Implementation of Smart Water Grid System as a Green Technology in Gedebage Sports Centre, Bandung City, Indonesia

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Abstract. Smart Water Grid system has been widely applied to the Master Plan water distribution system in developed countries, such as Japan, and Singapore. However, this system has not been widely applied to the Master Plan designs in Indonesia. This system has advantages in a more controlled distribution system to minimize the risk of damage to the water distribution system. Specifically, this system is capable of meeting water needs in multi-, because it uses various water sources in its application. The purpose of this article in general: to provide a precedent for review on the application of Smart Water Grid in the form of study precedents from Japan and Singapore; Explaining Smart Water Grid and its components that are applied, reviewing monitoring methods, discussing the advantages, and disadvantages. In the end, this precedent study will be a recommendation for water treatment planning applications in the design of the Gedebage Sports Centre. Smart Water Grid design parameters such as (1) Able to fulfil the water needs in the multi-source (2) Able to prevent further damage of distribution system (3) facilitate maintenance of the water distribution system. Then, it can overcome to meet water needs by using a green technology system. Scope of this research is implementing the system of Smart Water Grid in Master Plan area as a smaller area than city’s area.

1. Introduction
Water is among the most prominent elements in the evolutionary development of human society. In recent years, due to climate change, global warming and population growth, the utilization of global water resources are under pressure and water resources management is facing challenges [1]. Water networks are vast and consist of various components (pipe segments, pumps, valves, etc.). These components vary in age and material type [2]. As they age their performance and efficiency decrease, making them prone to failures and leaks. Because water networks are so vast and hard to access, some municipalities may not have a complete inventory of their assets or be aware of any leaks in the systems. This time, hard-economic condition, funding is very limited, which sets water infrastructure lower on a priority list. Traditional water management in separated system are not efficient [3]. Today, in Indonesia, the use of traditional water management proves less effective because it usually uses only a single water source and only utilize the distribution of water from the water company. It causes problem between supply and demand of water needs in Indonesia. Now, in Indonesia the urban growth is 4.1% in a year, and water company can’t fulfil this demand [4]. So, single-source water can’t reach
to fulfil water demand in the future. Whereas, using Smart Water Grid System, the water comes from the multiple-source water, then water has been used cleaned back to be reused. Therefore, smart water management, an effective method, which is applied to solve these problems.

1.1. **Smart Water Grid System**

Smart water grid system is integrated system of water distribution use multi-source water and use sensor system to control it [5]. Water through the data acquisition instrument, the wireless network, water quality on-line monitoring equipment such as hydraulic pressure gauge real-time perception running status of urban water supply and drainage system, adopt the way of visualization of organic integration of water conservancy and water supply and drainage facilities, to establish a more subtle way of dynamic management dealing with the water resources system of the whole process of production, management and service, so as to achieve a state of "smart".

2. **Purpose**

The purpose of this paper is to perform a precedent review of information available regarding Smart Water Grid technology in Japan and Singapore. The objectives are outlined as follows: (1) discuss current water source in Gedebage Sports Centre Area; (2) describe implemented Smart Water Grid and its components; review the monitoring methods; discuss advantages, disadvantages, and vulnerability of smart water grid networks; (3) Finally, this precedent study and Smart Water Grid System will be applied to the Water System Plan at the Gedebage Sports Centre.

3. **Methods**

The author uses precedent study in this paper. The author takes a precedent from Singapore because in the climate context and geographical conditions are same as Indonesia. Meanwhile, choose Japan as precedent, with the reason because in terms of land topography, soil conditions, availability of resources, and disaster factors, are same as Indonesia. From this precedent study, the author tries to take the principles applied to the two types of precedents, then compare them to the context of the location to be applied. To find out the location conditions, the authors elaborated several area studies and analyses. After getting the context data, the principles that have been obtained are adjusted to the context of the land. Finally, this principle is tried to be implemented in the master plan of Gedebage Sports Centre. The author’s method shows in figure 1 below.

