International Journal of Control and Automation
Vol. 7, No. 11 (2014), pp. 117-126
http://dx.doi.org/10.14257/ijca.2014.7.11.12

A Study on Type of Smart Water Grid Pipeline System (multi water-loop system) and Application Method

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Abstract

In these days, water-loop system using multi water resources is lively discussed. This system distributes water effectively by using multi water resources instead of new water resources development. Multi water resources consist of surface water, rainwater, reclaimed water, seawater etc. This system would be distributing sanitary water stably, and able to economical maintain the related facilities. Also, this system has an emergency reaction ability when system is faced with accident. Especially, if multi water loop system is constructed by using the city's securable water, nation's water resources will be utilized effectively and water resources will be developed or reused on a small scale. The neces elements of water-loop system design are suggested in this research. The elements are the followings; Model of connected water-loop pipe networks, platform model of multi water resources loop system, range of technology, difference with existing systems and direction of construction.

Keywords: Multi Water Resources; Water loop system; Smart water grid; ICT

1. Introduction

Nowadays, water resources utilization is increased due to the construction of New city or Innocity, but natural water resources such as dam, stream water from the waterworks system mainly. In water-stressed area, development of variable water resources like rainwater, reclaimed water, seawater and utilizing techniques are in progress actively to develop the water resources.

Although variable water resources are existing near the consumer, the current system of water resources utilization is hard to operate because connecting pipe network for water resources utilization are not constructed.

Generally, inner city waterworks system has increased the stress of water resources utilization. This problem caused by distant locality of dams. These dams are increasing the cost of network construction, operation energy of pumping station and WTP. Instead of water resources development at a long distance, system that can utilize the unused water resources such as reclaimed water, rainwater etc. is constructed, water resources of a small scale can be developed without new water development.

If supply system of small scale is constructed, costs of water resources development can be reduced because intraregional unused water resources of can be utilized. But, water resources development and supply network construction technology using intraregional unused water resources are not completely researched yet. Therefore, system that can effectively utilize the intraregional

ISSN: 2005-4297 IJCA
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unused water resources is constructed, self-reliance ability of water resources will be enhanced.

To improve the self-reliance ability of water resources, it needs a development of multi water loop system. Multi water loop system secures variable water resources and is able to utilize them for optimal utilization/distribution of water resources. To achieve this, some researches such as development of water-loop and maintenance system, standardization technology development, economic analysis, feasibility study etc. have to be carried out in parallel.

2. Construction Method of Multi Water-Loop System

2.1. Definition and Necessity

Multi water-loop system would be distributing sanitary water stably, and able to economical maintain the related facilities. Also, this system has an emergency reaction ability when system is faced with accident. The differences from existing water distribution system are the followings; ① Consideration of multi water resources(classify the potable and non-potable), ② Storage function of raw water and treated water, ③ Connection of waterworks in the basin unit, ④ Mutual exchange of water-related data between each system.

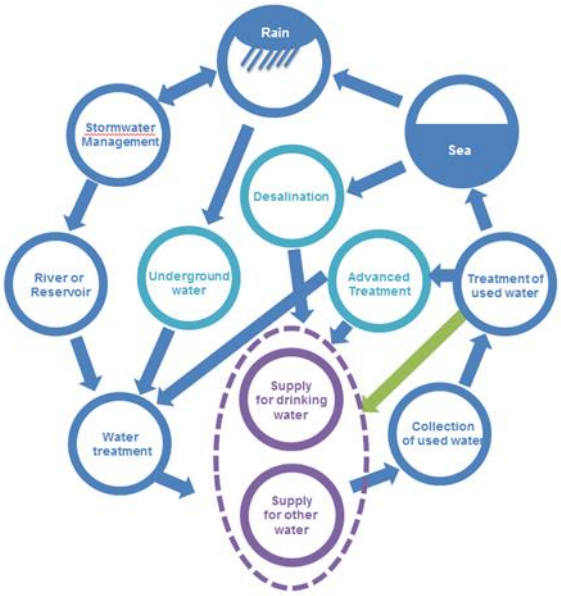

Figure 1. Expansion Concept of Water-Loop

Multi water-loop system needed to be constructed in cyclic loop type, in order to utilize the variable water resources in city. It is more efficient than supply system using a single water resource. To utilize variable water resources in city, system has to have three facilities. First of all, facility for reservoir (water platform) of intake water resources is needed, then water treatment plant which treats the mixing water resources has to be constructed. Lastly, water-loop network distributing the treated water to consumer is also needed.

