Appendix A2
Collection of Good Practice Reports
Part 1: CA01 - JP07

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CA01

Name of the Power Plant : McNair Creek Hydropower Station

Country(State/Prefecture) : Canada(British Columbia)

Owner

Name of owner: Renewable Power Corporation (now owned by AltaGas Ltd.)

Type of ownership: Independent power producer

Type of market: Long-term Power Purchase Agreement with Electric Utility

Commissioning Year: Nov., 2004

Project Evaluation:

Financial Viability: Recovering initial investment, Securing the cost of maintenance and management, Securing proper profits & reinvestment

Economic Benefits: Tax revenue, employment opportunities, tourism

Social Aspects: Local Environment: Infrastructure improvement, River environment conservation

Local Community: Vitalization of local community, Facilitation of regional development, Creation of leisure opportunities

Keywords Squamish First Nation, Coanda intake screen, Soil restrained buried penstocks, HDPE buried penstocks, Fisheries enhancement and habitat creation

Abstract

The McNair Creek hydroelectric Project is a 9MW run of river project located on British Columbia's Sunshine Coast, about 30km northwest of Vancouver in the traditional territory of the Squamish First Nation. The project was commissioned on November 3, 2004, and is now owned by AltaGas Ltd. which provides energy to BC Hydro under a long term energy purchase contract. The environmental concerns were given special consideration in choosing the location and design of the plant. In the earliest stages of the project, scientific studies were conducted to ensure minimum impact on existing fish populations. The power station portion of the facility includes a spawning channel and rearing habitat for the salmon and steelhead that return to the river system each year. There has also been an increase in sightings of other wildlife, including deer, elk and bears, especially along the

buried penstock alignment. Hiking trails were re-established in the area, including a bridge across the tailrace channel, and all disturbed areas were revegetated.

1. Outline of the Project

The McNair Creek Hydroelectric Project is a 9MW run of river project located in the lower Sunshine Coast region of British Columbia near the town of Gibsons in Port Mellon, about 30km northwest of Vancouver in the traditional territory of the Squamish First Nation. The lead designer was Knight Piésold Consulting. It is an IPP hydro plant that was constructed under an EPC contract by Peter Kiewit Infrastructure Co. The construction was completed in November 2004. A Renewable Power Corporation owned the plant until it was sold to AltaGas Ltd. in 2010. Fig.-1 shows the project outline and Table-1 shows the project specifications. The basic characteristics of the project are summarized as follows:

Table-1 Project Specifications

Items	Specifications
Name of river/river system	McNair Creek
Installed capacity (MW)	9.0
Maximum discharge (m^3/s)	3.3
Gross head (m)	338
Turbine type	One 5-Jet Vertical Axis Pelton unit
Type of power plant	Run-of-river, conduit type
Connection type	On-grid
Average Annual Energy (GWh)	35

Diversion Weir & Intake : A reinforced concrete structure comprising a free overflow spillway incorporating a Coanda screen; a bypass sluiceway and penstock isolation gate (See Photo-1)

Intake : Sluice channel, screens, trash rake, vortex desander and penstock isolation gate

Tributary Intakes : Two tributary intakes with a maximum combined capacity of $0.6m^3/s$ divert water into the main intake headpond

Power House : Concrete substructure and pre-fabricated steel super structure, with removable roof panels to allow for extraction of the turbine generator set with the use of a mobile crane. (See Photo-2)

Switchyard : 4.16kV to 25kV

Transmission & Interconnection ：25kV

Fisheries Enhancement Channel：200m long with both rearing pond and spawning channel habitat

Photo-1 Diversion Weir and Intake[2]

Photo-2 Power House[2]

GREEN POWER
MCNAIR CREEK HYDROELECTRIC PROJECT

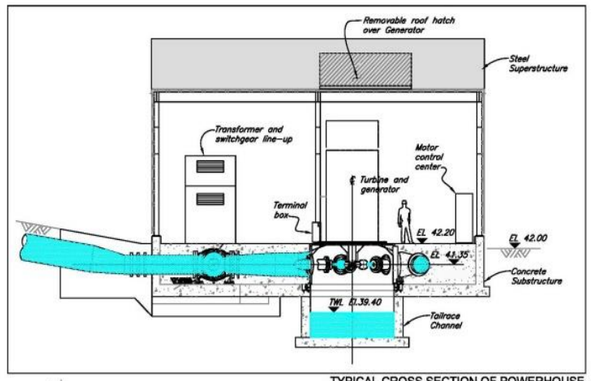
Knight Piésold CONSULTING


DIVERSION WEIR & HEADPOND

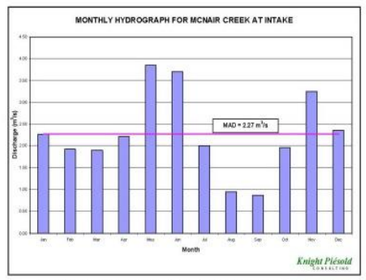

COANDA SCREEN INTAKE


WEIR & BYPASS/SCOUR STRUCTURE

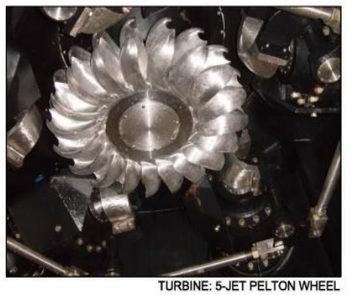

REVEGETATED PENSTOCK RIGHT-OF-WAY



TYPICAL CROSS SECTION OF POWERHOUSE



AVERAGE MONTHLY HYDROGRAPH FOR MCNAIR CREEK


TURBINE: 5-JET PELTON WHEEL

TYPICAL CROSS SECTION OF WEIR


REVEGETATED PENSTOCK RIGHT-OF-WAY


PENSTOCK INSTALLATION


FISH REARING CHANNEL


POWERHOUSE

OWNER: RENEWABLE POWER CORPORATION

EPC CONTRACTOR: PETER KIEWIT SONS CO.

OTHER CONSULTANTS/CONTRACTORS:
AMNIS ENGINEERING LTD.
COLONY MANAGEMENT
PETER SCHOBER, P.ENG
WHITEHEAD ENVIRONMENTAL CONSULTANTS
WISMER RAWLINGS ELECTRIC LTD.

Figure-1 Project Outline

2. Financial Viability of the Project

(1) Risk hedge by EPC[1] contract with regard to construction cost / scheduling management

Teamwork between the Client, EPC Contractor and Lead Designer were key in realizing a project that was completed on time and budget and exceeded performance goals. In addition, the fixed EPC price enables the Owner secure long term debt financing for the project.

(2) Secured economic efficiency by long-term energy purchase contract

The project now provides clean renewable energy to BC Hydro under a long term energy purchase contract, helping BC meet the goal of energy self-sufficiency by 2016 with 90% of its electricity coming from renewable sources.

The installed capacity was optimized so as to ensure the best possible return on investment for the Owners.

Renewable Power Corporation has received EcoLogo Certification[2] for the project, which is awarded to companies who meet a set of benchmarks related to social and environmental responsibility. BC hydro pays a premium for energy from these certified projects.

(3) Reduction of cost and construction period by innovative design concepts

1) A Coanda screen intake design eliminated the requirements for an expensive reinforced concrete desander and help to reduce the project operating costs.

2) The use of soil restrained penstock design helped to eliminate the expensive anchor blocks along the pressurized steel penstock. (See Photo-3)

3) The use of solid wall HDPE pipe for the upper portions of the penstock helped to reduce costs and speed up the construction schedule.

Photo-3 Soil restrained penstock[2]

3. Economic Benefits of the Project

(1) Tax revenue

Tax Revenue (e.g., local government tax on property, corporate tax, and water rental rates based on energy and plant capacity)

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[1] EPC stands for Engineering, Procurement, Construction and is a prominent form of contracting agreement in the construction industry. The engineering and construction contractor will carry out the detailed engineering design of the project, procure all the equipment and materials necessary, and then construct to deliver a functioning facility or asset to their clients.

[2] ECOLOGO Certified products, services and packaging are certified for reduced environmental impact. ECOLOGO Certifications are voluntary, multi-attribute, lifecycle based environmental certifications that indicate a product has undergone rigorous scientific testing, exhaustive auditing, or both, to prove its compliance with stringent, third-party, environmental performance standards.

(2) Employment opportunities

Opportunities of direct employment in the power plant's O & M, and increased in-direct employment due to the development of tourism resources around the plant. This included opportunities for First Nations (aboriginal peoples) training, employment and revenue sharing. First Nations training program at the time of the plant construction involved OJT that resulted in them being used as one-third of the total work force.

4. Social Aspect of the Project

4.1 Local Environment

1) Natural environment conservation by environmental assessment

This project had to go through a rigorous environmental assessment and permitting phase in order to secure all the Provincial and Federal approvals and Licenses. A typical run-of-river project in BC will require more than 50 permits, licenses, approvals and reviews from 14 regulatory bodies, including federal, provincial, local and First Nations.

2) Fish protection

In the earliest stages of the project, scientific studies were conducted to ensure minimum impact on existing fish populations. Also, an ongoing monitoring of fish stocks has been providing scientific evidence of how low flow requirements helps to sustain fish and other aquatic populations. The monitoring system of this project is one of the most advanced systems which monitors plant operations and environmental variables such as rainfall, temperatures and flows.

The fisheries habitat enhancement and spawning channels were constructed in downstream of the powerhouse tailrace. The ongoing studies now show that the trout that live in the creek and holding pond are bigger and greater in number than before construction began.

3) Conservation of river environment

A dry transformer (without oil) was used eliminating the possibility of an oil spill.

4.2 Local Community

1) Distribution of the benefit to the First Nation

The project resulted in Partial ownership and employment for First Nations.

2) Creation of leisure opportunities

The penstock was buried for greater resident/wildlife access, Hiking trails were improved, and provided the place of recreation for the regional communities. (See Photo-4)

Photo-4 Enhanced Hiking Trails[2]

3) Improvement of fire hydrants facilities

A high pressure water offtake was added to the penstock for the local firefighters, to assist them in battling local forest fires.

5. Reasons for the Success

(1) Financial Viability of the project

The development team improved the economic efficiency of power plant construction by applying the new technologies for construction cost reduction.

Teamwork between the Client (Renewable Power), EPC Contractor (Kiewit) and Lead Designer (Knight Piésold) were key in realizing a project that was completed on time and budget and exceeded performance goals.

A fixed EPC price and other agreements in the contract guarantee price and construction schedule which, along with the optimized installed capacity, helps the Owner secure long term debt financing for the project.

(2) Contribution to local environment and community

Early stage community consultation, strict environmental management plans and monitoring, project management, innovative design concepts and project installed capacity optimization were all key aspects to the successful completion of the project.

6. Outside Comments

(1) The Award of Excellence for Resource, Energy and Industrial Projects (2005) was granted by the Consulting Engineers of British Columbia (CEBC).

(2) Renewable Power Corporation has received ECOLOGO Certification for the project, which is awarded to companies who meet a set of benchmarks related to social and environmental responsibility.

7. Reference

[1] International Water Power & Dam Construction (May 2009): Best of the best in small hydro

[2] Knight Piésold Ltd (https://www.knightpiesold.com/en/)

[3] Renewable Power Corporation (http://www.renewablepowercorp.com/)

CA02

Name of the Power Plant: Rutherford Creek Hydropower Station

Country(State/Prefecture): Canada(British Columbia)

Owner

Name of owner: Innergex Power Income Fund

Type of ownership: Independent power producer

Type of market: Long-term Power Purchase Agreement with Electric Utility

Commissioning Year: Jun., 2004

Project Evaluation:

Financial Viability: Recovering initial investment, Securing the cost of maintenance and management, Securing proper profits & reinvestment

Economic Benefits: Tax revenue, Employment opportunities, Tourism, Local industrial promotion

Social Aspects: Local Environment: Infrastructure improvement, River environment conservation

Local Community: Vitalization of local community, Facilitation of regional development, Creation of leisure opportunities

Keywords: Lil'wat Nation, Inflatable Rubber Dam, Vortex Desander, Soil restrained buried penstocks, Weholite (hollow wall HDPE) buried penstocks, White Water Kayaking Park, Snowmobile, Hiking Access

Abstract

The Rutherford Creek Hydroelectric Project is a 49 MW run of river project located in British Columbia about 20km north of the Whistler ski resort in the traditional territory of the Lil'wat First Nation. The project was completed in June 2004 and is owned and operated by Innergex Power Income Fund which provides energy to BC Hydro under a long term energy purchase contract. The project faced numerous challenges during construction, including a major flood event, and work hour limitations due to forest fire risk, but the civil works were still completed on schedule. The project includes many unique and innovative design features, including "Inflatable rubber diversion weir", "Combined vortex desander and environmental flow bypass", "Large diameter Weholite (HDPE) pipe" and "Whitewater

kayak channel built into the powerhouse tailrace". The project resulted in Partial ownership and employment for First Nations.

1. Outline of the Project

The Rutherford Creek Hydroelectric Project is a 49 MW run of river project located in British Columbia's Coastal Mountains about 20km north of the Whistler ski resort. Innergex Power Income Fund had it constructed under an EPC contract that guaranteed price, schedule and performance with Peter Kiewit Sons Co. as the prime contractor and with Knight Piésold Ltd. as the lead design engineer. The project was completed in June 2004 and is owned and operated by Innergex Power Income Fund. The project faced numerous challenges during construction, including a major flood event, and work hour limitations due to forest fire risk, but the civil works were still completed on schedule. Fig.-1 shows the project outline and Table-1 shows the project specifications.

Table-1 Project Specifications

Items	Specifications
Name of river/river system	Rutherford Creek
Installed capacity (MW)	49
Maximum discharge (m^3/s)	17.5
Gross head (m)	378.5
Turbine type	Two 6-Jet Vertical Axis Pelton units
Type of power plant	Run-of-river, conduit type
Connection type	On-grid
Average Annual Energy (GWh)	180

The basic characteristics of the project are summarized as follows:

Diversion Weir & Intake : A 3m high inflatable rubber dam plus reinforced concrete structure comprising a free overflow spillway incorporating a bypass sluiceway and reservoir desanding headpond

Intake : Sluice channel, screens, trash rake, vortex desander and penstock isolation gate

Tributary Intake : A tributary intake with a maximum diversion capacity of 1.5 m^3/s diverting water into the main intake headpond

Penstock : A 9 km long buried penstock approximately 3m in diameter. The upper low pressure section, is about 3 km long and made use of Weholite (HDPE) pipe. A world first for a hydropower application. The remaining 6km of the penstock were steel, buried and making use of a soil

restrained penstock design to eliminate expensive concrete anchor blocks.

Power House : Concrete substructure and pre-fabricated steel super structure, with two vertical axis 6-jet Pelton units.

Switchyard : 13.8kV to 230kV

Transmission & Interconnection : 230kV

White Water Kayaking Channel : 650m long and now used for Provincial and National white water and slalom kayaking championships

Photo-1 Diversion Weir and Intake[2]

Photo-2 Power House[2]

Photo-3. Buried Steel Penstock Construction[2]

Photo-4 Weholite (HDPE) Pipe[2]

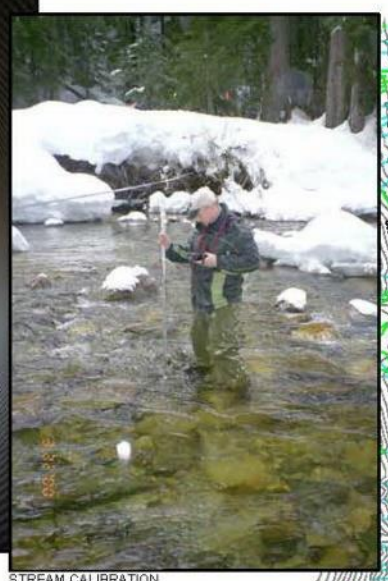
INNERGEX II

Rutherford Creek Power LP

CLOUDWORKS ENERGY INC.

ANATOMY OF THE RUTHERFORD CREEK HYDROELECTRIC PROJECT

LOW PRESSURE CONDUIT (WEHOLITE PIPE)



STREAM CALIBRATION

RUBBER WEIR - 3m HIGH

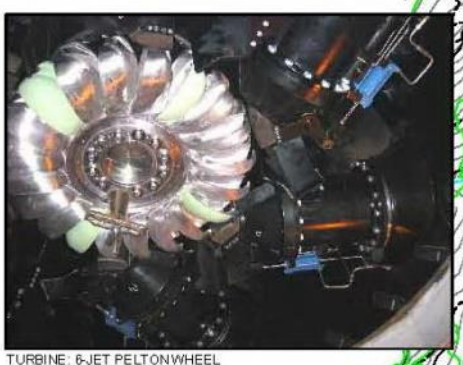
INTAKE MODEL - TESTING OF RUBBER DAM

INTAKE WITH RUBBER WEIR - HEADPOND

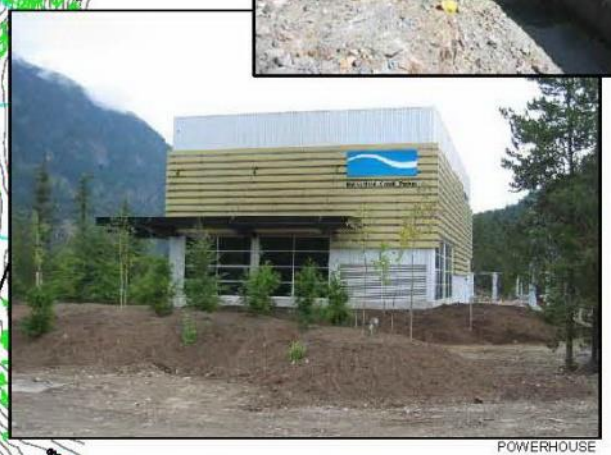
LOW PRESSURE CONDUIT INSTALLATION

FISHERIES STUDIES

PENSTOCK INSTALLATION



TURBINE: 6-JET PELTON WHEEL



POWERHOUSE

EPC CONTRACTOR:

PETER KIEWIT SONS CO.

DESIGN ENGINEERS:

Knight Piésold CONSULTING

DESIGN INPUT:

Amnis Engineering Ltd.

nhc NORTHWEST HYDRAULICS CONSULTANTS

AVERAGE MONTHLY HYDROGRAPH FOR TYPICAL PROJECT

Figure-1 Project Outline

2. Financial Viability of the Project

(1) Risk hedge by EPC [1)] contract with regard to construction cost / scheduling management

Teamwork between the Client, EPC Contractor and Lead Designer were key in realizing a project that was completed on time and budget and exceeded performance goals. A fixed EPC price and other agreements in the contract guarantee price and construction schedule which, along with the optimized installed capacity, helps the Owner secure long term debt financing for the project.

(2) Secured economic efficiency by long-term energy purchase contract

The project now provides clean renewable energy to BC Hydro under a long term energy purchase contract, helping BC meet the goal of energy self-sufficiency by 2016 with 90% of its electricity coming from renewable sources.

The installed capacity was optimized so as to ensure the best possible return on investment for the Owners.

Innergex has received EcoLogo Certification[2)] for the project, which is awarded to companies who meet a set of benchmarks related to social and environmental responsibility. BC hydro pays a premium for energy from these certified projects.

(3) Reduction of cost and construction period by innovative design concepts

The innovative design concepts, listed below, resulted in significant cost and schedule benefits.

1) An inflatable rubber weir and reservoir desander design together with a vortex desander eliminated the requirements for an expensive reinforced concrete desander and help to reduce the project operating costs.

2) The use of soil restrained penstock design helped to eliminate the expensive anchor blocks along the pressurized steel penstock.

3) The use of Weholite (larger diameter HDPE) pipe for the upper portions of the penstock helped to reduce costs and speed up the construction schedule

3. Economic Benefits of the Project

(1) Tax revenue

Tax Revenue (e.g., local government tax on property, corporate tax, and water rental rates based on energy and plant capacity)

---

1) EPC stands for Engineering, Procurement, Construction and is a prominent form of contracting agreement in the construction industry. The engineering and construction contractor will carry out the detailed engineering design of the project, procure all the equipment and materials necessary, and then construct to deliver a functioning facility or asset to their clients.

2) ECOLOGO Certified products, services and packaging are certified for reduced environmental impact. ECOLOGO Certifications are voluntary, multi-attribute, lifecycle based environmental certifications that indicate a product has undergone rigorous scientific testing, exhaustive auditing, or both, to prove its compliance with stringent, third-party, environmental performance standards.

(2) Employment opportunities

Opportunities of direct employment in the power plant's O & M, and increased in-direct employment due to the development of tourism resources around the plant. This included opportunities for First Nations (aboriginal peoples) training, employment and revenue sharing. First Nations training program at the time of the plant construction involved OJT that resulted in them being used as one-third of the total work force.

(3) Promotion of tourism

Increase of tourists is achieved by promoting the improvement of White Water Kayaking Park, Snowmobile and Hiking Access.

(4) Local industrial promotion

Development of First Nations businesses, including pre-cast concrete structures like road barriers. The Prime Contractor (Peter Kiewit Sons Co.) and the Lil'wat First Nation also formed an ongoing joint venture after the construction was complete and built a pre-fabrication business for concrete products such as freeway barriers.

4. Social Aspect of the Project

4.1 Local Environment

(1) Natural environment conservation by environmental assessment

This project had to go through a rigorous environmental assessment and permitting phase in order to secure all the Provincial and Federal approvals and Licenses. A typical run-of-river project in BC will require more than 50 permits, licenses, approvals and reviews from 14 regulatory bodies, including federal, provincial, local and First Nations.

(2) Fish protection

In the earliest stages of the project, scientific studies were conducted to ensure minimum impact on existing fish populations. Also, an ongoing monitoring of fish stocks has been providing scientific evidence of how low flow requirements helps to sustain fish and other aquatic populations. The monitoring system of this project is one of the most advanced systems which monitors plant operations and environmental variables such as rainfall, temperatures and flows.

4.2 Local Community

(1) Distribution of the benefit to the First Nation

The project resulted in Partial ownership and employment for First Nations.

(2) Creation of leisure opportunities

The penstock was buried for greater resident/wildlife access, Hiking trails and snowmobile access were improved. Further, artificial and controlled white water kayaking channels were added to the areas downstream of the powerhouse tailrace. (See Photo-5)

Photo-5 White Water Kayak Park[2]

5. Reasons for the Success

(1) Financial Viability of the project

The development team improved the economic efficiency of power plant construction by applying the new technologies for construction cost reduction.

Teamwork between the Client (Innergex, previously Cloudworks Energy), EPC Contractor (Kiewit) and Lead Designer (Knight Piésold) were key in realizing a project that was completed on time and budget and exceeded performance goals.

A fixed EPC price and other agreements in the contract guarantee price and construction schedule which, along with the optimized installed capacity, helps the Owner secure long term debt financing for the project.

(2) Economic spin-offs of the project

Participation of the First Nation in the construction work and the development of business after the project was finished are included in the proactive efforts for local industry promotion and creation of employment opportunities.

(3) Contribution to local environment and community

Early stage community consultation, strict environmental management plans and monitoring, project management, innovative design concepts and project installed capacity optimization were all key aspects to the successful completion of the project.

6. Outside Comments

Innergex has received EcoLogo Certification for the project, which is awarded to companies who meet a set of benchmarks related to social and environmental responsibility. BC hydro pays a premium for energy from these certified projects.

7. Reference

[1] International Water Power & Dam Construction (May 2009): Best of the best in small hydro

[2] Knight Piésold Ltd (https://www.knightpiesold.com/en/)

[3] Innergex Renewable Energy Inc. (http://www.innergex.com/en/)

CA03

Name of the Power Plant : Atlin Hydropower Station

Country(State/Prefecture) : Canada(British Columbia)

Owner

Name of owner: Xeitl Limited Liability Partnership(XLP)[1)]

Type of ownership : Local & wholesale producer / Local community-owned Limited Liability Partnership

Type of market : Long-term wholesale power supply to provincial utility

Commissioning Year: April, 2009

Project Evaluation:

Financial Viability: Recovering initial investment, Securing the cost of maintenance and management, Securing an appropriate level of profit

Economic Benefits: Employment opportunities

Social Aspects: Local Environment: Infrastructure improvement, River environment conservation
Local Community: Vitalization of local community, Facilitation of regional development

Keywords: Taku River Tlingit First Nation (TRTFN), Taku Land Corporation (TLC), BC Hydro, Community-owned power plant, Capacity building, Limited Liability Partnership, Off-grid, First Nation Regeneration Fund,

Abstract

Being located in a remote area and not connected to the provincial electricity grid, the unincorporated community of Atlin in British Columbia, Canada heavily relied on the local grid with the diesel generators owned by BC Hydro. To improve the local energy security, the economy, the health and the environmental sustainability of the region, the Taku River Tlingit First Nation (TRTFN) started a project to switch from diesel engine to hydropower generation which came to a realization in 2009 with commissioning of a 2.1MW small hydropower plant. This plant is operated by Xeitl Limited Liability Partnership(XLP)

[1)] Xeitl Limited Liability Partnership is a community-owned power utility under Limited Liability Partnership (LLP) incorporated by Taku River Tlingit First Nation (TRTFN).

which was founded by TRTFN, and as such is the first plant that TRTFN owns. Financial viability of the project was secured by grants from a number of government sources and the First Nation Regeneration Fund, along with a long-term Energy Purchase Agreement with BC Hydro. The revenues will be reinvested into economic development, and training and education of local human resources to create employment in the region.