![Figure 1. Author’s method diagram.](image_url)
3.1. **Precedent Review: WaterWise in Singapore**

WaterWise is a real-time monitoring platform for water distribution systems that can be used by utilities to improve system management and operations by providing integrated measurements and analysis [5]. WaterWise can operate as a standalone system with its own analysis and management interface, or it can be integrated into water companies' existing infrastructure and geographic information platforms. WaterWise has an integrated multi-probe and associated wireless sensor node that can sample and transmit data in real time from within the network. This could be used as WaterWise's primary data source. But if a utility has an appropriate existing data flow, it does not need to operate the integrated data electronic alert system (IDEAS) and decision support tool module (DSTM). In stand-alone mode, IDEAS and DSTM both provide map-based web interfaces and dashboards. The user interface is accessible through web browsers on regular desktops and tablets and smartphones and can be analysed live by the operating team. As an integrated, end-to-end, real-time decision support system, WaterWise provides key monitoring, decision support and feedback components that will form the building blocks of a smart water grid. A scheme of monitoring in Singapore Water Grid shown in figure 2 below.

![Figure 2](image_url)  
*Figure 2. Monitoring process in Smart Water Grid Singapore (WaterWise).*

The national water department (NSW) has launched the "smart water system roadmap" to digitize the entire water system in Singapore to improve management and operation and meet future water needs. There are four main objectives:
- intelligent and automatic water quality management.
- improvement and intelligent prediction of key networks.
- integrate customer participation test water data.
- apply automation and robotics to redesign smarter jobs.

3.2. **Precedent Review: Japan Smart Water Grid**

Japan’s vision for a smart water cycle is to combine water treatment systems with information and communication technology (ICT) to contribute to the overall optimization of the water cycle.
In Kitakyushu, Japan, for example, the smart water network ensures water safety in terms of both water quantity and water quality. Kitakyushu city is in the north of Kyushu island, where there is abundant rainfall. The main water sources are river water, desalinated seawater, and recycled water [6]. Ongawa, as the main water source, has a storage capacity of 67.7% of the total river water, which is rich in water and able to provide a stable water supply. In terms of seawater desalination, Kitakyushu city water plaza is the first domestic facility in Japan that has pilot equipment for operational demonstration and a test bed for research and development of water treatment elements technology using equipment provided by private enterprises. The system is energy efficient, low cost and low environmental load through the synthesis of seawater desalination and sewage reuse and can provide 1.400m of production water per day. Due to the natural lack of energy resources, Japan attaches great importance to the recycling of energy resources. There are five sewage treatment centres in Kitakyushu city. Among them, the sewage and sea water purification units of riming purification centre adopt MBR+RO (sewage) and UF+RO (sea water) treatment procedures respectively, which can treat the water quality to the drinking water standard and remove more than 99.99% of bacteria and other substances. The recycled water can be used for industrial, agricultural irrigation, groundwater recharge, landscape pool and other purposes.

A water purification centre is a way to eliminate contaminants dissolved in water, so that water can be used for human life, for example for drinking water, and for cooking [7]. Some contaminants that are removed during the water purification process include bacteria, algae, viruses, fungi, and chemicals, and heavy metals that can cause problems for human life. The step of water purification from river is:

![Figure 3. Japan Smart Water Grid system diagram.](image)

In terms of water quality, the water quality of the five fixed points in the middle reaches of Ongawa is tested once a month, and the two water intake points of the estuary weir are tested more than 4 times a month. In case of water quality deterioration or accident, it can be tested at any time. Tonda reservoir

![Figure 4. River water cleaning process.](image)
is a reservoir for pumping and storing the surface water of Ongawa. Conduct monthly water quality tests at all depths. The surface water quality of other reservoirs is tested once a month, and the water quality at all depths is tested once every two months. The pollution detection in the catchment area and the inflow water quality detection at the time of discharge shall be carried out in a temporary manner. The water introduced from the reservoir or river first enters the highly purified water treatment facility (BCF) in the treatment plant, and then supplies water to each household through the rapid mixing tank, flocculation tank, sedimentation tank, filter tank, tap water tank and washing tank.

