73RD INTERNATIONAL EXECUTIVE COUNCIL MEETING

24th ICID INTERNATIONAL CONGRESS
73rd IEC MEETING
3RD OCT - 10TH OCT 2022
ADELAIDE | SOUTH AUSTRALIA

Theme: Innovation and research in agriculture water management to achieve sustainable development goals

INTERNATIONAL WORKSHOP ON
"THE WATER ENERGY FOOD NEXUS: IMPLEMENTATION AND EXAMPLES OF APPLICATIONS"

04 October 2022: 08:45-10:30 and 11:15 to 13:00 Hours
Adelaide, Australia

24th International Congress on Irrigation and Drainage & 73rd IEC Meeting
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DUAL USE OF IRRIGATION WATER FOR FOOD PRODUCTION AND HYDROPOWAER GENERATION IN JAPAN

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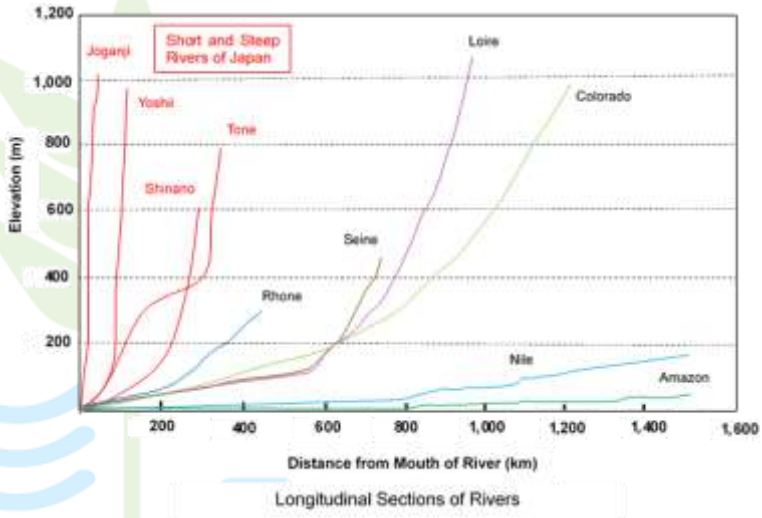
- About 70% of Japan's land area is mountainous or hilly, thus the rivers are short, and their gradients are quite steep, so are Japan's irrigation channels developed along rivers.
- These irrigation channels often require energy dissipaters such as falling drops in open canals or pressure reducing facilities like surge tanks in closed pipelines.
- Irrigation channels with these energy reduction facilities can be used for the production of hydroelectric power instead of reducing the energy of water flow.



Longitudinal Sections of Rivers

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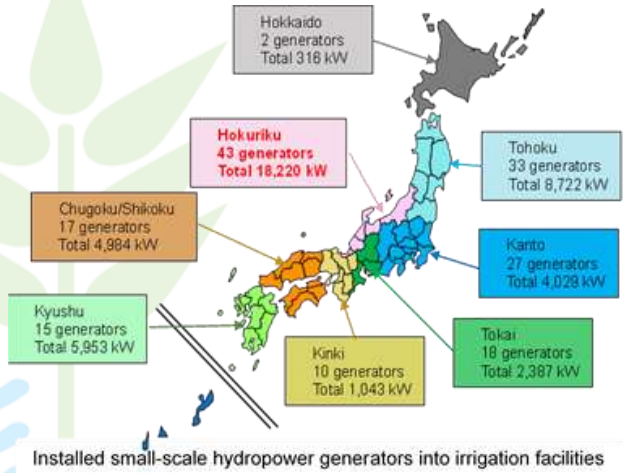
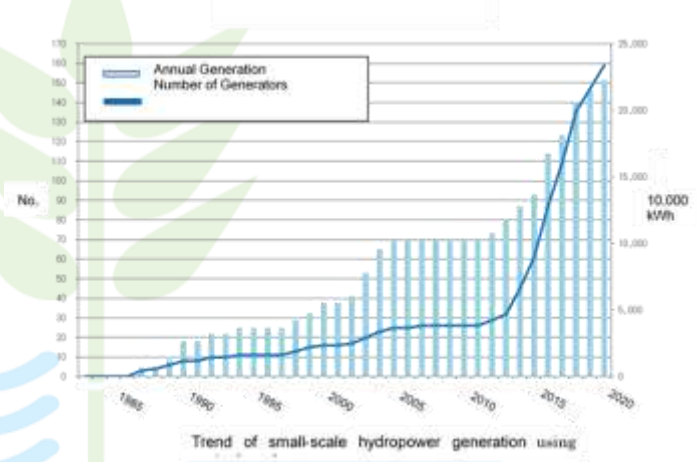
- Small-scale hydroelectric power generators using irrigation water flow have been attracting attention as a low-cost source of renewable energy in Japan.
- So far, 165 small-scale hydropower generators have been installed into irrigation facilities such as agricultural dams, steep irrigation channels, and pipeline surge tanks.
- Most of such generators can produce less than 1,000 kW each but their total production is estimated as 228 million kWh, correspond to the annual consumption of 76,000 households.