1. Outline of the Project

There are 175 aboriginal or northern off-grid communities in Canada, most of which rely on diesel generators. The Taku River Tlingit First Nation (TRTFN)'s first community-owned hydropower plant enabled a switch over from diesel power generation. At the earliest stage in discussing a replacement of its diesel generators, TRTFN developed a strategic plan that focused on full consultation with community members and discussions with BC Hydro. It conducted research related to environmental, regulatory frameworks, as well as business and economic consideration. The First Nation also conducted a human resources study to determine what kind of training community members needed to compete for jobs in projects that would spin off from the plant. As a result of the Taku River Tlingits' initiative, BC Hydro has agreed to turn off its diesel generators in favour of hydroelectricity for Atlin.

The Atlin Hydro Project is located at Atlin, in a relatively remote area of British Columbia, Canada. The intake is located at the downstream of Surprise lake outlet, where water flows into Pine Creek through a storage control. The intake consists of a small gravity dam and a reinforced concrete intake (see Fig.–1 and Photo–1). The concrete gravity dam has a maximum height of 9.25m from its bedrock base. The intake structure includes a penstock slide gate as well as coarse and fine trashracks. Atlin's cold climate was considered in the design of the intake and weir, including winter operation and the impacts of ice. The weir is higher than for comparable projects because the required submergence over the penstock inlet includes a 0.5m thick ice allowance. Non-metallic trashracks were used at the project intake to reduce the tendency of frazil ice to stick to these structures. The buried penstock is 3,910m long and made of 1.22m HDPE (High Density Polyethylene) and steel pipe. The minimum depth of fill over the penstock is 1.35m; this burial depth ensures that water in the penstock does not freeze (see Photo–2). During construction, surroundings were patrolled once a week. After burying the penstock, the location was revegetated to preserve the landscape. It was difficult to foresee the magnitude of environmental impact by fluctuating Surprise Lake levels after a storage control was built at the outlet, but it was expected that it could have a negative impact on nesting shorebirds and

Photo-1. Dam[1]

waterfowl. In response to this concern, a set of interim lake level guidelines was drafted. In addition, the fish way was built to help graylings get around the small dam.

The generating equipment consists of a 2MW horizontal shaft Pelton wheels, double turbine runners are overhung on a single generator shaft(see Photo−3). To prevent damage to the river caused by possible leakage of lubricating and operational oil, biodegradable oil is used. Since the community of Atlin is not connected to the provincial main electricity grid, the controls for the turbine and generator needed to be different from conventional run-of-river projects. The hydro plant constantly adjusts to meet the community's electricity demand with a governing system that controls the jets and a load bank so there is always a slight power surplus to manage the moment to moment demand fluctuations.

Photo-2. HDPE Penstock during construction[5]

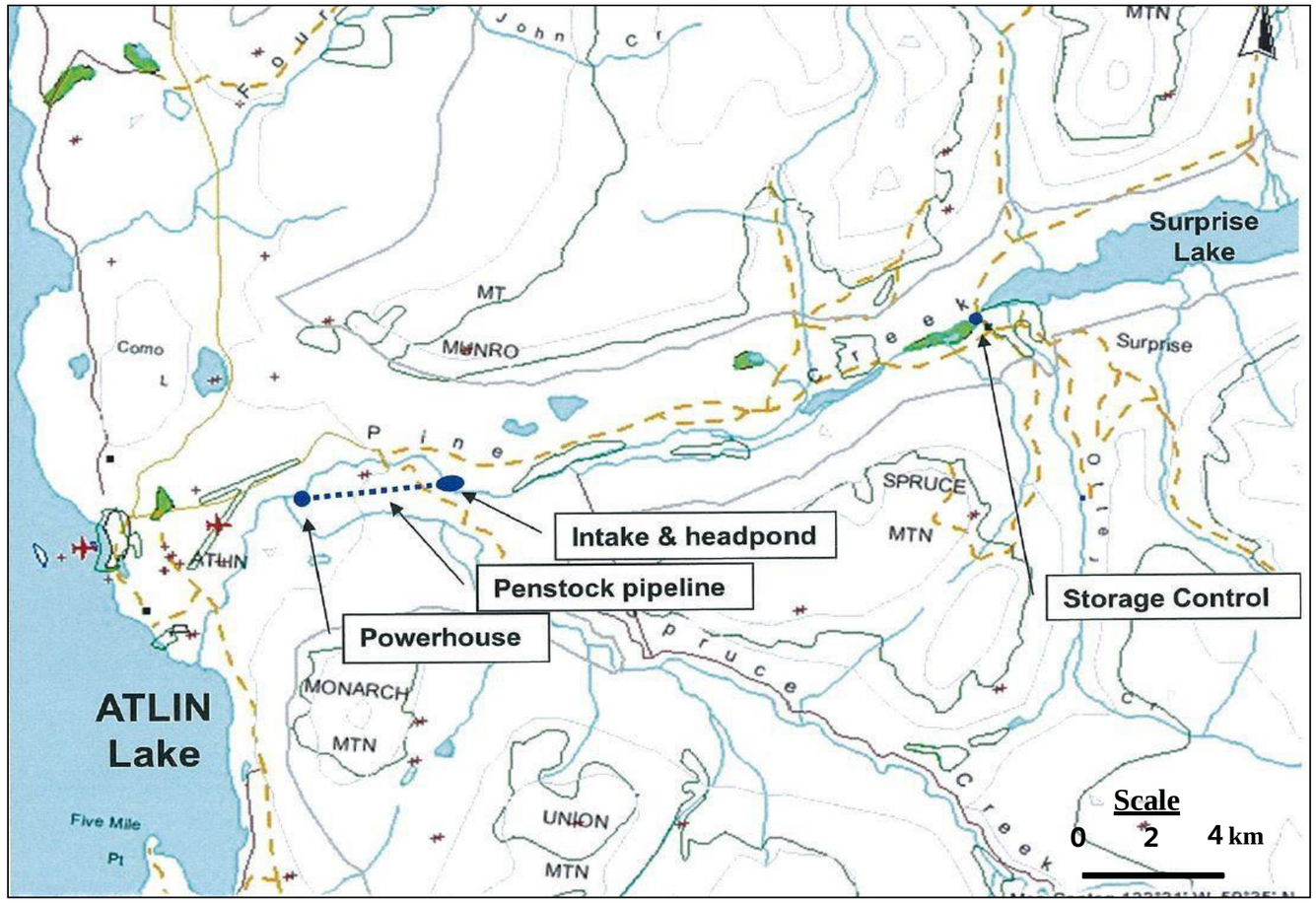
Photo-3. Powerhouse Inside[1]

A 750m long, 25kV powerline and 3.15km of 25kV express feeder connect the project to the diesel generating station and the local Atlin grid. The diesel generators remain in the community as a source of backup generation during periods of routine maintenance of the new hydro facility and in case of emergencies.

Fig.−1 shows the locations of power plant facilities and Table−1 shows the project specifications.

Table-1. Project Specifications

Items	Specifications
Name of river/river system	Pine Creek
Installed capacity (kW)	2,100
Maximum discharge (m^3/s)	2.7
Effective head (m)	107.6(Gross Head)
Turbine type	Horizontal axis Pelton wheels, double overhung
Generator type	3-phase synchronous
Type of power plant	Run-of-river with Lake Storage
Connection type	On-grid (Connected to the local grid and diesel generators)



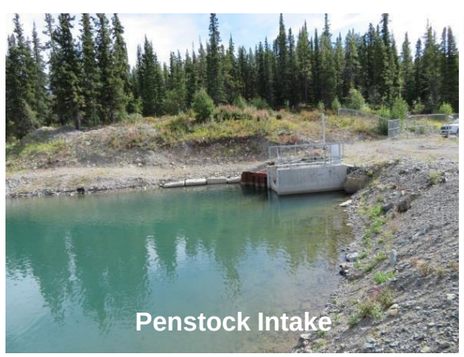


Fig.1 Location Map of Atlin Hydroelectric Power Plant

2. Financial Viability of the Project

(1) Project cost and funding sources

The total construction cost was $16.4 million. The project was funded through a combination of grants, equity financing and debt financing. The cost was higher than would usually be expected for a project of its size due to its remote location and the moderate penstock gradient (average slope 2.7%).

Table−2 shows the breakdown of Funding sources. Out of these sources, grant funding are from a number of government sources aimed at reducing climate change. Equity financing was provided by the First Nation Regeneration Fund, a partnership between Eco Trust Canada, the Tale'awtxw Aboriginal Capital Corporation and the Tribal Resources Investment Cooperation.

The majority of the project's construction was funded through debt financing provided by the Canada Life Insurance Company of Canada.

Table-2 Funding sources

Grant funding from:	Share (%)
Grant funding from: Indigeous and Northern Affairs Canada[2)] Aboriginal and Northern Communities Action Programme[3)] British Columbia Ministry of Energy Mines & Petroleum Resources[4)]	 1.2 1.5 14.7
First Nation Regeneration Fund[5)]	6.7
Bank Loan (Debts)	75.9
Total $16.4 million	100

(2) Annual average electricity generation

Annual average electricity generation is approx.. 5 GWh / year.

Electricity unit price sold to BC Hydro is determined by negotiations. FIT is not applicable for this sold price.

[2)] Indigenous and Northern Affairs Canada (INAC) supports Aboriginal peoples (First Nations, Inuit and Métis) and Northerners in their efforts to improve social well-being and economic prosperity; develop healthier, more sustainable communities and participate more fully in Canada's political, social and economic development – to the benefit of all Canadians.

[3)] The ecoENERGY for Aboriginal and Northern Communities Program 2011-2016 provides funding to Aboriginal and northern communities for renewable energy projects. It supports the development and implementation of renewable energy projects that reduce greenhouse gas (GHG) emissions arising from electricity and heat generation in these communities.

[4)] The Province is providing more than $670,000 to support the development of clean, efficient energy supplies and energy conservation projects for First Nations and remote communities. The BC Energy Plan supports First Nations and remote community energy programs to implement alternative energy, energy efficiency, conservation and skills training solutions.

[5)] The First Nation Regeneration Fund focuses on renewable energy projects that minimize environmental impact and maximize socio-economic benefits to local First Nations. The Regeneration Fund provides financing that enables First Nations to purchase equity positions in Independent Power Producer (IPP) projects developed in their traditional territories. Financing is made available as a loan to the First Nation. The First Nation then repays its loan through dividends and royalties from the power project. Once the loan is repaid, the dividends and royalties become long-term discretionary income that can be used by the Taku River Tlingit First Nation for economic and social development.

(3) Operation and maintenance cost

Electricity invoices are paid based on monthly generation, and this revenue covers bank loan repayment and operation/maintenance expenses of about 300,000 annually.

(4) Depreciation period

A depreciation period of 25 years has been scheduled.

(5) Replacement for diesel

The town of Atlin is one of the off-grid communities in British Columbia in which a higher electricity rate is charged compared with other on-grid power users due to dependency on diesel. This project replaces diesel generation and electricity users will be charged the same purchase price for electricity; therefore, it is financially viable.

(6) A long term energy purchase agreement to secure a revenue stream

BC Hydro and Xeitl Limited Liability Partnership (XLP) have signed an Energy Purchase Agreement, which secures a renewable source of energy for BC Hydro and a revenue stream for the XLP for 25 years.

(7) Cost reduction by procurement of materials and employment on site

Atlin is located in a very cold and relatively remote area of British Columbia. When possible, TLC[6] engaged local people and businesses to provide materials and services. Hiring locally helped to keep costs down. There were approximately 150 individuals and 35 companies involved and of these, approximately 10 were from the Atlin area and 20 were from Northern BC.

3. Economic Benefits of the Project

(1) Tax revenue

XLP is not under obligation to pay corporate tax but it pays municipal and property taxes, water rental fees and land lease payments to the province of BC.

(2) Creation of employment opportunities and reinvestment in the region

This hydro facility will reduce the cost of energy, and result in a long-term revenue stream for the local First Nation. The benefit will include the fact that all revenue will be reinvested into the local economy creating local employment (including human resources development such as training and education). It is also used to support feasibility studies for other possible hydroelectric development projects and activities of river environment conservation groups.

(3) New hydropower plant planning

In August 2014, the government of British Columbia concluded First Nations Clean Energy Business Fund Revenue-sharing Agreements[7] with 19 First Nations with

[6] A construction company of the Taku River Tlingit First Nation (TRTFN)

[7] First Nations Clean Energy Business Fund Revenue-sharing Agreements are negotiated between B.C. and First Nations to provide revenue sharing opportunities for clean energy projects. Section 20 of the *Clean Energy Act* creates provisions

regard to run-of-river type hydropower projects. One of the First Nations, Taku River Tlingit First Nation, is now conducting a feasibility study on Pine Creek (Atlin) to expand the Atlin Hydro Project to sell power to the Yukon Territory via a new 100km power line. If the project is deemed feasible, the First Nation will start negotiation with Yukon Energy to conclude power purchase agreement.

4. Social Aspect of the Project

4.1 Local Environment

1) Local energy security

Heavy dependency on diesel fuel in the past always meant facing some risk in the course of transportation, fuel supply, or equipment breakdowns. With the hydropower plant, there is a higher level of energy security.

2) River environment conservation, preservation of landscape and culture

- Biodegradable operation oil is used.
- During construction, surroundings were patrolled once a week. After burying penstock, the location was revegetated to preserve the landscape.

3) CO_2 emission reduction by replacement of diesel

In the past, Atlin has burned almost 1.2million liters of fuel each year. That amounted to 4,500 tonnes of greenhouse gases. The new hydro plant is estimated to prevent the emission of over 100,000 tonnes of greenhouse gases (CO_2 and NO_2) over the next 25 years.

4) Fish protection

Since the fish way is built to help graylings get around the small dam, fish counts have increased (see Photo-4).

Photo-4. Fish way in Pine Creek

5) Bird protection by lake water level control

In situations where foreseeing the magnitude of environmental impact was difficult, an adaptive management plan was implemented to ensure that these effects are mitigated. For example, fluctuating Surprise Lake levels could have a negative impact on nesting shorebirds and waterfowl. In response to this concern, a set of interim lake level guidelines was drafted. Nesting habitats will be monitored during critical nesting periods for shorebirds, and the lake level guidelines will be adjusted as appropriate.

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through agreements between the B.C. government and eligible First Nations for revenue-sharing from clean energy projects based on new, net, incremental revenues to government derived from water rentals, land rents and, eventually, wind participation rents in First Nations traditional territories and treaty areas. The First Nations Clean Energy Business Fund Revenue-sharing Agreements are provided as an outcome of the First Nations Clean Energy Business Fund (FNCEBF).

4.2 Local Community

1) Emergency power source

Hydropower generation is controlled to produce more electricity than actual demand in preparation for load fluctuation. In addition, diesel generators are always on standby. Therefore, both surplus hydropower and diesel generators are prepared for emergency situations.

2) Human resources development by education and training

All revenue are reinvested into the local economy creating local employment (including human resources development such as training and education). Photo-5 shows an example of workshops that are arranged for local elementary school students to learn environmental and energy issues through site visits to power plant.

Photo-5. Local elementary school students during a site visit to the power

5. Reasons for the Success

(1) Financial viability of the project

The Canadian government proactively supports renewable energy projects. The government grants for this project and other funding helped reduce the initial investment costs. Another considerable contribution to secured income was that BC Hydro that supplies power produced by its diesel generators through the local grid supported the decision of TRTFN to own a hydropower plant and signed a long-term Energy Purchase Agreement.

(2) Promotion of project through leadership

The project's success is largely due to the resolve of TLC, XLP and the people who have spent the past five years advancing the work, including Peter Kirby (president) and Stuart Simpson (project manager). Good teamwork and effective communication, despite large geographic separations, were also a paramount achievement.

(3) Understanding and sharing of the project goal in the community

The project is a perfect example of how water power can be environmentally beneficial and socially responsible. It demonstrates what can be accomplished when people in the community strive to reach a common goal. Based on the experience, the XLP team is now frequently solicited to speak at conferences as well as to provide advice to other First Nations across Canada about building their own small hydro projects.

(4) Contribution to local community

At the earliest stage of discussions leading up to this project, TRTFN developed a strategic "Community Energy Plan" based on consultation with community members and discussions with BC Hydro. In this Plan, the First Nation conducted research related to environmental, regulatory frameworks, as well as business and economic consideration. Therefore the vision in the Plan was comprehensive enough to realize contributions to local community such as reinvestment into creation of employment opportunities and financing activities would be used to revive local culture.

6. Outside Comments

There has been a great deal of media coverage in newspapers and magazines of this project.

7. Reference

[1] The Atlin hydro project – embodying First Nation principles - International Water Power & Dam Construction, 9 November 2009

[2] Best Practices in Small Hydro Development – a perspective from British Columbia, Canada, by Matt Hammond, PGL Environmental Consultants

[3] Generation for Generations, November 04, 2009, Peter Kirby, Taku Land Corporation

[4] Atlin Tlingit Economic Limited : http://trtfn.com

[5] Atlin kicks diesel – Yukon News April 17 2009 : http://www.yukon-news.com/business/atlin-kicks-diesel

CL01

Name of the Power Plant: Central Hidroeléctrica Mallarauco

Country(State/Country): Chile(Metropolitan Región)

Owner

Name of owner: Gestión de Proyectos Eléctricos S.A.(GPE)

Type of ownership: Wholesale Power Supplier

Type of market: Wholesale Power Supply

Commissioning Year: Sep. 2011

Project Evaluation

Financial Viability: Recovering initial investment, Securing the cost of maintenance and management, Securing an appropriate level of profit

Economic Benefits: Tax revenue, Employment opportunities, Tourism, Local industrial promotion

Social Aspects: Local environment: Preservation of landscape, Infrastructure improvement

Local community: Improvement to public appeal of the local region, Facilitation of regional development

Keywords Agricultural products using renewable energy, Benefit for Irrigation Association, No impact on landscape, Use of irrigation water for power generation, Government energy policy

Abstract

Mallarauco Hydro Electric Plant is located in the valley of Mallarauco, about 80km away from the Chilenian capital Santiago. It is a 3.52MW hydropower station that harnesses the existing infrastructure for irrigation. The project was realized through the joint efforts of the company Gestión de Proyectos Eléctricos S.A. (GPE) and the Association Channel Mallarauco (a group of farmers in the Mallarauco valley) to be commissioned in September 2011. Revenue generated by the plant helps finance the maintenance and repair of the channel system. This project was in the government's "energy mix" plans, and it has contributed in making the area well known for the use of renewable energy to produce

crops. At the EXPO APEMEC in Chile the project was heralded as an excellent example for utilization of small water channels in Chile.

1. Outline of the Project

The water from the river Mapocho flows into the valley through a 2km long bored tunnel, which is then diverted into three smaller channels – North, Central and South branches. The network of channels that are associated with the Mallarauco Canal extends 198km and irrigates 10,000ha in which farmers are cultivating avocados, lemons and oranges. The North and South channels follow the mountainside with a gradient of about 1 degree. The Central channel slopes steeply down into the valley.

The project to produce power from this Central channel started as a private initiative of the Association Channel Mallarauco and GPE. However, at the outset it was simply an agreement between the two parties to construct a 3.5MW hydropower plant which did not materialize for the following 8 years. When Argentina started to reduce the power supply to Chile it resulted in a fuel shortage and a sharp rise of electricity charge, leading to the review of this plan and the agreement came into force in January 2009.

The plant has a design head of 109 meters and a maximum output of 3.52 MW turbine and 3,900KVA synchronous generator, and has a remote control system(SCADA). This power plant is connected to SIC (the Central Interconnected System)[1)], allowing to cover the electricity consumption of 7,000 households with an annual generation of 24,000MWh. In order to secure irrigation water, discharge through the generator is restricted between1.8 and 3.6m^3/s. The design also considered to minimize the visual impact by providing the powerhouse of the plant in a position under the visual level. Photo–1 is the landscape around the power plant and Photo–2 is the intake canal that leads water from the irrigation canal to the generator. Power is transmitted through a 20km long 13.2kV line to SIC. This transmission line was partially set-up using helicopters, due to mountainous terrain.

Photo-1 Landscape around the Power Plant[3]

Photo-2 Project Intake Canal[2]

1) SIC (the Central Interconnected System) is one of 4 independent power systems in Chile.

Photo-3 Turbine Generator[2]

Photo-4 MW line erected by helicopter[2]

Table-1 Project Specifications

Items	Specifications
Name of river/river system	Mapocho river
Installed capacity (kW)	3,430
Maximum discharge (m^3/s)	3.6
Effective head (m)	109
Type of power plant	Conduit type
Connection type	On-grid
Other utilization	Irrigation

2. Financial Viability of the Project

(1) Project cost and funding

Capital investment amounted approximately US$ 11 million funded on low interest rates from CORFO (Corporación de Fomento De la Producción), Banco BICE and the German Development Bank KfW. No subsidies.

Payback period for capital investment cost is estimated in 6 years.

(2) Secured proper revenue

The project started as a private initiative of the irrigation sector and GPE in order to optimize irrigation infrastructure and agricultural development through the hydroelectric potential.

The average annual power generation is 24GWh, and operation and maintenance costs are approximately 5% of the revenue. Appropriate profits can be secured.

(3) Cost reduction by applying new material

The construction cost of penstock is reduced by applying soil restrained penstock design helped to eliminate expensive anchor blocks, and new materials of high

density polyethylene (HDPE) pipe for upstream side and steel pipe for downstream side. (Penstock diameter： Φ1,300mm, Total length：approx. 450m)

3. Economic Benefits of the Project

(1) Tax revenue

The tax revenue is very important for the local communities.

(2) Added value of agricultural products by the use of clean energy

In fruit farming in the future, the CFP (Carbon Footprint)[2] will be the determinant for worldwide export. The more clean energy is used, the better process for farmer's products abroad.

(3) Employment opportunities

Opportunities for direct employment of 6 operators and temporally 10 maintenance personnel were born by this project..

4. Social Aspects of the Project

4.1 Local Environment

1) Repair cost of irrigation canals secured by the profit

The revenue from power generation allows farmers to settle the high costs of channel improvement and repair. The Association Channel Mallarauco will re-invest all the income into the improvement of the network of channels. It is anticipated that the power plant will help to finance close to 50% of this.

2) Preservation of local landscape

The design considered to minimize the visual impact by providing the powerhouse in a position under the visual level. About 1 km of transmission line that connects the power plant to CIS is buried in the underground cable for the same purpose.

4.2 Local Community

1) Power plant operation in cooperation with agricultural irrigation water needs

The management of water flow available for generation of the plant is determined by the Canal Association Mallarauco use, according to their agricultural irrigation needs of the moment.

2) Environmental and energy education

The hydropower plant is used for environmental and energy educational purposes and for supporting the public understanding of hydropower's role in the reduction of greenhouse gas emission.

3) Contribution to the National Energy Policy

Public appeal of the local region is improved and the region is revitalized by implementing low-carbon development programs based on hydropower. In addition,

[2] Carbon footprint (CFP) is a mechanism to display the amount of CO2 emitted from the lifetime of a product (raw material procurement to disposal / recycling) on products.

this type of power plant supports the ambitious goal of diversification of the national energy mix, generating clean and renewable energy.

5 Reasons for the Success

The active participation of local residents in the project helped realize the power plant construction. The project was promoted by the local population's understanding of the technology and the mutual agreement of local communities. The project was promoted by the establishment of new business.

6 Outside Comments

(1) Minister Rodrigo Alvarez said that this project is an example that shows what can be achieved by joining efforts between the association and private enterprise, and how a joint initiative can have this kind of non-conventional renewable energy, which is fully in the government's plans to diversify its energy mix to meet future energy demands in the country.

