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INITIAL ASSESSMENT

Energy Efficiency & Nonrevenue Water

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List of Abbreviations

ADB	Asian Development Bank
AMR	Automated meter reading
B&C	Billing and collection
CAPEX	Capital expenditures
DBOM	Design, build, operate, and maintenance
DMA	District metered area
DMZ	District metered zone
DOC	Direct online
EE	Energy efficiency
E/M	Electrical and magnetic
EMF	Electromagnetic flow
EPA	Environmental Protection Agency
ESMAP	Energy Sector Management Assistance Program
FIT	Feed-in tariff
GIS	Geographic information system
HR	Human resources
IT	Information technology
IWA	International Water Association
JMP	Joint Monitoring Program
MCC	Motor Control Center
MoC	Ministry of Construction
NRW	Nonrevenue water
O&M	Operation and maintenance
OPEX	Operational expenditures
PBC	Performance-based contracting
PLC	Programmable logic controller
PM	Prime minister
PPC	Provincial Peoples Committee
PPIAF	Public–Private Infrastructure Advisory Facility
PRV	Pressure-reducing valve
Q&P	Flow and pressure

SAWACO	Saigon Water Supply Corporation
SBR	Sequencing batch reactors
SCADA	Supervisory control and data acquisition
SDG	Sustainable Development Goal
SOE	State-owned enterprise
UNICEF	United Nations International Children's Emergency Fund
UFW	Unaccounted-for water
VWSA	Vietnam Water Supply and Sewerage Association
WHO	World Health Organization
WLC	Whole-life cost
WSP	Water and Sanitation Program (World Bank)
WTP	Water Treatment Plant
WTW	Water treatment works
WwTW	Wastewater treatment works

Note: All dollar amounts are U.S. dollars unless otherwise indicated.

Executive Summary

To come

Policy note to be drafted based on the report. The policy note will provide the basis of the exec summary

Chapter 1

Introduction

1.1 Improving Nonrevenue Water and Energy Efficiency

Reducing nonrevenue water (NRW) and increasing energy efficiency improves outcomes for consumers and water utilities in three important and inter-connected ways by:

- Reducing the costs of providing water and wastewater services.
- Improving service levels for consumers
- Enhancing the capacity to fund much-needed investments

In recent years, Vietnam has made remarkable progress in increasing access to improved water supply and sanitation services. Despite the achievement, the water sector still faces challenges in meeting the future demand associated with rapid socioeconomic development and population growth. Inefficiencies and quality deficiencies remain high in the sector. Among the drains on efficiency are high energy consumption and water losses.

The water sector encompasses highly energy-intensive processes (e.g., pumps, motors, and other equipment operating 24 hours a day, 7 days a week). The energy costs incurred by the water and wastewater systems account for a significant proportion of total operating costs (Environmental Protection Agency [EPA] 2013; Ostojic et al. 2013). In Vietnam, it is estimated that the average energy cost of water utilities is approximately 35 to 40 percent of the total operating expenditures for the utilities. The rate of average specific energy consumption of the water supply system is approximately 0.2 to 0.5 kilowatt-hours per cubic meter. Given that the energy use is expected to rise due to urban expansion, population growth, increasing demands for higher-quality services, and stricter water quality and environmental regulations, there is increasing pressure for water utilities to become efficient and financially self-sufficient.

Excessive NRW is another large drain on the efficiency of a water utility. NRW is water that is lost through leaks and water supplied to customers but not invoiced to customers. Reducing technical loss (leakage) improves services to customers. It conserves water resources, increasing the ability to supply customers with water, and reduces the need to manage leakages through reduced water pressure. While technical loss is the main cause of NRW, commercial losses are also significant. It seriously affects the financial viability of water utilities through lost revenues, additional energy consumption for distribution, and increased operational costs. In Vietnam, NRW was estimated at approximately 30 percent of the water supply in 2009, nowadays it stands at [--]. In some cities, NRW is as high as 75 percent (Asian Development Bank [ADB] 2009), and nowadays it ranges between 6-45%.

The recent sector strategy in Vietnam highlights the need for utilities to achieve full cost recovery. Improving energy efficiency (EE) and reducing NRW are important tools to help increase revenue and reduce operational expenditure, thus increasing the efficiency and financial performance of water utilities.

Recent studies indicate that energy consumption in most water systems worldwide could be reduced by at least 25 percent through cost-effective efficiency actions alone (Ostojic et al. 2013; Van den Berg et al. 2011). For example, a water pump improvement project (implemented in 2007) at a Brazilian water treatment plant reduced energy consumption by approximately 33 percent (Liu et al. 2012). The savings achieved indicate a simple payback period of less than 4 years. In Mexico, optimization of the water distribution network contributed to a 27 percent reduction in electricity use (with a payback period of 1.9 years). Recent research by Liemberger and Wyatt, presented at the Water and Development Congress in Buenos Aires and currently under review for journal publication by the International Water Association, highlights the seriousness of the global NRW problem. Liemberger and Wyatt estimate the global volume of NRW at 346 million cubic meters per day, or 126 billion cubic meters per year. In terms of financial implications, this amounts to over $39 billion per year slipping through the cracks.

Improving EE and reducing NRW are thus important steps toward financial sustainability and universal access and are particularly crucial as policy makers focus on how to deliver the Sustainable Development Goals (SDGs).

1.2 Context for Reform: Support and Constraints

The Vietnamese government has recognized the importance and potential benefits of reducing NRW. Prime Minister (PM) Decision 2147/2010/QD-TTg provides hard targets for NRW reduction (18 percent by 2020). Substantial progress is being mad but achieving the targets for NRW is challenging due to the budgetary constraints and a lack of technical capacity in water utilities. In comparison, the awareness of the importance of EE management is just at the beginning stage. The Socioeconomic Development Plan (2011–15) emphasizes the need for better environmental protection and stresses EE in the water and sanitation sectors (ADB 2009), but the ability of utilities to pursue EE opportunities by utilities is limited by governance, technical knowledge, and financing constraints. Utilities lack of capacity to identify and develop EE improvement projects and limited financing resources are available for the up-front capital expenditure. In addition, significant gaps in information and data remain in the sector. With the exception of NRW, other measures for EE in the water sector are not yet included in the benchmarking of system performance. Even for NRW, the reliability of the data is questioned.

Since 1997, the World Bank has provided support in urban water supply and wastewater management through eight projects, with a total lending amount of approximately $1 billion. The integration of EE improvement in the projects has been limited. There are only a few projects that focus on the reduction of NRW in cities in Vietnam.

1.3 Sector Context

The water supply industry in Vietnam covers 63 provinces, including 780 towns and cities. Approximately 81 percent of the urban population of the country is served by a centralized water supply, and the urban water treatment and distribution systems in the country have a combined capacity of approximately 7.5 million cubic meters per day. Across the country, there are approximately 650 urban water supply systems, operated by 100 separate utility companies. Domestic water quality standards are set by the central government. There are 111 urban water companies in Vietnam, with a combined installed capacity of 5.9 million cubic meters per day, but the current operating capacity is 4.5 million cubic meters per day (77 percent of the designed capacity) (World Health Organization [WHO] and United Nations International Children's Emergency Fund [UNICEF] 2012). The government aims to add more water and wastewater infrastructure to improve water and sanitation access. It is estimated that the government would need to spend $1.8 billion per year in the sector to achieve the service level standards. Efficiency gains in NRW and energy use would be useful for the planned sector-development strategies.

Equitization has been the key element in the restructuring of the sector in recent years. New Decree 15/2015 encouraged the cooperation of the public and private sectors in the development of urban water treatment, with 100 of the 111 urban water supply utility companies undergoing some form of equitization. Currently, only approximately 10 percent of water companies are not yet equitized, including companies in Hanoi and Ho Chi Minh City (Vietnam Water Supply and Sewerage Association [VWSA] 2018).

Importantly, the water industry is a key consumer of electrical energy. The Ministry of Construction (MoC) has developed cost norms (i.e., benchmarking values for the energy consumed by water treatment processes) that all utilities are required to benchmark themselves against. These norms are presented in Decision 590/QD-BXD and are discussed in more detail in the main report. The Government has also prioritized reducing NRW. PM Decision 2147/2010/QD-TTg set out the goals of reducing the sector average unaccounted-for water (UFW) and NRW from 30-31% in 2010 to:

- 25% by 2015
- 18% by 2020
- 15% by 2025

The PM decision also provides various guidelines for utilities in grade II cities**.** The most important elements are the establishment of an NRW unit and the restructuring of the network into district metered areas (DMAs) to enhance NRW management.

The process for the collection and treatment of urban wastewater in Vietnam is in its early stages of development, with few areas of the country having any centralized systems in place. Only 45 municipal wastewater treatment plants were in operation as of November 2017, with a combined treatment capacity of 750,000 cubic meters per day. A further 30 plants are planned or under construction, with a capacity of 1.5 million cubic meters per day. Ninety percent of households are currently served by septic tanks. In comparison, 65 percent of industrial zones have centralized wastewater treatment. Currently, EE in wastewater treatment is not a concern for most of the utilities in Vietnam because the government covers most of the cost. As the sector develops, it is anticipated that the subsidies will decrease, and the EE of wastewater treatment will become much more important to the financial performance of the utilities and impact tariffs for consumers.

There is no centralized formal system of regulation of tariffs, reducing the incentives for the water utilities to improve NRW and EE. While a circular has been issued to guide the determination of tariffs there are questions in regard to its implementation. Tariffs are determined by the utilities and the local Provincial Peoples Committees and the extent to which the water utility benefits financially from reductions in NRW and improvement in EE over the medium to long term is unclear.

1.4 PBC for NRW Management

Castalia (2019)[1] examined the options for improving NRW management using Performance Based Contracting (PBC). PBCs can be extended to cover EE as well as NRW, and combine the setting and monitoring of targets with outsourcing delivery under strong financial incentives. This report recommends to further explore the use of PBC within a strengthened regime for setting targets and monitoring performance.

1 Castalia, Preliminary Business Case: Developing Options for the Government of Vietnam to Establish a Funding Facility for Nonrevenue Water Projects, Final Report, July 2019

In NRW management, PBC is a method for outsourcing technical, commercial, and construction activities related to NRW reduction that provides the contractor with incentives to achieve the desired results. Such a program for NRW reduction and EE improvement would adopt the approach of PBC. Initially the program would be implemented in selected cities and, if successful, then rolled out nationally. The specific objective of such a program would be to improve Vietnam's ability to effectively analyze and implement PBC for NRW management. This includes reducing the time and cost for preparation of PBC transactions and increasing the number of market participants (suppliers and seekers) active in the market. In the medium- to long-term horizon. This will improve the return on PBC activities in NRW management and better embed ongoing improvements in participating utilities post-PBC.

The program consists of three main components:

- Development of a common business case tool for water utilities across Vietnam
- Identification of potential NRW reduction projects
- Development of a national program

The business case tool will be used throughout different cities in Vietnam to objectively analyze the business case for implementing PBC for NRW reduction in a given area. It will use the revenue data from different utilities across the country and determine the costs and potential return on investment for each city. This will allow the prioritization of the most promising cities for effective PBC for NRW reduction.

Component 2 will develop a pipeline of projects that can be undertaken when the national program is finalized and adopted. This will require a detailed analysis of the different regions and their potential opportunities for NRW management via PBC. The analysis will be transparent with the findings clearly explained in a report. This will help the Vietnamese government to further prepare the details for implementation of the national NRW reduction program. The pipeline of projects can be guided by the business case tool discussed previously.

Cities will be ranked based on their potential for the effective use of PBC. This step will be performed simultaneously with component 3, and the two will inform one another. Component 2 will identify the activities that can reasonably use the national program developed in component 3.

Component 3 will support the implementation of multiple PBC systems in Vietnam. This can be done through financing arrangements, guarantee mechanisms, or other arrangements that attract commercial finance. It will require careful financial analysis to create a fund that guarantees both the payment of utilities and the funds for the PBC program. High cost recovery is anticipated in Vietnam, which should help with the development of this component.

1.5 Objectives of the Report

This report is a key analytical study of the project and is centered on addressing the knowledge gaps and providing technological recommendations on EE improvement and NRW reduction to generate positive impacts in the water sector in Vietnam. The main objectives of the report are to expand and disseminate knowledge on issues related to EE in the water and wastewater sectors and to inform the development of the national program for NRW reduction and EE improvement practices in the water sector in Vietnam. To fully achieve the objectives, the report focuses on performing a rapid assessment of EE and NRW in the water sector in Vietnam, formulating potential areas for NRW reduction and EE improvement in the utilities, and identifying potential candidates for follow-up "deep-dive" studies on EE and NRW.

1.6 Methodology for the Rapid Assessment

The assessment of the report was conducted based on data and information on 18 utilities in Vietnam:

- North Vietnam: VIWACO, Ninh Bình, Thanh Hóa, Phú Tho, Hà Nam, and Lạng Sơn
- Central Vietnam: Lâm Đồng and Quảng Nam
- South Vietnam (Mekong Delta): Bình Dương, Cần Thơ, Saigon Water Supply Corporation (SAWACO), An Giang, Long An, Kiên Giang, Cà Mau, Bạc Liêu, Hậu Giang, and Sóc Trăng.

The data and information were collected by the World Bank team, in close collaboration with the MoC, through questionnaires on EE and NRW, site visits, and interviews with the management and technical teams of the utilities. All utilities completed questionnaires for EE and NRW (appendix D), which were designed by the team and endorsed by the MoC. Two missions to Vietnam were carried out.

The focus of the first mission in April 2018 was to introduce and explain the objective and roadmap of the potential performance-based contracting (PBC) NRW program to seven utilities and the MoC. The utilities were visited between April and July of 2018 (with the exception of Bạc Liêu, Hậu Giang, and Sóc Trăng, which were assessed in May and June of 2019). During the second mission in July 2018, the team visited another group of eight utilities. Direct interviews were held to enrich the information obtained from the returned questionnaires. The first findings of the second mission were presented to and briefly discussed with the MoC.

For each utility, a brief report has been compiled (appendix E). The report includes both energy efficiency (EE) and NRW parameters.

1.7 Report Structure

The report is divided into four chapters. Chapter 1 introduces the EE and NRW assessment program and the objectives of the report. In chapter 2, the results of the rapid assessment for NRW management are presented. Chapter 3 focuses on the assessment of EE in the water and wastewater sectors. Chapter 4 analyses the possibility for a deep dive into the utilities. Summaries of the key laws, decisions and circulars are provided in Appendix A. Appendix B provides a summary of the proposed actions for the utilities, and appendix C provides a summary of key metrics for the utilities. Appendix D provides the EE and NRW questionnaires used in assessing the utilities. Appendix E presents a brief report on the EE and NRW assessment for each utility.

Chapter 2

Rapid Assessment of Nonrevenue Water

2.1 Reducing NRW: Measurement and Benefits

2.1.1 Measurement of NRW and its components

NRW is the difference between the volume of water put into the water supply system ('system input volume') and billed authorized consumption.[2] The figure below sets out the various components of NRW and their sources. The components are:

- **Unbilled authorized water.** This is typically the smallest component and includes, for example, water used for firefighting.
- **Commercial losses**. This is highly variable and includes unauthorized consumption (e.g consumption by users with illegal connections (theft)) and metering/recording inaccuracies.
- **Technical losses**. This covers losses on the supply system between the input point for bulk water and connection points (authorized and unauthorised) of customers. A level of technical losses is inevitable and will vary with factors such as the age of the system.

Figure 2.1: Components of NRW

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption
			Billed Non-metered Consumption
		Unbilled Authorized Consumption	Unbilled Metered Consumption
			Unbilled Non-metered Consumption
	Water Losses	Commercial Losses (Apparent Losses)	Unauthorized Consumption
			Metering Inaccuracies (and data handling errors)
		Technical Losses (Real Losses)	Leakage on Transmission and/or Distribution Mains
			Leakage and Overflows at Utility's Storage Tanks
			Leakage on Service Connections up to Customers' Meters

Source: CEPA

2 This includes estimates of the consumption by billed customers without meters.

In practice, measurement of the components of NRW requires significant estimation. As commercial losses are typically measured as the residual after the other components have been estimated the errors in the estimation of the other components can compound into the estimation of commercial losses.

2.1.2 Approaches to incentivize reductions in NRW

Table 2.1 below sets the various combination of options to incentivizing reductions in NRW. The approaches are not exclusive but build upon each other. Integral to all approaches is the setting of targets in terms of outputs (measured NRW) and/or inputs (specific measurable actions, such as number of new meters installed, leak repairs, km of mains replaced). Incentives can be reputational (public reporting of performance), specific sanctions or rewards for performance relative to the targets, or financial incentives integrated with the regulation of prices/revenues for the water utilities. The strength of the incentives under price regulation depends on:

1. the extent and period for which the benchmark NRW used in setting tariffs is independent of current actual performance; and
2. rules for sharing the revenue increases or cost reductions with customers.

The benchmark may be based on a technical assessment of optimal losses, peer performance or average lagged losses for the utility.

A key component of all approaches is timely, accurate, transparent, and independent monitoring of performance.

NRW reductions can be delivered in-house or out-sourced under any of the approaches. If out-sourced the incentives will depend on the contract with the service provider. The incentives in the contracts can be independent of the mechanism for regulating the utility's tariffs, and any deficiencies therein. Hence, contracts, such as PBCs, can provide stronger and more time-consistent incentives, as well as accessing external financing, skills, and experience.

Table 2.1: Framework for incentives for Reducing NRW

Targets	Inputs	Total	Targets based on: • Past Performance • Optimal Levels • Peer performance
	Outputs	Components (eg commercial, Technical)	
Sanctions	Reputation	Transparent reporting of performance	
	Financial	Penalty only	
		Penalty and reward - symmetric	
		Penalty and reward – asymmetric	
Economic Regulation	Integrated with price and Revenue Regulation	Sharing of benefits Period of retention of benefits	Sharing rules/formulae Basis of target

2.1.3 Benefits of reducing NRW

NRW increases costs for suppliers and customers (though higher tariffs and reduced supply), reduces revenues, and creates inequities in the supply of water. Together these reduce the capacity to fund essential investments and operational improvements to improve services to customers. Hence, reducing NRW to more economic levels should have a high priority, but there are important differences between the benefits of reducing technical and commercial losses. Furthermore, underpricing can create a wedge between the economic and financial valuation of reducing NRW through, for example, meter replacement.

2.1.3.1 Benefits of reducing technical losses

Reducing technical losses can reduce costs and improve services in a number of ways:

- **Reducing utility costs.** Technical losses mean that for a given supply to customers the utility must access, treat, and transport more bulk water. This increases bulk water costs, treatment costs, and pumping costs. A key component of the higher pumping costs are higher energy costs. By reducing costs, reductions in technical losses will increase the utility's cash flows, and capacity to finance investment, and/or reduce tariffs (depending on how these losses are treated in setting prices).
- **Increasing supply to customers.** Where there is limited bulk water supplies or constraints on treatment and distribution systems, higher technical losses can result in customers going unserved or facing extended supply interruptions. This increases the cost to households of obtaining the clean water needed, and health costs if alternative supplies are of lower quality. Typically these costs are considerably higher than the costs of reticulated supply of clean water if adequate volumes were available. If the reduction in technical losses increases the capacity to supply water it also increases the revenue base for the utility, increasing the capacity to finance new investment.
- **Increasing pressure (service quality).** One means of managing excess technical losses is to reduce pressure. Reducing technical losses allows pressure to be restored to more normal levels.

2.1.3.2 Benefits of reducing commercial losses

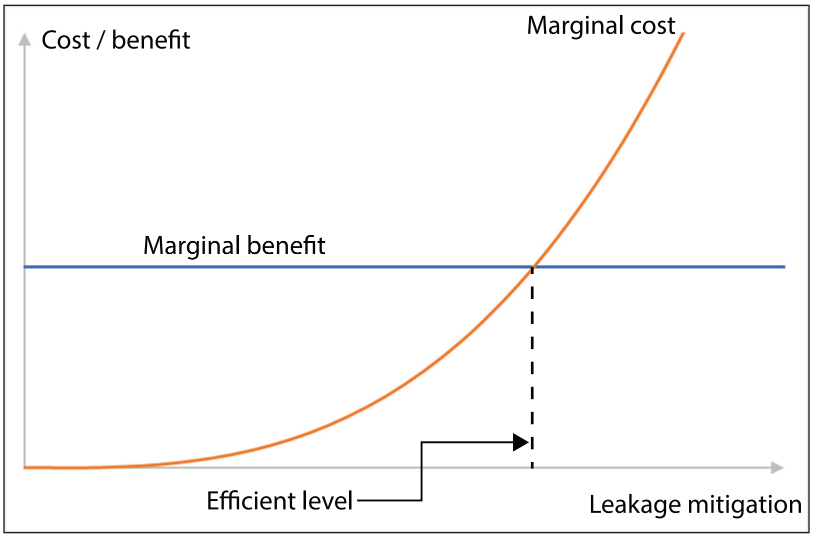
Reducing commercial losses can improve cash flows and services in a number of ways:

- **Increasing the revenue base for the utility.** Commercial losses reduce the revenue base for the utility but it still incurs the cost of providing the water consumed by those users. Depending on how these losses are treated in setting prices, reducing commercial losses will increase the utility's revenues (and capacity to finance investment) and/or reduce tariffs for other users.
- **Increasing the equity of water supply.** Commercial losses increase the tariffs for other customers: in effect other customers have to pay for the costs of supplying water to customers with illegal connections.
- **Increasing the efficiency of water use.** Illegal connections increase water wastage or inefficient use of water in two distinct way. Firstly, the quality of illegal or informal connections may be lower and more prone to leakage. Secondly, because users are not paying for the water received they may be less concerned to use it carefully and, for example, fix leaks. In both cases, reducing commercial losses also reduce the costs for the utility of supplying water.

2.1.3.3 Economic levels of losses

Companies should reduce technical losses until the Economic level of Leakage (ELL) is reached: that is the point at which the marginal cost of additional loss reduction exceeds the marginal benefit.

Figure 2.2: Illustration of Economic Level of Leakage



Source: CEPA

If leakages do no constrain supply to users this involves the identification of the marginal costs of leakage (eg additional costs of bulk water, treatment and distribution). Typically the evaluation will focus on the financial costs to the utility and the marginal costs of losses will be less than the average cost. If tariffs are set to recover actual costs, reducing technical losses to the ELL will lower customers' bills because the costs saved exceed the costs of reducing leaks.[3]

Where leakages constrain supply to users – due to limited bulk water supplies/system capacity and capacity to finance new investments – the benefits of reductions in technical losses can be significantly greater. In this case the relevant marginal benefits are the benefits to consumers from increased supply, rather than the reduction in costs for the utility. These include the health benefits from access to clean water and the reduced costs of accessing alternative clean water sources.

Whereas determining the economic level of technical losses rests on the benefits of reduced costs for the utility or consumers, the benefits from reduced commercial losses primarily come from the recovery of foregone revenues. The test is whether the cost of reducing the commercial loss is less than the revenue foregone: e.g is the cost of replacing meters earlier less than the additional revenue from meter errors? In this case the calculation is affected by the level of tariffs. If the tariffs are below full cost recovery, a longer meter replacement cycle will be optimal.

2.2 Legal and regulatory framework for Nonrevenue water in Vietnam

Consistent with the importance of reducing NRW, the national legal framework under which the water utilities operate establishes obligations to manage NRW and sets targets for the average NRW of:

- 25% by 2015
- 18% by 2020
- 15% by 2025.

3 A social economic evaluation will include externality benefits such as reductions in carbon emissions from reduced energy usage and would support a lower ELL that may, at the margin, increase bills. That is, going from current technical losses to the financial ELL reduces bills, but reducing losses beyond this to the full ELL may increase bills relative to the bills at the financial ELL.

The targets and obligations are set by the GoV and the MOC is responsible for monitoring performance against the obligations and targets. However, the framework does not specify how NRW is to be reduced nor provide specific incentives or sanctions for the achievement, or non-achievement, of the NRW targets. The water utilities are in the process of being equitized, with 101 of the 111 utilities undergoing some degree of equitization. In principle this should strengthen the capacity of the sector to respond to financial incentives where these are well-defined.

The obligations to manage NRW are set out in:

- *Law No.17/2012/QH13 dated June 21th, 2012, on Water Resources* which requires utilities to manage water resources to ensure the "economical and efficient use of water. This would require utilities to reduce NRW to economically efficient levels (i.e. to the point where the costs of further reductions exceed the benefits). However, the law does not include specific provisions in regard to the management of NRW.
- *Decree No.117/2007/ND-CP, dated July 11th, 2007, on water production, supply and consumption* which requires all those engaged in water supply to "work out programs against unaccounted-for water and non-revenue water, adopt contracting and rewarding mechanisms while setting the maximum levels of unaccounted-for water and non-revenue water eligible for inclusion into production costs so as to encourage water supply units to operate with efficiency." (Article 51.7)
- *Decree No.124/2011/ND-CP, dated December 28th, 2011 on amendments and supplements to a number of articles of Decree No.117/2007/ND-CP* which requires that planning for water supply include consideration of the rate of unaccounted-for water and non-revenue water (Article 1.6).

The targets for NRW are set out in

- *Decision No.2147/QD-TTg dated November 24th, 2010 of Prime Minister, approval of national unaccounted-for water (UFW), non-revenue water (NRW) program to 2025*. This decision requires utilities to reduce UFW/NRW from an average of 30% in 2009 to below 15% by 2025. The targets are expressed as sector-wide targets rather than as targets for individual utilities. The decision does not specify a target for each utility and its enforcement is not clear.
- *Decision No.2502/QD-TTg, dated December 22nd, 2016 of Prime Minister, approving adjustments to the development orientations for water supply for urban areas and industrial parks through 2025, with a vision toward 2050*: This decision disaggregates the target set in Decision No.2147/QD-TTg. Utilities in in urban areas of grade IV are to reduce UFR and NRW to less than 18% by 2020, while for in grade-V urban areas the target is under 25%. The target of under 15% by 2025 was unchanged. The Decision provides for priniciple norms but does not set specific strategies, approaches or mechanisms for achieving the targets.

MOC is required to develop a National program for the management and development of water resources having regard to, among other matters, the UFW/NRW targets set by the GoV.

The principles for setting water tariffs are set out in *Joint Circular No.75/2012/TTLT-BTC-BXD-BNNPTNT dated May 15th, 2012, of Ministry Of Finance - Ministry Of Construction - Ministry Of Agriculture And Rural Development***.** The Circular specifies that tariffs should recover the reasonable costs of supply of water (including 'reasonable profit norms'). Tariffs should consider the interests of both the utilities and consumers and provide incentives to undertake necessary investments, reduce water losses, and encourage efficient use of water. The water utilities estimate the tariffs necessary to recover its costs, having regard to cost frames set by the MoF. The MoF, in coordination with MoC and Ministry of Agriculture and Rural Development (MARD), may appraise the utility's assessment of reasonable costs. The utility submits the proposed tariffs to the PPC for approval. If the tariff set by the PPC is below the tariff necessary to cover appraised reasonable costs the PPC should fund the gap in revenues.

These principles allow the possibility of strong incentives to reduce NRW. PPCs need not allow for actual losses in determining tariffs. Instead PPCs can use a benchmark, such as an assessment of the efficient level of losses. Using a benchmark rather than actual losses can provides a powerful incentive for the utility to reduce NRW: i.e. the utility retains the financial benefit of any reduction in NFR for a specified period or indefinitely.[4] The Circular specifies presumptive limits to the NRW percentage based on eth age of the network and requires the PPCs to have regard to the targets set by the GoV in determining the NRW allowance in setting tariffs.

What can we say about the application of these principles by PPCs? The text suggests doubts re how the PPCs have implemented this?

The relevant laws, decisions and circulars are summarized in Appendix A.

2.3 Review of the National Non-revenue Water Reduction Program implementation

This section sets out the current NRW program to achieve the targets set by the GoV and the reduction in NRW under this program. Details of the activities undertaken by the 18 utilities reviewed are provided in Annex E.

2.3.1 Brief outline of the program

This section is quite brief– is it possible to provide a bit more on the current activities to give a better understanding of what is currently being done?

The National NRW reduction program consists of five key activities

- Improve public awareness about NRW
- Improve capacity of the local governments in management of water distribution network to reduce NRW
- Improve capacity of the water utilities in management of water distribution network to reduce NRW
- Develop policy framework for NRW reduction, and
- Implement NRW reduction projects.

Program implementers include:

- MoC, the Government agency in charge of water supply service, managing the program
- PPCs, being responsible for development of NRW reduction plans and targets for their provinces, approving tariffs, and managing the implementation of these plans, and
- Water utilities, who are the owners of water networks, being responsible for planning and implementing NRW reduction projects to achieve the targets set by PPCs.
- A Central Steering Committee (CSC), established by the Prime minister, responsible for directing the development of annual and five-year program implementation plans and reviewing, monitoring and supervising Program implementation in the provinces. MoC is a permanent member and chairman of the CSC.

