A Case Analysis of Historical Approach to First Hydro Power Project with Long-Distance Power Transmission in Japan, From British-Japanese Hydroelectric Co., Ltd. to Ikawa Dam Construction

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Abstract: Oigawa river is a Class A river in Shizuoka prefecture and one of the longest rivers in eastern Japan (168 km). In this river catchment area, 14 hydropower plants were constructed since 1906. These total capacities are approximately 611 MW. Out of these 14 hydropower plants, 12 plants have dam based and 2 are run of river type.
This paper aims to show a development history of Oigawa river catchment area clearly, based on a text analysis and fieldwork on site. Because, there are original source on hydro technology in Japan here, which were transferred technology from British and U.S.A to Japan. Therefore, it will be tried to re-construct the history about emerging of Japanese hydropower technology and its evaluation.

Keywords: Hydropower Plant, Dam Based Hydropower, Japanese Hydropower

1. Introduction

Japan first large hydropower plant was the"Ikawa Umeji Project" planned by British-Japanese Hydroelectric Co., Ltd. in 1906. The project was built on a 100 m high dam and transmitted power to Tokyo and Yokohama.
Although the concept fell down in 1910 due to economic and technological problems. After that, the project was restarted 50 years later in 1957, with the construction of the Ikawa and Okuizumi power plants. Why did the project fall down and how the problem was solved? Further, many hydropower plants had been built on the Oigawa river catchment area where the first project was constructed. In this paper, we will discuss the history of the hydropower plants that were installed on Oigawa river catchment area and together with the development of the hydropower. We will discuss the overseas and domestic situation to make it success.
First, I will introduce the previous study and related documents on this paper. There are "Oigawa River: The History and Development" and "Ikawa Power Plant Construction Documents" published by Chubu Electric Power as documents on hydropower development in the Oigawa river catchment area. Moreover, the Chubu Electric Power Inc. business includes "Chubu Electric Power 10-Year History" and "Chubu Electric Power 20-Year History". Documents for the power business in the Chubu region include "Power Business History in Chubu Region" and "Civil History in Shizuoka Prefecture", which summarizes the history of civil engineering in Shizuoka Prefecture. For the power business in Japan as a whole, refer to "Dynamism of the Development of the Japanese Electric Power Industry" written by Takeo Kikkawa and "Modern Japanese Civil History Second Edition" written by Yutaka Takahashi.
According to the previous study, there was "British-Japanese Joint Venture Power Company After Rosso-Japanese War: About British-Japanese Hydroelectric co., Ltd" written by Takeo Kikkawa that revealed the concept of British-Japanese Hydroelectric Co., Ltd. from the perspective of economics and management since the beginning to the fall down era. There was also another one called "Genealogy Development of a Huge Power Sources in Korea: From Oigawa River to Pujon river" written by Ryuichi Tanigawa that revealed the relationship between British-Japanese Hydroelectric Co., Ltd and hydropower development in Korea. Last one, "Introduction of Technology in the Electric Power Business" written by Kohei Hamada

and Kiichi Takahashi talked about overseas technology related to the power business after World War II.
In this paper, we will discuss the history of hydropower development in the Oigawa river catchment area in three major periods. Chapter 2 will contain the development history until 1930. Chapter 3 will contain the development history until World War II, chapter 4 will contain the continuation up to after World War II.
In chapter 2, we will focus on British-Japanese Hydroelectric Co., Ltd. This company was very advanced in Japan at that time. In chapter 3, we will consider the relationship between Anzaemon Matsunaga and the hydropower development in the Oigawa river catchment area. In chapter 4, we will consider how to develop the technology that will support the construction of the Ikawa dam.