(2) APEMEC Awards; best project year 2011

7 Reference

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http://www.expo21xx.com/news/wasserkraft-volk-3-5mw-hydro-power-station/

[2] International Water Power & Dam Construction (17 January 2013): Innovations in Chile
http://www.waterpowermagazine.com/features/featureinnovations-in-chile/

[3] INDUSTRIA (Octubre 2011): Central Hidroeléctrica Mallarauco "Aportando al abastecimiento energético y al desarrollo del sector agrícola"
http://www.emb.cl/electroindustria/articulo.mvc?xid=1704

[4] Gestión de Proyectos Eléctricos S.A. (GPE) : http://www.gpe.cl/

DE01

Name of the Power Plant: Prater Hydropower Plant

Country (State/Prefecture): Germany (Munich City)

Owner of the Power Plant

Name of owner: Stadtwerke München GmbH, Green City Energy AG

Type of ownership: Public Utility/Municipality

Type of market: Feed-In-Tariff Scheme

Commissioning Year: 2010

Project Evaluation

Financial Viability: Investment cost recovery, Securing operation & maintenance cost, Securing proper profits

Economic Benefits: Tax revenue, Local industrial promotion

Social Aspects: Local Environment; River environment conservation, Preservation of landscape and/or culture
Local Community; Vitalization of local community, Facilitation of regional development, Education for environment/energy, Improvement to public appeal of the local region, Local government policy

Keywords: Stadtwerke München, Underground power station, Landscape preservation, SWM Renewable Energies Expansion Campaign, fish protection

Abstract

The City of Munich aims to produce as much green electricity at its own plants as required to power the entire city by 2025 and become the first city / city area with 1 million or higher population in the world fully powered by renewable energy. To this end, Stadtwerke München (SWM) launched the SWM Renewable Energies Expansion Campaign. As part of the campaign, SWM partnered with Green City Energy Corporation to jointly fund the construction and launch of the 2.5MW Prater Hydropower Station, using the latest wind-power technology, on the Isar River that runs through the city in February 2010. This is a completely underground power station with all the power generation facilities installed on the bed of the Isar River so as to be considerate toward local residents' natural

environment and river environment. With the understanding and cooperation from the local people and the businesses over the development of RE sources, SWM's projects make effective use of regional resources, thereby contributing to the circulation of funds and creation of jobs within the municipality, as well as facilitating Munich's CO2 reduction strategy and SWM's RE strategy.

1. Outline of the Project

The City of Munich joined the Climate Alliance[1)] in 1991, and aims to 'cut CO2 emissions by 10% every 5 years' and 'halve per-capita emissions from the 1990 level by 2030,' which are the common goals of the Climate Alliance. In order to accomplish these goals, in 2008 the City of Munich set itself two ambitious targets for electricity from renewable sources in its own plants and facilities. The first was to produce enough green electricity through its municipal utility company Stadtwerke München GmbH (SWM)[2)] to meet demands for all 800,000 households and the electrically powered public transport system in Munich (2 billion kWh/year) by 2015. The second was to generate enough electricity from renewables to meet all electricity requirements of the entire municipality of Munich (7.5 billion kWh/year) by 2025. The SWM formulated "Renewable Energies Expansion Campaign" to achieve these targets, and set a budget of about €9 billion through 2008~2025, the annual average €500 million per year, in renewable facilities, like wind power, hydropower solar/heat, biomass and geothermal plants. The first target was achieved in May 2015. The City of Munich is one of the local governments that have adopted the most advanced policy on climate change. It attracted attention from not only Europe but also from the rest of the world when the City set the goal of generating enough renewable energy to supply electricity to the entire municipality by 2025.

The locations of power plants are prioritized in the City of Munich and its suburbs; however, these locations are spread to across German and even Europe, aiming to construct the cost-effective renewable energy power plants that are self-sustaining.

SWM has been investing in clean energy projects, such as the following in their respective regions, including a solar heat plant in Andalusia, Spain and off shore wind farms in the North Sea. The clean electricity from these installations is fed back into the integrated European grid (see Fig.-1).

Munich Region: Hydropower Plant: 13 plants, Biomass Power Plant: 1 plant, Wind Power Plant: 1 plant, Photovoltaic Plant: 20 plants Geothermal Plant: 5 plants
(1 combined heat and power plant, 2 power plant, 2 heat plants)

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1) Climate Alliance was formed by 12 municipalities of Germany, Switzerland and Austria in 1990 so that the forward-thinking European local governments can support and network joint voluntary actions for mitigating greenhouse gas emissions in the region. The membership includes 1,723 cities and municipalities from 20 European nations as of October 2015.

2) SWM is a limited liability corporation fully capitalized by the City of Munich, supplying energies for electricity, gas and district heating as well as water and public transport.

In Germany: Offshore Wind Park: 3 parks in the North Sea,
Onshore wind plants: more than 100 plants
Photovoltaic Plant: 2 plants

In Europe: Offshore Wind Park: 1 park in UK
Wind Park: Belgium, Finland, France, Croatia, Poland, Sweden
Solar Thermal Plant: Spain

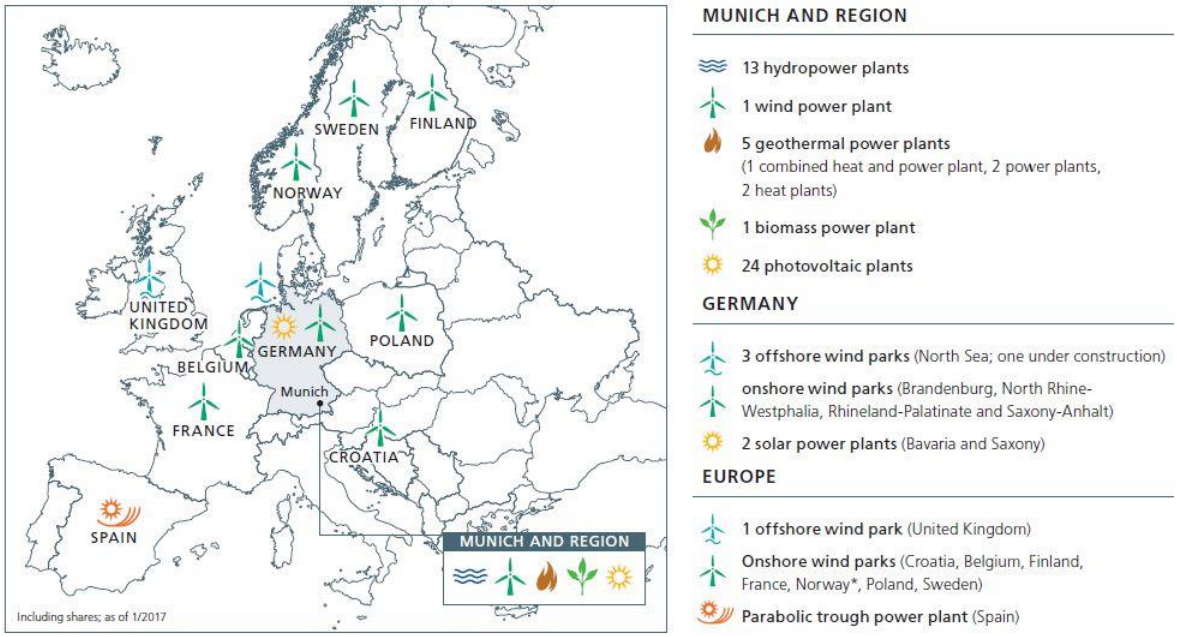

Fig.-1 SWM's green energy plants (Munich and region, Germany and Europe)[2]

Multiple hydropower plants along the Isar River that flows through the city are the maximum renewable energy power source in the City of Munich (see Table 1).

Table-1 Small-scale Hydropower Plants in Munich

Plant Name	Isarwerk 1	Isarwerk 2	Isarwerk 3	Stadtbachstufe	Maxwerk	Praterkraftwerk
Type of Power Plant	Run-of-river					
Plant Capacity	2.4MW	2.2MW	3.3MW	50kW	400kW	2.5MW
Head	5.76m	4.2m	5.7m	2.8m	4.8m	Approx.9.0m
Discharge	64.5m^3/s	70m^3/s	65 m^3/s	2.5m^3/s		34.0m^3/s
Turbine type	Francis	Old: Francis Renewal: Kaplan	Old: Renewal: Bulb	Archimedean	Propeller	Kaplan type Bulb
Unit No.	3	Old: 2 units Renewal: 4 units	Old: Renewal: 2units	1	1	1
Commissioning Year	1908	1923	1923	2006	1895	2010
Renewed Year	Under construction	2010	1978			
Remarks	Note *1		Note *2	Note *3		Note *4

(Note) *1: The building is registered as a historic landmark.
*2: Renewal plan is studying.
*3: Built by the revenue of M-Ökostrom aktiv surcharge fee.
*4: Built by the joint investment with SWM and Green City Energy.

Isarwerk 1 HEP　Isarwerk 2 HEP　Stadbachstufe HEP　Praterkraftwerk HEP

Photo-1 Small-scale Hydropower Plants in Munich[2]

SWM is modernizing the Isarwerke 1 and 2 and Maxwerk plants, which were constructed around 80~100 years ago, SWM is also pursuing other new hydropower projects in the region. It is currently planning to build a small ecological and fish-friendly movable hydropower plant at the confluence of the Amper and Isar Rivers near Wang/Moosburg. In addition, SWM is modernizing existing hydropower plants on the Isar River to generate more green energy and reduce even more carbon dioxide emissions.

In February 2010, SWM constructed and started the 2.5MW Prater Hydropower Plant in the Isar River in a joint investment with Green City Energy Corporation (SWM : 49%, Green City Energy : 51%). The Prater Hydropower Plant is an underground type power station, and its construction cost is reduced by applying a wind turbine generator, available for installing on very narrow spaces of underground. This power plant generates 10.5 million kWh of green electricity a year, enough electricity for 4,000 households. Fig.-2 shows the locations of the intake weir on the left bank of Isar River, the headrace from the intake weir to the power plant, and the power plant. The Prater Hydropower Plant itself is located on the downstream of the last cascade stage and is not visible from the outside. The plant extends underground from Prater weir, located on north of the Maximilian Bridge, to below the cascade of the Isar River. The Isar River water is diverted at the Prater weir and fed to the plant by an underground pressure tunnel under the river bed. The water level difference between intake weir and the last cascade is used for power generation. The natural green space with the natural trees and the urban ensemble around the Maximilian Bridge were left as far as possible in its original state (only 4 trees were cut down). The power station itself is provided with a Kaplan bulb turbine with a multi-poles, variable-speed generator. No speed increaser is equipped between turbine and generator. The generator was developed specially for very narrow spaces and combines advanced technology from wind and water power. In 2012, the Prater Hydropower Plant yielded some 20% above forecast.

In addition, 27m^3/s of water was drawn from the intake at the upstream for 'river surfing' in the Eisbach River at the English Garden in central Munich, and also used for other purposes. This hydropower station is one of the features that was newly developed in urban rivers used for multi purposes.

Fig.-2 Layout of Prater Hydropower Plant[8]

2. Financial Viability of the Project

(1) Securing financial viability with FIT and scale merit

The FIT rate for selling electricity has been fixed for 20 years as follows:

～500kW	12.67€¢/kWh
500～1,200kW	8.65€¢/kWh
1,200～2,500kW	7.65€¢/kWh

The Prater Hydropower Plant has a maximum output of 2,500kW with the average output of 1,200kW and generates annual average power generation of 10.5GWh/year. At the average electricity charge of 10.5€¢/kWh, the payback period is estimated to be approximately 20 years, securing funds for maintenance / management and an adequate level of profitability. (Hydropower's operation cost (OPEX) in Germany is generally around 2～3€¢/kWh.)

(2) Funding from joint capital participation

The construction of this power station was jointly funded by SWM (49%), which has a stable management base, and Green City Energy Corporation (51%), run by the conservationist group Green Member Association. This is one of the factors that have helped the power station become accepted by local citizens. Green City Energy can recover the fund in 30 years through receiving the power station's profit.

(3) Use of new technologies for rationalizing and streamlining the facilities

The latest technologies for hydropower and wind power generation facilities are applied on the Prater Hydropower Plant to minimize the initial investment and install the equipment in a narrow space of the Isar River bed underground power house. Photo-2 shows the turbine set-up condition inside the power plant.

The intake racks are set in the horizontal direction to reduce head loss (increasing power generation), simplify trash removal and prevent fish from entering the intake.

Photo- 2 Internal view of power plant
(Turbine in back; hydraulic unit in front)

3. Economic Benefits of the Project

(1) Revenues for the City of Munich

Since SWM is a limited liability corporation fully capitalized by the City of Munich, the basic principle is to return the profit made by the power plant to the citizens. (The plant is leased to the City on €9,000 per year.) Corporation tax is charged on the profit made by the plant.

(2) Contribution to the local economy and employment through SWM's business

SWM's power plant operation, heat supply (by co-generation) and transportation businesses etc. make effective use of local resources, setting off fund circulation within the municipality and creating local employment.

(3) Developing RE power sources with the voluntary surcharge

The voluntary surcharge of 1.53€¢/kWh from the citizen are used for the development of other renewable energy power generation. Special taxation rate is charged on the voluntary surcharge. This voluntary surcharge is used for investment in regional projects of renewable energy utilization.

With the 8-million-euro revenue from the voluntary surcharge, SWM has built, among other things, 18 photovoltaic plants, 2 small hydroelectric plants, a biogas power plant at the Munich Zoo, a biogas processing plant in Eggertshofen and a biogas cogeneration plant in Michaelibad public swimming pool. Together, the plants generate around 3,000MWh of electricity per year and around 2,500MWh of heat, achieving CO2 mitigation equivalent to approx. 2,650 tons.

4. Social Aspects of the Project

4.1 Local Environment

1) Installation of an underground power station to conserve the surrounding environment

The natural green space with the natural trees and the urban ensemble around the Maximilian Bridge were left as far as possible in its original state. Considering the environments of surrounding residents and riparian, the Prater hydropower plant was built under the Isar river bed.

2) Use of fishway, etc. to protect the river environment

The Isar River used to be more like a canal in the 1900s, but has been turned into a nature-rich river (Environmentally Friendly) from the 2000s.

The Isar River branches to and merges with the Große Isar canal and the Klein Isar river, from which the Praterkraftwerk power plant draws water immediately upstream and downstream. The City of Munich has set up and owns fishways in the Klein Isar River, but the Praterkraftwerk Power Station is responsible for their maintenance and management.

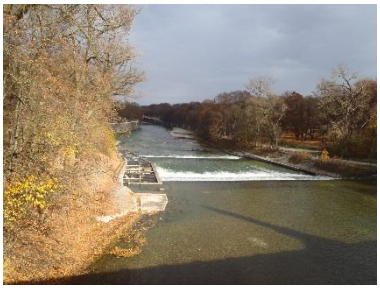

Photo-3 Fishway built on the left bank of Isar River

The power station paid 50% of construction and maintenance costs (see Photo-3).

4.2 Local Community

1) Understanding and cooperation of Munich residents on the development of RE power sources

All citizens wishing to support SWM's expansion campaign can opt for one of SWM's M-Ökostrom green electricity products. More and more Munich residents are joining in this and driving SWM's environmental protection activities forward. Moreover, lots of business customers have also switched to green electricity.

Furthermore, the German Alpine Association and a lot of the festival landlords, entertainment providers and fairground rides at the Oktoberfest and Tollwood festival are SWM green electricity customers.

2) Contribution to the City of Munich's CO2 mitigation strategy and SWM's RE strategy

The City of Munich and SWM have worked together to promote the introduction of wind, water, solar / thermal, biomass and geothermal energies, under the City's commitment to 'cutting CO2 emissions by 10% every 5 years' and 'halving per-capita emissions from the 1990 level by 2030,' which are the common goals of the Climate Alliance, and under SWM's Renewable Energies Expansion Campaign to achieve these goals. The first goal of generating enough renewable energy to supply all of Munich's private households, subways and trams combined, was achieved in May 2015.

5. Reasons for the Success

Munich's ambitious goals and strategy for the development of renewable energies are supported by politicians with strong leadership as well as local residents and companies with a high level of environmental awareness (seeking zero fossil fuel and zero nuclear plant). Thus the Prater hydropower project has been promoted smoothly with public acceptance as a part of the SWM Renewable Energies Expansion Campaign.

Partnership with Green City Energy (the Munich environmental protection organization) to build the power plant has made it easier for the project to be accepted by local residents.

6. Outside Comments

C40 Cities Awards[3]: City Climate Leadership Awards 2013 (Green Energy category)

Munich – 100% Green Power (http://www.c40.org/profiles/2013-munich)

[3] The C40 Cities Awards are granted in 10 categories and provide global recognition for cities that are demonstrating climate action leadership.

7. Reference

[1] Kaori Takigawa, Atsushi Murakami, Noriaki Ikeda, Kaoru Tashiro, Madoka Omi: (To 100% Renewable Energy! Energy Independence Region in Europe) (2013.3: Gakugei Publisher)

[2] SWM Renewable Energies expansion campaign https://www.swm.de/english/company/energy-generation/renewable-energies.html

[3] Praterkraftwerk GmbH (http://www.praterkraftwerk.de/)

[4] Green City Energy AG (http://www.greencity-energy.com/)

[5] Das Praterkraftwerk (Brochure) https://www.greencity-energy.de/wp-content/uploads/2015/06/Praterkraftwerk-von-Green-City-Energy-und-den-Stadtwerken-M%C3%BCnchen.pdf

[6] Tajchman, Kristina L. (University of Texas, Community & Regional Planning): IGERT Trip Report_ Munich, Germany (Summer 2013) http://research.engr.utexas.edu/igertsustainablegrids/images/Germany_2013_IGERT_Trip_Report_KTajchman.pdf

[7] C40 Blog; Mayors' Voices: Munich Mayor Hep Monatzeder (November 07, 2013) http://www.c40.org/blog_posts/mayors-voices-munich-mayor-hep-monatzeder

[8] Climate Friendly Urban Structure and Land Use : http://www.terport.hu/webfm_send/1753

JP01

Name of the Power Plant: Kachugawa Citizens Small Scale Power Station

Country (State/Prefecture): Japan (Yamanashi Prefecture)

Owner of the Power Plant

Name of owner: Tsuru City
Type of ownership: On-site Power Generator / Local Municipality
Type of market: Selling Excess Power by Feed-in Tariff Scheme

Commissioning year: Genki-kun Unit 1: 2006
Genki-kun Unit 2: 2010
Genki-kun Unit 3: 2012

Project Evaluation

Financial Viability: Investment cost recovery, Securing the cost of maintenance and management
Economic Benefits: Tourism resource, promotion of local industries
Social Aspects: Local environment: Conserving the river environment, maintaining local landscape and culture
Local community: Revitalizing the local community, promoting local development, providing environmental / energy education, and improving local brand

Keywords: Citizens-participating small scale hydro project, citizen-participation local bonds, environmental study, community vision with small scale hydro power, practical collaboration research under community-academia partnership

Abstract

The City of Tsuru in Yamanashi Prefecture became the first municipality in Japan to build a citizens-participating small scale hydro plant as a community development project under the collaboration of citizens, local government and academia, in order to proliferate and educate people about small scale hydro electricity. The plant features three types of power generation facilities with output ranging from 7.3kW to 20kW. It supplies enough electricity to cover around 40% of power use at the City Office, and also feeds excess power back into the grid. The project's economic performance has improved through the use of government grants, etc. as part of the construction costs. By implementing the project and disseminating its information, the City of Tsuru has become known as a local government actively taking on

the spread of small scale hydro. It now receives numerous visitors from in and outside Japan for environmental education and inspection tours themed on small scale hydro. The expansion of its human networking and exchange with other local communities, as well as greater participation of private enterprises, had revitalize the city, while also enhancing its citizens' environmental awareness and bringing benefits to the local economy.

1. Outline of the Project

Tsuru City drew up its Environmental Conservation Action Plan in 1999, Regional Global Warming Mitigation Action Plan in 2001 and Regional New Energy Vision in 2003. Based on these plans, it has been working on reducing energy use (e.g. by reducing electricity use and promoting low emission vehicles) and procuring more recycled products.

The Genki-Kun Unit 1 of the Kachugawa Citizens Small Scale Hydro Station is a small scale hydro plant, built with participation of local citizens, featuring a wooden water turbine measuring 6m in diameter and outputting up to 20kW of electricity. Marking the city's 50th anniversary, Tsuru City worked in partnership with local citizens, government and academic organizations to build the small scale hydro plant on the Kachugawa River running outside the Tsuru City Office, supplying electricity to the City Office, as a symbol of the water town Tsuru, and to spread and educate people on small scale hydro, which is attracting the highest expectations as the future of community energy.

After Genki-Kun Unit 1's construction in 2006, the city continued to promote and work toward the 'Aqua Valley Vision [1)]' based on the outcome of its project to explore ways of promoting the 'Small scale Hydro Town (Aqua Valley Tsuru)' project, which was selected for the Power Supply Region Development program by the Ministry of Economy, Trade and Industry. The outcome was the completion of the Genki-Kun Unit 2 and Unit 3 at the Kachugawa Citizens Small Scale Hydro Station in 2010 and 2012 respectively (Table-1, Fig.-1).

Electricity generated by these small scale hydro facilities is normally used to power the City Office, or fed back into the grid under the Feed-In Tariff system (under the Special Measures Act concerning the Use of New Forms of Energy, etc. by the Electric Power Industry (aka Renewable Portfolio Standard Act) until FY2012) when the Office's power load is low at night, on weekends, etc. The electricity not only helps reduce the City Office's power bill but is also utilized at the Tsuru City Eco House exhibition facility showcasing environmentally-friendly housing and ways of living. From FY2009 to FY2013, the added environmental value of such electricity was sold in the form of 'Tradable Green Certificates.'

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1) The Aqua Valley Vision was defined as an initiative for achieving the goal of 'environmental community development for symbiosis between human and nature,' listed in the city's 5th long-term general plans. It envisages developing a hands-on environmental learning grounds based on micro hydro mainly in areas around the City Office to attract those who engage in environmental studies, those interested in micro hydro and universities / private enterprises seeking a hardware testing site in a bid to expand the city's non-residential population.

Table-1: Specifications of the power station

Item	Specifications		
Power plant name	Genki-Kun Unit 1	Genki-Kun Unit 2	Genki-Kun Unit 3
Name of the water system / river	Kachugawa River in the Katsura River section of the Sagamigawa River system		
Maximum output	20 kW	19 kW	7.3 kW
Maximum discharge	2.0 m^3/s	0.99 m^3/s	0.99 m^3/s
Effective head	2.0 m	3.5 m	1.0 m
Water turbine type	Open-type undershot water turbine	Open-type overshot water turbine	Open-type spiral water turbine
Power generation type	Run-of-river type / canal type		
Grid connection	Yes		

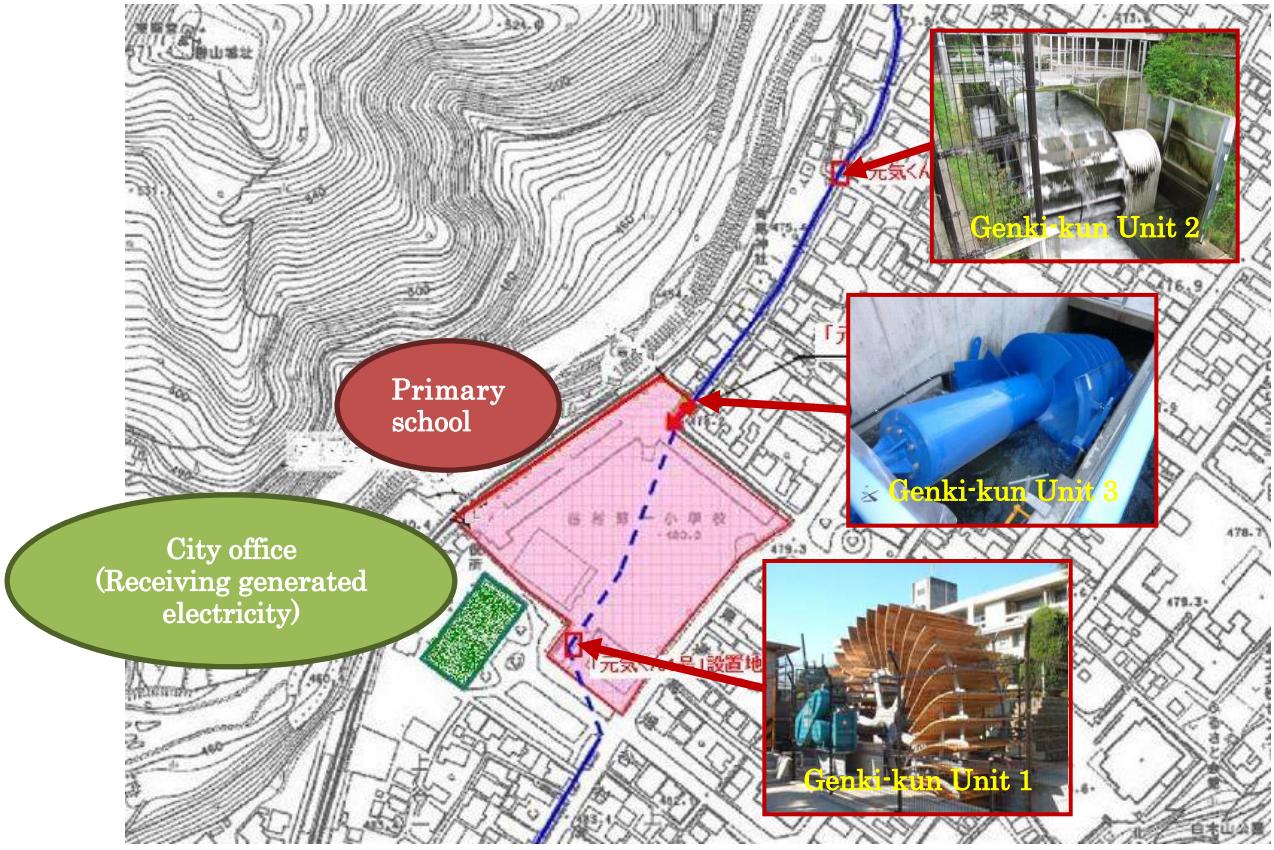

Fig.-1: Layout of the Kachugawa Citizens Small Scale Power Station (Genki-Kun Units 1, 2 and 3)

2. Financial Viability of the Project

(1) Using government subsidy for economic viability and issuing citizen-participation local bonds for fundraising (Fig.-2)

The Genki-Kun Unit 1 was developed under NEDO's (New Energy and Industrial

Technology Development Organization) program for introducing new technologies in the installation of hydropower facilities (first local government project under this program), and secured 50% funding for the portion where new technology [2)] was applied, making it economically viable. The Genki-Kun Unit 2 received grants from NEDO, NEPC (New Energy Promotion Council) and GIAC (Greater-kanto Industrial Advancement Center) to achieve economic viability. The Genki-Kun Unit 3 took advantage of Yamanashi Prefecture's subsidization program for local projects that promote the introduction of clean energies[3)] to cover almost 100% of the installation cost.

