INCHEON
NATIONAL UNIVERSITY

Ministry of Land,
Infrastructure and Transport

KAIA
Korea Agency for Infrastructure
Technology Advancement

SWG

Water Management Research Business
from Ministry of Land, Infrastructure & Transport

『Intelligent Water Grid』
Research Project

May 28, 2015

National Smart Water Grid Research Group
Dr. Hosun LEE, Eunseul Hong
hilhs21@daum.net

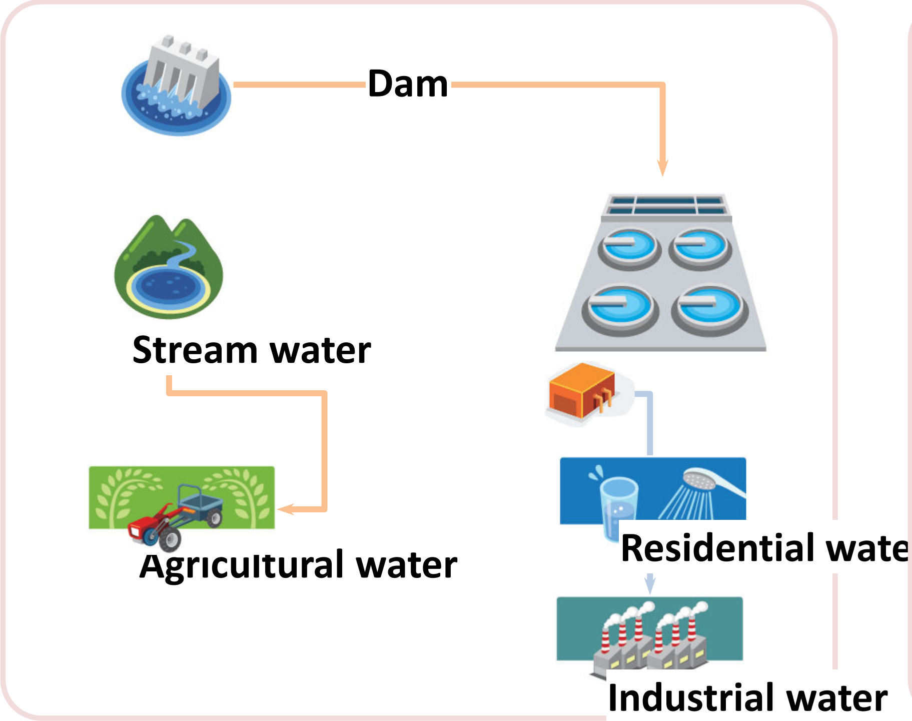
Contents

- Introduction
- SWG Research Project in Korea
- SWG Technologies
- Future Prospects

I. Introduction

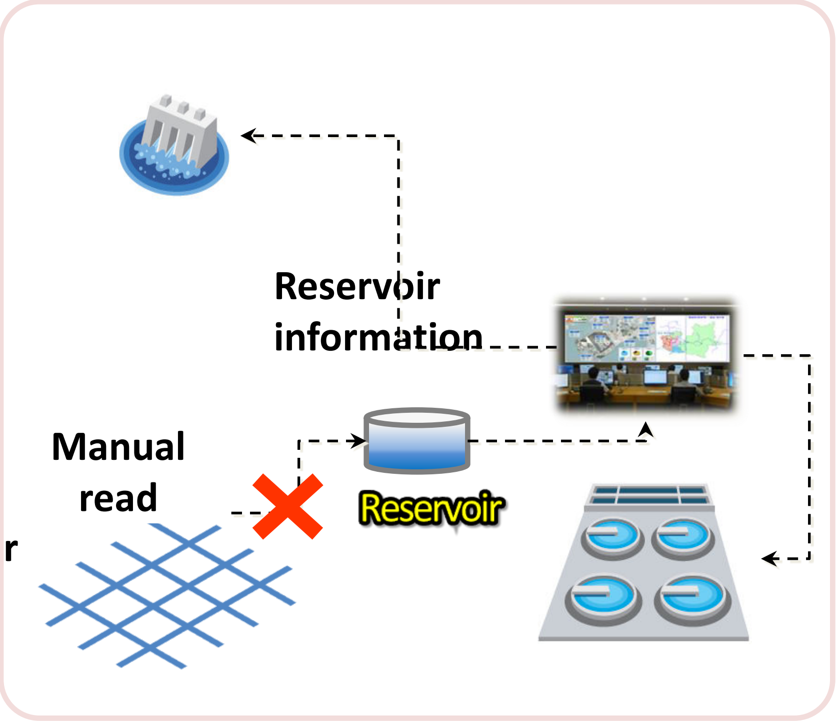
1. Introduction

Using single water source


Dam
Stream water
Agricultural water
Residential water
Industrial water

- Increase of transportation costs
- Unable to deal with emergencies

Simple, unidirectional monitoring


Reservoir information
Manual read
Reservoir

- Unable to deal with accidents in the water source
- Unable to deal with accidents in the pipes

How to Solve?

1. Introduction

“Smart” is the main keyword in the 21th century

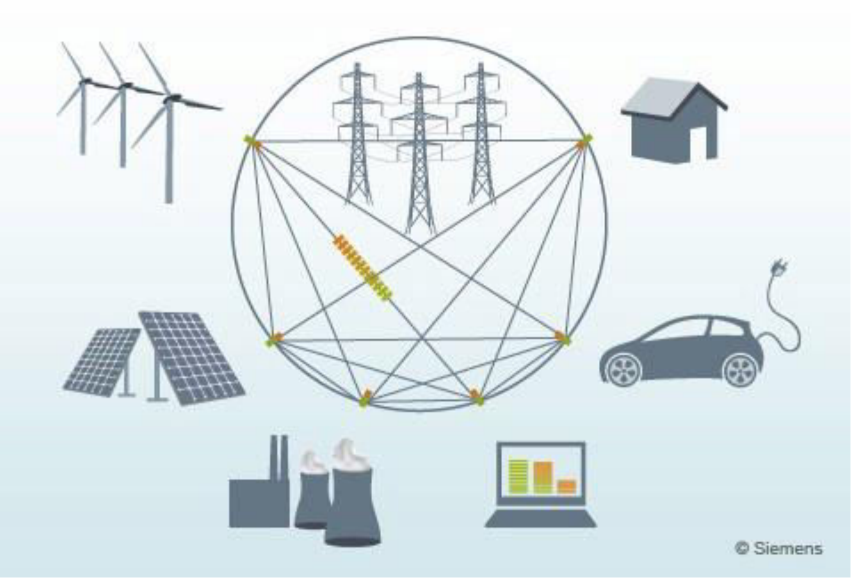
Smart Cities
Smart Technology
Smart Infrastructure
Smart Energy
Smart Mobility
Smart Buildings
Transparent Smart Window
World Map
Smart Windows
Smart Clouds
Smart Materials
Smart Bandages
Smart Factory
Smart Meters

Source: Frost & Sullivan

1. Introduction

Smart Grid = Electricity + ICT

"Smart Grid" is a modernized electrical grid that uses information and communications technology (ICT) to gather and act on information in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity[1].



The concept for "Smart Grid" has been developed to solve the energy crisis. But what about water crisis?

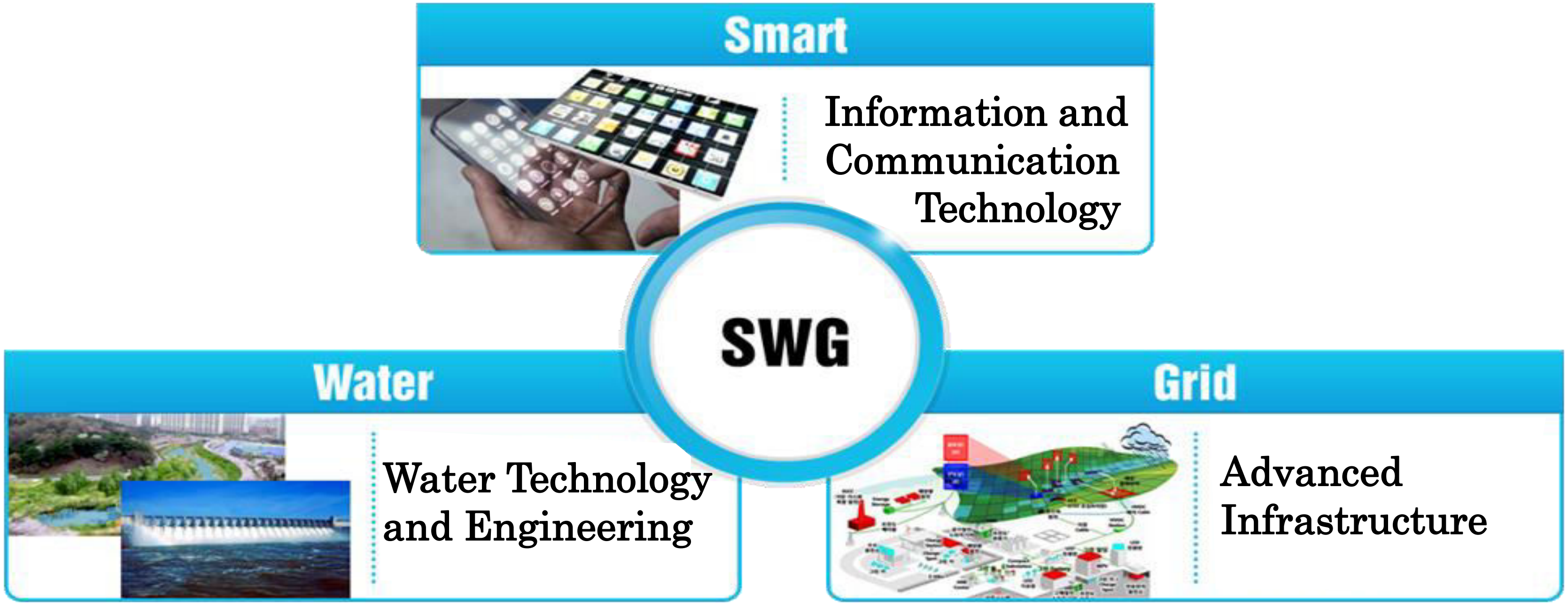
---

[1] U.S. Department of Energy. "Smart Grid / Department of Energy", 2012.

1. Introduction

Smart Water Grid = Water + ICT

"Smart Water Grid" is a new platform for intelligent and integrated water management. It allows high reliability, diversification of water sources, low energy consumption, and cost reduction.



