A milestone in the Atlantic rainforest: Itatinga dam and its power station

Gildo Magalhães, USP[1]

Abstract

At the end of 19th Century the growing exportation of sugar and coffee in the southern state of São Paulo, Brazil, led to the expansion and modernization of the ancient harbor of Santos. Electrical equipment prevailed as the choice for larger capacity hoisting equipment in charge of cargo to be picked up from the incoming railway Jundiaí-Santos and loading it onto the ships. Soon after the new Republic was inaugurated, a concession (1891) was given to build a dam 700 m above the sea level, taking advantage of the turbulent waters of Itapanhaú River, running in the tropical woods covering Serra do Mar, a mountain range separating the seaside from the interior lands. The stream was channeled through a 3-km stone tunnel, flowing into the dam and downhill through pipes to power the turbines of Itatinga substation, not far away from the sea docks.

Construction had to be interrupted several times because of difficult sanitary conditions that plagued swampy coastal areas as Itatinga and Santos, including yellow fever and malaria. Finally the service began to operate in 1910, and the private company that owns the power station has been able, due to the excess energy produced, to supply or complement electricity for neighboring cities, even nowadays. This service was however, during many decades, subject to constant economic and political struggles with the monopolistic British-Canadian Light and Power Co., which held the concession for the nearby city of São Paulo and surroundings.

This power station had a deep impact in the social, cultural and economic history of the region, since the surplus generated by coffee exports were instrumental in the industrialization of São Paulo, at an ever increasing pace since the 1910's. It is a living part of the national electrical heritage, which is not well-known and remains to be better utilized. The processes of designing, building, operating and maintaining this enterprise, as well as the machines, architectural and engineering features, and the role of the technicians and workforce involved there await to be highlighted in the future.

Historical Background

The vital harbor city of Santos in Southwestern Brazil descends from a village founded by the Portuguese in the early 1500's. It was only during the 19th century though,

[1] University of São Paulo, Department of History. The research on small power generating plants, of which Itatinga is an outstanding example) is part of a project on the history of electrification in São Paulo (1890 - 2005), whose first part (1960 – 2005) was financed by the government agency FAPESP (Process 2007/53866-4); funding for the second part (1890 – 1960) has been requested to FAPESP (Process 2012/51424-2).

that the sugar commerce and the increasing importance of coffee exports led the Brazilian authorities to earnestly consider expanding and modernizing that city's port.[2]

At this time Santos was becoming a hub from where the economic modernization of Brazil would be concentrated. The conjunction of economic development of Santos' port was instrumental to further the fantastic growth of the relatively near city of São Paulo and many other inland cities of the State of São Paulo, that would traansform a bucolic landscape in what became known as the "locomotive of Brazil", with its hectic industries and fast growing population. Politically, Brazil had just(1889) changed from a monarchy into a republic, in a peaceful military coup which followed shortly the turmoil of the slave abolition campaign (1888). Coffee plantations in the inland of São Paulo State were linked to the harbor in Santos through the English-built Santos-Jundiaí railway, which was inaugurated in 1867, followed by other railways. Coffee prices were very high, and the good soil of the State of São Paulo gradually replaced coffee farmlands from other places, stimulating the country's largest economic transformation up to now.

Santos' port at the turn of the century was receiving a large quantity of immigrants, mainly from Italy, Portugal, Spain and Japan to work primarily in the coffee plantations, and later in the industries blooming specially in the capital city of São Paulo, in great part as a result of reinvestment of large profits derived from coffee exports. However, yellow fever was epidemic in Santos, which was worldwide notorious, specially in the years 1895-97, causing a high number of casualties. In the lethality ranking yellow fever was followed by malaria, all of which made the harbor unattractive for bringing immigrants to the country [3]. The necessity of keeping the inflow of immigrants arriving through Santos' harbor made it necessary to start solving ancient sanitation problems, and this became one of first public displays of the technical capacity of an increasing body of Brazilian engineers graduated at the new Polytechnical Schools of Rio de Janeiro and São Paulo – they dedicated a great effort to the design and implementation of activities such as sewage disposal, water supply and swampy land recovery, a work undertaken in Santos from 1905 to 1913 [4].