Under the philosophy of citizen participation, the fund for Genki-Kun Unit 1 and Genki-Kun Unit 2 was raised by issuing citizen-participation local bonds (Tsuru-no Ongaeshi Bond). The bond offered the interest rate 0.1% higher than that of government bond for the respective years, i.e. 0.9% for Genki-Kun Unit 1 and 0.6% for Genki-Kun Unit 2.

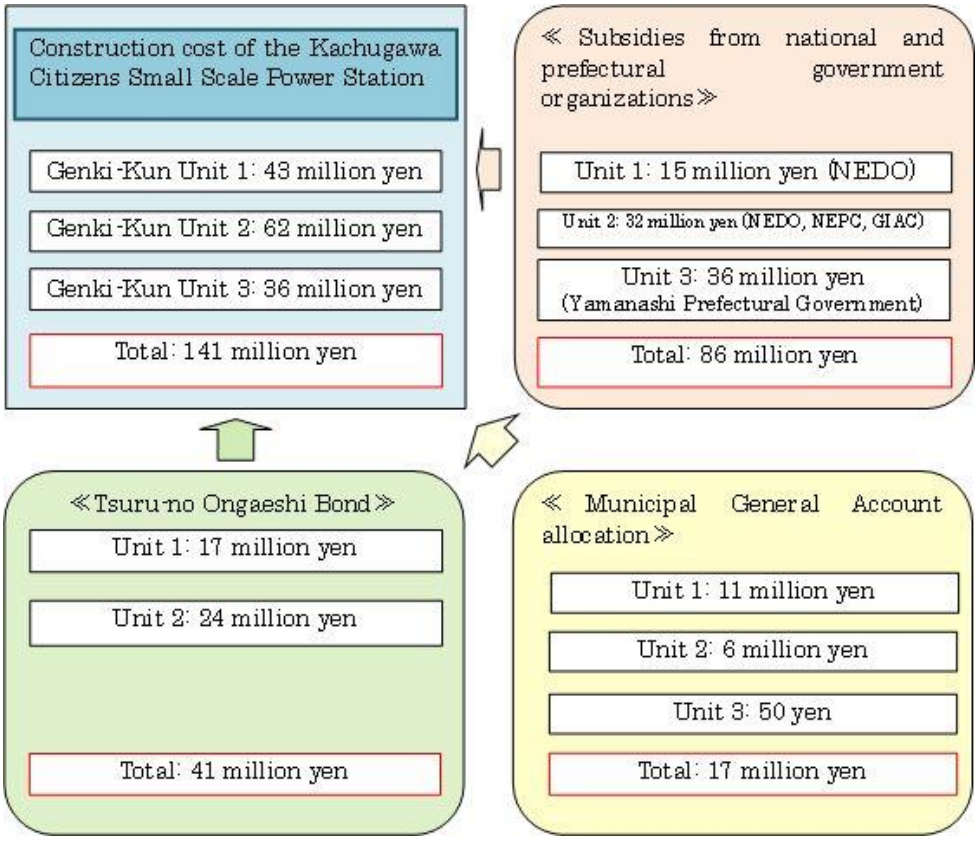

Fig.-2: Fund raising for the construction
of the Kachugawa Citizens Small Scale Power Station

[2)] Large variable-speed undershot water turbine hydropower system fitted with a new type of water screening equipment: This variable-speed undershot water turbine hydro power system incorporates a new type of water screening equipment, which combines fixed rake, variable screen and back washing, into PMG (Permanent Magnet Generator) and power conditioner (semiconductor power converter) to accommodate the change of water volume.

[3)] Based on the Green New Deal Funds plan, this program subsidizes Yamanashi municipalities' projects that promote energy conservation and application of green energy technology in order to reduce CO_2 emissions.

(2) Keeping the cost of maintenance and management low

The new type of water screening equipment, adopted at Genki-Kun Unit 1, and the remote-monitoring system based on mobile phones, introduced to Genki-Kun Units 2 and 3, have reduced workload for and simplified the Station's maintenance and management, thereby lowering the maintenance and management costs. (Table-2)

Table-2: Annual maintenance and management cost for the Kachugawa Citizens Small Scale Hydro Station (approximation)

Breakdown	Amount (yen)	Remarks
Maintenance outsourcing	429,000	
Remote monitoring system	120,000	Genki-Kun Units 2 and 3
Other costs (e.g. cost of replacing parts)	480,000	
Total	1,029,000	

3. Economic Benefits of the Project

(1) Cutting costs through the use of generated power and gaining FIT revenues

Electricity generated by the small scale power station Genki-Kun is connected to the City Office's high-voltage receiving equipment to power the City Office, its indoor farming display facility, etc. The City buys less power from electric utilities and saves on costs as a result. (Fig.-3)

Based on actual power output data from FY2012, the project's effect of cost reduction is estimated as follows:

Gross power generated: 149,762 kWh

Power fed back into the grid: 23,250 kWh

Unit cost of power purchased: 22.8 yen/kWh (December 2012 data)

Cost reduction effect: (149,762-23,250) × 22.8=2,884,474 yen

When the electricity demand of the City office decreases at night or on a holiday etc., the excess power is sold to the utility by the Feed-in Tariff started in 2013, which increase the revenue of the City.

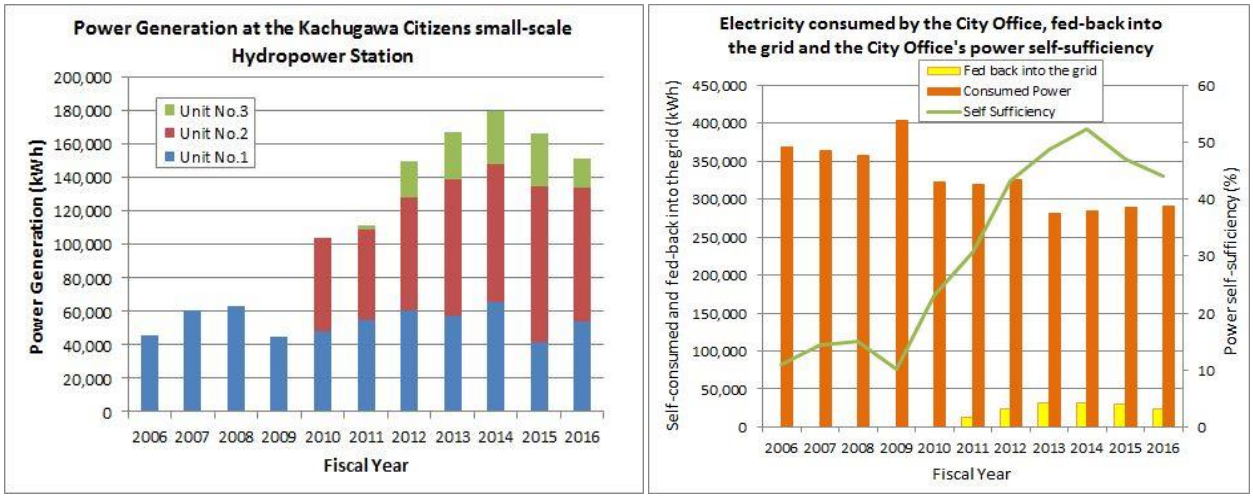

Fig.-3: Kachugawa Citizens Small Scale Hydro Station's gross power generation and the City Office's electricity consumption, power fed back into the grid and power self-sufficiency

(2) Economic effects of environmental-learning field inspections and trainings

Tsuru City is placing the emphasis on environmental education, using hands-on grounds based on small scale hydro theme. Hands-on experiences, inspections and trainings for environmental education are offered at the periphery of Citizens Small Scale Hydro Station using the electricity generated by the station.

4. Social Aspects of the Project

4.1 Local Environment

1) Boosting local residents' awareness on making the environment beautiful

The introduction of the water mill-based small scale hydro system has sparked developments such as volunteer cleaning of the Kachugawa River and reduced illegal disposal of empty drink cans, fostering positive social manners and building awareness on making the local environment beautiful. (Photo 1)

Photo-1: Local volunteers cleaning Kachugawa River and other areas

4.2 Local community

1) Promoting the small scale Hydro Town (Aqua Valley Tsuru) vision

Water mill have long been used in the Kachugawa River as a power source for distributing domestic-use water, milling grains and rice and operating looms. From

1905 to 1953, the river had the Sannomaru Hydropower Station for commercial use. Against this historical background, emerged the installation of an experimental small scale hydro generator by the Tsuru Hydro Energy Forum (committee of local citizens) and the Small scale Hydro Town (Aqua Valley Tsuru) vision for promoting 'environmental education' using clean energies and exploring 'sustainable social equilibrium.' Under this vision, the City had investigated the installation of small scale hydro facilities as one of its core policies.

2) Enhancing the region's name value through spreading and educating the public about small scale hydro

As a pioneer site of small scale hydro, Tsuru City had staged the 'National Small scale Hydro Summit in Tsuru' and 'Genki-Kun Unit 2 Seminar', inviting organizations and small scale hydro experts seeking to proliferate small scale hydro technology in a bid to spread and enlighten people about small scale hydro.

5. Reason for the Success

(1) The project's economic viability

In the construction of the power station, new technologies and offshore-sourced materials (water turbines, generators) were introduced to streamline and simplify facilities in order to reduce the cost of construction, maintenance and management. The project's economic viability is also enhanced by making use of national / prefectural small scale hydro subsidies and issuing citizen-participation local bonds.

(2) The project's economic benefits

The stable plant operation has helped the City Office reduce its power expense and gain revenues by feeding excess power back into the grid.

(3) Contribution to local environment and society

In a community development initiative backed by active participation of local citizens and government partnership, Tsuru City became the first municipality to build a citizen-participation small scale hydro station with the aim of spreading and educating the public about small scale hydropower. Consequently, the City has become widely known as the 'small scale hydro town,' attracting an increasing number of visitors for environmental learning, inspections and trainings and creating exchange or partnership with other local governments. This way, the project has significantly contributed to boosting the appeal of the region and revitalizing the local communities. The regional development under partnership between local citizens and local government has heightened the environmental awareness of local people, who are actively participating in projects for making the environment beautiful and conserving nature. Tsuru City also offers a field testing ground for small scale hydro facilities to private businesses, and explores regional revitalization through partnership with local academia, in an active effort for local development as the top-runner in small scale hydro.

6. Outside omments

(1) New Energy Foundation Chairman's Award in the New Energy Awards by NEF (FY2006)

(2) Minister of Internal Affairs and Communications (MIC) Commendation for outstanding community development (FY2007)

(3) Ministry of the Environment (MoE) Gold Award for the outstanding 'One Village One Product campaign for mitigating global warming' (FY2007)

(4) Selection by METI / NEDO as one of the top 100 new energy projects (April 2009)

7. Reference

[1] Tsuru City website : http://www.city.tsuru.yamanashi.jp/forms/top/top.aspx

[2] Tsuru City: Tsuru City Report on Regional New Energy Vision and other projects, Summary edition, February 2003

[3] Yoshimitsu Kobayashi: City Planning Institute of Japan and Japan Association of City Mayors / Reference material for the City Planning Symposium "Discussing 21st-century city planning with mayors --- Boosting local capacity", *Initiative of the Kachugawa Citizens Small scale Hydro Station Genki-Kun*, February 2013

JP02

Name of Power Plant: Taio Small scale Hydropower Station

Country (State/prefecture): Japan (Oita Prefecture)

Owner

Name of Owner: Hita City, Oita Prefecture

Type of ownership: On-site Power Generator / Local Municipality

Type of market: Selling Excess Power by Feed-in Tariff Scheme

Commissioning Year: 2004

Project Evaluation

Financial Viability: Recovering initial investment, securing the cost of maintenance and management

Economic Benefits: Job creation, tourism resource

Social Aspects: Local environment: Developing local infrastructures, protecting natural environment

Local community: Promoting local development, providing environmental / energy education

Keywords: Use of existing check dam, experimental model project for improving mountain villages' environmental conservation, forest conservation activity, emergency power supply, next-generation energy park

Abstract

The City of Hita in Oita Prefecture utilized the Ministry of Agriculture, Forestry and Fisheries' mountain villages environmental conservation program in building the Taio small scale hydropower Station. The station makes use of abundant water resource from local mountains, and is designed sympathetically to the area's natural landscape, making a significant contribution to local tourism development. The project made use of existing check dam and received a government subsidy to enhance its economic viability. Generated electricity is supplied to a community exchange facility nearby as well as to a tourism facility at the decommissioned Taio Gold Mine, with excess fed back into the power grid. The saving made from the reduced consumption of power from an electric

utility and the revenues from the Feed-in Tariff have been allocated to lower the current expenditures of those facilities' operations and develop tourism facilities. At the time of emergency, e.g. a natural disaster, the facilities can be operated off the grid, and excess power can be directly supplied to local needs.

Furthermore, volunteers from local communities and nearby prefectures engage in forest conservation work at the headwater, initiating exchange between upstream and downstream residents. The station also accepts visitors as one of the government-funded facilities promoting / enlightening the public about future generation energy, thereby contributing to energy education.

1. Outline of the Project

Nakatsue Village (today's Nakatsue district in Hita City) is located in North-Western Oita Prefecture. Mountains and forests account for 90% of its total area. A gold mine was found in the village in 1894. The Taio Gold Mine, which boasted the largest gold production in Japan at one stage, used to employ some 3,000 people in its peak period. However, the village's population dwindled rapidly following the submersion of farmlands and houses following the construction of the Shimouke Dam from 1964 to 1968, and the closure of the Taio Gold Mine in 1970. In 1983, Nakatsue Village reinvented itself as a tourism-oriented community, turning the disused gold mine into the Taio Gold Mine Underground Museum. It also began offering a rest area for motorists, and developed a hall at the Taio Gold Mine for disseminating local information, winning designation by the Ministry of Land, Infrastructure, Transport and Tourism as a 'Michi-no Eki' roadside station[1)] in 2000. In the 2002 FIFA World Cup co-hosted by Japan and South Korea, the village became a pre-tournament camp site for the Cameroon national team. The footage of Nakatsue villagers welcoming the athletes was broadcast live across the nation, turning Nakatsue into a symbol of traditional Japanese countryside and starting to attract a large number of tourists.

The Taio power station was planned not only to reduce the power bills of the roadside station 'Taio Gold Mine' (10 million yen per year) but also in view of the local history of having used small scale hydropower for drilling at the Taio Gold Mine and powering springwater drain pumps; a series of past mayors' intentions ((1) reducing current expenses for new tourism development and employment expansion, (2) promoting forestry conservation to secure stable water sources 20 – 30 years ahead and (3) effectively utilizing environmental resources to generate clean energy and use the site for public education); and one-week power blackout following Typhoon No.19 in September 1991 (Table-1).

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1) Facilities designated by the Ministry of Land, Infrastructure, Transport and Tourism, combining the 'rest area function' for motorists, 'information dissemination function' for motorists and local people, and 'community collaboration function' connecting communities together for community development with vitality

The power station's construction was designated as a special mountain village development project for FY2002 (experimental model project for improving mountain villages' environmental conservation[2)]), and commenced in 2003. The plant's operation began in April 2004.

Table-1: Specifications of the power station

Item	Specifications
Name of the water system / river	Tsuegawa River in the Chikugogawa River system
Maximum output	66kW
Maximum discharge	0.5m^3/s
Effective head	18.0m
Flow required for power generation	0.07m^3/s
Power generation type	Run-of-river type / canal type
Grid connection	Yes

Table-2: Specifications of the Taio Check Dam

Dam type	Concrete gravity dam
Dam length	62.70m
Dam height (at spillway section)	12.50m
Wing height	5.80m
Slope gradient	Upstream 1:0.2, downstream 1:0.68
Sediment trap capacity	80,260m^3
Crest elevation (at spillway section)	EL.483.80m
Completion	February 1989

Water for power generation is drawn from a modified existing check dam (Table-2). Pipes with the diameter of 600 – 700mm are laid underground (approx. 550m in total length, materials; FRPM, iron and hume pipes) along a forest road to a Francis turbine generator with the maximum output of 66kW via 500mm-diameter penstock (approx. 40m in total length, materials: FRPM and iron pipes) (Fig.-1 and Fig.-2). Generated electricity is connected to the electric utility's distribution network via 1.2km-long 6.6kV cable to supply electricity to the roadside station and Taio Gold Mine tourism facilities, with excess power fed back to the grid. The Hita City Taio Gold Mine tourism facilities, including this power plant, are managed by the Nakatsue Village Earth Foundation, designated by Hita City.

2) Model project involving appropriate environmental management and environmental load reduction in mountain villages in order to improve such villages' environmental conservation function (Subsidization rate: 50%)

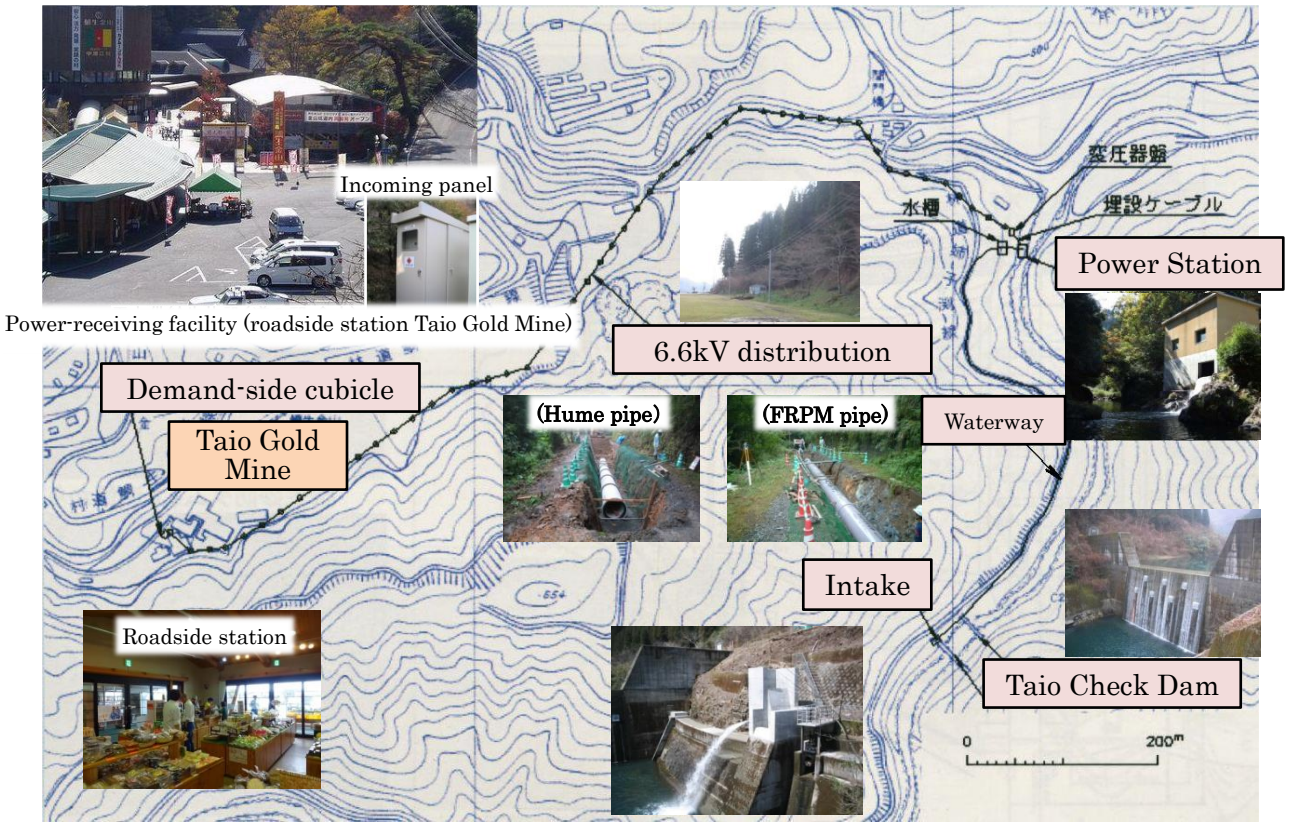

Fig.-1: Plan view of the Taio power station

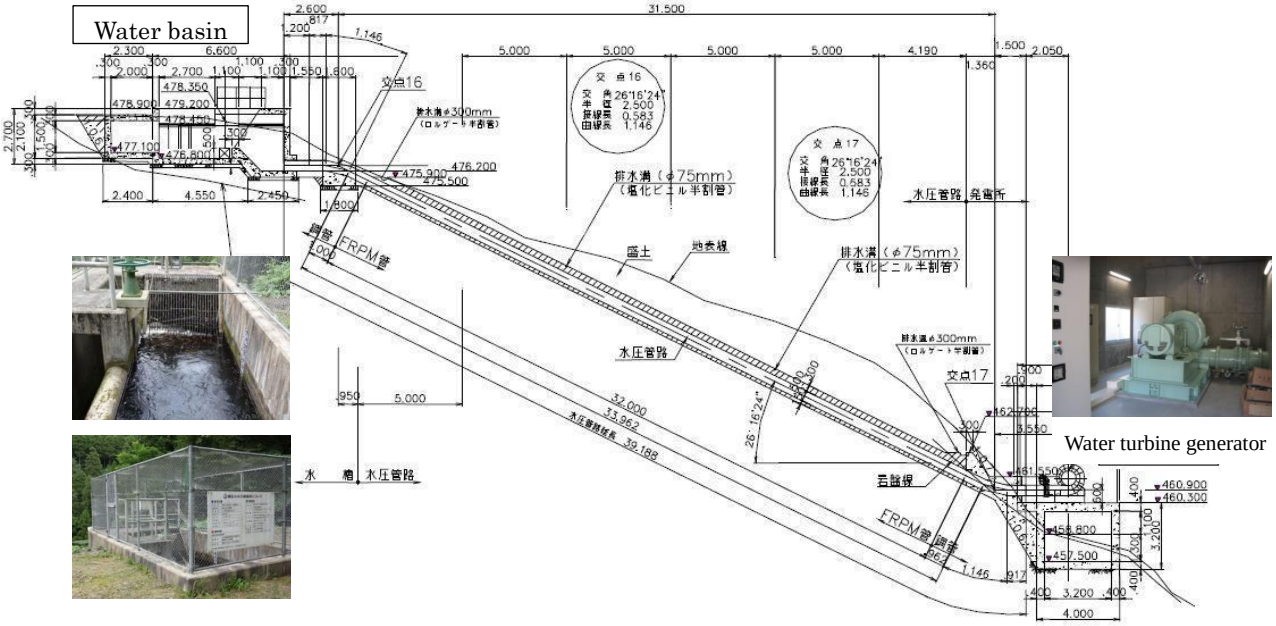

Fig.-2: Longitudinal section of the penstock

2. Financial Viability of the Project

(1) Using existing facilities and low-cost materials to reduce construction costs

The power station draws water from the existing check dam. The use of the dam which was built (1989) with an intake, envisaging the future installation of a small scale hydropower station, effectively reduced the cost of civil engineering during

plant construction. Also, hume pipes and FRPM pipes were buried underground to form aqueduct channels to lower the installation cost.

