Water in Circular Economy and Resilience (WICER)

The Cases of Tugu Tirta and Adhya Tirta Batam, Indonesia

Promoting Nonrevenue Water Reduction and Energy Efficiency in Indonesia’s Water Utilities

This case study is part of a series prepared by the World Bank’s Water Global Practice to highlight existing experiences in the water sector. The purpose of the series is to showcase one or more of the elements that can contribute toward a Water in Circular Economy and Resilience (WICER) system. This case focuses on interventions on the utility’s supply side to increase efficiency and minimize waste.

Note: NRW = nonrevenue water.

Context

There are close to 400 water utilities in Indonesia with varied performance and capacity; only around half are considered well performing. Inefficient operations has been identified as one of the key issues hampering performance and reducing utilities’ capacity to provide reliable water supply services. If not addressed, water utilities’ inefficiency could hamper government efforts to achieve development targets.

High rates of nonrevenue water (NRW) pose a major challenge to the operational efficiency of many of Indonesia’s water utilities. Based on water utilities’ reports, the average NRW level in Indonesia is estimated at around 32 percent—much higher than the 20 percent target set in the strategic plan put forward in 2019 by the Ministry of Public Works and Housing. The actual NRW rates of many water utilities is estimated to be greater than the figures reported, as most utilities do not have accurate measurement capabilities. For example, many do not have meters installed at main production and distribution centers, or do not maintain meters adequately to ensure their reliability.
High rates of NRW represent significant losses for both a water utility and the community it serves. They affect a utility’s financial viability due to reduced revenue, increased production costs, additional energy consumption for distribution, and the deterioration of distributed water quality, among others. Considering the volume of NRW (1.56 billion cubic meters [m$^3$] of water a year) across Indonesia, at the average tariff of US$0.37/m$^3$, the potential loss of revenue reaches US$579 million per year.

Energy consumption is another factor that influences utilities’ operational efficiency. A few water utilities in Indonesia rely on gravity to distribute water and thus do not require much energy for their operation. The majority, however, rely on pumping systems to extract and transfer freshwater to treatment plants and to distribute the treated water to their customers. On average, more than 30 percent of Indonesian water utilities’ total production costs are for energy. Because a significant share of these high energy costs is due to NRW, addressing water losses could improve overall energy efficiency.

This case study parallels the experiences of two water utilities that implemented a NRW reduction program that has consequently improved their energy efficiency: Tugu Tirta, a public utility, and Adhya Tirta Batam (ATB), a private concessionaire. With their success, these two utilities have set a benchmark for NRW reduction and energy efficiency improvements in Indonesia.

Tugu Tirta is a municipality-owned public water supply utility, providing piped water supply services to a population of 870,682 in Malang Municipality, East Java. The municipality’s water sources are 10 springs (mostly located outside the municipality) and 9 deep wells, with a combination of gravity and pumping systems based on the location of raw water sources and the service area. In 2009, the utility’s service coverage was only 59 percent, with 95,000 customers, and the average NRW rate was 42 percent. With a total production capacity of 1,300 liters per second (lps) at that time, Tugu Tirta was able to provide 24-hour water supply to only 80 percent of its customers. In 2010, Tugu Tirta started implementing a NRW reduction program.

ATB is a private water utility operating under a 25-year concession contract with the Batam Development Authority in Batam Island since 1996. Batam is a small island located south of Singapore, with an area of around 415 square kilometers (km$^2$) and a population of 1.37 million in 2019. It has limited raw water sources, and depends on rainfall. The amount of raw water has not increased over the past 25 years, leaving little margin to meet the demand spurred by population growth. By the end of 2015, there were 252,262 customers; an average of 9,000-10,000 connections were being added per year, implying an average annual growth rate of 3-4 percent. NRW was at around 26 percent. In a context of limited freshwater resources, improving operational efficiency by reducing NRW was found to be the most cost-effective way to extend the availability of water services in Batam Island.