Smart

Information and Communication Technology

SWG

Water

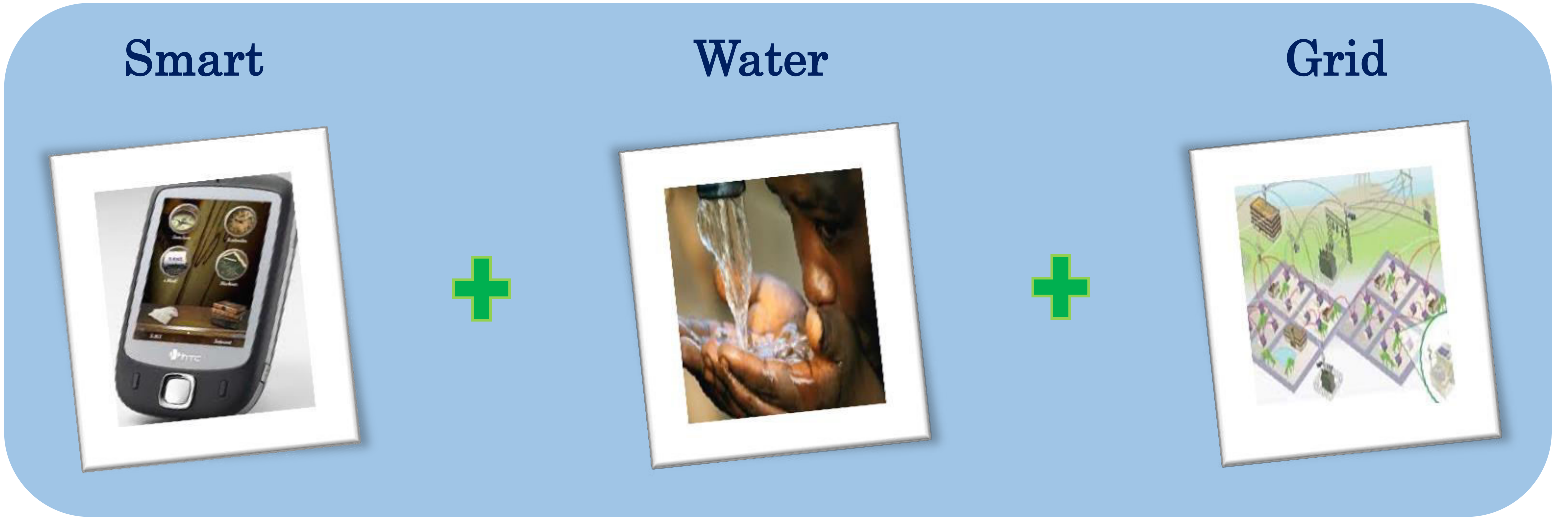
Water Technology and Engineering

Grid

Advanced Infrastructure

1. Introduction

Smart Water Grid Technologies



Smart

Water

Grid

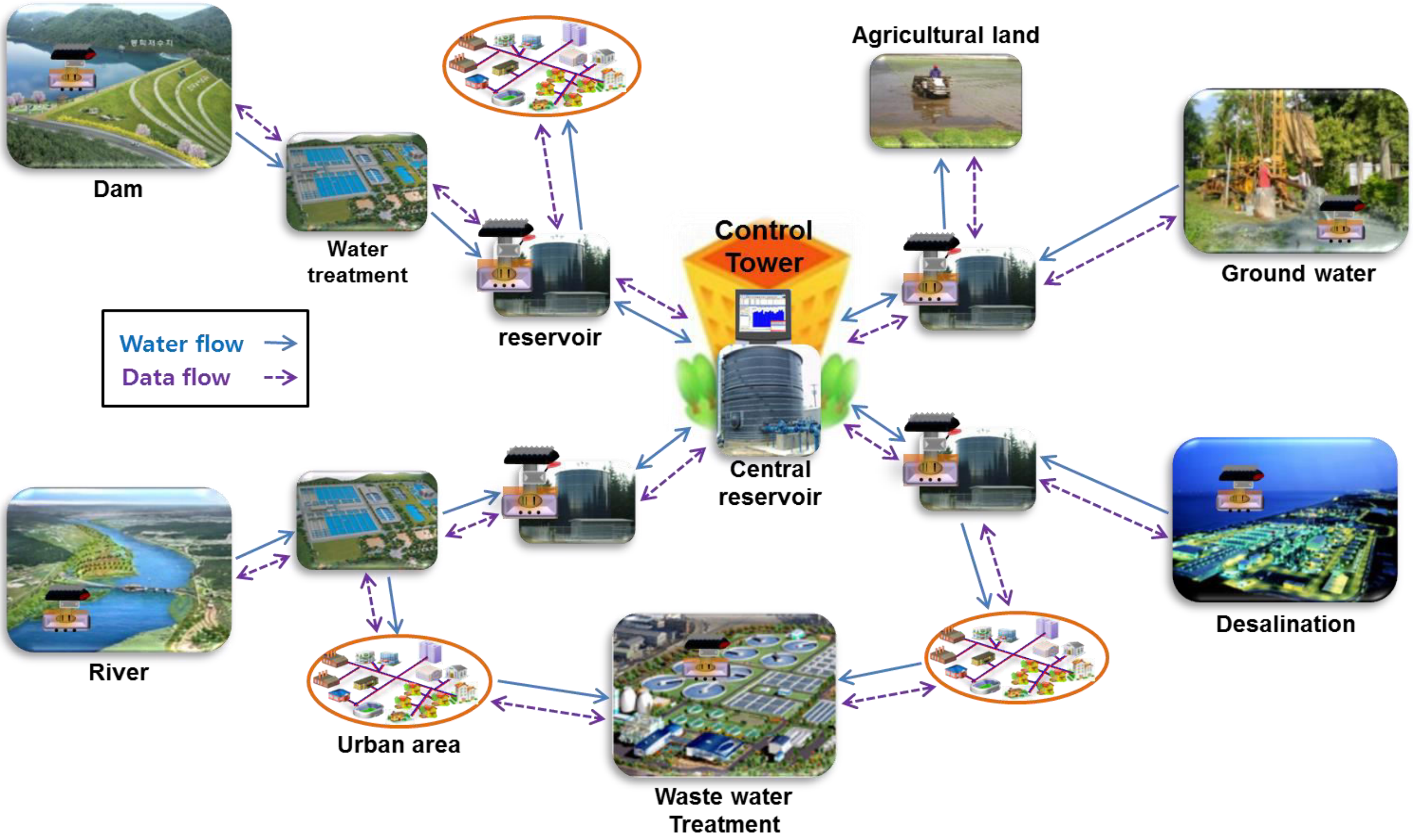
- IT Industry
  (Real-time monitoring)
- Utility optimization
- Basis of Smart Power Grid
- Demand estimation from bidirectional management
- Increase of energy efficiency

- Water Industry
  (Natural/Active water resources)
- Diversifying water resources
- Smart drinking water/waste/sewerage water management system

- Infrastructure Industry
  (Network for delivering source)
- Associated infrastructure with Smart green city
- Solution of basic infrastructure

1. Introduction

Smart Water Grid System


Dam
Water treatment
reservoir
Agricultural land
Ground water
Control Tower
Central reservoir
Water flow →
Data flow ⇢
River
Urban area
Waste water Treatment
Desalination

1. Introduction

Smart Water Grid: Why?

- Water management is increasingly influenced by development in Smart Technology.
- Many of the management system heavily rely on the management of large amounts of information and data.
- Smart water grid technologies can lead to a significant contribution in overcoming water management challenges in the 21st century

Smart Water Grid Pilot Plant in Bupyeong WT

1. Introduction

Smart Water Grid: Three Main Effects

Water Efficiency
Security
Welfare

- **Increased Efficiency and Reduced Cost**
- Water loss control, energy saving, automation
- Decrease in O&M costs
- **Stable and Safe Water Supply**
- Demand response (DR) for water
- Water supply under emergency situations
- **Water for people**
- Equally good public water service to everyone
- Open access to water information

1. Introduction

Smart Water Grid Pilot Plant in Bupyeong WT

Smart Water Grid:
What?

Smart water grid may include:

- ICT and disruptive technology
- GIS and Remote Sensing
- Smart Pipes, Smart metering
- Decision Support System
- 3D modeling of geospatial data
- Measuring water demand and supply
- Water footprint, efficient water use
- Climate adaptation

There are some **"missing links"** between available technologies and smart water grid

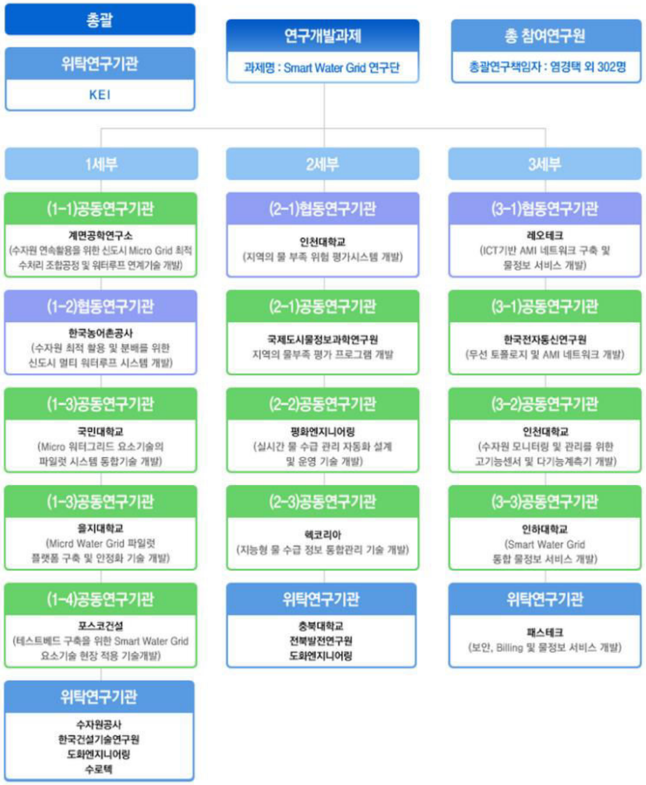
II. SWG Research Project in Korea

- 『Intelligent Water Grid』 Research Project

2. SWG Project

Smart Water Grid Research Group:
An Ambitious First Step Toward Innovative Water Management

The Smart Water Grid Research Program started on July 2012. The main organization is the Incheon National University and more than 50 organizations are involved in this project. The final goal of this project is to establish ICT-based water management infrastructure with high efficiency.


총괄
위탁연구기관
KEI
연구개발과제
과제명 : Smart Water Grid 연구단
총 참여연구원
총괄연구책임자 : 염경택 외 302명
1세부
2세부
3세부
(1-1)공동연구기관
계면공학연구소
(수자원 연속활용을 위한 신도시 Micro Grid 최적 수처리 조합공정 및 워터루프 연계기술 개발)
(1-2)협동연구기관
한국농어촌공사
(수자원 최적 활용 및 분배를 위한 신도시 멀티 워터루프 시스템 개발)
(1-3)공동연구기관
국민대학교
(Micro 워터그리드 요소기술의 파일럿 시스템 통합기술 개발)
(1-3)공동연구기관
을지대학교
(Micrd Water Grid 파일럿 플랫폼 구축 및 안정화 기술 개발)
(1-4)공동연구기관
포스코건설
(테스트베드 구축을 위한 Smart Water Grid 요소기술 현장 적용 기술개발)
위탁연구기관
수자원공사
한국건설기술연구원
도화엔지니어링
수로텍
(2-1)협동연구기관
인천대학교
(지역의 물 부족 위험 평가시스템 개발)
(2-1)공동연구기관
국제도시물정보과학연구원
지역의 물부족 평가 프로그램 개발
(2-2)공동연구기관
평화엔지니어링
(실시간 물 수급 관리 자동화 설계 및 운영 기술 개발)
(2-3)공동연구기관
헥코리아
(지능형 물 수급 정보 통합관리 기술 개발)
위탁연구기관
충북대학교
전북발전연구원
도화엔지니어링
(3-1)협동연구기관
레오테크
(ICT기반 AMI 네트워크 구축 및 물정보 서비스 개발)
(3-1)공동연구기관
한국전자통신연구원
(무선 토폴로지 및 AMI 네트워크 개발)
(3-2)공동연구기관
인천대학교
(수자원 모니터링 및 관리를 위한 고기능센서 및 다기능계측기 개발)
(3-3)공동연구기관
인하대학교
(Smart Water Grid 통합 물정보 서비스 개발)
위탁연구기관
패스테크
(보안, Billing 및 물정보 서비스 개발)