Various funding sources will be needed for the investment in capex and improved operations to achieve the reduction in NRW. The PM Decision 2147/2010/QD-TTg indicates that the funding sources that will need to be

4 Depending on the extent to which future benchmarks reflect past performance.

mobilized include state budgets, ODA, credit and other sources of capital for NRW reduction activities. Priority is to be given to large urban centers and water supply companies with high NRW rates.

2.3.2 Summary of outcomes of the program:

The Rapid Assessment has found that substantial reductions in NRW have been achieved, but NRW levels are slightly above the trend required to achieve the 18% target for 2020. The program has achieved a significant awareness of NRW as an important issue and built the capacity of stakeholders to address it. However, there are still many mechanisms and policies which could be implemented and could increase the effectiveness of the program. This will be important as further reductions in NRW may become more difficult to achieve.

2.3.2.1 Reduction on NRW

The average level of non-revenue water decreased from 30-31% in 2010 to about 21.5% in 2018 (see table below). Generally, under the instructions of relevant ministries and local administration over the recent years, most of the NRW targets of the Program have been achieved and some are exceeded.

Table 2.2: Performance indicators compared to the expected targets

Performance indicators	2010 (4)	2018 (4)	2020 (targets)
Total capacity of urban water supply (million m3/day)	6.1	9.0	*9.4 -9.6 (1)*
Rate of urban population supplied with water (%)	76	86	*90-95 (2)*
Average water consumption (L/person/day)	95	115	*120 (2)*
Average NRW ratio (%)	30-31	21.5	*18 (3)*

Notes: (1) According to calculations; (2) According to Adjusting Orientations Decision No. 2502; (3) According to Decision No. 2147 approving the Program; (4) Survey

NRW performance still varies widely between utilities. Water utilities have achieved very positive results, such as Binh Duong Water and Environment Joint Stock Company with the NRW rate of 6.1%; and companies like Ba Ria - Vung Tau, Thua Thien Hue, Hai Phong, Hai Duong, Bac Ninh, Bac Giang which have NRW levels of about 13-15%. However, some companies still have high NRW rates such as Nghe An, Dien Bien, and Lang Son Water Supply Joint Stock Company with about 29-34%. The study has not identified specific characteristics of the utilities that can explain relative performance. In the absence of such factors performance may be more strongly related to the capacity and commitment of the management of the utilities. This in turn focuses the policy proposals on capacity development and strengthening incentives/ governance frameworks.

2.3.2.2 Review of effectiveness of the program

Community awareness raising

Through the communication tools, conferences and seminars, the Program information has been disseminated to many audiences, ranging from the authorities, agencies, consulting and training institutes, to the communities. However, results from the rapid NRW assessment of the 18 utilities show that utilities' community awareness programs are very rudimentary, mostly limited to complaint handling.

Capacity building of Local Government

Through conferences, workshops and through meetings with local authorities and authorized agencies (working with over 30 provinces during 2010-2017), there has been a shift in awareness. Local authorities have worked more closely to set up a Provincial Steering Committee for improving NRW mitigation, setting water prices, ensure funding for, or calling for, investment in the water sector.

Develop and consolidate mechanisms and policies on NRW mitigation

After nearly 10 years of implementing the Program, many new regulations have been issued, researched, revised, adjusted and gradually improved, as synthesized in the legal basis (Law on Water Resources, Decree 124/2012; Decision No. 2502; Decision No. 1566; circulars guiding water prices, Ensuring water safety...). However, there are still many mechanisms and policies, which have not been studied and promulgated but could enhance the effectiveness of the program activities and support to the utilities. These include:

- **Development of water sector evaluation criteria and reporting regime for the management and supervision of water supply activities**. The NRW-reduction performance of the utility is mostly reported with one parameter (i.e. NRW in percentage only) and the estimates were often difficult to validate. Reporting only one parameter is "scratching the surface" of the NRW performance of an utility as a whole. It provides limited insight on how NRW management is embedded in the utilities. Nor is it possible to evaluate if the achieved NRW reduction is potentially sustainable. The information is insufficient for MOC to assess the effectiveness of policies and mechanisms. Furthermore, the lack of an appropriate reporting framework and regime does not incentivize utilities to develop an internal monitoring and diagnostic capability. In many cases it appears that utility's capability to plan and implement NRW programs is very rudimentary. The rapid assessment showed that essential asset management programs virtually are non-existent. Nearly all 18 utilities cannot differentiate the prevailing NRW-level between apparent (commercial) and real (technical) losses. The practice in the international water industry is that this differentiation is a starting point for designing cost effective NRW-reduction interventions.
- **Development of incentives for water utilities to reduce the NRW ratio.** It is unclear how the utilities are incentivized to reduce NRW and sustain the reduced NRW-level. In this context it should be noted, that contractual arrangements between PPCs and utilities still need to be formalized. This contractual arrangement is an important key to incentivize the utility to perform efficiently, and therefore should include key performance indicators and reporting frameworks for NRW management. At present the local governments have not implemented incentive mechanisms for utilities to reduce NRW. There are various ways to incentivize utilities to reduce and manage NRW. For example, the relation between tariff increase or dividend pay-out and NRW performance could be used as a potential incentive mechanism.
- **Development of mechanisms to encourage water utilities and private sectors to invest in improving the pipeline network, managing the network and preventing NRW.** Creating financial incentives to reduce NRW (see above), together with ensuring pricing is cost reflective, can be an important step in providing a better financial basis for investment for NRW reduction. However, it the sector also needs to tap into private sector resources and capability. Equitization will increase access to private funds and strengthen the responsiveness of the utilities to financial incentives. PBC can also play an important role in increasing access to capabilities outside Vietnam's water sector.

- **Development of preferential mechanisms and financial support for projects aiming to reduce NRW.** The rapid NRW assessment of the 18 utilities revealed that the utilities do not have a strategic NRW-management plan that includes a (bankable) investment plan for NRW reduction. Such a strategic plan is required to be eligible for financial support but the current framework does not provide the drive to do so or the funding required. The interviewed utilities indicated, that apart from their own resources, access to external financial instruments is very limited. A better governance and regulatory structure can provide incentives to reduce NRW and the financial returns that can help fund the necessary investments.
- **Development of a reward regime** for individuals who detect and inform water leaks and incidents, sanctions against organizations and individuals that commit water fraudulence, such as not paying water tariff or damaging the pipelines.

2.3.3 Observations from Rapid Assessment of 18 Utilities

2.3.3.1 NRW Levels and Components

Table 2.3 presents a summary of the performance of NRW management and the estimated distribution between real (technical) and apparent (commercial) losses.[5] The levels of NRW real and apparent losses are presented in liters per connection per day (l/conn/day), showing the actual volume of distributed water that was not billed.[6] The volume of water distributed (i.e., system input) in cities varies between 795 and 1,333 liters per connection per day, with the system inputs of Lạng Sơn and Long Xuyên being particularly low.[7]

NRW in most cities varies between 200 and 300 liters per connection per day. In two cities, Cần Thơ and Rạch Giá, the NRW is well above 300 liters per connection per day. This is above the level of international good practice and requires attention.

The NRW level in the whole province of Bình Dương is one of the lowest. As a percentage, NRW is reported to be 6 percent; however, based on the data provided, the calculated NRW is 7.5 percent, which is equivalent to 109 liters per connection per day[8]. Factors specific to Bình Dương may contribute to the low NRW: the connection density is low (60 connections per kilometer) and the volume of nondomestic water billed accounts for 60 percent of the total billed. The number of nondomestic connections is 25 percent of the total number of connections. This percentage implies a system consisting of many commercial customers with a large volume delivered per customer, which facilitates NRW performance. While the circumstances are favorable, overall NRW performance is good, and if applicable, best practices from this utility should be replicated, based on experiences in the capital of the province, Việt Trì. Five utilities have NRW levels, expressed in percentages, above the national NRW target of 2015 (from Prime Minister [PM] Decision 2147/2010/QD-TTg).

5 Quantitative data for the provincial capital from four northern utilities were not made available; these are Phú Tho, Ninh Bình, Thanh Hóa, and VIWACO.

6 Because the utilities have different levels of system input (in liters per connection per day), NRW levels presented in percentages obscure the actual level of NRW.

7 It is suggested to verify the annual volume of water distributed in a later stage.

8 The reported NRW of 84 liters per connection per day for Bạc Liêu is not considered realistic, see Appendix A.

Table 2.3: Nonrevenue Water Management Performance of 18 Utilities

Utility	Water supply system	Total connections	System input	Nonrevenue water		Real losses	Apparent losses
		No.	l/conn/day	l/conn/day	%	l/conn/day	
Cần Thơ	Cần Thơ	60,000	1,333	393	29.0	317	76
Kiên Giang	Rạch Giá	50,000	1,016	304	30.0	226	78
Lạng Sơn	Lạng Sơn	27,000	795	298	37.5	230	68
Long An	Tân An	17,500	1,303	276	21.0	176	100
Lâm Đồng	Đà Lạt	57,326	1,012	273	27.0	205	68
Hà Nam	Phủ Lý	40,500	988	267	27.0	181	86
Cà Mau	Cà Mau	39,200	994	234	23.5	159	74
Quảng Nam	Tam Kỳ	19,081	1,043	229	22.0	146	84
SAWACO	HCMC	1,378,023	890	206	23.0	159	47
Bạc Liêu	Bạc Liêu	27,751	759	84	11.0	4	80
Hậu Giang	Province	52,599	637	124	19.5	87	37
Sóc Trăng	Province	84,254	712	110	15.4	27	83
An Giang	Long Xuyên	72,166	897	177	19.7	72	105
Bình Dương	Province	229,352	1,465	109	7.4	58	51
Phú Thọ	Province	126,528	552	99	18.0	66	33
Ninh Bình	Province	-	-	-	-	-	-
Thanh Hóa	Province	-	-	-	-	-	-
VIWACO	Hanoi	-	-	-	-	-	-

Source: Individual utility assesments
Note: SAWACO = Saigon Water Supply Corporation

Utilities provided estimates of the split between apparent and commercial losses but it is important to note that:

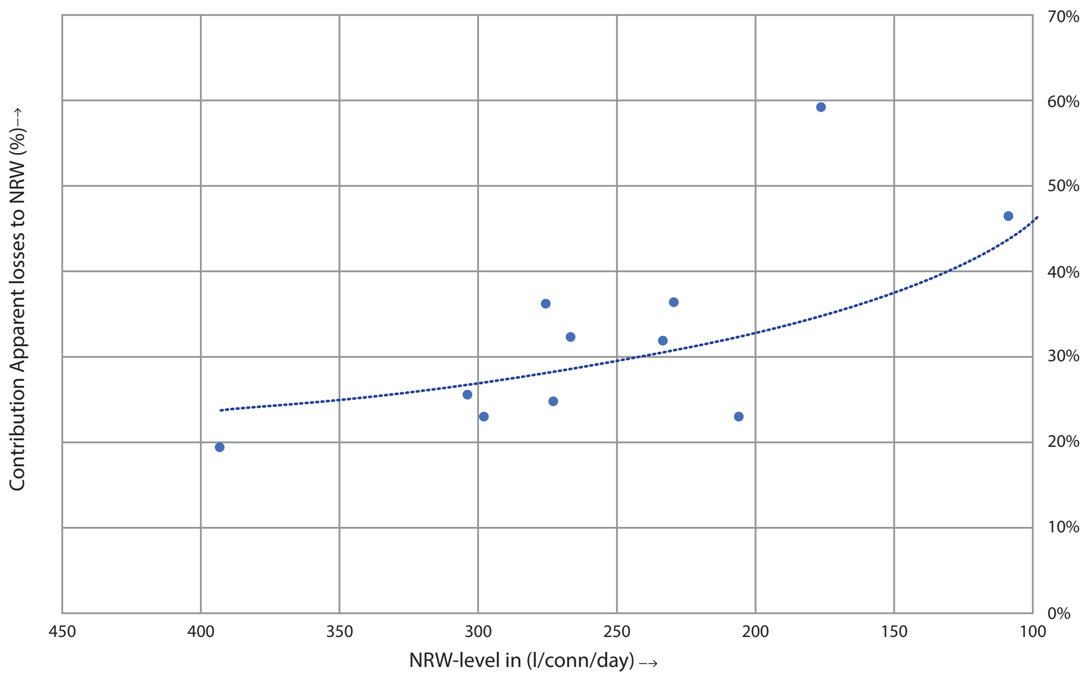
- the estimates of apparent losses may be subject to significant margins of error and systematically understated. Estimates of commercial losses are a residual after the estimates of the other components of NRW have been deducted from the gross estimate of NRW for the other steps of the billing process was assumed.
- the utilities do not normally estimate, and therefore are not aware of, the current distribution between apparent and real losses and the economic level of these components. Insight into this distribution is a prerequisite for prioritizing intervention strategies.

Based on the estimates provided apparent (commercial) losses in the (large) city systems vary between 47 and 105 liters per connection per day, or between 20 and 95 percent of the reported NRW. The calculated 60 percent and 95 percent contribution of apparent losses to NRW in Long Xuyên and Bạc Liêu, respectively, are unrealistically high.[9] Apparent (commercial) losses in four provinces vary between 33 and 51 liters per connection per day, or between 35 and 50 percent of the reported NRW. It can be concluded, however, that real losses still largely contribute to the prevailing NRW levels, varying between 145 and 317 liters per connection per day (excluding Long Xuyên and Bạc Liêu). Possible main causes are discussed in the sections below.

As presented in Figure 2.3, the contribution of apparent losses becomes more dominant at lower levels of NRW. This may reflect the absence of a correlation between the levels of real and apparent losses.

9 The reported low level of system input and NRW levels of Long Xuyên and Bạc Liêu need to be verified.

Figure 2.3: Contribution of Apparent Losses to Nonrevenue Water for 12 Utilities



Source: Calculated based on data from individual utility assessments

2.3.3.2 International Benchmarks for NRW

The guidelines of the NRW Task Group of the International Water Association (IWA) were used as a reference to assess the technical performance of the networks. The level of real losses per meter water pressure was calculated, and the technical performance category was determined, as presented in Table 2.4. Losses are calculated relative to pressure as there is trade-off between water pressure and losses.

Table 2.4: Technical Performance Category

Real losses		Recommendation
Category L/conn/day/m		
A	1-5	Further loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost-effective improvement
B	5-10	Potential for marked improvements; consider pressure management; better active leakage control practices, and better network maintenance
C	10-20	Poor leakage record; tolerable only if water is plentiful and cheap; even then, analyze level and nature of leakage and intensify leakage reduction efforts
D	>20	Horrendously inefficient use of resources; leakage reduction programs imperative and high priority

Source: IWA Nonrevenue water task group

The results show that the technical performance of the networks of most utilities is poor (categories C and D).[10,11]

Table 2.5: Listing of Utilities by IWA Performance Category

IWA Category	Utility	Real Losses (l/conn/day)
A	An Giang	72
	Bin Durong	58
	Phu Tho	66
	Soc Trang?	27
	Bac Lieu ?	4
B	Ha Nam	181
	Ha Giang	87
C	Lang Son	230
	Ca Mau	159
	Quang Nam	146
	SAWACO	159
D	Long An	176
	Lam Dong	205
>D	Can Tho	317
	Kien Giang	226

2.3.3.3 Strategic planning for NRW Management

Currently, the utilities are gearing up their NRW management efforts to reach the national target. Most utilities do not operate on the basis of a comprehensive and endorsed 5-year rolling NRW strategy plan, which has requirements for operating expenditures (OPEX) and capital expenditures (CAPEX), as described in box 2.1. The strategic plan for NRW management should preferably feed into a utility's business plan. An NRW strategy plan could be useful to mobilize funds, which is recommended in Article 1 of PM Decision 2147/2010/QD-TTg.

Box 2.1: Strategy Plan for Nonrevenue Water Management

The NRW management strategy plan is a 5-year rolling plan in which the utility's strategy for NRW reduction and management is formulated and prioritized. The plan is a source document used to operationalize intervention strategies (with underlying actions) in the utility's business plan. The NRW management strategy plan is also an important source document for the asset management plan and for use in financial planning. The strategy plan is annually updated in parallel with the business plan and asset management plan. At a minimum, the NRW management strategy plan should address the following topics:

10 The estimation for An Giang and Hà Nam requires further validation of data.

11 Due to incomplete information, a cross-check between the technical performance category and the annual rate of burst/leaks repaired per kilometer could not be made.

- NRW targets with timeline, based on analysis of economically optimal NRW level
- Intervention strategies with sets of prioritized actions
- Factors or actions that are or can be outsourced
- Organizational responsibilities and requirements to manage NRW
- Human resources and capacity-building requirements
- OPEX requirements
- Investment (CAPEX) plan
- Monitoring and reporting framework
- Planning and/or phasing of interventions

The absence of appropriate asset management policies is mostly due to budget constraints. The technical management of the network is very limited. Regular replacement projects are budget driven[12] and are not based on essential asset management principles, such as policy development using, for example, comprehensive data on leaks and bursts. In this context, it should be noted that 5 of the 18 utilities have implemented a geographic information system (GIS). Various utilities indicate that the working procedures to record and update data for the mains and connections with a GIS tool need to be improved.

Most of the utilities have a relatively young network, with an average age in the cities of less than 21 years (see Table 2.7). The exception is Da Lat, of which approximately 90 percent of the network is older than 21 years.[13] In general, it can be stated that. A few utilities have implemented major replacement projects in their networks during the last 10 years, and rapid urbanization and industrialization have induced extensions of the networks. Extensions of the networks are installed by the utilities and by project developers and It is generally felt by the utilities that the quality of construction is poor, particularly in cases where the construction is carried out by real estate developers. In addition, the quality of the workmanship of their own field staff needs to be enhanced.

As discussed in the next section, the majority of the utilities use district metered areas (DMAs) and the bulk metering infrastructure mostly for daily operational purposes only. In systems where customer metering is high, it is not very difficult to develop a water balance and identify water losses for each component.

2.3.3.4 Monitoring and Diagnostic Capabilities

As Table 2.6 shows, most utilities have:

- installed bulk metering infrastructure, including supervisory control and data acquisition (SCADA) for reporting
- fully or partly restructured the network into DMAs, more or less in compliance with Article 2e of PM Decision 2147/2010/QD-TTg.

Restructuring the network into DMAs with a bulk metering infrastructure is a well-accepted approach to managing NRW. The infrastructure is mostly used for operational purposes and to a lesser extent for diagnostic and strategic purposes. Almost without exception, the DMAs that are operational are used to

12 Utilities claim that tariffs cover operating costs up to a 50 percent margin. This margin may conceal underspending on operations and maintenance

13 The most recent major replacement project in Da Lat was executed in 1985.

manage and reduce real losses, such as through active pressure management and the repair of reported pipe bursts and leaks. Some utilities carry out minimum night flow measurements in DMAs as a method of leak detection.

Of the 18 utilities, 12 have established an NRW unit or assigned NRW management tasks to a specific department, in compliance with Article 2d of PM Decision 2147/2010/QD-TTg. The rapid assessment was not meant to carry out an in-depth analysis of the role and mandate of these units and departments; however, the general impression is that the units mainly focus on operational interventions to reduce and manage NRW. As mentioned earlier, the distribution between apparent and real losses at the company level, as well as in the operational DMAs as a whole, is not determined, nor are comprehensive NRW strategy plans available. The performance of diagnostic tasks and a policy-making role would thus be expected to be important responsibilities of the NRW unit/department of a utility.

Table 2.6: Infrastructure for Monitoring and Diagnostic Purposes

Region	Utility	Town	Number of connections	NRW unit/department	Number of DMAS	DMA coverage (%)	Connections per DMA	Determine monthly water balance in DMA	Assessment of apparent and real losses	Type of bulk meters	Data transfer technology	SCADA
Mekong	An Giang	Long Xuyên	72,166	Yes	87	100	829	No	No	Mech	Data loggers	No
	Bình Dương	Province	229,352	Yes	200	100	1,147	-	No	E/M	AMR	Yes
	Cà Mau	Cà Mau	39,200	Yes	20	50	1,960	No	No	Mech	Data loggers	Yes
	Cần Thơ	Cần Thơ	60,000	No	42	40	1,429	No	No	E/M	AMR	Yes
	Kiên Giang	Rạch Giá	50,000	Yes	39	100	1,282	No	No	E/M	AMR	Yes
	Long An	Tân An	17,500	Yes	14	100	1,250	No	No	E/M	AMR	Yes
	SAWACO	HCMC	1,378,023	Yes	600	n.a.	2,929	No	No	-	Data loggers	Yes
	Bạc Liêu	Bạc Liêu	27,751	Yes	0	0	n.a.	n.a.	No	E/M	Partly AMR	Yes
	Hậu Giang	Province	52,599	Yes	0	0	n.a.	n.a.	No	E/M	AMR	Yes
	Sóc Trăng	Province	84,254	No	0	0	n.a.	n	No	Mech	Manually	No
Central/ highland	Lâm Đồng	Đà Lạt a)	57,326	No	61	n.a.	n.a.	No	No	Mech	n.a.	No
	Quảng Nam	Tam Kỳ	19,081	No	0	0	n.a.	n.a.	No	Mech	n.a.	No

North	Hà Nam	Phủ Lý	40,500	No	0	0	n.a.	n.a.	No	Mech	n.a.	No
	Lạng Sơn	Lạng Sơn b) c)	27,000	No	9	n.a.	3,000	n.a.	No	Mech	n.a.	Pilot
	Ninh Bình	Province	-	Yes	-	n.a.	-	-	No	Mec + E/M	-	Yes
	Phú Thọ	Province	126,528	Yes	100	60	Yes	Yes	No	E/M	-	Yes
	Thanh Hóa	Province	-	Yes	0	0	-	-	No	-	-	Yes
	VIWACO	Hanoi	-	Yes	0	n.a.	Yes	Yes	No	E/M	AMR	Yes

Source: Individual utility assessments

Note: AMR = automated meter reading; DMA = district metered area; E/M = electrical and magnetic; HCMC = Ho Chi Minh City; Mech = mechanical; n.a. = not applicable; NRW = nonrevenue water; SAWACO = Saigon Water Supply Corporation; SCADA = supervisory control and data acquisition; — = not available.

Footnotes:

a. DMA and SCADA are no longer in use.

b. Administrative boundaries of DMAs have been established.

c. Only raw water is measured.

As mentioned above, MoC monitors the NRW-level. It is important that MoC at least continues monitoring the NRW-level, but preferably expand the monitoring of NRW-performance with a more indicators, such as:

- NRW in % as well as in L/connection/day (annual average)
- Volume billed in L/connection/day (annual average)
- Apparent Losses in L/connection/day (annual average)
- Real Losses in L/connection/day or m3/km/year (annual average)
- CAPEX and OPEX related to NRW management

In order to build up a reliable database, MoC should develops a protocol to validate the data provided by the utilities.

2.3.3.5 Real Losses and Network Management

In general, it can be concluded that the real losses of more than half of the utilities are relatively high, ranging between 145 and 320 liters per connection per day (see Table 2.4). This level of real losses is obscured by the low supply pressure applied in the tertiary network (in DMAs).[14] Many utilities apply active pressure management to the extent that the water pressure for customers at the fringes of the network is substandard. This approach to reducing real losses is not energy efficient; it is estimated that the pressure reduction by means of pressure-reducing valves (PRVs) varies between 10 and 30 meters, and the low end pressure forces customers to install individual pumping systems. This energy inefficiency is estimated to range between 0.08 and 0.17 kilowatt-hours per cubic meter (assuming the total indoor pump head is equal to 10 meters).

14 The average system pressure in the tertiary network was roughly estimated during the interview sessions with the utilities and based on information in the questionnaires.

Table 2.7: Characteristics and Technical Performance of Network

Region	Utility	Town	Connections				years	years	project						
			No.	Conn/ km	km		km	%	year	L/conn/day	L/conn/day	m	A	No.	No./km/yr
Mekong	An Giang	Long Xuyên	72,166	100	-	n.a.	40	0.9	%	72	5	15	A	-	1.0
	Bình Dương	Province	229,352	62	n.a.	3,696	2.2	1	n.a.	58	2	25	A	1,053	0.3
	Cà Mau	Cà Mau	39,200	248	n.a.	n.a.	1	0	2010/5	159	16	10	C	500	1.8
	Cần Thơ	Cần Thơ	60,000	117	n.a.	511		-	0	317	26	12	>D	2,200	4.3
	Kiên Giang	Rạch Giá	50,000	304	n.a.	n.a.	0	0	2009/10	226	27	8	>D	862	2.5
	Long An	Tân An	17,500	97	n.a.	n.a.	8	3.4	2016/5	176	23	7	D	200	0.9
	SAWACO	HCMC	1,378,023	192	n.a.	7,184	559	7.8	n.a.	145	14	10	C	29,220	4.1
	Bạc Liêu	Bạc Liêu	27,751	12	n.a.	270	0	0	n.a.	4	0	24	?A	-	-
	Hậu Giang	Province	52,599	68.5	n.a.	768	n.a.	n.a.	n.a.	87	6	15	B	n.a.	n.a.
	Sóc Trăng	Province	84,254	92	n.a.	916	91.8	10	n.a.	27	2	15	?A	n.a.	n.a.
Central/ highland	Lâm Đồng	Đà Lạt a)	57,326	249	n.a.	n.a.	200	87.0	1985/2	205	20	10	D	1,200	5.2
	Quảng Nam	Tam Kỳ	19,081	100	n.a.	n.a.	46	24.0	1997/10	146	12	12	C	1,825	9.6
North	Hà Nam	Phủ Lý	40,500	n.a.	n.a.	n.a.	n.a.	-	-	181	9	5	B	-	n.a.
	Lạng Sơn	Lạng Sơn b) c)	27,000	148	n.a.	n.a.	0	0	-	230	18	12	C	1,900	
	Ninh Bình	Province	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5	n.a.	n.a.	n.a.
	Phú Thọ	Province	126,528	316	n.a.	401	n.a.	0	-	60	2	3	A	550	1.4
	Thanh Hóa	Province	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	VIWACO	Hanoi	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: Individual utility assessments

Note: Conn = connection; HCMC = Ho Chi Minh City; SAWACO = Saigon Water Supply Corporation

n.a. = not available; - = unknown

The effort to reduce real losses is limited to pressure management and burst/leak repair. It is estimated that 10 of the 18 utilities have implemented active pressure management to reduce the leakage and burst rates in the network (see Table 2.8). Most utilities apply active leak control (detection and repair of hidden leaks) on a structural basis; however, the appropriate analysis of the economic level needed to support the leak control policy is lacking.

Table 2.8: Overview of Real Losses and Network Management

			Real losses management				Asset management aspects		
Region	**Utility**	**Town**	**Pressure management**	**Hydraulic model for flow and pressure management**	**Active leak control**	**Analysis of economic leakage level**	**Comprehensive analysis of bursts and historical events**	**Geographic information system**	**Budget for repair and minor replacements**
Mekong	An Giang	Long Xuyên	Yes	No	Yes	No	No	No	Constrained
	Bình Dương	Province	Yes	No	Yes	No	No	Yes	Yes
	Cà Mau	Cà Mau	Yes	No	Yes	No	No	No	Constrained
	Cần Thơ	Cần Thơ	No	No	No	No	No	Yes	Constrained
	Kiên Giang	Rạch Giá	Yes	No	-	No	No	No	Constrained
	Long An	Tân An	Yes	No	Yes	No	No	No	Constrained
	SAWACO	HCMC	Yes/no	Yes/no	Yes	No	-	Yes	-
	Bạc Liêu	Bạc Liêu	Yes	No	YEs	No	No	No	Constrained
	Hậu Giang	Province	Yes	Yes	Yes	Yes	Yes?	No	-
	Sóc Trăng	Province	Yes	No	Yes	Yes?	No	No	-
Central/ highland	Lâm Đồng	Đà Lạt a)	Yes	No	No	No	No	No	Constrained
	Quảng Nam	Tam Kỳ	No	No	No	No	No	No	Constrained
North	Hà Nam	Phủ Lý	Yes	No	No	No	No	No	Constrained
	Lạng Sơn	Lạng Sơn b) c)	Yes	No	Yes	No	No	Pilot	Constrained
	Ninh Bình	Province	Yes/partly	No	Yes	No	No	Yes	-
	Phú Thọ	Province	Yes	No	Yes	No	No	No	-
	Thanh Hóa	Province	Yes	No	Yes	Yes	No	No	-
	VIWACO	Hanoi	Yes	No	Yes	No	Yes	Yes	-

Source: Individual utility assessments
Note: HCMC = Ho Chi Minh City; SAWACO = Saigon Water Supply Corporation; — = not available.

2.3.3.6 Commercial Operations (Billing Processes)

An important cause of the prevailing level of apparent losses is the high average age of the domestic water meters in operation, which varies between 5 and 15 years (see *Table* 2.9). Water meters are classified in several quality classes. Most of the meters in use in Vietnam are class B water meters. The utility of Lâm Đồng (Da Lat) is an exception, in which the relatively expensive class C meters are calibrated or replaced every 3 years. Considering the low tariff, the business case for this replacement policy is expensive and somewhat asymmetric within the whole process of manual meter reading and billing.

