Research and Development of IWRM Technologies for Low-Carbon and Energy-Saving Water Uses in Korea

Sung KIM (金勝), director
Sustainable Water Resources Research Center
Korea Institute of Construction Technology
Korea has extremely variable climate.

Seoul annual precipitation (1777 ~ 2007)

- Data Sources: KMA, JG Jeon, and GH Lim
Korea is classified as “water stress country.”
Renewable Water Resources: 1,471 m³/p

※ Source: http://www.unep.org/dewa/vitalwater/article69.html
Water Withdrawal Ratio is very high. (Korea: 35.6% ➞ Highest among NE Asian Countries)

Thus, difficult to manage water resources.
GW use increases (www.gims.go.kr)

- 10% of total water use (3.7 bil/yr)
- Intensive use (37mm/yr)
- 50% of observation wells show water level decreasing while 33% increasing
- After 20yrs, GW level may be decreased by 58cm and 4.3 bil. CM of GW storage would be lost.
- Many small- and mid-sized streams have been dried up after flood season.
Drought occurs every 5-7 yr period since 1970’s.

※ Deviation of annual rainfall expands gradually.

Source: Hwang (2009)
Korea has solved fundamental needs for water management by around 1990. But...
# Sustainable WR R&D Program

<table>
<thead>
<tr>
<th>Period</th>
<th>2001. 8. 1 – 2011. 3. 31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budget</td>
<td>147.5 B Won (Gov. 73%, Industries 27%)</td>
</tr>
<tr>
<td>Ministries</td>
<td>MOST 70%, MOCT 30%</td>
</tr>
<tr>
<td>Participants</td>
<td>77 orgs (Univ. 28, Res 11, Industry 13), 800 people</td>
</tr>
</tbody>
</table>

## Tech Development

<table>
<thead>
<tr>
<th>2001</th>
<th>1st Phase</th>
<th>2004</th>
<th>2nd Phase</th>
<th>2007</th>
<th>3rd Phase</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>TechImp</td>
<td>Component Tech Application</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figures correspond to different phases of the Sustainable WR R&D Program.*
Foundation for water management has been established by the WR Research Program.

- SW tools for WR design, Planning and operation
- HW tools for investigation and monitoring
- Water saving technologies: reuse, recycling, desalinization, artificial recharge, rain harvest
WR Planning, Design and Operation SW

- Developed and implemented for National WR mgmt

**K-WEAP**
- K-WEAP (Korea Water Evaluation and planning System)

**HyGIS**
- HyGIS (Hydro Geographic Information System)
- 311 orgs., 1,150 users

**IRM**
- Integrated River Management System
- Multi-purpose dams
- ADB projects
WR Planning, Design and Operation SW

Urban development, River management SW

- CAT (Catchment hydrologic cycle Assessment Tool)
- HDAMS / SWMM-GE (Hydrologic Data Acquisition & Management)
- RAMS (River analysis and Modeling System)

www.watercycle.re.kr
WR Investigation tools

- Traditional tools with advanced ITs

- GPS Floating Bar

- Image River Stage Monitoring System

- R2V2
  - Remote Control Monitoring Boat
  - 1.2m, 2.5m/s
Water Saving, Reuse and Desalination

- New and traditional technologies

- TDR
- Automated Leakage Detecting Pipe

- Agricultural Water Reuse

- Carbon Electrode Desalination
Capacity Building

• 74 Ph.ds, 347 Masters (89% works in water fields)
• Weekly newsletter for 15,000
• New Tech Users Meetings
• New Tech Exhibitions
Green Growth Korea

- Basis of new economic growth strategy in the faces of today’s low growth economy
- Eco-innovation and fostering green industry
- The Korean Government adopted the “National Strategy and Five-Year Plan for Green Growth” in 2009
- By 2020 30% of CO2 Emission Reduction
- By 2020 World 7th Green Power
  - Mitigating climate change
  - Creating new engines for economic growth
  - Improving quality of life
Summary and Prospects

- Sustainable Water Resources Research and Development Program (SWRRP) was effective to improve WR technologies for Korea.
  - Before the program launched (1991-2000), Koreans published 24 SCI papers, during the program period (2001-2010), published 385 SCI papers for researched area.
- Technology potentials are assessed to be 3.7 billion cubic meters of water (about 10% of national water uses) if applied.
  - During the research period, 100 million cubic meters of water have been created through technological implementation.
- Korea can facilitate “Green Growth” policy for Low-Carbon and Energy-Saving by implementing IWRM technologies.
Thank you very much

http://water21.re.kr
Low-Carbon and Energy-Saving Efforts Using Agricultural Water

Masahiro Goto
National Institute for Rural Engineering, National Agriculture and Food Research Organization

