Latest Hydropower Development in Kelani River Basin; Broadlands Hydropower Project

K.G.C.P. Gamage[1], and Dr. Kamal Laksiri[2],
Project Engineer (BHP)[1], Project Director (BHP)[2], Ceylon Electricity Board, Sri Lanka.

Background

National electrification level in Sri Lanka has grown to 99.7% by 2017 and reached 100% accessibility. Net annual generation has exceeded 14,000 GWh. Maximum reported peak demand during 2017 was 2,523 MW on 17th May 2017 and demand for electricity is growing at a rate of about 6% per year. To meet the growing demand for electricity, new power plants are needed to be constructed and connected to the national grid with a proper long-term plan. In early stages, the electricity requirements were mainly supplied by hydropower plants and the contribution from thermal power plants was minimal. With time, thermal generation has become prominent. At present, thermal generation share is much higher than that of hydropower generation [1]. In 2017, the total installed power generation capacity of the country was 4,087 MW, consisting of 900 MW of coal power, 1,233 MW of oil burning thermal power, 1,745 MW of hydropower and 179 MW of non-conventional renewable energy sources such as wind, mini hydro, biomass, and solar power plants. [2].

The power system in Sri Lanka is gradually transforming into a mixed thermal and renewable energy system, and hydropower plants with storage are expected to be increasingly operated for peaking duty. This aspect was studied and reported under the JICA funded project, "Study of Hydropower Optimization in Sri Lanka" conducted in year 2004 [1], and in CEB's own long-term generation expansion plan published once in two years.

Hydropower is the main indigenous source of energy in Sri Lanka. The rstimated potential of hydro resource is about 2,000 MW, of which more than half has already been harnessed. Most major renewable resources (large hydro) have been developed and further exploitation of remaining hydro potential is becoming increasingly difficult owing to social and environmental impacts often associated with large-scale developments. At present, the following large to medium scale hydropower projects are under construction [1].

1. *Broadlands Hydropower Project: 35 MW*
2. *Uma Oya Multipurpose Hydropower Project: 120 MW*
3. *Moragolla Hydropower Project: 31 MW*

Among the above, Broadlands Hydropower Project (BHP) is a plant identified in the Master Plan Study for hydropower development (1988) and, presently the project is under construction. The project is located in the Kelani river basin near Kitulgala area.

There are five hydropower plants already operational in Kelani river, grouped and named as Laxapana Complex, with a total installed capacity of 354.8 MW (26% of the total hydropower capacity in the country). BHP now under construction will be the last feasible hydropower plant of that scale along the Kelani river with an installed capacity of 35 MW. BHP is expected to generate 126 GWh of electrical energy in a year with average hydrological conditions.

Project History

Initial pre-feasibility studies on BHP were conducted in 1986 by the Central Engineering Consultancy Bureau (CECB). In that study, seven alternative layouts were considered. Based on the result of geological investigations, some layouts were eliminated owing to poor geological conditions at dam sites. Some sites too, were eliminated owing to unfavorable geological conditions at the power plant site. Finally, considering the economic efficiency and social impacts such as resettlement, the layout of BHP shown in Figure 1 was recommended to be the optimum layout for implementation [3].

Later in year 2003, under the title "Study on Hydropower Optimization in Sri Lanka", a JICA study team conducted a review of the CECB feasibility report of 1986. The study team re-examined the geological data and conducted further geological site reconnaissance surveys and confirmed the validity of selection of the layout in the 1986 study.

Based on the feasibility and feasibility review studies, the basic layout for the BHP was confirmed as the optimum layout for the Project

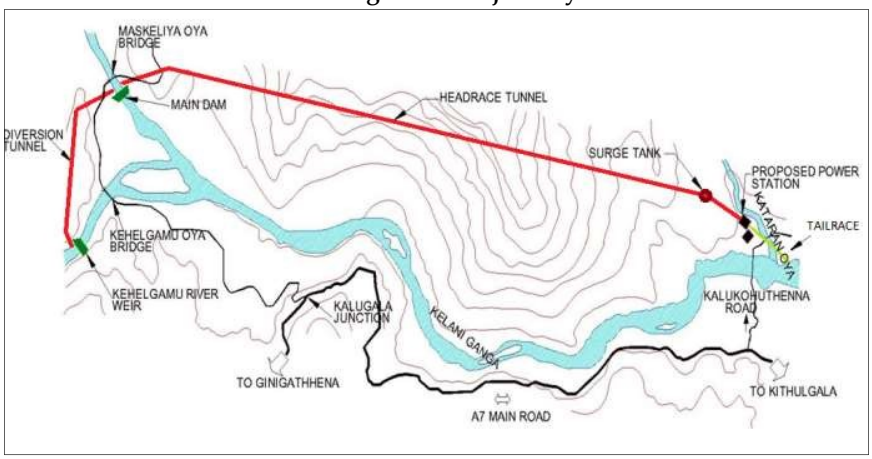
(Figure 1) and proceeded to the implementation stage.