The first decade of the 20th Century witnessed the continuation of exploratory scientific exploration of natural resources. The São Paulo State Geological and Geographical Commission continued the previous survey undertaken during the monarchy and was increasingly revealing unsuspected potential of agricultural lands and rivers to the

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[2] Vargas, Milton. "Construção de portos", in Motoyama, Shozo (org.), *Tecnologia e industrialização no Brasil.* São Paulo, EDUNESP, 1994, p. 71.

[3] Ribeiro, Maria Alice Rosa. *História sem fim ... Iinventário da saúde pública.* São Paulo: EDUNESP, 1993, pp. 51-63.

[4] Vargas, Milton. "Obras de saneamento (abastecimento de água, esgotos e recuperação de terras)", in Motoyama, S. (org.), op. cit., pp. 91-92.

west of the state [5]. In the 1910's and 20's, because of the significant level difference at waterfalls, the rivers were dubbed the "white coal" of Brazil, given the lack of good quality coal in the country [6]. Industrialization was relatively very fast thanks to this form of electricity availability, and even today hydroelectric generation is responsible for most of the electricity generated in Brazil (nearly 76 %) [7].

At the turn of the century international capital had just begun to be invested for the formation of large electrical companies and monopolies in the southwest of Brazil, but this economic movement hadn't yet reached the coastal city of Santos when its modernization was carried out. Long before the industrialization phase, the Brazilian entrepreneurs Cândido Gaffré and Eduardo Guinle had already realized that electric energy was vital for the development of the harbor in Santos, which needed it to operate modern cranes and other heavy machinery, as well to illuminate it for securing night operations. They invested in the construction of power plants in several locations of Brazil, and in 1890 received a 90-year concession to operate the harbor provided they modernized the harbor equipment and administration, to overcome its well known high costs and inefficiency. They incorporated a new company for that purpose, *Docas de Santos*, which managed to inaugurate the first new pier and warehouses in 1892. This was the first Brazilian port where large ships could dock directly at the pier; previously in Santos the larger ships had to anchored 100 m away. In 1891 the new company was authorized to build a hydroelectric power plant up in the steep mountain range of Serra do Mar, above Santos, by constructing there a dam across Itatinga river, which flows down from the highlands at the top of the mountain range towards the lowlands by the seashore. The plant was designed by the Brazilian engineer Guilherme Weinschenk [8], and the civil works began in 1906, and operation was successfully inaugurated in 1910.

Itatinga power plant faced many obstacles for its construction. It was built to channel water through a steep downhill from the dam into a marshy terrain where the only transportation was aquatic. The typical exuberant Atlantic forest vegetation was already a hindrance, and on top of that the region was plagued by the mosquito that carried yellow fever and malaria. The construction demanded opening many kilometers of trails in the dense forest, this preliminary work began in 1904, and the next year it had to be suspended

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[5] Figueirôa, Silvia. *As ciências geológicas no Brasil: uma história social e institucional, 1875 – 1934.* São Paulo: Hucitec, 1995, Chapter 4.

[6] Magalhães, Gildo. *Força e luz: eletricidade e modernização na República Velha*. São Paulo: EdUNESP, 2000.

[7] Ministério das Minas e Energia, *Balanço Energético Nacional 2012.*

[8] Guilherme Weinschenk (1847-1921) graduated as an engineer in Germany, a common pattern during most of the 19th Century before schools of engineering were implanted. He had previously worked in railways, and he was also the engineer in charge of the construction of the new Santos harbor for Gaffré&Guinle. Telles, Pedro Carlos da Silva, *História da engenharia no Brasil*, vol. 1. Rio de Janeiro: Clube de Engenharia, 1994, p. 377.

due to the ensuing malaria epidemics. The sanitation expert Carlos Chagas [9] was charged with the malaria eradication measures. After systematical observation of the local conditions, followed by disinfecting the workers' lodgings and then caulking them, Chagas was able to eradicate the mosquito in three months, and his profilatic method began to be copied and used all over the world [10].