The smart water grid control system applied in Singapore uses the FlexNet Smart Meter Network Solution (SenSus) system. This system allows to supervise water systems such as water flow, pressure, temperature, quality, consumption, and energy use [8]. This system uses a wireless sensor, so it does not require complicated wiring in its installation. Broadly speaking, the SenSus system is divided into 5 stages, which are illustrated in figure 6 below.

![Figure 5. Smart Meter Network Solution (SenSus, 2012a).](image)

Measurement and Sensing Information functions to collect data about measuring water discharge and detect damage and abnormalities that occur in the system (1). Then the next system is Communication Channel which functions to gather information from the first stage. This system can also double, which is to close the water valve in case of damage (2). After all, information has been collected from the second system, the next is Basin Data Management. This stage serves to translate the damage that occurs into visual form through GIS, spreadsheets, and graphing tools (3). After the information is drawn and the point of damage is known, then the Real-time Data Analytics and Modelling stage are followed. At this stage, the computer presents analysis and solutions to repair the damage that has occurred. Computers collect information effectively (4). After the system is completely repaired by engineers, entering the final stage, is the stage of Automation and Control. This stage allows the remote control of the utility system in this area. This system can control the distance and control of the first stage if there is another damage (5). All these systems are located within the Smart Utility Control, which relates to FlexNet tower to control all sensors within the region.

3.3. Study Area
The object of the study is a provincial-level Sports Centre planning located on Rancanumpang Stadium Street, Gedebage Sub-district, Bandung City. Location coordinates are at -6°57'33.87" S and 107°42'45.61" E. The total land area of the Sports Centre is 468,177.12 m². The area consists have Sports Function Area, Public Function Area, Residential Public Area. Based on disaster data, the area that became the location of the Sports Centre often flooded. In BNPB data, 374 floods occurred in this area [9]. Floods that occur are due to overflowing rivers and soil conditions that cannot absorb water. Water overflow can be used as a source of irrigation within the region.
The site is in an area prone to floods. This flood is usually caused by an overflow of the Citarum river and sub-river Citarum. The site distance from the river is 432 m and 20 m from the site's outer boundary. Floods are caused by the condition of dirty river water, so that water easily overflows. Therefore, to use river water, a water purification centre is needed to clean the water before it is consumed by the user.

3.4. Master Plan Study

Figure 7. Master Plan of Gedebage Sports Centre. Gedebage Sports Centre’s Master Plan is shown in figure 7 left. In the master plan, there are several buildings, which is: 1 Stadium, 1 Basketball Hall, 1 swimming pool arena, 1 Karate Hall. The other building is the Sports Centre's Office, Multipurpose Building, Clinic, and Athlete Guesthouse and retention pool. This retention pool can be used to harvest rainwater, considering that based on climate analysis, rainwater can be water source for this area. So, this pool serves to accommodate rainwater from site water runoff.

3.5. Climate Analysis

Based on data obtained from Meteoblue Bandung, the total number of days with rainy weather is 285.9 days (can be seen in figure 5b). In addition, if seen in figure 5a, it can be concluded that precipitation days on land are quite large. So, based on this climate condition, rainwater can be used as a source.
3.6. Analysis and Decision

Based on the precedent's explanation and the context of the applied site, several criteria were obtained which became the principles in implementing the Smart Water Grid system. The criteria are presented in table form then compared between precedents 1, precedents 2, site context, and implementation decisions. The results of the analysis are shown in table 1 below.