2. Hydropower development until 1930

2.1 Summary of British-Japanese Hydroelectric Co., Ltd.

An important part of the hydropower development until 1930 in the Oigawa river is the concept of British-Japanese Hydroelectric Co., Ltd. The company began this concept in 1906 and fell down in 1910. However, the concept had 4 features which include: 1. First large-scale hydropower development with the long-distance transmission; 2. Aiming to form a joint investment between Japanese and British; 3. The capital was larger than Tokyo Electric Power, which was the largest power company in Japan at that time(Takeo Kikkawa 1983 pp.48); 4. It was the highest earth dam in the world at that time with the height of about 100 m. Therefore, we will consider the concept of British-Japanese Hydroelectric Co., Ltd.
British-Japanese Hydroelectric Co., Ltd began to apply this concept in 1906(Chubu Electric Power Inc. 1961 pp. 372). At that time, many positive effects immediately came after the end of the Russo-Japanese War and the British-Japanese alliance on the post-war economic recovery in Japan. Therefore the possibility of introducing foreign capital to the establishment of the company increased(Chubu Electric Power Inc. 1961 pp.373). The opposite from this background, it was decided to establish together with the British White Company. Moreover, British-Japanese Hydroelectric Co., Ltd. was launched for power transmission to Tokyo and Yokohama, and when the company has not established yet, the company signed a subcontract to supply 10,000 kW in 1910 and after 1944 they signed again to get 15,000 kW supply to the Tokyo Electric Power company. The subcontract was concluded because there were many representatives from various committees and they had a strong backup(Chubu Electric Power Inc. 1961 pp.391-392).
White Company dispatched Howells(Julius Merriam Howells, 1859-1927)(Ryuichi Tanigawa 2017 pp.386), a direct hiring engineer, and selected the development site by using the geological map. At this time, he conducted a comparative survey of power generation points(Tonegawa River, Kidogawa River, Katsuragawa River, Fuji Five Lakes, Tenryugawa River) within 150-miles circle around Tokyo. Then Oigawa was selected(Chubu Electric Power Inc. 1961 pp.373). He also discovered the “Sawarajima Homura Plan", which later changed to Tashirogawa No. 1 and No. 2 power plant(Chubu Electric Power Inc. 1961 pp.374). Kosaburou Unno, who came from the owner’s house in Ikawa village, met and talked with Dr. Keijiro Kishi, and found that Sessokyo was a suitable place for hydropower generation. Beside that, Howells and Schuyler(James Dix Schuyler, 1848-1912)(Ryuichi Tanigawa 2017 pp.387), which was also being dispatched from White Company studied and made the plan “Ikawa

Umeji Plan"(Chubu Electric Power Inc. 1961 pp.374). With these subordinate roles, they considered to change the "Ushinokubi Plan" to became the Oyama Power Plant.
Schuyler entered Ikawa Village in 1908 to create the "Ikawa Umeji Plan". Schuyler did survey in Ikawa Village for about a month. He made a written opinion on the power generation plant, and submitted it to White Company(Chubu Electric Power Inc. 1961 pp.374). This plan was about 100 m height dam that has already mentioned above. However, when this power generation plan was announced in May 1908, the residents on the downstream coast worried about the dam will be collapse and this thing caused an opposition. Koichi Furuichi, the civil engineering supreme authority in Japan at the time, he was together with Shuzaburo Nakayama in the August Federation of 1908 "Opinion for Oigawa Hydro Power". There was a description that "We never allow the height of the dam to be 100 m upright". The knowledge of Japanese engineers was delayed, and they think that only domestic engineers were opposed, but the British capitalists also asked for the opinions from British civil authorities, but they didn`t agree with it (The Deceased Baron Furuichi Memorial Society 1937 pp.181-182), and the British engineers also did not agree, they thought there was a technical problem with this plan.
Moreover, Schuyler quoted in the plan, "Necaxa dam in Mexico was causing a massive landslide accident on the dam during construction on May 20, 2009. A large accident occurred at an advanced overseas site with the same type of dam that was large but still smaller than Ikawa". Regarding the plan, Tanigawa said, "It can not be denied that American engineers have made a semi-forced plan to reveal their ambitions in undeveloped land in Japan."(Ryuichi Tanigawa 2017 pp.390). Because of that, the Ikawa dam construction plan of British-Japanese Hydroelectric Co., Ltd. was seen as an unprecedented large plan. There were many questions about safety and feasibility.
In addition to these technical problems, at that time in Japan, the economic crisis in 2007 triggered a bad effect after the Russo-Japanese War, and there was severe financial pressure"(Takeo Kikkawa 1983 pp.50), and the British side did not understand the difference between Japanese and British stock offering methods, and was unable to offer stock in July and August 1908. They failed to solicit shares, making it difficult to establish British-Japanese Hydroelectric Co., Ltd.. After that, the Japanese founders carried out various plans for the establishment of British-Japanese Hydroelectric Co., Ltd., such as a capital investment plan centered on the UK. They also made a plan to establish a large parent company in the UK, and joint plan with Kidogawa Hydro Power Co., Ltd. However, everything was unsuccessful and the concept of British-Japanese Hydroelectric Co., Ltd. fell down(Takeo Kikkawa 1983 pp.51-59).

