Key Issues: **11- Benefits due to power generation**

Climatic Zone:
Df : Cool and humid zone

Subjects:
- Large-scale Power Source Development including Alterations of the Catchment Basins of 4 Rivers in the Hidaka Region

Effects:
- Provision of approximately 60% of the Hokkaido Island's total hydroelectric power based on a sequential development scheme that combines power sources for peak loads, large reservoirs and bold catchment basin alterations in Hokkaido's undeveloped areas.

Project Name: Integrated Hidaka River System Hydropower Development
Country: Hokkaido, Japan (Asia) (N42°20' – N42°55', E142°20' – E142°50')

Implementing Party & Period:
- Project: Hokkaido Electric Power Co., Inc.
1956 (Commencement of construction) -
- Good Practices: Hokkaido Electric Power Co., Inc.
1956 (Commencement of operation) -

Key Words:
Integrated power source development, catchment basin alteration, sequential development

Abstract:
To accommodate sharp increases in electricity demand that accompanied the rapid postwar economic growth of Japan, an Integrated Hidaka Power Source Development Project has been undertaken in the Hidaka region (Hokkaido Island) which has abundant water resources and large heads. The Project comprises a sequence of development projects in the catchment basins of four rivers in the Hidaka region which involves catchment basin alterations using large and small dams as well as water conduit tunnels that connect the dams to each other.

1. Outline of the Project

The Hidaka region, which spreads southward from the center of Hokkaido, has many rivers with abundant water resources that originate in the steep Hidaka Mountains and discharge into the Pacific Ocean. Although many hydroelectric power source development projects had been planned to utilize these rich water resources, the region had been left undeveloped because of difficulties in dealing with complex geological features and characteristics in a remote area with no road.

Hokkaido Electric Power Co., Inc. took this challenge and started an Integrated Hidaka Power Source Development Project that uses a network of water conduit tunnels which extract water from the Soshubetsu River, Saru River, Niikappu River and Shizunai River to generate the additional power needed to accommodate sharp increases in electricity demand that accompanied the rapid postwar economic growth of Japan.

In terms of power station construction, the construction of the Saru River Iwachishi Power Station and that of the Niikappu River Iwashimizu Power Station started in 1956 and 1957, respectively, and a total of 14 power stations have been completed to date including the Hidaka Power Station completed in 1998. Taken together, these power stations in the Hidaka region now generate approximately 640,000 kW of power, making the region an important power source area which accounts for about half of the total hydroelectric power output of Hokkaido Electric Power Co., Inc. Fig.-1 and Table-1

show the locations of the power stations constructed through the Integrated Hidaka Power Source Development Project and the basic specification data on the power stations, respectively.

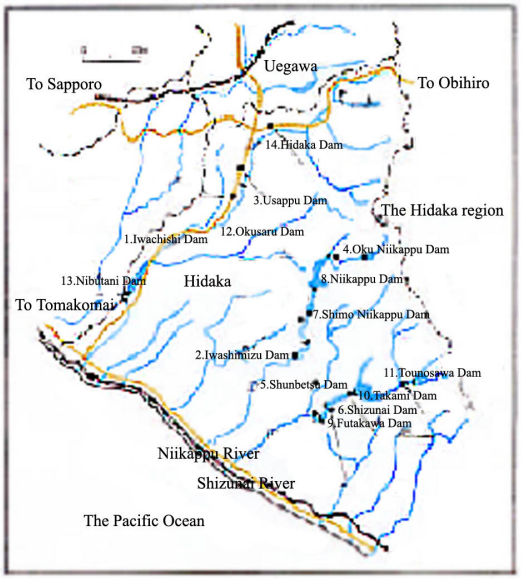

Fig.-1 Locations of the Power Stations Constructed through the Integrated Hidaka Power Source Development Project

Table-1 Basic Specification Data on the Power Stations Constructed through the Integrated Hidaka Power Source Development Project