Table 1. Site context analysis based on precedent

| Criteria                  | Precedent 1 (Singapore) | Precedent 2 (Japan) | Site context analysis | Decision                      |
|---------------------------|-------------------------|---------------------|-----------------------|-------------------------------|
| Water source              | Desalination water      | River               | Site is close to the river and have a retention lake. The site can’t use water sources from sea water desalination because the site location far from sea. | With the existing potential, the water source that can be utilized is the Citarum River and the retention pool. Needs: • River pipping system • Retention pool pipping system • Water purification centre |
|                           | Reservoir               | Desalination water  |                       |                               |
|                           | Rainwater               | Retention           |                       |                               |
|                           |                         | Sewers              |                       |                               |
|                           |                         | Water recycles      |                       |                               |
| Method to harvest rain water | Reservoir             | Retention pool      | The site is far to the city reservoir, but we can use the site’s retention pool as rain water harvester. | Retention pool is able to harvest rain water effectively, especially for stormwater [9]. Then, the water from the retention pool is processed into a water purification centre. Needs: • Retention pool |
|                           |                         | Sewers              |                       |                               |

Figure 8. Climate data of Bandung (a) Precipitation days and (b) Precipitation Amount chart.
and the type of pump used

| Water condition | Tropical area: have a long day rain | Subtropical area: have a rain and snow. Snow processed becomes water | The site is in an area with tropical climate conditions. The tropical region will get rain for 6 months. So that the source of water from the rain will be very abundant and can be utilized. |
| Water purification system, to clean up the water, a water quality tower is needed to divide the iron from water use gravity. | In Singapore water purification system, to clean up the water, a water quality tower is needed to divide the iron from water use gravity. | All of water that comes from rain, rivers or flood runoff needs to be cleaned before use [10]. Water must be cleaned because for human health. To clean iron and metal, use water quality tower to separate it. Water quality tank is needed to check and monitoring the water. | Devices such as water quality towers and water quality tanks are needed to clean water in the area before being distributed [11]. |
| Needs: | • Distribution pump |
| | Water sewers system |
| Climate impact | Tropical area: have a long day rain | Subtropical area: have a rain and snow. Snow processed becomes water | The site is in an area with tropical climate conditions. The tropical region will get rain for 6 months. So that the source of water from the rain will be very abundant and can be utilized. | Water is harvested in retention pool to harvest stormwater. This water is then pumped into the water purification centre to be cleaned, then distributed to all sites. |
| Needs: | • Retention pool, water purification centre |
| Disaster resistance | Drought | Flood | Based on the regional context, site conditions during the dry season are always drought, meanwhile during the rainy season there are always floods. | Utilizing flood water during the rainy season, then water is stored inside sewers [12]. The harvested rainwater can become a reserve of water when the dry season arrives. |
| Energy resource | Water energy | Sun energy | Based on regional context and geographical | Use solar energy sources, as the main energy source to |
4. Results

Based on the results of the analysis above, there are several needs needed to implement the Smart Water Grid System. First, the water from the river; harvested stormwater-rainwater into the retention pool; and flood runoff water flowed into the water purification centre. Water purification centre functions to treat dirty water into water that is suitable for distribution. In this water purification centre, water purification must occur which must be controlled by a water quality tower (to separate metals) and water quality tanks (to mix water with water purifying substances). Both controls also function to monitor the circulating water content.

Then, the clear water is distributed throughout the zone. Zones are divided based on the power of the pump to distribute it to the intended buildings. This zone division also functions to facilitate water control. Water from this large pump goes into smaller pumps to be distributed to buildings. The used water from the building is then flowed back to this water purification centre to be cleared. The control system is controlled by a smart utility control centre that contains computers and engineers to control the system. The signal from this control centre is channelled to the FlexNet tower. Then the signal is spread throughout the area to control temperature, pressure, water quality, central utility control, and control of sanitary water networks. The principle scheme for implementing the Smart Water Grid system is shown in figure 9 below.

![Diagram of Smart Water Grid System](image)

**Figure 9.** Smart water grid principle diagram.
Based on the results of the analysis, to implement the Smart Water Grid system, it is necessary to follow the following rules below.