2.2 Long-distance power transmission technology

There was another technology to consider in the 1906 plan. By the time until 1906, major electric power companies such as Tokyo Electric Power Co., Ltd, Osaka Electric Power Co., Ltd., and Nagoya Electric Power Co., Ltd. would construct a small-scale thermal power plant near the city center, mainly for the demand for electric lights in the city. This can happened because long-distance transmission technology has not been established. The first long-distance transmission with a high voltage of 50,000 V or more was found in the 1900s in the U.S.. It was in 1905 that Tokyo Electric Power Co., Ltd. conducted the first actual survey as a Japanese company. Based on the research report, Tokyo Electric Power Co., Ltd. constructed a Komahashi power plant with an output of 15,000 kW in the Katsura River catchment area in Yamanashi Prefecture, and did the transmission for 76 km to Tokyo with a voltage of 55,000 V. The Komahashi power plant was completed in December 1907(Takeo Kikkawa 2004

pp.55). In other words, British-Japanese Hydroelectric Co., Ltd. conducted a water survey on the premise of long-distance transmission of 150 miles (about 240 km) in 1906, when the long-distance transmission was not yet established in Japan. From here, it can be seen that the British-Japanese Hydroelectric Co., Ltd. had an advanced plan.

2.3 Oyama power plant and Jina power plant

The plan from British-Japanese Hydroelectric Co., Ltd. Was not good and it went bankrupt. At the same time, the British-Japanese Water Electricity Co., Ltd. Was the only founders in the Japanese side, Oyama power plant is a first hydropower plant in Oigawa river catchment area. The Oyama power plant was a model of the Ushinokubi plan which was designed by engineers such as Howells and Schuyler. The output of the Oyama Power plant was 1,400kW, and it was completed in December 1910. The power plant constructed at the same time as the Oyama Power plant is the Jina Power Plant(Chubu Electric Power Inc. 1961 pp.423). Jina power plant was built in 1910 by Tokai Paper Co., Ltd. Since July 1910, Tokai Paper's ground-wood factory was built in Shimada, and until the Jina power plant was built, they had purchased electricity from the British-Japanese Water Electricity Co., Ltd. However, Tokai Paper planned to generate its power and built the Jina power plant for the ground-wood factory. The output of the Jina power plant was 2,250 kW(Chubu Electric Power Inc. 1961 pp.424).
The hydropower development in the Oigawa river catchment area until 1930 is the concept of British-Japanese Hydroelectric Co., Ltd., the Oyama power plant, and the Jina power plant, that have been described so far. After this, development did not progress easily because the suitable points for the power plant in the Oigawa catchment area were far from the existing transportation infrastructure, making it difficult to transport the materials. In the next chapter, the solution to that problem and the hydropower development until World War II will be explained.

3. Hydropower development until World War II

3.1 Summary of hydropower development in the Oigawa river catchment area before World War II

As mentioned at the end of the previous chapter, in the Oigawa river catchment area, the problem of the material transportation was so big that the development was difficult. The suitable points for the development of the Oigawa river were concentrated upstream, and the distance to carry large amounts of construction materials such as concrete was long. However, at that time, the area around the Oigawa river was not equipped with the transportation infrastructure, and even roads were not well-developed. Oigawa Railway was built to solve this problem. Today, the Oigawa Railway is popular among tourists due to steam engines, but actually it was created for the hydropower development. The Oigawa Railway was opened in 1931. The construction of this Oigawa Railway was the most important matter in the Oigawa river catchment area development in that period. Along with the construction of the Oigawa Railway, many power plants were built.