As summarized in Table 2.9, the meter-reading, billing, and collection processes are manually executed by most utilities. However, the common and best practice in the national (e.g., Saigon Water Supply Corporation [SAWACO] and Cà Mau) and international drinking water sector is to fully automate these processes, either through smartphones and apps or through handheld recording. In an automated process, the manual interfaces and risks of introducing errors are minimized. In Article 2d of PM Decision 2147/2010/QD-TTg, the utilities are encouraged to implement new technologies to reduce and manage NRW.

Obviously, the rapid assessment was not meant to carry out an in-depth analysis of the quality of the billing processes and databases. An assessment of the governance and audit framework of the billing and collection processes was likewise not carried out. However, based on the interviews with the utilities, the impression is that many utilities do not perform regular analysis of the complete billing database, which would help to identify anomalies.

The interviews showed that most utilities manage the big customers (non-domestic) closely through monthly or quarterly inspection of the water meter and connection. However, at various utilities appropriate meter management was found to be lacking, in that the results of calibration tests and economic/financial are not used to develop a management policy for the meters.

Table 2.9: Overview of Billing and Collection Processes

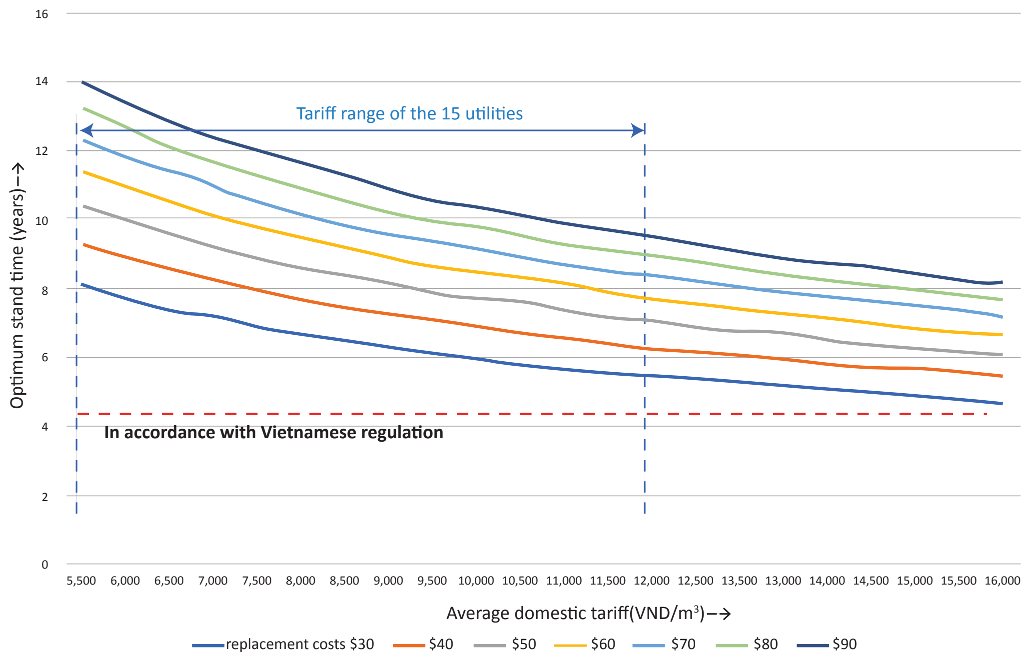
			Domestic Water Meter				Big Customers			Billing processes		
Region	**Utility**	**Town**	**Meter coverage (%)**	**Management of customer meter**	**Meter class**	**Average age (years)**	**Meter type big customers**	**Management of customer meters**	**Billing**	**Meter reading**	**Internal audit of billing database**	**Collection**
Mekong	An Giang	Long Xuyên	100	No	B	15	Mech	No	Manually	Manually	No	Manually
	Bình Dương	Province	100	Yes	unclear	5	E/M	Yes	Automated	Manually	-	-
	Cà Mau	Cà Mau	100	No	B	9	Mech	No	Automated	Smartphone	No	Manually
	Cần Thơ	Cần Thơ	100	Yes	-	8	E/M	Yes	Manually	Handheld	-	Manually
	Kiên Giang	Rạch Giá	100	No	B	7	Mech	No	Manually	Manually	No	Manually
	Long An	Tân An	100	No	B	9	E/M	No	Automated	Handheld	No	Manually
	SAWACO	HCMC	100	Yes	-	5.6	Mech +E/M	Yes	Automated	Handheld/ smartphone	-	Manually
	Bạc Liêu	Bạc Liêu	100	Yes	B	18	-	Yes	Manually	Manually	Yes	Manually
	Hậu Giang	Province	100	Yes	B	7	E/M	Yes	Automated	Manually	Yes	Manuall
	Sóc Trăng	Province	100	Yes	B	20	Mech	Yes	Manually	Manually	No	Manually
Central/ highland	Lâm Đồng	Đà Lạt a)	100	Yes	C	3	Mech	Yes	Manually	Manually	No	Manually
	Quảng Nam	Tam Kỳ	100	No	B	8	Mech	No	Manually	Manually	No	Manually
North	Hà Nam	Phủ Lý	100	No	B	15	Mech	No	Manually	Manually	No	Manually
	Lạng Sơn	Lạng Sơn b) c)	100	No	B	15	Mech	No	Manually	Manually	No	Manually
	Ninh Bình	Province	-	Yes	unclear	-	Mech +E/M	-	Manually	Manually	-	Manually
	Phú Thọ	Province	100	Yes	-	5	E/M	Yes	Manually	Smartphone	No	-
	Thanh Hóa	Province	-	Yes	-	-	-	-	Manually	Manually	-	-
	VIWACO	Hanoi	-	Yes	-	-	E/M?	-	Manually	Handheld	-	-

Source: Individual utility assessments
Note: E/M = electrical and magnetic;
HCMC = Ho Chi Minh City;
Mech = mechanical;
SAWACO = Saigon Water Supply Corporation;
— = not available.

Comments in the interviews indicated that utilities are reluctant to replace water meters in accordance with the guidelines of the MoC (once every 5 years), mostly due to budget constraints. However, it may also reflect low tariffs that make it less financially attractive to replace meters. As presented in Figure 2.3, from an economic perspective, the optimum stand time of domestic water meters in the tariff range of 5,000 to 12,000 Vietnamese dong per cubic meter of the 18 utilities is more than 5 years. The economic calculation[15,16] shows that a higher total replacement cost of the water meter increases the optimum stand time of the meter, whereas a higher average water tariff reduces the optimum stand time. The optimum stand time approaches the guideline of 5 years in the tariff range of 14,000 Vietnamese dong per cubic meter or more for low meter replacement costs ($30). For higher replacement costs the optimum stand time ranges from 6-9 years.

As is well known, other aspects, such as the built quality of the water meter, the water quality (turbidity, sediment, and incrustation characteristics), and installation standards, are also important factors in determining the recommended stand time of a water meter.

Figure 2.3: Optimum Stand Time of Domestic Water Meters for Various Meter Replacement Costs and Average Domestic Tariffs



Source: Computation Ad Doppenberg
Note: VND = Vietnamese dong

2.4 Case Studies: Replicating Best Practice through PBC.

Castalia (2019) reviewed the options for funding and implementing programs to reduce NRW in Vietnam and recommended the adoption of PBC. Castalia found that this was the most effective mechanism for tapping both additional private sector funding and external capabilities and expertise.

15 Based on a study of water meter accuracy performed by UNESCO-IHE, an accuracy degradation rate of water meters equal to 0.003 percent per cubic meter throughput is assumed.

16 The calculation determines in which year the sum of the cumulative value of not-registered water consumption and the annual replacement costs of water meters is the lowest.

PBC for NRW has been implemented around the world, in large cities and smaller towns, reducing both physical and commercial losses and improving utilities' financial performance. Most of the 18 utilities covered in this assessment have done some work on NRW reduction, but this work has not always been done in a structured manner or continually managed to sustain the low level of NRW over a long period of time. A lack of annual budget allocation, changes in management directions, frequent turnover of field staff, and lack of institutionalized expertise are common reasons for failure. Successful NRW reduction comprises good asset management, with adequate technology, capable resources, and commitment to ensuring the sustainability and accountability of the interventions.

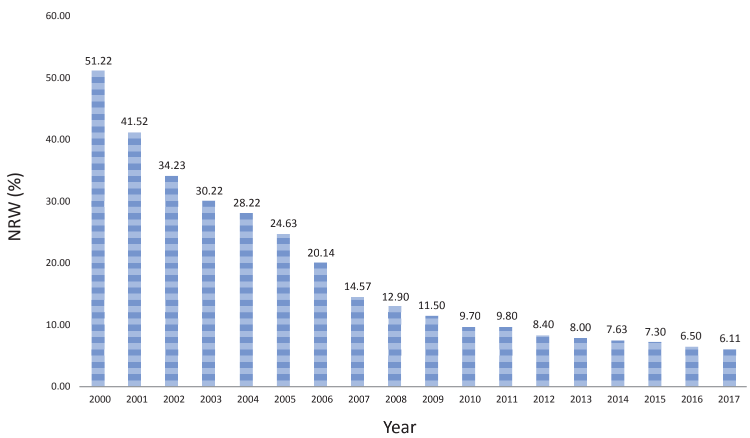
In this section, four examples of NRW reduction are explored: two from Vietnam and two from neighboring countries with similar settings and challenges. Three of the utilities in the case studies used PBC. After presenting the cases, this section summarizes key elements for success and lessons learned.

2.4.1 Long-Term Technical Assistance on NRW Reduction: The Case of Bình Dương

The Bình Dương Water Supply and Sewerage Company has been working on NRW reduction for over two decades. The company is an urban water utility providing water services to the Thủ Dầu Một area in the north of Ho Chi Minh City. It operates nine water treatment plants, with a total capacity of 417,000 cubic meters per day. In 2017, the actual treated water production volume (system input) was approximately 122,643,000 cubic meters, whereas the billed volume was 113,478,000 cubic meters. The company has approximately 229,000 connections and 1,523,000 people to serve.

The company has been working on both apparent and real losses through traditional technical assistance, which is one of the most common approaches for NRW reduction. The company manages 200 DMAs and 12 district metered zones (DMZs). The company's NRW team uses SCADA to monitor flow volume and water pressure and detect leakage in each DMA. The main activities for managing NRW are (1) active leakage detection, (2) timely replacement and repair of pipes, (3) pressure control, (4) the use of improved materials, and (5) DMA management. The team also uses GIS for facilitating asset management. The billing system is fully automated, and meter readers use electronic reading devices. The company also carries out spot checks to supervise the performance of meter readers. It establishes the water balance for the whole company. With these efforts, the company successfully reduced the NRW level from 51.2 percent in 2000 to 6.1 percent in 2017, which excludes 1.8 percent of unbilled, unmetered consumption[17] (see Figure 2.4).

Figure 2.4: Nonrevenue Water Reduction in Bình Dương Water Company



Source: Bình Dương water company

17 Each Water Treatment Plant (WTP) and its network has a different NRW figure, which ranges from 3 to 8 percent. The average is 6.1 percent.

What makes the Bình Dương case stand out is the company's ability to maintain the low NRW level for over a decade, which requires managerial and institutional commitment. The company received long-term technical assistance in the early 2000s. Even after the technical assistance was completed, the company maintained good practice through extensive and continuous training of field staff. According to chief engineer of the company, educating the staff was the most challenging part of the NRW reduction efforts.

The company has calculated the economic level of leakage. According to the company's calculation, it still makes economic sense to reduce NRW further by focusing on replacing meters. The company plans to invest in electromagnetic flow (EMF) meters to improve accuracy. This may make sense for the case of Bình Dương because the share of nondomestic connections is relatively high (25 percent), whereas non-domestic water accounts for 60 percent of the total billed.

2.4.2 NRW Reduction with PBC: The Case of Ho Chi Minh City

Ho Chi Minh City (HCMC) is one of the first cities in Vietnam to implement NRW reduction with PBC. The initiative was driven by physical and political pressures. In the late 1990s and early 2000s, the city was facing a severe water shortage due to low water supply capacity and the high level of water losses. Only 60 percent of the urban population was covered by piped water supply services, leaving the rest of the population, particularly poor households, to rely on other expensive or unsafe sources. The total production capacity in 2004 was 1,250,000 cubic meters per day, and NRW was at a high level (39 percent in 2003). Of total losses, 90 percent occurred at the connections at service networks and homes.

In 2003, the Saigon Water Supply Corporation (SAWACO) was instructed by the HCMC People's Committee to bring down NRW to less than 30 percent. After several years of discussion and preparation, SAWACO signed a service design, build, operate, and maintenance (DBOM) contract in 2010 with an international operator. The World Bank provided a loan of $37 million, of which $15 million was used for the service contract. It was a 5-year contract, including 1 year for maintenance. The contractor was paid with fixed costs for the construction of DMAs and the installation of new connections, as well as reimbursables based on performance, which was measured against an agreed target for NRW reduction (26 percent, or 37,500 cubic meters per day).

The scope of work had mainly two elements: DMA establishment and leak detection and repair. The work covered Zone 1, covering 23 square kilometers of area with approximately 140,000 connections in four districts. The contractor divided the service area into 114 DMAs so that the size was manageable. Procedures for active leak control, timely repair, and pressure management were put in place, and minimum night flow was established for each DMA. During the contract period, approximately 12,000 leaks were repaired in the distribution system of 662 kilometers (18 leaks per kilometer). Under this scheme, the contractor had an incentive to maintain the losses at the low level because payment depended on the situation at the end of the contract. As more sources of leakage were fixed, water pressure was restored to a normal level (8 meters).

As a result, SAWACO achieved its target and successfully saved approximately 92,000 cubic meters per day in 20 months of implementation, and the reduced leakage level was almost half of the amount of leakage before the project was implemented. This result was achieved through the replacement of less than 1 percent of the distribution system (3,422 meters out of 662 kilometers). The saved water could serve 500,000 people in the city. The intervention reduced operating costs by saving energy (23,000 kilowatt-hours per day) and chemicals.

2.4.3 Long-Term Engagement through PBC: The Case of Selangor, Malaysia

Selangor, a state encircling Kuala Lumpur (KL), the capital of Malaysia, has implemented one of the biggest performance-based contracts for NRW reduction, totaling $109.5 million. In the late 1990s, Selangor and the Federal Territory of KL were facing a serious water shortage due to climate change (El Niño). For five months of 1998, 1.5 million people were given rations for water. This crisis prompted the State Waterworks Department to address the high level of NRW, about 40 percent, of which 25 percent, or 500,000 cubic meters per day, was accounted for by real losses. In 1998, the NRW reduction task was contracted to a consortium of a local firm and an international operator. The contract was for 18 months, with an amount of $4.5 million (Phase 1). Later, it was extended for 9 more years, with an amount of $105 million (Phase 2).

As in the HCMC case, the contractor had full responsibility and freedom to design, build, and operate the water supply system. The contractor could also choose the zone to work with, and the contractor brought its own staff to carry out the activities. The payment for the contractor was in a lump sum, with incentives for achieving certain targets in a given time. The end target for Phase 1 was a reduction in NRW of 18,540 cubic meters per day; however, the contractor exceeded the target in 18 months, saving 20,898 cubic meters per day.

Based on a successful implementation of Phase 1, the State Waterworks Department extended the contract for another 9 years with a similar contractual framework in April 2000. In total, 222 DMAs were established, more than 11,000 leaks were repaired, and 119,000 customer meters were replaced. This resulted in achieving the fixed target of 198,000 cubic meters per day of NRW reduction, accounting for 10 percent of the total water production of the city at the start of the project. Despite the successful results, it remains questionable whether the contractual framework of Phase 2 was cost-effective in this case. In fact, the contractor had already achieved the agreed target 4 years before the end of the contract. It might have been possible for the contractor to go beyond the target, but there was no incentive mechanism for the contract to reduce NRW levels even further. In both Phase 1 and 2, the contractor was selected without competition. The Phase 2 contract could have been shorter in terms of the contractual period and lower in price if it had been bid out.

2.4.4 Competition and Demonstration: The Case of Bangkok, Thailand

Like many other Asian cities, Bangkok faces a water shortage due to rapid urbanization since the 1980s. To catch up with the growing demand, the city invested in water resources to increase production capacity from 1.7 million to 3 million cubic meters per day in 10 years. At the same time, NRW levels also went up because of increased system input and pressure. In 1997, the city's NRW peaked at 42 percent or 1.9 million cubic meters per day. To address the high NRW, the Metropolitan Waterworks Authority contracted private operators to manage 3 of 14 service areas in 2000. The main objective was to reduce real losses. The companies were selected on a competitive basis; one company was awarded the contract to cover two areas, and the other company received a contract for one area. The total project cost was $56 million.

The contractual arrangement was different from that of Selangor. There was no fixed target for leakage reduction in the contract; instead, the contractors were remunerated based in part on the actual water savings. Therefore, the incentive was rightly aligned with the objective: the more water saved, the more money the contractors received as a management fee to cover overhead, profits, and fees for internal experts. In addition to the performance-based management fee, the contractors were also paid fixed fees (to cover local labor) and reimbursables (for outsourced services, materials, and works performed in the field). The contractors replaced more than 550 kilometers of the main network, established more than 235 DMAs, and repaired 150,000 leaks over the 4 years of the contract period. As a result, the projects successfully saved 165,000 cubic meters per day of water, enough to serve an additional 500,000 people in the city. The cost per cubic meter per day for NRW reduction ranged from $246 to $518, which gives some insight of into the contractors' performance. Interestingly, the contractor that worked more intensively on active leakage detection and replaced 18 percent of the infrastructure—and consequently had a higher contract value—achieved higher NRW reduction and more efficient per-unit cost. Moreover, the payment for the contractors could have been arranged differently by transferring more risks to contractors and reducing reimbursables. Nevertheless, the interventions largely alleviated the city's water shortage and avoided investment in alternative water sources.

2.4.5 Key Elements for Success and Lessons Learned

Although there is no perfect example that can be replicated easily, the case studies present some lessons on the components of an effective NRW program and the design of contracts for NRW reduction.

Key elements for an NRW program can be categorized into three areas: technology, resources, and transparency and accountability.

Technology

- Establishment and management of NRW in DMAs
- Establishment of regular water balance for diagnostic and accountability purposes
- Active leakage detection
- Flow and pressure management by a central control unit
- Use of SCADA for flow and pressure management
- Implementation of smart pressure management, where relevant
- Asset management, including the use of GIS
- Automated billing and collection, with appropriate billing software
- Establishment and implementation of meter replacement policy

Resources

- Institutionalization and operationalization of NRW management and policy in the utility's ongoing business
- Annual allocation of OPEX and CAPEX for NRW and asset management
- Human resources (HR) management and training programs for management and field staff
- Exploration of incentive mechanisms

Transparency and accountability

- Institutionalization of NRW management strategy plan with monitoring and reporting framework
- Establishment of NRW targets with related performance indicators
- Timely responses to claims and repairs
- Customer care

The lessons for contracting for NRW programs and embedding the programs are:

First, NRW reduction is not a one-time arrangement; it requires a long-term commitment and investment for utilities. To ensure low levels of NRW can be sustained, NRW management and programs need to be institutionalized within a utility at all levels. Having a long-term engagement with external experts or an experienced contractor can be effective, but it is also expensive. To sustain the same level of service and reduced NRW, the (temporary) outsourcing of NRW reduction tasks should be done within the framework of a 5-year rolling NRW management strategy plan, including an extensive training program for management and field staff. Moreover, the management of the utility needs to acknowledge the need and assign adequate staff and resources (OPEX and CAPEX) to carry out the tasks. Incentive mechanisms can also help to encourage the staff to deliver better results.

Second, examples from inside and outside of Vietnam show that NRW PBC programs can be more cost-effective than utility-led programs, with a lasting impact, if the right elements are incorporated in a contract. These include (1) setting a payment mechanism against performance, rather than a fixed target; (2)

striking the right balance of risks to be transferred to a private contractor; (3) having incentives and penalties for not meeting the targets; (4) giving the freedom for a private contractor to design, build, operate, and maintain the system; (5) incorporating a program for training and transfer of knowledge and technology; and (6) having a reasonable project period so that knowledge is transferred to utility staff. Where feasible, a private contractor should be selected competitively. Once proven to be successful, an NRW PBC can have a demonstrative impact on other service areas, encouraging the utility or the private operator to replicate the same approach.

Third, although giving some freedom and flexibility to a private operator is essential for successful PBC, the utility should ensure that the contractor's approach is aligned with the utility's strategic focus. It is often misunderstood that the roles of the utilities diminish in the case of NRW PBC. However, it is proven to be more effective if the utility takes more initiatives and manages the PBC contractor. For example, the service areas where the contractor works and the number of connections in DMAs should be discussed thoroughly after an initial survey so that these aspects are aligned with the utility's focus and practices.

2.5 Conclusions and Recommendations for NRW

2.5.1 Summary of conclusions and recommendations

In general, the utilities have achieved a considerable reduction in NRW. In recent decades, the approach to reducing NRW has basically been achieved by implementing replacement investments on a project basis. The utilities have implemented various actions as recommended in PM Decision 2147/2010/QD-TTg for utilities in Grade II cities. The most important elements are the installation of an NRW unit and the restructuring of networks into DMAs with a basic bulk metering infrastructure. This approach is appropriate to reduce high levels of NRW but is unlikely be sufficient to achieve the GoV's target of 18% NRW by 2020 and 15% by 2025

The findings and recommendations of the rapid assessment can be broken down into four areas: planning for NRW reduction; components of the NRW program, incentives and governance for NRW reduction, and mechanisms for implementing NRW reduction. In brief:

Planning

Findings

While the potential benefits of NRW reduction are recognized current programs are largely reactive and there is often a lack of focus or awareness on NRW reduction. NRW reduction is not supported by integrated resource plans.

Recommendation

- MoC should work with utilities and local authorities to increase awareness and capacity for NRW planning through guidance notes on planning, continued capacity building, and increased reporting requirements and monitoring of utility planning.

Components of NRW Program

Findings

Key components of an NRW plan are.

- Funded capex and opex initiatives that are consistent with the strategic plan
- Enhanced monitoring and diagnostic capabilities, including analysis of losses by component and location
- Enhanced flow management and system performance monitoring
- Upgrading of the billing and collection (B&C) process and metering

Recommendations

- Utilities should ensure that the NRW program provides an integrated set of implementable actions covering these components.
- MoC should work with utilities and local authorities to provide relevant guidance notes and facilitate sharing of practice and experience

Governance and Incentives

Findings

The practical implementation of the governance arrangements and the incentives created are uncertain. The targets are sector-wide average and it is not clear how these apply to individual utilities and what are the sanctions for non-compliance. It is also not clear how the framework for setting tariffs in *Joint Circular No.75/2012/TTLT-BTC-BXD-BNNPTNT* is applied in practice. Hence the incentives are unclear and do not provide a bankable revenue stream for investing in NRW reduction. Local distribution and connection systems built by property developers are a significant source of leaks and supervision of these works is not strong.

Recommendations

1. MoC should establish a standard methodology for the calculation of economically efficient NRW levels consistent and monitor its application by utilities.
2. MoF and/or MoC should provide further guidance for PPCs and the utilities on the application of *Joint Circular No.75/2012/TTLT-BTC-BXD-BNNPTNT* in setting prices, the benchmark for losses to be used to set prices, and the sanctions/rewards for NRW performance.
3. Systems for monitoring the quality of work undertaken by developers and other third parties should be reviewed and strengthened.

Implementation and PBC

Findings

PBCs are a well-recognised, effective and widely adopted mechanism for implementing NRW. Well-designed PBCs can tap private sector funding and external expertise and provide stronger, more certain incentives to reduce NRW.

Recommendations

- PBCs should be trialled in Cần Thơ, Kiên Giang, Lâm Đồng, and Lam Song to demonstrate their effectiveness. If successful, PBCs should be rolled out to other utilities

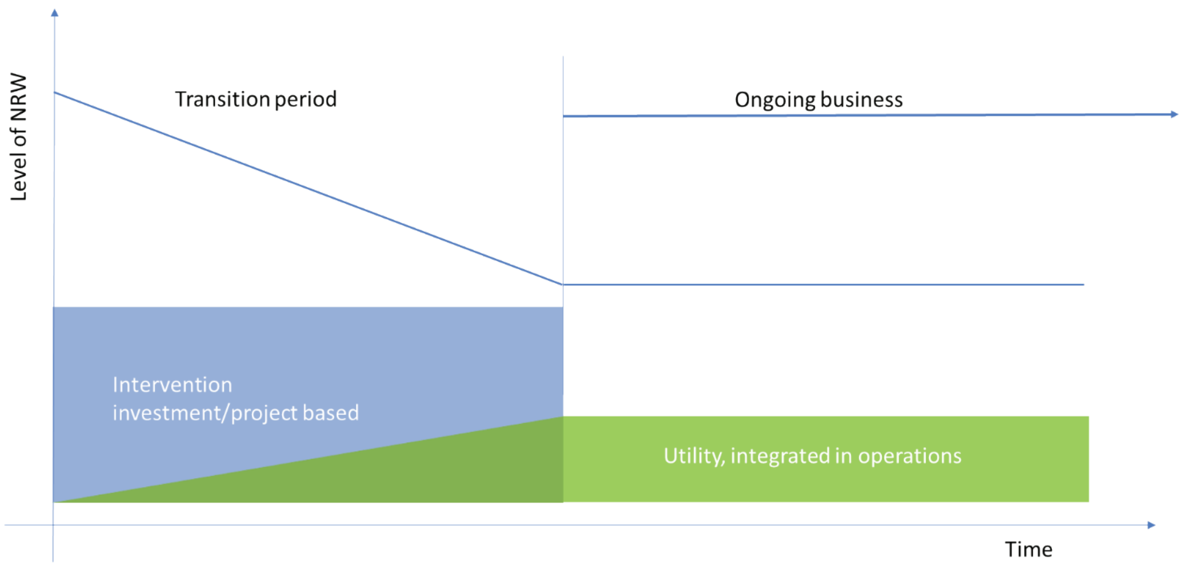
2.5.2 Planning for NRW Reduction

The awareness of NRW at most utilities is limited. NRW levels (in percentages) are reported on the company level only, and thus there is a limited understanding of the distribution between apparent and real losses at the company level as well as in the supply zones and DMAs. The existing DMA and metering infrastructure is not used for diagnostic purposes, which is required to develop an NRW management strategy, including OPEX and CAPEX requirements. Hence, the approach to NRW management has a reactive character, with a focus on short-term solutions, such as pressure management. Less attention is given to asset and water meter management.

In general terms, the potential economic return of NRW reduction is appreciated by the utilities, but a detailed analysis of the economic level of apparent and real losses in relation to the current water tariff is not performed. Given the situation of budget constraints and the moderate water tariffs, an economic benefit for NRW management efforts is needed to prioritize the use of the scarce resources of most utilities. In this context, it should be noted that the average water tariff must increase to provide a sufficient financial basis[18] to achieve and sustain the targets of PM Decision 2147/2010/QD-TTg NRW (18 percent in 2020 and 15 percent in 2025).

As mentioned previously, the approach to reducing NRW is basically achieved by implementing replacement investments on a project basis. As presented in Figure 2.5, the NRW management needs to evolve from this so-called transitional approach to a more sustainable, long-term approach, consisting of a mix of operational and CAPEX interventions, that is integrated into the daily, ongoing business of the utilities.

Figure 2.5: Conversion from transitional to long-term Nonrevenue Water Management



Source: Computation Ad Doppenberg

To initiate the evolution of a more sustainable approach to NRW management, five main areas of improvement are identified:

- Upgrading of the billing and collection (B&C) process
- Enhancement of the monitoring and diagnostic capabilities
- Enhancement of real losses management
- Development and implementation of asset management tools
- Capacity building

Based on the identified major causes, sets of interventions, which are related to the aforementioned improvement areas, are proposed for each utility. The interventions are presented with an indicated priority setting (red and bold crosses) in appendix B. It is beyond the scope of the rapid assessment to determine the scope and volume of each proposed intervention.

The existing decisions and circulars create an obligation for the utilities to prepare plans for managing NRW, but increased support and supervision from MoC, or other central agencies is desirable. In other regimes, such

18 The assessment of the 18 utilities did not find a relation between the level of water tariff and NRW performance. The sound financial position of a utility is, however, conditional on implementing and sustaining changes and improvements.

as New South Wales (Australia), where the water services are delegated to a large number of local agencies, this is provided by detailed guidance notes or mandatory requirements, supported by monitoring and supervision.

Recommendation

NRW 1: MoC should work with utilities and local authorities to increase awareness and capacity for NRW planning through:

a. Detailed guidance notes on planning and NRW evaluation
b. Continuation of capacity building programs
c. Increasing reporting requirements and NRW planning and performance and monitoring against these requirements

2.5.3 Components of the NRW Program

Key components of an NRW plan are.

