SUSTAINABLE VALORISATION OF THE NETWORK OF HYDROPOWER PLANTS OF ITALIAN ALPINE VALLEYS

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Summary

Hydroelectric power plants were built in the 19th and 20th century, designed by famous architects, and most of them are still functional. Their importance as industrial heritage derives from their technological and architectural features, and from their landscape location. In each Italian Alpine valley many plants have been built within a few kilometres, forming a repertoire of industrial archaeology and eclectic and modern architecture. The proximity between the various complexes stimulates their valorisation as emerging elements of a tourist route constituted by the ways and waterways that innervate each valley. The interventions of conservation and valorisation must follow a sustainable approach that should not destroy the memory of industrial heritage, and must create accessible and safe itineraries between and inside the plants.

Keywords: industrial heritage, hydroelectric power plants, Italian Alpine valley

1 The spread of electricity in Italy

Since Middle Ages water has been used as motive power for mills, sawmills, forges, etc.

Despite the technological innovations in the field of water wheels and turbines occurred in the first half of the 19th century, in Italy the restriction on the location of industrial plants in proximity to large water flows and hydraulic jumps, together with the lack of fossil fuels prevented the start of industrial development that had characterized other countries [1]. The first Italian power stations were coal plants and were built in the 1880s (e.g. Milanese St. Radegund power plant of 1884), but the high costs of produced energy reserved its use almost exclusively for public lighting [3].

In Italy the industrialization started to spread in the major cities of the northern regions only in the 1880s, when the rail network consolidated thanks to the post-unification investments. However, during this period, industrial development was held back by the "energy bond", the cost of coal was very high (in Milan it was three times higher than in England), and the major cities (in particular Milan) lacked of hydraulic energy. These economic factors disadvantaged the development of large-scale city industry [2].

Nevertheless in the meanwhile, between 1880 and 1890, processors began to be produced on an industrial scale spreading the use of alternating current and allowing to realize power lines capable of transporting the electricity a great distance [3]: in fact processors allow to raise the operating voltage of the alternating current plants and thus to reduce the dissipation of energy in the form of heat, significantly increasing the electricity's efficiency of transport. The possibility of long-range transmission of electricity made the

exploitation of the large amounts of water of the Alpine valleys economically advantageous, and promoted greater industrial development and economic growth of northern regions since the last decade of the century [4].

In the years before the First World War, a comprehensive project of exploitation of the potential of river basins was outlined [5], and the energy produced by coal plants is progressively replaced by hydroelectric energy. The difficulty of coaling experienced during the war made aware of the precariousness of the Italian industry who lacked a safe source of energy, therefore in the postwar period the country invested significantly in the construction of new dams and new power plants.

The continuous progress of the turbines and hydraulic systems was not followed by significant changes in the architectural types of power plants [1, 5], which were designed as simple building envelopes. Only since the 1930s underground power station began to be built diffusely with plants placed inside the mountain [5].

2 The electric heritage

Hydropower plants constitute a built heritage which is of great historical technological and energy importance: they were built mainly between the late 19th and first half of the 20th century and they are often quite large; their hydraulic, mechanical and electric systems were designed by engineers, while the plan of their building envelope was assigned to eclectic architects that gave the buildings a style typical of the time.