3.2. Anzaemon Matsunaga and Oigawa Railway

Anzaemon Matsunaga was a person who is called the "Power Demon" in Japan and has great achievements in the power business. He was involved in the establishment of various electric power companies, and during the restructuring period of the Japanese electric power industry after World War II, he promoted the regional division of power distribution. He was also

involved in Oigawa development. He was also involved in the construction of the Tashirogawa Daiichi Power Station, the Tashirogawa Daini Power Station, and the Oigawa Power Station in the Oigawa Development, but the biggest one was the construction of the Oigawa Railway. As the president of Oikawa Electric, he was planning to build an Oigawa power plant. However, there was no transportation to get up and down the Oigawa River. For this reason, there was a proposal to construct the Oigawa Railway, but it required enormous funds, struggling to procure it, and no one could construct it. He broke through the situation. He succeeded in raising 1.5 million yen in the Oigawa region and 4.5 million yen in Tokyo(Chubu Electric Power Inc. 1961 pp.425-426).

Matsunaga took the lead and opened the Oigawa Railway. The opening of the Oigawa Railway was a very big matter in the history of Oigawa development. This was because of the important problem in the development of Oigawa was the material transportation problem. Therefore, when the Oigawa Railway was opened, power plants were built one after another. The power stations constructed by the opening of the Oigawa Railway were the Yuyama Power Plant, the Oigawa Power Plant, the Oma Power Plant, and the Kunowaki Power Plant. Details of these power plants are summarized in Figure 3. Along with the construction of these power plants, the development of the middle stream of Oigawa has made great progress. Upstream and downstream development will be constructed after World War II.

4. Hydropower development after World War II

4.1 Summary of hydropower development in the Oigawa river catchment area after World War II

In this chapter, Ikawa dam construction, which was the largest development of Oigawa, will be described. Ikawa dam has been planned since the days of British-Japanese Hydroelectric Co., Ltd., and various people and power companies have tried to build it, but it was not built until after World War II. The biggest reason why the dam could not be built so far was that it was large. Furthermore, Ikawa Village, where Ikawa dam was constructed, was facing a problem of the material transpiration because it was in a very poor location. Moreover, the construction of the Ikawa Dam caused a problem that 190 houses and forests, about 2.8k ㎡ (about one-third of Ikawa Village) were submerged(Chubu Electric Power 10-Year History Editorial Committee 1961 pp.636).

The construction of the Ikawa dam required the construction cost of the dam and the extension of the tunnel for material transportation and a guarantee that the village would not be submerged. For this reason, the Ikawa dam construction was known to require enormous funds. But it was still worth building. This was because the construction of the Ikawa dam not only generates enormous power at the Ikawa power plants and Okuizumi power plants but also increases the amount of power generated at the downstream power plant, which has already been constructed, due to the stabilization of the downstream flow rate. For these reasons, the Ikawa dam construction was regarded as the most important point for hydropower development in the Oigawa river catchment area, and construction was awaited. It was Chubu Electric Power that achieved the construction of the Ikawa dam.

4.2 GHQ reform after World War II and the improvement of hydropower technology

Before considering the Ikawa dam, I would like to clarify how Japanese people have acquired the huge dam construction technology that has been an issue since the days of British-Japanese Hydroelectric Co., Ltd. The 1950s was the time when the Ikawa dam and huge dams are being built nationwide. For example, the Kurobe dam and Sakuma dam were also constructed during this period. Why were the huge dams being constructed throughout the country during this period? One of the factors that can be considered was technological innovation.
Regarding to the technological innovation, two major technological innovations occurred during this period. It was the improvement of hydroelectric power generation technology through the introduction of overseas technology and the improvement of construction efficiency through the introduction of heavy machinery. These two innovations have allowed huge dams to be built at an unprecedented speed, which could not be built before. Why did this innovation can happen?
The background of these two innovations were the GHQ policy. Among the GHQ policies, the one related to this technological innovation was the establishment of the "Foreign Capital Law". Because of this establishment, in 1950 it became possible to actively introduce foreign capital and excellent technologies(Kohei Tomita, Kichi Takahashi 1963 pp.23). As a result, hydroelectric power generation technology had been improved and large-scale hydropower plants were constructed. GHQ has sent Overseas Consultants, Inc. (OCI) to various hydropower sites in Japan to provide direct technical guidance.