- Funded capex and opex initiatives consistent with NRW plan
- Enhanced the monitoring and diagnostic capabilities, including analysis of losses by component and location
- Enhanced of flow management and system performance monitoring to facilitate management of real losses
- Upgrading of the billing and collection (B&C) process and metering

The utilities have put considerable effort into DMA systems, but as noted above the other components are lagging. Utilities do not appear to have robust data on the components of NRW for use in developing the plans. Current uncertainty on the application of the pricing rules and rewards/sanctions for performance against the targets mean that there is not a bankable revenue stream for funding NRW projects. Hence, in a number of the 18 utilities reviewed there was not a clear link between the capex and opex plans and a strategy to reduce NRW. As noted earlier, the utilities have not meet the norms for replacing meters due to capital constraints and/or lower returns due to the low tariffs.

Recommendations

NRW 2: Utilities should ensure that the NRW program provides an integrated set of implementable actions covering, among other matters:

a. Funded capex and opex initiatives consistent with NRW plan
b. Enhanced monitoring and diagnostic capabilities, including analysis of losses by component and location
c. Enhanced flow management and system performance monitoring to facilitate management of real losses
d. Upgrading of billing and collection (B&C) processes and metering

NRW 3: MoC should work with utilities and local authorities to provide guidance notes on each of these areas and facilitate sharing of practice and experience.

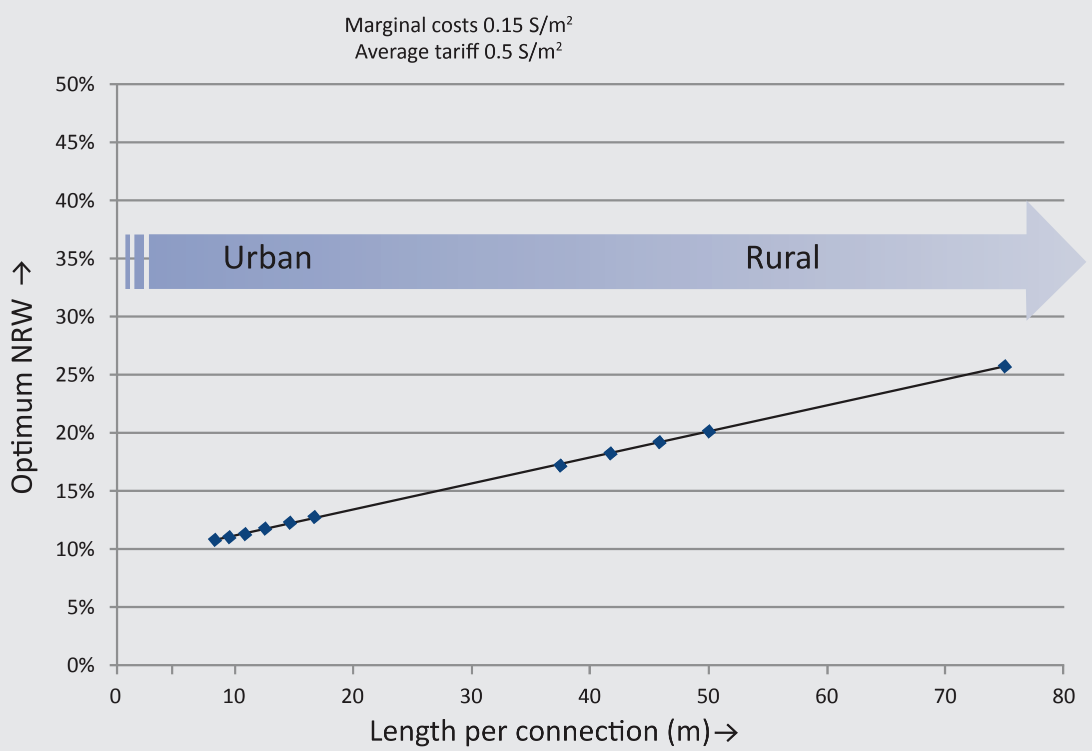
2.5.4 Governance and incentives

The GoV aims to reduce the NRW to a sector average of15 percent for the middle-range term (2025), as captured in PM Decision 2147/2010/QD-TTg. The target of 15 percent may be appropriate for use as a general guideline but it should not be applied uniformly to each utility. Many utilities are responsible for the water supply in a province, distributing and retailing the drinking water in high-density urban areas and medium- to low-density semirural areas. It is known that in semirural areas with low connection densities, the economic level of NRW is higher than in urban areas because of the higher costs of NRW reduction (see box 2.2).[19] Hence, applying a general NRW target for all the water supply systems of a utility may result in negative business cases. It is therefore recommended that the utilities should determine the economically optimal NRW level of the water supply systems as a key performance indicator in the contractual arrangement between the Provincial Peoples Committee (PPC) and the utility. In this context, it is important to note that it will be necessary to set up a protocol for a standardized methodology for calculating the economically optimal NRW level, as described in box 2.2.

Box 2.2: Economic optimal NRW

The calculation of the economically optimal NRW level is based on various system and financial parameters. In figure B.2.2.1, the relation between the important system parameter of connection density and the optimum NRW level is presented. The cost of active leakage control and connection surveys in semirural areas (with lower connection densities) is higher than in urban areas because fewer mains and connections can be surveyed in a given time. Hence, the optimum NRW level based on a balance between costs and return on NRW reduction is higher in systems with lower connection densities.

Figure B 2.2.1: Relation between Economically Optimum Nonrevenue Water and Connection Density



Note: Marginal costs = 0.15 US$/m^3; average tariff = 0.5 US$/m^3; NRW = nonrevenue water.

Urban water services are being corporatized in Vietnam, and the process of reform is under way to strengthen their autonomy and open them further to private investors. Initially, private equity was the minor shareholder;

19 Based on cases of various utilities in other countries.

however, the equity process has accelerated in recent years, and in various cases, private equity is now the major partner. This is the case for 5 of the 18 utilities[20] (see Table 2.10). Although the sample of 18 utilities is too small to draw firm conclusions, it seems that the rate of private equitization does not have an impact on the NRW performance of the utilities. Perhaps the lack of formal governance structure contributes to this situation.[21] As mentioned, contractual arrangements between PPCs and utilities need to be formalized, which should include key performance indicators and reporting frameworks for NRW management. An important part of this will be to provide greater clarity and certainty on how tariffs are set and the loss factors used in determining tariffs. The current rules can in principle provide strong financial incentives to reduce NRW. But how they are applied and whether they are applied consistently over time appears to be unclear.

The pace of urbanization and industrialization has been rapid, creating the risk that development could outpace the planning and implementation of water and sanitation infrastructure. In the interviews, various utilities indicated that private project and real estate developers install the underground piping infrastructure. Although the utilities have a role in supervising the quality of projects during construction, it seems that the implementation of the formal role of the utility needs to be enhanced. Here again, a governance framework is needed to support this role, particularly as the utilities are corporatized with an increasing share of private equity.

Table 2.10: Rate of Private Equitization of 18 Utilities

Utility	WS system	Private shareholder	Total connections	NRW	
An Giang	Long Xuyên	36	60,000	393	29.0
Bình Dương	Province	0	50,000	304	30.0
Cà Mau	Cà Mau	5	27,000	298	37.5
Cần Thơ	Cần Thơ	40	17,500	276	21.0
Kiên Giang	Rạch Giá	60	57,326	273	27.0
Long An	Tân An	100	40,500	267	27.0
SAWACO	HCMC	29.5	39,200	234	23.5
Bạc Liêu	Bạc Liêu	100	19,081	229	22.0
Hậu Giang	Province	0	1,378,023	206	23.0
Sóc Trăng	Province	98	27,751	84	11.0
Lâm Đồng	Đà Lạt a)	51	52,599	124	19.5
Quảng Nam	Tam Kỳ	51	84,254	110	15.4
Hà Nam	Phủ Lý	10	72,166	177	19.7
Lạng Sơn	Lạng Sơn b) c)	100	229,352	109	7.4
Ninh Bình	Province	-	126,528	99	18.0
Phú Thọ	Province	-	-	-	-
Thanh Hóa	Province	-	-	-	-
VIWACO	Hanoi	-	-	-	-

Source: Information individual utilities
Note: HCMC = Ho Chi Minh City; NRW = nonrevenue water; SAWACO = Saigon Water Supply Corporation; WS = water supply; — = not available.

20 SAWACO Holding is a state-owned enterprise (SOE); the majority of distribution companies in Ho Chi Minh City are equitized.

21 As mentioned earlier, the contractual arrangement between PPCs and utilities has not yet been implemented (Water and Sanitation Program [WSP] 2014).

Recommendations

NRW 4: MoC should establish a methodology for the calculation of economically efficient NRW levels consistent with achievement of the specified sector-average targets. The methodology would be applied by the utilities and monitored by MoC. This should include guidance on measurement of NRW in aggregate and for components (eg real and apparent losses).

NRW 5: MoF and/or MoC should provide further guidance for PPCs and the utilities on the application of *Joint Circular No.75/2012/TTLT-BTC-BXD-BNNPTNT* in setting prices, and in particular the benchmark for losses to be used in setting prices and the sanctions/rewards for under/over performance. MoF/MoC should monitor the application of the pricing rules to ensure their consistent application over time.

NRW 6: Systems for monitoring the quality of work undertaken by developers and other third parties should be reviewed and strengthened.

2.5.5 Promising Candidate Utilities for PBC NRW

Based on the information and assessment results,[22] four utilities can be earmarked as potential candidates for a follow-up assessment, termed a "deep dive," to evaluate their appropriateness as pilots for a PBC NRW arrangement. The proposed selection of utilities is based on the following criteria:

- High level of NRW in percentage and liters per connection per day
- Size of utility[23] (or possible selection subcriterion)
- The mix of proposed interventions
- Benefit outcome possibly achievable in 3 to 4 years

The first two criteria are important in estimating the potential savings of NRW reduction in terms of both volume and money. The last two criteria are important in obtaining a first indication of whether the implementation of the proposed interventions is achievable within the PBC period of 3 to 4 years. Although limited information is available on the actual field conditions, the value of the current NRW level, the potential impact of a PBC NRW, and the value of reduced NRW for the four candidate utilities are briefly discussed herein. The four candidates are Cần Thơ, Kiên Giang, Lâm Đồng, and Lam Song.

The estimated value of the current level of NRW is presented In Table 2.11,. The NRW value is the total value of apparent and real losses, which can be determined as follows: because apparent losses are the direct loss of sales, the value is based on the average water tariff. The calculation of the value of real losses depends on the local supply condition. In a situation where the service provision of water is sufficient (coverage is 100 percent, 24/7 supply condition), the value of real losses should be offset against the marginal costs of the water distributed,[24,25] In a situation of insufficient water service (coverage is less than 100 percent and/or intermittent supply conditions), saved real losses can be converted into additional sales. Hence, the value of real losses should be offset against the average water tariff.

The level of service provision of the four utilities is very high, having a high coverage rate and full supply conditions. Therefore, it is expected that a portion of the recovered real losses, but not all, can be converted into additional sales. During the deep-dive phase, more information will become available to assess the potential to convert recovered real losses into additional sales.

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22 Not all northern utilities have been considered because crucial data are not yet available.

23 Except for Lạng Sơn.

24 Marginal costs are estimated and need to be verified.

25 Deferred investment costs in new water production facilities are not considered (due to real losses reduction).

However, with the information gathered in the rapid assessment, a range of NRW value can be calculated, as presented in table 2.7. Although the system in Lạng Sơn is about half the size of the other three systems, the value of NRW is—due to the high average tariff—more or less in the same range as that of Rạch Giá and Da Lat. The range of NRW value in Cần Thơ is the highest due to the high number of connections and the NRW level of 393 liters per connection per day.

Table 2.11: Value of Current Nonrevenue Water

	Utility		**Cần Thơ**	**Kiên Giang**	**Lâm Đồng**	**Lạng Sơn**
	Town		**Cần Thơ**	**Rạch Giá**	**Da Lat**	**Lạng Sơn**
	Connections (No.)		**60,000**	**50,000**	**57,326**	**27,000**
	System input	m3/year	29,200,000	18,545,286	21,170,000	7,838,170
Current situation	System input	l/conn/day	1,333	1,016	1,012	795
	Volume billed	l/conn/day	940	712	739	497
	NRW	%	29%	30%	27%	38%
	NRW	l/conn/day	393	304	273	298
	Apparent losses	l/conn/day	76	78	68	68
	Real Losses	l/conn/day	317	226	205	230
	NRW	l/conn/day	393	304	273	298
	Average pressure	m	12	9	10	13
	Service coverage	%	91%	85%	95%	85%?
	Average tariff	VND/m3	6,275	7,000	7,000	11,680
	Marginal costs	VND/m3	2,259	2,831	2,924	3,010
	Value Apparent Losses	VND, million	10,407	9,919	10,031	7,873
	Value Real Losses, service level < 100%	VND, million	43,590	28,923	20,980	26,459
	Value Real Losses, service level =100%	VND, million	15,692	11,697	12,523	6,818
	Value NRW, service level < 100%	**VND, million**	**53,996**	**38,841**	**40,011**	**34,331**
	Value NRW, service level =100%	**VND, million**	**26,099**	**21,615**	**22,554**	**14,691**

Source: Individual utility assessments
Note: VND = Vietnamese dong; NRW = nonrevenue water.

In order to demonstrate the potential impact of a PBC NRW, the reductions in apparent and real losses have been estimated, in which the following assumptions were made (see Table 2.11):

- The target level of apparent losses is 5 percent of the volume billed.
- The level of real losses is reduced to the extent that the technical performance of the network is in category B (from table 3.5). In this context, the average pressure in the tertiary network is assumed to be 15 meters, which is higher than the current pressure in the four systems.
- The PBC NRW will start in 2019 and last till 2023; therefore, the 2025 target of PM Decision 2147 TTg of 15 percent is used as a guideline.
- Except for the system in Lạng Sơn, the NRW in percentage is reduced to 15 percent, which is equal to the NRW target set for 2025. To achieve the national target of 15 percent in 2025, the reduction of real losses in the system of Lạng Sơn needs to go further, unrealistically pushing the technical performance of the network into category A.

As summarized in Table 2.12, investments are required to upgrade the billing system, and handhelds or smartphones are recommended to be introduced. Except for the case of Da Lat, customer water meters need to be replaced as well.

The required reduction of real losses (in liters per connection per day), which is in the range of 25 to 38 percent of the original level, is ambitious to achieve in 3 to 4 years. One of the important causes of the prevailing level of real losses is the poor quality (material and workmanship) of the relatively young network. The utility of Cần Thơ indicated that most of the leaks are located at the service connections. Most likely, a PBC NRW program will consist of substantial replacement and leak-repair packages. The most important interventions are as follows:

- Replacement investments in the network, mains, and connections
- Implementation of smart pressure management, a key strategy to reduce the level of real losses in a short period of time
- Further roll-out of DMAs, which is essential for implementing smart pressure management and for enhancing the diagnostic capabilities of the utilities
- Implementation of enhanced active leak control (detection and repair) in conjunction with smart pressure management.

Table 2.12: Potential Impact and Savings of Performance-Based Contracting for Nonrevenue Water

	Utility		Cần Thơ	Kiên Giang	Lâm Đồng	Lạng Sơn
	Town		**Cần Thơ**	**Rạch Giá**	**Da Lat**	**Lạng Sơn**
	Connections (No.)		**60,000**	**50,000**	**57,326**	**27,000**
Current situation	System input	l/conn/day	1,333	1,016	1,012	795
	Volume billed	l/conn/day	940	712	739	497
	NRW	%	29	30	27	38
	NRW	l/conn/day	393	304	273	298
	Apparent losses	l/conn/day	76	78	68	68
	Real losses	l/conn/day	317	226	206	230
	Real losses	Category	>D	>D	D	C
	Average pressure	m	12	9	10	13
	System input	l/conn/day	1,107	838	866	582
	Volume billed	l/conn/day	940	712	739	497
	NRW	%	15	15	15	15
	NRW	l/conn/day	167	126	127	85
	Apparent losses	l/conn/day	47	36	37	25
	Real losses	l/conn/day	120	90	90	60
	Real losses	Category	B	B	B	A
	Average pressure	m	15	15	15	15
	Saving per year					
	Apparent losses	VND, million	3,945	5,370	4,622	5,012
	Real losses, service level < 100%	VND, million	27,099	17,425	16,798	19,552
	Real losses, service level =100%	VND, million	9,756	7,047	7,017	5,039
	Total savings per year					
	service level < 100%	**VND, million**	**31,044**	**22,795**	**21,420**	**24,564**
	service level =100%	**VND, million**	**13,701**	**12,417**	**11,639**	**10,050**
	service level < 100%	**US$**	**1,334,651**	**980,007**	**920,905**	**1,056,056**
	service level =100%	**US$**	**589,021**	**533,828**	**500,377**	**432,085**

Source: Individual utility assessments

Note: VND = Vietnamese dong; NRW = nonrevenue water.

As explained previously, the total value of NRW savings depends on the possibility of converting the recovered real losses to additional sales. Although the system in Lạng Sơn is about half the size of the other three systems, the value of savings is in the same range as that of the other three systems. The average tariff in Lạng Sơn is 50 to 60 percent higher than that of the other three utilities (see Table 2.7).

In this context, it should be noted that with the exception of Lạng Sơn, the average tariff of the other three candidate utilities may be too low to carry out and maintain changes and improvements. This is an issue that will be verified and addressed during the deep dive.

Based on the interviews and visits to the 4 utilities Can Tho and Kien Giang are most receptive for support. The key and middle management of Can Tho and Kien Giang demonstrated a genuine need to set up a program to reduce and manage NRW in a coherent and effective manner. Both utilities need an impulse/support to implement such a program. The utilities are already focusing on certain areas of NRW-management, such as:

- Both utilities are piloting with strategies to reduce Real (technical) losses. The reduction of these high losses will reduce the strain and dependency on the surface water resources
- Both utilities are piloting with e-billing, which requires the implementation of automated billing and collection system. Supporting the utilities to implement these systems will boost their revenues
- Can Tho is piloting to implement Active Leak Detection
- Kien Giang wants to enhance its diagnostic capabilities, which is required to formulate NRW-reduction strategies. The utility has already restructured a major part of its distribution network into DMAs.

Table 2.13: Summary of Interventions Proposed for the Promising Utilities

		Mekong		Central/Highland	North
Area of improvement	**Utility**	**Cần Thơ**	**Kiên Giang**	**Lâm Đồng**	**Lạng Sơn**
	Town	**Cần Thơ**	**Rạch Giá**	**Da Lat**	**Lạng Sơn**
	Connections (No.)	**60,000**	**50,000**	**57,326**	**27,000**
Upgrade B&C process	Replacement of domestic water meter	X	X		X
	Upgrade/automate billing system	X	X	X	X
	Handhelds/smartphone		X	X	X
Enhance monitoring and diagnostic capabilities	Control center for flow and pressure management	X	X	X	X
	Regular NRW, AL and RL assessment in DMAs	X	X	X	X
	Implement (additional) DMAs	X		X	X
	Implement AMR infrastructure	X			
	Upgrade bulk meters			X	
	Implement SCADA				
	Expand existing SCADA	X		X	X
Enhance real losses management	Implement (smart) pressure management	X			
	Replacement of connections	X	X	X	X
	Replacement of tertiary mains	X	X	X	X
	Enhance active leak control	X	X	X	X
Asset management tools	Hydraulic model for operational purposes	X	X	X	X
	Recording of underground assets with GIS		X	X	X

Continued…

Capacity building	NRW management strategies	X	X	X	X
	Customer relation management	X	X	X	X
	Commercial operations	X	X	X	X
	Asset management	X	X	X	X

Source: Individual utility assessments

Note: AL = actual losses; AMR = automated meter reading; B&C = billing and collection; DMA = district metered area; GIS = geographic information system; RL = real losses; SCADA = supervisory control and data acquisition;

Recommendations

NRW 7: PBCs should be implemented for a selection of utilities to demonstrate their effectiveness in the Vietnamese context. Cần Thơ, Kiên Giang, Lâm Đồng, and Lam Song are recommended for trialling PBCs.

NRW 8: If successful, PBCs should be adopted more widely by other utilities

Chapter 3

Rapid Assessment for Energy Efficiency

Energy is one of the largest cost for a water utility – for Vietnamese water utilities it often accounts for 20% of costs, despite subsidized energy costs. Hence, improving energy efficiency can make a measurable difference to costs and the utilities cash flows and/or customers tariffs. Because the water utilities are a major water users improvements in the efficiency of their usage of energy can have a measurable effect on the efficiency of the use of energy resources more generally and associated emissions.

This rapid assessment examines the current energy use of the sector, the potential to improve its energy efficiency, and the policy settings required to unlock this potential. In general, EE investment will have the greatest payback in larger treatment and distribution systems where the energy consumed is relatively higher than that for smaller systems because a small percentage of savings in energy consumption in a large system can still represent substantial energy (and therefore financial) savings. However, some smaller treatment and distribution systems may still offer valuable opportunities for EE investment.

The EE assessment is based on the following:

- Comparison of the energy consumption of each utility with MoC "cost norms" for that type of treatment and distribution system
- Comparison of the specific energy consumption of each utility with other utilities operating in similar environments
- Consideration of the utility's approach to asset planning, energy auditing (or similar approaches to monitoring energy efficiency) and implementing the recommendations of the audits

This approach allows the relative energy efficiency of the different utilities to be compared and conclusions drawn about the relative energy efficiency of each utility, along with potential areas for improvement.

3.1 Observation from 18 Utilities

3.1.1 Specific Energy Consumption at the Utility Level

Power costs represented between 15–24% of operating costs for the utilities which reported results. On the standardized measure of energy efficiency used (specific energy consumption for water treatment) the utilities performed better than the MoC cost norms. However, the performance against overseas peers was more mixed. Further analysis of the energy use decomposed into different categories and utility characteristics increases the understanding of the patterns of energy usage. It also helps identify usage patterns that may be unusual and suggest EE opportunities (e.g. energy used in distribution in Hà Nam).

Table 3.1 presents key information on the EE performance of each utility. The key metric for energy efficiency of the utility is the specific energy for treatment, that is, the energy consumed by a treatment plant (including the energy required for the high-lift pumps lifting flows into the distribution network), which is measured in units of kilowatt-hours per cubic meter.

Table 3.1 Utility Energy Efficiency versus Ministry of Construction and International Benchmark Values.

Utility	Location	Raw water source	Water production (m^3/day, total)	Specific energy (kWh/m^3)	Power costs as percentage of operational costs (%)	MoC cost norm (kWh/m^3)			Benchmark cost norm (kWh/m^3)		
						Best	Worst	Median	European Union	United States	China
An Giang	Mekong	Surface and ground	64,716	0.32	—	0.43	0.52	0.48	0.37	0.35	0.29
Bình Dương		Surface	290,000	0.35	19	0.43	0.52	0.48	0.37	0.35	0.29
Cà Mau		Ground	38,959	0.39	—	0.39	0.46	0.43	0.37	0.35	0.29
Cần Thơ		Surface	79,500	0.21	21	0.36	0.53	0.45	0.37	0.35	0.29
Kiên Giang		Surface and ground	74,900	0.38	15	0.36	0.52	0.44	0.37	0.35	0.29
Long An		Ground	22,800	0.41	12	0.43	0.5	0.47	0.37	0.35	0.29
SAWACO		Surface	182,500	0.38	20	0.42	0.52	0.47	0.37	0.35	0.29
Bạc Liêu		Ground	22,000	0.20	—	0.42	0.53	0.47	0.37	0.35	0.29
Hậu Giang		Surface	33,485	0.18	—	0.45	0.53	0.49	0.37	0.35	0.29
Sóc Trăng		Ground	76,600	0.37	—	0.43	0.52	0.48	0.37	0.35	0.29
Quảng Nam	South	Surface	19,904	0.29	—	0.43	0.63	0.53	0.37	0.35	0.29
Lâm Đồng	Central	Surface and ground	75,000	0.39	11	0.36	0.52	0.44	0.37	0.35	0.29
Hà Nam	North	Surface	40,000	0.49	—	0.45	0.53	0.49	0.37	0.35	0.29
Lạng Sơn		Surface and ground	22,800	0.41	—	0.43	0.58	0.51	0.37	0.35	0.29
Ninh Bình		Surface	33,000	0.27	17	0.5	0.58	0.54	0.37	0.35	0.29
Phú Tho		Surface	62,100	0.41	24	0.43	0.52	0.48	0.37	0.35	0.29
Thanh Hóa		Surface	90,000	0.25	17	0.36	0.52	0.44	0.37	0.35	0.29
VIWACO		Surface (3rd party)	202,000	—	—	—	—	—	0.37	0.35	0.29

Source: Individual utilities
Note: MoC = Ministry of Construction; SAWACO = Saigon Water Supply Corporation; — = not available.

The MoC "cost norms,"[26] are intended to be the standards for specific energy consumption that should be met by each utility. The MoC cost norms are specified as a range, as shown in table 3.2, and represent the upper and lower limits for energy efficiency expected by the MoC. The cost norms are specific to plants treating water from different raw water sources and of various sizes ('design throughputs'). The specific energy consumption reported by a utility can be compared to the cost norm to estimate the utility's relative energy efficiency.

Further efficiency and performance indicators for the water industry are also available in the MoC's online Water and Sewerage Database (*http://www.vnw.gov.vn/sub02/report04.aspx*). The database has not been updated since 2015, and it is recommended that it is updated on an annual basis in order to ensure that the energy efficiency of the industry can be monitored and understood. The key indicators for energy efficiency in the database are B5.1 (specific energy consumption in kWh/m^3), and B6.3 (energy costs as a percentage of operational costs), with B5.1 being equivalent to the measure of specific energy consumption as used in this report.

26 MoC Decision No. 590/QD-BXD, "*On the cost norms of water production and operation for water supply systems*".

Table 3.2: Ministry of Construction Cost Norms for Energy Efficiency in Water Utilities

Plant capacity (m^3/day)	1,000	5,000	10,000	20,000	30,000	50,000	100,000	300,000
For groundwater treatment[a] (kW/m^3)	0.53 (best) –0.62 (worst)	0.48–0.60	0.43–0.53	0.43–0.50	0.39–0.46	0.36–0.44	0.36–0.42	0.34–0.42
For surface water treatment[b] (kW/m^3)	0.60–0.70	0.53–0.66	0.50–0.63	0.50–0.58	0.45–0.53	0.43–0.52	0.42–0.49	0.37–0.44

Source: Ministry of Construction

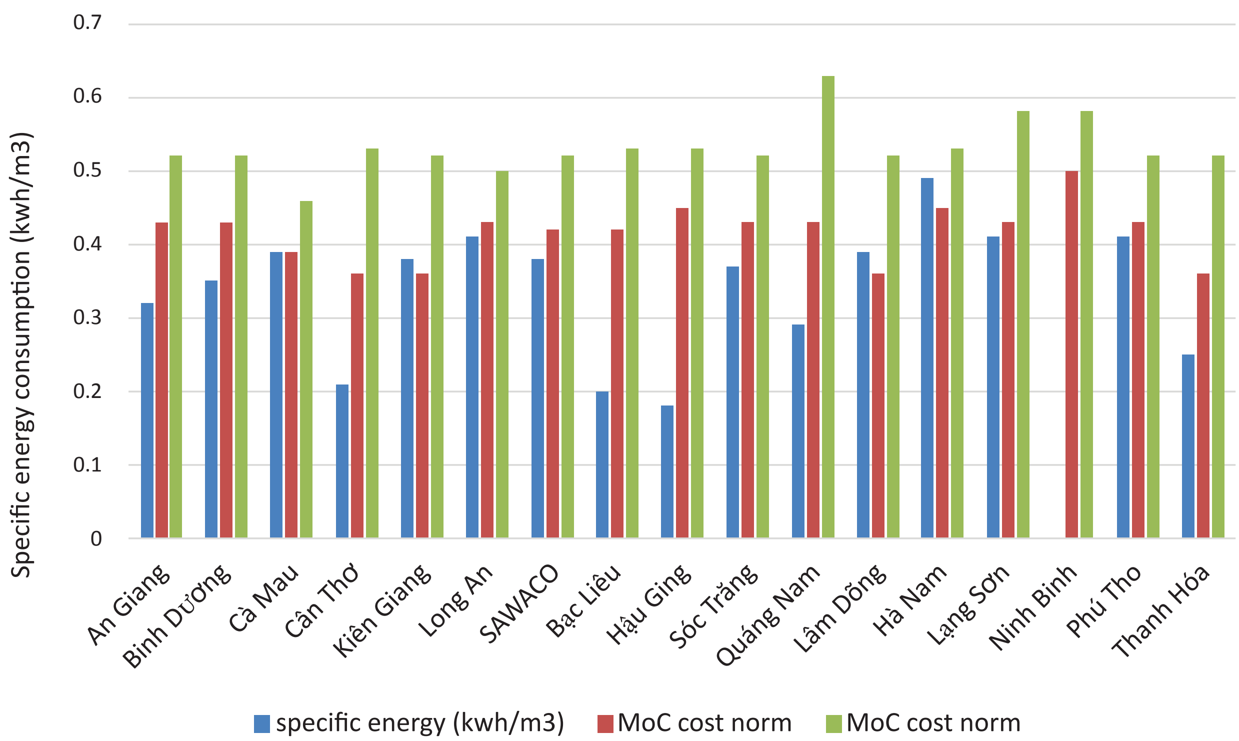
a. Applied for a total head of groundwater (raw) pumping of less than 5.5 bar.

b. Applied for a total head of raw water pumping of less than 2.0 bar.