Itatinga is a hydroelectric of the run-of–the-river type, i. e. it uses the river level difference without the need to create a large lake as a water reservoir. Water from Itatinga river is captured where there was already a waterfall, about 800 meters above the sea level, and is then channeled through a three-km rock canal (partly open and subsequently in a more than 2 km tunnel) to two reservoirs (700,000 liters), a chamber with valves to control the flow, and thence through five pipelines (with diameters between 600 mm and 900 mm), until it reaches the turbines and generators at the power plant 640 m down the water chamber, carrying a peak flow of 3600 liters of water per second to produce up to 20 MW of electricity. The original basic equipment, German (Voith) alternators, and American (GE) Pelton turbines are still in use, only modern control and safety equipment have been added. After the conclusion of the pipelines a cable-car service line from the plant to the chamber improved operation and maintenance of the complex.

The plant was built in land that belonged then to the district of Bertioga, and a 44,000 Volt transmission line was necessary to bring the electricity to the port, distant some 30 km away. Two three-phase circuits do this job. A small village was built to lodge the plant workers with 70 houses, including a shop, chapel, medical post, and elementary school. Transportation was and still is difficult in the region. The road from Bertioga to Itatinga stops at Itapanhaú river, which has to be crossed by boat, and from there a small-gauge (800 mm, electric or diesel-powered) tram railway covers the 7 km from the river edge to the Itatinga plant.

With the operation of Itatinga power plant, electricity substituted the steam motors of the harbor. As the generating capacity was larger than the ports' demand, the surplus was commercialized and sold to the twin cities of Santos and São Vicente. The owners of Docas de Santos, Gaffrée and Guinle, and their Brazilian partners saw this sale as a very profitable business prospect, and managed to obtain already in 1909 a concession by São Paulo State to distribute electric energy in the city of São Paulo, the state's capital. They were also interested in electrifying transportation, as in the Brazilian railroads the locomotives ran with imported and expensive coal [11]. Thus the group engaged in a major commercial and

[9] Carlos Chagas (1878 - 1934) was a medical doctor whose famous research led to the discovery of a new disease (named after him) and its vector, an insect known in Brazil as "barbeiro".

[10] Castilho, Ana Luisa Howard de. *Itatinga, a hidrelétrica e seu legado.* São Paulo: Neotropica, 2010. It is the best historical survey of the topic, though it does not discuss the technology aspects.

[11] Later, the railroads continued almost entirely dependent on imported fuel (Diesel oil), and gradually passenger transport was abandoned, finally coming to a halt during the 1970's "oil crises". The remaining

political dispute with *The São Paulo Tramway, Light and Power Co*., also known in Brazil simply as *Light*. This was a major Anglo-American concern, based in Canada, which had rapidly conquered markets in Latin American countries (like Mexico, Cuba and Argentina), besides being present in Canada as well as in parts of Europe (Belgium, Spain, Portugal) [12].

Light Co. sought to consolidate its monopoly in electric generation and distribution, as well as in urban transportation on rails (basically streetcars). The dispute grew beyond São Paulo borders, and caused attrition in several other Brazilian states. *Light Co*. tried to buy out *Docas de Santos*, and exercised a powerful political pressure through the São Paulo State governor and the mayor of São Paulo City for that purpose. *Docas de Santos* resisted and made a bold offer to sell Itatinga's surplus energy to the city of São Paulo, at a much lower price than *Light Co*. However, the pressure continued and after several discussion sessions in the City Council of São Paulo, a decision was reached favoring the monopoly of multinational *Light Co*., and the all-Brazilian partners of Guinle's gave up the attempt to enter this new entrepreneurial field [13].

The plant at Itatinga played a major role in the social, economic and cultural development of the region. Until 1930 it provided all electricity used by the cities of Santos and São Vicente. It also provided energy for the construction in the 1920s of nearby Henry Borden power plant, owned by the former commercial rival *Light Co*, and at this time the largest hydroelectric in the world [14].