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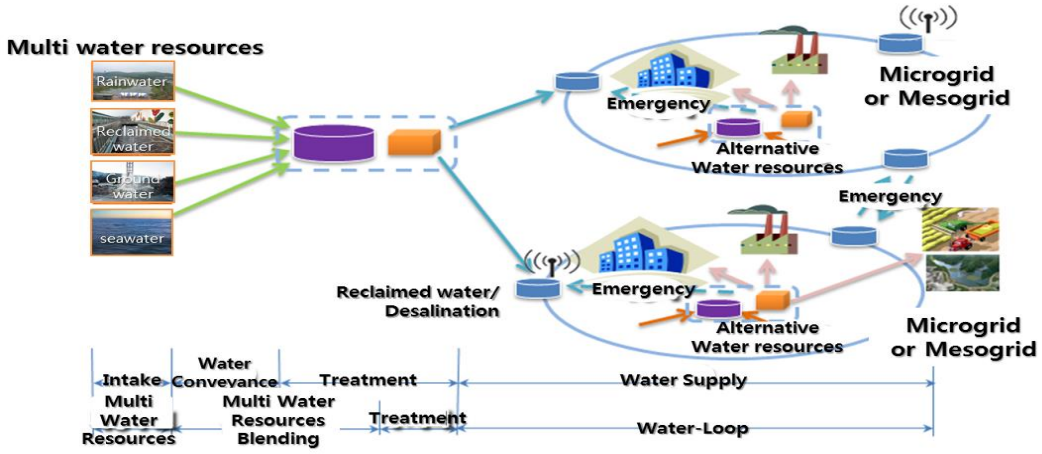


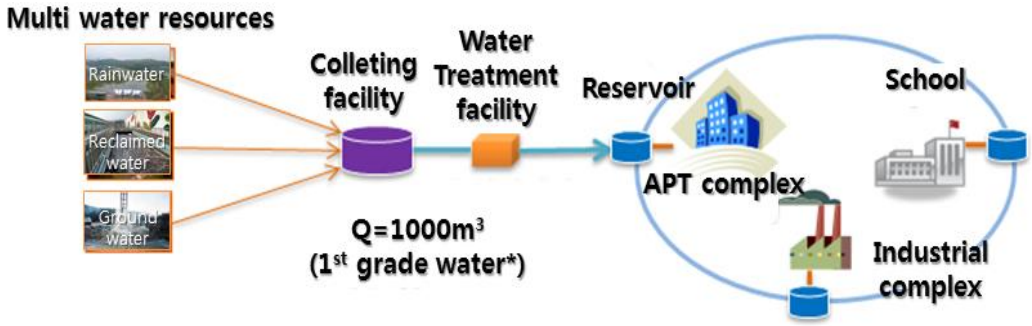
Figure 2. Conceptual Diagram for Multi Water-Loop System

Multi water-loop system is the intelligent system which combined with ICT (Information and Communication Technology). It means that intelligent operation and management system which contains intelligent water blending process, optimization technique, intelligent development of water resources based on realtime monitoring is integrated with the ICT.

Available water resources are stream water, rainwater, reclaimed water, ground water and seawater *etc*. So, multi water-loop system for utilizing this resources is divided into two types, New city and existing city. Due to the new construction, New town's pipelines need to be constructed separately, waterworks for potable water and distribution networks for agricultural water, industrial water, irrigation water, etc. In case of existing city, multi water-loop system can be established by adding the connected water-loop networks to existing networks or constructing the independent water-loop as demands.

2.2. Model of Connected Multi Water-Loop Pipe Networks

Multi water-loop models can be classified according to storage use, centralized or decentralized type. Another is the hierarchical type that distributes water on purpose such as agricultural water, industrial water, residential water, *etc*. In centralized type, small scale water resources are reserved in just one reservoir and distributed to block system.



*Grade : 1st(very good), 2nd(good), 3rd(moderate), 4th(a little bad), 5th(bad), non-rated(very bad)

Figure 3. Centralized Water-Loop System

In case of decentralized type, small scale water resources are reserved in several (more than 2) reservoirs and distributed to block system. In this type, size of water production system can be downsized because reservoirs of this system are decentralized. And it can

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also distribute water to each block system on demands. When emergency situations occur, it can supply the water continuously through connecting the each reservoir. It means that blended multi water resources can be exchanged among each reservoirs by constructing the loop system.

