Operation & Management: Arisu Small Hydropower (SHP) Plant

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Introduction

Small Hydropower Plant in Noryangjin Reservoir

Hydroelectric power is a type of renewable energy that uses the head (the difference between upstream and downstream water levels) and flow of moving water to produce energy; a small hydropower plant (SHP) in particular is the result of the development of hydroelectric power on a scale serving a small community or with a capacity of up to 10,000kW in general. SHP eliminates pollutants and allows for a constant supply of electricity. They have not been widely adopted in Korea due to difficulties involving the high initial investment cost and plant site selection.
Our Arisu small hydropower plant takes advantage of the kinetic energy of non-pressurized water or head (difference between upstream and downstream water levels) of 24 meters, which is produced in the Amsa purification center and Noryangjin reservoir. This is the first time a waterwheel has been installed in the drinking water supply network to produce hydropower.

Currently, the 103MWh per month generated through this system is being purchased by KEPCO (Korea Electric Power Corporation) for KRW 1.6 million every month. In line with Seoul's **"One Less Nuclear Power Plant"** project, the Arisu SHP is expected to play a pivotal role in solving the electricity shortage in the country and reducing CO_2 emissions; thus contributing to the country's wider environment preservation initiative.

Overview of the Policy

Installing small hydropower plants: generation capacity of 300 kW (100 kWx3 ea.)
<< Using water flowing from the Amsa purification center to the Noryangjin reservoir, we built the country's first small hydropower plant where waterwheel is installed in the drinking water supply network.

<< The Seoul Metropolitan Government sells the electricity from the SHP's monthly generation capacity of 103 MWh, earning revenue of KRW 1.6 million every month.

Background

Electricity production capacity was not able to meet the rapid increase in electricity demand.

The ratio of aggregate electricity consumption to GDP in Korea is 0.44 kWh/USD, which is far higher than the OECD average of 0.2 kWh/USD. On top of such a high energy consumption pattern, Korea's reserve electricity has been falling short due to occasional surges in demand caused by abnormal weather patterns such as heat wave, cold wave, etc.

Nuclear power plants are no longer be the answer to address the shortage issue due to strong opposition to this type of energy generation. Opposition has especially increased since the Fukushima accident in March 2011 and after a scandal that involved fake certificates for some parts in Korea's nuclear reactors.

Seoul is moving forward in line with the government's renewable energy policies.

In Korea, 91.9% of power is generated by thermal and nuclear energy, whereas other advanced nations are expanding their ratio of renewable energy for their stable supply of electricity. Following suit, the Korean Ministry of Trade, Industry, and Energy (MOTIE) has been implementing various policies and making investments such as Green Home, Green Building, and Green Community. The Arisu hydropower project is part of this government initiative to support municipalities in adopting more renewable energy projects.

Environmental preservation has become a social issue.

As citizens have become more aware of the direct and indirect impact of global warming, rises in sea level, endocrine-disrupting chemicals, and other environmental issues, they recognize the need to preserve the environment, and ask the government to do its part and to engage more in the cause.

Trends in SHP

Global Trend

recognizing the economic and social benefits of SHP, many advanced countries around the world have already acquired hydrologic statistics and technology in this field. These countries regard SHP not only as a source of energy, but also as an important energy industry. They have already established an assessment method as to the feasibility of SHP as well as optimal design for plants, streamlined and standardized waterwheels system, and automatic control

system, all of which have contributed to the wider adoption of SHP globally.

• China: 38,500MW, Japan: 1,700MW, Germany: 1,600MW, France: 1,956MW, Italy: 2,233MW

Other countries have developed low-head waterwheels since low-head units are much smaller in capacity than the conventional large hydro turbines but just as economically viable.

• Higher capacity means more economical options. Korea's capacity is around 1,400kW while other countries are around 1,000kW.

Policies and Institutions of Other Countries

Governments around the world have adopted various systems relative to their own situations in terms of demand, supply, generation capacity, and production levels.

I Table 3-1 I Support Schemes of Countries around the World

Country	Support Mechanism	Remarks
Germany Spain Denmark	Introduction of FIT ※ FIT (Feed In Tariff): a policy tool designed to encourage the deployment of renewable electricity technologies by providing a fee (a "tariff") or a certain amount of money to those who generate their own electricity through renewable energy technologies above the retail rate of electricity	
US/Canada India	Introduction of RPS ※ RPS (Renewable Portfolio Standard): a regulation that requires power producers of a certain size to supply a certain amount of the total power generated using renewable energy	

Country	Support Mechanism	Remarks
China	Legal and institutional mechanisms are in place to encourage hydropower, especially SHP, anywhere possible.	
Japan	Micro-hydropower (output is less than 100kW) and pico-hydropower (less than 5kW) are in operation.	

