TECHNOLOGY FACTSHEET

PUMPING WATER FROM LOWER STREAMS INTO EXISTING HYDRO RESERVOIRS[1]

1. Sector: Energy Supply

2. Introduction:

In Sri Lanka there are around 12 large and small water reservoirs are used in hydropower generation. These reservoirs store water to cater to seasonal or daily load variations. These reservoirs are located at different elevation to the mean sea level. Also these reservoirs are clustered into groups and are connected in a cascade manner within the group. Water from the top most reservoir is sent through tunnel/ open channel and penstock to power plant located at a lower elevation relative to the top most reservoir. Water discharged from the power plant is stored in a reservoir located very close to the power plant and at an elevation slightly lower than the discharge level of the power plant. Water in this reservoir is sent through another set of tunnel/ channel and penstock and used to drive another power plant. This process is repeated until the water discharged from the power plant located at the lowest elevation is discharged into a reservoir to be used for non-power generation application such as irrigation, industrial or household water needs.

Water flowing along streams between the levels of spill level of a reservoir and inlet level of reservoir immediately below it is usually ends up entirely in the lower reservoir. However, in respect of some parts of such water streams the difference in elevation between the point of the stream and the spill level of the upper reservoir is significantly less than the difference in levels between the inlet and outlet of the power plant utilizing the head of water in the higher reservoir. What this means is that if we pump water from such a stream at from such a point into the upper reservoir, then, the amount of water pumped into the upper reservoir will be able to generate more energy than the energy expended in pumping the water. This is possible because the difference in head against pumping is significantly less than the difference head used to generate power.

3. Technology Characteristics: (Feasibility of technology and operational necessities)

Feasibility of Technology:

The amount of energy required to pump a unit mass of water, neglecting frictional losses, is directly connected to the difference in height between the point of water intake and the point of discharge. Likewise, energy that could be generated from a unit mass of water from a reservoir is

[1] **This fact sheet has been extracted from TNA Report – Mitigation for Sri Lanka. You can access the complete report from the TNA project website** http://tech-action.org/

directly depends on the difference in height between the water intake in the reservoir and the point of discharge of the water from the hydro turbine.

In this technology, it is proposed to pump water from streams which conform to the above mentioned criterion. Such opportunities are available in plenty in Sri Lanka.

Operational Necessity

The total annual amount of electrical energy generated from the hydropower plants in Sri Lanka clearly depends on the amount of water collected by the reservoirs. Hence if more water could be collected into these reservoirs, then more electricity could be generated. However, care should be taken to ensure that the additional energy generated is significantly larger than the energy expended in pumping such water into the reservoirs.

As the amount of water collected by the natural process in the reservoirs is inadequate to meet the electrical energy demand of the people in Sri Lanka. Hence oil based and coal based power plants are operated to meet the shortfall.

4. Country Specific Applicability

Electrical Energy Generation Sector

The data provided by the Sri Lanka Sustainable Energy Authority (SEA) in their web: www.energy.gov.lk show that the present the national peak electricity demand is 2033 MW (28^{th} September 2011) and the corresponding daily electrical energy consumption is 33.35 GWh/ day. The same data published during this year (2011) also show that the annual electricity peak demand growth is growing at about 400 MW per year and the daily electrical energy demand is growing at around 8 GWh/day/year.

In order to meet the above mentioned growth, the Ceylon Electricity Board (CEB), the sole utility responsible for the generation and distributing most of the electricity generated to the final consumers have been annually preparing and releasing their Long Term Generation Plan (LTGP). According to the last published LTGP, most of the future generation of electricity would be generated from coal based power plants as shown in figure 1.

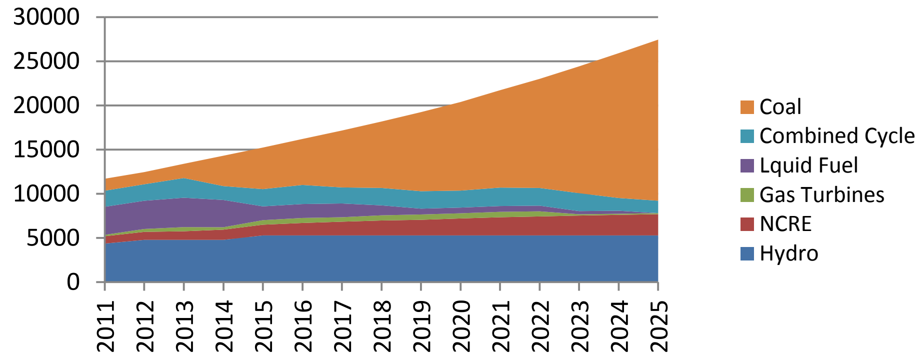

Figure 1: Annual Energy Generation (GWh/y)