Installed small-scale hydropower generators into irrigation facilities

- The government of Japan has been supporting the utilization of renewable energy including the use of irrigation water flows.
- The Ministry of Agriculture, Forestry and Fisheries provides several subsidies for the installation of small-scale hydropower generators into irrigation facilities.
- The Ministry of Economy, Trade and Industry established a feed in tariff (FIT) framework for the procurement of electricity generated from renewable energy sources.



Trend of small-scale hydropower generation using

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- Under the New Energy Law, renewable energy is defined as solar energy generation, wind power generation, biomass generation, biomass fuel production, thermal energy convention, geothermal power generation and small hydropower generation less than 1,000kW.
- The 2022 tariffs for hydropower are as follows: 34 JPY/kWh (0.25 US$) for less than 200kW, 29 JPY/kWh (0.21 US$) for 200kW to 1,000kW, 27 JPY/kWh (0.20 US$) for 1,000kw to 5,000kw, 16~20 JPY/kWh (0.12 ~ 0.15 US$) for 5,000kW to 30,000kWh

FIT purchase prices

Energy Source	Generation Scale	Price per 1kWh	Purchase Period
Solar	> 50 kW	10 JPY	20 years
	10 – 50 kW	11 JPY	20 years
	< 10 kW	17 JPY	10 years
Wind	on shore	14 – 16 JPY	20 years
	off shore	29 - 36 JPY	20 years
Middle to Small Scale Hydropower	5,000 – 30,000 kW	20 JPY	20 years
	1,000 – 5,000 kW	27 JPY	20 years
	200 – 1,000 kW	29 JPY	20 years
	< 200 kW	34 JPY	20 years
Geothermal	> 15,000 kW	12 – 26 JPY	15 years
	< 15,000 kw	19 – 40 JPY	15 years
Biomass		13 – 40 JPY	20 years

Example 1
Utilization of the head difference of a pipeline system

- The area is located Hukui-Sakai plain spread over Kuzuryu lower basin of Fukui Prefecture, Hokuriku region, the middle-north of Japan.
- The size of the benefited field is 11,674 ha.
- The purpose of the national project is to reconstruct a deteriorated open irrigation channels into a semi-closed pipeline system.

the Area of the Kuzuryu National Irrigation Projec

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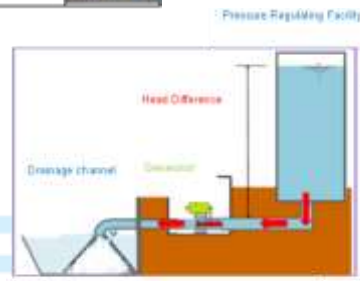
- The intake facility, Naruka headworks, is located at relatively higher altitude.
- Four pressure regulating facilities, surge tanks, were constructed to control the water pressures.
- In order to utilize the height pressure of the pipeline system, four small-scale hydropower generators are installed downstream of each pressure regulating facilities.

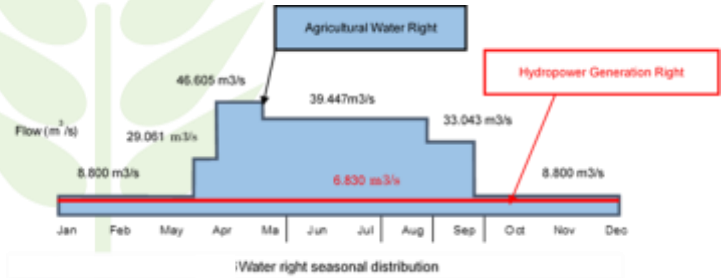
Pressure Regulating Facilities

Name	Dimension	Structure	Water Level	Picture
Jyugou	H=30.0 m D=36.0 m V=30,536 m³	Prestressed Concrete	NWL=EL24.0 m	
Haruehokubu	H=20.1 m D=14.1 m V=3,139 m³	Prestressed Concrete	NWL=EL20.0 m	
Kawaharuchika	H=21.6 m D=11.5 m V=1,135 m³	Steel	NWL=EL24.5 m	
Egami	H=19.8 m D=11.0 m V=1,882 m³	Steel	NWL=EL22.0 m	



The system of hydropower generation

- The downstream of these four generators is connected to secondary and tertiary pipeline systems which require head energy to provide agricultural water to the fields.
- Depending on the crop season the maximum amount of water that can be used for irrigation (water right) is controlled by the government.
- Daily use of irrigation water is often less than this maximum limit. These four hydropower generators use the difference between the maximum limit and the actual use of water.