The specific energy consumption of the 18 water utilities varies between 0.18 and 0.49 kilowatt-hours/ m^3, with a median value of 0.37 kilowatt-hours/m^3 . One utility, VIWACO, did not report specific energy consumption because it does not treat any water but instead purchases treated water under pressure from a third party.

As depicted in Figure 3.1, all the utilities are performing either as well as, or better than, the cost-norms set by the MoC. The best-performing utility (Hậu Giang) has a specific energy consumption value 63 percent below the median MoC cost norm and 49 percent below the median international benchmark value. The worst-performing utility (Hà Nam) still has a specific energy consumption value equivalent to the median MoC cost norm, but it is 40 percent above the median international benchmark (described next). Typically, the utilities outperform the median MoC cost norm by approximately 19 percent.

Figure 3.1: Energy Efficiency Benchmarks versus Ministry of Construction Cost Norms



Source: Individual utility assessments
Note: MoC = Ministry of Construction.

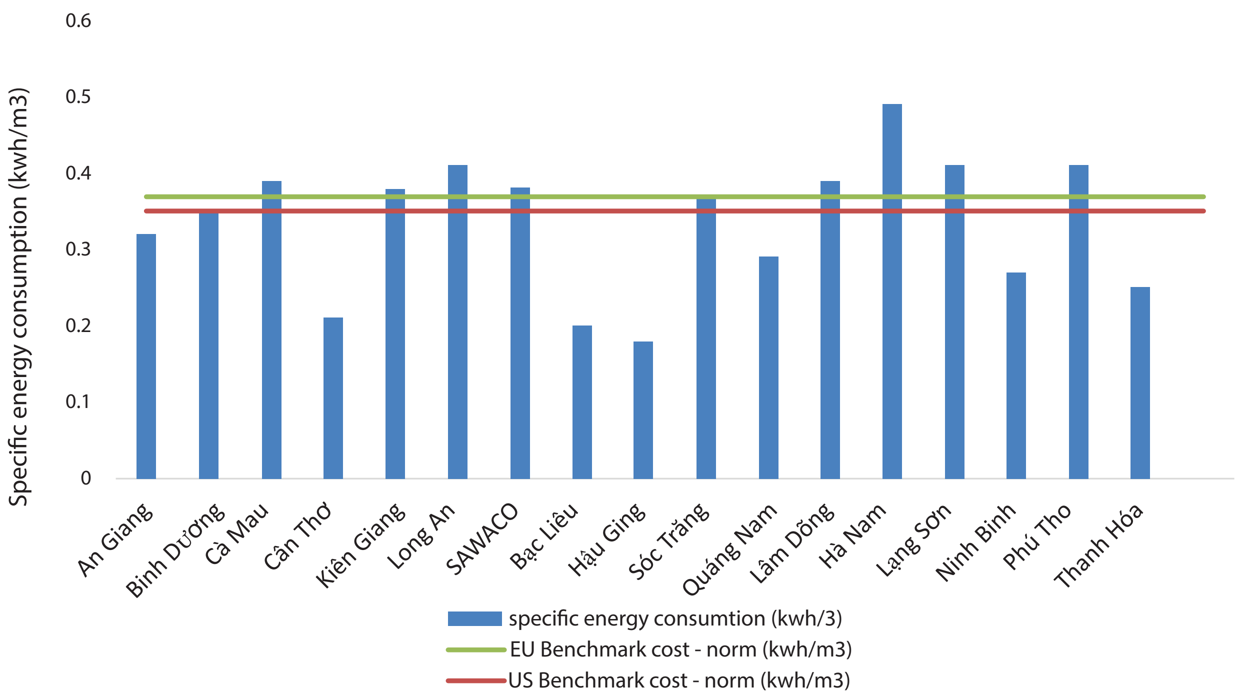
International cost norms broadly comparable to those developed by the MoC to assess the energy efficiency of water treatment have been used to assess the EE performance of the water industry. These cost norms are not graded by raw water source or treatment type. The cost norms are:

- China, 0.29 kilowatt-hours per cubic meter (Smith and Liu 2017)
- European Union, 0.37 kilowatt-hours per cubic meter (Jacobsen 2012)
- United States, 0.35 kilowatt-hours per cubic meter (Carlson and Walburger 2007)

These international benchmarks for energy consumption, which apply across a broad range of treatment plant design throughputs and raw water sources, are more stringent than the MoC cost-norm figures. It is apparent that the MoC cost norms are relatively easy to achieve (see Table 3.1). It is strongly recommended that the cost-norms are reviewed and updated on a regular basis, in order to ensure that the water industry in Vietnam remains internationally competitive in energy efficiency terms, and that the efficiency targets for the industry continue to be stretching.

In general, the EE performance of half the 18 utilities is slightly worse[27] than the international benchmarking norms, although the margins are not large for most. Furthermore, even the utilities that are performing well against these EE benchmarks may still have room to deliver improvements in their performance (see Figure 3.2).

Figure 3.2: Energy Efficiency Benchmarks versus International Norms



Source: EU - Jacobsen 2012, U.S. - Carlson and Walburger 2007, China - Smith and Liu 2017.
Note: EU = European Union; MoC = Ministry of Construction.

The cost-norm values set by the MoC are generous and are by themselves unlikely to drive significant EE improvements. However, during the utility interviews, all the utilities noted that a key driver for improving energy efficiency was financial. Hence, even when the MoC cost-norm values are being met, a desire to reduce operating costs may still drive some utilities to improve their energy efficiency.

27 Overall, the 18 utilities visited have specific energy consumption values approximately 9 percent above the median of the international benchmark values. ***Can this be checked – it looks inconsistent with the graph***

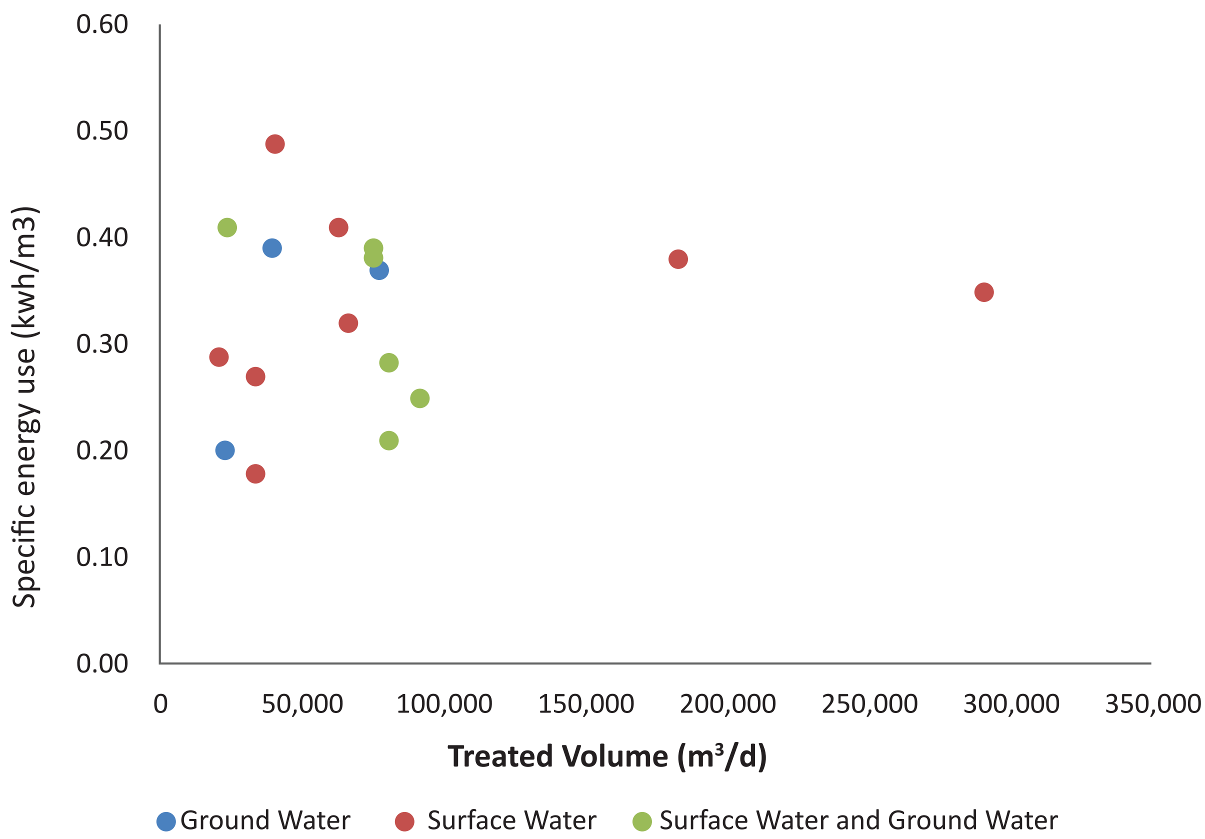
3.1.2 System Specific Energy Consumption

In general, the energy use of a water supply system is influenced by various important factors, which are as follows:

- The size of the system (i.e., the volume of water produced and distributed) can be an important factor because economies of scale make it possible to fine-tune and optimize the design of systems and equipment.
- The type of raw water source used is important because the specific energy use of well-designed surface water treatment works is generally low.[28] The specific energy use of deep wells depends on the quality of exploitation of the groundwater source, which can vary considerably.
- The connection density in the distribution network determines the head loss over the supply area. The lower the connection density, the relatively longer is the conveyance distance of water to the consumer, inducing higher specific energy use.

Figure 3.3, which plots specific energy use of the utilities, does not show a coherent relation between the different water sources used and the specific energy use, irrespective of the size of the system (i.e., the volume of water produced and distributed). Despite the limited detailed information available for the water systems, this will be examined further by analyzing the impact of connection density and the volume of water distributed per connection (system input per connection) on the specific energy use.

Figure 3.3: Specific Energy Consumption by Water Source and Volume Produced



Source: Data provided by MoC.

28 In cases where the distance of raw water transmission is limited.

In general, the specific energy use of drinking water production[29] is approximately 10 percent of the total specific energy use. Hence, the bulk of a utility's energy uptake is used for water distribution. However, taking into account the system characteristics of the 18 utilities,[30] the contribution of the specific energy use of water distributed[31,32] varies between 39 and 94 percent of the total specific energy use (see last column of Table 3.3). This variation in contribution is much broader than the (international) rule of thumb and can be summarized as follows (and also presented in table 3.3):

- The specific energy use of distributed water of four surface-water-based utilities in the Mekong Delta, with flat terrain, is estimated to be approximately 90 percent of the total specific energy use.
- The specific energy use of distributed water of three utilities that use groundwater in the Mekong Delta, with flat terrain, varies between 39 and 55 percent of the total specific use. It is estimated that the specific energy use of borehole pumping is relatively high due to the depletion of the groundwater sources, with the dynamic water level dropping to 35 to 40 meters below ground level. The utilities of Cà Mau and Long An (Tân An and districts) are in the process of converting to surface water. The main driver of the planned conversion is that the current water production falls short of the total water demand.
- The specific energy use of distributed water of the three utilities using a mix of surface and groundwater (Cần Thơ, Phy Ly, and Phú Tho, all with flat terrain) is approximately 70 percent of the total specific use. The estimated average production head is based on the ratio of the volumes of surface and groundwater used.
- The specific energy use of distributed water of the two utilities in the central and highland region, both using a mix of surface and groundwater, varies between 73 percent (Quảng Nam) and 86 percent (Lâm Đồng). Quảng Nam distributes mostly to Tam Kỳ (which is on relatively flat terrain) and to coastal areas. Lâm Đồng distributes in mountainous areas.

Table 3.3: Specific Energy Use of Distributed Water

	Utility	WS Supply	Water Source	System input	Connection density	Total specific energy use		Estimated head production	Specific energy use of water distributed			Contribution to total energy consumption
				L/conn/day	conn/km	kWh/m^3	kWh/conn/year	m	kWh/m^3	kWh/conn/year	kWh/km/year	%
Mekong	**An Giang**	Province	SW	401	140	0.34	50	7	0.31	45	6.315	91
	Bình Dương	Province	SW	1,595	70	0.32	186	7	0.29	168	10.106	90
	Cà Mau	Province	GW	697	178	0.30	76	40	0.12	30	5.348	39
	Cần Thơ	Province	SW and GW	1,332	117	0.20	97	14	0.14	67	7.165	69
	Kiên Giang	Province	SW	673	160	0.31	21	7	0.28	19	2.966	90
	Long An	Province	GW	2,239	75	0.40	328	40	0.22	179	13.432	55
	Long An	Tan An	GW	1,303	100	0.40	190	40	0.22	104	10.374	55
	SAWACO	HCMC	GW	890	177	0.35	114	7	0.32	103	18.29	91
	Bạc Liêu	Bạc Liêu	SW	759	12	0.20	58	24	-	-	-	-
	Hậu Giang	Province	SW	637	69	0.18	42	15	-	-	-	-
	Sóc Trăng	Province	GW	712	92	0.37	123	15	-	-	-	-
Central/ highland	**Lâm Đồng**	Province	SW and GW	789	320	0.76	219	24	0.65	188	21.428	86
	Quảng Nam	Province	SW and GW	1,034	56	0.39	147	24	0.28	107	5.997	73
North	**Hà Nam**	Phủ Lý	SW	988	118	0.49	177	7	0.46	165	19.446	94
	Lạng Sơn	Lạng Sơn City	SW and GW	795	148	0.41	119	25	0.30	86	12.817	73
	Ninh Bình	Ninh Bình	SW	-	-	-	-	-	-	-	-	-
	Phú Thọ	Province	SW	552	184	0.37	75	26	0.27	54	9.954	72
	Thanh Hóa	Province	SW and GW	-	-	-	-	-	-	-	-	-
	VIWACO	Hanoi	SW	-	-	-	-	-	-	-	-	-

Source: Data provided by MoC and individual utilities.

Note: GW = groundwater; HCMC = Ho Chi Minh City; SAWACO = Saigon Water Supply Corporation; SW = surface water; "-" = not available.

29 Excluding high-lift pumping in the distribution network.

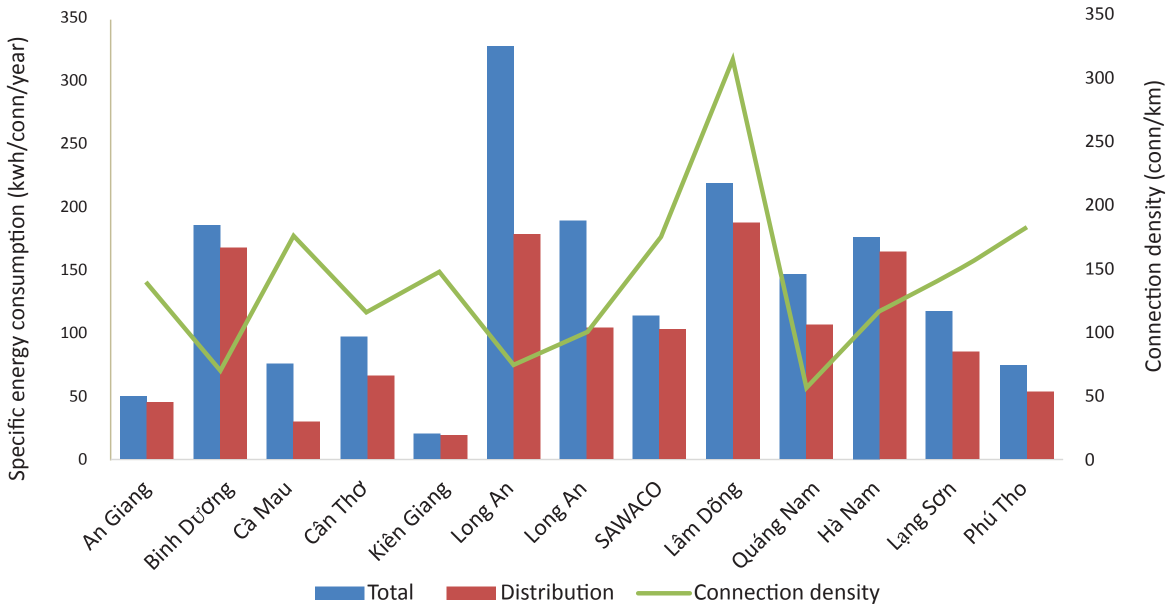
30 Quantitative data for three utilities are not yet available.

31 Ten utilities at the company level, plus Tân An and Phủ Lý.

32 Based on estimated head of production, see individual utility reports. During the deep-dive stage, these estimations need to be verified.

As presented in Figure 3.4, the values for the specific energy use of distributed water—in kilowatt-hours per connection per year—for three of the utilities with low connections densities (Bình Dương, Long An, and Quảng Nam) are the highest, ranging between 107 and 179 kilowatt-hours per connection per year. A considerable portion of the water is distributed to industrial areas and big customers. Furthermore, as mentioned previously, the specific energy use of distributed water in Lâm Đồng is high (188 kilowatt-hours per connection per year) due to the mountainous terrain. In contrast however, three utilities with low connection densities (Bạc Liêu, Hậu Giang, and Sóc Trăng), report very low specific energies. This may be due to their location in flat areas of the Mekong Delta.

Figure 3.4: Specific Energy Use of Distributed Water per Connection for 12 Utilities



Source: Data provided by MoC and individual utilities.

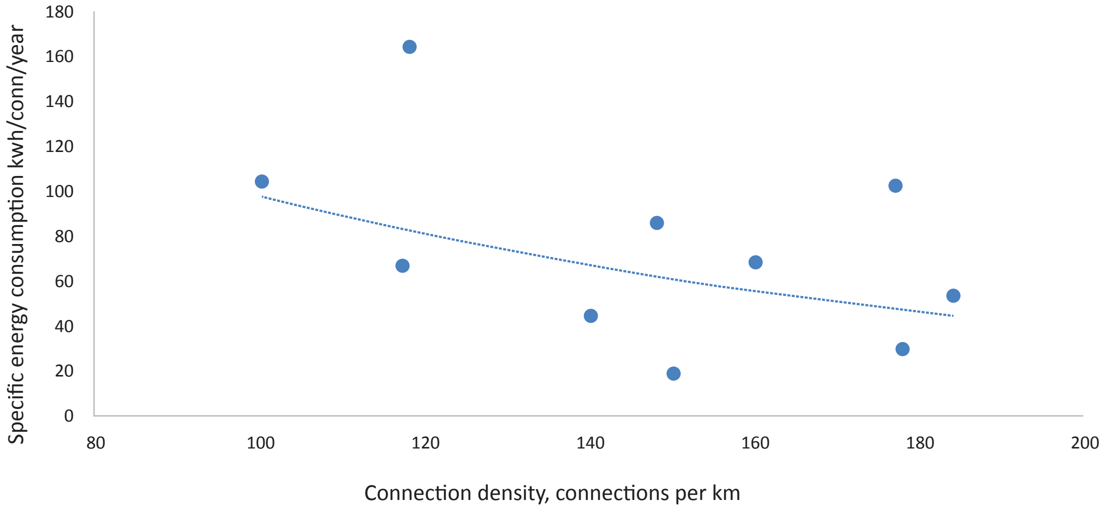
When filtering out the specific situations of the aforementioned seven utilities, and excluding the specific energy use of water production, the specific energy use of the remaining nine distribution systems,[33] which have a similar operational environment, can be compared.

Figure 3.5 plots the specific energy use of distributed water against the connection density. It is obvious that the specific energy use is lower in distribution systems with higher connection densities (see plotted trend line). The specific energy use of distributed water of two utilities is noticeably a reasonable bandwidth above the trend line. Perhaps the system specifics are a reason for the high specific energy use, as is the case for SAWACO (107 kilowatt-hours per connection per year, with a connection density of almost 180 per kilometer), where the location of the two major production facilities is asymmetric to the water supply area, requiring relatively long transmission lines.

At this stage, with limited knowledge of the system of Hà Nam (Phủ Lý, 165 kilowatt-hours per connection per year, with a connection density of almost 120 per kilometer), the high specific energy use of distributed water cannot be explained.

33 Seven utilities at the company level, plus Tân An and Phủ Lý.

Figure 3.5: Specific Energy Use of Distributed Water of Nine Systems with High Connection Densities



Source: Data provided by MoC and individual utilities.

It can be concluded that an assessment of the specific energy use of the major components of a water supply system is a useful exercise to identify possible opportunities to improve the energy efficiency at the system level. The results from the rapid assessment (see sections 3.2.4 and 3.2.5) show that the utilities mainly focus on EE improvements at the equipment level, which is understandable. Most EE improvements in existing systems would require investments with long return periods.

From the preceding discussion,[34] it is clear that the assessment of specific energy use at the system and subsystem levels will support a utility in obtaining insight and enhancing the awareness of EE bottlenecks of various systems and subsystems, as well as in the daily operation of the production and distribution system.[35] The insight gained can be used to inform replacement and extension policies, including the concept of whole-life cost (WLC),[36] which includes capital costs and capitalized energy costs, as an important (new) design parameter.

3.1.3 Current EE Strategies and Management

During the interviews, it was clear that all of the 18 utilities recognized the importance of energy efficiency to some extent, with every utility citing operational cost management as a key driver for controlling energy efficiency. Ten of the 18 confirmed that they have a formal energy management strategy, and eleven confirmed that they have a formal strategy to deliver improvements in energy efficiency (see Table 3.3). In some cases (e.g., Lâm Đồng), although the utility does not have a defined energy strategy and does not have specific EE targets, improvements have been made in energy efficiency through a program of capital investment.

However, this recognition has not always been translated into action. For example, Lạng Sơn has no defined approach to the management of energy and no energy-auditing process, with energy data available only at the company level. Where the only EE drivers are compliance with MoC cost norms and the avoidance of an increase in energy consumption over historical levels, there is little incentive for a utility to improve its EE position.

34 The assessment made, with limited system knowledge, is obviously crude and indicative only.

35 In the case of sufficient production and distribution capacity.

36 Economic diameter or water velocity of transmission and distribution mains.

Table 3.3: Energy Efficiency Management Strategies

Region	Utility	Specific energy (kWh/m3)	Dedicated energy management staff	Defined energy strategy	Defined energy efficiency improvement strategy
Mekong	Bình Dương	0.35	Team	Yes	Yes
	Cần Thơ	0.21	Team	Yes	Yes
	SAWACO	0.38	Team	Yes	Yes
	Long An	0.41	4	Yes	Yes
	An Giang	0.32	Team	-	Yes
	Kiên Giang	0.38	Team	Yes	Yes
	Cà Mau	0.39	2	Yes	Yes
	Bạc Liêu	0.2	0	No	No
	Hậu Giang	0.18	0	Yes	Yes
	Sóc Trăng	0.37	0	No	No
South	Lâm Đồng	0.39	0	No	No
Central	Quảng Nam	0.29	-	-	-
North	VIWACO	NA	Team	Yes	Yes
	Phú Tho	0.41	Team	No	No
	Thanh Hóa	0.25	-	Yes	Yes
	Ninh Bình	0.27	-	Yes	Yes
	Hà Nam	0.49	0	No	No
	Lạng Sơn	0.41	0	No	No

Source: Data provided by MoC and individual utilities.
Note: "-" = not available.

It is not always certain that the data reported by a utility is accurate. For example in the case of Hà Nam, the reported high specific energy consumption seems out of step with the flat topography of the supply area, and it is possible (though not certain) that the reported energy consumption may not

A lack of a formal energy strategy or EE improvement strategy does not preclude a company from operating in an energy-efficient manner—for example, members of site operations teams can be proactive in developing and implementing EE measures. However, the provision of a dedicated energy management team and the institutionalization of the utility's approach to EE management at the company level are best practices and should be undertaken by all utilities.

Nine of the 18 utilities confirmed, either during the interviews or in their responses to questionnaires, that they have some staff members dedicated to monitoring and managing energy efficiency. Six of the 18 confirmed that they currently have no staff dedicated to the management of energy efficiency.

To allow energy efficiency to be properly managed, some approach to measuring and benchmarking of EE performance, and the development of a program of operational and capital investment interventions, is required.

As a part of this process, some form of regular assessment of energy consumption is necessary. Ideally, this would involve the completion of detailed energy audits at individual plants on a regular basis. Although there is no "best" frequency for energy auditing, international practice would generally dictate that a detailed assessment of major energy-consuming plant items be completed at least once every 5 years.

The level of detail to which an energy audit is completed is also important. During the assessment, it became apparent that the different utilities had different approaches to the process of auditing their energy efficiency. Five typical approaches were found, and these are summarized in Table 3.5. Quality grades for each approach, ranging from A (best) to D (worst), have been applied.

Table 3.4: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site, **or** ad-hoc audits conducted when a piece of equipment has been identified as having reached the end of its service life.
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually.
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least every five years

The assessment revealed that there is a wide variance in practice between utilities, with some utilities completing a robust program of regular audits and a small number completing no audits. The details of each utility's approach are discussed in more detail in this section. A summary of the approaches is given in Table 3.5.

Table 3.5: Energy Auditing Approaches Applied by Utilities

Utility	Frequency	Type	Grade
Bình Dương	Annual	External, independent	A
Cần Thơ	Triennial	External, independent	A
SAWACO	Annual	Internal	B
VIWACO	Ad hoc	Internal	B/C
Phú Tho	Limited	Internal	C
Thanh Hóa	Ad hoc	Internal/external, independent	B/C
Ninh Bình	None	None	D
Long An	Ad hoc	Internal	A/B
An Giang	Monthly	Internal	C
Kiên Giang	Ad hoc	Internal/external, supplier driven	A/B
Cà Mau	Monthly	Internal	B/C
Hậu Giang	Ad hoc	Internal	C
Sóc Trăng	Ad hoc	Internal	C/D
Bạc Liêu	Ad hoc	Internal	C/D
Lâm Đồng	Ad hoc	Internal	C
Quảng Nam	Ad hoc	Internal	C
Hà Nam	Monthly	Internal	C
Lạng Sơn	Ad hoc	Internal, limited	C/D

3.1.4 Operating EE Measures

Having completed some form of EE assessment, a utility must then act on the findings to successfully manage or improve its energy efficiency. The recommendations from any EE audit fall into two categories: operational interventions and capital investment interventions.

Operational measures are the easiest to implement, requiring either no investment in the plant or very low-cost interventions, where the cost can easily be absorbed in the operational budget. Examples of typical operational interventions are shown in Table 3.6

Table 3.6: Typical Operational Interventions Applied in Water Industry

Measure	Scope of work	Typical ease of implementation	Typical scale of benefit	Typical payback
Peak-tariff avoidance	Change operating periods for key plant items to avoid running during peak-tariff periods.	Medium	No reduction in energy consumption, but OPEX costs are reduced	<1 year
Optimized duty rotation	Adjust duty rotation of standby equipment to ensure that the most efficient equipment runs the longest hours.	Easy	Usually low unless there are wide variations in efficiency between plant items.	<1 year
Installation of energy-efficient lighting	Use energy-efficient lighting to replace existing lighting.	Easy	Low unless there are extensive areas of lighting (e.g., in offices)	<1 year
Pressure management	Reduce pressure in the distribution system.	Medium/difficult	Widely variable. The practicality of this option is very specific to individual distribution systems. If the distribution pressure is too low, this can lead to utility customers installing their own booster pumps, which may give a worse overall system efficiency than before the pressure was reduced.	<1 year

Note: OPEX = operation expenditure

The financial incentives to reduce consumption depend on the structure of electricity tariffs (see Table 3.7). Vietnam has Time-of-Use (TOU) tariffs that are uniform across the country. Regional uniformity means that all utilities have the same incentives to reduce energy consumption irrespective of location. A utility in areas that are more expensive to serv has no greater incentive to reduce consumption than a utility in an area with lower costs to serve. However, the TOU tariff creates an incentive to use less energy in peak periods. Because normal and low-rate tariffs are between 45 and 66 percent below the peak-tariff rates, avoiding the use of major energy-consuming assets during peak periods can still result in OPEX savings of 10 to 14 percent (after accounting for the periods for which peak tariffs apply).

Table 3.7: Tariff Rates

22–110 kV	Hours per week	Tariff rate (Vietnamese Dong per kWh)	
		From 2017	From 3/2019
Normal	96	1,452	1,555
Low	42	918	1,007
Peak	30	2,673	2,871
<6 kV			
Normal	96	1,572	1,685
Low	42	1,004	1,100
Peak	30	2,862	3,076

Source: EVN 2019

Through the program of questionnaires and interviews the 18 utilities, an initial assessment was made of the approach of each utility to delivering the asset-planning processes required to ensure energy-efficient operation. Some key findings from this process are summarized in Table 3.8.

