Hydropower Revival in Java's Tea Gardens

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Rising Fuel Prices Promote Green Energy for Green Tea

Beginning in the second half of the 19th century, large areas of West Java's mountainous rainforests were transformed into tea gardens. The volcanic soils, high rainfall, and cool climate of this region proved the perfect environment for such plantations (Figure 1). During this period, many tea factories were powered by small hydropower plants (SHPs). The location of the factories on tea estates was often determined by the availability of a suitable site for the SHPs. This renewable form of energy was the perfect match for the moderate power requirements of tea factories. However, after the peak in tea production at the beginning of the 20th century, a gradual decline in production took place in West Java. Unfortunately, this period also saw the degradation of the many SHPs that formerly powered the factories. Today most of the plants in the old factories have been destroyed, dismantled, or replaced by Diesel gensets. Rising fuel costs and increased consumer awareness are now providing the right environment for a revival of indigenous hydraulic resources.

FIGURE 1 The Putuah Wattee tea estate. At 1500 m, the rainy season is cold and damp – a perfect climate for growing tea. (Photo by Rolf Widmer)

Rise and fall of small hydropower plants (SHPs)

The history of small hydropower plants on the tea estates of West Java dates back to the establishment of the estates under colonial rule of the Dutch East Indies during the later part of the 19th century. At that time, the government leased land under long leasehold arrangements to private entrepreneurs, thus initiating the development of huge tea gardens throughout the highlands of West Java, known as the Preanger region.

Tea is grown in West Java at altitudes between 800 and 1700 m. Annual rainfall of approximately 3000 mm and temperatures between 13 and 30°C are required to cultivate tea. It is precisely in these surroundings that an abundance of small hydropower resources can normally be found—thus providing the perfect conditions for generating the power required to drive the variety of processing machines used in the tea production process. Therefore, it is not surprising that hydropower was the preferred option for supplying power to the tea factories. Alternatives such as steam and, later, diesel engines were used only where there was no potential for hydropower.

The first hydropower plants in West Java were built as early as 1880 (Figure 2). The moderate power output of between 10 and 40 HP was sufficient to drive a variety of machinery via an array of shafts, pulleys, and belts. All power transmission was purely mechanical, which required the power plant to be located within the factory. With the advance of turbine and generator technology at the beginning of the 20th century, hydroelectric power plants became more and more common. This allowed separation of the power plant and the factory. Electrical transmission at voltages up to 5 kV began in the early 1920s, permitting transmission of electrical power over distances of several kilometers.

Records show that, by 1910, 40 hydroelectric power plants had already been erected on the tea estates of West Java, mostly by private entrepreneurs. By 1925, approximately 400 small power plants with a total capacity of 17,000 HP were in operation throughout Java. Pelton or Francis turbines, with power outputs ranging from 40 to 200 HP, were commonly used. Also, in 1910, the state-owned national electric company began construction of a number of large power stations to provide electric power for the major towns. The first tea estates were connected to the public grid in the 1920s.

During the Japanese occupation of Indonesia in the Second World War, tea was uprooted in many areas to allow for the planting of food crops. Many factories and their power plants were dismantled or abandoned (Figure 3) to maintain production in more important industries. The postwar struggle for independence hindered recovery of the estates prior to 1950. And even then, the political climate did not encourage investment in rehabilitation of the estates.

The uncertainty surrounding the future of the plantations came to an end in 1957 with the takeover and subsequent nationalization of all Dutch-owned estates, known as PPN (Pusat Perkebunan Negara, or National Estate Center). Excessive rates of inflation and a depressed world tea market provided the new masters of the estates with little incentive and few means for tackling the backlog of technical problems facing the industry. In 1971–1972, the two main PPNs of West Java were converted to private limited estates (PTP, Perseroan Terbatas Perkebunan; PTP XII and XIII). Although wholly government owned, they are corporate bodies and are required to operate on a fully commercial basis.

The Indonesian economy began to develop only during the "New Order" regime of Suharto. To ensure access to essential goods for the poor, the Suharto government operated a system of subsidies and price controls for basic commodities, including fossil fuels. The consequence of this policy was minimal initiatives in the renewable-energy sector. With such a cheap supply of diesel fuel, there was little incentive to consider alternatives. This situation was further exacerbated by the monetary crisis in 1997. While the Indonesian rupiah was devalued by a factor of three against the US dollar, the domestic price of diesel fuel could be increased by only 34%. Today the price of diesel fuel is 7 US¢/L. This is by far the cheapest throughout the Southeast Asian region and among the cheapest in the world; fuel prices in Indonesia are highly subsidized. The near future will see a price hike and a revival of hydropower.