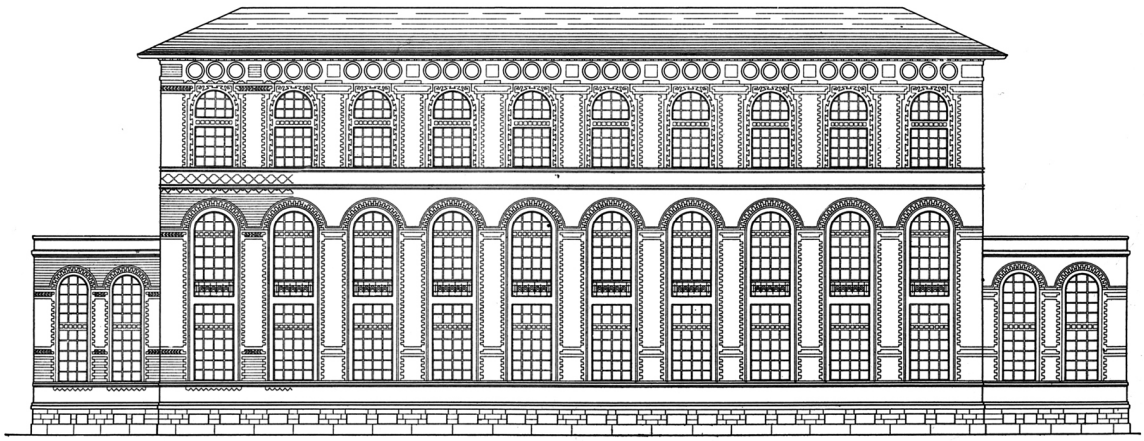

Fig. 1 *Drawing for the project of the hydropower plant of Grosotto (1907), attributed to the eclectic architect Gaetano Moretti (1860–1938).*

The plants take on the appearance of a crenellated medieval castle, of a fortress, of a palace, of a cathedral, they took Gothic and neo-Renaissance style, with vernacular or liberty hybridizations and polychrome geometric decorations [6].

They were built in isolated locations along paths separated from the valleys daily life, visible only from afar, they celebrated in a symbolic way the myth of progress and electricity and the greatness of the technical innovations, without communicating outside the inner workings and the grandeur of the machinery [7].

Although they clearly stand apart from the architectural context, often consisting solely of rural houses and small towns, the quality of the architectural choices of the designers and the use of local materials and stones create a meaningful dialogue with the surrounding landscape.

The interiors were often well-refined and designed with attention to detail, using high quality flooring materials, etched wall decorations, wrought iron railings and lamps, stained glass windows, scenic staircases built as balconies overlooking the play of energy, performed in the large engine rooms with the humming noise of the turbines [7].

There is still no complete and systematic inventory of the built plants, but the available documentation is extensive: the companies retain in their archives (often available to scholars) a rich written, drawn, photographic and cinematographic documentation of the plans and of the underground and surface building works [6, 8], real challenges of the construction technique: large amounts of workers were employed for long periods in extreme working conditions, temporary isolated villages were constructed in the Alpine valleys in which dams, underground pipes, and plants had to be built.

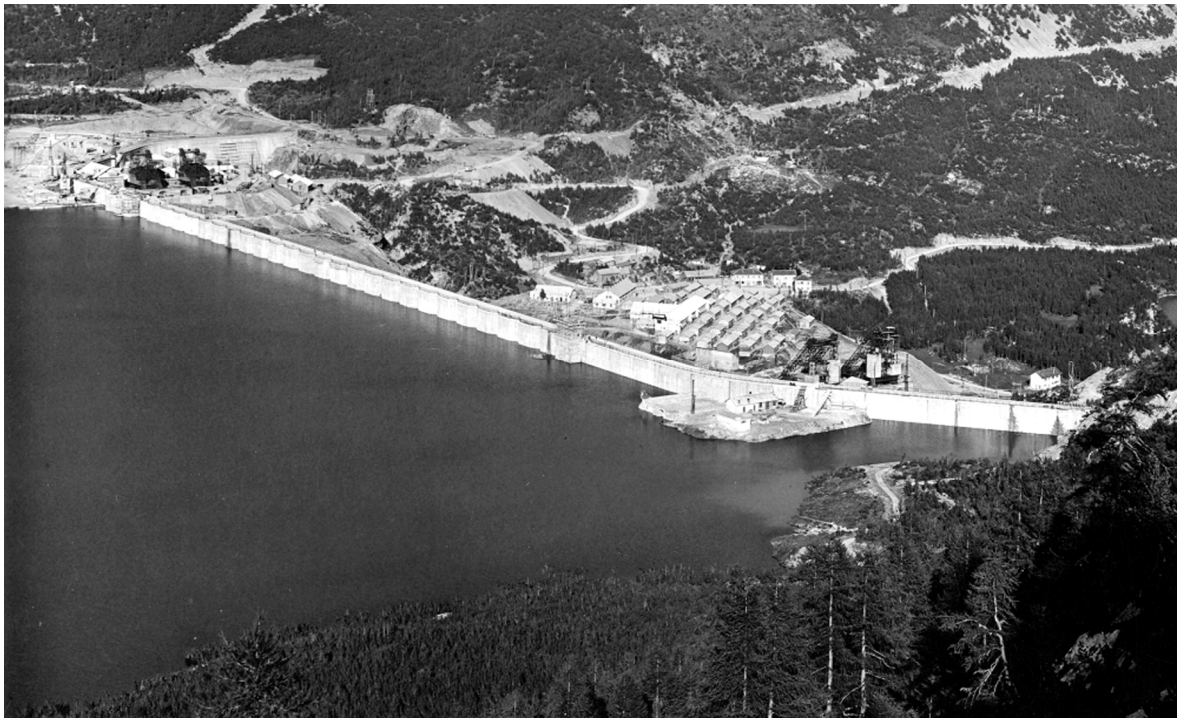

Fig. 2 *San Giacomo's dam in the upper Valtellina (completed in 1950). Downstream of the dam, Digapoli can be see: it's the village specifically built to house the labour force employed in the construction of dam and hydraulic systems.*