Policy, Institutional, and Regulatory Environment

As part of the National Mid-term Development Plan 2020-24, the Government of Indonesia targeted the provision of piped water services to 10 million new households. As the country is highly decentralized, the provision of basic services, including water supply, is the responsibility of local governments (district or municipality). In urban areas, most local governments delegate this role to their water utility enterprises, some established as public-private partnership contracts. The central government, via the Ministry of Public Works and Housing, provides guidance and technical assistance and implements policies and regulations to ensure the quality of service. The Ministry of Home Affairs issues regulations for the calculation of water tariffs and tariff subsidies (in case the water utility cannot implement a cost-recovery tariff).

The government has fostered the development of NRW reduction programs with the creation of key performance indicators targeted by regulations at the central
and local government levels. The Ministry of Public Works and Housing Regulation No. 13/2013 on National Policy and Strategy for Water Supply Development stipulated that water utilities should reduce the NRW level to 20 percent at maximum. This regulation has become a reference for provincial and local government policies and strategies and should be reflected in the Drinking Water Master Plan and water utilities’ business plans. In the case of Tugu Tirta, the Drinking Water Master Plan of Malang Municipality for 2014–28, issued by a Mayor’s Decree No. 7/2014, set a target that Tugu Tirta reduce its NRW level to 16 percent within five years from 2015. This target was also reflected in Tugu Tirta’s business plan for the period 2014-19. ATB’s concession contract, meanwhile, stipulates that NRW be reduced from 46 percent at the beginning of the contract in 1996 to 20 percent at the end of the contract in 2020.

Other factors that prompted the two water utilities to implement an NRW reduction program were the limited availability of water sources and lack of clarity regarding water rights. As part of the government’s decentralization plan, following the enactment of decentralization law in 1999, many districts separated into two or more districts and municipalities, a process that was typically followed by the separation of their water utilities. As a result, some utilities must rely on water sources located outside their jurisdiction area, as in the case of Tugu Tirta in Malang. This situation has made it difficult for Tugu Tirta to obtain water abstraction permits to increase its production capacity. Also, a lack of regulation or clarity around the bulk-water tariff arrangement during the separation process has caused conflicts between the Malang Municipality and neighboring districts, making it more difficult for Tugu Tirta to rely on neighboring springs as its main water sources. Therefore, to be able to meet the increased demand of growing urban population and development, the utility had to find other water sources located in its jurisdiction area or implement NRW reduction programs. In Batam Island, ATB depends on rainfall collected in rainwater reservoirs. There are five rainwater reservoirs/dams with capacities ranging from the smallest, Nongsa Dam at 30 lps, to the largest, Duriankang Dam at 2,700 lps. Out of the total capacity of 3,850 lps, ATB was using 3,500 lps, meaning that only 10 percent of water resources were left available for other uses.

**Solution: NRW Reduction and Energy Efficiency Strategy**

Both utilities managed to improve their operational efficiency by reducing their NRW through the establishment of district metered areas (DMAs), implementation of pressure management using pressure-reducing valves (PRVs), and active leakage control. Both also utilized innovative technology by installing controlling instruments and supervisory control and data acquisition (SCADA) systems. Aligned with NRW reduction, both utilities have managed to reduce their energy consumption and improve their energy efficiency.

In 2014–15, Tugu Tirta selected a pilot area based on NRW level (>30 percent), a distribution network that could be easily isolated, and high commercial losses. With the support of consultants, Tugu Tirta designed a DMA, calculated the water balance, conducted pressure management, implemented active leakage control, accelerated leakage repairs, and handled commercial losses. Following this pilot project, Tugu Tirta scaled up the NRW reduction program and replicated in stages the establishment of DMAs in other areas depending on availability of funding. Tugu Tirta divided its service area into DMAs consisting of 500–1,000 connections. By 2018, Tugu Tirta had established 240 DMAs of which 180 were fully isolated and equipped with PRVs and a master meter. Monitoring was improved by installing controlling instruments and a SCADA system. In addition to the NRW reduction program, Tugu Tirta also improved energy efficiency by developing an application for asset management, particularly for mechanical and electrical equipment, installing capacitor banks in the main distribution panel, and conducting energy audits in all pumping
stations on a regular basis. Through the energy efficiency program, Tugu Tirta has managed to reduce its electricity costs by around 21 percent.