4.3 Installation of heavy machineries and construction of Sakuma dam

The introduction of overseas technology was described in the previous section, however, there was another important technological innovation behind the rapid construction of large-scale hydropower plants. That was the introduction of heavy machinery. The first heavy machinery that was introduced at a Japanese hydropower construction site was for the construction of the Sakuma power plant. The power plant was built on the Tenryu River, about 40 km west from the Oi River. The construction of the Sakuma power plant was started in April 1953 by Electric Power Development Co., Ltd. The dam was completed in August 1955 within 2 years and 4 months. This was a shortest construction period at that time(Yutaka Takahashi 2007 pp.144).

The Sakuma dam construction site looked completely different from the construction sites of the conventional dams and was like an exhibition hall for large civil engineering machinery. The success of the mechanized construction were changed not only the subsequent dam construction but also the scenery of all large civil engineering projects. Therefore, it can be said that the Sakuma dam not only revolutionized the dam construction method, but also revolutionized the entire civil engineering method in Japan, and even revolutionized the entire civil engineering method in Japan(Yutaka Takahashi 2007 pp. 145-146).
After the Sukuma dam construction, the construction of a large-scale hydroelectric power plant in Japan later was carried out by mechanized construction, taking the Sakuma power plant as an example.
So far, we have looked at the introduction of overseas technology and heavy machinery, which became a major factor in the technological innovation of hydroelectric power generation after World War II. As a result, it became clear how the technology that forms the foundation of the Ikawa dam has been constructed. However, the issues for the construction of the Ikawa dam remain, and the issues will be discussed in the next section.

Figure 1: Oigawa river and Tenryu river. This map is a reproduction of the Digital Topographic Map published by Geospatial Information Authority of Japan. I added some information.

4.4 Problems of Ikawa dam construction and their solutions

The Ikawa dam construction still had the problem of material transportation. Ikawa Village, where the Ikawa power plant was built, was a village in the mountains that was extremely inconvenient. There are no roads or railways to bring construction materials, and the only transportation route is to go up from the direction of Shizuoka city, cross the 4 km Dainichi mountain pass on foot, and enter the village via the 105m Oigawa suspension bridge. It was in a state where the Umeji mountain pass, 715m above sea level, was blocking traffic between Ikawa and Okuizumi(Chubu Electric Power 10-Year History Editorial Committee 1961 pp.635).

Therefore, it was decided to extend the railway from the endpoint of the Oigawa Railway introduced in the previous chapter. An improvement of 9.7 km between Senzu and Yakuri and a new 17.5 km track between Yakuri and Nishiyamasawa were promoted, and the entire track was opened on September 10, 1954(Chubu Electric Power Inc. 1961 pp.467).

Moreover, a “Hollow Gravity Type” that can reduce the amount of concrete used was adopted. At the time of the construction of the Igawa dam, it was the most advanced type of dam. It was first of its kind in Japan. Originally planned a normal gravity type, but after hearing successful cases in Italy, they decided to adopt the hollow gravity type. According to “Ikawa Power Plant Construction Documents”, “As a result of research, it was found that hollow gravity dams have similar adaptability to gravity dams, it can be built on the foundation bedrock of Igawa dam site, and the amount of concrete in dams is 75% of that of gravity dams. Furthermore, since it was found that temporary construction equipment was also reduced, they decided to adopt this type.”(Chubu Electric Power Inc. Construction Department 1961 pp.33). As you can see, the important point in adopting the enamel gravity dam was the reduction materials to be transported. This decision would not be unrelated to the land of Oigawa, who had trouble transporting materials due to poor transportation.