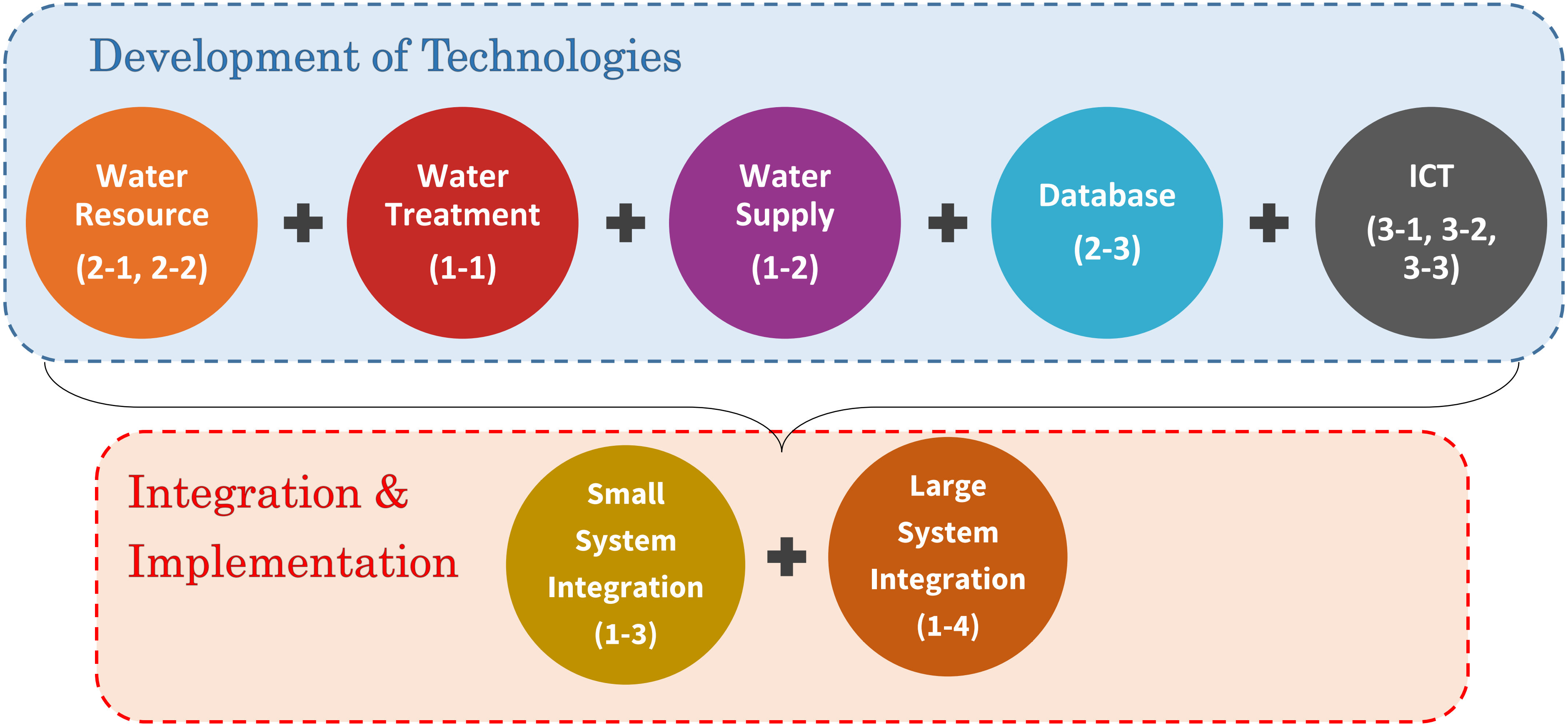
2. SWG Project

Research Overview

Sub-project 1 Water Supply	
1-1	Micro-grid based **Water Treatment** and Water-loop Application Technology for Sustainable Multiple Water Resources Utilization in New To
1-2	Development of **Multi Water-loop** System for Optimal Water Resources Utilization and Allocation
1-3	Development of Stabilization Technology and **Pilot Platform** for Micro Water Grid
1-4	**Designing** Technology for Smart Water Grid for **Test Bed**
Sub-project 2 Water Resources	
2-1	Development of **Water Shortage Risk Evaluation** System
2-2	Development of Technology for **Automated Real Time** Water Supply Design and Operation
2-3	Smart and **Integrated Management** Technology for Water Supply Information
Sub-project 3 ICT	
2-1	Establishment of ICT based **AMI Network** and Water Information Service
2-2	Development of High-Tech **Sensors** and Smart Multi-functional Measuring Instrument for Water Resources Monitoring and Management
2-3	Development of **Modeling/Simulation** based Optimized DSS

2. SWG Project

Develop, Integrate, and Implement



Development of Technologies

Water Resource (2-1, 2-2) + **Water Treatment (1-1)** + **Water Supply (1-2)** + **Database (2-3)** + **ICT (3-1, 3-2, 3-3)**

Integration & Implementation

Small System Integration (1-3) + **Large System Integration (1-4)**

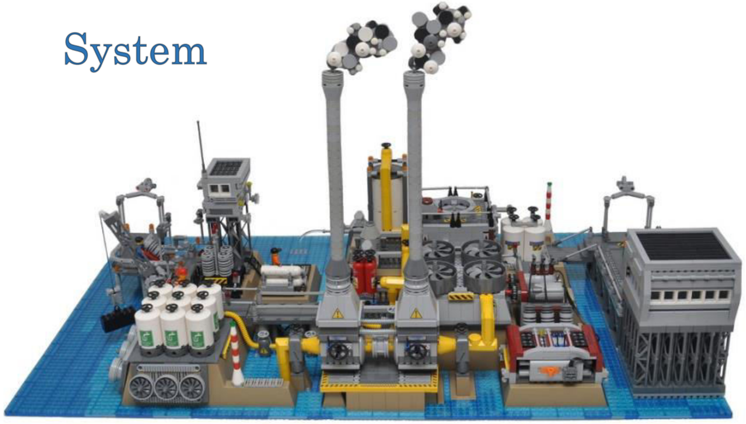
2. SWG Project

SWG Technologies:
Innovations in water management

There are a lot of innovative technologies that enable SWG: water treatment for multi-source water; multi-water loop; intelligent and integrated water resource management; smart water meter; advanced metering infrastructure; real time collaboration platform; and smart water simulation.

From now on, you will see a few examples of such technologies.

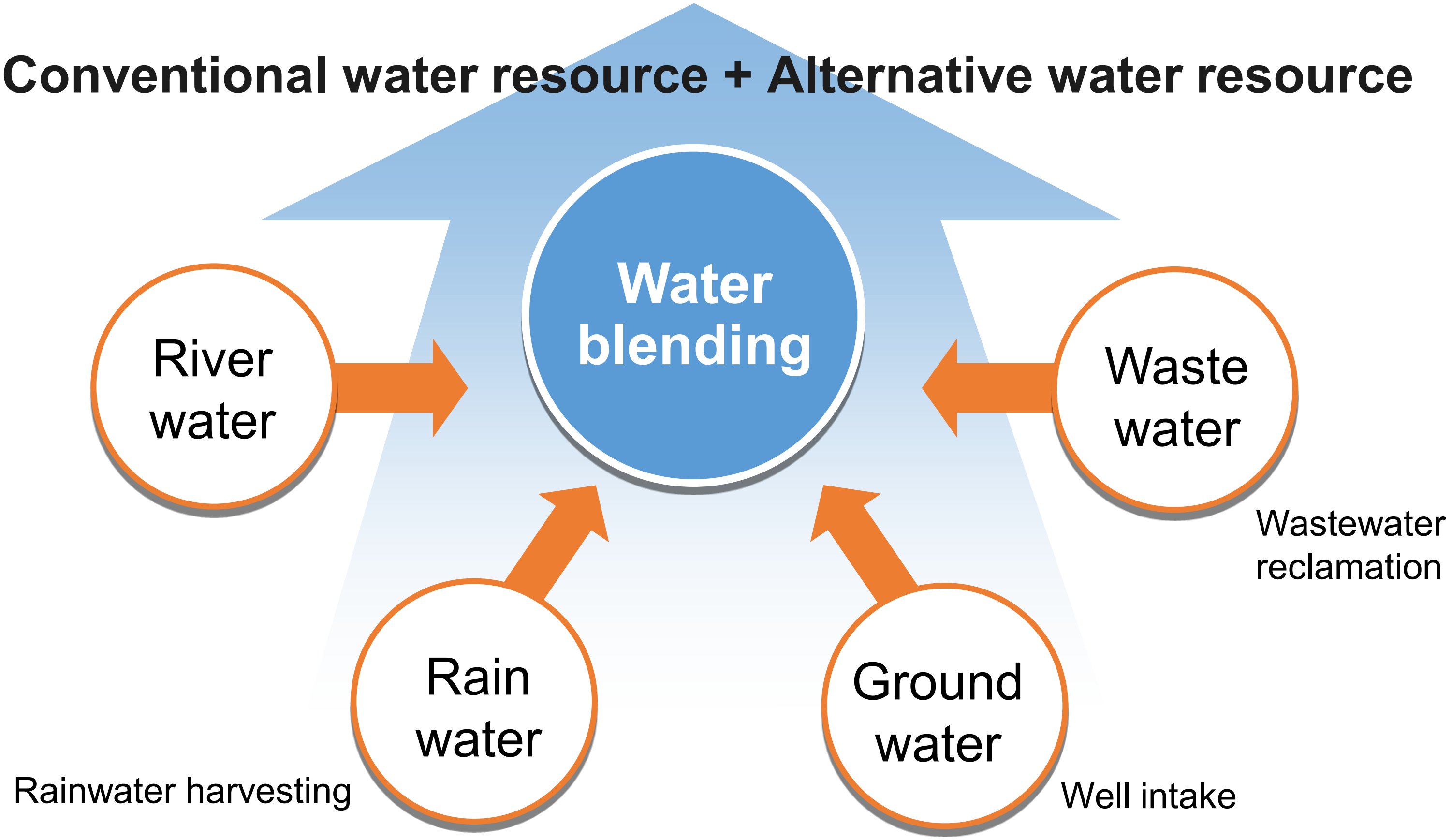
System



Technologies

III. SWG Technologies

Smart Water Treatment (1-1): Use of various water resources for various purposes



Conventional water resource + Alternative water resource

Water blending

River water

Waste water

Wastewater reclamation

Rain water

Rainwater harvesting

Ground water

Well intake

Smart Water Treatment (1-1) : The Pilot Plant

This is the first pilot plant that has various water treatment combinations using multi-source water.

Smart Water Grid 연구단 Pilot-Plant

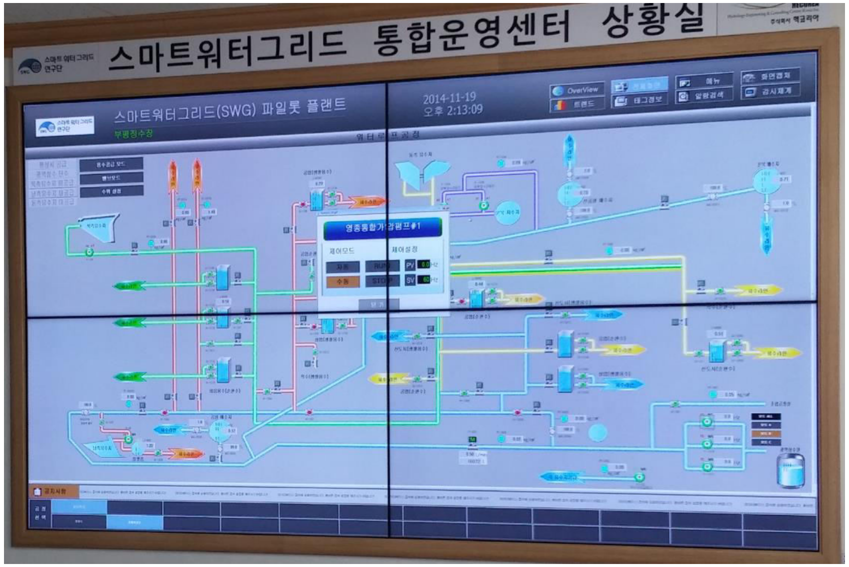
Smart Water Treatment (1-1) : Water Treatment

River water and groundwater are used as the source water for the water treatment system. Novel unit processes such as a microbubble system are also considered.

SM AOP SYSTEM
마이크로오존버블(MOB)을 이용한 고도정수처리 시스템
오존 버블 처리
활성탄 자동재생 수처리 여과기

Smart Water Treatment (1-2) : Wastewater Reclamation

Together with collected rainwater, wastewater effluent from secondary treatment is used as the source water. The treated water is intended to be used for industrial purposes.