Before 2015, ATB’s NRW level was higher than 26 percent and NRW reduction had been focused on reducing physical losses using the “find and fix” method, which centers on trying to find as many leak points and fix them as soon as possible. Most of the pipe leakages were caused by the high pressure applied to meet customers’ demand. However, this reactive method was not able to further lower the NRW value to 20 percent as per the concession contract and business plan. To be able to achieve this target, ATB had to develop a more comprehensive and effective NRW reduction strategy, suited to its financial capacity. As a concessionaire, ATB is not eligible to receive funding support from the government. Starting from 2015, ATB developed a NRW reduction strategy that featured efforts to:

1. develop an updated and well-calibrated network map;
2. design and establish DMAs that are continuously monitored and updated based on customers’ growth;
3. install a SCADA system integrated with a geographic information system (GIS) to control, monitor, and automate operations of water treatment plants and the distribution network (Figure 1); and
4. utilize results of data collection and analysis to identify the priority areas and activities for NRW reduction.

ATB divided its service area into 23 DMAs. Based on the results of data analysis, ATB prioritized DMA 07 (Batam Center), which represents around 17 percent of...

FIGURE 1. ATB’s Smart Water Management with SCADA System. Source: PT. Adhya Tirta Batam, 2019
total customers. To allow for the modification of distribution networks into more manageable pressure areas, DMA 07 was further divided into three pressure management areas (PMAs) by installing isolation valves and PRVs. This has allowed ATB to implement pressure management since 2017, in which it provides adequate pressure to meet customers’ demand during the peak hours and reduces pressure on the distribution network during minimum-consumption hours to reduce leakages. As part of this process, ATB also installed variable speed drivers (VSDs) and proportional integral derivative (PID) controllers that have allowed it to reduce energy consumption and lower energy costs by around 12 percent.

Both ATB and Tugu Tirta established a team to implement the NRW reduction program and engage all departments across the water utility (finance and administration, production, distribution, and customer service). In addition, Tugu Tirta allocated an adequate budget to create in-house training programs and external training or workshops for all employees to strengthen employee performance.

Another important aspect of the NRW program in both cases was stakeholder engagement. Tugu Tirta updates its targets in a five-year business plan. Before obtaining approval from the mayor, all planned activities and targets need to be shared with the public through consultations that involve a supervisory board, a representative forum of customers, and the local parliament. In the case of ATB, it needs approval from the Batam Island Authority and needs to conduct public consultations before changing its business plan or adjusting tariffs. ATB has set up a good communications strategy and public campaigns regarding water conservation measures and illegal connections. As part of its public engagement, ATB invites the community to visit infrastructure such as the water treatment plant and the dams.

Financial and Contractual Arrangements

As a public utility, besides using its own equity, Tugu Tirta Malang receives funding support in the form of equity contributions from its owner (Malang Municipality) and grants from the central government through the Ministry of Public Works. To cover operation and maintenance (O&M) costs and maintain assets properly, Tugu Tirta must apply a full cost-recovery tariff. Tugu Tirta Malang has also demonstrated its strong commitment to continuously improving its services and performance and as a result received funding support from the central government for various pilot programs including for NRW reduction. In 2010–17, a total of US$6.8 million was invested to establish 280 DMAs, build 15 reservoirs with a total capacity of 30,000 m³, replace 100,000 water meters, and build an integrated command center (Figure 2). For the energy efficiency program, Tugu Tirta invested approximately US$145,000 in 2011 for the installation of 12 unit capacitor banks. Forty percent of the investment was funded by the central government in the form of equipment, and 60 percent from Tugu Tirta’s own fund.