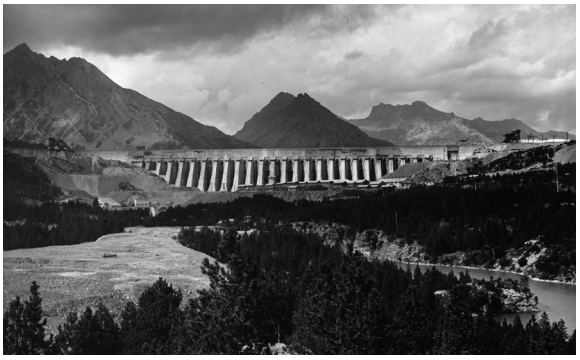

Fig. 3 *A view from downstream of the San Giacomo's dam with its huge buttresses.*

Fig. 4 *Poor working conditions inside a cave destined to lodge pipes (1952).*

3 The system of hydroelectric power plants in Valtellina

An emblematic case study of the phenomenon of territorial conversion promoted by the exploitation of hydroelectric power is the Valtellina, a valley rich in water in northern Lombardy carved by the river Adda (about 120 km long, with a surface area of 3˙212 km^2), whose catch basin still supply with water a widespread network of hydroelectric plants. Until the beginning of the 20th century the valley was a poor and isolated territory plagued by seasonal migration, with an agricultural economy based on the cultivation of the grapevine in the terracing laboriously obtained from the slopes.

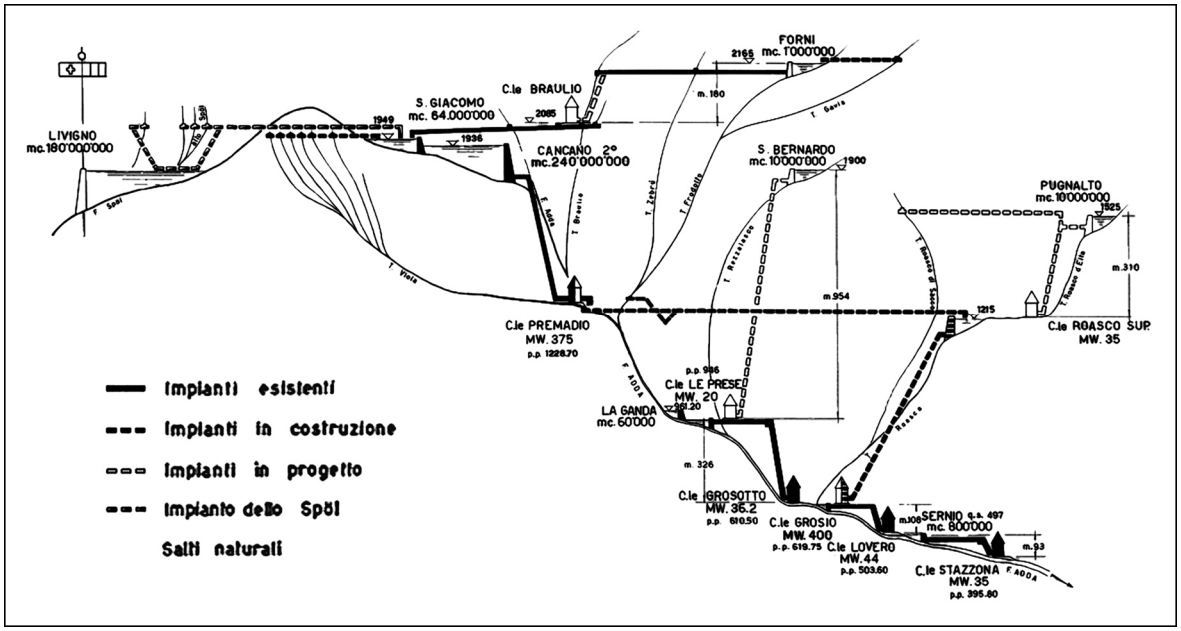

Fig. 5 *Scheme of the hydroelectric exploitation of the high Valtellina catch basin by AEM (1960s).*