(2) Securing economic viability through the use of subsidization programs

The Taio power Station's project cost totaled 170 million yen. It made a major progress as a project after being selected as an experimental model project for improving mountain villages' environmental conservation (subsidization rate: 50%) by the Ministry of Agriculture, Forestry and Fisheries. The project also gained fund from local bonds for depopulated communities by incorporating it into a tourism renewal initiative as one of eco-energy facilities along the walking route at the Taio Gold Mine. These factors have secured the project's economic viability, allowing it to make a major advancement (Table-3).

Table-3: Taio power station's project costs and fundraising

		Amount (million yen)	Remarks
Project costs	Total project cost	170	
	Civil engineering facilities	26	
	Electric facilities	137	
	Others	7	
Fundraising	Government subsidization	85	Experimental model project for improving mountain villages' environmental conservation: Subsidization rate 50%
	Bond issuance	79	Depopulation countermeasure bond: 70% assistance from the prefectural government
	Own finance	6	

3. Economic Benefits of the Project

(1) Reducing costs with in-house power generation and feeding excess power back into the grid to develop tourism facilities

Electricity generated at the Taio small scale hydropower station covers around 60% of power used at the roadside station Taio Gold Mine, etc. for lighting and air conditioning, which has reduced the amount of power purchased from the local electric utility, thereby reducing costs. With revenues from feeding excess power back into the grid, the site's operator (Nakatsue Village Earth Foundation) has enjoyed an increase in current income, and allocated it to the development of enhanced facilities (Table-4, Table-5, Fig.-3). At present, approximately 72kW of power load is used for light fittings. They are being replaced with LED fittings, which will reduce the power load to 22kW.

The enhancement of tourism resources has increased the visitor counts to the roadside station Taio Gold Mine and the Taio Gold Mine Underground Museum to 120,000 per annum and 45,000 – 50,000 per annum respectively. As for the effect of job creation, an associated facility has employed 2 part-time workers, generating the economic effect equivalent of approx. 5 million yen per year.

Table-4: Actual costs of electricity at the tourism facilities (FY2009)

Item	Amount	Remarks
Revenue	6,800K yen	Savings in electricity bills: 5,410K yen FIT revenue: 1,390K yen
Expenditure	730K yen	Labor (outsourced): 600K yen Consumables, etc.: 130K yen

Table-5: Actual amount of electricity generated

Fiscal year	2006	2009	2012	2014
Power generation (MWh)	381	360	399	377

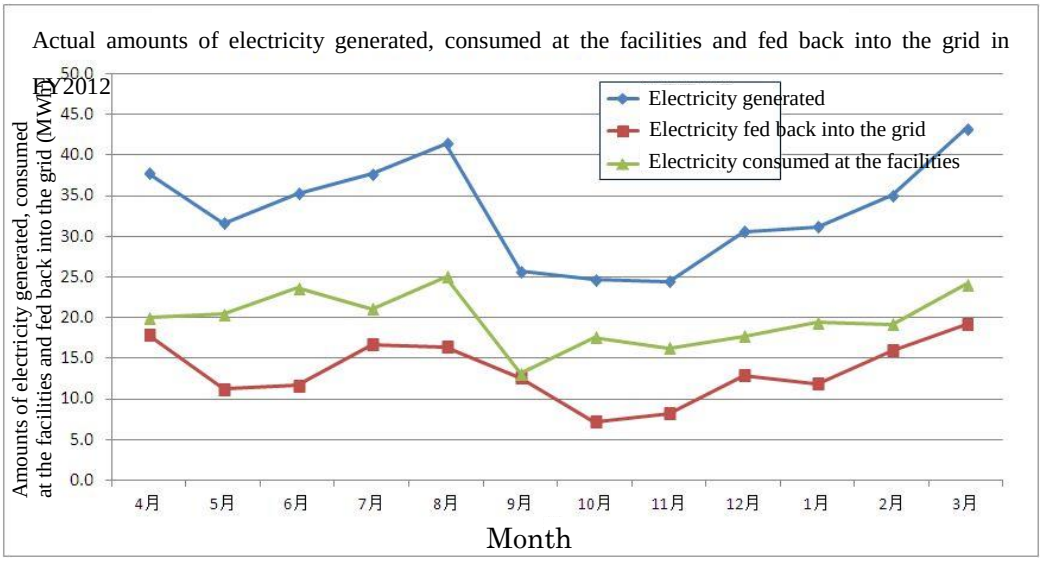

Fig.-3: Actual amounts of electricity generated, consumed at the facilities and fed back into the grid (FY2012)

4. Social Aspects of the Project

4.1 Local Environment

1) Developing a forest road in relation to the plant construction

The aqueduct channel for the Taio power station is laid (underground) along a forest road, which was treated with bitumen due to the construction of the power plant.

2) Developing forests at the headwater area under the '200 Mile Forest Development' program[3)]

The '200 Mile Forest Development' program was launched in 2000 with the aim of restoring forest damage from typhoons and developing the forest environment. The Nakatsue Village Earth Foundation holds sessions twice a year, attracting some 150 – 200 volunteers from the Hita City, Fukuoka Prefecture, etc. Under the program, weeding and tree planting activities have been carried out in the upstream region of the power plant (Photo-1).

The program was commended by the Ministry of Land, Infrastructure, Transport and Tourism[4)] for its contribution to water resources in FY2011.

Photo-1: Undergrowth weeding and tree planting under the 200 Mile Forest Development program

4.2 Local Community

1) Establishing the plant as an emergency source of power

Electricity generated at the Taio power station can be used as emergency power for surrounding communities in the event of emergency.

2) Facilitating environmental and energy education

The Taio power station is part of Oita Prefecture's Next-Generation Energy Park[5)] as the venue for deepening future-generation's understanding on the importance of using ecological energy. Students from nearby schools tour the plant around twice a year for environmental and energy education. Furthermore, the site has about 10 visits each year to inspect small scale hydropower as an example renewable energy operation.

[3)] The program involves the residents of city areas in the downstream areas of Chikugo River for forest development of Hita City's Nakatsue Village, located on the river's upstream, in order to help them re-recognize the importance of the river system, its ecology and the presence of headwater forest, thereby boosting their awareness on forest development.

[4)] The Ministry extends commendation to individual persons and organizations that have made outstanding contributions to the promotion of water resource administration, e.g. the development / utilization of water resources and headwater conservation.

[5)] The Next-Generation Energy Park is a program run by the Ministry of Economy, Trade and Industry (Agency for Natural Resources and Energy), seeking submissions from local governments, selecting suitable projects for designation and announcing successful projects.

5. Reason for the Success

(1) The project's economic viability

The plant draws water from an existing check dam. Hume pipes and FRPM pipes are laid underground to form aqueduct channels to lower the cost of civil engineering work. Government subsidies for small scale hydro projects and local bonds are also utilized to enhance this project's economic viability.

(2) The project's economic benefits

Generated electricity is used to power the tourism facilities, etc. to reduce their costs, with excess power fed back into the grid. The resulting saving and revenue have been allocated to enhance the tourism facilities, etc., consequently boosting the number of visitors and creating new jobs.

(3) Contribution to local environment and society

A series of Nakatsue Village mayors exercised their leadership in restoring small scale hydro facilities in order to make best use of past hydropower potential.

The construction of this plant has resulted in the development of the forest road, and initiated weeding and tree planting operations by volunteers from local communities and nearby prefectures, which strengthened the bond between upstream and downstream residents, while the plant has also accepted visitors for an inspection tour, teaching the public about energy and the importance of water resources.

6. Outside Comments

(1) Selection by METI / NEDO as one of top 100 new energy projects (April 2009)

(2) Commendation by the Ministry of Land, Infrastructure, Transport and Tourism for its contribution to water resources in FY2011

(3) Featured in "Homerare Town 100 [6]" on Oita Broadcasting System for its use of rich water resources

The program featured the site as a small scale hydro plant in symbiosis with nature, paying considerations to the habitat of fish.

7. Reference

[1] Hisanori Ito, Tomokazu Shinozaki, Takahiko Nakazawa: Introduction of small scale Hydro in Consideration for Local Revitalization (NEF 71st Practical Workshop concerning Medium and Small scale Hydro Plant Technology), July 2004

[2] NEDO: Top 100 New Energy Projects, Taio Small scale Hydro Station in Hita City

[3] Nakatsue Village Earth Foundation http://taiokinzan.jp/index.html

[6] This is a joint campaign by 33 AM radio stations nationwide in conjunction with the government's drive to promote a civic movement for mitigating global warming. It selects new technologies, key player activities and initiatives by local governments / shopping streets for achieving 'low carbon society,' and introduces them as 'Homerare Town' cases.

JP03

Name of Power Plant: Nasunogahara Small Scale Hydro Power Stations

Country(State/Prefecture): Japan (Tochigi Prefecture)

Owner

Name of owner: Nasunogahara Land Improvement District Association, Ministry of Agriculture, Forestry and Fisheries

Type of ownership: On-site Power Generator / Land Improvement District Association

Type of market: Selling Excess Power by Power Purchase Agreement

Commissioning year: Nasunogahara Station: 1992
Momura No.1 and No.2 Stations: 2006
Hikinuma No.1 and No.2 Stations: 2009
Shin Aoki Station: 2014

Project Evaluation

Financial Viability: Recovering initial investment, securing the cost of maintenance and management, securing an appropriate level of profit

Economic Benefits: Job creation, local industry revitalization

Social Aspects: Local environment: river ecosystem conservation
Local community: Revitalizing local communities, providing environmental / energy education

Keywords: Power generation fully dependent on agricultural water, Use of idle drop, HYDRO-AGRI, Reduced levies

Abstract

The Nasunogahara Land Improvement District Association generates a total of 1,500kW of power at six power plants, taking advantage of Nasunogahara alluvial fan's 480m altitude difference between upstream and downstream areas, and using underutilized drops that exist in irrigation facilities such as canals and open channels. Generated electricity is sent, via an electric utility's distribution lines, to irrigation facilities (remote-monitoring and gate control facilities for managing agricultural water), with excess fed back into the grid. The construction of the power plants employed new

technologies and new materials to reduce costs, and received government subsidies, etc. for improved economic viability.

This project has reduced farmers' burden of irrigation maintenance and management charges (levies), and generated awareness among them about the importance of sharing water's benefits within the communities. It voluntarily led to the discharge of maintenance flow into Nakagawa River, which boasts one of the largest Ayu sweetfish catches in Japan, in a contribution to the conservation of the river's ecosystem.

This project has encouraged local land-users' participation from the early stage, creating a mechanism that facilitates the establishment of their understanding toward the project. It took the approach of carrying the success of one project over to the next project, to become a pioneering model for small scale hydropower projects undertaken by Land Improvement Districts around the nation.

1. Outline of the Project

Nasunogahara is an approximately 40,000-hectare alluvial fan between Nakagawa River and Hokigawa River in the north-eastern part of Tochigi Prefecture. The Ministry of Agriculture, Forestry and Fisheries launched a national farmland development project in Nasunogahara in 1967 to secure its headwater and eliminate shortage of agricultural water. To supply water for irrigation, power generation and tap water to communities in the upper reach of Nakagawa River, this project built the Fukayama Dam (completed in 1974) with the effective reservoir capacity of 21 million m^3, and established the 1.2 million m^3 Akada regulating reservoir and 1 million m^3 Toda regulating reservoir. It also built or upgraded the Itamuro Dam, Nishi-Iwasaki Weir and Kinomata Weirs (new and old), while updating main and branch water canals with the total length in excess of 330km (Figure1). Since these canals have a large drop of around 480m between upstream and downstream, multiple drop structures are set up to send water downstream at a reduced flow, creating potential for small scale hydropower at numerous points. The details and locations of hydro plants constructed so far are shown in Table 1 and Figure 1.

The Nasunogahara hydropower station is a run-of-river power station fully reliant on agricultural water with the maximum output of 340kW. It makes use of the idle drop (approx. 30m) of the 1,400m-long Toda Higashi canal (pipeline), which draws water from the Upper East Main Canal and the new / old Kinomata Canal to the Toda regulating reservoir.

The Momura No.1 and No.2 hydropower stations are run-of-river power stations fully reliant on agricultural water with the maximum output of 120kW (30kW x 4 locations). They make use of the maximum water discharge of 2.4 m^3/s and effective head of 2m at four drop structures situated one after another along the Upper Main Canal. These are private power plants introduced in FY2005 following empirical tests conducted from April 2004 to September 2005 with the aim of developing a low-drop water turbine generator.

The Hikinuma No.1 and No.2 hydropower stations are run-of-river power stations fully

reliant on agricultural water with the maximum output of 540kW (No.1 = 360kW and No.2 = 180kW). They use FRPM pipes buried in the Hikinuma Canal to exclude dirt from water for power generation and reduce the cost of civil engineering work.

The Shin Aoki Station is a run-of-river power station fully reliant on agricultural water with the maximum water discharge of 1.4 m^3/s, effective head of 44m and maximum output of 500kW. It makes use of the idle drop of the Toda East Canal connecting the Toda regulating reservoir and the Lower Main Canal, and uses FRPM pipes to reduce the cost of civil engineering work.

Generated electricity is supplied to irrigation facilities dotted around the site via Tokyo Electric Power Company's distribution lines. Excess power is fed back into the grid, with revenues allocated to the maintenance and management of agricultural canals, etc. across the site.

The first installed power station, Nasunogahara, was realized with the idea of 'Reducing the beneficiaries' cost burden for maintenance and management of land improvement facilities by the power generation project', and as a result of persistent efforts by the national project office's manager and Land Improvement District Association's director. As a result of this, other power stations were constructed under consultation with related organizations and local residents' understanding / cooperation (agreement formation).

Table-1: Specifications of the hydropower stations

Power station name	Nasunogahara	Momura No.1	Momura No.2	Shin Aoki	Hikinuma No.1	Hikinuma No.2
Name of the water system / river	Nakagawa River, etc. in the Nakagawa River system				Sabigawa River in the Nakagawa River system	
Owner	MAFF(Note 1)	Nasunogahara Land Improvement District Association				
Maximum output	340kW	30kW	90kW (30kW×3)	500kW	360kW	180kW
Maximum water discharge	1.6m^3/s	2.4m^3/s	2.4m^3/s	1.4m^3/s	1.6m^3/s	1.6m^3/s
Effective head	28.0m	2.0m	2.0m	44.0m	29.11m	15.51m
Power generation type	Run-of-river type / canal type					
Grid connection	Yes					

(Note 1) Ministry of Agriculture, Forestry and Fisheries.

The power station is managed by Nasunogahara Land Improvement District Association.

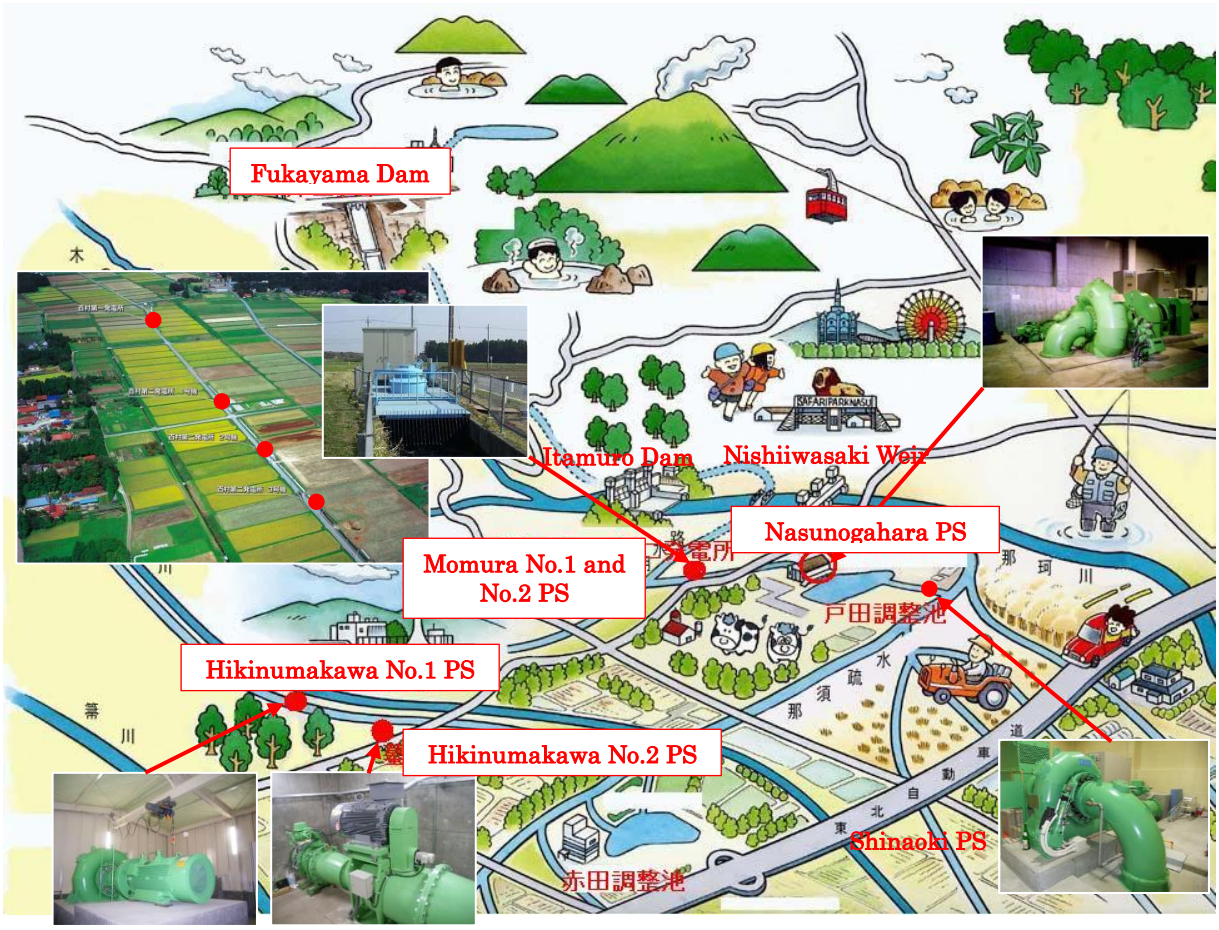

Fig.-1: layout of the Nasunogahara small scale hydropower stations

2. Financial Viability of the Project

(1) Using subsidies to secure economic viability

Government subsidies have been used in installing each of the plants to reduce the construction costs (Table-2).

The Nasunogahara Land Improvement District Association's reserve fund (self fund) was allocated to cover the rest of the costs.

Table-2: Subsidies used in plant installation

Power station name	Subsidization program	Jurisdiction	Subsidy rate (%)	Gross project cost (million yen)
Nasunogahara	National farmland development project in Nasunogahara	Ministry of Agriculture, Forestry and Fisheries	56.4	640
Momura No.1	New agricultural irrigation system conservation project	Ministry of Agriculture, Forestry and Fisheries	50	25
Momura No.2	Medium and small scale hydro development subsidy	Ministry of Economy, Trade and Industry	30	75
Hikinuma No.1 and No.2	Local new energy introduction promotion project	Ministry of Economy, Trade and Industry	50	430
Shin Aoki	Water environment development project for group-managed areas	Ministry of Agriculture, Forestry and Fisheries	50	640

(2) Employing new technologies and new materials for cost reduction

The Momura No.1 and No.2 hydropower stations use the small scale Kaplan Turbine Generator system (HYDRO-AGRI), which packages together a turbine generator and its control system (Figure 2). It takes advantage of existing drop structures to reduce the cost of civil engineering work, and carries out assembly at factories to shorten the duration of on-site installation. The plants facilitate easy operation, maintenance and management.

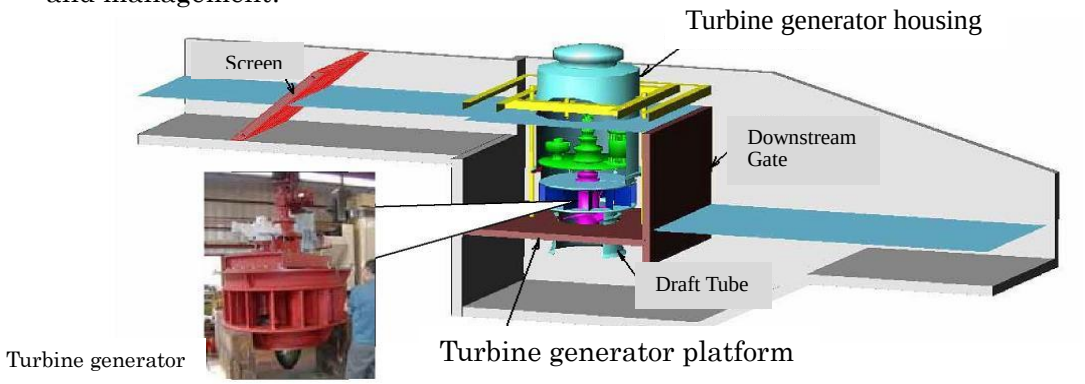

Fig.-2: Momura Power Stations /
Schematic diagram of the plants' system structure

The Nasunogahara Station, Hikinuma No.1 and No.2 Stations and Shin Aoki Station use FRP(M) pipes for pipeline to reduce the cost of installation and shorten the installation time. The pipes are buried underground in consideration for surrounding landscape. (Figure 3 and Photo 1)

The initial cost of the plants is reduced by applying the simplified intake screen (See Photo-2).

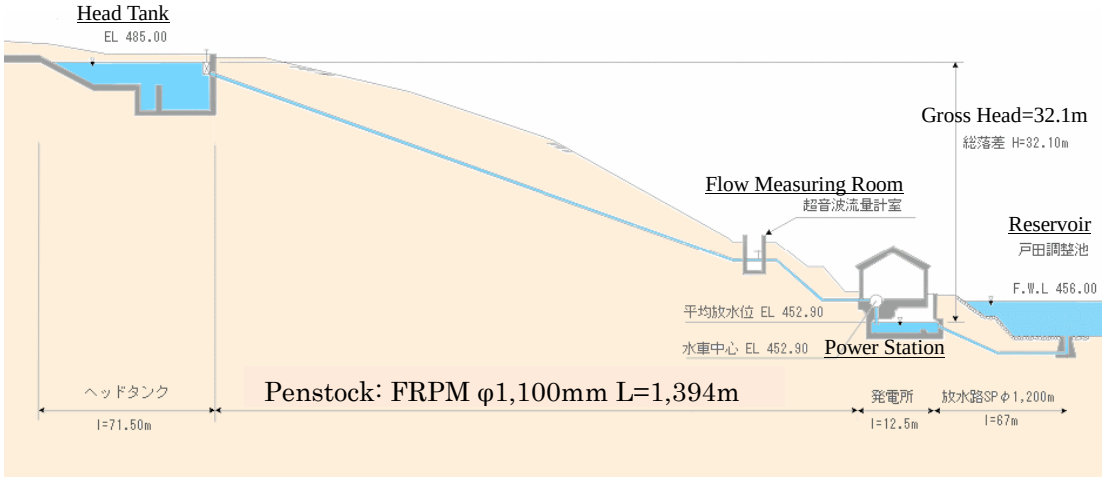

Fig.-3: Cross-section of canals at the Nasunogahara Station

Pipeline (under underground installation)

Pipeline (after underground installation)

Photo-1: Hikinuma No.1 and No.2 Stations

Fish trap-type screen (Momura Station)

Net filter (Hikinuma Station)

Photo-2: Intake screen

(3) Feeding excess power back into the grid to cover the cost of maintenance and management

The development of a series of small scale hydro plants in Nasunogahara has steadily increased the amount of power generation. Generated electricity is supplied to irrigation facilities dotted around the site via Tokyo Electric Power Company's

distribution lines. Excess power is fed back into the grid, with revenues allocated to the maintenance and management of agricultural canals, etc. across the site (Fig.- 4).