스마트워터그리드 통합운영센터 상황실
스마트워터그리드(SWG) 파일롯 플랜트
2014-11-19
오후 2:13:09

Smart Water Treatment (1-2) : Desalination

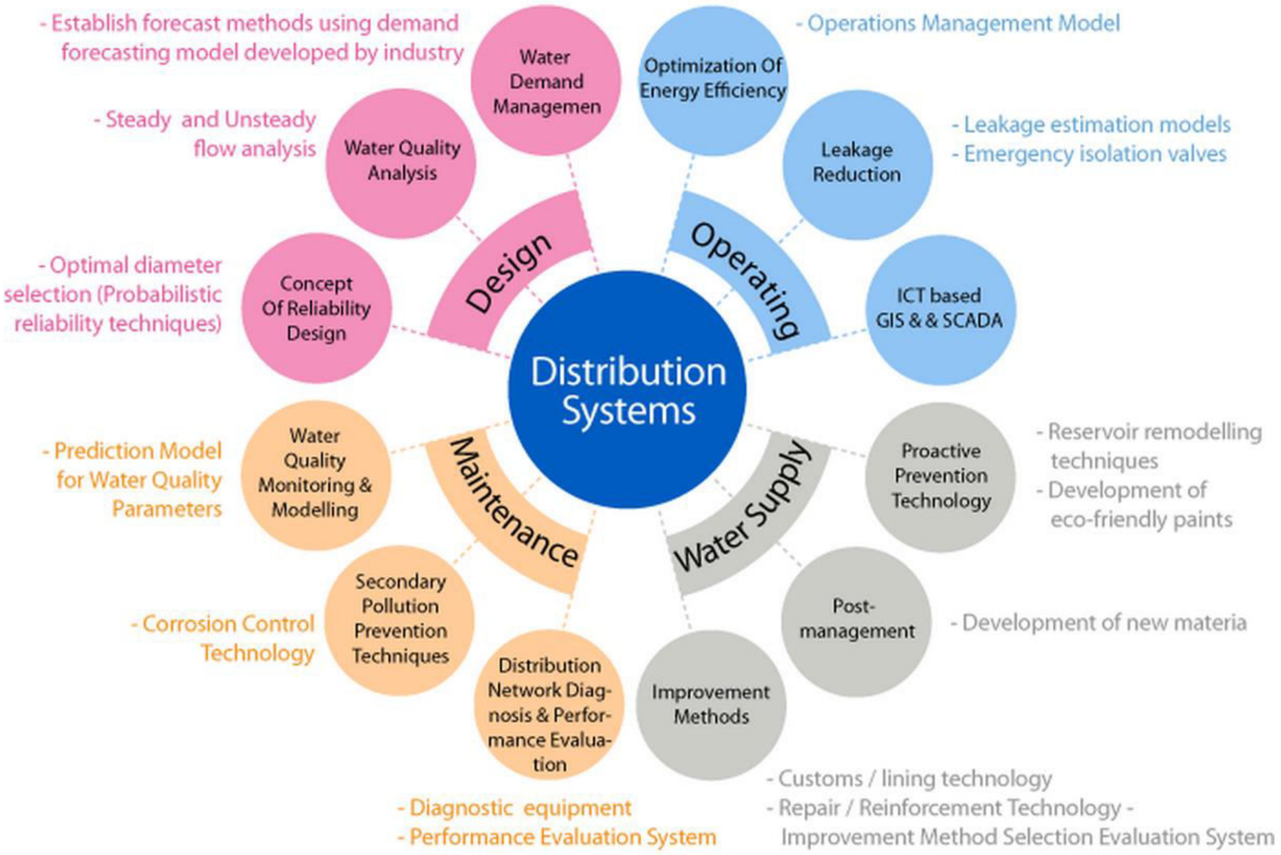
In this desalination system, brackish water and seawater are used as the source water. A submerged flat-sheet membrane is adopted as the pretreatment for RO.

침지식 역세 평막을 이용한 하이브리드형 해수담수화 시스템
SWRO 막 여과

3. SWG Technologies

Multi-Water Loop (1-2)

Multi-water loop consists of conventional water distribution networks and reclaimed water distribution networks. It also has advanced features compared with conventional water network technologies



Distribution Systems

Design

- Establish forecast methods using demand forecasting model developed by industry

Water Demand Managemen

- Steady and Unsteady flow analysis

Water Quality Analysis

- Optimal diameter selection (Probabilistic reliability techniques)

Concept Of Reliability Design

Operating

- Operations Management Model

Optimization Of Energy Efficiency

- Leakage estimation models
- Emergency isolation valves

Leakage Reduction

ICT based GIS & & SCADA

Maintenance

- Prediction Model for Water Quality Parameters

Water Quality Monitoring & Modelling

- Corrosion Control Technology

Secondary Pollution Prevention Techniques

Distribution Network Diagnosis & Performance Evaluation

- Diagnostic equipment
- Performance Evaluation System

Water Supply

- Reservoir remodelling techniques
- Development of eco-friendly paints

Proactive Prevention Technology

- Development of new materia

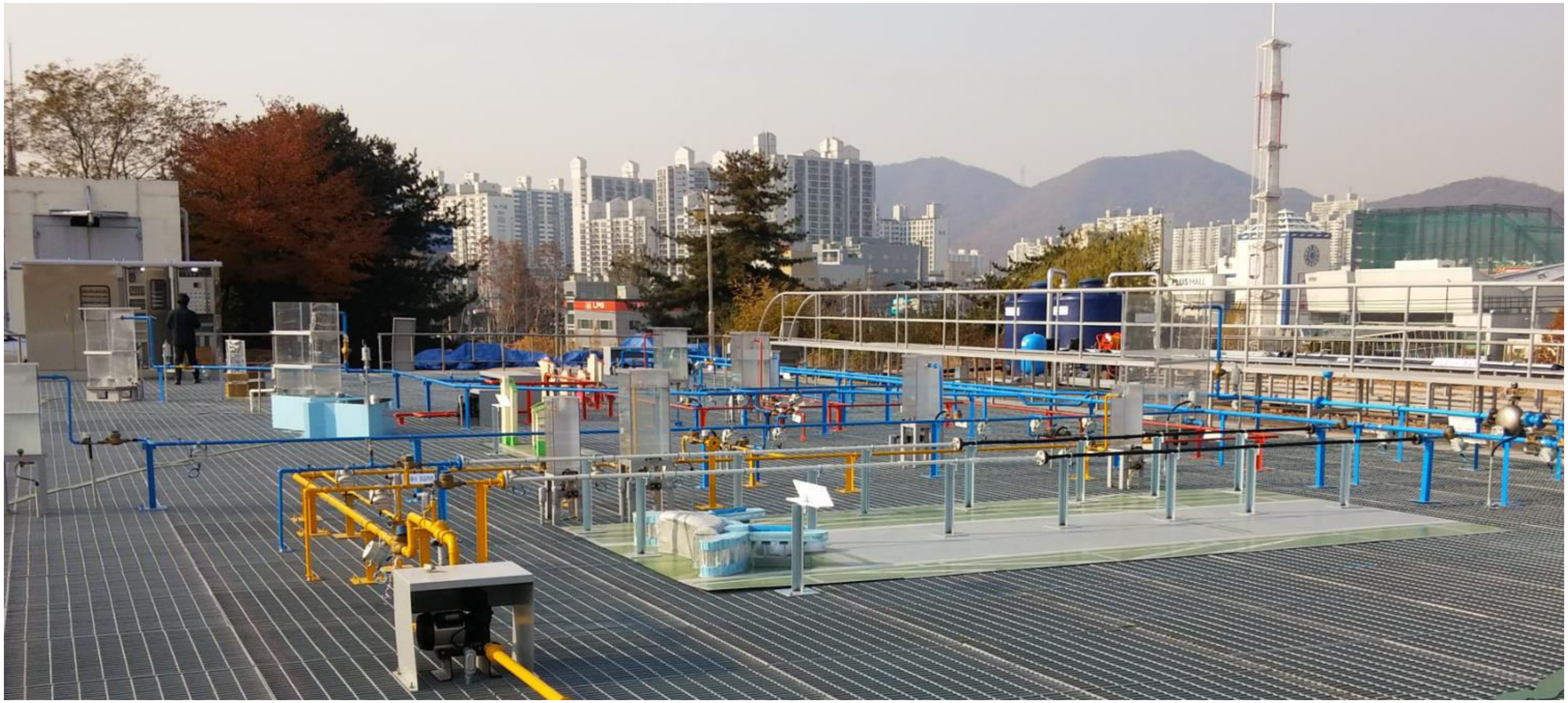
Post-management

Improvement Methods

- Customs / lining technology
- Repair / Reinforcement Technology - Improvement Method Selection Evaluation System

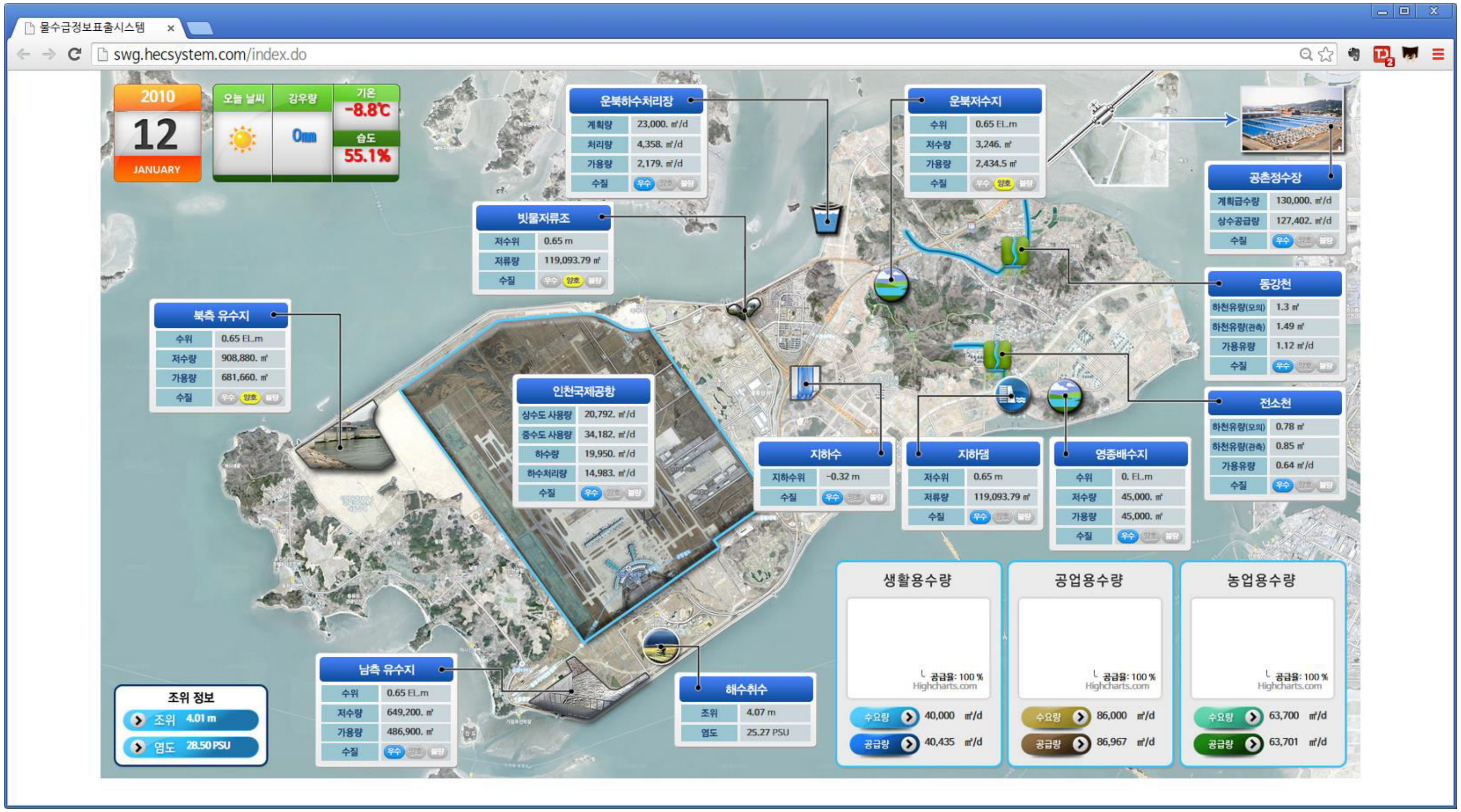
Multi-Water Loop (1-2) : Field Test System

Pilot-scale experiments for simulated multi-water are ongoing to determine key parameters to successful its design and operation in full-scale.



Water Resource Information System (2-1)

Water resource information system can visualize the real-time data from various sensors and devices, allowing the optimized use of various water resources.