I Table 3-2 I SHP generation by countries

Country	Capacity (Mw)	Country	Capacity (Mw)	Country	Capacity (Mw)
Argentina	400	Italy	2,233	Belgium	60
Austria	843	Japan	1,700	Luxemburg	40
Brazil	859	**Korea**	**65**	Portugal	317
Canada	1,056	Norway	806	Britain	68
China	38,500	Pakistan	107	Greece	60
Czech	201	Peru	215	Ireland	37
Finland	309	Rumania	311	Malaysia	107
France	1,956	Spain	1,700	Bolivia	104
Germany	1,600	Sweden	935	Vietnam	70
India	1,694	Turkey	83	Congo	65
Indonesia	58	United States	3,420	Sri Lanka	35

Data : Renewable Energy R&D Strategy 2030(2007)

[Table 3-1] Support Schemes of Countries around the World

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Domestic Trend

In Korea, as of the end of 2010, SHP generation capacity was 95,220kW at 68 plants, and annual SHP generation at 3.39 million kWh.

I Table 3-3 I SHP in Korea

Classification	Generation Capacity (kW)	Share (%)
68 plants	95,220	100
KEPCO and other public power generation companies (13 plants)	33,573	35.2
Independent power producer (IPP) (18 plants)	30,559	32.1
K-Water (19 plants)	18,054	19
Korea Rural Community Corporation (11 plants)	10,659	11.2
Municipalities (7 plants)	2,375	2.5

[Table 3-3]SHP in Korea

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68 plants		
KEPCO and other public power generation companies (13 plants)		
Independent power producers (IPP) (18 plants)		
K-Water (19 plants)		
Korea Rural Community Corporation (11 plants)		
Municipalities (7 plants)		

SHP plants constructed before 2000 were mostly run by IPPs, but this trend reversed after 2001 when the government began a variety of projects including Feed-in-Tariffs. Since then, most SHP plants have been controlled by municipalities or other public corporations.
Currently, SHPs are not utilized to the full extent of their high potential. They can be adopted at agricultural reservoirs and sewage treatment plants; hence the huge room for use. With RPS now adopted in Korea, SHPs are becoming an even more economical option and one in which investment interest is growing.

Process of Policy Implementation

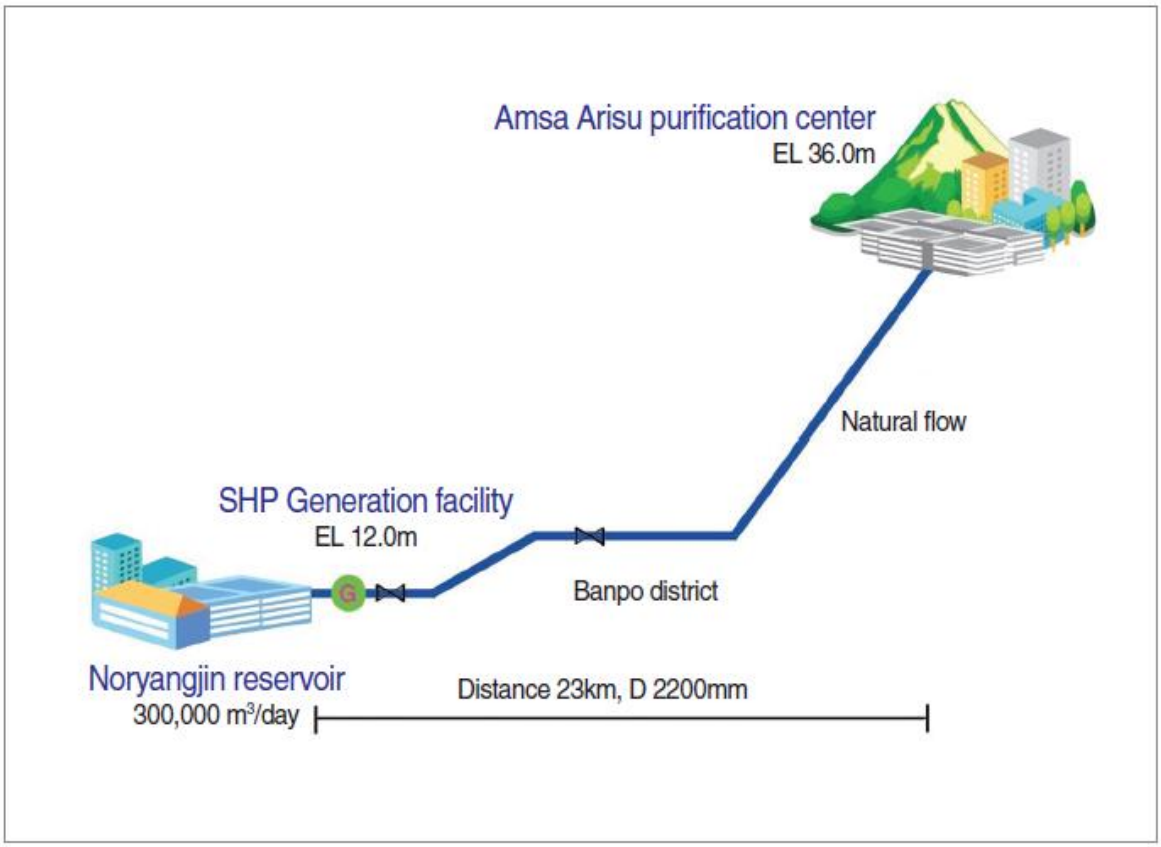
• Feb. 25, 2012: Report on measures to implement lessons learned from the Mayor's visit to Japan (pilot project for 1 SHP, 1 PV)
• Mar. 13, 2012: Report on ways to adopt SHPs
• Oct. 10, 2012: Budget secured for investment in SHP (KRW 1.231 billion appropriated by the Korean Ministry of Knowledge Economy)
• Apr. 4, 2013: Working design
• Jul. 2, 2013: Service performance
• Oct. 16, 2013: Permitted as utility enterprise (300kW generation)
• Aug. 2013~Jan. 2014: Construction of SHP plant begins
• Jan. 29, 2014: Construction completed