4.1. Multi-Water Source

To implement a Smart Water Grid system, multi-water sources are needed, because it is not enough through just 1 water source. Water sources that can be applied in this area are retention lakes, rainwater harvesting, rivers, and flood water overflow. Rain water harvesting is aimed to take advantage of rain water. There are various methods to do this rainwater harvesting. The simplest and most applicable method is to utilize the roof as a medium of falling rainwater, then channelled through a horizontal gutter which channelled down and combined with retention pool [14]. Juliana has studied the rainwater harvesting (RWH) system based on tank capacity and catchment area [10].

4.2. Piping system has resistant from Thermal and Rain

Components of the water network system consist of pipes, valves, reducers, water purification centres, which function to purify water to be suitable for use, water quality, namely, to control the quality of water being distributed, and control tanks to accommodate water discharge. This piping component must be made of stainless-steel material to prevent damage caused by the weather. Stainless-steel have anticrosive substance.

4.3. Control System use wireless networks

The sensor component consists of pipe sensors, Wi-Fi networks, antennas, smart utility centres, temperature monitors, pumps, pipes, and settings, as well as computers and software. This system consists of 2 main systems, which is a water distribution system consisting of distributor components. This component combines sources from this source, then is processed in a water purification centre, then distributed throughout the Region.

4.4. Make sewers systems as water storage, which water will use during in dry season

In Tokyo, sewers of this system are used to contain flood runoff that flows in the city of Tokyo. Sewers can accommodate large amounts of water so that floods can be avoided. The flood water is then accommodated in a large sewer, which later can be utilized in the summer to arrive. During the summer, water from these sewers is cleaned, then distributed to all cities for consumption. This water sewer is one of the principles of implementing a smart water grid system as one of the water sources to meet the user's water needs. Sewers system is very useful, especially for areas where always damaged by floods.

4.5. Human as a brain ware system

Humans are the most important component in implementing this smart water grid system. Humans function as brain ware to control all running systems [15]. In addition, humans also make repairs after the computer reads the damage.

5. Discussions

Based on the results, the author tries to implement the Smart Water Grid system in the Gedebage Sports Centre located in Bandung. The Smart Water Grid system that is applied is by utilizing multi-source water, which is by utilizing retention pool, rainwater harvesting, rivers and runoff water. The water network system that is applied in site is shown in figure 10 below.

This wireless sensor system serves to regulate all network performance, and control flowing water, the direction of water flow and regulate water quality. This system is cantered on a smart utility centre that contains a computer to regulate the sensor system. This system is controlled by the FlexNet tower which serves to spread all signals throughout the Region.
Figure 10. Smart water grid system implementation in Gedebage Sports Centre.

The advantage of this Smart Water Grid System is that it can store water for investment when the dry season arrives. This system holds water in the sewer and can be used when the dry season arrives. During the dry season, the air source decreases dramatically. Designed, water that was previously accommodated during the rainy season can be an investment during the dry season. Meanwhile, the disadvantage of the Smart Water Grid system is that the installation is very complicated, because it needs to install a piping system as well as a system sensor. In addition, special experts are needed in the installation [16]. Although this technology is expensive, this technology is included in green technology because it can save water for the future.

Figure 11. One of example of a rainwater storage system in buildings shown in figure 11 left. Rainwater that falls to the roof flows towards the gutter. The gutter is installed every 1m² of the roof area to get optimum accommodate water. After that, the water is then flowing through a pipe into the water reservoir in the building and then flowed into the retention pond. The picture beside is an example of water storage in a stadium building.

Regulation of this system in Indonesia

Indonesia didn’t have yet the regulation about smart water grid system. So, to implement a smart water grid system, it is necessary to review the existing water source regulations. The smart water grid system is a water distribution system using multi-source water so that to implement this system, it is necessary to pay attention to regulations related to the sources of water to be used.

The source of water from the river is regulated through Indonesian government regulations regarding the exploitation of water resources. While for the utilization of rainwater, it is regulated through the
regulation of the minister of environment regarding the utilization of rainwater. Then, for a water treatment system through a water treatment plant, it is regulated through the regulation of the environment minister regarding the regulation of quality of wastewater for business and/or activities of thermal power plant.