Power Station		River	Operational since	Type	Max. Output (kW)	Volume of water used (m^3/s)	Effective Head (m)	Remark
1	Iwachishi	Saru River (Saru River System)	July 1958	Dam-and-conduit type	13,500	27.50	58.95	
2	Iwashimizu	Niikappu River (Niikappu River System)	August 1959	Dam-and-conduit type	15,000	15.00	118.50	
3	Usappu	Saru River (Saru River System) Soshubetsu River (Mukawa River System)	August 1961	Dam-and-conduit type	25,000	15.00	193.90	
4	Oku Niikappu	Pankenushi River and other rivers (Saru River System) Niikappu River (Niikappu River System)	August 1963	Dam-and-conduit type	44,000	15.80	326.22	
5	Shunbetsu	Niikappu River (Niikappu River System) Shunbetsu River (Shizunai River System)	October 1963	Dam-and-conduit type	27,000	29.50	107.92	
6	Shizunai	Shizunai River and Shunbetsu River (Niikappu River System)	November 1966	Dam type	46,000	120.00	45.10	Unit No.2 was completed in July 1979.
7	Shimo Niikappu	Niikappu River (Niikappu River System)	September 1969	Dam type	20,000	58.00	40.40	

Power Station		River	Operational since	Type	Max. Output (kW)	Volume of water used (m^3/s)	Effective Head (m)	Remark
8	Niikappu	Niikappu River (Niikappu River System)	August 1974	Dam type	200,000	234.00	99.60	
9	Futakawa	Shizunai River (Shizunai River System)	September 1979	Dam type	7,300	73.00	12.50	
10	Takami	Shizunai River and Shunbetsu River (Shizunai River System)	July 1983	Dam type	200,000	230.00	104.50	Unit No.2 was completed in April 1993
11	Tounosawa	Koikakushushibichari River and Shizunai River (Shizunai River System)	February 1987	Dam type	20,000	19.00	124.50	
12	Oku Saru	Uenzaru River (Saru River System)	April 1994	Conduit type	15,000	6.10	291.20	
13	Nibutani	Saru River (Saru River System)	July 1996	Dam type	3,000	35.00	10.70	Hokkai Hydroelectric Power Generation Co., Ltd.
14	Hidaka	Saru River (Saru River System)	April 1998	Conduit type	10,000	21.00	56.50	

2. Features of the Project Area

The Hidaka region has a great potential as a hydroelectric power generation area because of the abundant water resources and large heads of the Mukawa River, Saru River, Niikappu River and Shizunai River that originate in the Hidaka Mountains (a mountain range with 2,000m class mountains that lies in southern Hokkaido like the backbone of the island) and run along western slopes of the Mountains to discharge into the Pacific Ocean.

The Hidaka Mountains are characterized by ubiquitous geological discontinuities and fault fractures developed as a result of orogenesis activities that took place during the period in which many of the major mountain ranges in the world such as the Alps, Andes and Rocky Mountains were formed, and thus have many beds of serpentine and similar metamorphic rocks. Because beds of these rocks often make the construction of hydroelectric facilities extremely difficult, finding a way to survey and investigate this remote area which did not have a road and for which no adequate map existed and finding ways to deal with the difficulties arising from the topographical and geological features and characteristics of the area were two major challenges that had to be met if a power source development project were to be conducted in this area.

Fig.-2 Location of the Integrated Hidaka Power Source Development Project

Fig.-2 shows the location of the Integrated Hidaka Power Source Development Project.

3. Benefits

3.1 Features of the Power Generation Plan

During the period of Japan's rapid postwar economic growth, one of the most urgent tasks for Japan was to develop hydroelectric power stations capable of handling peak loads to accommodate sharp

increases in electricity demand that accompanied the economic growth.
The selected Power Generation Plan area in the Hidaka region was an area characterized by narrow and long river catchment basins which were located close to each other and whose rivers were small- and medium-sized ones, and by dam site space/location constraints imposed by the area's geographical and geological characteristics/features. In addition, there were also elevation-related dam site space/location constraints.
To cope with these constraints, the Integrated Hidaka Power Source Development Project attempted to (1) increase the volumes of water available for hydroelectric power generation by connecting adjoining rivers to each other by means of conduit tunnels for combined and coordinated water extraction (catchment basin alterations) and (2) fully optimize the water resource utilization system from the upstream end Oku Niikappu Reservoir (high water level elevation = 723m) to the downstream end Futakawa Power Station (tailwater level elevation = 52.6m) (total head = 670.4m) in such a manner that the head loss between them is minimized.
The Power Generation Plan was developed as one involving the construction of a total of 14 power stations in the river catchment basins of the Mukawa, Saru, Niikappu and Shizunai Rivers coupled with alterations of the upstream catchment basin of the Saru River to combine water of the Saru River with water of the mainstream Niikappu river and the construction of a large-scale reservoir on the Niikappu River. The Plan also involved the construction of a large-scale reservoir on the mainstream Shizunai River as a joint development project including flood control measures and the connection of the Niikappu Reservoir with the Shizunai Reservoir via a network of many conduits and regulating ponds to develop the area as a large pool of electricity to accommodate Hokkaido's peak loads.
Fig.-3 shows the catchment basin alterations made and the elevations of the main facilities.