Water right seasonal distribution

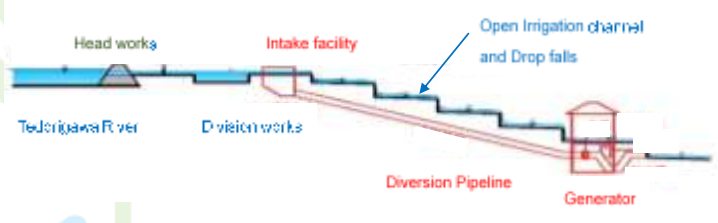
- The four small-scale hydropower generators are managed and maintained by Naruka Headworks Land Improvement District.
- Actual annual revenue of fiscal year 2021 from those four generators was US$ 0.68 million.
- The annual costs of the management and maintenance of those generators was US$ 0.17 million, therefore the net profit was US$ 0.51 million.
- Nearly 80% of the management and maintenance costs of their irrigation facilities paid off by the revenue of the electricity generated by the small-scale hydropower generators.

Costs and Benefit (* calculated as US$ 1.0 = JPY 135.0)

Name	Construction Costs	Maximum Annual Production	FIT Price per kWh	Maximum Annual Revenue
Jyugou	US$ 2.6 million	923 MWh	US$ 0.215	US$ 0.20 million
Haruehokubu	US$ 1.0 million	372 MWh	US$ 0.215	US$ 0.08 million
Kawaiharuchika	US$ 3.7 million	1,572 MWh	US$ 0.215	US$ 0.34 million
Egami	US$ 3.5 million	1,747 MWh	US$ 0.215	US$ 0.38 million
Total	US$ 10.8 million	4,614 MWh	US$ 0.215	US$ 0.99 million

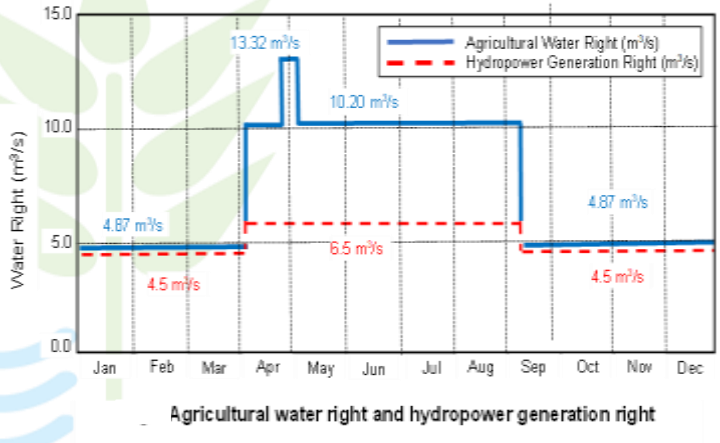
Example 2
Reconstruction of drop falls into hydropower generation

- The upper stream of Miyatake irrigation channel has a steep slope, so that it is required to construct a number of drop falls to reduce the speed of the water flow.
- Two small-scale hydropower generators have been installed to utilize the head difference of Miyatake irrigation channel.
- In order to utilize the head difference of 15.4m along Miyatake irrigation channel, a diversion pipeline was constructed and small-scale hydropower generator was installed.



Hydropower generator installed into Miyatake irrigation channel

- The upper stream of Miyatake irrigation channel has a relatively small number of irrigated fields, so the large amount of water can be diverted for the generation of electricity.
- During the high irrigation season for paddy fields, 6.5 m/s out of 10.2 or 13.32 m/s of agricultural water right can be diverted for electricity generation, and during lower irrigation season, 4.5 m/s out of 4.87 m/s of agricultural water right can be diverted for electricity generation.



Agricultural water right and hydropower generation right

- The revenue of fiscal year 2021 by first and second Miyatake generator was US$ 0.33 million and US$ 0.93 million respectively.
- US$ 0.15 million was necessary for the management and maintenance of the generators.
- US$ 0.30 million was used for the management and maintenance of the other irrigation facilities that is under control of Tedorigawa Miyatake Land Improvement District.
- More than 85% of the maintenance cost is covered by the electricity generation.

Costs and Benefit

Name	Construction Costs	Expected Annual Production	Price per kWh	Expected Annual Revenue
First Miyatake	US$ 12.3 million	4,454 MWh	US$ 0.074	US$ 0.330 million
Second Miyatake	US$ 15.8 million	4,036 MWh	US$ 0.215	US$ 0.868 million

* calculated as US$ 1.0 = JPY 135.0

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Conclusion

- ✓ **Water right for generating electricity during non-irrigation seasons**
- Because the flow of irrigation channels is subject to farming seasons, in the case of Japan from May to October, the efficiency of these hydropower generators is limited.
- In order to facilitate the procedures to obtain water right for small-scale hydropower generation, several enhancement orders under the River Act were amended in 2013.
- In order to utilize a full capacity of irrigation facilities for electricity generation, further amendment of water rights allocation system is required.
- ✓ **Government support to promote the triple use (for food, energy and the environment) of irrigation water flow**
- It is estimated that the 17 small-scale generators installed into irrigation facilities can reduce 12,992 t/year of greenhouse gas.
- Under the global emergent necessity to reduce greenhouse gas emission, irrigation water has to be used not only for the food production but also for the reduction of greenhouse gas.
- Government supports such as FIT framework or government subsidies for the initial construction costs are required.

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