Details of the Policy

Arisu SHP plant

• Project Overview
  - Location: Noryangjin Reservoir in Seoul
  - Transmission Pipe: 23.2 km (diameter: 2,200 mm) of water pipes from the Amsa purification plant to the Noryangjin reservoir
  - Water Level: head of purification plant (upstream): 37.79m, head of reservoir (downstream): 12m
  - Waterwheels (3 units): pump-turbine, rated capacity of 94kW, maximum output of 107kW
  - Generators: three-phase induction (capacity: 100kW x 3 units)
  - Operation: Automatic, remote control from the main control center at Noryangjin reservoir
• Budget: KRW 2.341 trillion (central government: 50% / city government: 50%)
• Characteristics
  - A natural effective head of 10m is guaranteed.
  - A large amount of water (daily average of 300,000m^3) flows to the reservoir.
  - No additional establishments or structures required.
  - There is no impact (noise, vibration, other environmental) on surrounding areas; therefore, low likelihood of civil complaints.

[Arisu SHP Distribution Diagram]



[Arisu SHP Distribution Diagram]

Amsa Arisu purification center

Natural flow

Banpo district

SHP Generation facility

Noryangjin Reservoir

Know-how & Insight

Concerns of potential threat to water quality

There were concerns of oil leaks from waterwheels, which could affect 800,000 households. After thorough inspections including numerous discussion sessions with expert advisory groups, more than 20 site inspections, and analysis of overseas cases, we selected noncorrosive, pump-type waterwheels

that can ensure lubricant-free operation, eliminating any possibility of oil leaks. Other concerns existed. Sudden changes in pressure to the pipeline could cause slime formation that contaminates the water. Moreover, mid-valve operation to increase water flow – a necessary step to compensate for pressure loss when SHP is operating -- can drastically change water velocity, which can also compromise water quality. To prevent such problems, measures included generator pilot operation, real-time monitoring of water quality parameters, and mid-valve adjustments.

Countermeasure meetings in case of compromised water quality

Countermeasure meetings for emergency valve operation

Meetings on countermeasures in the event of compromised water quality

Meetings on countermeasures involving use of emergency valves

Technical issues related to construction

To ensure that the related construction work does not affect households in Seoul, we took advantage of a special piping technology that eliminates the possibility of water interruptions during the construction at 4 sites. We also used pipe sleeves to prevent the pipes from being pushed under pressure and strengthened the support fixtures to be used for water pressure simulation.
To compensate for the limited space in workstations, we had 2 workers in 1 group when carrying materials to pump stations and contracted a company specializing in such operations. Most importantly, all safety and accident-prevention measures were in place with our inspectors, who stayed at the sites throughout the construction period.

Perforating works for pipes connected to the ground

Valve connected to the ground

Perforating pipes connected to the ground

Valve connected to the ground

Policy Outcomes & Evaluation

Contributing to the energy reduction initiative of the national and Seoul Metropolitan governments

SHP generation helped realize CO^2 reduction of 1,032 tons/year and energy savings of 482 toe/year.

※ toe (tons of oil equivalent): 1 toe = 107kcal

In addition, 2,286 MWh of power generated by the SHP were sold for KRW 500,000/year to KEPCO, creating revenue for the city.

Raising awareness and educating on renewable energy

The SHP project has been documented in the form of video materials, which are being used to teach middle and high school students in Korea on various sources of energy and the importance of energy. The SHP project has also been promoted via media broadcasts and newspaper articles to raise public awareness of renewable energy.

Applicability of the Policy

Seoul's SHP plant uses water supply pipelines and can be applied to other municipalities in Korea as well as developing countries in Southeast Asia and South America.

Q&A

Where would more SHP plants be installed in the future?

We are looking into sites with lower head (over 2m) such as Yeongdeungpo Purification Station (200kW) and Samsung Reservoir (30kW).

Arisu Small Hydropower plant takes advantage of the kinetic energy of non-pressurized water produced in the Amsa purification center and Noryangjin reservoir. For the first time in Korea, Arisu SHP uses waterwheel installed in the drinking water supply network to produce hydropower.

Arisu Small Hydropower plant takes advantage of the kinetic energy of non-pressurized water produced in the Amsa Purification Center and Noryangjin Reservoir. Arisu SHP is the first installation in the country to use waterwheels in the drinking water supply network to produce hydropower.