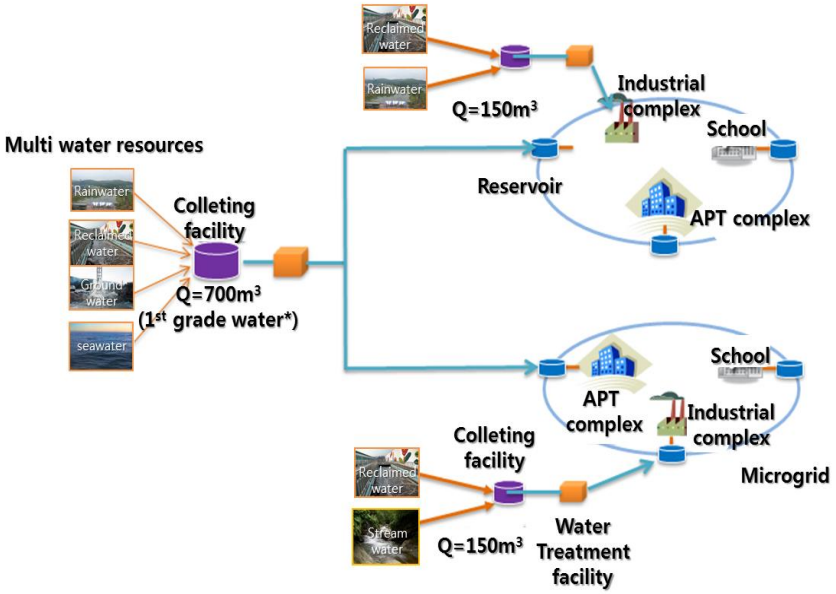

Figure 4. Decentralized Water-Loop Type

Reservoirs of hierarchical type are dispersed like decentralized type, but its distribution method is different with decentralized type. In hierarchical type, upstream area uses the low grade water(>4th grade) but this water is treated as customer' s demand in each water treatment plant. Similar to decentralized type, size of water production system can be downsized because reservoirs of this system are decentralized.

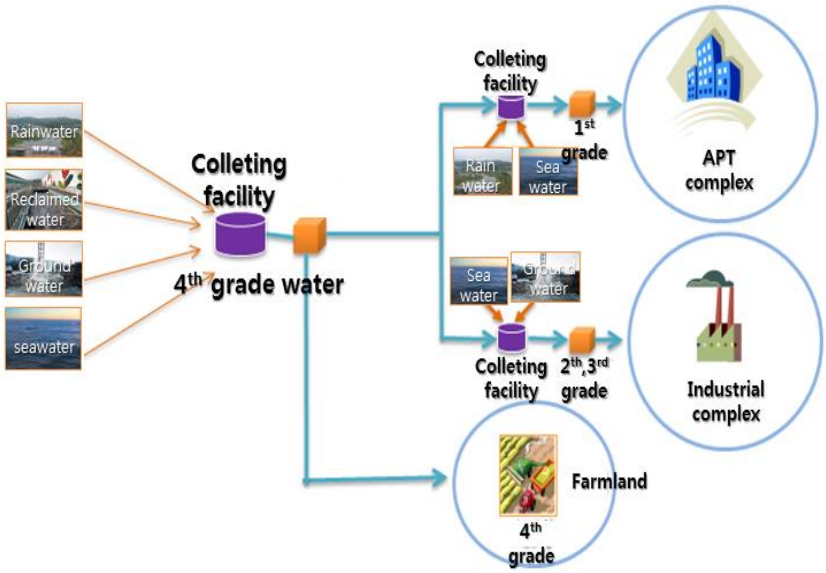

Figure 5. Hierarchical Water-Loop Type

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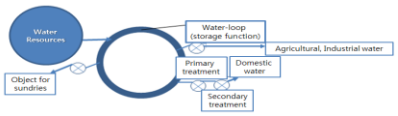
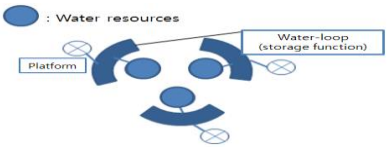
2.3. Model of Multi Water Resources Platform

Table 1. The Types of Water Platform

Type		Function	Diagram
Storage platform type	Single storage type	Multi water resources are collected in just one reservoir	Refer to Figure 3
	Decentralized storage type	Multi water resources are collected in several distributed reservoir	Refer to Figure 4, 5
Networks platform type	Storage networks type	Multi water resources are utilized as consumer by using the networks which have a storage ability	
	Decentralized networks type	Multi water resources are utilized as consumer by using the decentralized networks which have a storage ability	

Water platform (blending reservoir) means that storage facility of multi water resources in water-loop system, it can be divided into two platform types, storage type and networks type. Storage platform type can be divided into single storage type and decentralized storage type. Also, networks type is divided into storage networks type and decentralized networks type.