물수급정보표출시스템

swg.hecsystem.com/index.do

2010
12
JANUARY

오늘 날씨	강우량	기온	습도
☀	0㎜	-8.8℃	55.1%

운북하수처리장

계획량	23,000. ㎥/d
처리량	4,358. ㎥/d
가용량	2,179. ㎥/d
수질	[✓ 우수] 양호 불량

운북저수지

수위	0.65 EL.m
저수량	3,246. ㎥
가용량	2,434.5 ㎥
수질	우수 [✓ 양호] 불량

공촌정수장

계획급수량	130,000. ㎥/d
상수공급량	127,402. ㎥/d
수질	[✓ 우수] 양호 불량

빗물저류조

저수위	0.65 m
저류량	119,093.79 ㎥
수질	우수 [✓ 양호] 불량

동강천

하천유량(모의)	1.3 ㎥
하천유량(관측)	1.49 ㎥
가용유량	1.12 ㎥/d
수질	[✓ 우수] 양호 불량

북측 유수지

수위	0.65 EL.m
저수량	908,880. ㎥
가용량	681,660. ㎥
수질	우수 [✓ 양호] 불량

인천국제공항

상수도 사용량	20,792. ㎥/d
중수도 사용량	34,182. ㎥/d
하수량	19,950. ㎥/d
하수처리량	14,983. ㎥/d
수질	[✓ 우수] 양호 불량

전소천

하천유량(모의)	0.78 ㎥
하천유량(관측)	0.85 ㎥
가용유량	0.64 ㎥/d
수질	[✓ 우수] 양호 불량

지하수

지하수위	-0.32 m
수질	[✓ 우수] 양호 불량

지하댐

저수위	0.65 m
저류량	119,093.79 ㎥
수질	[✓ 우수] 양호 불량

영종배수지

수위	0. EL.m
저수량	45,000. ㎥
가용량	45,000. ㎥
수질	[✓ 우수] 양호 불량

남측 유수지

수위	0.65 EL.m
저수량	649,200. ㎥
가용량	486,900. ㎥
수질	[✓ 우수] 양호 불량

해수취수

조위	4.07 m
염도	25.27 PSU

조위 정보

조위 4.01 m
염도 28.50 PSU

	생활용수량	공업용수량	농업용수량
공급율	100 %	100 %	100 %
수요량	40,000 ㎥/d	86,000 ㎥/d	63,700 ㎥/d
공급량	40,435 ㎥/d	86,967 ㎥/d	63,701 ㎥/d

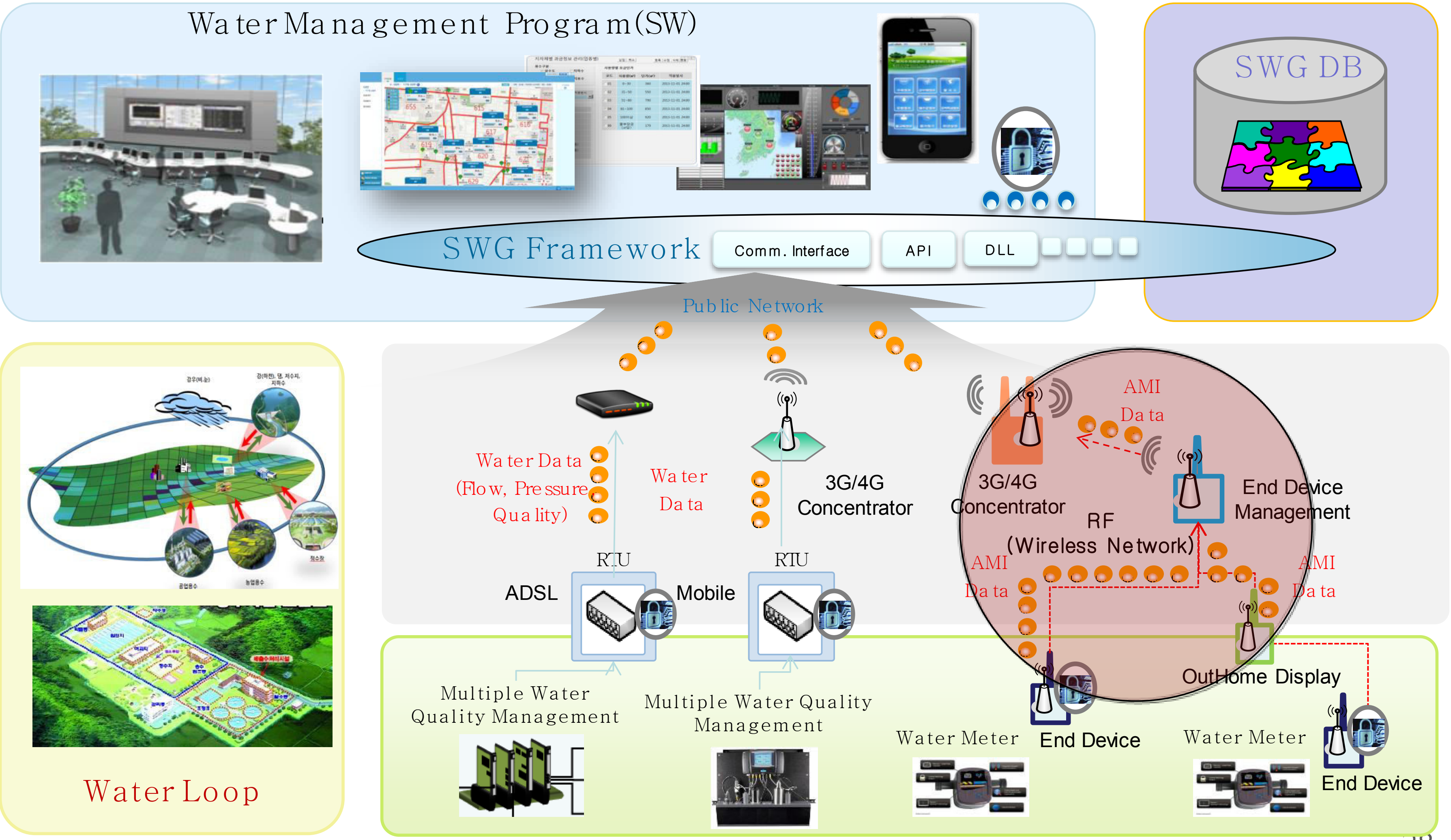
3. SWG Technologies

AMI (3-1)

A smart water meter is usually an electronic device that records consumption of water in intervals of an hour or less and communicates that information for monitoring and billing purposes. An advanced metering infrastructure (AMI) containing smart water meters enables two-way communications with the meter.

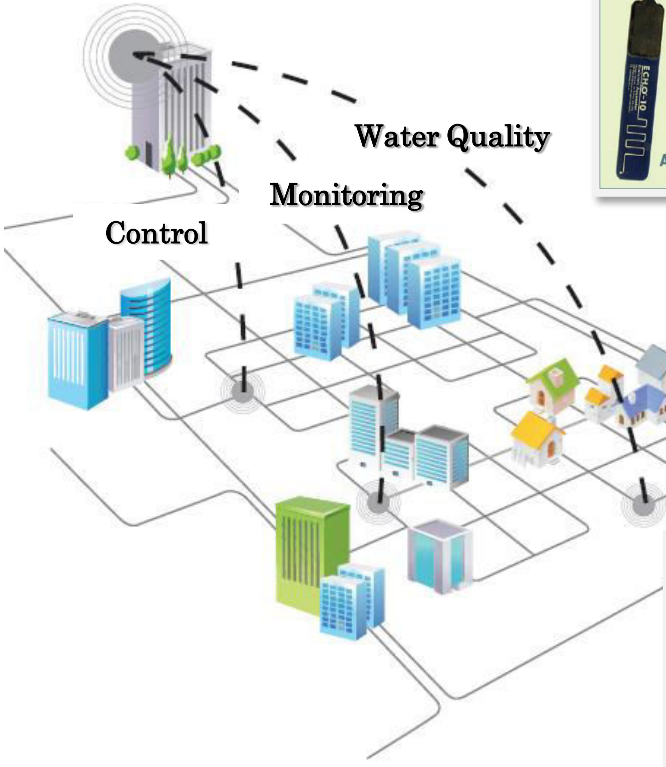
CUBEE PROBE
www.leotek.co.kr
Network Concentrator
CUBEE AMI System
LEOTEK Co.,Ltd
www.leotek.co.kr

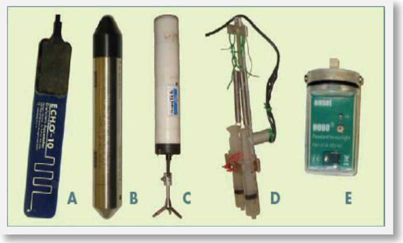
AMI (3-1) : Advanced Metering Infrastructure


Water Management Program(SW)
SWG DB
SWG Framework
Comm. Interface
API
DLL
Public Network
Water Data
(Flow, Pressure
Quality)
Water
Data
3G/4G
Concentrator
3G/4G
Concentrator
AMI
Data
RF
(Wireless Network)
End Device
Management
AMI
Data
AMI
Data
RTU
RTU
ADSL
Mobile
OutHome Display
Multiple Water
Quality Management
Multiple Water Quality
Management
Water Meter
End Device
Water Meter
End Device
Water Loop

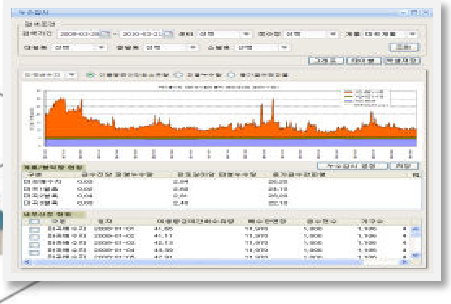
Smart Sensor Network (3-2)

The smart sensor network allows the continuous monitoring of water quality and quantity, leading to better management under various situations.


Water Quality
Monitoring
Control



Pipe Network
High-Tech Sensors



Automatic Detecting
And Real Time Data
Analysis System

Integrated Operation
System
(For Emergency)

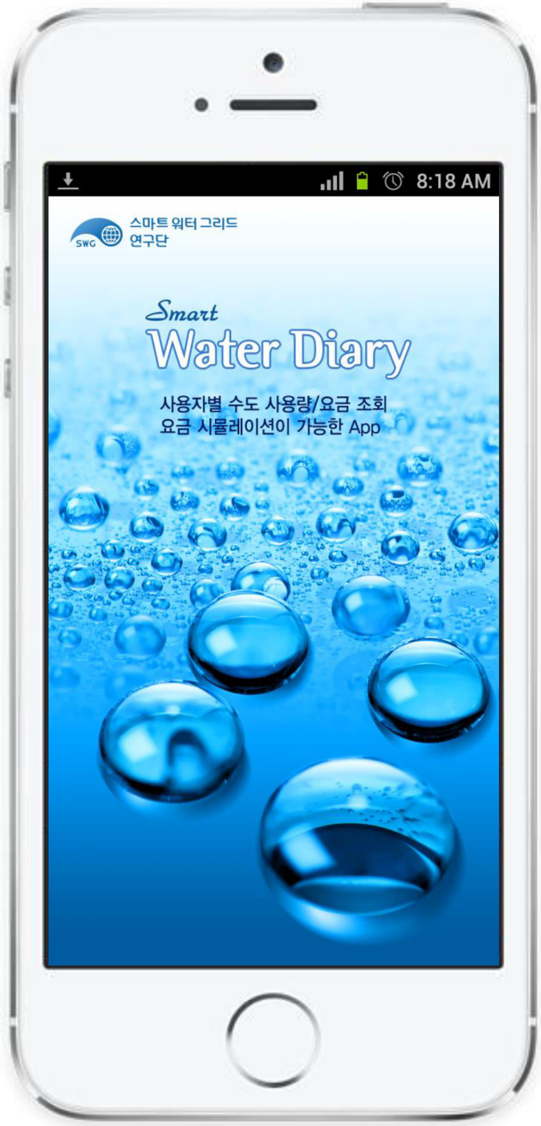
3. SWG Technologies

Smartphone Apps for Smart Water User (3-3)

Water management is increasingly influenced by development in Smart Technology.

Many of the management system heavily rely on the management of large amounts of information and data.