Following the end of the "New Order" regime, the government is aware of the need to gradually remove subsidies for fuel. Fuel price hikes, however, are a politically sensitive issue in Indonesia and frequently provoke popular unrest. Consequently, the government is adopting a step-by-step approach, with the aim of removing all subsidies on fuel by the year 2003.

Hydropower on Indonesian tea plantations today

Of a total of 160,000 ha of tea in Indonesia as of 1997, 55,000 ha (34%) were state owned (PTP) and 44,000 ha (28%) belonged to private estates. The remaining 61,000 ha (38%) were owned by a

FIGURE 2 The oldest power plant found during our investigations was a Swiss-built turbine dating from 1885. (Photo by Rolf Widmer)

FIGURE 3 Some abandoned plants are vanishing in the jungle. Those still operating are doing so due to generations of dedicated operators, who make sure that technical equipment remains functional. (Photo by Sven Dernedde)

large number of smallholders. The distribution of annual production (approximately 160,000 t) reveals a somewhat different picture: due to low productivity, the smallholders contribute only 20%, led by the private estates with 23%. The state-owned estates contribute 57%. Despite recovery in the Indonesian tea industry—Indonesia is presently the world's fifth largest tea exporter after Sri Lanka, China, Kenya and India—extremely low energy prices for diesel fuel and electricity as a result of government subsidies have provided little incentive for reinvestment in exploiting abundant hydropower resources.

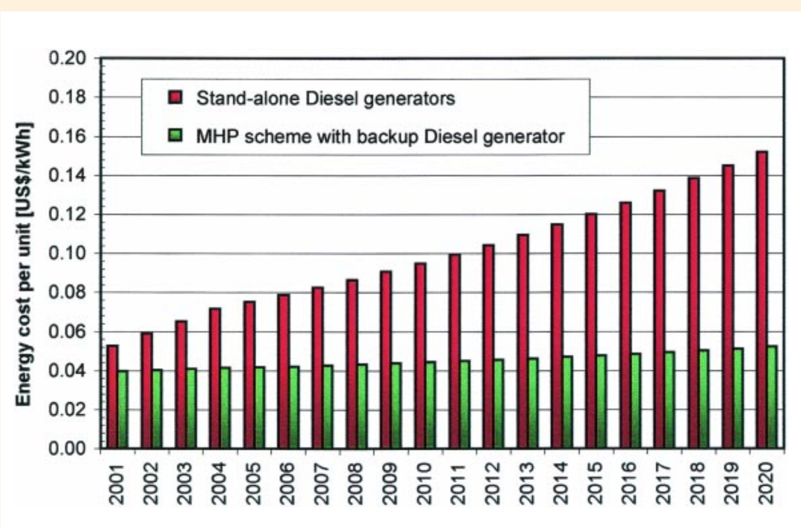
At present, the Indonesian tea industry suffers from low world market prices for tea (1 US$/kg in 1995). Some estates have been forced to close down, and many of the private estates in particular reacted by targeting niche markets. In order to do this, they invested in modern processing machinery (CTC: crush, tear, and curl) and switched their production to green tea, which commands higher prices with lower processing costs.

A study conducted in 1995 revealed that, of the 44 hydropower sites identified at tea estates from historical data, only 18 were still operational. Of those still in operation, almost all were still operating with the originally installed equipment. In many cases, this machinery had never been refurbished. Much of this equipment was better suited for a museum than a power plant (see Figure 2).

More and more estates have apparently either installed diesel generators or obtained a connection to the national electricity grid in the past decades, regardless of the untapped hydropower potential at many of these sites. Despite low fuel costs, hydropower development remains an attractive proposition for estates when seen in a long-term perspective (Figure 4). The reasons for this are:

- Demand at the tea factories is relatively stable throughout the production cycle, resulting in a reasonably high load factor.
- The potential hydropower sites are usually located in the immediate vicinity of the factory, thus avoiding costly transmission lines.
- Advances in local manufacturing capacity mean that the local content of schemes today is much higher, reducing the need for expensive imported components.

FIGURE 4 Unit energy cost for the current set-up, with stand-alone diesel generators and the proposed hybrid set-up with a mini-hydropower scheme and a back-up Diesel.



The Dewata Tea Estate

The Dewata Tea Estate is a typical example of a West Javanese tea estate with an interesting potential for hydropower. Established in 1932, it is located about 50 km southwest of Bandung. The plantation covers an area of approximately 600 ha and produces over 1200 tons of tea annually. The factory has a green leaf processing capacity of about 20 tons per day. Dewata is home to over 1000 people, the large majority of whom live in the village located next to the tea factory. There is no other source of electrical energy at the estate apart from four diesel generators installed at the factory. The distance from the estate to the nearest grid supply is around 8 km. In addition to the tea processing equipment at the factory, the administration buildings and most of the houses in the village are also connected to the electricity supplied by the diesel generators.