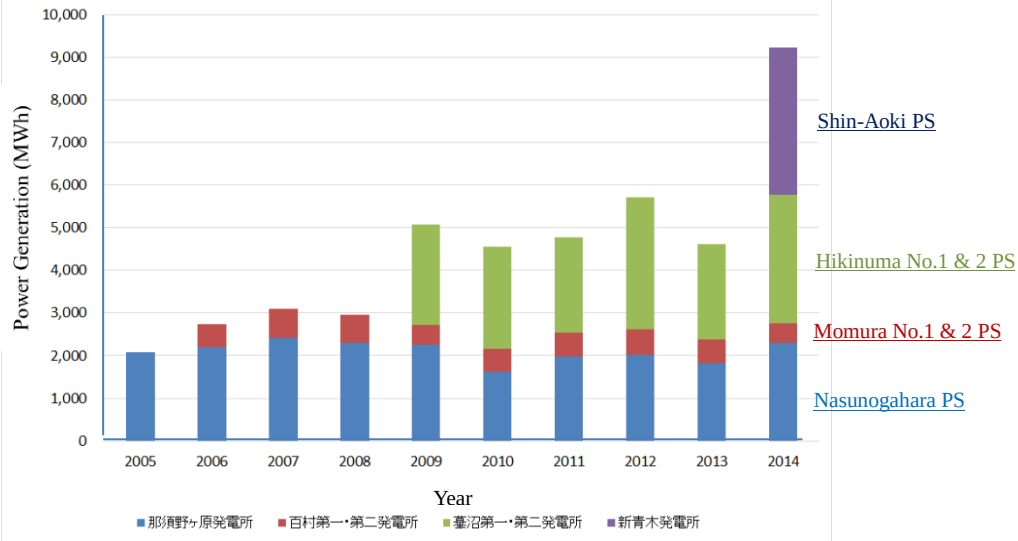

Fig.-4: Transition of the amount of electricity generated

A system involving the use of mobile phones for controlling remote-monitoring at the Water Management Center and for reporting any facility issues has been developed to monitor and control power generation facilities. Day-to-day walk-downs are carried out by Land Improvement District Association's staff to reduce the cost of maintenance and management.

3. Economic Benefits of the Project

(1) Introducing the power stations to reduce the financial burden of users (levies)

Electricity generated at each of the plants is used to power irrigation facilities, with excess power fed back into the grid. This has reduced the maintenance and management cost associated with the land improvement facilities (unit cost per farming field), keeping it low despite the increase of facility updating and development spending.

1) Upon completion of the national project (1995)

Unit cost per rice field: No less than ¥6,000/10are (including the ordinary levies)

2) Present (2014)

Unit cost per rice field: ¥1,998/10are (including the ordinary levies)

Unit cost per other farming field: ¥333/10are (including the ordinary levies)

Since the revenue from FIT is used to repay the cost of the project, beneficiaries (land users) have no financial burden associated with the power generation project.

(2) Creating jobs for the maintenance and management of the power plants

The maintenance and management needs of the power plants have created job.

1) Water screening (once every morning and evening): Nearby farmers (commissioned)
2) Extra work at the time of water intake and emergencies such as lightening strike: Staff / maintenance inspection contractor
3) Maintenance inspection (twice a month) and annual inspection: Maintenance inspection contractor
4) Handling visitors and trainings: Staff / paid volunteers

4. Social Aspects of the Project

4.1 Local Environment

1) Contribution to local environment

At the Nakagawa River, from which agricultural water (for power generation) is drawn, with beneficiaries' understanding of the benefits of the water usage (reduced financial burden in levy payment, brought about by hydropower), the Nasunogahara Canal's water management system is utilized to save on the amount of water drawn from the Nishi Iwasaki Weir (Fig.-1) while discharging the maintenance flow (river contribution volume) for the conservation of the river's ecosystem. The river discharge of 0.5m^3/s (43,200m^3 per day) was determined in the resolution of the Nasunogahara Land Improvement District Association's general assembly. Intake is regulated every morning and evening to ensure reduced and rotated use of water for each of the canals, saving on water, regulating water volume and securing fishways. This initiative has fostered the mentality of 'sharing water across local communities,' helping Nakagawa River maintain its No.1 position in Ayu sweetfish catches in Japan.

2) Inspection and improvement of irrigation facilities by beneficiaries

Local beneficiaries in each of the improvement districts have carried out inspection and improvement operations for irrigation facilities, e.g. cleaning canals and weeding the areas (Photos-3 and 4). Other community activities include cooperation with local parents' groups and the 'Hana Ippai' landscaping campaign[1)].

[1)] The Hana Ippai campaign was launched in 1952 by Isamu Komatsu, an elementary school teacher in Matsumoto City, out of his desire to enrich people's lives with flowers and make society 'more beautiful, brighter and easier to live' in the bleak days of post-war Japan. The campaign has since spread nationwide, adopted by a number of local governments.

Photo-3: Cleaning water canals

Photo-4: Weeding

4.2 Local Community

1) Creating a sustainable social model

In February 2007, cross-industry limited liability partnership (LLP) was formed between the agriculture, energy and educational sectors to create a sustainable social mode. Parties including Land Improvement District Association (Nasunogahara Land Improvement Association) staff, farmers, local businesses and local inn proprietors have joined forces to work on effectively utilizing a variety of resources including natural energies for revitalizing local communities.

2) Succeeding local history and culture and providing environmental / energy education

The LLP produced brochures and signage inviting the public to the land improvement facilities and introducing examples of the use of natural energies in agriculture and farming communities in order to publicize the multi-faceted functionality of agricultural canals. It also compiled the 'Water and Agriculture' booklet for use as a teaching material for general studies in elementary schools and for the local Prefectural Nasu Seiho Senior High School in an effort to assist environmental learning and succession of Nasu canals' history and culture. The small scale hydropower sites also accept around 6,500 elementary school pupils as a social studies excursion, bringing the total number of visitors to the irrigation systems to around 70,000 per annum (Photo-5).

Furthermore, the 'Tanbo-no Gakko' hands-on program for experiencing waterside environment (Photo-6) provides the venue for interaction between farmers and non-farmers as well as between seniors and young people. This has revitalized farming villages and helped decelerate the loss of village functions due to population aging.

Photo-5: Family facility tour (Nasunogahara Station)

Photo-6: Tanbo-no Gakko program

5. Reason for the Success

(1) The project's economic viability

In the construction of the hydro plants, new technologies and new materials are introduced to reduce costs. Subsidization programs (subsidies) by the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Economy, Trade and Industry are used to secure economic viability.

(2) The project's economic benefits

The stable operation of the plants using agricultural water has enabled the supply of power to irrigation facilities and feeding of excess power back into the grid to receive revenues. This has reduced the land improvement facilities' cost of maintenance and management as well as levies on beneficiaries (farmers who are the members of the Association).

(3) Contribution to local environment and society

The Nasunogahara Station was Japan's first small scale hydropower plant aimed at reducing maintenance and management costs of land improvement facilities under the National Land Improvement program. The aim was achieved thanks to the strong leadership of the national program office and staff of the Land Improvement District Association, and persistent efforts to gain the understanding and cooperation (consensus formation) of relevant organizations and local residents. The five other plants were subsequently constructed in a cycle of applying the success of a project to the next project. In all of the cases, local residents were involved from the project planning stage, creating a mechanism that facilitates the development of community understanding. This was one of the success factors.

The Nasunogahara Land Improvement District Association has become known as the pioneer of small scale hydropower using agricultural water. It now attracts numerous Japanese and international visitors wishing to inspect the facilities, and receives various awards and media coverage, boosting the community's appeal and name value. The Association is also contributing to revitalizing the local

communities by offering environmental / energy education at its land improvement and power generation facilities, and taking on the challenge to create sustainable local society in partnership with local businesses and residents.

Since Nakagawa River, from which agricultural water (for power generation) is drawn, boasts one of the largest Ayu sweetfish catches in Japan, the maintenance flow is discharged voluntarily into the river at the weirs in contribution to the conservation of Nakagawa River's ecosystem.

6. Outside Comments

(1) Featured in numerous media reports (newspapers, TV, etc.) as a pioneering model in small scale hydropower undertaken by a Land Improvement District

(2) Japan River Association: Winner of the Minister of Agriculture, Forestry and Fisheries Award in the Japan Water Awards [2] --- 21st Century Land Improvement District Creation Campaign (2005)

(3) Water Resources Environment Center: Commended for excellence in risk management on dams and weirs [3] --- Indefinite support for Nakagawa River's ecosystem conservation (2006)

(4) Ministry of Agriculture, Forestry and Fisheries: Selected as the Good Practice District in the Emerging Agricultural, Mountain and Fishing Villages program[4] (2007)

7. Reference

[1] Nasunogahara Land Improvement District website: http://www.nasu-lid.or.jp/top/top.htm

[2] Emiko Hoshino: The use of idle drop in agricultural canals for developing small scale hydropower plants (NEF 79th Practical Workshop concerning Medium and Small scale Hydro Plant Technology), October 2007

[3] National and Regional Policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism: FY2013 Case Studies concerning Regional Revitalization through the Use of Renewable Energies, March 2014

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[2] The Japan Water Awards recognize various activities (including research and technological development) in the fields of water emergency preparedness, water resources, water environment, water culture and reconstruction, which are believed to contribute to the improvement of water circulation system in terms of soundness and safety against water disasters.

[3] This award is given to outstanding creative initiatives concerning risk management in on-site management of dams and weir facilities. The aim is to share information and contribute to the improvement of facility management technologies.

[4] This is a pioneering program that is passionate about revitalizing an agricultural, mountainous or fishery village, and takes on fresh initiatives without getting too caught up with conventional concepts and rules, thereby stimulating the economy of the applicable agricultural, mountainous or fishery village to secure employment.

[4] Mizkan Center for Water Culture website (Emiko Hoshino, Water Culture Human Network): http://www.mizu.gr.jp/fudoki/people/042_hoshino.html
[5] Nasunogahara Land Improvement District Association http://www.nasu-lid.or.jp/

JP04

Name of Power Plant: Fujioiro Power Station and
Fujioiro No.2 Power Station

Country(State/Prefecture): Japan (Oita Prefecture)

Owner

Name of owner: Fujioiro Land Improvement District
Type of owner: On-site Power Generator / Land Improvement District
Type of market: Selling Excess Power by Power Purchase Agreement

Commissioning Year Fujioiro Power Station: 1914, 1977 (upgrading)
Fujioiro No.2 Power Station: 1984

Project Evaluation

Financial Viability: Recovering initial investment, securing the cost of maintenance and management, securing an appropriate level of profit
Economic Benefits: Tax revenues, activation of local industries
Social Aspects: Local environment: local infrastructure development, maintenance of local landscape and culture
Local community: Revitalizing local communities, providing environmental / energy education

Keywords: Act on the Promotion of Introducing Electricity into Farming and Fishing Villages, agricultural canals, use of idle drop, loan repayments, reduced levies

Abstract

The Fujioiro Power Station and Fujioiro No.2 Power Station, built by Oita Prefecture's Fujioiro Land Improvement District using idle drop of agricultural canals, have powered the pumping of irrigation water to higher grounds for over 100 years, with excess power fed back into the grid. When upgrading, reinforcing or expanding the plants, the District used the government's low-interest loan program for assisting the establishment of grid connection to farming, mountain or fishery villages, in an effort to enhance economic viability.

The revenue from feeding excess power back into the grid is allocated to the repayment of debts incurred for repairing and improving water canals, while also reducing beneficiaries' levies for irrigation facility maintenance / management and the cost of

repairing, maintaining and managing the irrigation facilities. This has led to the preservation of farmlands while contributing to resolve the issue of farming successors.

Photo-1 Old Fujioiro Power Station (under construction)

1. Outline of the project

The serious drought that struck Fujioiro in 1867 prompted the settler Shikataro Goto to spend his private fund to develop irrigation canals. The Fujioiro Power Station is a 200kW hydro power plant, installed in 1914 at the same time as irrigation canal construction "Iro[1)]", to take advantage of the main canal's drop to power water pumping equipment to send irrigation water to the Kusabukano and Katagase uplands measuring 300,000 m^2 combined (see Photo-1). By 1921, it was also known as the Fujio Lighting Plant distributing electricity for household lighting to over 1000 households in the villages of Kofuji, Kamiogata and Hasegawa. In 1924, the irrigation canals' water volume dropped below one-fifth of their designated level. In order to ensure stable distribution of agricultural water, the Hakusui pond dam was constructed on Onogawa River. The plant began feeding excess power back into the grid of Kyushu Electric Power Company (previously Kyushu Power Distribution Company and originally Kyushu Hydro Electric Power Company).

The Fujioiro Power Station then became subject of debate on whether to decommission or repair it, as the aging of its equipment increased the cost of maintenance and labor, undermining its profitability. In 1977, a low-interest loan under the Act on the Promotion of Introducing Electricity into Farming and Fishing Villages was secured to upgrade the facilities with the total cost of 65,000,000 yen, boosting its output from 200kW to 380kW and introducing a remotely-monitored semi automatic control system to enable un-manned operation. The plant's pipeline was upgraded in 2008.

At the time of facility upgrade at the Fujioiro Power Station, the Land Improvement District had the outstanding debt of around 1 billion yen, spent for repairing water canals. It was facing the prospect of having to increase the levy per 10 acres from 17,000 yen to 30,000 yen over ten years for the repayment as well as due to the reduction in farmlands

1) Iro means a common name for agricultural irrigation canals. It consists of a series of agricultural civil engineering facilities consisting of water intake facilities, trunk lines, branch lines and descendants, division facilities, drainage facilities. Each irrigation canal is managed and operated by agricultural corporative.

subject to the levy under the government's rice acreage reduction policy. As a solution, the District devised a plan to build the Fujioiro No.2 Power Station with the output of 1,500kW, taking advantage of the drop of 100m at the end of the main canal. In 1984, the plant was constructed at the total cost of 767,700,000 yen, funded in part with government subsidy (15% of the project cost) as well as a low-interest loan and the District's own fund (Table 1 and Fig.-1).

Table-1: Specifications of the power stations

Power plant name	Fujioiro Power Station	Fujioiro No.2 Power Station
Name of the water system / river	Onogawa River in the Onogawa River system	
Maximum output	380 kW	1,500 kW
Maximum discharge	2.0 m^3/s	2.0 m^3/s
Effective head	25.5 m	96.62 m
Water turbine type	Horizontal-axis single-wheel multiple-flow spiral Francis water turbine	Horizontal-axis single-wheel single-flow spiral Francis water turbine
Generator type	Horizontal-axis three-phase induction generator	Horizontal-axis three-phase induction generator
Power generation type	Run-of-river type / canal type	
Grid connection	Yes	

Fig.-1: Locations of the Fujioiro Power Station and Fujioiro Daini Power Station

【Fujioiro Power Station specifications】

Approved output	380KW	Effective head	25.50m
Discharge	Maximum 2.0m^{3}s		
Penstock	Pipe thickness 4.5mm	Internal diameter 900mm	Total length 38.834m
Water turbine	Type: Horizontal-axis single-wheel single-flow spiral Francis turbine		
Generator	Type: Horizontal-axis three-phase induction generator		
	Rated output 400KW	Rated voltage 3,300V	
	Rated current 158A	Revolution 730rpm	
Completion	July 20, 1914	Project cost 65,000,000 yen	
Location	Umegasako, Oate, Oaza, Oagata-cho, Ono County Oita Prefecture		

【Fujioiro No.2 Power Station specifications】

Approved output	1,500KW	Effective head	96.62m
Discharge	Maximum 2.0m^{3}s		
Penstock	Pipe thickness 6-9mm	Internal diameter 1200mm	Total length 255.298m
Water turbine	Type: Horizontal-axis single-wheel single-flow spiral Francis turbine		
Generator	Type: Horizontal-axis three-phase induction generator		
	Rated output 1,500KW	Rated voltage 6,600V	
	Rated current 158A	Revolution 915rpm	
Completion	April 24, 1984	Project cost 767,700,000 yen	
Location	Yamanokamito, Jikumaru, Oaza, Oagata-cho, Ono County Oita Prefecture		

2. Financial Viability of the Project

(1) Using a low-interest loan system to ensure economic viability

The Fujioiro Power Station received a low-interest loan under the Act on the Promotion of Introducing Electricity into Farming and Fishing Villages [2]to upgrade its facilities at the total cost of 65,000,000 yen, and repaid the loan over ten years with revenue from feeding excess power back into the grid. The Fujioiro No.2 Power Station was built at the total cost of 767,700,000 yen, 15% of which was funded with a government subsidy. The rest was covered with the District's own funding and the low-interest loan under the said law. The loan was repaid over 20 years with revenue from feeding excess power back into the grid.

3. Economic Benefits of the Project

(1) Receiving fixed asset tax revenues

Both of the power stations pay several million yen per annum in fixed asset tax to the local township Ogata.

(2) Using FIT revenues to reduce beneficiaries' financial burden (levies) and cost of maintaining and managing canals

Both of the power stations operate almost at the maximum output during the non-irrigation period (October to April). While they may not be able to operate at times during the irrigation period (May to September) and paddy ploughing period (late May to mid June), they maintain operation at around half of the maximum output over the course of year. Annually, the Fujioiro Power Station and the Fujioiro No.2 Power Station generate 2,500MWh and 10,000MWh respectively at the capacity

[2] This Act facilitates the introduction of electricity to farming, mountain and fishery villages with no or insufficient grid connection or with underdeveloped hydroelectricity, with the aim of increasing such communities' agricultural, forestry and fishery capacities and improving residents' standard of living. (Interest rate: 1.15% (as of May 23, 2014), loan limit: 80% of the project cost, repayment period: within 20 years (with up to 3 years of grace period)

factor in 75% and higher.

FIT revenues are estimated to total around 100 million yen in combined total. Some of this money is allocated to the aforementioned loan repayments, while the rest is designated for reducing beneficiary farmers' levies and the cost of maintaining / managing canals. This has reduced the levy from 17,000 yen per 10 acres in 1977 to 8,000 yen in 1985 and 2,000 yen in 2000, contributing to the preservation of farmlands and alleviating the successor issue among farmers. Each year, canals are repaired and upgraded, with covers now provided to 90% of non-tunneled canals to prevent soil from entering at the time of downpours.

4. Social Aspects of the Project

4.1 Local Environment

1) Improving agricultural roads and irrigation canals

Revenues of both stations are allocated for large-scale enhancement of agricultural roads and canals (adding covering).

2) Maintaining and managing historical heritage

The Hakusui pond dam and irrigation facilities (aka Hakusui Dam, Photo 2), built in 1938 to provide stable distribution of agricultural water, are described as 'Japan's most beautiful dam,' and won a government designation as an important cultural asset in 1999. It has been maintained and managed for future generations as historical heritage under proper care of the Fujioiro Land Improvement District, which carries out tree planting, etc. in consideration of the local environment (Photo-3).

Photo-2: Hakusui Dam

Photo-3: Onogawa River

4.2 Local Community

1) Maintaining and managing irrigation facilities by beneficiaries

Following efforts to transform the mentality of farmers on water conservation and management, local residents have become involved in cleaning irrigation facilities, weeding and setting up simple facilities such as flumes (Photo 4).

2) Revitalizing local communities with revenues from the power stations

Revenues from the power stations are allocated to reduce levies and address the issue of successors at local farms, as well as for local friendship / networking events to revitalize the communities.

3) Providing environmental and energy education

The Fujioiro Power Station played a pioneering role in power generation using agricultural water in the Kyushu region, attracting visitors from relevant organizations for tours conducted 15 – 20 times per year (5 – 30 people per session). Students from local elementary schools also come for excursions each year (Photo 5). The success of these micro hydro stations has also contributed to enhancing the local brand.

Photo-4: Weeding by local residents

Photo-5: Local elementary school pupils on excursion

5. Reason for the Success

(1) The project's economic viability

In the construction of the power stations, government subsidies and low-interest loans were used for better economic viability. The area is relatively blessed in terms of drops and flow volumes for generating power with agricultural water, and boasts capacity factor as high as 75%. Thanks to the resulting stable FIT revenues, the loans to cover the cost of construction were fully repaid in 10 – 20 years. Reasons of this project's financial success include foresight of local leaders and natural conditions ideally suited to hydropower

(2) The project's economic benefits

Revenues from feeding power back into the grid are allocated to reduce the cost of maintaining and managing canals and the amount of levies charged on beneficiaries (farmers belonging to the cooperative), resulting in the preservation of farmlands and contributing to the issue of farming successors. The Fujioiro No.2 Power Station, in particular, was built to reduce the levies. Combined with FIT revenues from the Fujioiro Power Station, the project has successfully reduced the levies substantially.

(3) Contributing to local environment and society

The power stations' FIT revenues are also appropriated to the construction of farm roads / water canals and local exchange events, contributing to revitalizing the local communities. The Hakusui pond dam, built in 1938 for distributing agricultural water, has been designated by the government as an important cultural asset, boosting the area's appeals as historical heritage inherited to posterity by proper maintenance.

6. Outside Comments

(1) Nikkei Newspaper (September 2, 2011, electronic edition)

"Oita's series of power generation projects using agricultural water"

This article introduces these power stations as a model case of hydropower generation using agricultural water, with FIT revenues allocated to repay loans taken out for developing irrigation canals and reduce the levies on farmers.

(2) Oita Godo Shimbun Newspaper (October 9, 2014)

"100th Anniversary of Fujioiro: Unveiling a monument celebrating water's benefits for greater agricultural development"

This article features the head of the Land Improvement District voicing gratitude to his predecessors' foresight, and explains that the two hydro plants' FIT revenues are allocated to project administration.

7. Reference

[1]Fujioiro District Project Overview --- Prefectural Irrigation Facility Repair Project ---: Fujioiro Land Improvement District, Oita Prefecture Takeda Naoiri Revitalization Bureau

[2] Fujioiro Power Station Overview: Fujioiro Land Improvement District, May 28, 1977

[3] Completing the Fujioiro No.2 Power Station: Fujioiro Land Improvement District, May 14, 1984

[4] Editorial Committee, Rural Culture Association: "Rural Culture Association's Stance: From Nuclear Power to Agricultural Hydro Power" (Gendai Nogyo, November 2011 issue) , Rural Culture Association (General Incorporated Association) (http://www.ruralnet.or.jp/syutyo/2011/201111.htm)

JP05

Name of Power Plant: Taishakugawa Power Station, Shin-Taishakugawa Power Station

Country(State/Prefecture): Japan (Hiroshima Prefecture)

Owner

Name of owner: Chugoku Electric Power Company

Type of ownership: Electric utility

Type of market: Electric utility

Commissioning Year: Taishakugawa Power Station: 1924, 2003 (re-development) Shin-Taishakugawa Power Station: 2006 (re-development)

Project Evaluation

Financial Viability: Recovering initial investment, Securing the cost of maintenance and management, Ensuring an appropriate level of income

Economic Benefits: Tax and grant revenues, Tourism resource

Social Aspects: Local environment: Developing local infrastructures, protecting river environment, Maintaining local landscape and culture, Protecting nature parks

Local community: Revitalizing local communities, Creating local leisure opportunities

Keywords: Hiba Dogo Taishaku Quasi-National Park, Taishakukyo Gorge, Protection of rare plants and animals, Top 100 dam reservoirs, Sightseeing ship, Beautification campaign

Abstract

During the maintenance work for the Taishakugawa Dam, built in 1924 inside a quasi-national park in Hiroshima Prefecture, Chugoku Electric Power Company redeveloped an existing power station in 2006 to make effective use of underutilized drops. The dam-and-conduit Shin-Taishakugawa Power Station was newly built with the maximum output of 11,000kW, while the existing Taishakugawa Power Station has been scaled back from 4,400kW to 2,400kW.

The project had its economic viability assured according to the Fully Distributed Cost (FCD) method under the Electricity Business Act. To minimize the cost of power generation, the company utilized existing facilities (e.g. dam) and underutilized drops in the construction work, and received government subsidies as part of fund-raising, reducing the overall costs.

The Taishaku Gorge near the Taishakugawa Dam is a government-recognized scenic site. The dam reservoir and its surrounding areas are key tourism resources for the local region. For this reason, the company ensured man-made changes were kept to minimum for harmony with surrounding landscape, while implementing conservation measures for rare plants and animals in the region. The power generation operations give considerations to any change of reservoir's water level to maintain its value as a tourism resource. Campaigns to beautify the Gorge and various events involving tourists and volunteers are held to revitalize the area's tourism industry.

1. Outline of the Project

The Taishakugawa Dam is a concrete gravity dam completed in 1924 as a water intake reservoir for the Taishakugawa Power Station. Chugoku Electric Power Company took over its management in 1951. The company decided to carry out maintenance work on the Taishakugawa Dam (improving flood-controlling capacity and reinforcing the structures) and redevelop the power station from 2003 to 2006 due to the facts that the 80-year-old plant no longer complied with the day's design-basis operation stability criteria, that the tunnel-type spillway's discharge capacity was too small, creating constraint on the reservoir's administration during a discharge period, and that there were underutilized drops measuring up to 35m. (Fig.-1, Tables- 1 and 2, Photos-1 and 2)

The Taishakugawa Power Station is a dam-and-conduit plan with the maximum output of 4,400kW, drawing water from the Taishakugawa Dam and Fukumasugawa River. At the Taishakugawa Dam, water's pressure and force were reduced in the basin directly underneath the dam, with water channeled to the power plant via a pressure-less headrace. The maintenance work changed the structure so that water is only drawn from the Fukumasugawa River's intake dam, which has reduced the plant's maximum output to 2,400kW since 2003.

