC back to back mode, which will give us the means to incorporate all needed power into the Nepal INSP, and then export power to India. But at the moment, Nepal should first focus on fulfilling the internal power demand to boost its national economy.

Sustainable Development of Hydropower

India needs about 100,000 MW electric Power to maintain its double digit economic growth. Beside Peaking Power there is a huge shortage of Base Load Energy in India; this requirement can't be accomplished by Hydro Energy, India has to go for Super Thermal and Nuclear Energy in a big way. Geographically small country like Nepal has already suffered enormous Ecological Disaster (Deforestation and Chure-Vaber Erosion) to satisfy the huge construction material demand of India. So, if our policy makers are thinking of unlimited exploitation of Nepal's water resources/ hydropower to satisfy the insatiable demand of India, the consequences will be worse than above mention ecological disaster.

India's current power system is based primarily on thermal plants. In such a power system, hydro plants can play a very important role for economic operation and balancing the power system. As such, the value of hydro energy and power is much higher than thermal energy. So, for these reasons, India needs to import electricity from Nepal, but it wants to do so with control over that power, in an exploitative fashion much like they are doing in Bhutan. Nepal has already paid a huge price through the Koshi, Gandaki and Mahakali treaties, which are all similar to the Bhutan model. As for Mahakali Treaty; it was never meant for building so called Panchesower 6740 MW Project, India just wanted to renew the old Sarda treaty at free of cost and legalize the illegally build Tanakpur barrage/dam in the common river, violating the international water/ river law.

Therefore, in the name of liberal economic policy, Nepal shouldn't sell out its precious rivers and land to Indian companies. It should be developed by the Nepalese for the benefit of the Nepalese people.. Nepal should first fulfill its internal electricity demand/ need, and then only it should think of exporting to foreign country. All the electrical power export-import/exchange should be carried out through Nepal Electricity Authority utilizing the INPS.

Private Public Participation (PPP)

Adequate supply and self-sufficiency electrical energy not only boost the national economy but it also helps to keep country's self-esteem and sovereignty intact. Nature has bestowed Nepal with water resources to fulfill this obligation. But sadly enough, Nepalese men in power and vested interest group want to hand over/ relinquish these precious natural resources to foreign companies in the name of foreign investment. Foreign direct investment (FID) may be beneficial in other sector, but in power sector especially in hydropower development priority should be given to Nepalese capital investment. The investment should be in public private participation (PPP) modality similar to Chilime or Upper Tamakoshi.

Chilime provides an instructive example. The share value of Chilime Hydropower Company has gone up more than 20 times and it has already given 70 percent bonus/dividend (share and cash) which is much higher than the value of gold or return in the (unproductive) investment in gold. Similarly, the cost of less than 1000 US $ per kW in Upper Tamakoshi is the lowest in Nepal. On other hand, the National Hydropower Company (100 percent private company), which also has forecasted more than 15 percent rate of return like Chilime, after more than 10 years of its operation, the share value is almost half and it has never given any dividend. In hydropower sector, where the operation cost is 2-3 percent of capital investment this is an impossible incident. It's all due to lack of transparency and faulty accounting / auditing system in the private sector.

Conclusion

Coal and crude oil, the raw material for thermal generation are exhaustible natural resources. Climate change compels re-evaluation of hydro potentiality, and the recent nuclear plant mishap has made its development vulnerable. In such a scenario, the following conclusion can be made for the sustainable development of Nepal's Power Sector.

- The privatization of hydro generation has held up the development of power sector in Nepal. Even with a 70 percent tariff increase, NEA could recover only about 50 % from energy sales vis-à-vis high cost power purchase. NEA couldn't invest in new projects, as a result load shedding increased from 2 hours to 12 hours. NEA is on the brink of bankruptcy, this means total collapse of power sector. It is surprising that the World Bank and ADB the creators of NEA, has just become a spectator to this crisis.
- Deforestation, land erosion, climate change, population growth, resettlement and environmental concerns have significantly reduced the hydropower potentiality. As such, Nepal's hydro potentiality will be sufficient to meet the internal power demand only. In severe power crisis situation, with no project at hand, the government should stop distribution of hydro generation license to foreign companies for power export. Maximum utilization of Nepal's hydropower for industry, transportation and cooking will reduce the import of LPG, petroleum product and other commodities, enabling Nepal to eliminate its long standing trade deficit.
- The master plan studies carried out on three major basins of Nepal confirm that the levelized energy cost of hydropower project in Nepal as 2 to 3 US cent per kWh. But privatization of hydro generation forced electricity consumer to pay 7 to 9 US cent per kWh for the electricity generated from Nepali rivers.
- Currently, NEA is building the largest 456 MW Upper Tamakoshi Project utilizing country's own financial resources at less than US$ 1000 per kW, scheduled to be completed in the year 2016. Therefore, the government should facilitate NEA to immediately undertake hydro projects similar to Upper Tamakoshi with a total capacity of 1000 MW. With such arrangements, the electricity tariff will be very competitive (about 5 US cent/kWh) and reliable.

Therefore, all the stakeholders of the power sector, especially the donor agencies and electricity consumer, should understand that only a strong and healthy NEA will be able to provide reliable and economic power supply to the consumers and rescue power sector of Nepal from collapsing.

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