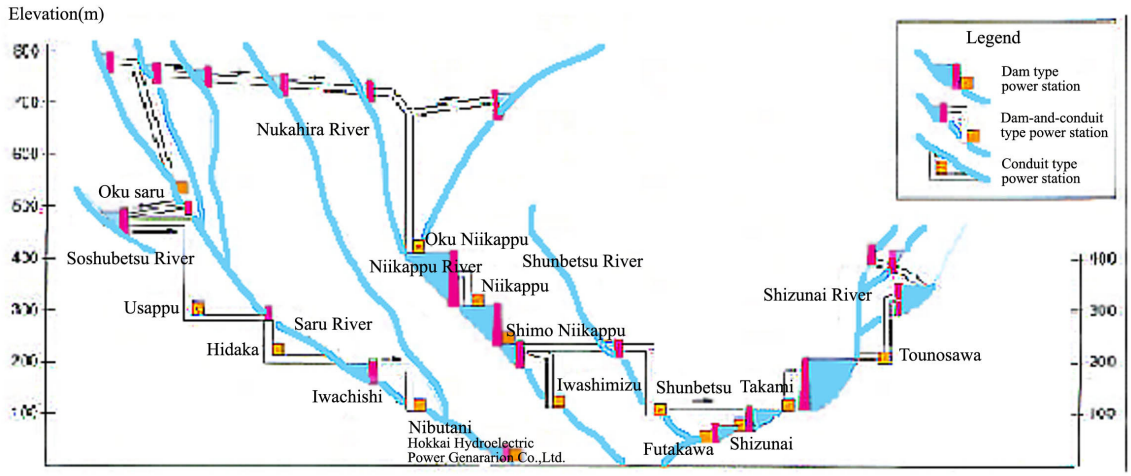

Fig.-3 Catchment Basin Alterations Made and the Elevations of the Main Facilities

3.2 Staged Sequential Development

The Development Plan was implemented as a sequence of individual projects with the order and timing of the projects determined taking into consideration the supply and demand relationship and system status of the time as well as the relationship of the time between the projects and other entities' power station development projects. The development was pursued under a 4-stage development scheme explained below (see Figs.-4 to 7).

1) Stage 1 (1956-1959): During this stage, advance bases for the development projects were developed in each river system. In the development of these advance bases, priorities were given to securing access to good transportation infrastructures and ensuring that the development will be carried out as relatively short-term and small-scale projects.
   * Iwachishi: Saru River (13,500kW)
   * Iwashimizu: Niikappu River (15,000kW)

2) Stage 2 (1959-1963): During this stage, projects to connect river systems by means of catchment basin alterations were completed.
   * Usappu: Mukawa and Saru Rivers (25,000kW)
   * Oku Niikappu: Saru and Niikappu Rivers (44,000kW)
   * Shunbetsu: Niikappu and Shizunai Rivers (27,000kW)

3) Stage 3 (1963-1983): During this stage, facilities to handle peak loads and intermediate reservoirs were constructed. This included the construction of the Niikappu and Takami pumped storage power stations, which were developed as centerpiece facilities of the Integrated Hidaka Power Source Development Project. The development of the two power stations provided the Hidaka region with two central reservoirs (the Niikappu and Shizunai River Reservoirs) and a large-scale base to handle peak demands. During the period between 1975 and 1983, which was the culmination period of the Integrated Hidaka Power Source Development Project, construction and expansion projects for 7 hydroelectric power stations were undertaken and completed to add a total output of 400,000kW, driven partly by the increased appreciation of hydroelectric power as a result of the first oil crisis.
   * Shizunai: Shizunai River (46,000kW)
   * Shimo Niikappu: Niikappu River (20,000kW)
   * Niikappu: Niikappu River (200,000kW)
   * Futakawa: Shizunai River (7,300kW)
   * Takami: Shizunai River (200,000kW)