Fig.-1: Locations of the Taishakugawa Dam and

The Shin-Taishakugawa Power Station is the result of the Taishakugawa Power

Station's redevelopment, which involved the construction of 11,000kW dam-and-conduit power station fitted with pressure headrace to make effective use of the Taishakugawa Dam's underutilized drop (up to 35m).

The areas around the Taishakugawa Dam and its reservoir include 'Taishakugawa Valley (Taishaku Valley), designated as National Site of Scenic Beauty, and the Hiba Dogo Taishaku Quasi-National Park (Category 1 special region), with abundant wilderness consisting of karst topography and landscape unique to limestone areas and a large number of rare animal and plant species. It is a valuable tourism resource for the local communities, with tourism operations including a sightseeing boat at the reservoir (Shinryu Lake). In the maintenance work for the dam and redevelopment of the power station, efforts were made to minimize man-made changes for harmony with surrounding landscape, while steps were taken to protect rare animal and plant species in the area. The dam was designed and worked on in a way that maintains a specific water level so as not to hinder the operation of the sightseeing boat.

At the Taishaku Valley near the Taishakugawa Dam, tourists, volunteer guides, local residents and other supporters carried out a campaign to beautify the gorge and implemented various events to revitalize local industries (tourism).

Table-1: Specifications of the power stations

	Before redevelopment	After redevelopment	
Power plant name	Taishakugawa Power Station	Shin-Taishakugawa Power Station	Taishakugawa Power Station
Name of the water system / river	Taishakugawa River and Fukumasugawa River in the Takahashigawa River system	Taishakugawa River in the Takahashigawa River system	Fukumasugawa River in the Takahashigawa River system
Maximum output	4,400 kW	11,000 kW	2,400 kW
Maximum discharge	5.7 m^3/s	10.0 m^3/s	3.1 m^3/s
Effective head	95.17 m	129.0 m	95.17 m
Power generation type	Reservoir type / dam canal type	Reservoir type / dam canal type	Run-of-river type / canal type
Grid connection	Yes	Yes	Yes

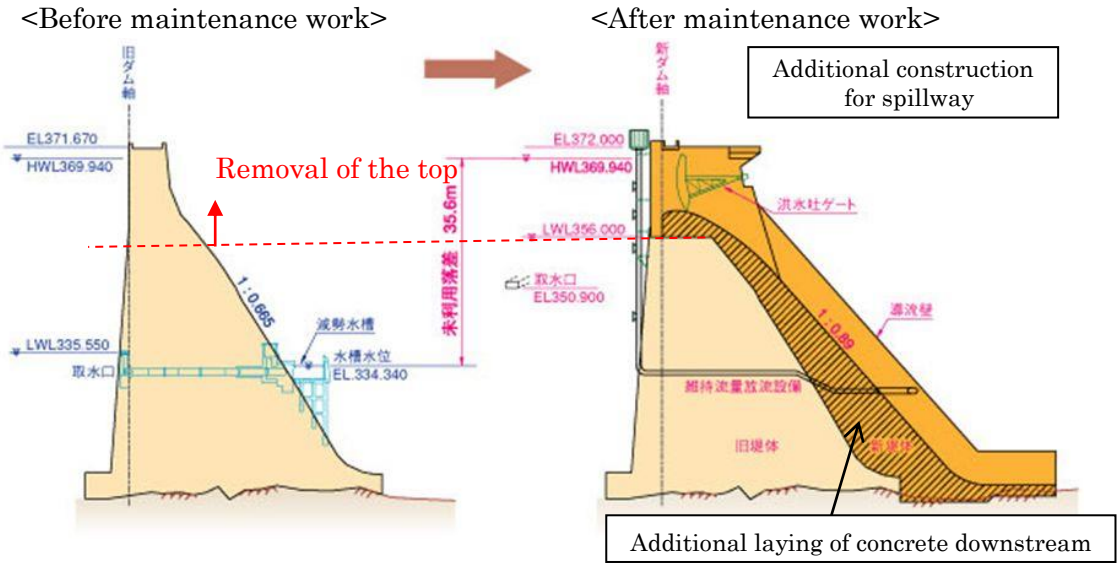

Fig.-2: Schematic diagrams of Taishakugawa Dam's maintenance work

Photo-1: Before maintenance

Photo-2: After maintenance

Table-2: Specifications of the Taishakugawa Dam

Item	Before maintenance work	After maintenance work
Type	Concrete gravity dam	Concrete gravity dam
Dam height	62.10 m	62.43 m
Crest length	35.15 m	39.50 m
Dam volume	31,000 m^3	45,000 m^3
Effective storage capacity	12,995,000 m^3	7,490,000 m^3
Flood control capacity	720 m^3/s	1,610 m^3/s
Flood control method	Tunnel-type spillway: 720 m^3/s	Tunnel-type spillway: 720 m^3/s Overflow-type spillway: 890 m^3/s

2. Financial Viability of the Project

(1) Economic viability of a hydropower project by a general electric utility

This is a redevelopment of an existing hydro power station, planned and implemented according to a general electric utility's (Chugoku Electric Power Company) supply plan. General electric utilities have various types of power stations including thermal, nuclear and hydro plants. They examine individual projects' economic viability not only based on each project's revenue-expenditure balance but also on how it compares with alternative power sources and whether it meets their own criteria in construction unit cost. Projects carried out by general electric utilities, which have supply responsibility under the Electricity Business Act, have their economic viability secured according to the Fully Distributed Cost method. Additionally, to minimize the cost of power generation, cost cutting measures are implemented in the course of construction, maintenance and management. In the case of this project, the use of existing facilities including the dam and the availability of a relatively large underutilized drop of 35m have contributed to cost reduction.

(2) Cost reduction in engineering work on the dam's main body

Due to the relatively small volume of concrete required for the dam (approx. 15,600m^3), the project used ready-mixed concrete from a local supplier to significantly reduce costs.

(3) Cost reduction through facility simplification and workload saving

From the perspective of facility simplification and workload saving, the project adopted coolant-less and pressure oil-less turbines and generators, and introduced a transformer integrated with a switch, positioned above the transformer, to minimize hardware layout and area for site preparation, thereby reducing the overall costs of electrical and civil engineering work. To stabilize slopes around the power stations, the removal of talus deposits was minimized, and the construction of the power station's administrative building was omitted for cost reduction.

(4) Enhanced economic viability from the use of subsidies

The Taishakugawa Dam maintenance work and the construction of the Shin-Taishakugawa Power Station were partially funded with the medium and small scale hydropower development subsidization program (approx. 14,500 million yen) for enhanced economic viability.

3. Economic Benefits of the Project

(1) Receiving fixed asset tax revenues

Both of the power stations pay fixed asset taxes to Jinsekikogen Town and Shobara City.

(2) Developing local infrastructures with grants

The government grant designed for communities hosting hydroelectric plants of a

certain scale or above was used to develop public facilities and promote social welfare services in Jinsekikogen Town and Shobara City, improving the welfare of local residents.

(3) Reservoir as a tourism resource

The Taishakugawa Dam's reservoir (Shinryu Lake) is located at the heart of Taishaku Gorge, designated as National Site of Scenic Beauty, in the Hiba Dogo Taishaku Quasi-National Park. Following the official 'lake opening' each spring, the reservoir is used for cruising, kayaking and other outdoor activities mainly in early spring, summer holiday season and autumn leaf viewing season. The site, along with the National Park Resort 'Taishaku Valley,' attracts a large number of visitors each year. Although the visitor count is on the decline in recent years, some 100,000 people have enjoyed the cruise and stay at the National Park Resort per annum since 2006, when the maintenance work on the Taishakugawa Dam was completed. (In 2005, an incident of falling rocks near the sightseeing boat dock caused a temporary drop in visitor count, as shown in Fig.-3.)

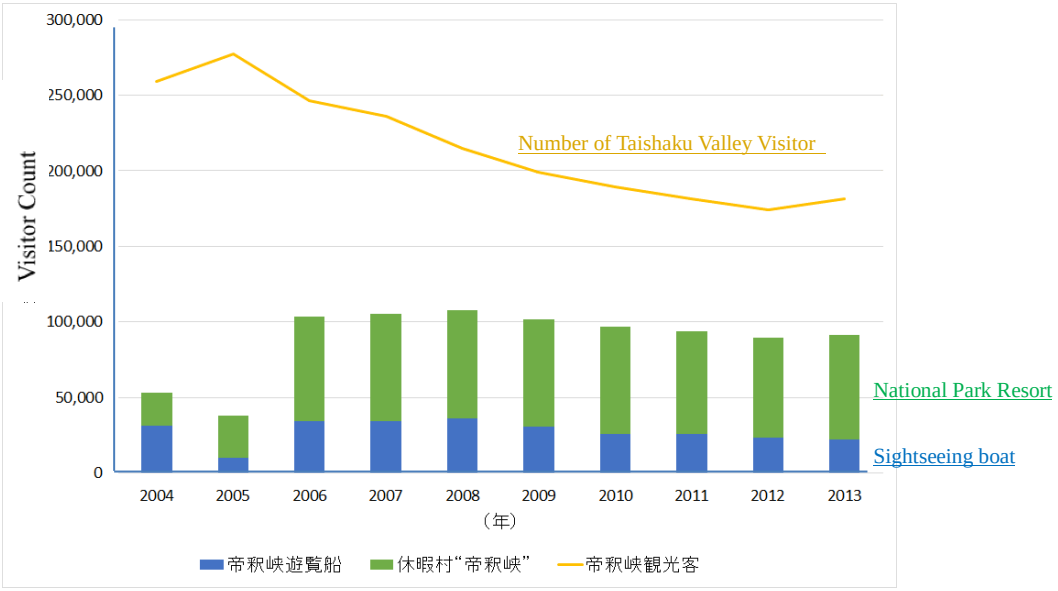

Fig.-3: Taishaku Valley visitor count and user count of the sightseeing boat and Park Resort (2004 – 2013)

4. Social aspects of the Project

4.1 Local Environment

1) Measures for conserving the river environment

Photo-3: Flush discharge

The results of simulation concerning the reservoir's water temperature raised concerns about the adverse effect of discharging low-temperature water in spring on aquatic life including fish and aquaculture. As the countermeasures for this anxiety, the porous selective intake system is used for maintenance flow discharge facilities. The flush discharge technique, which fluctuates the volume of maintenance flow discharge, is used to move pebbles and sand, preventing sludge buildup and improving the river environment downstream.

2) Landscape preservation

The dam is nestled in a rich natural environment designated as National Site of Scenic Beauty in a Quasi-National Park, and serves as an important tourism resource for the local communities. Under expert guidance, landscape design is applied, sympathetic to the surrounding environment. Since the spillway gate is the most visually prominent structure from the sightseeing boat that cruises the reservoir, the gate is colored in dark green to blend it into the surrounding environment and lake surface. The lifting winch is positioned as discreetly as possible when seen from the reservoir, and a radial gate in the rear-winching system was adopted in consideration for the view of the limestone rock face (commonly known as Taroiwa) downstream (Photo-4). Man-made changes to nature associated with the work were minimized, and any modified areas have been replanted with native plants for correcting the landscape. Since the series of concrete structures at the power stations could look imposing, retaining walls are patterned with lines for harmony with the surrounding landscape (Photo-5).

Photo-4: Spillway gate

Photo-5: Exterior view of the power

3) Protecting rare plant and animal species during construction

Rare plant and animal species were protected during construction work to preserve the area's natural environment and ecosystem, which are key tourism resources for local communities.

The drilling of bedrock was suspended during the breeding season (January – July)

of rare mountain hawk eagles (Photo-6) in applicable areas. The project also used low-noise construction machinery, soundproof doors and soundproof panels as well as sodium lamps at night, while monitoring the habitat and breeding status of the rare birds and reporting the findings to the experts. Among permanent measures implemented was the use of dark brown paint on waterway to make it more discreet. The construction area features 19 rare plant species include Japanese box, anemone nikoensis maxim and amur adonis, and is home to 5 rare animal species including stereophaedusa costifera (Photo-7) and giant purple butterfly. Specimens identified in the affected areas were transferred / transplanted to sites prior to the construction. During construction, careful monitoring was carried out to identify the habitat and living status of rare plants and animals to be reported to relevant experts. Except for some plant species, most of the transferred / transplanted plants and animals are generally doing well at their respective new sites.

To enforce these protective measures thoroughly, the company distributed a booklet giving an overview of applicable rare species to all persons involved in the construction, and organized on-site information sessions to raise conservation awareness.

Photo-6: Mountain hawk eagles

Photo-7: Stereophaedusa costifera

4.2 Local Community

1) Cooperating with the dam reservoir's use for tourism and recreation

In carrying out maintenance work on the Taishakugawa Dam, in view of the fact that the reservoir (Shinryu Lake) is an important tourism resource, the power company designed the dam's main unit and planned flow diversion so that the reservoir maintained a certain water level enabling the sightseeing boat to safely navigate through during the construction work. For the administration of the Shin-Taishakugawa Power Station, the company supplies the reservoir usage plan to the tourism operator for coordination, and reduces power generation during peak tourism seasons including autumn with colored leaves, in order to maintain the reservoir's water level high in cooperation with the local tourism industry (Photo 9). Furthermore, a new road for managing the Taishakugawa Dam was built as part of the Chugoku Natural Trail (Taishaku Valley Route) and made available for public use. Public access is also allowed to the toilet facilities at the Dam management office,

establishing the area as the space for enjoying nature, culture and history.

Photo-9: Shinryu Lake sightseeing boat

2) Developing local infrastructures along with plant construction

Alongside the construction of the dam and power plants, the company developed an access road and established it as a municipal road, while also restoring the tunnel's soil disposal bank and makeshift yard for arranging farming ground in a contribution to developing local infrastructures.

3) Becoming involved in various events to revitalize local communities

The Taishaku Valley area around Shinryu Lake has a number of events such as the Lake Opening and the Spring Gorge Cleaning. Utility employees are actively participating in those events in their contribution to revitalizing local communities.

5. Reason for the Success

(1) The project's economic viability

This is a project by an electric utility to redevelop an existing hydropower station. Its economic viability is secured based on the Fully Distributed Cost (FCD) method. The construction utilized the existing dam and underutilized drops, used ready-mixed concrete for the dam's main body, and simplified facilities to save on workload in order to reduce the overall costs. Government subsidies were also used to enhance the project's economic viability.

(2) The project's economic benefits

The Taishakugawa Dam's reservoir (Shinryu Lake) is the Quasi-National Park's main sightseeing spot designated as National Site of Scenic Beauty.It is at the center of the Taishaku Valley Gorge. The lake is the region's important tourism resource, being used by sightseeing boat and other modes of outdoor activities and attracting numerous tourists.

(3) Contribution to local environment and society

The Taishakugawa Dam is utilized in consideration for the fluctuation of water levels at its reservoir to maintain the value of the tourism resource. The site hosts a variety of events including the beautification of the overall Taishaku Valley Gorge by visitors and volunteers to revitalize the local tourism industry. In order to preserve the

natural landscape and ecosystem, which represent the area's valuable tourism resource, the company made conscious efforts to minimize any changes to nature and ensure harmony with the surrounding environment in carrying out maintenance work on the Taishakugawa Dam and building the Shin-Taishakugawa Power Station, while also implementing conservation measures for rare plant and animal species.

6. Outside Comments

(1) Water Resources Environment Center (General Incorporated Association): 100 Dam Reservoirs[1)] Shinryu Lake

(2) Jinseki Plateau PR material (December 2005 issue / 14th issue)
The Shinsaka Community Association reported that the power station is the pride of the community and one of the major sources of revenues for the community / town.

(3) Science and Technology Trend (March 2010 issue)
The publication featured an article about this project's efforts to minimize alterations to the surrounding environment, conserve the landscape and usage of the dam's reservoir due to its aspect as a tourism resource, and pay full considerations to potential impact on local plants and animals.

(4) Japan Society of Civil Engineers (Public Interest Incorporated Association): Civil Engineering Heritage of Modern-Day Japan --- 2000 Existing Civil Engineering Structures of Significance (Taishakugawa Dam) (2001)

(5) Japan Science and Technology Agency / Science Channel (released in October 2015)

7. Reference

[1] Ichiro Yoshioka / Chugoku Electric Power Company: Planning, Designing and Implementing the Construction of the Shin-Taishakugawa Power Station (October 2006: The 78th workshop on micro and medium hydro power technology / New Energy Foundation (Incorporated Foundation))

[2] Toshiharu Okita, Ichiro Yoshioka, Shoji Ichihara: Overview of the Construction of the Shin-Taishakugawa Power Station, Electric Power Civil Engineering, No.309, p98 - 101, 2004.1

[3] Junichi Hayashi, Katsufumi Konishi, Atsushi Mukohara: Protection of Rare Plant and Animal Species in the Construction of the Shin-Taishakugawa Power Station, Electric Power Civil Engineering, No.319, p50 - 54, 2005.9

[4] Hiroshima Prefecture website:
http://www.pref.hiroshima.lg.jp/site/toukei/doukou-index.html(Statistical information / Trend of tourists visiting Hiroshima Prefecture)

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1) Dam reservoirs that are essential part and contributor of local communities are selected and commended so that they becomes a more integral part of their respective communities, making greater contributions to their revitalization.

[5] Motoyuki Inoue, Eiichi Shiraishi: Hydropower as a Renewable Energy Source in a New Era, Science and Technology Trend, p21- 35, 2010.3
[6] Chugoku Electric Power Company http://www.energia.co.jp/

JP06

Name of Power Plant: Kochi Prefecture Public Corporation Bureau's hydropower stations

Country(State/Prefecture): Japan (Kochi Prefecture)

Owner

Name of the owner: Kochi Prefecture Public Corporation Bureau

Type of ownership: Wholesale Power supplier / local public corporation

Type of market: Wholesale Power supply

Commissioning Year: Yoshino Power Station in 1953
Nagase Power Station in 1955
Sugita Power Station in 1959

Project Evaluation

Financial Viability: Recovering initial investment, Securing the cost of maintenance and management, Securing an appropriate level of profit

Economic Benefits: Tax and grant revenues, Promotion of local industries

Social Aspects: Local environment: Developing local infrastructures, Protecting natural environment
Local community: Revitalizing local communities, Providing environmental and energy education, Creating local recreational opportunities

Keywords: Regional public corporations, promotion of public welfare, Project for improving the environment around a dam, Headwater forest improvement project, Headwater replenishment, School visit

Abstract

Kochi Prefecture's Public Corporation Bureau owns three hydro power plants with the combined output of 39,200kW along the Monobe River, and sells generated power to the general electric utility, Shikoku Electric Power Company. Together with this electricity business, the Bureau subsidizes environmental improvement projects by local municipalities, carried out around dams along the river, and conduct preservation work at headwater conservation forests in mountainous regions along the same river, in order to fulfill the public corporation's original purpose of promoting public welfare. This project, undertaken by the Public Corporation Bureau, generates revenues from selling electricity with economic viability assured according to the Fully Distributed Cost (FCD) method.

The program to enhance the environment around the dams has developed infrastructures such as parks, tourism facilities and roads, contributing to improving local residents' living environment and increasing visitors for outdoor leisure and tourism. The headwater preservation program is expected to generate benefits such as containing the spread of brush fires, preventing soil loss and improving water retention performance, thereby contributing to the revitalization of local forestry industry. Furthermore, Bureau staffs are conducting classes at elementary and junior high schools, whose students are also invited to dams and power plants for an inspection tour, in promotion of environmental and energy education.

1. Outline of the Project

Kochi Prefecture planned the construction of the Nagase Dam (for flood control, irrigation and power generation) as the centerpiece of the general development project for Monobe River (total stream length of 71km, basin area of 508km^2, Class 1 River) at the point 31.4km from the river's estuary (Nagase district). It commenced the dam's construction as a direct government project in 1950 and completed it in March 1957. Kochi Prefecture's Public Corporation Bureau built the Yoshino Dam and Sugita Dam downstream of the Nagase Dam as part of its hydropower project, and subsequently developed the Nagase Power Station, Yoshino Power Station and Sugita Power Station with the combined output of 39,200kW, selling generated power to the electric utility, Shikoku Electric Power Company (Table-1, Fig.-1).

Table-1: Specifications of the power stations and dams

Power station name	Nagase Power Station	Yoshino Power Station	Sugita Power Station
Name of the water system / river	Monobe River in the Monobegawa River system		
Maximum output	22,800 kW	4,900 kW	11,500 kW
Maximum discharge	30.0 m^3/s	37.0 m^3/s	40.0 m^3/s
Effective head	89.63 m	16.12 m	35.02 m
Power generation type	Reservoir type / dam canal type	Reservoir type / dam type	Reservoir type / dam type (reverse regulation)
Grid connection	Yes		
Dam name	Nagase Dam	Yoshino Dam	Sugita Dam
Basin area	295.20 km^2	343.40 km^2	440.00 km^2
Type	Concrete gravity dam	Concrete gravity dam	Concrete gravity dam
Crest length	207.00 m	115.50 m	140.50 m
Dam height	87.00 m	26.90 m	44.00 m
Dam volume	380,000 m^3	21,670 m^3	66,930 m^3
Reservoir capacity (January 2014)	38,417,913 m^3	471,000 m^3	5,888,000 m^3

Fig.-1: Locations of the power stations

In order to fulfill the original purpose of promoting public welfare[1)], Kochi Prefecture's Public Corporation Bureau carries out public welfare projects as a way of passing income from the electricity business back to communities. They include a hospital project as well as a program to subsidize environmental improvement projects by local municipalities, carried out around dams along the river, and the Public Corporation Bureau Forest program aimed at nurturing headwater conservation forests in mountainous regions along the same river (mainly planting broadleaf trees). These efforts promote community revitalization while contributing to natural environment conservation and environmental education.

2. Financial Viability of the Project

(1) Determining the price of generated electricity according to the Fully Distributed Cost (FCD) method to secure economic viability

The Public Corporation Bureau sets and reports the price of the electricity it generates to the Ministry of Economy, Trade and Industry based on negotiations and agreement with the general electric utility. The price is calculated according to the FCD method, in which an appropriate level of profit (business revenue) is added to the cost required for administrating the wholesale power business (labor, consumables, repairs, water license, depreciation, municipal grants). Projects carried out by the Public Corporation Bureau have their economic viability secured with income from the sale of electricity according to the FCD method. In addition to the hydro electricity, the Bureau operates wind power plants. Income from selling wind-generated electricity is combined with hydropower income and included into the electric business account (Table-2).

[1)] Article 3 of the Local Public Enterprise Act (Basic management principle): Local public enterprises must be operated to always show their economic viability and promote public welfare, which is their original objective.

Table-2: The amount of hydro- and wind-generated electricity supplied and sold and revenue balance of the electric business account

Item \ Fiscal year	2008FY	2009FY	2010FY	2011FY	2012FY	2013FY
Hydro-generated electricity supplied (MWh)	134,899	149,763	172,995	202,036	203,057	157,076
Nagase Power Station (MWh)	77,281	90,874	107,652	130,241	126,627	94,931
Yoshino Power Station (MWh)	13,308	16,820	19,183	23,242	20,482	17,571
Sugita Power Station (MWh)	44,310	42,070	46,160	48,552	55,948	44,574
Wind-generated power sold (MWh)	3,623	3,611	4,630	4,379	4,127	3,724
Revenue (million yen)	1,267	1,293	1,360	1,388	1,376	1,311
Expenditure (million yen)	1,176	1,142	1,128	1,372	1,239	1,148
Net income (million yen)	91	151	231	16	137	163

3. Economic Benefits of the Project

(1) Grants to siting municipalities in lieu of fixed asset tax, etc.

The Public Corporation Bureau is exempt from the fixed asset tax, and the amount equivalent to its fixed asset liability is paid to applicable municipalities as grants in lieu of fixed asset tax, etc. In FY2012, 34 million yen was paid as grant.

(2) Local economic benefit from the environment improvement program for areas around the dams

Since FY1981, the Bureau has run an environment improvement program for areas around the dams as a way of supporting siting communities. The program subsidizes (60%) the cost of environment improvement projects (e.g. park development, civic hall renovation, waterway repair) that Kami City, where the dams are located, carries out in the dam's surrounding areas.

The program has the annual budget of approx. 20 million yen. The municipality carried out 158 applicable projects between FY1981 and FY2013. The bureau provided approx. 720 million yen in subsidies against the total project cost of 1.09 billion yen (Table 3). The specifications listed below are specified for engineering work within the environment improvement projects to promote the local forestry industry and also pay considerations to the environment.

1) Actively utilizing key items based on procuring under the legal requirement to purchase environmentally-friendly goods, etc. (Green Procurement Act)
2) Giving priority to materials produced within the prefecture
3) Using formworks put together with Japanese cedar and cypress timbers from forest thinning as standard supplies
4) Submitting recycled resource usage (promotion) plan and implementation report, etc.