Table 3.8: Operational Energy Efficiency Measures Implemented by Utilities

Region	Utility	Specific energy (kWh/m³)	WLC assessments for new equipment	Asset deterioration monitoring	Granularity of power metering	Peak-tariff avoidance	Asset operation	Distribution pressure management
Mekong	Bình Dương	0.35	Yes	Yes	Process level	Yes	Semiautomated	Yes?
	Cần Thơ	0.21	Yes	Yes	Process level	Yes	Semiautomated	No
	SAWACO	0.38	Yes	Yes	Site level	Yes	Semiautomated	Yes/no
	Long An	0.41	Yes	Yes	Site level	Yes	Semiautomated	Yes
	An Giang	0.32	-	No	Site level	-	Semiautomated	No
	Kiên Giang	0.38	Yes	Yes	-	Yes	Semiautomated	Yes
	Cà Mau	0.39	No	Yes	-	Yes	-	Yes
	Hậu Giang	0.18	Yes	Yes	Site level	Yes	Semiautomated	Yes
	Sóc Trăng	0.37	No	Yes	Site level	No	Semiautomated	Yes
	Bạc Liêu	0.20	No	Yes	Site level	Yes	Semiautomated	Yes
South	Lâm Đồng	0.39	No	Yes	Site level	Yes	Semiautomated	Yes
Centre	Quảng Nam	0.29	-	-	-	-	-	No
North	VIWACO	-	Yes	Yes	Site level	Yes	NA	Yes?
	Phú Tho	0.41	-	Yes	Process level	Yes	Semiautomated	Yes
	Thanh Hóa	0.25	Yes	Yes	Site level	No	Manual	-
	Ninh Bình	0.27	Yes	Yes	Site level	Yes	Manual	Partial
	Hà Nam	0.49	-	Yes	Site level	No	Automated/ semiautomated	Yes
	Lạng Sơn	0.41	-	-	-	-	-	Yes

Source: Data provided by MoC and individual utilities.
Note: "-" = not available.

Nine of the utilities confirmed that when procuring new equipment, WLC analysis is completed. WLC assessment when procuring new equipment is a key aspect of ensuring energy-efficient operation. When procuring a pump, for example, the capital cost of the pump represents only 5 to 10 percent of the WLC, with the remainder mostly comprising energy costs. Failing to consider WLC when procuring equipment may lead to an undue focus on the capital cost of a piece of equipment, potentially leading to the procurement and installation of inefficient assets.

Fifteen of the utilities reported that they had sufficient information available to detect when the efficiency of a piece of equipment was deteriorating. During the interviews, most utilities confirmed that this required the operational staff at a site to monitor the performance of the equipment on a regular basis. This type of day-to-day monitoring can allow utilities to maintain awareness of the need for replacement of key plant items without requiring a detailed EE audit. However, there is a risk that a slow deterioration in the energy efficiency of an asset may not be detected.

For example, when a detailed energy audit was completed at the Dan Kia Suoi Vang water treatment works in Lâm Đồng, a severe deterioration was found in the energy efficiency of the raw water pumps, which had not previously been detected through day-to-day operational monitoring.

The granularity of power monitoring was generally found to be low, with eleven utilities reporting power consumption at the site level as opposed to the process or asset level. The monitoring of the power consumed by a process or individual asset, through the use of submetering, is a key aspect of operational monitoring of energy efficiency, with greater granularity allowing more robust monitoring of asset efficiency. In the worst case, power consumption was measured only at the level of the utility.

Twelve utilities confirmed that they were carrying out tariff management, such as turning off large plant items, where possible, during high-tariff periods. Although this does not result in improved energy efficiency per se, it does reduce energy OPEX and is best practice.

The vast majority of utilities were operating their water treatment assets in a manner described as "semiautomatic"—that is, with a general reliance on manual intervention from site operations personnel. Reliance on true automated operation using online instrumentation was very limited. Although there is nothing inherently inefficient about operating assets in this manner, this approach does rely on the experience and diligence of the site personnel. There is also a risk that if, for example, an asset operates in an inefficient manner when outside of site personnel hours, there will be a significant delay before personnel return to the site and the situation is rectified. Full automation using online instrumentation and programmable logic controllers (PLCs) / supervisory control and data acquisition (SCADA) is preferable. However, there is a lack of experience with this type of control in Vietnam, and the high cost of installation, coupled with the relatively low cost of labor, has led to limited uptake of this type of control so far.

Thirteen utilities reported carrying out some degree of pressure management in the distribution networks. Where pressure management is not carried out, energy efficiency will be compromised.

Best practice, which should be implemented by all utilities, is as follows:

- WLC analysis should be carried out when procuring any new equipment, particularly where it consumes significant energy.
- Asset deterioration should be monitored by on-site operational personnel. For large assets (e.g., large pumps), this should be done at least monthly, preferably by measuring the flow and power consumed by the pump and calculating its efficiency. There should be a means of reporting any deterioration in asset efficiency to the utility's energy management team.
- Ideally, power monitoring should be completed at the Motor Control Center (MCC) level. For large assets (e.g., larger pumps), consideration should be given to the installation of submetering at the

asset level. The power readings from the submeters should be noted at regular intervals (ideally daily, but at least monthly), and any increasing trend should be reported to the utility's energy management team.

- Peak-tariff-avoidance measures are good practice, and a tariff management plan should be completed for every site.
- Consideration should be given to automation of asset operation wherever possible. However, it is unlikely that it will be feasible to retrofit this in most existing sites.
- Distribution system pressure management is best practice from both the NRW and EE perspective and should be implemented by all utilities.

In general, most of the 18 utilities reported carrying out at least some of the best-practice approaches just listed. However, few utilities were carrying out all the best-practice measures, leaving room for improvement.

3.1.5 Capital EE Measures

Capital investment measures are generally more difficult to implement than are operational measures, requiring some degree of capital investment, which must usually be provided from a central budget. As a result, these measures may be more difficult to justify commercially, and they typically take longer to deliver than operational measures. Payback periods for viable schemes would typically be expected to be less than 5 years, as shown in table 3.9.

Table 3.9: Typical Capital Investment Measures at Equipment Level Applied in Water Industry

Measure	Scope of work	Typical scale of cost	Benefit	Typical payback
Replacement of life-expired or inefficient mechanical and electrical equipment (typically pumps)	Replacement of pumps or other assets that have reached the end of their asset lifetime or otherwise become inefficient	0.3–2 billion D per plant item	Life-expired mechanical and electrical equipment becomes inefficient through general wear and tear. Life-expired pumps may have an energy efficiency of 40% to 50%, compared with the 70% to 80% efficiency of new pumps.	1–5 years
Installation of power-factor-correction equipment	Installation of equipment to improve the power factor of major plant items or processes	150–750 million D per plant	Many large items of equipment can have a poor power factor, leading to substantial energy waste. The installation of power-factor-correction equipment can deliver energy savings of 5% to 10% (depending on the uncorrected power factor).	2–3 years
Installation of soft starters	Replacement of old (typically DOL or star-delta) starters with soft starters	3–6 million D per plant item	Soft starters can reduce the operating power for electric motors by 10% or more compared with more simple starters.	0–3 years
Installation of variable-speed drives	Replacement of old (typically DOL or star-delta) starters with variable-speed drives	6–300 million D per plant item	Reducing the speed of a rotating machine can substantially decrease its power consumption, deliver energy efficiency benefits, and improve pump control.	0–3 years
Installation of automated control systems	Installation of online sensors and PLC control for processes on-site, replacing manual operation	1.5–4.5 billion D per plant	Automated processes can respond more quickly to process deviations and monitor energy efficiency online in real time. There are potential fringe benefits in terms of reduced personnel costs, which must be offset against the additional complexity of looking after new process control instrumentation. The installation of site PLCs can be extremely expensive and complex.	3–5 years

Installation of renewable energy technology	Installation of solar PV, wind, hydro, or similar renewable energy technologies on-site to generate renewable energy	16–18 million D per kW of capacity for solar PV	Renewable energy technology brings benefits through both energy offsets and income from feed-in tariffs (FITs). The Ministry of Industry and Trade has set the FIT value at $0.0935 per kWh until July 2019, making investment in solar PV financially favorable.	5–10 years

Note: D = Vietnamese dong; DOL = direct online; PLC = programmable logic controller; PV = photovoltaic.

Nine of the 18 utilities were able to confirm the details of capital investments that had been made under an EE driver; these are listed in Table 3.10.

Ten of the 18 utilities confirmed that a capital investment budget was available to fund any EE interventions that were identified. During the interviews, most of the utilities stated that to allow money to be released from the capital budget, it would be necessary to produce a case for investment that would be justified in commercial terms.

However, despite such budgets being notionally available, relatively few utilities had actually made any investment. A common theme during interviews was that funding within capital budgets for EE was often insufficient to allow significant plant items to be replaced.

Table 3.10: Capital Investment under Energy Efficiency Driver

Region	Utility	Capital budget available	Equipment replacement	Power factor correction	Soft starters	Variable speed drives	Automated control	Renewable energy
Mekong	Bình Dương	Yes	Yes	No	No	Yes	No	No
	Cần Thơ	Yes	No	No	No	Yes	No	Yes
	SAWACO	Yes	No	No	No	Yes	No	No
	Long An	Yes	Yes	No	No	Yes	No	Yes
	An Giang	-	-	-	-	-	-	-
	Kiên Giang	Yes	No	No	No	No	No	Yes
	Cà Mau	-	-	-	-	-	-	-
	Hậu Giang	Yes	Yes	Yes	Yes	Yes	No	No
	Sóc Trăng	No	Yes	Yes	Yes	Yes	No	Yes
	Bạc Liêu	No	Yes	Yes	Yes	Yes	No	Yes
South	Lâm Đồng	Yes	Yes	Yes	Yes	No	No	No
Centre	Quảng Nam	-	-	-	-	-	-	-
North	VIWACO	No	No	No	No	No	No	No
	Phú Tho	Yes	No	No	No	No	No	No
	Thanh Hóa	Yes	No	No	No	No	No	No
	Ninh Bình	No	No	No	No	No	No	No
	Hà Nam	Yes	No	No	No	No	No	No
	Lạng Sơn	-	-	-	-	-	-	-

Source: Data provided by individual utilities.

Note: "-" = not available.

The installation of variable-speed drives was the most popular EE option confirmed as having been delivered.

Only six utilities confirmed that they had replaced life-expired equipment with new equipment on the basis of improved energy efficiency, and four utilities confirmed that soft starters had been installed along with power-factor-correction equipment.

Five utilities had installed renewable energy technologies, with all the investment in this area being in solar photovoltaic (PV) systems. Despite the professed availability of capital funding, many of the utilities discussed the difficulty of obtaining funding for capital investment during the interviews.

3.2 Wastewater Treatment

Of the 18 utilities, only 4 —Lâm Đồng, Phú Tho, Cần Thơ, and Bình Dương—were involved in the operation of wastewater treatment plants.

The available information on the energy efficiency of the plants operated by the utilities was sparse. The operational costs of the wastewater treatment plants operated by each utility were paid via the local People's Committee in each case. In discussions with the utilities, it became clear that there was little or no incentive for the utilities to improve the energy efficiency of the plants they operated because the costs incurred would be refunded regardless.

All the utilities levy an "environmental charge" of 10 percent on the water tariff for domestic customers. This additional tariff is passed on to the People's Committee, with the utility generally being paid a fraction of the charge, to cover the costs of collection. This charge is used by the People's Committee to fund various environmental improvement measures and is not a charge to cover the costs of sewage treatment.

The early stage of development of wastewater treatment in Vietnam represents an opportunity for the water sector to ensure that any new wastewater treatment plants are designed with energy efficiency in mind. Energy efficiency should be designed into all new plants, as far as possible. Guidance from the MoC on process selection may be beneficial in ensuring that this happens, although any guidance should avoid being too prescriptive because energy efficiency is just one consideration when designing a new plant.

Wastewater treatment facilities may use suspended growth processes, in which the microorganisms and bacteria treating the wastes are suspended in the wastewater being treated, or attached growth processes, in which the microorganisms and bacteria treating the wastes are attached to the media in the reactor. In the case of the 18 utilities, the findings are as follows:

- BIWASE (Bình Dương) and Phú Tho operate plants designed around suspended growth processes, which are relatively energy intensive. A typical benchmark value for energy efficiency for suspended growth processes of this type would be 0.42 kilowatt-hours per cubic meter.
- Cần Thơ and Lâm Đồng operate plants designed around attached growth processes, which consume relatively little energy. A typical benchmark value for energy efficiency for attached growth processes of this type would be 0.26 kilowatt-hours per cubic meter.

Wherever possible, new plants should be designed around energy-efficient biological processes, using fixed films wherever possible. Where the space for the development of a new plant is limited, the additional operational cost for the installation of a suspended growth process may be justified.

A general lack of comprehensive forward planning in the development of urban wastewater treatment was evident during the utility interviews and site visits. The recently constructed plant overseen by Phú Tho had not been connected to any mains-drainage system, due to a lack of funding for the construction of the mains drainage required to serve the plant. The plant in Lâm Đồng had also recently been upgraded to accept additional flows for treatment, but few additional households had been connected by the time of the site visit.

As with potable water treatment, all utilities should institute robust asset-planning procedures to ensure that plants can be maintained in an energy-efficient state throughout their design asset life. The best-practice approaches outlined in the preceding sections apply equally to water and wastewater and should be applied in the case of wastewater treatment.

In the future, as the sector develops further, the management of residual sludge from the increasing number of plants will become a more critical issue. Wastewater sludge represents a potential source of energy, which should be harnessed wherever possible. None of the sites visited during either mission were making any beneficial use of their residual sludge.

Although the number of wastewater treatment plants in service currently appears too low to support a large-scale energy recovery plant (based on, e.g., anaerobic digestion), in the future, sufficient sludge may be available to make such plants commercially viable. Given the economies of scale associated with such plants, it may be necessary for utilities to work together to provide feedstock to a small number of centralized plants. The blending of sludge with other feedstocks (e.g., food waste) may also be worth considering.

Due consideration should also be given to the potential to install renewable energy technology, such as solar PV panels and wind turbines. Renewable energy technology, although it does not directly improve the energy efficiency of a plant, can significantly reduce the utility's operating costs and carbon footprint.

3.3 Case Studies: Replicating Best Practice

Energy efficiency is a global issue, and water utilities across the world have developed an increasing focus on the delivery of improvements to their energy efficiency over recent years. The majority of the utilities assessed under the scope of this report have completed some work on improving their EE position. The approaches taken by the utilities vary, and many will require further development to ensure the long-term sustainability of EE savings. Common issues that prevent the successful delivery of EE improvements include a lack of capital investment, poor monitoring, a lack of central leadership, and a lack of a robust strategy.

EE improvements are delivered primarily through good asset-planning processes. These require the development of a robust EE improvement strategy; data collection to ensure that the EE position can be understood; the development of programs of actions, which may be operational or funded with capital investment; and the delivery of these programs.

In this section, four case studies of EE improvement are illustrated as good practice: two from Vietnam and two from neighboring countries with similar settings and challenges. After presenting the cases, this section also summarizes key elements for success and lessons learned.

3.3.1 Regular Energy Audits and Clear Strategy on EE Management: Cần Thơ

The Cần Thơ Water Supply and Sewerage Joint Stock Company manages the water supply in six districts in Cần Thơ City (Bình Thủy, Cái Răng, Ninh Kiều, Ô Môn, Phong Điền, and Thốt Nốt). The company operates three water treatment and distribution systems, with design capacities ranging between 2,500 and 75,000 cubic meters per day. The population served by the utility is 247,433.

The company set a target energy consumption for water treatment of 0.18 to 0.19 kilowatt-hours per cubic meter, as compared with the reported current consumption of 0.21 kilowatt-hours per cubic meter, a reduction of 9 to 14 percent. The key driver for the company's robust approach to EE management is the cost of energy, which is anticipated to increase between 5 and 10 percent in the period through 2028.

The current specific energy consumption of the company is well below both the MoC cost norms and that of most of the other 17 utilities that were included within the scope of work for this assessment.

Cần Thơ WASSCO provides a good example of best practice in water treatment and distribution energy management; this utility has a clear focus on energy efficiency. The areas of best practice at WASSCO that could be replicated elsewhere are as follows:

- Development of a clear EE target and delivery strategy, driven by the central management of the utility
- Employment of good operational practices (e.g., tariff management)
- A program of regular third-party energy audits at operational sites
- Provision of capital investment funding to enable the recommendations of the energy audits to be delivered.

WASSCO has maintained a focus on operational efficiency at its water treatment and distribution sites. For example, filter backwashes from water treatment plants are delayed until low-tariff periods, and high-lift pump operation is restricted (within the bounds of the requirement to provide sufficient volumes of pressure and water in distribution) during peak-tariff periods.

WASSCO has also made some significant capital investments in energy efficiency, mainly as a result of the recommendations of EE audits. For example, the installation of variable-frequency drives on the Cần Thơ 1 water treatment plant's high-lift pumps were implemented at a cost of 27.176 million VND, delivering annual savings of approximately VND 41.526 million per annum. The installation of inverters at other locations was also completed, at a combined cost of VND 28.47 million, with predicted annual savings of VND 111 million.

3.3.2 Considering EE in the Design of Wastewater Treatment Systems: Lâm Đồng

The Lâm Đồng Water Supply and Sewerage Company is a water and wastewater utility that is responsible for both water treatment and distribution in the province of Lâm Đồng and the operation of the wastewater treatment plant serving the city of Da Lat.

The development of urban wastewater treatment in Vietnam is still at a relatively early stage, with a significant proportion of urban areas lacking any wastewater treatment. There is therefore a significant opportunity for good energy efficiency to be designed into new plants, with energy-efficient processes being selected when new wastewater treatment plants are developed.

The Da Lat wastewater treatment plant is a good example of a site where energy efficiency has been designed into the flow of processes. Two key aspects of best practice from this plant could be replicated elsewhere:

- Energy-efficient biological treatment processes (conventional percolating filters and anaerobic filters) have been selected. Tertiary treatment uses stabilization ponds, which do not require any energy to operate.
- The topography of the steeply sloping site has been utilized to allow the flow through the plant to be maintained by gravity only, with no need for pumping of the wastewater.

The current approach to funding the operating costs for wastewater treatment plants does not incentivize the utilities that operate them to reduce the plants' energy consumption. Currently, operational costs are refunded to the utilities from the People's Committee. The People's Committees levy an environmental charge—an additional tariff on the water bills charged by utilities—but this is not linked directly to the operational costs for wastewater treatment.

Because utilities that operate wastewater treatment facilities are directly recompensed for any expenses incurred, there are currently limited incentives to improve the energy efficiency of wastewater treatment plants. The implementation of EE targets would be an improvement to the existing best practice as seen in Lâm Đồng.

3.3.3 Systematic EE Management Strategies and Efficient Implementations: CAGECE, Brazil

Companhia de Aguas e Esgoto do Estado do Ceara (CAGECE) is a regional water utility serving the province of Ceara in northeastern Brazil. The utility is large, serving approximately 6.7 million customers in 150 municipalities.

In 2001, CAGECE commenced involvement in a program of EE improvement known as Watergy. Under the program, the utility developed and implemented a series of best-practice approaches to ensure that its operations were as energy efficient as possible.

During the period 2001–2003, there was a focus on the completion of EE audits, following which a detailed investment program was developed. The focus of the audits was on the development of engineering solutions, funded by capital investment, with an emphasis on not only the replacement of inefficient assets but also the implementation of automated control. Alongside the engineering solutions, improvements to operational approaches were also developed.

During the period 2003–2005, the findings of the audits were implemented, resulting in significant improvements in the utility's EE performance.

The best-practice areas developed included the following:

- Improvements in the collection and analysis of energy consumption data
- Improvements in the automation of treatment and distribution processes, including pressure control, pumping control, and automated tariff avoidance, among others
- Improved asset-level efficiency through the refurbishment of inefficient assets (e.g., motors) or their replacement with high-efficiency equivalents
- The development of robust operational practices to manage day-to-day EE issues, formalized in operations and maintenance manuals
- The development of system-level reporting and analysis tools, allowing the EE impacts of the interactions of different assets, such as water treatment plants, pumping, and booster stations, to be understood and managed

The program was successful in delivering EE savings of 88 gigawatt-hours over a period of 4 years, with a capital investment of $1.1 million delivering operational cost savings of $2.5 million per year, with a simple payback period of less than 6 months.

3.3.4 Capital Investment and Capacity Building in Energy Efficiency: Pune, India

The Municipal Corporation of the city of Pune, India, provides approximately 3 million people with potable water services. During the period 1997–2006, the Municipal Corporation maintained a focus on delivering improvements to the energy efficiency of its assets, in cooperation with the Alliance to Save Energy.

The Municipal Corporation and the Alliance to Save Energy completed a program of detailed energy audits to establish the energy efficiency of the asset base and allow the identification of low-cost EE improvement measures through improved staff training and operational efficiency improvements.

Subsequently, technical solutions, funded by capital investment, were developed and implemented. Specific interventions included the following:

- Refurbishment or replacement of inefficient pumps
- Improvements in power-factor correction
- Improvements in staff training

The total capital investment program was relatively modest, at $198,000, but delivered energy savings of approximately 3.9 gigawatt-hours per year, with a payback period of less than 7 months.

3.3.5 Key Elements for Success

Experience in the delivery of improvements to energy efficiency both within Vietnam and globally allows some key themes to be identified. International experience has demonstrated that there are four key barriers to the successful delivery of EE improvement programs:

- **Lack of information on the energy efficiency of the existing asset base.** Poor data-collection practices can limit the ability of a utility to develop a meaningful approach to energy efficiency. For example, information on the age, condition, and performance of individual assets may be missing or incomplete, or it may be available on-site but not provided to central asset-planning teams.
- **Lack of incentives to improve energy efficiency**. Delivery of improvements to energy efficiency requires time, dedication, and money. Where operational interventions are identified, site personnel may be distracted by other priorities if energy efficiency is not driven as a high priority by the utility's management team. The cost of energy may be insufficient to drive good practice within the utility, or other priorities may override energy efficiency. In Vietnam, this barrier is particularly prevalent in the operation of wastewater treatment plants.
- **Lack of financing, preventing investment in energy efficiency**. Limitations on water tariffs, a lack of available capital investment, or limitations on borrowing may prevent utilities from investing in EE improvements. Where capital investment interventions are identified, a lack of available funding may drive utilities to deliver only those that have very short payback periods.
- **Lack of an effective delivery mechanism**. Some utilities may identify potential EE interventions but lack the internal expertise to deliver them. The effort required to identify and engage suitable contractors that can deliver the investment may overwhelm the resources available to some smaller utilities, preventing the delivery of EE measures.

The development of an effective approach to the management and improvement of energy efficiency that can overcome these barriers should be viewed first and foremost as an exercise in effective asset management.

Asset management processes should be driven by the central management of a utility. The development of a clear EE strategy, with firm targets for energy consumption, and the provision of personnel to deliver the strategy are prerequisites for success.

A second fundamental aspect of a successful asset management program is the collection and analysis of asset data. Hence, in the case of energy efficiency, the development and maintenance of a robust process for data collection and analysis is a prerequisite for success.

In Vietnam, the utilization of automated collection of data via online sensors and SCADA systems is at an early stage of implementation; however, international experience has demonstrated the power of this type of approach in successful EE management, and consideration should be given to investment in this area. In the absence of automated data-collection systems, the importance of the development and implementation of a robust program of energy audits is increased. Regardless of whether automated data collection is available, a regular program of EE audits is essential.

The final fundamental requirement is the development and delivery of programs of interventions to improve energy efficiency. These interventions may be deliverable through operational changes, requiring formal personnel training. Alternatively, they may require capital investment. Once EE interventions of either type have been delivered, ongoing monitoring is required to ensure that the interventions have been successful.

3.4 Conclusions and Recommendations

There is a general understanding of the importance of energy efficiency among Vietnam's water utilities. The utilities are motivated primarily by the need to comply with MoC cost norms for energy consumption in water treatment and the desire to manage operating costs. All the utilities comply with MoC cost norms, which are relatively relaxed compared with international benchmarks. All utilities were aware of their specific energy consumption when interviewed, but the depth of understanding of the opportunities to improve energy efficiency was often limited.

Most of the utilities have instituted an energy management strategy, generally based around some type of regular energy-auditing program. However, there are broad discrepancies between utilities in the quality and frequency of the audits.

There are also wide variations in the resources put in place by utilities to ensure that energy efficiency is effectively monitored, with some utilities having a dedicated energy management team and others relying on operational personnel to identify opportunities for improved energy efficiency.

In general terms, the elements of good EE management were present in many of the utilities, but there were frequent gaps in the investment process.

Drawing upon the case studies on best practice (Section 3.3) findings and recommendations of the rapid assessment can be broken down into four areas: asset management planning and EE strategies; components of the EE strategy, and the framework and incentives for EE:

- **Asset Planning and EE strategy:** Despite being aware of the importance of EE not all utilities have dedicated resource to EE and developed an EE strategy. To address this all utilities should establish a dedicated EE unit and commit to developing and EE strategy and associated energy auditing capacity. The MoC should work with the utilities to develop mandatory requirements EE strategies, monitor compliance, and provide support through guidance notes.
- **Components of NRW Program:** While the assessment found that the utilities have generally developed opex and capex programs to improve EE, funding for these programs was not assured and only half have used whole of life cost (WLC) approaches to assessing capex proposals. Because funding was not assured even projects that could show lower costs on a WLC basis due to energy savings may not proceed. To address this utilities should ensure that the EE program provides an integrated and funded set of implementable actions consistent with the EE strategy and underpinned by WLC analysis. MoC should work with utilities to provide guidance notes on WLC analysis.
- **Governance and Incentives:** The rapid assessment found that:
    - the utilities consistently do better than the MoC cost norms and these cost norms are higher the energy usage of peers in other jurisdictions
    - there was scope to provide increased support for the utilities in developing and implementing EE strategies and sharing experience between utilities
    - the financial incentives for EE were not clear.

In response MoC should:

- review and update the EE cost norms to ensure that they set challenging but achievable targets for the utilities.
- MOC should issue further guidance notes on EE planning and auditing and specific opportunities to improve EE and enhance its monitoring of EE performance
- MOC should review the application of the current water pricing guidelines and provide guidance on their application, particularly in regard to EE incentives.

3.4.1 Asset Planning and the EE Strategy

3.4.1.1 Developing the EE Strategy

The development and implementation of a rigorous and robust energy strategy is the foundation of successful energy efficiency management. The energy strategy depends in turn on well-developed asset management planning, strong commitment of senior managements, and robust, comprehensive asset and energy usage data. Where an energy strategy is not yet in place, its development requires the following steps:

- Appointment of an Energy Manager, who will maintain overall responsibility for the energy strategy.
- Development of an understanding of the key issues facing the business. Consideration should be given to the use of energy within the business, including performance against reasonable benchmarks.
- Completion of energy efficiency audits (see below) to allow specific energy efficiency issues to be identified.
- Development of programmes of interventions based on audit findings.
- Investment in interventions.
- Ongoing monitoring and updating of the energy strategy.

The assessment found that while all the utilities appreciated the importance of EE a significant minority do not have an energy management strategy and only half have units dedicated to developing and energy strategy.

3.4.1.2 Energy Efficiency Assessment

Some form of regular assessment of energy consumption is essential for the development of an EE strategy. Ideally, this would involve the completion of detailed energy audits at individual plants on a regular basis. The review reviewed the energy auditing undertaken by the utilities and assessed the quality and scope of the audits on a scale from A-D. Only 4 of the 18 utilities were rated B or above. Three were rated B/C and 11 were C or below. Furthermore, questions were raised as to the adequacy and accuracy of the energy audit data.

The energy audit process should be completed at each operational site, with the level of effort reflecting the energy consumption of the site; large sites using significant energy should be audited in the greatest detail. The steps required to complete an energy audit are development of disaggregated energy usage baselines and the analysis of specific loads.

Development of a baseline energy consumption for each site, based on the current energy consumption. This baseline energy consumption will provide the basis of understanding the 'as-is' energy consumption for the site, and should be developed with the greatest possible granularity. For example, when developing a baseline energy consumption for a water treatment works, it would be preferable to baseline the energy consumption of the site at the level of individual treatment processes. However, where sufficient data to allow this is not available, the baseline should be developed at site level. The units used in the development of the baseline are important. In the case of a water treatment works, it may be sufficient simply to normalise the energy consumption against treated flows.

However, where there are significant variations in raw water quality or distribution pressures, this should be taken into account when developing a baseline, since these may significantly affect energy efficiency. Where such variations exist, it may be necessary to develop more than one baseline to account for variations in energy efficiency under different circumstances.

The energy efficiency baseline should be recorded, and used as the basis for calculating the success of energy efficiency measures.

The load schedule is a record of the electrical loads which contribute to the power consumption for a site or distribution system. A load schedule may be provided when a site (or system) is constructed, but, if this is not the case, or the original load schedule has been lost, a new one should be developed.

In developing a load schedule, a complete list should be prepared of all the electrical loads at the plant. The rated power, absorbed power, efficiency, starter type, and power factor should be recorded. As far as possible, some estimation should be made of the running hours for each of the individual loads. The completed load schedule can be used to develop a detailed understanding of the areas of the plant in which energy is consumed. This information can then be used to focus energy efficiency interventions on the assets which are the most significant consumers of energy.