2.4. Technological Scope of Multi Water-Loop System

Technological scope of multi water-loop system contains a lot of element technologies in consumed place. These things are this followings; selective intake, design of water platform capacity, intelligent supply/distribution, forecast of demand (smart water mining), smart meter & sensor, energy saving (smart energy harvesting), asset management(smart water mapping), smart building, smart irrigation, *etc*.

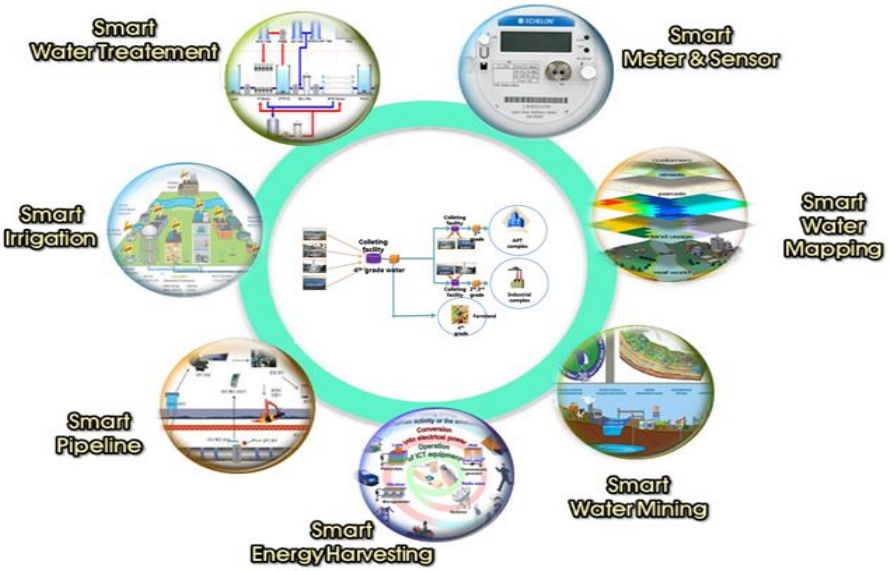


Figure 6. Technological Scope of Multi Water-Loop System

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2.5. Superiority of Multi Water-Loop System

Existing waterworks system distributes the water through the processes such as intake of single water resource, water conveyance, treatment (purification) and distribution. However, multi water-loop system utilizes multi water resources, so It need reservoir facilities (water platform) that collect the multi water resources.

Multi water-loop system utilize the intraurban water resources, and can reduce the construction cost of pipeline network because multi water-loop does not need a long distance transmission pipe. So, this system also produce and supply the multi water resources at a low cost and small scale. Further, it should be a effective water resources operation system which vitalizes the city's water industry as well as boosts the city's self-reliance ability.

Table 2. Difference Between Existing System and Multi Water-Loop System

Item	Existing waterworks system	Multi water-loop
Intake	Single water resource (dam, stream water)	Multi water resources (ground water, rainwater, reclaimed water, seawater, riverbank filtrate)
Supply network	Intake → Conduct pipe(linear pipeline) → WTP(single water quality) → Transmission pipe → Reservoir(single inflow way) → Consumer	Intake of multi water resources → Conduct pipe (networks) → Storage facility (water platform) → WTP (produce as demand) → Reservoir (circulating water inflow, connection between reservoirs) → Consumer
Connect waterworks with wastewaterworks	· Not connected · Single utilizing system · Reclaimed water is not used	· Connection of systems in the basin unit · Reclaimed water is used by connected pipe networks
Be smart(ICT)	· Waterworks and wastewaterworks respectively · Individual TM/TC	· Integration of waterworks and wastewaterworks · Integrated control ICT platform base · mutual exchange for water related data

2.6. How to Construct the Multi Water-Loop System

Multi water-loop system is divided into New city water-loop and existing city water-loop by development type and also divided into mountainous area, plains, coastal, island by location of area.