The plant nowadays

In 1980 the state-owned CODESP (*Companhia Docas do Estado de São Paulo*) took over Santos harbor's administration, including Itatinga. It has been able to keep conserving the area covered by the plant (some 37 km^2 inside the protected Serra do Mar State Park), and the wilderness of the environment has been preserved, with a minimum

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railroads are overall devoted only to freight, a very atypical situation when compared with other large countries in the world, a situation aggravated because both passenger and cargo transportation are very inefficient in Brazil.

[12] The complex of financial and personal interests in the electrical business world is a quite entangled web, treated in Hausman, William J., Hertner, Peter, and Wilkins, Mira, in *Global electrification. Multinational enterprise and international financing in the history of light and power, 1878-2007*. Cambridge: C.U. Press, 2008. Cf. also Bartolomé, Isabel, *La industria eléctrica em España (1890-1936), in Estudios de Historia Económica*, 50. Madrid: Banco de España, 2007.

[13] Saes, Alexandre Macchione. *Conflitos do capital. Light versus CBEE na formação do capitalismo brasileiro (1898-1927).* Bauru: EDUSC, 2010, p. 89 f. Cf. also "O monopólio contestado", *Boletim Histórico Eletropaulo*, 5, 1986, pp. 5-7. It should be noted that the conflict involved not only electricity generation and application, but also the business of ports, since partners of *Light* were also major stockholders of other Brazilian ports.

[14] The Henry Borden complex in Cubatão (a town located between Santos and the Serra do Mar range) comprises two power plants fed by a water drop of 720 meters, and 14 groups of generators driven by Pelton turbines. The total installed capacity is 889 MW at water flow of 157 m^3/s.

impact [15]. The site displays an exquisite junction of tropical Atlantic rainforest vegetation and a rich mangrove habitat close to the seashore, crisscrossed by many waterways (and a potential for the construction of a set of other hydroelectric plants), springs and brooks. Tropical birds and other animals are also an attraction.

Over a 100 years after its inauguration, Itatinga still supplies power to the port and sells the surplus energy to EMAE, one of the companies that succeeded *Light Co*. after the 1997 wave of privatizations [16]. Thanks to its operation, Santos' harbor did not suffer the severe blackouts in 2001 that affected many Brazilian states. It is altogether impressive that the excellent design and construction have allowed for an installation that still runs today with the original equipment and installations. Currently a renovation contract provides for the application of a new sealing in the rock tunnel. More modern transformers replaced older ones, and a lightning protection system has been added.

The village houses have also been well preserved by CODESP, even after the 1980s the number of required employees at the plant diminished due to modernization efforts. As a consequence very few families now live there but they all still depend on the transportation service provided by the company, i. e . the boat service from Bertioga to the tramway terminal and the respective railway from there to the plant.

Prospects for industrial heritage

The organized inventory based on history, architecture, archaeology, as well as the affective and immaterial relationships of industrial heritage, may effectively contribute to evaluate the worthiness and the role of constructions and implantations for the general public. In a wider perspective industrial heritage may subside the policies towards preservation and use of the respective sites, fostering a better understanding of the past and the importance of its memory,

For the history of technology, industrial heritage carries a scientific and technical value, besides the aspects of architecture and landscape. These values are integrated in the industrial site and its structure, machinery, design, and also personal memories and traditions. The corresponding industrial archaeology should go further than the research about industrial heritage per se, thus expanding this dimension to the evaluation of the meaning of constructions and interventions in the proper context of social history and the history of science and technology.

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[15] Castilho, Ana Luisa Howard de. *Itatinga, a hidrelétrica e seu legado*, op. cit.

[16] *Light Co.* itself was expropriated after a tumultuous process in 1979, after a long series of public complaints against its lack of interest in modernizing and expanding its service. It was subsequently nationalized and subdivided; in 1981 the State of São Paulo incorporated its part of the company, which became *Eletropaulo*, subsequently almost wholly sold to the American AES in 1997.