In fact as per the above plan, EB has already commissioned and operating a 300 MW coal based power plant. The second phase of coal based power plant with a capacity of 2x300MW is under construction. Action has been initiated to construct another 2 x 500 MW coal based power plant in the country.

While the state owned utility CEB is planning to commission as many coal based power plants as necessary to meet the growing demand for electricity, the Ministry of Power and Energy, through the SEA is encouraging the private investors to develop renewable energy based power plants. In an attempt to generate at least 10% of the electrical energy requirements by the 2015, the SEA has offered an incentive scheme for the private sector to harness renewable energy resources and generate electrical energy and feed the national grid. A concessionary tariff based on the estimated cost of generation has been offered for each of the following technologies:

- Small Hydro: Rs. 13.04 / kWh
- Wind: Rs. 19.43 / kWh
- Biomass: Rs. 20.77 / kWh
- Agro/Industrial Waste: Rs. 14.60 / kWh
- Municipal Waste: Rs. 19.73 / kWh

As at December 2010, a total of 86 small hydropower plants with a total capacity of 175.763 MW have been commissioned. In addition 4 wind power plants with a total capacity of 30.15 MW have been commissioned. 2 agro-residue/ biomass based power plants with a total capacity of 11 MW have also been commissioned. It should be noted that the very high price paid for wind power generation is essentially payments made for the capital equipment, which is entirely foreign in nature with very little local value addition. Electricity generation using technology such as wind and solar do not contribute to the local economic growth.

Hence there is a need to develop renewable energy projects which contribute towards local value addition. The proposed technology will utilize equipment such as pumps, PVC pipes and cement are locally manufactured. All the materials, labour and skill required to implement this technology are local in nature. Moreover, the implementation of this technology will be able to help the country to increase its hydropower based electricity generation at the lowest cost. In this technology we are making use of an existing hydropower plants to increase their outputs with minimal capital and minimal operating costs.

This implementation of this technology will enable the country achieving the proposed targets.

Peak & Trough Problem of the Electricity Sector

A closer look at the daily load curve of the electricity system in Sri Lanka reveals the twin problems encountered by this sector. Please see figure 2.