In Batam, ATB’s capital expenditure (CAPEX) investment in the NRW reduction program from 2014 to 2019 and covering 23 DMAs amounted to a total of US$7.8 million or on average US$1.3 million annually. Specifically, for DMA 07, ATB invested approximately US$230,000 in NRW reduction activities that included pressure management and handling commercial and physical losses. ATB also invested approximately US$490,000 over six years, or US$82,000 per year on average, for the purchase and installation of VSDs and PID controllers as part of its energy efficiency program. All these investments were funded by ATB itself. This is in line with the conditions of the 25-year concession contract, which states that all investments should be financed by ATB with loans and equity from ATB.

Under the agreement, the Batam Island Authority benefits from an asset usage fee for existing assets and a royalty fee of 15 percent from share dividends. Every five years, ATB prepares a business plan that should be agreed on by both parties. The business plan presents detailed data on new facilities and other investments that will be undertaken over the next five years. ATB has the right to propose an annual tariff adjustment based on investment needs and indexation for consumables that consider the electricity cost increase,
labor cost, chemical cost, exchange rate, inflation rate, and so on. However, ATB made the last tariff adjustment in 2010 and, due to the political situation, the tariff has not been increased since. That pushed ATB to focus on improving operational efficiency to increase profitability, including reducing the NRW level.

Benefits

By 2019, Tugu Tirta’s NRW had been reduced to 16 percent and the service coverage reached 91.29 percent of the total population, with 168,500 connections. ATB successfully reduced its NRW from 26 percent in 2015 to less than 15 percent in 2020 and was able to provide services to its 290,617 customers (99.5 percent of the population). Both utilities are providing customers with continuous and reliable water supply 24 hours a day.

There are significant direct and indirect benefits from the NRW reduction and energy efficiency programs. The direct benefits are cost savings from water production and distribution, as well as from reduced energy consumption. Water savings from NRW reduction have allowed both utilities to improve and expand their services, thus increasing their water sales and revenue. The NRW reduction has also delayed the need for expensive water supply infrastructure such as new dams or new treatment plants (table 1).

In 2009, at the NRW level of 42 percent and production capacity of 1,300 lps, Tugu Tirta experienced water...
losses of 16.8 million m$^3$ per year and was only able to serve less than 60 percent of the population of Malang Municipality. By 2019, Tugu Tirta successfully reduced its NRW to 16 percent and increased its production capacity to 1,670 lps (150 lps from a new production unit and 220 lps thanks to the optimization of existing production units), serving more than 95 percent of the population with continuous supply. This means that in 11 years Tugu Tirta managed to reduce its NRW by more than 60 percent, or around 2.6 percentage points annually, equal to approximately 7.2 million m$^3$ of water saved per year. With an average NRW-related CAPEX of US$0.85 million per year and considering an average tariff of US$0.34 per m$^3$, the additional revenue gained by Tugu Tirta is US$2.5 million per year. For the energy efficiency program, with a total CAPEX investment of US$0.145 million in 2011, Tugu Tirta has managed to reduce its energy costs by 21 percent from US$0.05/m$^3$ to US$0.039/m$^3$. This results in total savings of US$0.57 million per year.

In Batam, ATB invested US$0.23 million for the reduction of NRW in DMA 07 and managed to save 1.3 million m$^3$ of water in one year. With the average water tariff of US$0.43 per m$^3$, the additional revenues were US$0.56 million in 2017. This means that the investment in DMA07 for NRW reduction reached the breakeven point in less than one year. For the entire system, covering 23 DMAs, ATB invested a total US$7.8 million from 2014 until 2019, or on average US$1.3 million annually, in NRW-reduction-related CAPEX. In 2014, with a NRW rate of 26 percent, ATB's water losses were 24.5 million m$^3$/year. In 2019, NRW had been successfully reduced to 14.9 percent, meaning a NRW reduction of 2.2 percentage points per year, equal to 7.75 million m$^3$/year of water saved or a total of 46.5 million m$^3$ from six years of NRW reduction programs. With an average tariff of US$0.43 per m$^3$, the potential additional revenue is US$3.32 million/year. In addition, the number of leakage points that it had to repair was reduced from 1,600 leakages per month to 400 leakages per month, leading to circa US$1 million/year of savings in leak repairs. ATB has also managed to reduce its energy costs by 12 percent from US$0.049 per m$^3$ to US$0.043 per m$^3$. This means that with an investment of US$0.49 million in
six years (or US$0.082 million/year) and total water distributed of 101 million m³/year, ATB has been able to save US$0.59 million/year.