The International Committee for the Conservation of the Industrial Heritage issued in 2003 the "Nizhny Tagil Charter", containing the principles on the subject, which essentially define industrial heritage as the remains of industrial culture of historical, technological, social, architectural or scientific value. Such remains include buildings and machinery, workshops, mills and factories, mines and processing and refining sites, warehouses and stores, places for energy production, transmission and use, transport and all its infrastructure, as well as the places used for social activities related to industry, such as housing, religious worship or education.

Industrial archaeology is related to industrial heritage insofar as it is an interdisciplinary method to study material and immaterial vestiges, artifacts, stratigraphy, structures, human implantation and landscapes created by industrial processes, to better understand the industrial past and present.

Another point that concerns industrial heritage is the consciousness that any action undertaken in a cultural good depends on the understanding that the present moment has acquired about it; the answers provided by heritage depend on the questions asked, which vary along time. It is therefore necessary to be based on ethical and scientific principles, and not to derive actions empirically solely based on the object, believing as it was common in the past, that the object itself would give all answers, and forever valid. [17]

Specifically for the industrial archaeology of electricity, it is recommended that equipment be situated in its correct technical context, thus avoiding anachronism, or in other words, that it be anchored in the history of science and technology [18]. For this purpose, specialists have recommended a field work capable of performing the activities of inspection, investigation, registry, and preservation of the objects. This action should be extended to the people involved in the heritage, including entrepreneurs, engineers, workers, and their families.

- Inspection needs techniques for measuring, photographing/filming, and dating for keeping the features of objects (constructions, equipment, tools).
- Investigation implies research and evaluation of objects that may contribute to the understanding and conceptualization of an industrial past.
- Registry is the formalization of collected information (physical or virtual) in a patterned archival instrument.
- Preservation is the main objective of producing an inventory. Through divulgation of information on industrial heritage preservation is possible inasmuch as it succeeds as a basis for respective public policies.

[17] Kühl, B. M. "Patrimônio industrial: algumas questões em aberto". *usjt - arq.urb*, 3, 2010: 23-30.
[18] Guedes, Manuel Vaz. "Arqueologia industrial", *Electricidade*, 372, 1999, pp. 293-299.

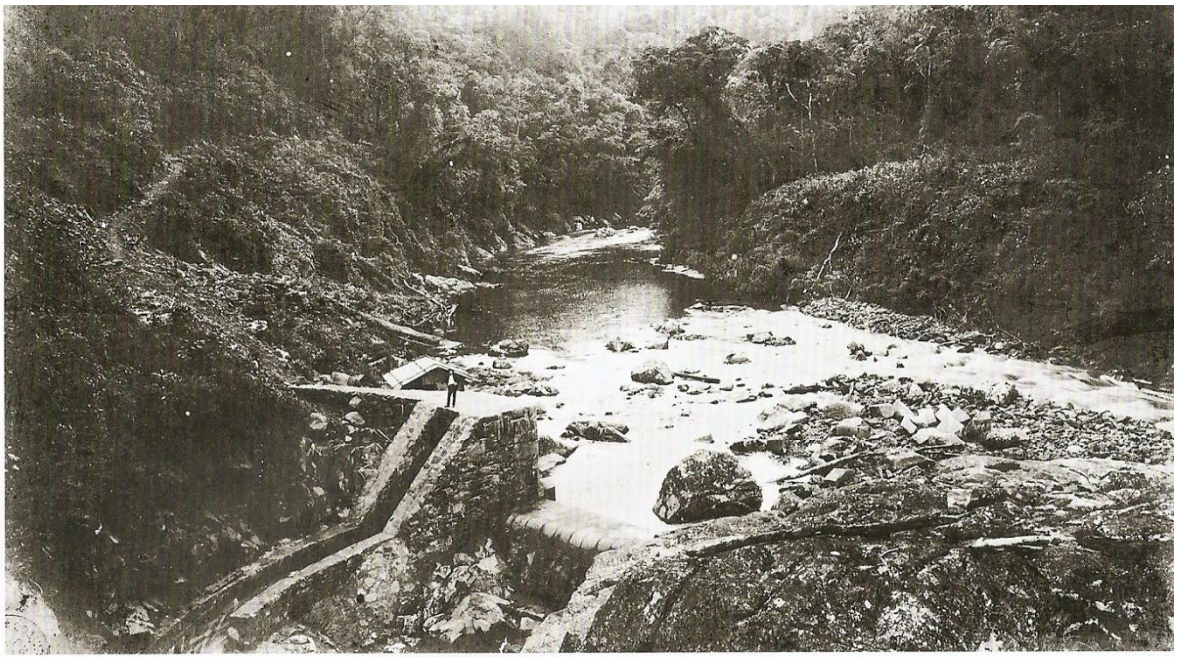
Of course, Itatinga power plant, including its forest environment, the village, tram, boat piers, and transmission lines, fulfills all these requisites and is an excellent candidate for industrial archaeology. In the case, this must be based on the history of electricity and the history of technology of its turbines, generators and transformers. As mentioned above, the objects contained in the complex are not clear enough for the layman, and this becomes patent during visitations. Tools, equipment, constructions, techniques, design at Itatinga should all fit into the required approach of industrial heritage and archaeology.