(3) 'Headwater Forest Improvement Project to revitalize local economy

Kami City and Kanan City receive subsidies for their plantation thinning operation in the upstream of the Sugita Dam under the subsidization program for improving the Monobe River's headwater forests. The program extends from FY2007 to FY2016 and provided approx. 40 million yen for thinning approx. 890 hectares of plantation, thereby contributing to the region's forestry industry (Table 3).

Table-3: Regional symbiosis programs by Kochi Prefecture, Public Corporation Bureau

Program name	Program period	Program cost
Subsidy for improving the environment around the dams	FY1981 –	20 million yen / year (cumulative total to FY2014: approx. 740 million yen)
Subsidy for improving Monobe River's headwater forests	FY2007 – FY2016 (planned period)	5 million yen / year (cumulative total to FY2014: approx. 40 million yen) Project area: approx. 890 hectares
School visits	FY2004 –	

4. Social Aspects of the Project

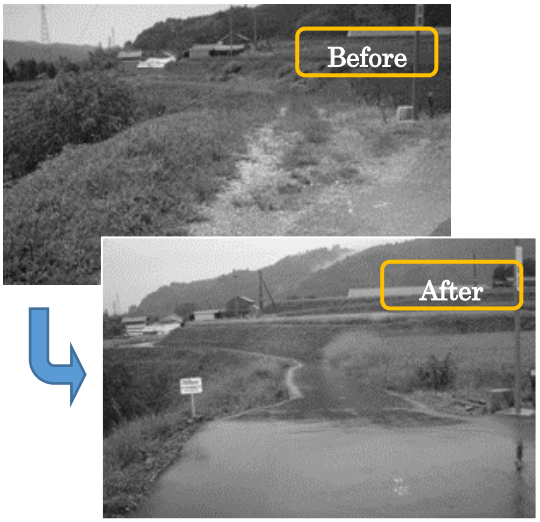
4.1 Local Environment

1) Developing the infrastructure by The projects of improving the environment around the dams

The Bureau partially subsidizes the cost of projects that contribute to improving the environment in areas around the dams with understanding and cooperation for its power generation business. Projects subsidized under this program include parkland development, tourism facility development and road improvement. This program has helped improve the living environment of local residents to ensure their safe and secure living (Photo 1).

Gate improvement project
(Tosayamada Town)

Drainage repair project
(Monobe Town)



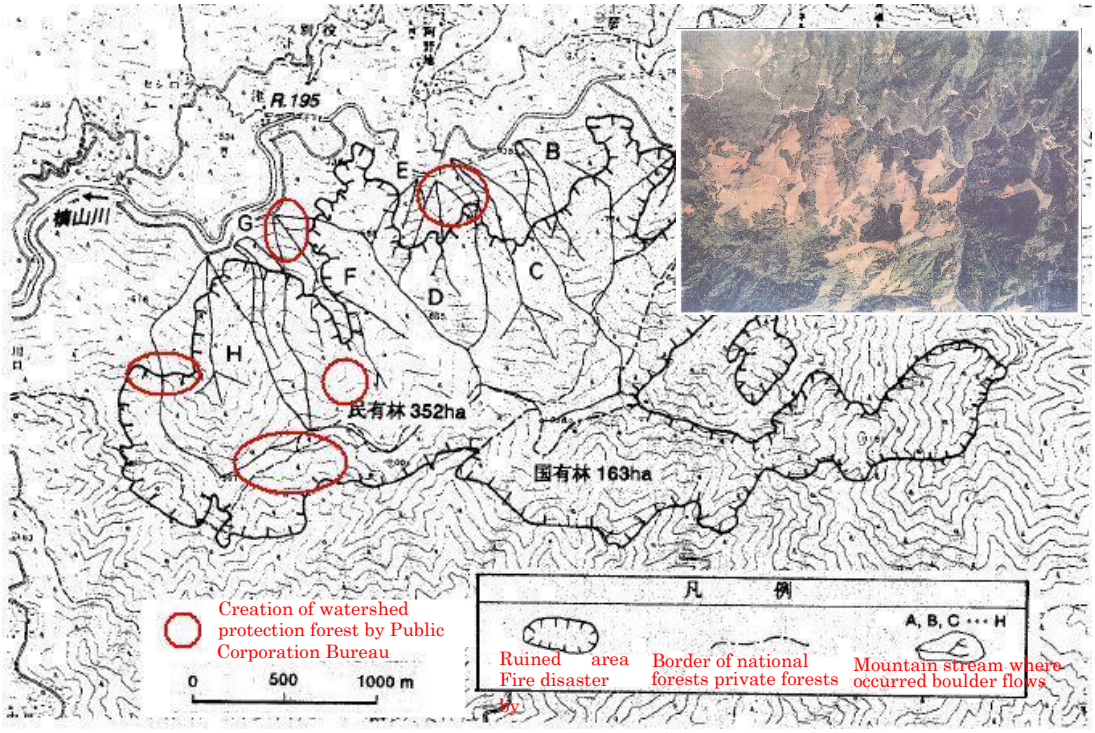
Farming road development project
(Kahoku Town)

Road improvement project
(Monobe Town)

Photo-1: Examples of the projects improving the environment around the dams (Kami City)

2) Conserving forests under the headwater forest improvement program

The Public Corporation Bureau Forest program, which began in FY1993, has acquired approx. 110 hectares of forests in Kami City and Kanan City, and planted mainly broad-leaf trees to establish headwater conservation forests. Local contractors are used for maintenance, including undergrowth clearing, to maintain and enhance the ground's water retention capacity. Since FY2007, the aforementioned Monobe River headwater forest improvement program has worked on improving the forests' water conservation function and promote local forestry industry (Fig.-3, Photos-2 and 3).



(Note) Major brush fires in April 1993 burnt down 352 hectares of privately-owned forests and 216 hectares of state-owned forests.

Fig.-3: Areas affected by brush fires along Monobe River and areas of headwater conservation forest development by the Public Corporation Bureau

Photo-2: Acquisition of burnt forests (Monobe Village, Kami County in 1993)

Photo-3: Appropriately thinned plantation

4.2 Local Community

1) School visits and inspection tours for environmental education on renewable energies (hydropower)

In order to promote children's environmental awareness and understanding on renewable energy, the Public Corporation Bureau has compiled and distributed information booklets as the teaching material for school classes. Bureau staffs also visit elementary and junior high schools to teach about hydro electricity and show

experiments to spread and educate people about renewable energies (around 10 school visits / year) (Photo 4). The Bureau also runs inspection tours for the dams and power stations to educate the public about the use of natural energies (Photo 5).


Photo-4: School visit by the staff of the Public Corporation Bureau


Photo-5: Dam inspection tour

2) Creating recreational opportunities

Facilities developed under the program for improving the environment around the dams are utilized to enhance communication and bond with local residents, and increase the number of visitors from outside the region for recreational and tourism purposes.

Number of Hinomiko River Park
camping ground users: Approx. 7,000 per annum

Number of Riders Inn Okumonobe users: Approx. 400 per annum

Riders Inn Okumonobe (accommodation and networking facility for motorcycle travelers)

Hinomiko river Park camping ground (cabins and barbecue facilities)

Kawakamisama 'eel-grabbing' summer festival (Local summer event)

Photo-6: Recreational facilities developed under the environment improvement program

3) Promoting the introduction of small scale hydropower

Under the FY2010 project for promoting 'Green Decentralization Reform,' the Bureau has explored ways of introducing and expanding renewable energies, and investigated the potential level of solar and small scale hydropower usage. It has compiled small scale hydro brochures and introduction guides based on the findings, and conducted the 'Advance Small scale Hydro Project,' 'Small scale Hydro Municipality Support Program,' and 'exploration of potential small scale hydro sites in local municipalities,' in which information sessions were held in municipalities of strong potential in an effort to promote greater introduction of small scale hydro.

5. Reason for Success

(1) The project's economic viability

This is a combination of Kochi Prefecture Public Corporation Bureau's wholesale power supply project using hydropower, and the environmental improvement project for areas around the hydro plants' dams and headwater forests. The income from selling electricity at the price determined according to the FCD method has secured the economic viability.

To ensure economic viability, the Public Corporation Bureau set up the Community Revitalization Fund within the electric business account to promote public welfare, which is the original objective of the project, to finance other projects for symbiosis with local communities.

(2) The project's economic benefits

Around 25 million yen per annum out of the income from selling electricity was given back to local communities in the form of grants to local municipalities for improving the environment around the dams and conserving headwater forests, thereby contributing to the region's forestry industry.

(3) Contribution to local environment and society

The environment improvement project for areas around the dams has led to the development of infrastructures such as parks, tourism facilities and roads, improving local residents' living environment, promoting community exchange and increasing the number of visitors for leisure and tourism purposes. At the upstream of the power stations, headwater protection forests have been developed through the plantation of mostly broad-leaf trees, which are relatively resilient to brush fires. This is expected to contain the spread of future brush fires, prevent soil erosion, reduce the flow of muddy water and improve the area's water retention capacity.

Furthermore, the Bureau sends its staffs to elementary and junior high schools for information classes and arrange a tour of the dams and power stations to educate children about the environment and energy. The program by the Ministry of Internal Affairs and Communications for promoting community-based energy has been utilized to provide information to local communities on the introduction of small scale hydro, in an effort for community revitalization.

6. Outside Comments

(1) TV Kochi: Gambare Kochi Eco Support Team (aired on December 30, 2005)

Featuring the Bureau's school visit (desktop study and facility inspection) on the theme of hydro electricity at Tosa-Yamada Municipal (currently Kami Municipal) Funairi Elementary School

7. Reference

[1]Electric Engineering Section, Pubic Corporation Bureau, Kochi Prefectural Government website: https://www.pref.kochi.lg.jp/soshiki/610301/

[2] Kami City website: http://www.city.kami.kochi.jp/

[3] Kochi Prefecture Public Corporation Bureau: Kochi Prefecture Public Corporation Bureau's Mid-Term Management Plan (3rd), April 2014

[4] Kochi Prefecture Public Corporation Bureau: Overview of the Public Corporation Bureau, June 2014

JP07

Name of the Power Plant: Ochiairo Power Station

Country(State/Prefecture): Japan (Shizuoka Prefecture)

Owner

Name of the owner: Tokyo Power Generation Company

Type of ownership: Power Producer

Type of market: Feed-In Tariff

Commissioning Year: 2006 (redevelopment)

Project Evaluation

Financial Viability: Recovering initial investment, securing the cost of maintenance and management, securing an appropriate level of profit

Economic Benefits: Tax revenues, tourism resource, promotion of local industries

Social Aspects: Local environment: river environment conservation, maintenance of local landscape and culture

Local community: Promoting local development, creating local leisure opportunities

Keywords: Regeneration of decommissioned power station, regeneration of river environment, revival of fisheries resources, landscape preservation, development of recreational facilities

Abstract

The Ochiairo Power Station, originally operated as a private power generation facility for a traditional Japanese-style inn in Shizuoka Prefecture, was decommissioned in 1995 following the aging of the plant facilities and plant operators. The facilities were then left abandoned, degrading the river environment to the extent that fish could not travel upstream.

Met with the inn proprietor's passionate plea for bringing the power plant back to life, Tokyo Electric Generation Company, which is an electricity distributor with focus on hydropower, produced a book on its redevelopment in 2004 after concluding that it can be revived with economic viability through the use of existing facilities and the introduction

of new technology. In 2006, the regenerated Ochiairo Power Station began its operation. The construction work involved using existing facilities such as the intake dam and waterway, and making use of government subsidies aimed at facilities subject to the RPS Act to enhance the project's economic viability. The owner manages it together with other nearby plants to reduce the overall cost of maintenance and management.

The redevelopment included the development of a fish passage to allow fish to travel upstream, while also reviving ponds and restoring river streams in surrounding areas in order to make the plant in harmony with nature, sympathetic to the surrounding waterside landscape. As a result, the plant is becoming embraced by local fisheries operators and inn-keepers as an important part of the community.

1. Outline of the Project

The Ochiairo Power Station operated from 1953 to 1995 as a private power generation plant for the traditional Japanese inn 'Ochiairo' in Izu City, Shizuoka Prefecture. It was decommissioned in 1995 due to the aging of facilities causing plant failures and the aging of plant operators. The facilities were then left abandoned, degrading the river environment to the extent that fish could not travel upstream.

Tokyo Electric Generation Company, which operates small- and medium-sized hydroelectric plants and sells generated power to general electric utilities, received a passionate plea by the proprietor of Ochiairo Murakami Inn to re-establish the power plant, and concluded that it could be revived with economic viability through the use of existing facilities and the introduction of new technology. The company subsequently acquired the plant and initiated the redevelopment of the decommissioned site in 2004, with the aim of effectively taking advantage of underutilized energy, regenerating the river environment (conserving streams), expanding fish habitat and reducing CO_2 emissions with the use of hydro power. The revived Ochiairo Power Station launched its operation in 2006.

As shown in Fig.- 1 and 2 and Table-1, this power station draws up to 3.00m^3/s of water discharge from the existing intake dam on the Kanogawa River system's Kanogawa River, transfer the water via waterway measuring 100m in total and a water basin to the plant built on the left bank of the Kanogawa River. Using the effective head of 4.8m, the plant generates up to 100kW of power and discharges water back into the Kanogawa River. The canal-type (run-of-river) power station has the annual generation capacity of 756MWh and costed 133 million yen to build. Photos 1 – 8 show the status of civil engineering and electrical facilities before and after the redevelopment.

Table-1: Specifications of the power station

Item	Specifications
Name of the water system / river	Kanogawa River in the Kanogawa River system
Maximum output	100 kW
Maximum discharge	3.00m³/s
Effective head	4.80m
Power generation type	Run-of-river type / canal type
Power generation equipment	Integrated propeller turbine – generator unit
Grid connection	Yes

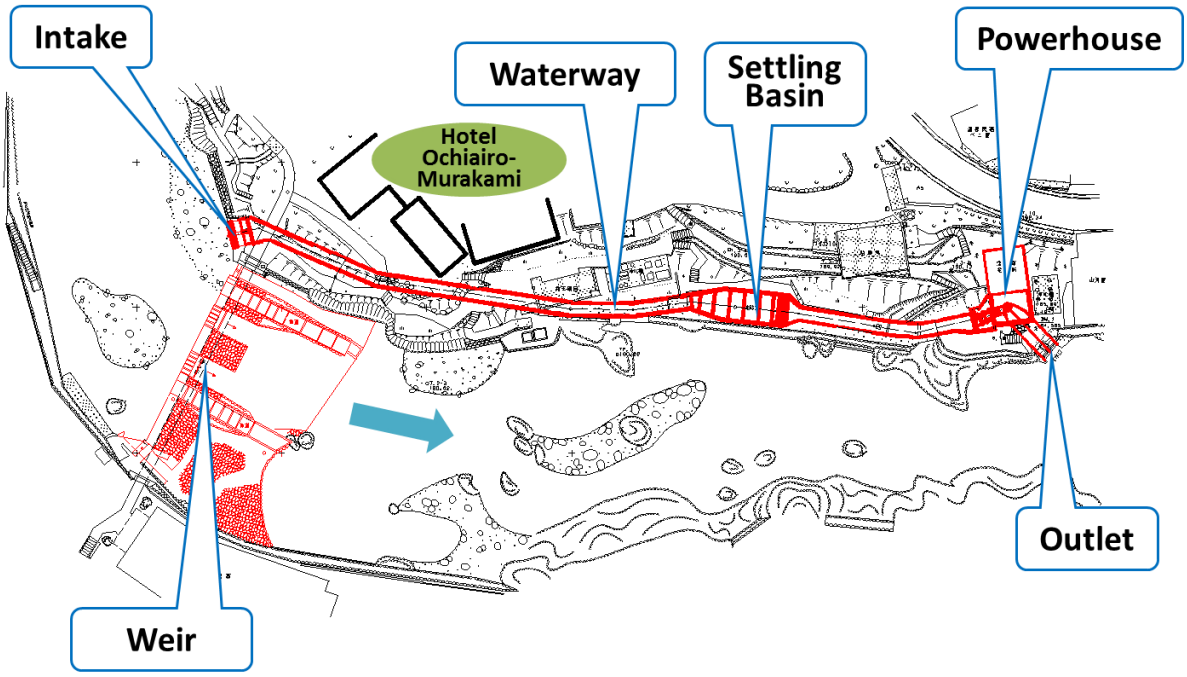


Fig.-1: Overview of the power station

Before the renovation

After the renovation

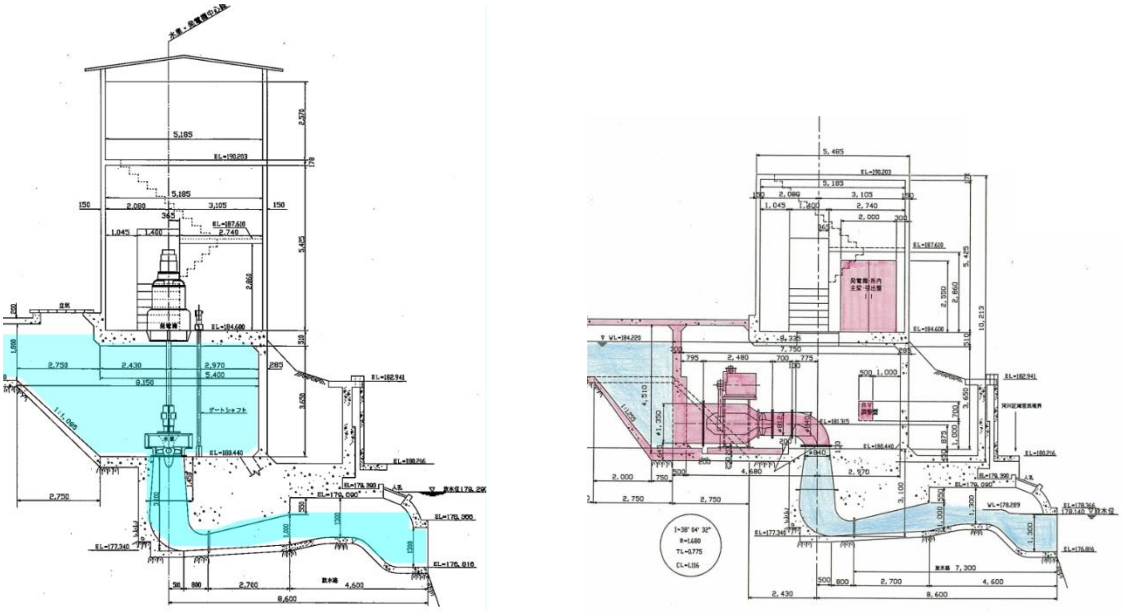


Fig.-2: Sectional view of the power station

Photo-1: Intake weir and intake (before the renovation)

Photo-2: Intake weir and intake (after the renovation)

Photo-3: Waterway
(Before the renovation)

Photo-4: Waterway
(After the renovation)

Photo-5: Power station
(Before the renovation)

Photo-6: Power station
(After the renovation)

Photo-7: Water turbine and generator
(before the renovation)

Photo-8: Water turbine and generator
(after the renovation)

2. Financial Viability of the Project

(1) Effectively utilizing existing facilities to reduce the cost of construction

The project decided to make diverted use of existing facilities including the intake weir, intake, waterway, settling basin, powerhouse, discharge canal and discharge outlet following a diagnostic investigation of existing structures, and carried out repair work on the head tank and replacement of the turbine and generator to achieve a substantial reduction in the cost of construction.

(2) Employing new technology to streamline the facilities

In order to achieve accurate discharge of river water at the time of flooding, the timber flush boards were replaced with an SR relief weir for automated gate control in flooding and shorter construction period.

The use of the latest small scale turbine integrated with the generator (Hydro-eKIDS) has achieved oil-less operation, improved reliability and increased power generation, enhancing economic viability.

(3) Use of subsidies

Since the project is subject to the RPS Act, the Ministry of Economy, Trade and Industry subsidizes 30% under the medium and small scale hydropower development subsidization program, keeping the cost of power generation to an economically viable level.

(4) Managing multiple sites to reduce the overall cost of maintenance and management

Tokyo Power Generation Company centrally maintains and manages this plant as well as three other plants it owns in the vicinity (Mukohara, Yugashima and Umeki Power Stations) to reduce the overall cost of maintenance and management.

3. Economic Benefits of the Project

(1) Receiving fixed asset tax revenues

This power station pays fixed asset tax of approx. 1 million yen to Izu City.

(2) Tourism resource effect with the power station's appearance in harmony with nature

The power station's appearance in harmony with nature complements the Kanogawa River landscape, attracting some 7,000 visitors per annum including those staying at local accommodation and those inspecting the plant.

(3) Promoting local industries

The original Ochiairo Inn filed for civil rehabilitation and the business was sold to today's Ochiairo Murakami Inn. It is enjoying an increased number of guests and stable business management thanks partly to enhanced landscape featuring the regenerated power station in harmony with surrounding nature.

Electricity generated at this plant powers the EV charging station for charging the electric vehicles of the inn's guests, creating an added 'environmental' value to the accommodation.

4. Social Aspects of the Project

4.1 Local Environment

1) Preserving the river environment

Since this site is along the main stream of the Kanogawa River system, which is nationally known for Ayu sweetfish fishing, the plant uses an SR relief weir, whose operation mechanism is powered with the force of air inflation rather than hydraulic power, so as to prevent any contamination of river water (Photo 9).

Maintenance flow is discharged from fish passage to allow fish to travel upstream. The fish passage's partition walls are designed with specific notch width and height to provide the flow speed, minimum width, minimum depth and break space required for upstream traveling of Ayu sweetfish and Amago red-spotted trout (Photo-10).

Photo-9: Relief weir

Photo-10: Development of fish passage

2) Preserving local landscape

Redeveloping the decommissioned power station has successfully restored waterside landscape around the inn. This project has regenerated a pond with the intake dam and produced landscape in harmony with nature that local people can enjoy.

4.2 Local Community

1) Restoring the use of local hydro power resources

Redeveloping the decommissioned Ochiairo Power Station, which operated from 1953 to 1995, has restored the effective use of local hydropower resources, which is welcomed by local communities.

2) Providing environmental and energy education

Local elementary school pupils, prefectural assembly members, representatives of Land Improvement Districts and various other parties visit the site (5 groups per year on average) as it features intake facilities, conveyance facilities and power generation facilities within a compact site, making it easy to present the structure of a hydro power station.

3) Providing use as a recreational facility

The pond with the intake dam, revived as part of the redevelopment, provides a recreational facility, allowing boating.

5. Reason for the Success

(1) The project's economic viability

The original power station's existing facilities were made maximum use of in order to improve the project's economic viability.

Since the project was subject to the RPS Act at the time of redevelopment, it received government subsidies to keep the cost of power generation low for economic viability. At the introduction of the FIT system in July 2012, the site shifted from an RPS-certified facility to an FIT-certified facility for even better economic viability.

(2) Contributing to local environment and society

The Kanogawa River, where the power station is sited, is also nationally popular for Ayu sweetfish fishing. For this reason, fish passage was arranged at the intake dam to allow the fish to travel upstream. The project also revived ponds around the inn and restored streams to establish the plant in harmony with nature, fully sympathetic to the waterside landscape. The plant is gaining community appreciation, embraced also by local stakeholders such as the Ochiairo Murakami Inn and Kanogawa Fishermen's Union.

6. Outside Comments

(1) Selection by METI / NEDO as one of the top 100 new energy projects [1] (April 2009)

(2) Cited as one of Shizuoka Prefecture's prominent industrial heritage[2] (July 2011)

(3) JAPAN Biz Cast (You Tube) : Tenjo Yugashima Hot Spring Resort Ochiairo Murakami Power Station (1)www.youtube.com/watch?v=RaqDNj30FNQ

(4) JAPAN Biz Cast (You Tube) : Tenjo Yugashima Hot Spring Resort Ochiairo Murakami Power Station (2)www.youtube.com/watch?v=5gzovi8jesM

(5) Shizuoka Shimbun Newspaper (April 26, 2012 morning edition for eastern Izu region): Kanogawa People's Story --- Plant Relaunch to Restore Local Landscape, featuring words of gratitude by the proprietor of the Ochiairo Murakami Inn about Tokyo Power Generation Company's role in redeveloping the power station and its understanding shown to local communities

7. Reference

[1] Hydropower Division, Tokyo Power Generation Company: "Case Study of Hydro Power Stations" (Basics workshop on NEF hydro power), May 2011

[2] Colla:j : http://collaj.jp/data/magazine/2011-07/index.html

[3] Tokyo Power Generation Company http://www.tgn.or.jp/teg/

[1] In consideration of local characteristics and following the assessment of nationwide initiatives on new energy use, the Ministry of Economy, Trade and Industry and NEDO selected 100 advanced and future-oriented cases from all of Japan's 47 prefectures.

[2] Many structures that have served as the foundation of modernization in Shizuoka Prefecture have been selected as important cultural resources and designated as 'industrial heritage'.