Renewable Energy Systems, Renewable Resources Engineering Division, National Institute for Rural Engineering
In order to produce good-quality crops, it is necessary to distribute good-quality water and then remove water rapidly → dams, intake weir, irrigation/drainage channels, etc. are developed for this purpose.
Example of agricultural irrigation/drainage channels

Irrigation: Artery
Drainage: Vein

Toyama Prefecture water/farmland map

Renewable Energy Systems, Renewable Resources Engineering Division, National Institute for Rural Engineering
An example of irrigation volume
Energy Consumption in Agricultural Water Use

Irrigation: information, communication and control facilities for driving valves, gates, pumps, etc. of dams, intake weirs and channels

Drainage: information, communication and control facilities for driving pump stations, dust collectors, floodgates, etc.
Energy Production Using Agricultural Water Facilities
Energy Production by Micro Hydroelectric

Water energy is converted to electric energy

\[ P(kW) = 9.8 \times Q(m^3/s) \times H(m) \times \eta \]

- \( P(kW) \): Generated output
- \( Q(m^3/s) \): Flow rate
- \( H(m) \): Effective head
- \( \eta \): Efficiency (efficiency of generator, water turbine, etc. \( \approx 0.72 \))

\[ P(kW) \approx 7 \times \text{flow rate} \times \text{head} \]

From the website of the National Federation of Land Improvement Associations

Renewable Energy Systems, Renewable Resources Engineering Division, National Institute for Rural Engineering
Reasons to promote micro hydroelectric generation using agricultural water:

1. Terrain conditions (head)
2. Water utilization conditions (flow rate)
3. Facility conditions (dams, water channels)
Agricultural Water and Exploitation of Water Power

1942:
Agricultural water mills for rice milling, turbines, etc.: 78,000 units
73,000 units of which are conventional water mills

1952: Agricultural/Fishing Villages Electricity Introduction Program
Land improvement districts, agricultural cooperatives, municipalities, forestry cooperatives, etc. constructed power plants.
About 200 plants in total have been constructed.

1983: Land Improvement Project
Enabled the construction of power plants as a new type of construction and renovation within the framework of irrigation/drainage projects (agricultural land development since 1985)
Power generation has started in 26 districts.
Districts of micro hydroelectric installation in a project of the Rural Development Bureau, Ministry of Agriculture, Forestry and Fisheries

From the website of the National Federation of Land Improvement Associations

Renewable Energy Systems, Renewable Resources Engineering Division, National Institute for Rural Engineering
Potential of Micro Hydroelectric

Distribution of small and medium hydroelectric installations by output (number of spots)

Source: a survey by the Agency for Natural Resources and Energy (as of March 31, 2007)
Comparison with Germany

Germany (2002)  
Plants of over 1,000kW: 403  
Plants of under 1,000kW: 5,500

Japan (2005)  
Plants of over 1,000kW: 1,407  
Plants of under 1,000kW: 437

In Germany, small hydroelectric plants with output under 5,000kW increased from 7,201 to 7,524 during the period from 2005 to 2006. In other words, as many as 300 power plants were built in one year. Average output is 160kW.
Potential of Micro Hydroelectric Generation

Agricultural water-use facilities
  Dams: 1,000
  Head works: 3,000
  Reservoirs: 210,000
  Agricultural water channels: 45,000km

→ Spots with a head and water

In addition, we have more favorable rainfall/terrain conditions compared with those in Germany.

According to Kobayashi (2010)

  100-1,000kW: Several thousand spots
  10-100kW: Tens of thousands of spots

Yamanashi Prefecture (2010.11)

  Micro hydroelectric in the prefecture: 745
Milieu R (Takeoka): 860,000 yen
runs 55km at 45km/h

REVA (Made in India): 2 million yen
runs 110km at 60km/h

EV-neo (Honda)
runs 30km at 30km/h

SEED (Terra Motors)
runs 35-45km at 30km/h

10km at 1kWh
Increasing the value of small water turbines

Max. output is 30kw at a 2.0m drop point of a main watercourse with a flow rate of 2.4m³/s
Micro hydroelectric in the future

Up until now micro hydroelectric generation has been used for electricity sales

Micro hydroelectric is considered as an energy source to substitute oil
Its impact has been limited to a narrow area related to electricity

Micro hydroelectric generation →
Local production and local consumption
Electric cars, smart grid, direct utilization
→will have a pervasive influence on the social system, values and lifestyle, for example.
Villages are Energy Sources

**Current state**
Farming and mountain villages = Remote area based on fossil fuel

**Society we should create**
Farming and mountain villages = source of natural energy

- Farming and mountain villages have untapped local resources and renewable resources
- Build a system for effective utilization of resources through their circulation within the region/basin zone.
- **Potential water power** of the region is the most effective resource, as principal, and it also contributes to the prevention of global warming.

Utilization of water power resources

Now we cannot continue to rely on exhaustible resources.

Farming and mountain villages cannot survive in the current social system.

It is possible to build a sustainable local economy using local resources as principal.