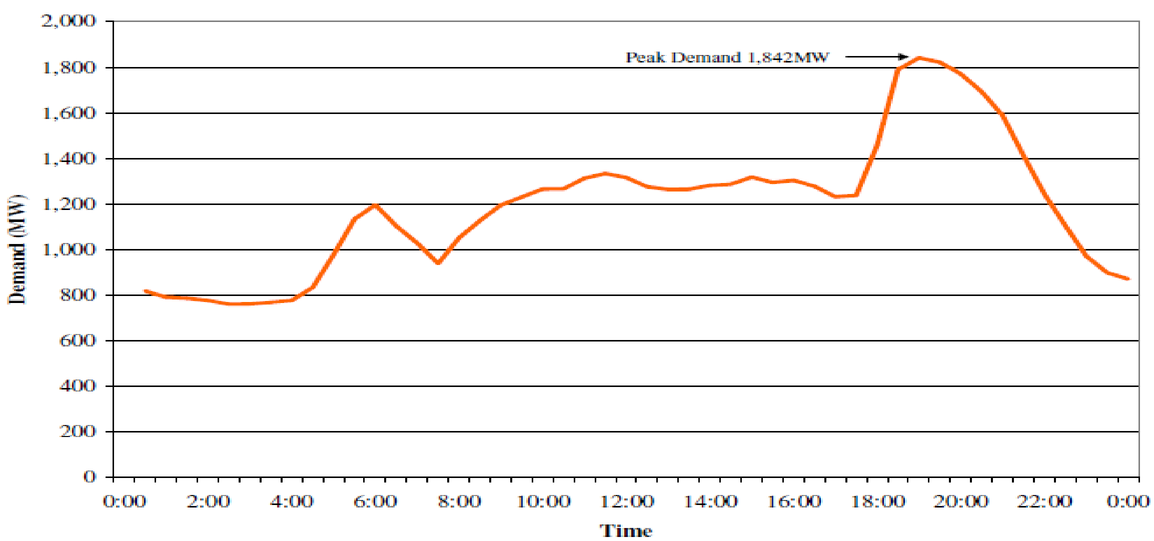

Figure 2: Electricity System Demand Profile on 28th November 2007

The first problem encountered is the very high demand of the system from around 6 p.m. to around 9 p.m. While the demand during this time interval is nearly twice that of the daily average demand, this high demand lasts only for a short period of 3 hours. The capacity of the system to meet this high demand is utilized only for a short time. This makes it difficult to recover the cost of the system in a reasonable period.

The additional water made available in the hydro reservoirs by the proposed technology, would enable to enhance the power output of hydropower plants to meet the demand for electricity during peak hours. Thus eliminating the use of fossil fuel based electricity generation.

The second problem encountered in the system is between 11 p.m. to 5 a.m. During this period the demand for electricity is very low. In fact the demand during period could be easily met from small renewable energy embedded generators and the “must run” hydro power plants. To balance the demand with the supply, power outputs of thermal power plants are reduced. For economic reason, output of the power plant with the highest marginal operating cost at that point of output is reduced. If necessary, the power output of the coal based power plant is also reduced and sometimes completely shut down.

Lowering energy output of coal based and petroleum fuel based combined cycle based power plants cause two problems: Firstly, capital cost of these base-load power plants being very high, these plants are expected to operate at high plant factors on a daily basis in order keep the total cost of electricity generated from these power plants are competitive. Secondly, base-load power plants have large thermal inertia. Varying the load, particularly shutting them down completely or starting them from no-load are not desirable for base-load power plants. Such operations affect the useful life of these plants.

The implementation of the proposed technology would enable the utilization of the power generation capacity available during the off-peak period to pump water from lower streams to upper reservoirs.

5. Status of the technology in the country and its future market potential:

Status of Technology in Sri Lanka
This technology is in its infancy. A prototype plant need to be constructed to convince the authorities concerned the merits of this concept.

Future Market Potential
The proposed technology could be applied to all the hydropower projects, both small and large, implemented in Sri Lanka. For the year 2010, a total of 5,634 GWh of electrical energy were generated through hydro power projects. The proposed technology is expected to increase this amount by 10%. In the future, the total hydropower generation is expected to increase up to around 6,000 GWh per year. Hence the future potential of the proposed technology is 600 GWh per year.

6. Barriers: -

7. Benefits: (How the technology could contribute to socio-economic development and environmental protection)

Social Benefits
The implementation of this technology would result in the engagement of skilled and unskilled labour forces for the following tasks:

- Construction of weirs across streams to facilitate water intake structure for water pumps.
- Increase in the production water pumps.
- Manufacture of PVC pipes and fittings.
- Laying and connecting of pipes linking the pumping stations and reservoirs.
- Linking the pumping stations to the nearest electricity network to provide electricity for the pumping stations.
- Operation and maintenance of pumping stations.
- Enhancing the generating capacities of existing hydro power plants.

Economic Benefits

The direct economic impact of this technology is the value of 600 GWh of electricity annually generated. Market value of this energy at the rate of Rs. 15 per kWh is Rs. 9 billion per year.
The following indirect economic benefits could also be achieved:

- Increase in the amount of electricity generated from renewable and indigenous resources.
- Reduction in the amount of electricity generated from expensive, polluting and imported fossil fuels, particularly during peak demand period.
- Reduction in the cost of electricity resulting from the reduction of oil based, high cost electricity generation.
- Savings in foreign exchange due to reduction in the import of oil for electricity generation.

Environmental Benefits

- Less NOX and SOX pollution from fossil fuel based electricity generation.
- Lower GHG emissions.

8. Operations: -

9. Costs

The cost of implementing this technology to a 1 MW small hydropower plant is estimated to Rs. 179 million. This technology could be extended to over 130 MW of hydropower plants, large and small, already installed. The cost of extending this technology to all the 130 MW hydropower plants would be Rs. 23,270 million.

10. References

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