Hydropower broke into the valley, after the construction (1899–01) of the first plant in Campovico (municipality of Morbegno), and modified the land use, transforming local economy and initiating a rapid modernization process [6, 8]. The business groups that invested in energy development in the early 20th century – the Società Idroelettrica Italiana, the Edison, the Società Anonima Acciaierie e Ferriere Lombarde (Falck), the Azienda Elettrica Municipale of Milan (AEM) – divided the territory by purchasing from municipalities water concessions granting for hydropower use.

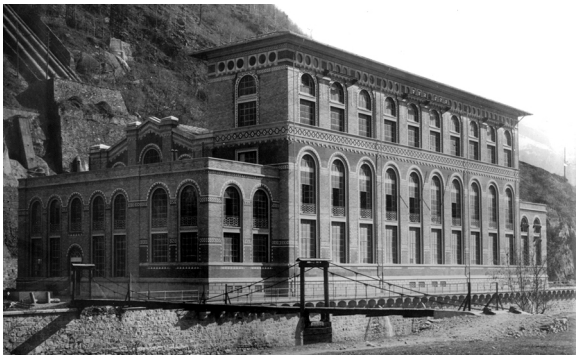

Fig. 6 *The Grosotto plant in the early 1930s.*

Fig. 7 *The Grosotto plant today. The upper part of the building has been demolished in the 1930s as a result of a change in the plant.*

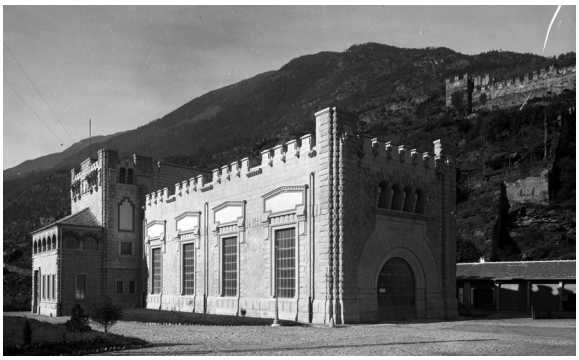

Fig. 8 *The Roasco plant (1918–22) designed by architect Piero Portaluppi, on the foothills of the Visconti castle, with which it seeks a dialogue through the use of crenellation.*

Fig. 9 *Turbine hall of the Roasco plant in the 1930s. At the opposite end of the roomthere is the control room overlooking the turbine hall.*

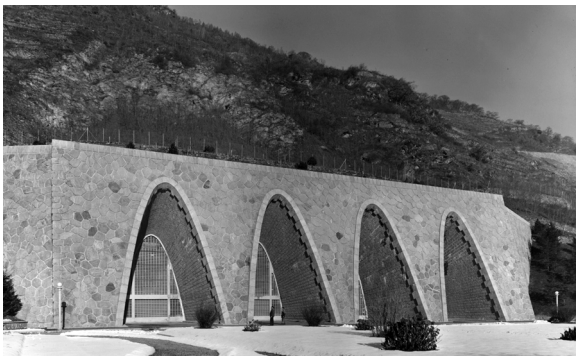

Fig. 10 *The Lovero plant (1942–48) built inside the mountain.*

Fig. 11 *Alternators hall of the Lovero plant.*

Fig. 12 *Alternators hall of the new Grosio underground plant (1956–60).*

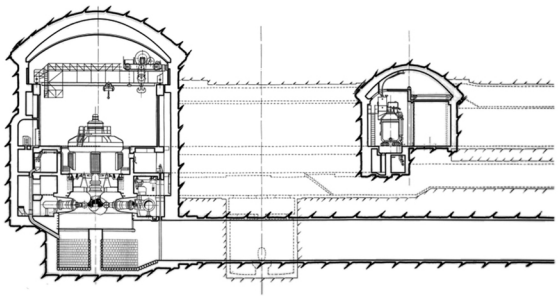

Fig. 13 *Section of the Grosio plant: on the left the hall of turbine and alternators, on the right the hall of transformers.*