Project Implementation

Construction of the BHP is being conducted under a design and build contract. The project contractor, China National Electric Engineering Co. Ltd. (CNEEC) was selected following an international competitive bidding (ICB) process. The total project cost, $ 82 million is facilitated through two commercial loans obtained from the Industrial and Commercial Bank of China (ICBC: 85%) and Hatton National Bank of Sri Lanka (HNB:15%). BHP is a run of river (ROR) type hydropower development located on the middle reach of the

Kelani river, near the confluence of the Maskeliya Oya and the Kehelgamu Oya, the two main tributaries of the Kelani river. The headworks comprising the main dam and the diversion weir are located in Polpitiya area in **Nuwara Eliya** district of Central Province, whereas the power plant and the switchyard are located in Kitulgala area in **Kegalle** district of Sabaragamuwa Province.

Figure 1 - Project Layout



Construction work of the project is in progress and has reached nearly 60% of physical progress by the end of October 2018.

When considering the main features, the project consists of a 96 m long, 24 m high concrete gravity main dam across Maskeliya Oya. To harness the potential of Kehelgamu Oya, a concrete diversion weir is being constructed, and water is diverted toward the main dam through a 811 m long diversion tunnel. Then, water from the main dam is conveyed to the power plant located at Kitulgala area through a 3.2 km-long headrace tunnel. A restricted orifice type surge shaft characterized with a 2.3 m diameter orifice is bring constructed at the beginning of the steel penstock. Electricity generated by two vertical-shaft Francis turbines with a total capacity of 35 MW (each of 17.5 MW) will be transmitted to the national grid through a 5.2 km long 132 kV double circuit overhead transmission line. After generating power, water is released back to the Kelani river through an open channel tailrace.

Main features of the project are;

Installed capacity	35MW (17.5MW x 2)
Annual electricity generation	126 GWh
Effective head	56.9 m
Main dam	24 m high, 96 m long concrete dam
Kehelgamu Oya weir	19 m high, 48 m long concrete dam
Main tunnel	3.2 km long underground pressure tunnel
Diversion tunnel length	811 m long underground tunnel
Powerhouse	Surface powerhouse with two of turbine-generator units
Transmission line	132 kV double circuit overhead transmission line, length about 5.2 km

CECB is the project consultant and rendering consultancy services including engineering supervision and this is the only project of this nature, which is being constructed under the supervision of a team of local experts.

Social and Environmental Aspects

Resettlement Activities

In the 1986 pre-feasibility, it was identified that people living within the project sites and directly affected by the project works are required to be resettled. As the project implementation commenced, a detailed socio-economic survey was conducted, and 48 affected families were required to be resettled. Based on the socio-economic survey, a resettlement action plan (RAP) was prepared, but the land identified for resettlement could not be acquired. Therefore, to avoid delay in commencing the project, the affected families were paid financial compensation.

The resettlement program of the project was based on the principle of ensuring that affected residents will improve or at least restore their income and livelihood to their original levels. At present these families have improved living condition at their new places of residence.

White Water Rafting

With the construction and operation of the BHP, part of the Kelani river currently used for popular white water rafting (WWR) sport in Kitulgala area will be affected owing to the reduced flow. Impact on WWR was identified during the Environmental Impact Assessment (EIA) conducted in year 2003 and as mitigation measures, it was proposed to provide alternative employment opportunities to those who engage in WWR. The WWR sport in Kitulgala had only three operators in year 2003/2004 but by 2012, there were nine operators but only four had the required registration. The number of WWR operators has significantly increased thereafter and by year 2016, about 36 rafting companies were in operation.

As the WWR sport has already been established in the area, the project could not just compensate WWR companies as proposed in the EIA. As the optimum solution for the WWR issue, it is now planned to release the minimum required volume of water to conduct WWR during day-time through a mini-hydropower plant. The power plant will be newly constructed, as an addition to the main project. With this solution, it is expected that WWR sport can continue after the project commences operations.