The power house at Itatinga has already been declared a historical landmark by the State of São Paulo. Access is strictly controlled by CODESP (the port authority), which allows group visitation coming from the seashore side using the company's boats and tram, or for people hiking nature trails down the mountain range from the plains above. On the other hand, Itatinga is a rare example of a fully living testimony of past technology. Doubts about the future ownership of the plant, due to constant changes in the governmental rules for concession and marketing of electricity might jeopardize any attempts to conduct a model project of industrial archaeology *in situ*.

Images [19]

Map of Itatinga power plant and transmission line to Santos

[19] The power room picture is by the author, while the others are from Castilho, Ana Luisa Howard de. *Itatinga, a hidrelétrica e seu legado,* op. cit.

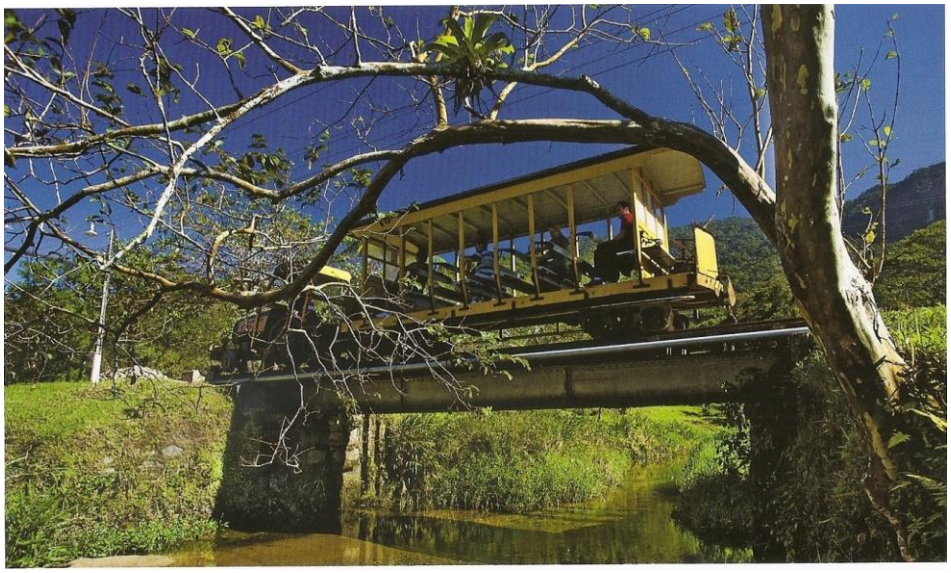


Construction of the dam around 1905-6

Itatinga dam nowadays

Cablecar track alongside pipelines from water chamber to plant

Turbine and generator room in use since 1910



Above: transmission line. Below: the tram used for transportation of power plant personnel and their families

View of landscape from the tram on the way to the plant

A typical house at Itatinga village