4.5 Details of Ikawa dam construction, Ikawa power plant, and Okuizumi power plant

As mentioned earlier, the first move of the Ikawa dam construction plan was the extension of the Oigawa Railway, then the next move was the construction of the Okuizumi Power Plant.This Okuizumi power plant was one of the two power plants in the Ikawa Dam Project. In the plan by Schuyler of British-Japanese Hydroelectric Co., Ltd., it was a power generation plan in one place, but as a result of the repeated examination by Chubu Electric Power Inc., it was generated at two places. The plan was to build an Ikawa dam and build an Igawa power plant on the right bank just below it. It can generate electricity then direct the water to the right bank and generate electricity at the Okuizumi power plant(Chubu Electric Power Inc. 1961 pp.457).

In January 1951, the Okuizumi power plant was completed. The amount of power generated was 87,000 kW(Satsukikai "Civil History in Shizuoka Prefecture" Editorial Committee 1985 pp.347). Later, the Ikawa dam and Ikawa power plant were constructed. The Ikawa dam and Ikawa power plant were finally completed in September 1957(Chubu Electric Power Inc. 1961 pp.447). The height of the dam was 100 m, the maximum water consumption was 80 m^3/s, the effective head was 92.7 m, the power generation was 62,000 kW, and the annual power generation was 188,400 kWh. The amount of power increased downstream due to the construction of the Ikawa dam was approximately 136,600 kWh per year. The amount of cement that has been thrown into the Ikawa dam was 150,000 tons and the reinforcing bars were 3000 tons. Moreover, the flood adjustment by the construction of the Ikawa dam drastically reduced downstream flood (Chubu Electric Power Inc. 1961 pp.479).

Figure 2: Ikawa Dam

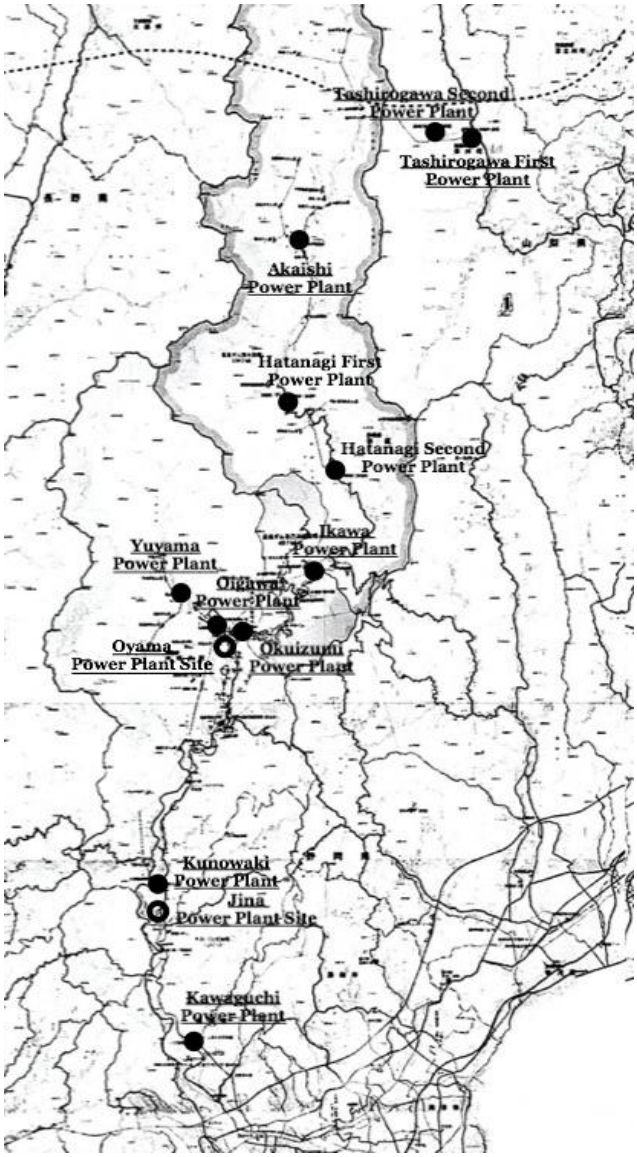

Figure 4 The Site of Hydro Power Plant in Oigawa river catchment area. This map is a reproduction of information magazine of Nagashima dam. I added some information. Oyama Power Plant and Jina Power Plant were demolished.