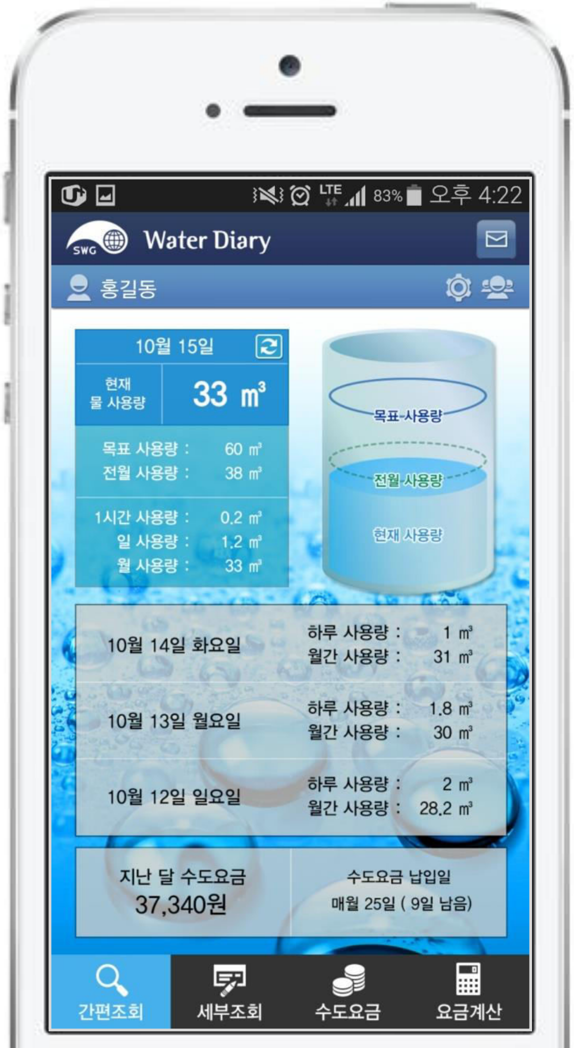
Smart water grid technologies can lead to a significant contribution in overcoming water management challenges in the 21st century



사용자별 수도 사용량/요금 조회
요금 시뮬레이션이 가능한 App

3. SWG Technologies

Main Menu


오후 4:22
Water Diary
홍길동
목표-사용량
전월 사용량
현재 사용량
간편조회
세부조회
수도요금
요금계산

10월 15일

현재 물 사용량 33 ㎥

목표 사용량 : 60 ㎥
전월 사용량 : 38 ㎥

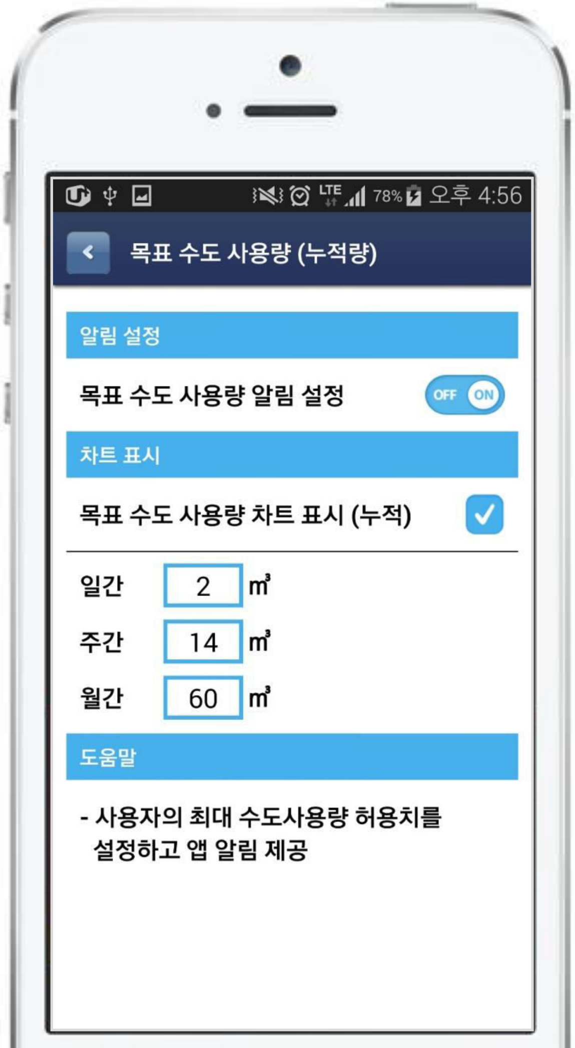
1시간 사용량 : 0.2 ㎥
일 사용량 : 1.2 ㎥
월 사용량 : 33 ㎥

10월 14일 화요일	하루 사용량 : 1 ㎥ 월간 사용량 : 31 ㎥
10월 13일 월요일	하루 사용량 : 1.8 ㎥ 월간 사용량 : 30 ㎥
10월 12일 일요일	하루 사용량 : 2 ㎥ 월간 사용량 : 28.2 ㎥

지난 달 수도요금 37,340원

수도요금 납입일 매월 25일 (9일 남음)

Setting Menu


오후 4:56
OFF ON

목표 수도 사용량 (누적량)

알림 설정

목표 수도 사용량 알림 설정 ON

차트 표시

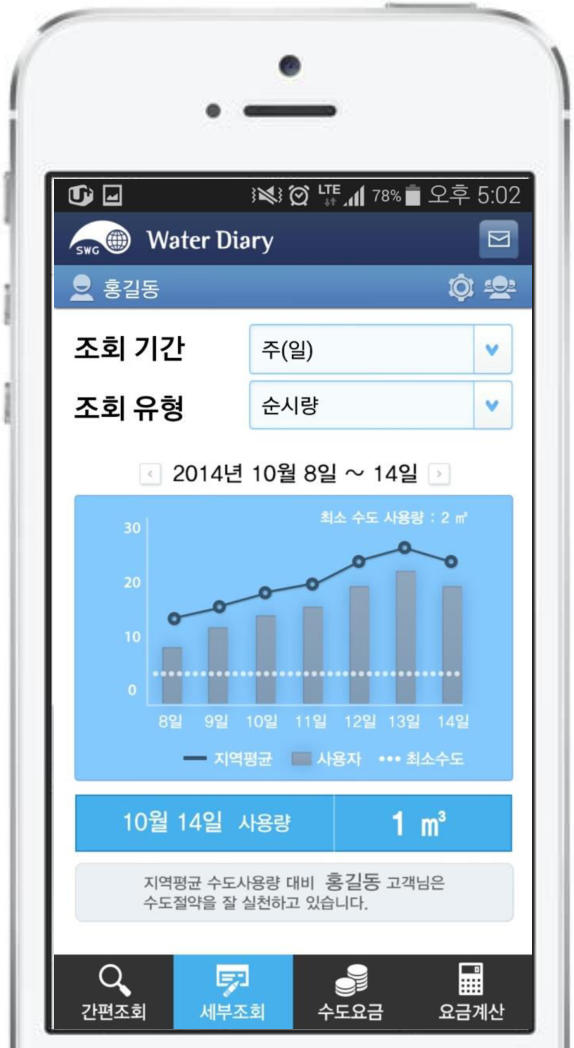
목표 수도 사용량 차트 표시 (누적) ☑

일간 2 ㎥
주간 14 ㎥
월간 60 ㎥

도움말

- 사용자의 최대 수도사용량 허용치를 설정하고 앱 알림 제공

Water Usage Report


오후 5:02
Water Diary
홍길동
최소 수도 사용량 : 2 ㎥
30
20
10
0
8일
9일
10일
11일
12일
13일
14일
지역평균
사용자
최소수도
간편조회
세부조회
수도요금
요금계산

조회 기간 주(일)

조회 유형 순시량

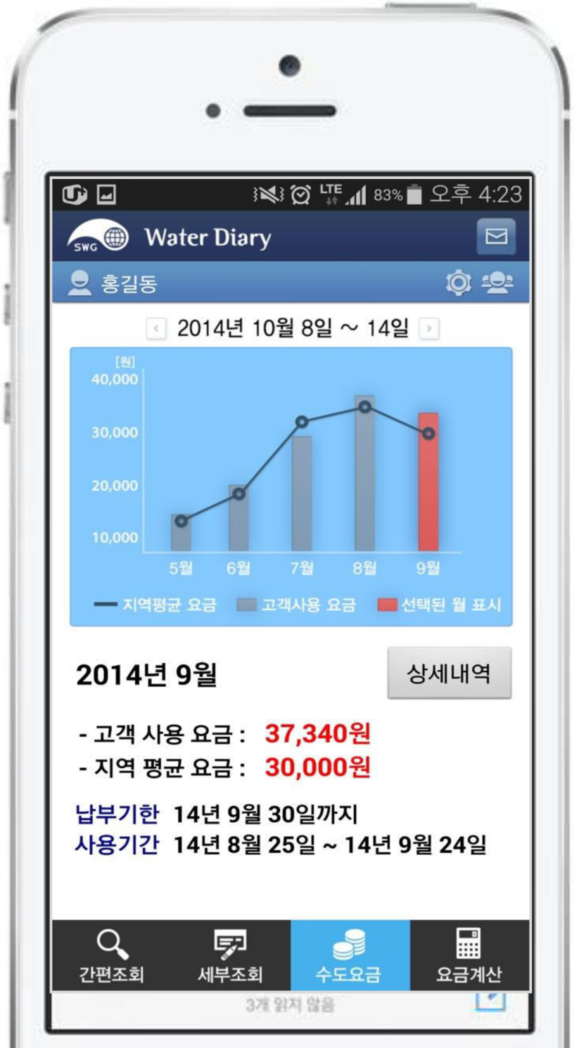
2014년 10월 8일 ~ 14일

10월 14일 사용량 1 ㎥

지역평균 수도사용량 대비 홍길동 고객님은 수도절약을 잘 실천하고 있습니다.

3. SWG Technologies

Water Tariff Report


오후 4:23
Water Diary
홍길동
[원]
40,000
30,000
20,000
10,000
5월
6월
7월
8월
9월
지역평균 요금
고객사용 요금
선택된 월 표시
상세내역
간편조회
세부조회
수도요금
요금계산
3개 읽지 않음