New city is newly constructed infrastructure (waterworks system); therefore, integrated utilization system of water resources that makes the best use of the available water in the city can be constructed. New city also need to set up the cyclic loop system, which utilize pure water, grey water and reclaimed water.

When multi water-loop system is constructed, pure water does not contain the reclaimed water, grey water but contain the dam, stream water, and ground water. In the New city, water for recreation, industry, irrigation, *etc*., is made by combining the reclaimed water, rainwater, *etc*. Areas using the grey water have to introduce the dual pipeline system for supplying contrary to pure water. If some areas use only grey water

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instead of pure water, these areas should not construct the pipeline for pure water. In case of contrary areas, areas do not have to set up the pipeline for grey water supply. But areas which use the both water need to construct the complex dual pipeline networks including pure and grey water pipelines (set up the dual system). Some construction methods are considered when multi water-loop system is constructed; Connection with system of rainwater use, addition of reuse system for reclaimed water, networks connection between each water-loop for emergency.

2.7. Construction Method Considering Potable/Non-Potable

It is important that consideration of potable/non-potable be reflected when intraurban water supply system is installed. Especially, ground water is able to use for potable water through simple treatment, so dependence of surface water will be reduced by development of ground water adequately. In case of non-potable, variable water resources are available except for ground water. Table 3 and 4 reveal the type of water-loop system that classified by potable and non-potable type and storage function of raw water or treated water.

These classifications are just example. Combinations of water resources and storage function make the type various. They can be set in these types; rural (domestic water, agricultural water), municipal public water (firefighting water, washing water, public water, *etc.*), fishing village (domestic water), island (domestic water), existing city (domestic water, public water), New city (domestic water, public water), and so on.

Table 3. Potable Water-Loop System

Type	Schematic of system
a	• Surface water (90%) → Reservoir → Water Purification → Supply system (Dual system) → Water treatment plant (Pure water reservoir/Water supply pump) or water distribution reservoir • Groundwater (10%) → Reservoir → Water Purification → Supply system (Dual system) → Water treatment plant (Pure water reservoir/Water supply pump)or water distribution reservoir
b	• Surface water (90%) → Water purification → Reservoir → Supply system (Dual line system) → Water treatment plant (Pure water reservoir/Water supply pump)or water distribution reservoir • Groundwater (10%) → Water purification → Reservoir → Supply system (Dual line system) → Water treatment plant(Pure water reservoir/Water supply pump)or water distribution reservoir

Table 4. Non-potable Water-Loop System

Type	Schematic of system
a	• Surface water (50%) → Reservoir → Water Purification → Supply system (Dual line system) • Precipitation (50%) → Reservoir → Water Purification → Supply system (Dual line system)
b	• Surface water (50%) → Water purification → Reservoir → Supply system (Dual line system) • Precipitation (50%) → Water purification → Reservoir → Supply system (Dual line system)
c	• Surface water (50%) → Water purification → Reservoir → Supply system (Dual line system) • Reclaimed water (50%) → Water purification → Reservoir → Supply system (Dual line system)

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d	• Surface water (50%) → Reservoir → Water Purification → Supply system (Dual line system) • Reclaimed water (50%) → Reservoir → Water Purification → Supply system (Dual line system)
e	• Rainwater (50%) → Water purification → Reservoir → Supply system (Dual line system) • Reclaimed water (50%) → Water purification → Reservoir → Supply system (Dual line system)
f	• Surface water (50%) → Water purification → Reservoir → Supply system (Dual line system) • Seawater Desalination (50%) → Water purification → Reservoir → Supply system (Dual line system)

3. Conclusions

To utilize the various water resources in the cities, water-loop system that uses the multi water resources has to be constructed for water supply; this water has the adequate water quality.

In this research, design methods of multi water-loop system are suggested. In detail, model of connected water-loop pipe networks, platform model of multi water-loop system, range of technology, difference with existing systems and direction of water-loop system construction are indicated. Therefore, they can be applied to design & construction of multi water-loop system to set up effectively.

It is not possible to determine the criteria that are standardized in one when building the multi water resource pipeline and it is applied to smart water grid. But present the direction close to the standardization method of smart water grid pipelines can facilitate the establishment of construction method.

Acknowledgements

This research was supported by a grant (12-TI-C01) from Advanced Water Management Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

This paper is a revised and expanded version of a paper entitled “Construction Method of Water-Loop System using Multi Water Resources” presented at NGCIT2014, Hochiminh (Vietnam), 24-26, Oct., 2014.

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