CDM Registration

During the feasibility study review conducted in 2004, BHP was identified as a potential project to register under the Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Changes (UNFCCC). Further, it is estimated that the implementation of the project will result in reducing the emission of 83,075 metric tons of CO_2 annually.

For a project to secure benefits under CDM, the Project Entity has to prove that there is a reduction of the emission of green house gases (GHG) such as CO_2, SF_6, N_2O and CH_4 to the environment with the implementation of the project and the entity will be rewarded by trading the measured reduction of GHG commonly known as carbon credits. The method of registering a project under CDM, monitoring the performance and measuring the emission reduction of the project etc. are based on rules and regulations laid down by UNFCCC.

In this regard, the BHP was successfully registered under CDM on 27th December 2012, and it is expected that 10% of the total project cost can be recovered under the CDM benefits by selling carbon credits earned by the project. BHP will be the first CEB power generation project and Sri Lanka's first large hydropower project to be registered and benefited under the CDM scheme.

Present Progress of Construction

The project construction work is in progress and total Project progress exceeded 56% by the end of September 2018. The main dam and spillway construction have reached 90% progress and only 170 m out of the total length of 3.2 km remains in the main tunnel excavation. Excavation of the surge chamber has been completed and concreting works are in progress. Power plant and tailrace construction work has reached 40% progress.

When considering electro-mechanical and hydro-mechanical activities, the main intake gate, steel pipes of the penstock including bifurcation pipes, both draft tubes and spiral casings are already installed. Installation of main tunnel intake gates has been completed. Manufacturing of main equipment including generator, turbine,

governor and excitation system, and the main inlet valve is in progress and these will be delivered to the site in the near future for installation.

Figure 2 - Main Dam

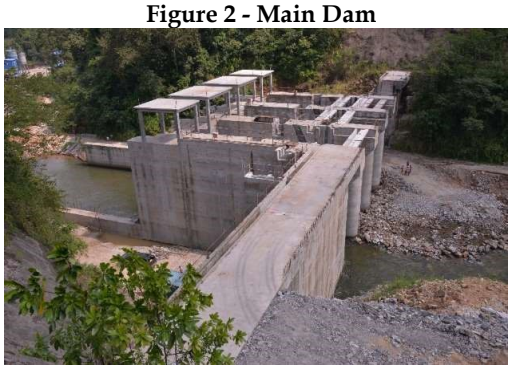


Figure 3 - Diversion Weir

Figure 4 - Main Tunnel Excavation

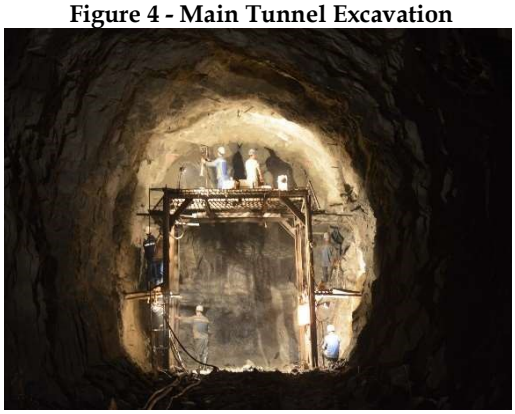


Figure 5 - Powerhouse Construction

Figure 6 -Turbine Spiral Casing Installation

Project construction activities were delayed due to typical practical issues which arose during project implementation, including legal issues, land issues, financial issues, public unrest on construction, etc. However, the project construction work is in progress now. It is planned to commission the power plant by 2019.

Other than the construction of the main power plant, the Project is also planning to install a micro-scale generating unit to its water diversion and two pico-hydro scale turbines for the environmental release outlets of the two dams. Further, the famous bridge on the River Kwai[1] film location is just upstream of the power station site. It is intended to construct the side views of the new bridge being built on the power house access road to be similar to the bridge built for the film "Bridge on the River Kwai", as a tourist attraction. Further, it is also planned to build a hydropower museum and an energy park in the project area.

[1] The movie depicting the World War II conflicts in Burma (now Myanmar) was filmed at a location near the project.

Thus, with all these additional features, the Project will be an environmentally friendly and sustainable generating facility for the country to provide electrical energy to serve its ever-increasing needs.

References

1. *Long Term Generation Expansion Plan 2018-2034, Ceylon Electricity Board, 2018.*
2. *Statistical Digest, Ceylon Electricity Board, 2017.*
3. *Study of Hydropower Optimization in Sri Lanka, JICA, 2004.*
4. *Project Progress Reports, Broadlands Hydropower Project, Ceylon Electricity Board, 2018.*