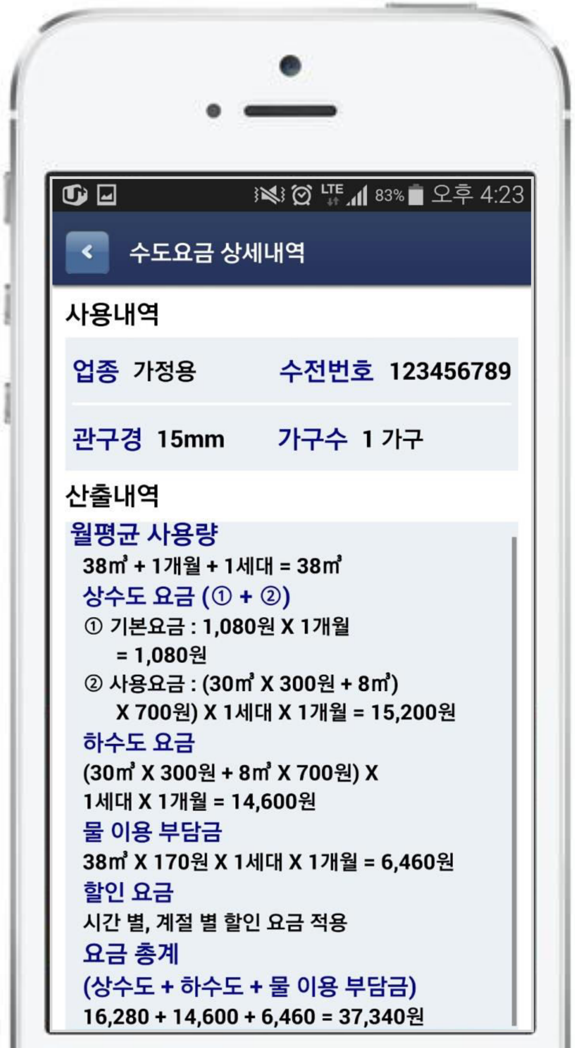
2014년 10월 8일 ~ 14일

2014년 9월

- 고객 사용 요금 : 37,340원
- 지역 평균 요금 : 30,000원

납부기한 14년 9월 30일까지
사용기간 14년 8월 25일 ~ 14년 9월 24일

Detailed Information


오후 4:23
수도요금 상세내역

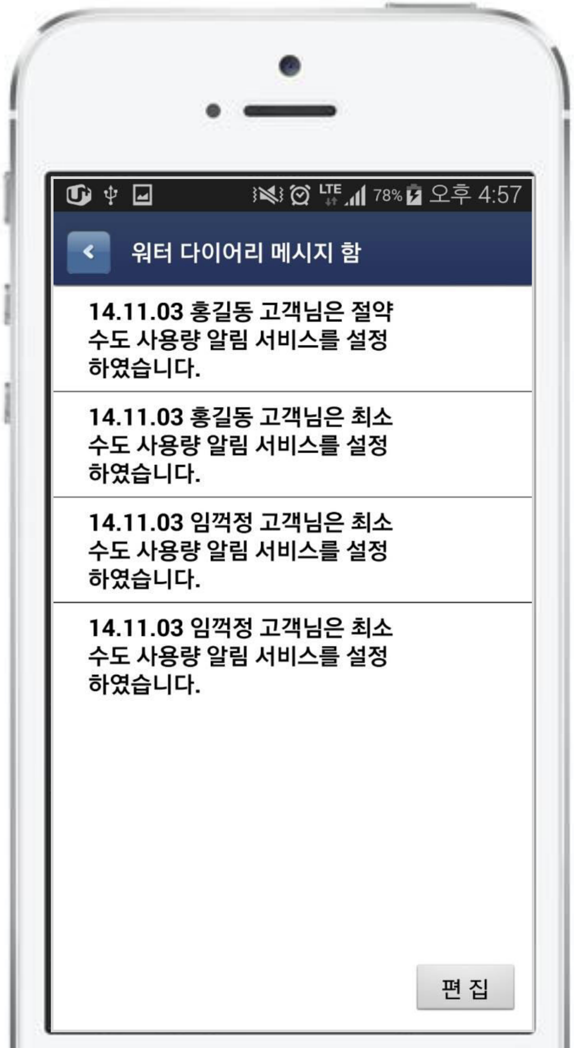
사용내역

업종 가정용 수전번호 123456789
관구경 15mm 가구수 1 가구

산출내역

월평균 사용량
38㎥ + 1개월 + 1세대 = 38㎥
상수도 요금 (① + ②)
① 기본요금 : 1,080원 X 1개월
= 1,080원
② 사용요금 : (30㎥ X 300원 + 8㎥)
X 700원) X 1세대 X 1개월 = 15,200원
하수도 요금
(30㎥ X 300원 + 8㎥ X 700원) X
1세대 X 1개월 = 14,600원
물 이용 부담금
38㎥ X 170원 X 1세대 X 1개월 = 6,460원
할인 요금
시간 별, 계절 별 할인 요금 적용
요금 총계
(상수도 + 하수도 + 물 이용 부담금)
16,280 + 14,600 + 6,460 = 37,340원

Alarm Menu


오후 4:57
워터 다이어리 메시지 함
편 집

14.11.03 홍길동 고객님은 절약 수도 사용량 알림 서비스를 설정 하였습니다.

14.11.03 홍길동 고객님은 최소 수도 사용량 알림 서비스를 설정 하였습니다.

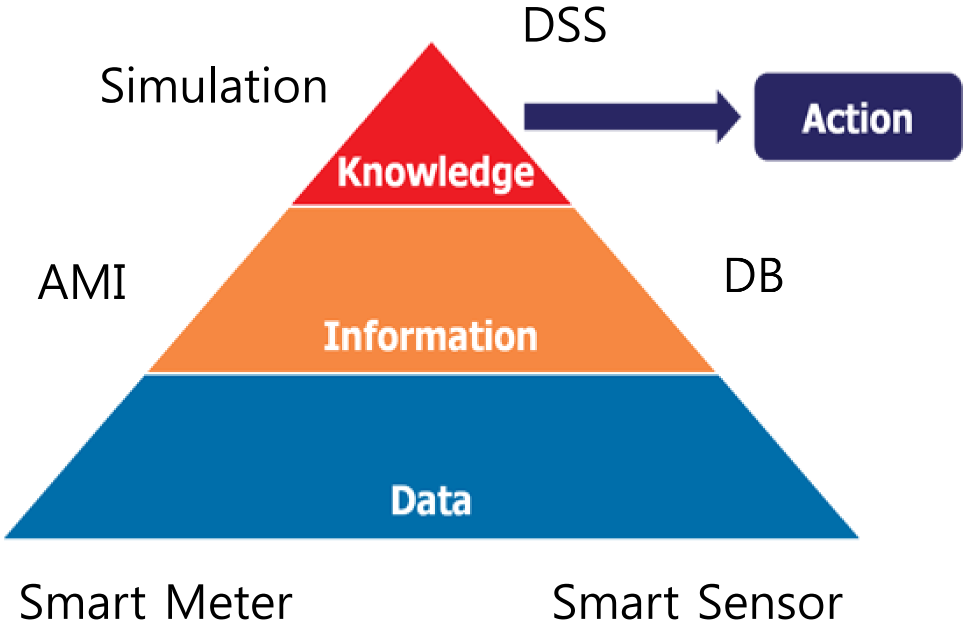
14.11.03 임꺽정 고객님은 최소 수도 사용량 알림 서비스를 설정 하였습니다.

14.11.03 임꺽정 고객님은 최소 수도 사용량 알림 서비스를 설정 하였습니다.

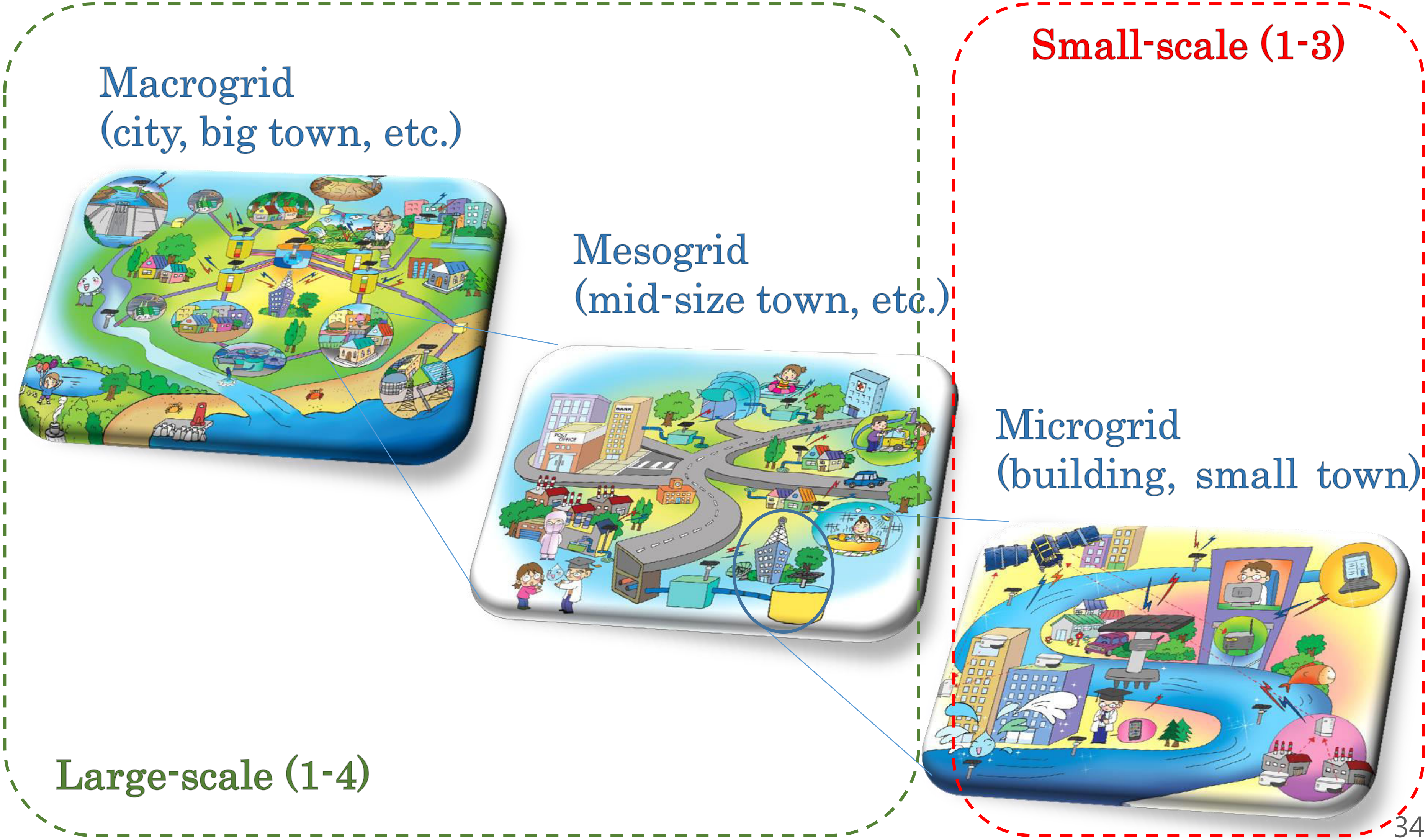
3. SWG Technologies

Water Decision Support System

A Decision Support System (DSS) is a computer-based information system that supports business or organizational decision-making activities. The water DSS serves the design, management, and operations of water infrastructures. and help to make decisions.


DSS
Simulation
Knowledge
Action
AMI
DB
Information
Data
Smart Meter
Smart Sensor

Smart Water Grid in Different Scales



Small-scale (1-3)

Macrogrid
(city, big town, etc.)

Mesogrid
(mid-size town, etc.)

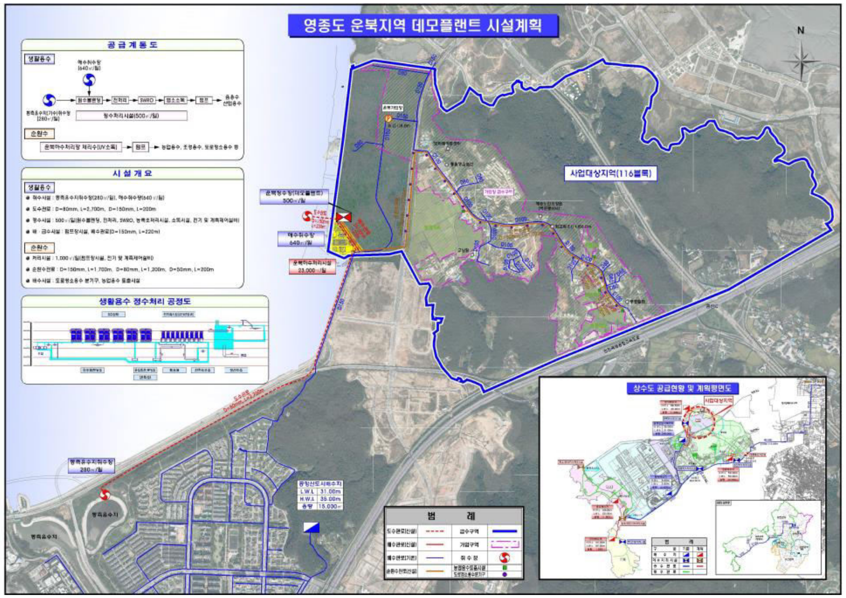
Microgrid
(building, small town)

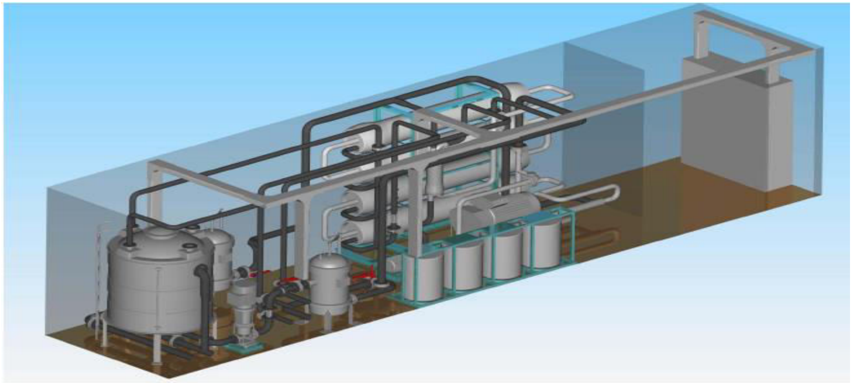
Large-scale (1-4)