![Diagram of water source and water system in Indonesia](image)

**Figure 12.** Regulation of water source and water system in Indonesia.

By combine the regulation, to implemented smart water grid system in Indonesia will facing some constrains and lack. It will cause a problem to combine this regulation because it must to be synchronize and need negotiation between these regulations. It still possible to implemented, but need a time to manage the regulation before implementation.

6. Conclusions
The implementation of Smart Water Grid systems in each region varies depending on climate conditions, water sources, and disasters. The principles needed to implement the Smart Water Grid system are multi-sources water, weather-resistant piping systems, the application of sensor systems as controlling, and the need for sewers to accommodate reserve water for the dry season. The application of this system has the advantages of being efficient and easy to control, and easy to find damage. Meanwhile, the disadvantages of this system are that it requires a large cost in its implementation, but this system is green technology because can save water for future.

7. References
[1] L. Xinjie, Y. Su, and W. Gao, “To achieve water security - Kitakyushu model,” pp. 3–6, 2018.
[2] Ronald A. Beaulieu, “National Smart Water Grid TM,” Lawrence Livermore Natl. Lab., vol. LLNL-TR-41, no. January 2010, pp. 44–45, 2009.
[3] A. Preis et al., “Case study: a smart water grid in Singapore The MIT Faculty has made this article openly available. Please share Citation IWA Publishing Publisher Version Accessed Citable Link Terms of Use Detailed Terms Case Study: A Smart Water Grid in Singapore,” 2015.
[4] M. F. Aziz, “Pengembangan Smart Water Grid di Indonesia dalam rangka mencapai tujuan ke-6 pada Sustainable Development Goals (SDGs),” 2018.
[5] T. Khoo, “Innovation in Vvater Singapore,” *An R&D Publ. PUB Singapore*, vol. 4, no. April, p. 36, 2011.

[6] “Kitakyushu Model Water Management,” 2015.

[7] A. Budiman, C. Wahyudi, W. Irawan, and H. Hindarso, “Kinerja Koagulan Poly Aluminium Chloride (Pac) dalam Penjernihan Air Sungai Kalimas Surabaya Menjadi Air Bersih,” *Widya Tek.*, vol. 7, pp. 25–34, 2008.

[8] C. Brzozowski, “the ‘Smart’ Water Grid,” *Water Effic.*, vol. 6, no. 5, pp. 10–23, 2011.

[9] BNPB, “Data Bencana Kota Bandung,” 2018.

[10] I. C. Juliana, M. S. B. Kusuma, M. Cahyono, H. Kardhana, and W. Martokusumo, “Performance of rainwater harvesting system based on roof catchment area and storage tank capacity,” in *MATEC Web of Conferences*, 2017.

[11] S. Byeon, G. Choi, S. Maeng, and P. Gourbesville, “Sustainable water distribution strategy with smart water grid,” *Sustain.*, vol. 7, no. 4, pp. 4240–4259, 2015.

[12] World Health Organization Geneva, “Guidelines for Drinking Water Quality,” *Surveill. Control community supplies*, vol. 5, no. June, pp. 1–4, 2010.

[13] R. Uematsu, “Sewerage Works in Japan Contents of Today’s Presentation 1. History of Sewerage Works in Japan 2. Current Issues and Policy,” 2018.

[14] N. I. Said and W. Widayat, “Bab 6 Pemanenan Air Hujan,” in *Pengisian Air Tanah Buatan, Pemanenan Air Hujan Dan Teknologi Pengolahan Air Hujan "Studi Kasus Kota Depok*, 1st ed., Jakarta: BPPT - Kelair, 2014.

[15] Olga Martyusheva, “the ‘Smart’ Water Grid Plan B Technical Report,” *Water Effic.*, vol. 1, no. 1, p. 70, 2014.

[16] E. F. Arniella, S. Water, A. Llc, and Y. Mellinger, “Evaluation of Smart Water.”

8. **Acknowledgments**

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