Moreover, both utilities also managed to utilize their limited water sources optimally and avoid the need for huge investments to increase their production capacity. In 2015, initially Tugu Tirta had planned to construct new deep wells and spring water collection by broncapturing with a total capacity of 250 lps and 28 kilometers (km) of transmission pipes, which amounted to Rs 75 billion (US$5.35 million). This plan was postponed due to the implementation of the NRW program that has allowed it to save 7.2 million m³ of water per year. In the case of ATB, since it was able to save 7.75 million m³ of water per year, investments in an additional water treatment plant with a capacity of 245 lps and related transmission pipes were postponed. The estimated investment for 1 lps ranges from Rs 200 million (US$14,000) to Rs 250 million (US$18,000). Therefore, ATB delayed the investment of US$4.4 million in new infrastructure.

Both ATB and Tugu Tirta have been able to implement their NRW programs without increasing their tariffs substantially. If we compare their tariffs with the national average water tariff of 0.38 per m³, it can be said that ATB’s tariff of US$0.43 and Tugu Tirta’s of US$0.34 are not very high. To compare, the concession of Jakarta water has an average tariff of US$0.68 per m³; the highest water tariff in Indonesia, in Balikpapan City, is US$0.72 per m³. That ATB and Tugu Tirta enjoy a high profit margin using an average tariff indicates that both utilities maintain efficiency in their operations.

Social and environmental benefits include the preservation of precious water resources, lower greenhouse gas emissions given the utilities’ improved energy efficiency, and benefits for local economies. In the case of Batam, the NRW reduction program has also avoided water shortages, and reliable water supply services have helped Batam Island maintain a positive investment climate, particularly for the industrial and commercial customers that are a relatively significant portion of ATB’s customers (23 percent).

Lessons Learned

In both utilities, the successful implementation of NRW reduction and energy efficiency was supported by the following key factors:

- National mandate and support from the central and local government to reduce NRW
- Strong and consistent management commitment
- Sufficient investment budget and an investment prioritization plan
- Well-planned and constructed infrastructure
- Appropriate methods based on best practices and supported by technological innovation
- Human resource development to support the program

Reducing NRW is not an objective that can be accomplished in the short term. It requires a holistic approach and a change in the culture of a utility. An NRW reduction program should be integrated into the overall operation and management of an institution, and a special working unit fully dedicated to NRW reduction should be established and embedded as an official part of a water utility’s organizational structure.

Stakeholder engagement is needed to fully support the implementation of NRW reduction.

Implementing a comprehensive NRW reduction strategy by establishing DMAs and applying the pressure management method has been proven more effective and efficient compared to the ad hoc “find and fix” method. However, the implementation of pressure management requires comprehensive
planning and good operational alignment between the production and distribution units of a utility. In addition, pressure management should be supported by a valid and accurate data and information system.

The implementation of a SCADA system played a very important role in both Tugu Tirta’s and ATB’s efforts to reduce NRW and improve operational management. The integration of GIS with SCADA allowed the SCADA system to be more optimal because it can represent the actual network map, PRV, reservoir, and location of the data logger.

As shown in both cases, the return on investments in NRW reduction are high. The implementation of NRW programs should be always considered before investing in new infrastructure. In many utilities, the investment in new treatment plants or in new water catchments cannot be justified if the amount of water wasted is high.

Notes

1. See a 2019 report of Badan Peningkatan Penyelenggaraan Sistem Penyediaan Air Minum (BPPSPAM), which collaborated with BPKP (acting as an independent auditor) to evaluate the performance of 380 public water companies owned by local governments.

2. The benefit of the economic analysis is based on the water tariff, as all the water saved from the NRW program is being sold.

Background Documents