The average annual energy production is almost 1000 MWh. Although peak demand is currently reaching 220 kW, the average annual demand is 120 kW. Approximately 350,000 L of diesel fuel are needed every year to generate electricity. Additional diesel fuel is also needed for the various burners used to dry tea. At the request of the management of the Dewata Tea Estate, a feasibility study was carried out with the assistance of the Joint ASEAN Mini Hydro Program (JAMP) in order to further assess the economic and financial viability of a potential project. The outcome of the study was positive, and it was agreed to go ahead with the construction of a hydropower plant to be commissioned in 2001.

The project

The proposed project exploits the hydropower potential of the Cikahuripan River in the vicinity of the tea-processing factory in a run-of-river scheme (Figure 5). The length of the headrace channeling the water along the main road is around 600 m; the penstock pressurizing the water down to the powerhouse is 195 m long. With a net head of 62 m and a design flow of 600 L/s, the maximum output of the scheme is 250 kW. The design flow will be available 44% of the time in an average year. A storage approximately 2000 m^3 in size, located at the end of the headrace, will help to make optimal use of the available potential, thus increasing the time when demand can be fully covered by the hydropower scheme to over 8 months of the year. The rest of the year, the plant will be run intermittently with one or two diesel generators.

The electromechanical equipment for the proposed scheme consists of two T14 cross-flow turbines controlled by a digital turbine controller (DTC). ENTEC AG, a Swiss company specializing in mini-hydropower technology development, will manufacture and supply the electromechanical equipment, together with a local Indonesian company experienced in the implementation of some 50 micro- and mini-hydropower schemes throughout Indonesia. The overall investment costs for implementation of the scheme are approximately US$ 360,000. Financing for a proportion of the project was secured with the assistance of JAMP. YBUL (Yayasan Bina Usaha Lingkungan), a local nongovernmental organization, channeled a GEF (Global Environmental Facility) loan to the Dewata Tea Estate. The remaining investment capital is equity from the estate company.

FIGURE 5 The Cikahuripan River in the vicinity of the tea-processing factory offers an attractive potential for hydropower. (Photo by Martin Roth)

Project benefits

A financial analysis that assumes the Indonesian government will adjust the price of diesel fuel annually shows that the proposed mini-hydropower scheme will pay back the GEF loan within 5 years (not including a 1-year grace period). Total investment payback would occur in 7 years, with an internal rate of return on investment of over 20%. The unit energy cost can be calculated as shown in Figure 4.

Financial attractiveness is only one of the benefits of developing hydropower as a source of power for tea factories. Using an environmentally friendly source of energy in the processing of tea also provides a strong marketing argument that is particularly relevant to export markets. For example, an annual reduction of 1000 tons of CO_2 will be achieved if a mini-hydropower scheme is used at the Dewata Tea Estate. Assuming a minimum life span of 20 years, the total avoided CO_2 emissions would amount to around 20,000 tons.

In light of the total investment, the cost per ton of CO_2 avoided can be calculated at US$ 18. In the case of Dewata, if the owner of the plantation made this

FIGURE 6 The impressive power plant at Malabar (1.5 MW). Though still running, it urgently needs renovation. Hopefully, this historic plant will benefit from the renewed interest in hydropower and remain operational for another century. (Photo by Sven Dernedde)

investment, it could also be argued that only the external support need be considered in the cost per ton of CO_2 avoided. Except for the contribution of JAMP in conducting the feasibility study, external support consists solely of the low interest rate for the GEF loan. If it is assumed that the interest rate for a commercial loan is on the order of 15% (compared with 8.75% for the GEF loan), this support translates into a sum of approximately US$ 32,000. External investment might then be as low as US$ 1.6 per ton of CO_2 avoided.

Outlook

The detailed design of the hydropower project is currently being finalized. The time schedule calls for civil engineering construction to begin in November 2000, with commissioning of the scheme planned for late 2001. Hopefully this will be the right time for the Dewata Tea Estate to switch its energy production from diesel to hydropower, before the planned increase in fossil fuel prices begins to affect production costs for tea.

Nevertheless, there are still many tea estates that have economically attractive hydropower potential but lack the financial resources to invest in its development (Figure 6). One important function of JAMP is to assist owners of such plantations in making the required funds available until the domestic financial market in Indonesia is fully developed and able to undertake this task independently. Prior to this, the enjoyment of drinking a cup of tea will often be limited by awareness that up to 2 kg of CO_2 are emitted to process each kilogram of tea.

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