Figure 5 Oigawa Power Plant

Figure 6 Kawaguchi Power Plant

5 **Conclusion**

In this paper, following the history of hydropower development in the Oigawa river catchment area, we discussed the development of the hydropower business and the hydropower technology introduced from overseas.

The large dam construction technology was a problem in the days of British-Japanese Hydroelectric Co., Ltd. Then it was solved within a year by the introduction of overseas technology and heavy machinery. Moreover, the material transport problem that has always been an issue in the hydropower development in the Oigawa river catchment area has been solved by the construction of the Oigawa Railway and the adoption of hollow gravity dams.

The background of these technological innovations was greatly related to the situation in Japan and overseas. In particular, it is indispensable to talk about the history of hydropower development in the Oigawa river catchment area that the concept of British-Japanese Hydroelectric Co., Ltd. It has been established under the influence of the Anglo-Japanese Alliance and that the introduction of technology within the GHQ policy has become easier. Moreover, flood damage, an important issue for the Oigawa River, has decreased since the flow rate became stable during the hydropower development process. In 2002, the Nagashima dam, the first multipurpose dam in the Oigawa river catchment area, was built by a national institution. This dam plays the role of flood control function, irrigation water supply, tap water supply and so on. No major flooding has occurred in the Oigawa river catchment area since this dam was completed. When the huge typhoon Hagibis, which hit Japan this year and flooded many rivers, landed, the Oigawa river did not flood and did not cause much damage. Currently, the Oigawa river is one of the most developed rivers in Japan for both power generation and flood control.

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Data

Hydro Power Plant Chronology in Oigawa River Catchment Area

Year	Power Plant Name	Maximum Output(kW)	Established Company Name	Source
1910	Jina Power Plant	2,250	Tokai Paper Co., Ltd.	Chubu Electric Power Inc.
1911	Oyama Power Plat	2,400	British-Japanese Water Electricity Co,. Ltd.	Chubu Electric Power Inc.
1927	Tashirogawa First Power Plant	21,000	Tokyo Electric Power Co., Ltd	Satsukikai “Civil History in Shizuoka Prefecture” Editorial Committee (1985)
1927	Tashirogawa Second Power Plant	6,500	Tokyo Electric Power Co., Ltd	Satsukikai “Civil History in Shizuoka Prefecture” Editorial Committee (1985)
1935	Yuyama Power Plant	24,000	Daini Fuji Electric Power Co., Ltd	Takeo Kikkawa (1995) volume
1936	Oigawa Power Plant	62,000	Oigawa Electric Power Co., Ltd	Takeo Kikkawa (1995) volume 2
1938	Oma Power Plant	16,000	Fuji Electric Power Co., Ltd	Takeo Kikkawa (1995) volume 2
1944	Kunowaki Power Plant	16,000	Chubu Electric Power Inc.	Takeo Kikkawa (1995) volume 2
1956	Okuizumi Power Plant	87,000	Chubu Electric Power Inc.	Takeo Kikkawa (1995) volume 2
1957	Ikawa Power Plant	62,000	Chubu Electric Power Inc.	Takeo Kikkawa (1995) volume 2

1960	Kawaguchi Power Plant	58,000	Chubu Electric Power Inc.	Takeo Kikkawa (1995) volume 2
1961	Hatanagi Second Power Plant	85,000	Chubu Electric Power Inc.	Takeo Kikkawa (1995) volume 2
1962	Hatanagi First Power Plant	137,000	Chubu Electric Power Inc.	Takeo Kikkawa (1995) volume 2
1992	Akaishi Power Plant	39,000	Chubu Electric Power Inc.	Takeo Kikkawa (1995) volume 2
	Total Output	614,200		

Figure3. Hydro Power Plant Chronology in Oigawa River Catchment AreaOyama Power Plant and Jina Power Plant were demolished. Therefore, those power plants output was excluded.