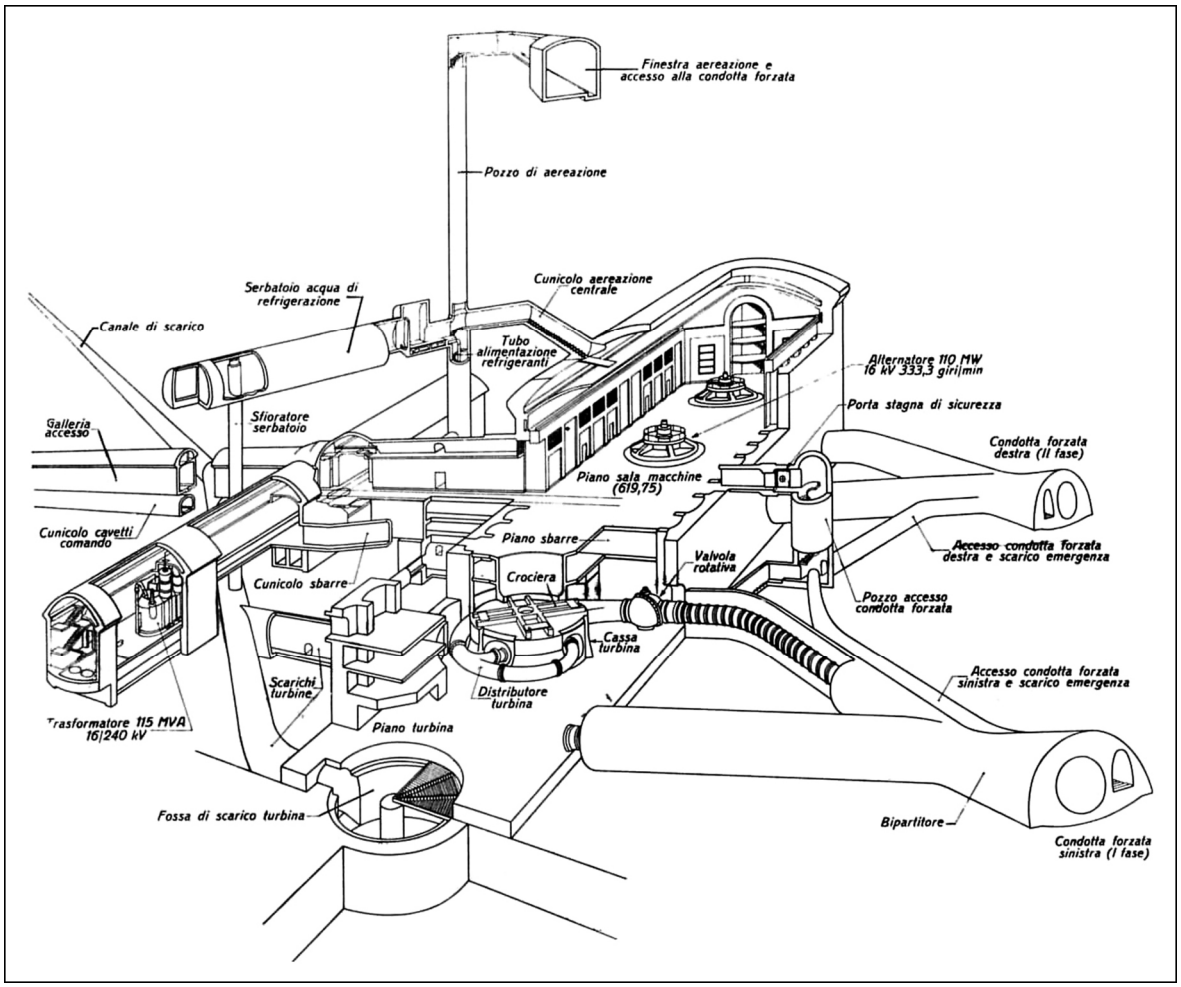

Fig. 14 *Perspective cutaway of the Grosio underground plant.*

In Valtellina the network of AEM (the Municipal Energy Enterprise of Milan founded in 1910 and absorbed in 2007 by A2A) is of particular interest [3]. The company realized its first power plant in Grosotto (1907–10), whose building is attributed to the architect Gaetano Moretti; it exploits a water jump of 318 m (maximum discharge of the pipes 3˙700 l/s), and it is connected to Milan with a 150 km long power line [6]. In a few

decades, AEM created a system for the water exploitation of the upper valley, which from Livigno at 2190 m above sea level comes down to Tirano (394 m), going from the reservoirs of San Giacomo (1950 m) and Cancano (1900 m) through penstocks, tunnel paths, waterfalls and a series of subsequent settling basins, surface or underground hydropower plants, and transformers [3, 6].