4) Stage 4 (1983-): In Stage 4, projects to complete the entire system were conducted, including those relating to integrated development and small- and medium-scale facilities.
   * Tounosawa: Shizunai River (20,000kW)
   * Oku Saru: Saru River (15,000kW)
   * Nibutani (Hokkai Hydroelectric Power Generation Co., Ltd.): Saru River (3,000kW)
   * Hidaka: Saru River (10,000kW)

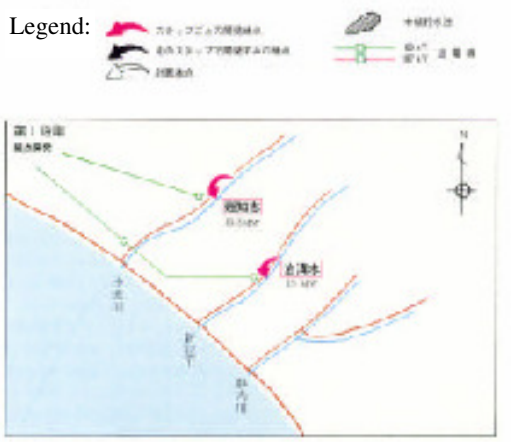

Fig. 4 Stage 1

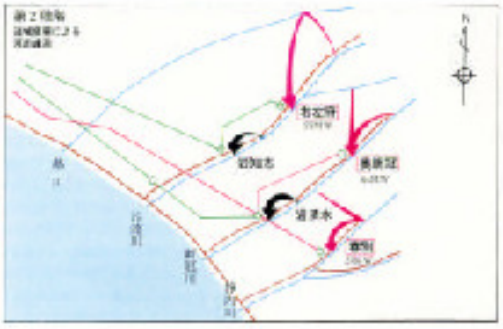

Fig.-5 Stage 2

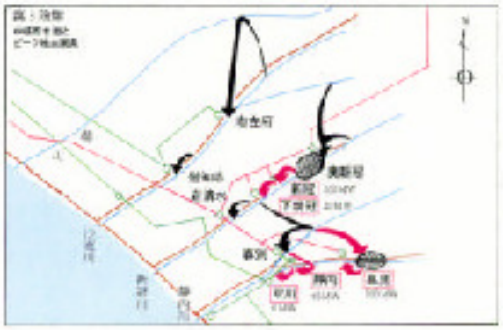

Fig.-6 Stage 3

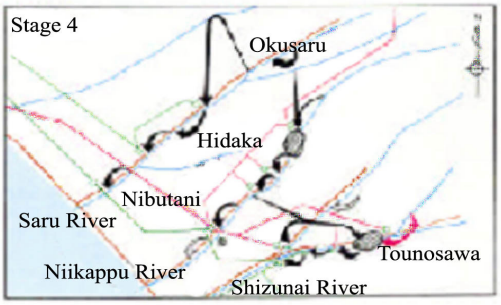

Fig.-7 Stage 4

4. Effects of the Benefits

As adjustment power sources for peak loads, the Hidaka region's hydroelectric power sources comprise a very important part of the Hokkaido's power sources. They are playing an indispensable role in modernizing Hokkaido's industries and maintaining and enhanceing Hokkaido's cultures. In addition, the power station construction projects have vitalized local industries of the related localities.

Furthermore, the Integrated Hidaka Power Source Development Project's advanced technologies and techniques for the construction of large-scale dams etc. as well as the Project's innovative hydroelectric power development scheme based on large-scale catchment basin alterations that effectively utilize the available water resources and heads by connecting 4 rivers using a network of conduits have been used to this day in engineering and development communities as a source of reference.

Because the development of a hydroelectric power station requires a vast amount of preparation work, a long construction period and huge investments in facilities, the Project's approach of developing hydroelectric power stations in a sequential manner over a long period has proven to be an ideal approach from the standpoint of reducing the annual capital cost burden and developing and effectively utilizing human resources, and has allowed the Project to become a giant project lasting for a very long period of about half a century. In addition, because each of the Project's dam sites had unique features and characteristics, the Project has become somewhat like a grand exhibition of civil engineering and power generation technologies/techniques. The adoption and/or use of these technologies and techniques has greatly contributed to raising technological levels of Japan's civil engineering and power generation industries. In addition, the Project's grand scale electric power system development is something that Japan can be proud of, because there are not many hydroelectric power source development projects of this scale in the world.