3. SWG Technologies

Design, Development, and Operation of Demo Plant (1-3)

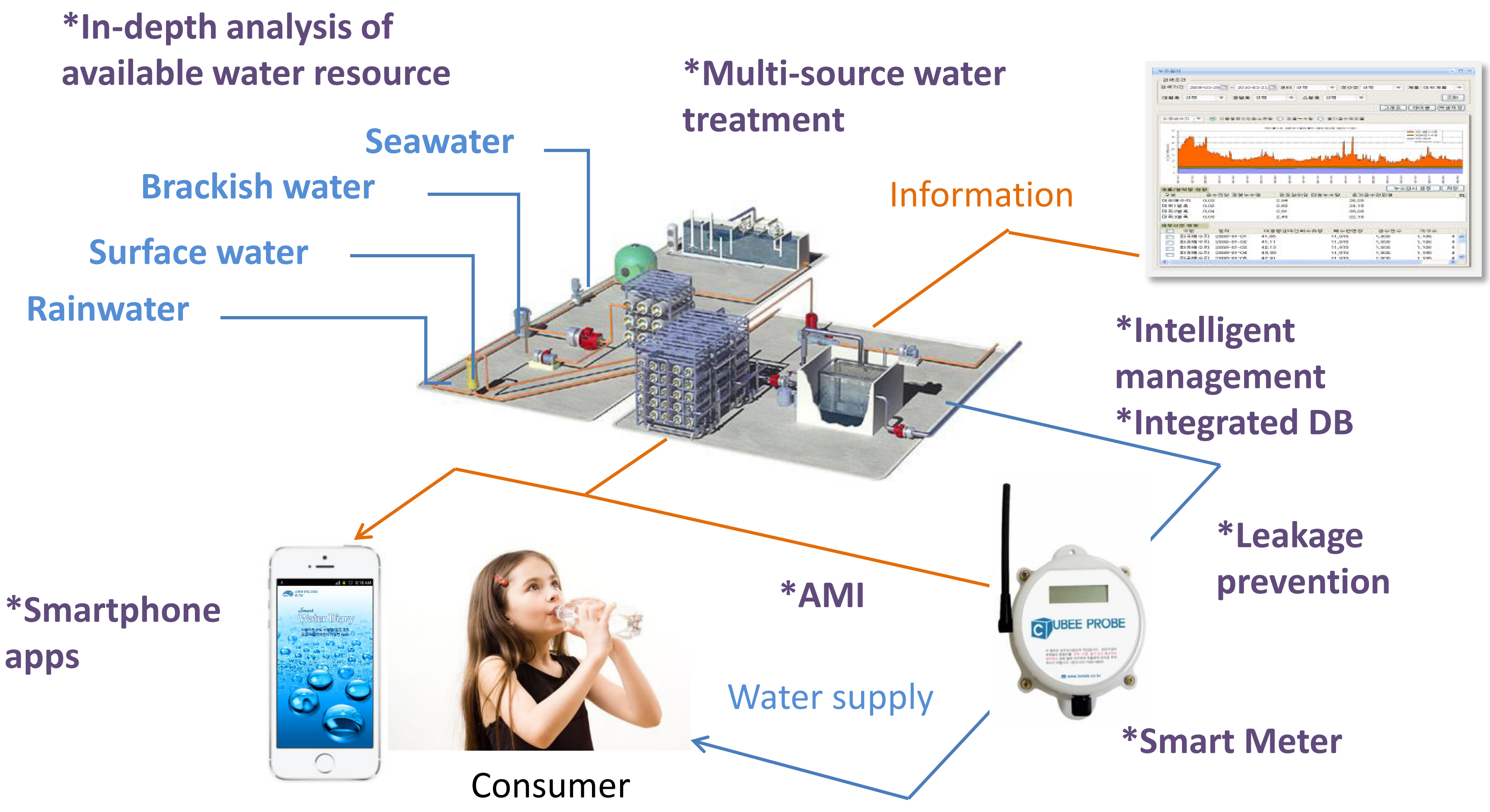
A demo plant is a system for evaluating the TRLs of the technologies. It will provide a platform for system integration and performance evaluation. Moreover, the demo plant will be a “reference” for small-scale smart water grid systems.


영종도 운북지역 데모플랜트 시설계획
공 급 계 통 도
시 설 개 요
생활용수 정수처리 공정도
사업대상지역(116블록)
상수도 공급현황 및 계획평면도
범 례
N



3. SWG Technologies

Type 1 : SWG System focused on water treatment



*In-depth analysis of available water resource

Seawater

Brackish water

Surface water

Rainwater

*Multi-source water treatment

Information

*Intelligent management

*Integrated DB

*Leakage prevention

*AMI

*Smart Meter

Water supply

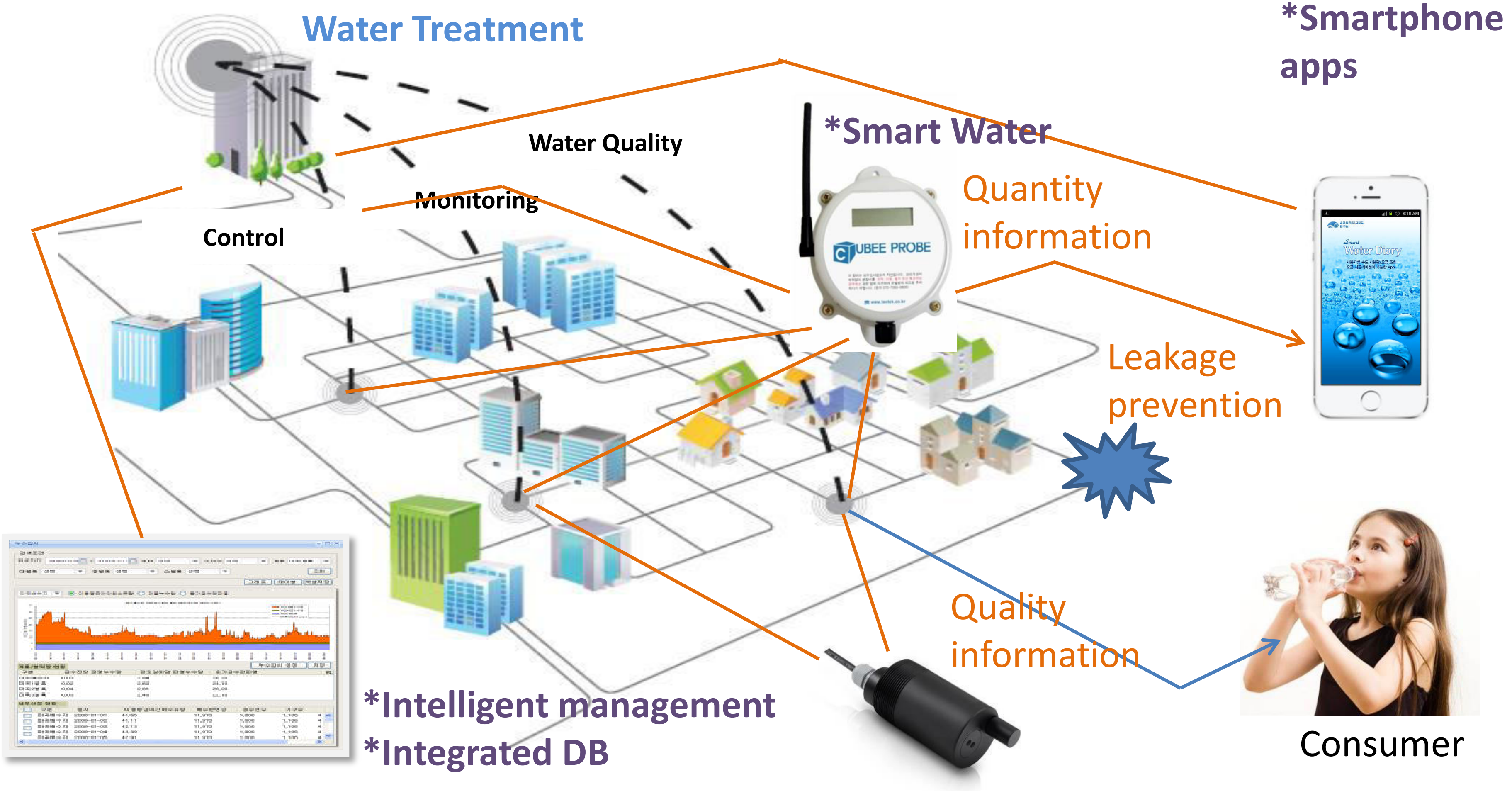
*Smartphone apps

Consumer

* SWG technologies

3. SWG Technologies

Type 2 : SWG System focused on water service



Water Treatment

Water Quality

Monitoring

Control

*Smartphone apps

*Smart Water

Quantity information

Leakage prevention

Quality information

Consumer

*Intelligent management
*Integrated DB

*Smart sensor

* SWG technologies

Design of Test Bed System (1-4)

A test bed is a platform for experimentation of large development projects. As one of the final results of the smart water grid research, test bed systems are designed to provide essential information for practical implementation of smart water grid system.

Saemangeum

Yeongjongdo

Test Bed System (1-4): Expected Effects

Water Efficiency
Security
Welfare

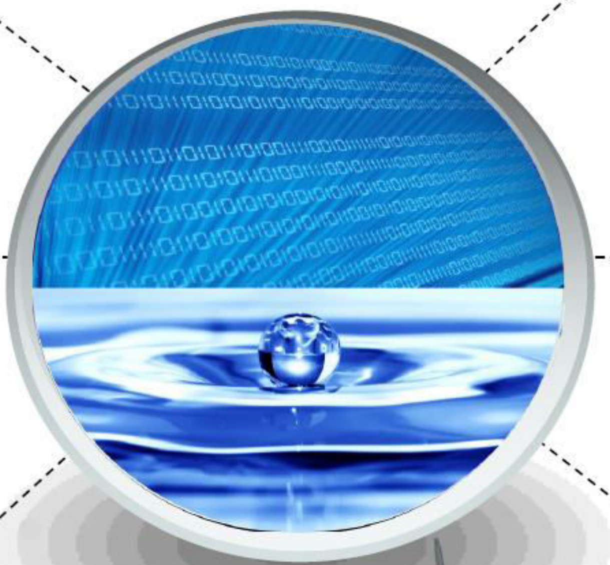
- **Cost reduction by 10 billon won**
- **Decentralized water supply up to 50%**
- **Increase in Customer Satisfaction Index by 20 %**

Total cost (1,000 million won)

Const. **O&M**

IV. Future

Applications of Smart Water Grid



Source: greatlakes.org

Smart Combined Sewer Overflows

Smart Irrigation and Agriculture

Source: agreenstarlandscape.com

Source: organo.co.jp

Smart Ultrapure Water

Smart Wastewater Management

Source: usa.siemens.com

Source: treehugger.com

Smart Water Supply Management

Source: precisionmeters.co.za

Smart Water Distribution Management

Source: Google Images

Expected Benefits of Smart Water Grid

Solution for Major Water Issues including:

Water Quantity

Water Security

Water Quality

Water Safety

Water Tariff

Smart

Water

Grid

Water welfare
&
Waternomics

4. Future

Key Restraints against Smart Water Grid

- **Political**
  - -Low government push
  - -Unsustainable subsidies
- **Organisational**
  - -Business Case
  - -Integration
  - -Risk averse
  - -Silos
- **Market**
  - -Fractured / Consolidating
  - -Low turnkey opportunity
- **Technological**
  - -Hardware v Software
  - -Simplification
  - -Integration
  - -Longevity
  - -Proprietary v Open
- **Social**
  - -Privacy
  - -Health
  - -Buy in
  - -Low incentive

Source: Frost and Sullivan

4. Future

Technology Roadmap for Smart Water Grid

2012~2013

- Development of unit technologies

2014

- Pilot-scale implementation
- Development of advanced technologies

2015

- Demo-scale implementation
- Integration of technologies
- Basic design of test bed

2016 ~

- Operation of demo plant
- Development of packaged systems

Smart Water Grid: Future of Water

Smart water grid can make better future for our children by providing technologies for sustainable water resources.
There are infinite possibilities from combinations of water technologies and ICT.
Our "Smart Water Grid Research Group" will do our best to develop and implement the technologies.

THANK YOU