During the development of a load schedule, on site audits should be completed to verify the accuracy of the schedule. During these audits, it will often be feasible to identify energy efficiency interventions. It may be necessary to deploy temporary energy monitoring equipment to ensure that sufficiently accurate information can be collected. Although there is no “best” frequency for the frequency of energy efficiency assessment, international practice would generally dictate that a detailed assessment of major energy-consuming plant items be completed at least once every 5 years.

Utilities that have not already done so should commit to creating units with dedicated resources responsible for developing an EE strategy (including energy auditing) and overseeing its implementation. MOC can help build capacity in the sector by setting clear mandatory EE planning requirements and developing guidance notes on the development of EE strategies and supporting analysis. Once published the MOC should monitor compliance with the mandatory requirements and guidance notes and update the guidance notes as required.

Recommendations

> ***EE 1:*** All utilities should establish a dedicated EE unit and commit to developing and EE strategy and associated energy auditing capacity.
>
> ***EE 2:*** MOC should work with the utilities to develop mandatory requirements for the development of EE strategy and monitor, and report on, compliance with these requirements.
>
> ***EE 3:*** MOC should develop guidance notes to build EE planning capacity and help utilities comply with these requirements.

3.4.2 Components of the EE Strategy

When the energy baseline and load schedule / audits have been completed, a program of intervention options can be prepared. These intervention options will fall into two key areas:

- Operational interventions, which can be delivered without the requirement for any capital investment. Operational interventions can generally be implemented immediately following their identification. Examples of typical operational interventions include changes to pressure setpoints, or changes to the duty rotation to ensure that more efficient pumps are run as priority. When implementing an operational intervention, care should be taken to ensure that there are no adverse impacts on the performance of the plant or equipment.
- Capital interventions, which can only be delivered following capital investment in new assets. Examples of typical capital interventions include replacement of life expired mechanical and electrical equipment with more energy efficient, modern alternatives, and replacement of direct on line starters with soft starters or variable speed drives. When planning the implementation an operational intervention, care should be taken to ensure that there are no adverse impacts on the performance of the plant or equipment. Careful assessment of the financial aspects of the intervention should also be completed, including calculation of simple payback periods and whole life cost assessment.

Generally more than one intervention will be identified, and multiple interventions can be combined into phased programs of investment. As interventions are delivered, their energy efficiency impact should be assessed through monitoring, in order to confirm their success or otherwise. The energy efficiency baseline can then be reassessed updated to reflect the improvements to energy efficiency following the delivery of interventions.

Capital investment measures are generally more challenging to implement than are operational measures, as capital investment must be available. As a result, these measures may be more difficult to justify commercially, and typically take longer to deliver than operational measures. Payback periods for viable schemes would typically be expected to be less than 5 years, as shown in table 3.9 above.

A real-world example of a costed capital intervention is given in the appendices to this report, and this approach should be used when assessing the viability of capital interventions.

While the assessment found that the utilities have generally developed opex and capex programs to improve EE, funding for these programs was not assured and only half have used whole of life cost (WLC) approaches to assessing capex proposals. Because funding was not assured even projects that could show lower costs on a WLC basis due to energy savings may not proceed.

Recommendations

EE 4: Utilities should ensure that the EE program provides an integrated and funded set of implementable actions consistent with the EE strategy and underpinned by WLC analysis.

EE 5: MoC should work with utilities and to provide guidance notes on WLC analysis.

3.4.3 Governance and Incentives

The rapid assessment found that:

- the utilities consistently do better than the MoC cost norms and these cost norms are higher the energy usage of peers in other jurisdictions
- there was scope to provide increased support for the utilities in developing and implementing EE strategies and sharing experience between utilities
- the utilities did not have a financial incentive to improve EE in wastewater treatment and disposal as the costs were treated as a pass-through.

The assessment for NRW also found that the rules for setting tariffs (*Joint Circular No.75/2012/TTLT-BTC-BXD-BNNPTNT dated May 15th, 2012,)* could provide incentives to reduce NRW. However, it was not clear how tariffs were set in practice. This clouded the incentives to reduce NRW and it is understood the same position may apply to EE.

To address these concerns MoC should:

- continue to assess and update the water industry cost norms to allow due consideration to be given to modelling of the energy efficiency impact of different features of water supply systems.
- provide guidance notes to assist utilities develop and implement EE strategies and actions. Areas for potential inclusion in updated guidance include:
  - EE strategy development
  - level of process automation (fully automatic, semi-automatic, manual).
  - type of treatment (e.g. type of clarification, type of backwash).
  - presence or absence of frequency converters
  - choice of wastewater treatment technologies and EE
  - WLC analysis of capex options (see above)
- ensure the updated cost norms reflect the technical advances in water supply technology in recent years.
- issue mandatory requirements on the frequency and methodology for energy auditing in the water industry. Ideally these would be in line with guidance from the Ministry of Industry, which states that all industrial enterprises must conduct the regular energy audits.
- include additional EE data in the MoC WSS benchmarking database. At the moment the WSS database has limited EE-related data. Water utilities should also be required to update the database with energy efficiency information on a regular basis (ideally annually, as of 2019 the database has not been updated since 2015).
- monitor and publish reports on trends in the EE of the utilities
- examine mechanisms and strategies to enhance the sharing of experience and knowledge within the sector and build EE capacity
- review and monitor the application of the setting of tariffs under …. and assess
  - the incentives created for the utilities to improve EE
  - the extent and timing of the sharing of improvements in EE with customers

This approach could initially be applied to potable water treatment plants, being applied to wastewater treatment plants in future.

Recommendations

EE 6: MOC should review and update the EE cost norms to ensure that they set challenging but achievable targets for the utilities.

EE 7: MOC should issue further guidance notes on EE planning and auditing and specific opportunities to improve EE.

EE 8: MOC should review the EE data captured in the WSS benchmarking database and enhance its monitoring and reporting of EE performance.

EE 9: MOC should review the application of the current water pricing guidelines and provide guidance on their application, particularly in regard to EE incentives. It should review the framework for setting wastewater tariffs to ensure there are incentives for the utilities to improve EE in wastewater treatment and disposal.

3.4.4 Implementation of EE strategies

Do you want to add anything here? Eg MoC to consider inclusion of EE in one or more trial PBCs for NRW

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Appendix A

Laws Decisions and Circulars relevant to Nonrevenue Water

This Annex summarises the various documents (laws, decisions and circulars) that set the legal framework for programs to reduce NRW.

Laws

Law No.17/2012/QH13 dated June 21th, 2012, on Water Resources

This Law sets out provisions on management, protection, exploitation and usage of water resources as well as prevention from, contest for and remediation of adverse effects caused by water. The Law includes 10 chapters and 79 articles. In term of non-revenue water, a chapter (Chapter IV) thereof stipulates exploitation, usage of water resources of which specifies on economical and efficient use of water with concrete measures; Available incentives for economical and efficient use of water; Development of science and technology for economical and efficient use of water. The non-revenue water provision in Article 40.1 indicates: "Organizations, individuals managing, operating the water supply system must obey technical regulations and regulations on operation of water supply system aiming to satisfy requirement on supplying water being stable, safe, uninterrupted and diminish loss and saving of water." Nevertheless, this Law fails to specify both mandatory provisions on diminution and reduction of such losses and involvement of communities in and responsibilities of setting those provisions into urban plans, investment plan for construction. It also cannot be found the regulation pertaining to a connection between non-revenue water and decrease of energy consumption.

Decrees:

Decree No.117/2007/ND-CP, dated July 11th, 2007, on water production, supply and consumption

This Decree provides for activities in the domains of production, supply and consumption of water under the complete concentrated water supply systems in urban areas, rural areas, industrial parks, export processing zones, hi-tech parks and economic zones; the rights and obligations of organizations, individuals and households engaged in activities related to water production, supply and consumption in the Vietnamese territory. It raised a point of unaccounted-for water and non-revenue water in only one norm: "Local administrations at all levels, organizations and individuals engaged in water supply activities must work out programs against unaccounted-for water and non-revenue water, adopt contracting and rewarding mechanisms while setting the maximum levels of unaccounted-for water and non-revenue water eligible for inclusion into production costs so as to encourage water supply units to operate with efficiency." (Article 51.7). This is the earliest Decree specifying management of water supply activities from formulation of urban plans, investment and construction, supervision of water supply activities, etc.. However, the provision on unaccounted-for water and non-revenue water thereof is deemed to be inexplicit and ambiguous.

Decree No.124/2011/ND-CP, dated December 28th, 2011 on amendments and supplements to a number of articles of Decree No.117/2007/ND-CP

In amended and supplemented Decree, the term "unaccounted-for water" are mentioned in formulation of planning scheme "Contents of planning scheme of urban water supply: Evaluation of the current state of water supply system: mining resources, capacity, efficiency of extraction, water quality, water pressure, connection rate, the rate of unaccounted-for water and non-revenue water and evaluation the operational status of works, water supply pipelines network." (Article 1.6)

Decisions of Prime Minister

Decision No.2147/QD-TTg dated November 24th, 2010 of Prime Minister, approval of national unaccounted-for water (UFW), non-revenue water (NRW) program to 2025

The Decision sets targets for mobilization of resources for UFW/NRW activities and reduction of UFW/NRW at rate averaging 30% in 2009 to below 15% by 2025. It is considered that it has a foot in door in a bright field and since then, authorities at level of ministry, sector and province maintain implementation of such policy. The UFW rate ranges from 30-31% (in 2010) to 21.5% (in 2018). It is expected to exceed the target as prescribed in this Decision.

Decision No.1566/QD-TTg dated August 09, 2016 of Prime Minister, approval national program for to ensuring water safety for the period 2016 – 2025

This Decision adds to the functions and tasks of Central Steering Committee (CSC) for National NRW/UFW Program to 2025 and change its name to Central Steering Committee (CSC) for National Assurance of Water Safety and NRW/UFW Program. The National Assurance of Water Safety sets targets of risk management and troubleshooting that may occur from water sources, water treatment facilities, transmission and distribution system of water to customers; improvement in unaccounted-for water and non-revenue water missions; avoidance of unsatisfied and unqualified water, interruption in water supply, maintenance for insufficient pressure. The program will contribute to promote the life quality and protection of human well-being. It establishes a link between security of water safety and non-revenue water mission. Approval of National Program also continues non-revenue water mission through combination activities.

Decision No.2502/QD-TTg, dated December 22nd, 2016 of Prime Minister, approving adjustments to the development orientations for water supply for urban areas and industrial parks through 2025, with a vision toward 2050

the Decision sets out the requirements to meet people's essential needs and national industrialization and modernization requirements, for use as the basis for determining specific solutions in each period and decrease of unaccounted-for water rate (to 2020, the rate of unaccounted-for water and non-revenue water will be under 18% in urban areas of grade IV or higher, and under 25% in grade-V urban areas; to 2025, this rate will be under 15% in urban areas). Furthermore, the requirements take account into climate change for stable supply of quality water and good services to meet water use demands per period. The policies of Vietnam on development of water supply sector and solutions for implementation of aforesaid unaccounted-for water and non-revenue water missions: To focus investment on expansion and upgrading of water supply pipeline networks, raising water supply service coverage and quality; to prioritize investment in projects on secure water safety and unaccounted-for water. However, the Decision only provides for prinicipal norms. It is neccessary to have comprehensive researches and promulgate specific and appropriate mechanisms, policies and law documents so as to approach the unaccounted-for water and non-revenue water targets as recorded in the existing strategies, planning schemes and plans.

Circulars of Relevant Ministries:

Joint Circular No.75/2012/TTLT-BTC-BXD-BNNPTNT dated May 15th, 2012, of Ministry Of Finance - Ministry Of Construction - Ministry Of Agriculture And Rural Development, guiding principles and method of determination and competence to decide water consumption price in the urban areas, industrial zones and rural areas.

This Joint Circular directs the principles and method of determination of water consumption price and competence to decide on water consumption prices in urban areas, industrial zones and rural areas of which certain percentage and financial mechanism for unaccounted-for water and non-revenue water applied by the water supply utility.

Circular No.08/2012/TT-BXD, dated November 21st, 2012, guiding the implementation of water safety.

The Circular underlines "Water safety means steady water supply, maintaining adequate and continuous pressure, sufficient water and ensuring water quality according to the set standards". Water safety not only secure quality of water but also retain excellent services such as sufficient pressure and steady water supply. The purpose of water safety activities is "to reduce, eliminate and prevent threats and risks causing unsafe water supply from water source through the process of water collection, treatment, storage and distribution to customers". In addition, it also contributes environmental protection and non-revenue water management.

Circular No.15/2017/TT-BXD, dated December 28th, 2017, National Technical Regulation on Energy Efficiency Buildings

This Circular provides for mandatory technical standards in design, construction or renovation of buildings with a gross floor area of 2,500 m2 or larger of the following types: (1) Offices; (2) Hotels; (3) Hospitals; (4) Schools; (5) Business and service buildings; (6) Condominiums. Nevertheless, it misses out standards for infrastructure constructions/works including water supply system.

Appendix B

Summary of Proposed Interventions for the 18 Utilities: Nonrevenue Water

		Mekong																	
Utility		An Giang	Bình Dương	Cà Mau	Cần Thơ	Kiên Giang	Long An	SAWACO	Bạc Liêu	Hậu Giang	Sóc Trăng	Lâm Đồng	Quảng Nam	Hà Nam	Lạng Sơn	Ninh Bình	Phú Tho	Thanh Hóa	VIWACO
Town		Long Xuyên	Province	Cà Mau	Cần Thơ	Rạch Giá	Tân An	HCMC	Bạc Liêu	Province	Province	Da Lat	Tam Kỳ	Phủ Lý	Lạng Sơn	Ninh Bình	Province	Province	Hanoi
Connections	(No.)	72,166	229,352	39,200	60,000	50,000	17,500	1,378,023	27,751	52,599	84,254	57,326	19,081	40,500	27,000	0	126,528	0	0
Average tariff	D/m^3	5,490	10,384	6,900	6,275	7,000	7,000?	—				—	—	5,700	11,680	—	9,500	—	—
NRW performance indicators																			
NRW	%	20	6	24	29	30	21	23	11	20	15	27	22	27	38		18		
NRW	L/ conn/ day	177	109	234	393	304	276	206	84	124	110	273	229	267	298		99		
Apparent losses	% of total billed	15	4	10	8	11	10	9	11	6	12	9	10	12	14		6		
Real losses category		A?	A?	C	>D!	>D!	D	C	A?	B	A?	D	C	B	C		A?		
Replacement of domestic water meter		X		X	X	X	X	X	X		X		X						
Uprgrade/automate billing system		X																	
Handhelds/ smartphone		X																	
Control of centre for flow and pressure management		X	X	X															
Regular NRW, AI and RL assessment in DMAs		X	X	X															
Implement (additional) DMAs		X		X															
Implement AMR metering infrastructure		X		X															
Upgrade bulk meters				X															
Implement SCADA		X																	
Expand existing SCADA				X															

Continued…

Implement (smart) pressure management	x		x															
Replacement of connections			x															
Replacement of tertiary mains			x	x														
Enhance active leak control	x		x	x														
Hydraulic model for operational purposes	x		x	x														
Recording of underground assets with GIS	x		x															
NRW management strategies	x		x															
Customer relations managemement	x		x															
Commercial operations	x		x															
Asset management	x		x															

Note: AL = actual losses; B&C = billing and collection; D = Vietnamese dong; DMA = district metered area; GIS = geographic information system; HCMC = Ho Chi Minh City; RL = real losses; SCADA = supervisory control and data acquisition; "—" = not available;

Appendix C

Summary of Key Metrics for the 18 Utilities: Energy Efficiency

Region	Utility	Location	Raw water source	Water production (m^3/day, total)	Specific energy (kWh/m^3)	Power costs as percentage of operational costs (%)	MoC cost norm (kWh/m^3)			Benchmark cost norm (kWh/m^3)		
							Best	Worst	Median	European Union	United States	China
Mekong	An Giang	Mekong	Surface	64,716	0.32	—	0.43	0.52	0.48	0.37	0.35	0.29
	Bình Dương		Surface	290,000	0.35	19	0.43	0.52	0.48	0.37	0.35	0.29
	Cà Mau		Ground	38,959	0.39	—	0.39	0.46	0.43	0.37	0.35	0.29
	Cần Thơ		Surface and ground	79,500	0.21	21	0.36	0.53	0.45	0.37	0.35	0.29
	Kiên Giang		Surface and ground	74,900	0.38	15	0.36	0.52	0.44	0.37	0.35	0.29
	Long An		Ground	22,800	0.41	12	0.43	0.5	0.47	0.37	0.35	0.29
	SAWACO		Surface	182,500	0.38	20	0.42	0.52	0.47	0.37	0.35	0.29
	Bạc Liêu		Ground	22,000	0.20	—	0.42	0.53	0.47	0.37	0.35	0.29
	Hậu Giang		Surface	33,485	0.18	—	0.45	0.53	0.49	0.37	0.35	0.29
	Sóc Trăng		Ground	76,600	0.37	—	0.43	0.52	0.48	0.37	0.35	0.29
South	Lâm Đồng	Central	Surface and ground	75,000	0.39	11	0.36	0.52	0.44	0.37	0.35	0.29
Centre	Quảng Nam	South	Surface	19,904	0.29	—	0.43	0.63	0.53	0.37	0.35	0.29
North	Hà Nam	North	Surface	40,000	0.49	—	0.45	0.53	0.49	0.37	0.35	0.29
	Lạng Sơn		Surface and ground	22,800	0.41	—	0.43	0.58	0.51	0.37	0.35	0.29
	Ninh Bình		Surface	33,000	0.27	17	0.5	0.58	0.54	0.37	0.35	0.29
	Phú Tho		Surface	62,100	0.41	24	0.43	0.52	0.48	0.37	0.35	0.29
	Thanh Hóa		Surface and ground	90,000	0.25	17	0.36	0.52	0.44	0.37	0.35	0.29
	VIWACO		Surface	202,000	—	—	—	—	—	0.37	0.35	0.29

Source: Data provided by MoC and individual utilities.

Note: EU = European Union; MoC = Ministry of Construction; "-" = not available.

Appendix D

Energy Efficiency and Nonrevenue Water Questionnaire

Energy Efficiency and Nonrevenue Water Assessment

Water Utilities Questionnaire

A. General Information

I. Contact Information		
Name of utility:		
Address:		
Phone/Fax/Email:		
II. Asset and Customer Base		
Service coverage (%)		
List of water supply systems:	1. Capacity (m^3/d):	2. Capacity (m^3/d):
	3. Capacity (m^3/d):	4. Capacity (m^3/d):
	5. Capacity (m^3/d):	6. Capacity (m^3/d):
	7. Capacity (m^3/d):	8. Capacity (m^3/d):
Total design capacity of water supply (m^3/d):		
Pumped supply (% of total):		
Gravity supply (% of total):		
Supply time (h/day):		
Average supply pressure in water supply system (in district metered area [DMA]) (m)	1.	2.
	3.	4.
	5.	6.
	7.	8.
Total raw water volume daily (m^3/d):		
List of wastewater treatment systems (if available)	1. Capacity (m^3/d):	2. Capacity (m^3/d):
	3. Capacity (m^3/d):	4. Capacity (m^3/d):
	5. Capacity (m^3/d):	6. Capacity (m^3/d):
Total design capacity of wastewater treatment (m^3/d):		
Total treated water production daily (m^3/d):		
Average liter per capita per day (L/p/d):		

Continued…

Population served:		
Total number of customer connections:		
Number of new connections per year, made by water company:		
Number of new connections per year, made by project/real estate developer:		
Number of other connections:		
Density of connections (connections/km):		
Billed volume (m^3/year):		
Billed volume of domestic customers (m^3/year):		
Proportion of water meters installed versus total connections:		
Proportion of water meters replaced/repaired/checked annually:		
Average age of domestic water meter:		
Type of domestic water meter, velocity or volumetric meters:		
Brand and country of origin of domestic water meter	Brand and country	Number:
	Brand and country	Number:
	Brand and country	Number:
	Brand and country	Number:
Total length of transmission pipes (diameter ≥ 300 mm) (km):		
Total length of distribution pipes (diameter = 100–300 mm), excluding service pipes (km):		
Total length of distribution pipes constructed by project/real estate developers (km):		
Total length of pipes used over 21 years (km):		
Current nonrevenue water (NRW) (%):		
Number of breakages in transmission pipes:		
Number of breakages in distribution pipes:		
Number of visible leaks repaired per year:		
Number of underground leaks detected and repaired per year:		
% of network already structured into DMAs:		
DMAs to be set (indication):		
Average number of connections per DMA (connections/DMA):		
Cost to repair a leak (D/leak):		
Meter reading with handheld or manually:		
Meter reading automatically transferred to billing software:		
Electricity consumption per m^3 of water production:		
Cost of energy per year (D/year):		
Current water tariff (D/m^3):		
Current wastewater tariff (how much % of water supply fee?):		
Raw water cost versus total production cost:		
Electricity cost versus total production cost:		
Labor cost versus total production cost:		
Chemical cost versus total production cost:		
Other costs versus total production cost:		
III. Financial Status		
Ownership of the water utility:		
Is the water tariff of the utility sufficient to cover the operation cost?		
Is the water tariff of the utility sufficient to cover additional capital investment?		

Energy Efficiency and Nonrevenue Water Assessment

Water Utilities Questionnaire
B. Energy Efficiency

I. Background	
Water supply and wastewater treatment encompass highly energy-intensive processes (e.g., pumps, motors, and other equipment operating 24 hours a day, 7 days a week). There is much scope to enhance energy efficiency (EE) in the sector. The power costs account for 5 to 40 percent of the total operation cost among water and wastewater utilities worldwide. It is estimated that energy consumption in most water systems worldwide could be reduced by at least 25 percent by cost-effective efficiency actions alone. Improving EE is a strong tool to increase the financial performance of the major water utilities. However, significant knowledge gaps remain in improving EE in the water and wastewater treatment sector in Vietnam and many other countries. Addressing knowledge gaps requires efforts to systematize data collection, training, and capacity building at utilities. Conducting EE assessments to address the knowledge gaps will be helpful to improve the awareness of EE opportunities for positive impacts in the sector.	
II. Strategic Level	
1. What is the predicted percentage growth rate of your customer base over the next 15 years?	
2. Do you have a program for improving energy efficiency over time?	If yes, please give a brief description:
3. Do you have a formal energy management strategy?	If yes, please give a brief description:
4. What do you feel are the key drivers that would lead you to improve the energy efficiency of your plant?	(Examples: rising energy costs, regulatory drivers, climate change, etc.)
III. Energy Budget	
5. What are your tariff rates for power?	
6. How long are your energy purchase contracts?	
7.How frequently is your energy budget planned?	
8. What is the process for signing off your energy budget?	
IV. Procurement	
9. When you are purchasing new plant items, do you use your own defined technical standards?	If yes, please give a brief description:
10. Do you assess whole-life costs when purchasing new plant items?	If yes, what is the whole-life cost assessment method?
11. Is there a capital investment budget available to you if you identify opportunities to invest in energy-saving measures?	
V. Energy measurements and consumption management	
12. Do you have a dedicated person (or team) who assesses energy consumption?	If yes, please indicate the number of people on the team:

Continued…

13. Do you manage your power consumption throughout the day to avoid high-tariff periods?	
14. Do you have enough information available to assess when your major power-using assets are deteriorating?	
15. Is your power consumption measured at the site level or at a more granular level through submetering (e.g., at the process or asset level)?	
16. Have you conducted energy audits at the water plants?	If yes, how often do you conduct energy audits? When was the most recent energy audit? Who conducts the energy audits (internal team/consulting companies)?
17. Have you taken any measures to improve energy efficiency at the water plants?	If yes, what measures? What is the payback of the EE improvement measures?
VI. Renewable energy technologies	
17. Do you have any renewable energy technologies on-site (e.g., solar photovoltaic (PV) panels, hydro, anaerobic digestion, wind turbines)?	If not, do you have any plans to invest in new renewable energy technologies?
VII. Water treatment processes and system	
18. How are your treatment processes controlled—automatically using online instrumentation or through manual intervention?	
19. Do you have any options to use different sources of raw water throughout the year?	
VIII. Data requests (please provide the following documents if possible)	
All sites: Process flow diagrams/piping and instrumentation diagrams for your treatment plants Organogram (or similar diagram) for your organization Energy strategy Energy consumption data for at least 1 year, at the most granular level available *Potable water treatment sites:* Flow to treatment for at least 1 year, at the most granular level available Raw water sample analysis data for at least 1 year, at the most granular level available Treated water sample analysis data for at least 1 year, at the most granular level available *Wastewater treatment sites:* Flow to treatment for at least 1 year, at the most granular level available Sample analysis data for any part of the site (including interstage where available) Final effluent discharge quality limits	

Energy Efficiency and Nonrevenue Water Assessment

Water Utilities Questionnaire
C. Nonrevenue Water

Background	
High levels of nonrevenue water (NRW) are detrimental to the financial viability of a water utility and may also strongly affect water availability and continuity of service. One of the root causes of high NRW levels is failing asset management of the distribution network. In reducing NRW, there is a tendency to aim for project-based interventions that may quickly yield results, but little attention is paid to long-term management of the distribution network. However, in order to reach sustainable low NRW levels, short-term interventions need to be integrated with a vision, strategy, and action plan for a phased implementation of long-term asset management. An essential part of the vision is to introduce responsibility and accountability at a lower level in the utility organization.	
Organizational elements influencing NRW	
Strategic level Is the reduction of NRW part of a plan/strategy? Is there board/managerial commitment in terms of decision-making and allocated resources? Is there a specific team assigned to it? Is there a specific target set? Are business plans of departments aligned with the specific targets? Are there means (financial resources, equipment, materials) allocated to achieve the targets?	
Availability and reliability of information Is there updated information on each of the components of the International Water Association (IWA) water balance (annual volume calculation) of the operator? System input: billed consumption, unbilled consumption, and unauthorized consumption; customer metering inaccuracies and data-handling errors; network data—length of transmissions mains, distribution mains, and service connections; number of registered connections and estimated number of illegal connections; average pressure; historic burst data; level of supply service (24 hours, intermittent, etc.) Is the system divided into clear entities, such as district metering zones and district metering areas? Metering infrastructure—are automated meter reading (AMR) bulk meters used? How are the recorded data consolidated—manually or by information technology (IT) system or management information system (MIS)?	
Procurement Can the implementation of measures be undertaken in a timely manner? Is there any delay due to the procurement of materials or equipment? Is there a materials handbook to control the quality of the purchased materials? Is there a proper warehouse with logbooks of ingoing and outgoing materials?	
Financial management What is the payment discipline to suppliers? Could payments to suppliers affect repair/maintenance materials? What are the reasons?	

Continued…

Customer service/fast response Is there communication aimed at customers to engage them in reporting burst pipes, faulty valves, leaks, and other issues? Are there quick/easy/free communication channels available for customers to report problems? Is there a call center to receive those calls that will quickly redirect the incidents to the responsible repair crew?	
Unbilled authorized consumption	
Unbilled metered consumption Is the proportion known? Is there a reason why this water is not being billed? Is there an attempt to start billing it?	
Unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) Is there a reporting mechanism for these kinds of water losses? Is the amount of water lost estimated by staff? Is the proportion known?	
Commercial losses	
Unauthorized consumption (includes illegal connections, meter bypassing, illegal use of hydrants, and poor billing systems) Finding and reducing illegal connections Is there a customer awareness program? Is there a legal arrangement to support disconnection or fines for illegal connections? Are amnesty periods offered to encourage illegal connections to be legalized? Is the detection of illegal connections part of the meter readers' duties? Is there any incentive? Do they receive any training in this area? Is it included in their work plan? Or is there a special team to detect illegal connections? Is there billing auditor to analyze monthly billing data on low or zero consumption? Preventing illegal connections Are there "lockable valves" to prevent customers who have been disconnected for nonpayment from connecting illegally by opening the valve themselves?	
Dealing with meter bypassing (commonly executed by large customers that construct an underground pipe where most of the water flows, leaving the official metered pipe a small flow) Is the consumption of large customers analyzed periodically? Is flow-balance analysis conducted to detect bypasses? Are consumer surveys and leakage step tests used to determine where the missing flow occurs? Preventing illegal use of fire hydrants (people use them illegally at night to fill tanks or as water supply connections at construction sites) Are flow measurements detecting this type of illegal consumption? Is there any measure in place to prevent them? Customer awareness and incentives to report them? Are there regulations to penalize those thieves?	