Fig.-8 Oku Niikappu Dam

Fig.-9 Takami Dam

Fig.-10 Oku Saru Dam

Fig.-8, 9 and 10 show the Oku Niikappu Dam (Oku Niikappu Power Station), which is the first arch dam in Hokkaido, the Takami Dam (Takami Power Station), which is the largest rockfill dam in Hokkaido, and the Oku Saru Dam (Oku Saru Power Station), which is the 12th dam developed under the Integrated Hidaka Power Source Development Project, respectively.

5. Reasons for Success

The Integrated Hidaka Power Source Development Project has successfully developed a large power source zone for peak loads that accounts for approximately half of the hydroelectric power generated by Hokkaido Electric Power Co., Inc. by storing (in large and small reservoirs and adjustment reservoirs) the water collected by altering catchment basins of 4 rivers and fully utilizing small- and

medium-scale hydroelectric power sources. It is considered that this success is attributable to the following factors:

5.1 Time

The Project was started and got into full swing in the second half of the 1950s and the first half of the 1960s, during which a transition from an "era of hydroelectric power" where thermal power stations were used as a supplementary source of energy to an "era of thermal power generation" where hydroelectric power stations were used as a supplementary source of energy occurred as a result of sharp increases in electricity demand in Hokkaido. During this period, the development of hydroelectric power stations became an urgent task as a means of accommodating peak loads because of the high adjustment capabilities of hydroelectric power stations.

5.2 Staged Sequential Development

The staged hydroelectric power source development approach allowed the individual power station development projects to be conducted in an appropriate order and at an appropriate time taking into consideration the electricity demand of the time, the system status of the time and the status, of the time, of development of other entities' power generation facilities, which in turn allowed appropriate core power generation capacities to be provided constantly while preventing sharp capital cost increases and thus keeping the Project financially healthy.

5.3 Resolution of Problems associated with Catchment Basin Alterations

One of the main reasons for the successful completion of the catchment basin alterations was the facts that the number of the towns and villages along the rivers covered by the Project was small, with each of the towns and villages having an area equivalent to those of prefectures of the main Honshu island, and that the populations of the towns and villages were small.

However, several problems did arise during the course of the alterations. These included (1) conflicts of interests among the affected towns and villages, which were inevitable because of the wide coverage of the Project that included several river systems and extended into several towns and villages, (2) estuary blockage due to reductions in dry season flow rates caused by river catchment basin alterations, (3) retardation of the growth of rice due to river water temperatures drops caused by river catchment basin alterations and (4) adverse effects of river water increases due to river catchment basin alterations on fishery facilities to catch fish that travel upstream such as salmons. However, all of these problems were resolved without any trouble by conducting appropriate compensatory work projects and making monetary compensations after conducting on-site surveys and investigations and consulting the affected municipalities and organizations to ensure their understanding and cooperation.

5.4 Power Source Development in conjunction with River Flood Control Projects

Flood control of the Shizunai River had started in 1952 with a river improvement project and had been going on in the form of several flood control projects, but a number of floods including the ones caused by the heavy storms in 1955 and 1966 inflicted serious damages on many of the riverside towns and villages. To prevent a recurrence of these disasters, the prefectural and local governments decided to take drastic dam-based flood control measures.

As part of these efforts, the Takami Dam development project was redesigned during the period from 1970 to 1973 as a joint project between Hokkaido Electric Power Co., Inc. and the Hokkaido prefectural government to develop a dual-purpose dam to be used to both generate power and provide flood control for the Shizunai River, with Hokkaido Electric Power Co., Inc. assuming the role of the project operator.

6. Further Information

6.1 References

1) "Developing the Hidaka Region (Three Decades of Power Source Development), " March 1988
2) "Serving the Electricity Needs of the Hokkaidoites (The 50-Year History of Hokkaido Electric Power Co., Inc.)," December 2001

6.2 Inquiries

Power Source Development Section
Civil Engineering Division
Hokkaido Electric Power Co., Inc.
Tel: +81-11-251-4622
Fax: +81-11-251-0425