The temporal sequence of the construction is uninterrupted: after the first plant built in Grosotto, the plant of the upper Roasco river next to the town of Grosio – no more in function – designed by architect Piero Portaluppi (1918–22) clearly communicates with the Visconti castle that dominates it; the no longer functioning plant of Fraele (a small secondary valley, 1928); the plant of Stazzona (in the municipality of Villa di Tirano, 1938); the plant of Lovero (1942–48) built inside the mountain as the one in Premadio (1956); the new plant of Grosio that that replaces the previous one and coordinates the whole system of plants, dams, and pipes from a unified control centre; and the Braulio plant in Bormio (1986).

Throughout the Valtellina 72 hydroelectric power plants are now present belonging to different companies, which are part of the Consortium of Municipalities of the mountain catchment of the river Adda: about the 43 % was built before the Second World War, the 30% between the end of the war and the 1970s, the 27 % since the 1980s.

Energetic industry exported energy out of the valley, but brought benefits in terms of water management, employment, start of local industrial businesses, and roads' upgrading, paving the way for the tourist exploitation of the territory.

Fig. 15 *The aboveground building of the Grosio plant that houses the control room of the whole hydroelectric system of A2A in Valtellina.*

Fig. 16 *The original control room of the Grosio plant, now replaced by an automated electronic control center.*

4 Preservation and enhancement

The enhancement of this industrial heritage, witness of man's ability to turn to his advantage and to use the forces of nature, is only possible by providing it for a new usability in respect of energy production and landscape. This process must be based on a thorough understanding of documents and artefacts, the assessment of the state of preservation, the interpretation of the environment, in order to find new functional solutions compatible with the preservation of the existing structures.

The museum fruition of symbolic places of technical innovation allows you to save power plants from abandonment and oblivion and the explanation of technical features of a machinery in its original context has great communicative power.

The linear and close distribution of hydropower plants along an Alpine valley allows their fruition by means of slow and non-invasive journeys in the landscape, leading to recognize their significance not only in local history, but also in the history of energy, industrial development and human achievements. Furthermore this kind of travel in the territory allows to reread the relationship between nature and technology, and to understand the cycles of water and energy.

For example a pedestrian and cycle route is already existent in the cited valley: the *Sentiero Valtellina*, along which power plants are easily reachable with short detours; some power plants of particular interest and architectural value can be made accessible also inside thanks to the breadth of the engine rooms and to the presence of areas vacated due to technical evolutions (e.g. the remote control of installations). The presence of still operating electrical and mechanical systems, however, impose a series of security and usability measures: compliance with the safety standards for workplaces, the creation of marked and protected footpaths to prevent potential hazards to visitors, the assessment of appropriately sized escape routes and exits; the use of effective solutions to ensure accessibility for all. The addition of new services – wardrobes, spaces for the consultation of technical or information documents, projection and conference rooms, spaces for stop and rest – can make stable and safer the fruition of these plants, some of which are already open to the public on specific days.

Fig. 17 *Panoramic view of the Valtellina: in the foreground you can see rural buildings overlooking the valley. The valley is innervated by a series of longitudinal paths that can be exploited as cycling and hiking trails.*

Leading electrical companies already dedicate specific days to guided tour for schoolchildren, whose organization may be extended and entrusted to environmental organizations or voluntary associations. Nowadays it would be very important to spread the knowledge of these technical realities; indeed the use of renewable energy (among

which water has primary importance), the diversification of energy sources, the consumption optimization and the technical innovation can become a new driving force for sustainable development.

5 Conclusions

The hydropower plants built up to the mid-20th century were designed with architectural quality, attention to detail and high quality materials; in still operating plants, the technical evolutions have decreased and sometimes reduced to zero the number of worker present in the plants, making the maintenance of the building an unnecessary burden for companies, who care to keep in efficiency only facilities.

The creation of visit paths in hydroelectric plants can spread the understanding of the architectural and technological values of these artefacts, promoting awareness of the social, economic and cultural role they played and still play, furthermore the periodic presence of visitors would favour the execution of minimal but essential acts of care and maintenance which can guarantee the preservation of the buildings.

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