Customer metering inaccuracies and data-handling errors Meter care Are commercial, industrial, domestic, and institutional customers (or any other billed customer) metered? If yes, how many (percentage)? Is there a maintenance/replacement program for meters? Which criteria are used to formulate a replacement policy? Is there a standard meter test rig/bench? Is an age profile of the meters available? Is there equipment to test the meters on-site (volumetric accuracy with an alternative portable meter; electronic functionality with meter manufacturer's test equipment)? Are different brands of meters in place, requiring different testing equipment? Is that equipment available? Is there a standardized process or plan for testing meter accuracy? How frequently are meters tested? Which proportion of meters are tested? Are the meters and the properties they belong to easily recognizable? Are the specifications of meter manufacturers taken into account when installing the meters (e.g., specific straight length of pipe upstream and downstream of the meter)? Is the water quality a potential hazard to meter accuracy (e.g., sediment accumulation, especially on mechanical meters; friction; meter reading slowly; under registered consumption)? If there are mechanical meters, is there a frequent cleaning practice for those meters? Does the selection of meters for purchase take into account the sizes and types of meters concerning where they will be installed to ensure precision (e.g., consumption, type of connection, quality of the water)? Are all meters installed above ground, where they can be checked easily?	
Billing Is the billing process automated? How does the customer receive the bill—by post, mobile text, email, from handheld of the meter reader? How many customers receive a monthly bill (percentage)? Is there a complete and updated customer database? Is the customer database validated with a comprehensive property survey? How many inactive connections are in the customer database? What are plausible reasons for the inactive connections? Has there been any effort to revise and update the database, such as through a complete customer survey in each district metered area (DMA), including a meter test? Is there a billing auditor to analyze billing anomalies, such as prolonged estimates or strange billing patterns of accounts? Are audit reports available? How are estimates generated—manually or by billing engine? Is there a clear standard process to update the customer database when disconnections, new connections, and reconnections take place? What is the procedure for issuing job orders to operations and receiving completion reporting? Is this procedure automated? What is the average backlog of billing after receiving a completion report?	

Continued…

Is there any specific billing software being used? Does the software incorporate a robust database with built-in analysis functions to detect errors? Which processes does the software incorporate? Do the meter readers use electronic meter-reading devices? If not, how is the data-transfer process from meters to bills organized? Do the meter-reader reports identify detected active connections that are not included in their route books? Is it a standard activity? Is there effective periodic supervision of meter readers (e.g., spot checks)? Do the meter readers receive any training on the proper handling of meters? Is there any measure to prevent internal corruption practices of meter readers, such as rotation of zones? Are step testing and flow balance used to detect anomalies in large customers?	
Physical losses	
Data acquisition in the system Are individual system inputs metered? Are there production flow meters (both own sources and imported bulk suppliers)? What is the frequency of meter data collection? Are input flow meters tested using portable flow-measuring devices? Are there programs/plans/standards for quick repair action when a leak is detected? Are repair records kept? Are estimates, based on the rate of repairs and estimated volume lost, made for the losses in transmission and distribution networks?	
Asset management Does the operator implement asset management practices? If so, which ones? Is there information on the length, materials, and age of the network? Is there a renewal program for pipelines, and are costs incorporated in the financial plans? Is leak reporting implemented? If so, are these reports static, or is this information used for policy development for designs, material use, maintenance, and replacement?	
Leakage on transmission and/or distribution mains Does the operator have an active leakage control program? Has the operator implemented a pipeline and asset management plan (selection, installation, maintenance, rehabilitation, and replacement)? Does the operator have a quick-response repair team for "speedy repair"?	
Flow metering Does the operator monitor flows into zones or district metered areas (DMAs) to detect unreported bursts or leakages? Or are DMA/AMR meters linked to a supervisory control and data acquisition (SCADA) system or equivalent? Has the operator developed a SCADA system via telemetry? If so, has the operator implemented an analysis package along with the SCADA?	

Leak localizing, locating, and pinpointing Has the utility implemented noise-based leakage detection systems, such as noise loggers, leak noise correlators, ground microphones, and sounding sticks? Does the utility analyze and calculate the economic level of leakage?	
Pressure management Has the operator implemented pressure management practices? If so, please indicate which of the following practices have been implemented: Identify potential zones, installation points, and customer issues through a desktop study. Identify customer types and control limitations through demands analysis. Gather field measurements of flow and pressure (usually an inlet, average zone point, and critical node points). Model potential benefit using specialized models. Identify control valves and control devices. Has the operator installed pressure-reducing valves (PRVs) or other systems (e.g., variable-speed pump controllers or break pressure tanks)?	
Speed and quality of repairs Does the operator follow a repair policy? Are repairs properly conducted following quality standards/norms? Are there efficient organization and established procedures in place from the initial alert until the repair itself? Are adequate equipment and materials available for the repairs? Do staff members have the qualifications, knowledge, and skills needed to properly conduct the repairs? What is the average time between reporting and repairing leaks/bursts, for HC, service lines, tertiary mains, secondary mains and bigger?	
Leakage and overflows at utility's storage tanks Are there regular overnight observations of overflows (physically or with data loggers)? Does the operator undertake "drop best" (close input and output valves) to estimate leakage from tanks?	
Leakage on service connections up to point of customer (this leakage is the most difficult to detect and should be frequently estimated, deducing transmission and distribution mains and storage leakages from total physical losses) Is there a standard design for service connections? Is there a monitoring process in place for service connections?	

Appendix F

Energy Efficiency and Nonrevenue Water Assessment Report of Individual Utilities

Report 1: An Giang Electricity and Water Supply Joint Stock Company

1.1 An Giang

The An Giang Electricity and Water Supply Joint Stock Company is a 90 percent state-owned joint-stock company. The utility manages 137 water supply systems and distributes electricity to 10 of 11 districts in the province. The capacity of the water systems in the provincial capital Long Xuyên is the biggest (64,716 cubic meters per day), accounting for approximately 25 percent of the province's total installed design capacity of 248,000 cubic meters per day. The utilization rate of the production facilities is unknown.

The raw water source is surface water from two major rivers. The utility is in the process of clustering the large number of water supply systems. Table D.1 summarizes the asset base.

Table D.1 Asset Base

Number of water supply systems	137
Total design capacity of water supply (m^3/d)	176,800
Total raw water volume daily (m^3/d)	256,000
Total design capacity of wastewater treatment (m^3/d)	35,000
Total treated water production daily (m^3/d)	248,000

Source: An Giang Electricity and Water Supply Joint Stock Company

The utility manages approximately 4,600 kilometers of mains and 449,000 connections. The age of the network in Long Xuyên is less than 10 years old. The age of the networks in the other 142 water supply systems is unknown.

All customers are metered. The nonrevenue water (NRW) at the company level in 2017 was 22.7 percent. The NRW in Long Xuyên is 21.6 percent.

Table D.2 Key characteristics

Average liter per capita per day (L/p/d)	1,101
Population served (million)	2.2
Total number of customer connections (No.)	449,000
Density of connections (connection/km)	140
Billed volume (m^3/year)	62,671,665
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually (No.)	17,071 (2017)
Total length of transmission pipes (diameter ≥ 300 mm) (km)	27.4
Total length of distribution pipes (diameter = 63–300 mm), excluding service pipes (km)	4,500
Total length of pipes used over 21 years (km)	40

1.2 NRW Management

1.2.1 Utility's General Approach

The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the 11 districts. The roles and responsibilities of the headquarters (HQ) and district managers can be summarized as follows:

- HQ carries out inspections and annual review.
- HQ is responsible for planning/strategy and the allocation of resources.
- NRW reduction measures are discussed with the technical department of each district and agreed on before being submitting to the executive board for approval.

The approach to NRW management mainly focuses on achieving short-term impact and can be summarized as follows:

- Smart pressure management, monitored and managed with supervisory control and data acquisition (SCADA)
- Timely repair of reported leaks and bursts
- Improved material use
- Management of unauthorized consumption

The utility is in the process of installing district metered areas (DMAs); in total, 87 of the planned 200 DMAs have been installed. The DMA coverage in Long Xuyên is 100 percent.

Table D.3: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	87
DMA coverage (%)	100
Connections per DMA	800-2,500

Monthly water balance in DMA	Not done
Assessment of apparent and real losses	Not done
Type of bulk meters	Electromagnetic/mechanical
Data-transfer technology	Manual
SCADA	Not available

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition.

1.2.2 Performance of NRW Management in Long Xuyên

The rapid assessment looks into the current NRW situation of the major cities of the utilities, and the NRW performance in Long Xuyên is considered in this section. The reason for the focus on the major cities is that the impact and viability of a potential performance-based contracting (PBC) NRW program are maximized in a relatively densely populated and big supply area.

Table D.4 presents a summary of the performance of NRW management in Long Xuyên and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 21.6 percent is equivalent to 177 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.4: NRW management

System input, volume billed and NRW levels	
System input (average daily production x 365) (m^3/year)	23,621,340
System input (l/conn/day)	897
Volume billed (l/conn/day)	720
Volume billed domestic (l/conn/day)	624
Per capita billed (l/cap/day)	139
NRW (l/conn/cay)	177
NRW calculated	
NRW reported in questionnaire (%)	21.6
Apparent losses	
Average age domestic meters (years)	15
Contribution of apparent losses to NRW (%)	59
Apparent losses (% of total billed)	15
Real losses	
Pressure in tertiary network (m)	15
Real losses (l/conn/day)	72
Real losses (l/conn/day/m)	5
Technical performance category	A

Note: NRW = nonrevenue water.

In Long Xuyên, the contribution of apparent losses to NRW is estimated to be 60 percent. The average age of the domestic water meters contributes considerably to the apparent losses. The utility reports that there is no unbilled authorized consumption. Unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is determined. Approximately 10 percent of the customer connections are inactive. The utility cannot contact this group of customers. Illegal practices are marginally present, with 82 known cases in the province.

Based on the data provided, real losses contribute 40 percent of the current NRW, which is 72 liters per connection per day. The level of real losses is surprisingly low. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[37] The technical performance of the network in Long Xuyên is very good (Category A; see table 2.5 for a description of the categories).

1.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meters is estimated to be 15 years. The average age of the water meters of the big customers is unknown. Class B domestic water meters are used. The utility has no structured meter maintenance policy.

Meter reading, billing, and collection processes are completed manually. Meter readers consolidate the readings manually, which are then transferred to the district manager via the internet. The consolidated district data are transferred to the company via the internet. Water bills are printed by the company. The bills are physically collected by each district, and each district sends collectors with the bills to collect payments manually.

Table D.5: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	No
Meter class	B
Average age	15
Type of meter (big customers)	Mechanical
Management of customer meter	No
Billing	Manual
Meter reading	Manual
Internal audit of billing database	No
Collection	Manual

The utility has an active program to address unauthorized consumption (i.e., illegal practices).

1.2.4 Real (Physical) Losses

As mentioned previously, the technical performance of the relatively young network is good. As summarized in table D.6, the management of real losses in Long Xuyên focuses on smart pressure management and active leak detection and repair. The utility does not perform economic analysis to determine the optimum leakage level.

37 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

Table D.6: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	?
Analysis of economic leakage level	No
Comprehensive analysis of bursts & historical events	No
GIS	No
Budget for repair and minor replacements	Constrained

Note: GIS = geographical information system; Q&P = flow and pressure.

True asset management is still in its infant stage. A comprehensive analysis of leaks/bursts and other historical events is not carried out. The distribution network data are recorded manually on drawings. The replacement policy is budget driven, which is a constraint.

1.3 Energy Efficiency Management

The company's current specific energy consumption for water treatment is 0.32 kilowatt-hours per cubic meter. In the interview, the utility confirmed that the annual targets for energy consumption are based on the company business plan (i.e., on previous performance) and that there are no firm targets to reduce energy consumption, although there is a general strategy to deliver energy efficiency where possible.

The company's strategy for energy efficiency (EE) management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- The completion of energy audits using internal staff to monitor performance against business plan targets

The company's energy-auditing approach relies on the use of internal staff from the electrical and water technical departments.

1.3.1 Performance of EE Management in An Giang

An Giang has a typical water production volume of 64,716 cubic meters per day and a specific energy consumption for water production of 0.32 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.43 to 0.52 kilowatt-hours per cubic meter.

An Giang utilizes staff working in the central electricity and water technical departments to oversee the management of energy efficiency at its water treatment plants. Staff members from the teams work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is assessed monthly, and any discrepancies in EE performance from month to month are identified and investigated. Energy business plans are developed annually, and although there is a general desire to improve energy efficiency each year, no firm targets for energy consumption have been set. The company does not have a formal EE strategy.

In the interview, the company confirmed that improvements in energy efficiency rely on the ability of the technical departments and site operations team personnel to identify deviations in power consumption through diligent monitoring of data from the site.

Accurate power metering is available at the site level, but more detailed, accurate submetering is unavailable. In the interview and in the returned questionnaire, the company confirmed that with the data available, it is not possible to gauge when assets are deteriorating.

The company's EE audits are carried out internally, and the audit process comprises the review of the Manufacturing Treatment Reports, which are completed for each plant, with monitoring of energy consumption against the targets set in the business plan for each plant.

An Giang's approach to energy auditing has been graded according to the criteria in table D.7.

Table D.7: Classification EE

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as having reached the end of its service life
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least every five years

According to the criteria in table D.7, An Giang's energy-auditing approach achieves a grade of C.

1.3.2 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. The company has a large number (143) water treatment systems, many of which are of small size and located in rural areas.

This large number of systems makes the delivery of detailed audits difficult. The company has a planned strategy for consolidating the small plants, leaving a smaller number of larger plants.

Mechanical and electrical equipment is maintained according to the manufacturer's standards.

1.3.3 Delivery of EE Management (Capital)

During the interview, the company confirmed that there is a significant number of aging mechanical and electrical assets, specifically pumps, in service and that this is a key concern for the company.

In order to ensure that the asset base is maintained in a serviceable condition, a depreciation fund is maintained, and this is used to fund the replacement of pumps that meet the following criteria:

- Consume more than 0.34 kilowatt-hours per cubic meter
- Have an unacceptably high level of breakdowns

The company has also made some investment in renewable energy, specifically the installation of solar panels on the roof of the company's main administration building and at the Tri Ton water treatment works.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.8.

Table D.8 General approach to EE

		An Giang
General approach to EE management	Specific energy (kWh/m3)	0.32
	WLC assessment for new equipment	Not done yet
	Asset monitoring	Partial
	Granularity of power metering	Site level
	Peak tariff avoidance	No information
	Asset operation	Semiautomatic
	Distribution pressure management	Yes
	Dedicated energy management staff	Yes
	Defined energy strategy	No
	Defined EE improvement strategy	No
	Capital budget available	Yes
EE intervention confirmed as completed	Equipment replacement	Yes
	Power-factor correction	-
	Soft starters	-
	Variable-speed drivers	Yes
	Automated control	Treatment and network
	Renewable energy	Investment made

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 2: Bình Dương Water Supply and Sewerage Joint Stock Company

2.1 General

The Bình Dương Water Supply and Sewerage Joint Stock Company (JSC) manages the water supply in all urban areas and industrial parks in Bình Dương province. Bình Dương JSC is also a holding company of two subsidiaries: Thuận An Water Supply Enterprise and Thủ Dầu Một Wastewater Treatment Enterprise. The holding company and the two subsidiaries deliver water supply and wastewater services in the province.

The design capacity of the water systems of Bình Dương JSC and its two subsidiaries is 417,000 cubic meters per day. The actual treated water production amounts to 365,780 cubic meters per day, which is equivalent to a utilization rate of 88 percent. The utility manages nine surface water treatment facilities, which are small-scale plants.

Table D.9: Asset Base

Summary of water systems				
Service coverage (%): 70				
Water supply systems and their capacity (m^3/d)	1.	NMN Thủ Dầu Một: 35,000	2.	NMN Khu liên hợp: 120,000
	3.	NMN Dĩ An: 190,000	4.	NMN Bàu Bàng: 30,000
	5.	NMN Chơn Thành: 15,000	6.	NMN Uyên Hưng: 2,000
	7.	NMN Phước Vĩnh: 2,000	8.	NMN Mỹ Phước (NN): 3,000
	9.	NMN Dầu Tiếng: 2,000		
Total design capacity of water supply (m^3/d):	417,000			
Pumped supply (% of total):	100			
Gravity supply (% of total):	0			
Supply time (hrs/day):	24			
Average supply pressure in water supply system (in DMA)	2–3 bar			
List of wastewater treatment systems (if available)	1. NMXL nước thải Thủ Dầu Một Capacity = 17,650 (m^3/d)		2. NMXL nước thải Thuận An Capacity = 17,000 (m^3/d)	
Total design capacity of wastewater treatment (m^3/d):	34,650			
Total treated water production daily (m^3/d):	365,780			

Source: Data provided by Bình Dương Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: DMA = district metered area.

The population served in the province amounts to 1,523,377, and the service coverage of the utility is 70 percent. The utility manages approximately 3,800 km of mains and 229,352 connections. Nearly all of the network is younger than 21 years.

Table D.10: Key Characteristics

Average liter per capita per day (l/p/d)	150
Population served	Approximately 1,523,377
Total number of customer connections	229,352 water connections - Dĩ An: 89,696; domestic use connections: 87,451 - Thủ Dầu Một: 49,761; domestic use connections: 48,568 - The Complex: 33,932; domestic use connections: 48,568: 31,382
Number of new connections per year, made by water company	35,000
Number of new connections per year, made by project/real estate developer	20,000
Number of other connections	Kinh doanh dịch vụ: 1,921 Hành chánh sự nghiệp: 1,431 Sản xuất: 6,957 Dân dụng: 219,043
Density of connections (connection/km):	70
Billed volume (m^3/year, 2017):	113,478,384
Billed volume of domestic customers (m^3/year) (2017):	Billed volume of domestic customers: 48,325,064 m^3 Total billed volume of water: - Dĩ An: 46,288,061 m^3 - Thủ Dầu Một: 11,666,230 m^3 - The complex: 34,901,027 m^3 Volume consumed by domestic customers: - Dĩ An: 22,306,800 m^3 - Thủ Dầu Một: 7,570,984 m^3 - The complex: 8,197,360 m^3
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually (%)	20
Average age of domestic water meters (years)	0.5
Type of domestic water meters, velocity or volumetric	Velocity, volumetric
Brand and country of origin of domestic water meters	Brand: GKM PSM Country of origin: Malaysia
	Brand: Baylan Country of origin: Turkey
	Brand: Nevos Country of origin: Indonesia
Total length of transmission pipes (diameter ≥ 300 mm) (km)	398.99
Total length of distribution pipes (diameter = 63–300 mm), excluding service pipes (km)	3,408
Total length of distribution pipes constructed by project/ real estate developers (km)	27.6
Total length of pipes used over 21 years (km)	2.2

2.2 NRW Management

The utility's NRW targets are much more stringent than the targets set in Prime Minister (PM) Decision 2147 TTg. The current NRW level is approximately 6 percent, which is much lower than the 2015 national target.

The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the technical and commercial departments in routine NRW management activities. The approach to NRW management mainly focuses on the following areas:

- Pressure management
- Active leak detection
- Timely repair of reported leaks and bursts
- Improved material use
- Improved customer service

The utility has installed 200 district metered areas (DMAs), covering 100 percent of the network. It is unknown if the utility determines the water balance in the DMAs on a regular basis (i.e., through assessment of NRW and apparent and real losses).

Table D.11: NRW management

Item	
NRW unit/department	Yes
DMAs (number)	200
DMA coverage (%)	100
Connections per DMA	1.147
Monthly water balance in DMA	—
Assessment of apparent and real losses	No
Type of bulk meters	E/M
Data-transfer technology	AMR
SCADA	Yes

Source: Data provided by Bình Dương Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: AMR = automated meter reading; DMA = district metered area; E/M = electrical and magnetic; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

2.2.1 Performance of NRW Management in Bình Dương

Table D.12 presents a summary of the performance of NRW management and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. Based on data provided, the calculated NRW is 7.5 percent, which is higher than the reported NRW level of 6 percent. The calculated NRW is equivalent to 109 liters per connection per day.

In Bình Dương, the volume of nondomestic water billed accounts for 60 percent of the total billed. The number of nondomestic connections is 25 percent of the total number of connections. Hence, the high system input per connection (1,465 liters per connection per day) somewhat obscures the NRW level, expressed in percentage.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utilities are performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.12: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	122,643,235
System input (l/conn/day)	1,465
Volume billed (l/conn/day)	1,356
Volume billed domestic (l/conn/day)	764
Per capita billed (l/cap/day)	170
NRW (l/conn/day)	109
NRW calculated (%)	7.5
NRW reported in questionnaire (%)	5.8
Apparent losses	
Average age of domestic meters (years)	5
Contribution of apparent losses to NRW (%)	47
Apparent losses (% of total billed)	4
Real losses	
Pressure in tertiary network (m)	25
Real losses (l/conn/day)	58
Real losses (L/conn/day/m)	2
Technical performance category	A

Source: Data provided by Bình Dương Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: NRW = nonrevenue water.

In Bình Dương, the contribution of apparent losses to NRW is estimated to be 47 percent, which is normal considering the low NRW level. With the information available at this stage, the average age of domestic meters is estimated to be 5 years. The utility's questionnaire answer on meter management was not fully clear; it stated that every 5 years, 2 percent of the meters are checked and calibrated. This would imply that the meters are very old, which is unrealistic.

The inaccuracy of the domestic water meters contributes to the apparent losses. The utility did not indicate the existence of unbilled metered consumption. The utility reported that the annual volume of unbilled unmetered consumption reported (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is equal to 1.8 percent of the volume produced. Hence, the other NRW components are therefore less than 5 percent of the system input.

The utility has a procedure to detect and handle Illegal practices.

It can be concluded, however, that real losses contribute marginally to the current NRW, which is 58 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[38] The technical performance of the network in Bình Dương is good (Category A; see table 2.5 for a description of the categories). Further reduction efforts are only needed if there is a shortage of water.

38 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

2.2.2 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meters is estimated to be 5 years. Most likely, class B meters are used. The utility uses electric and magnetic (E/M) meters for the big customers with automated meter reading (AMR) technology. The utility has implemented a structured meter maintenance policy.

Table D.13: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	Yes
Meter class	B?
Average age (years)	5
Type of meter (big customers)	E/M
Management of customer meter	Yes
Billing	Automated
Meter reading	Manual
Internal audit of billing database	—
Collection	—

Source: Data provided by Bình Dương Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: E/M = electrical and magnetic.

The meter reading and billing process is automated. It is unknown if e-billing for domestic customers is implemented.

2.2.3 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network in Bình Dương is good. The general approach to managing real losses is to detect and repair leaks (visible and invisible leaks). The utility has also implemented pressure management programs.

The utility has implemented an asset management plan, which is incorporated into the financial plan. Details are not available, such as a comprehensive analysis of leaks/bursts and other historical events or economic analysis, which are carried out for policy (assessment) purposes.

Table D.14: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	Yes
Budget for repair and minor replacements	—

Source: Data provided by Bình Dương Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: GIS = geographical information system; Q&P = flow and pressure; — = not available.

2.3 Energy Efficiency Management

The company's current specific energy consumption for water treatment is 0.35 kilowatt-hours per cubic meter. In the interview, the company confirmed that this represents a reduction of 12 percent from 2007 levels, when the specific energy was 0.4 kilowatt-hours per cubic meter.

In the interview, the utility confirmed that the annual targets for energy consumption are based on the company business plan (i.e., on previous performance). The company's strategy for energy management is based on the following key concepts:

- Employment of good operational practices (e.g., tariff management)
- A program of energy audits using external staff to monitor plant performance and energy efficiency (EE)

Since 2007, the company has had a fixed program of regular energy audits at its water treatment plants. The audits are carried out by an independent third party on an annual basis. The outputs of the audits are used to develop asset planning and maintenance programs.

2.3.1 Performance of EE Management in Bình Dương

Bình Dương has a typical water production volume of 290,000 cubic meters per day and a specific energy consumption for water production of 0.35 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.43 to 0.52 kilowatt-hours per cubic meter.

2.3.2 Approach to EE *Management* in Bình Dương

Bình Dương utilizes staff working in the central office to oversee the management of energy efficiency at its water treatment plants. Staff from the teams work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is assessed on a regular basis, and any discrepancies in EE performance from month to month are identified and investigated.

In the interview, the company confirmed that improvements in energy efficiency rely on the ability of the technical departments and site operations team personnel to identify deviations in power consumption through diligent monitoring of data from the site.

The company's EE audits are carried out by independent external staff. Bình Dương 's approach to energy auditing has been graded according to the criteria in table D.15.

Table D.15: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired

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B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to this grading, Bình Dương 's energy auditing approach achieves a grade of A.

A copy of an energy audit from 2010 was provided. The audit presented a high-level top-down assessment of the company's energy consumption and specific energy consumption, along with a more detailed assessment of four water treatment plants, with capacities from 10,000 to 90,000 cubic meters per day. The audit recommendations, which were general, included strengthening of the company energy management systems and refurbishment or replacement of some older equipment.

2.3.3 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. In particular, tariff management is carried out in order to ensure that key energy-consuming assets are operated, as far as possible, during low-tariff periods.

Operations such as filter backwashing and pumping of raw and treated water are scheduled so as to avoid their operation during peak-tariff periods. Although this tariff management does not improve energy efficiency per se, it is good operational practice and does reduce energy bills.

In the interview, the company confirmed that there is a significant internal focus on pump efficiency, with larger pumps being checked by operational personnel on a biweekly basis and any increases in specific energy being reported to the maintenance department to allow a deeper investigation to be carried out into the root cause of the deterioration. The checking process involves the assessment of the power being drawn by the pump and comparison with historical values.

The company confirmed that typically, pumps that exhibit a deterioration in efficiency are investigated by a maintenance team, with refurbishment (e.g., bearing replacement) being a typical intervention for low-efficiency pumps.

Although a site visit to a water treatment plant was not completed during the mission, the energy audit report provided by the company confirmed that the Dĩ An and Than Diep water treatment plants are equipped with modern automatic control systems. This contrasts with many other utilities visited during the course of the two missions, where a lack of automatic control was observed.

2.3.4 Delivery of EE Management (Capital)

During the interview, the company confirmed that the reduction in specific energy consumption since 2007 was due to a combination of improved operational practices and capital investment in energy efficiency, driven by the EE auditing program.

No details of specific capital interventions were available, although a copy of an EE audit was provided, which confirmed that there has been historical investment in the installation of both variable-speed drives and soft starters at some of the larger water treatment works. Typically, soft starters would be expected to provide an energy reduction in the region of 10 percent, and variable-speed drives would be expected to provide an energy reduction in the region of 20 to 30 percent, with a financial payback period in the region of 1 to 3 years.

Although the data are not available to confirm this, it is likely that much of the 12 percent reduction in specific energy consumption since 2007 has been delivered through capital investment.

The company's general approach to EE management, as discussed in the interview and the associated questionnaire, is summarized in table D.16.

Table D.16: General approach to EE

		Bình Dương
General approach to EE management	Specific energy(kWh/m³)	0.35
	WLC assessments for new equipment	Yes
	Asset deterioration monitoring	Yes
	Granularity of power metering	Process level
	Peak-tariff avoidance	Yes
	Asset operation	Automatic
	Distribution pressure management	Yes
	Dedicated energy management staff	Yes
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	Yes
	Variable-speed drivers	Yes
	Automated control	Treatment and network
	Renewable energy	Investment planned

Source: Data provided by Bình Dương Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: EE = energy efficiency; WLC = whole-life cost; "—" = not available.

2.3.5 Wastewater Treatment

The utility manages the operation of two wastewater treatment plants serving towns in the southern part of Bình Dương, constructed in 2013 and 2017, respectively, and funded by the World Bank.

The operational costs for the plant are refunded to the utility from the People's Committee. The plant utilizes sequencing batch reactors (SBRs) and is equipped with tertiary disinfection by ultraviolet (UV) treatment, which is a relatively energy-intensive treatment when compared with alternatives such as fixed-film processes.

There is a high level of automatic control at the plant, in line with modern process design standards, in contrast with the low levels of automatic control seen during site visits to water treatment works during both missions.

Some consideration has been given to energy efficiency at the wastewater treatment plant, for example, through dissolved oxygen feedback control of the SBR blowers and flow-based control of the UV disinfection plant.

Sludge from the plant is dewatered using a continuous decanter centrifuge and taken off-site for composting by a third-party company. The utility confirmed that the potential to recover energy from the sludge using anaerobic digestion had been considered but that the volume of sludge available was too small to justify the installation of this type of technology.

The company confirmed that no energy audits had been completed at the plant, and there were no plans to complete any at the time of the visit. The current contract structure, where100 percent of the site's operational costs are refunded to the utility, does not incentivize the utility to improve energy efficiency. The utility collects a 10 percent "environmental protection tax," which is a tariff on the water bill, on behalf of the People's Committee. This tax is not specifically to cover the operational costs of the wastewater treatment plant, which are accounted for separately.

Report 3: Cà Mau Water Supply Joint Stock Company

3.1 General

The Cà Mau utility is a joint-stock company of which the state owns 71.49 percent of the shares. The utility manages eight water supply systems in the provinces of Cà Mau and Bạc Liêu, as listed in table D.17. The capacity of the water system in the capital of Cà Mau province accounts for approximately 60 percent of the total installed design capacity of 68,948 cubic meters per day. The utilization rate of the production facilities is 70 percent.

The raw water source is groundwater. Forty-six boreholes up to 240 meters deep tap aquifers between 180 and 300 m deep. The major boreholes are monitored and managed with Supervisory control and data acquisition (SCADA).

The utility does not manage wastewater.

Table D.17: Asset Base

Water supply system	Capacity (m³/d)
1. Cà Mau city	39,503
2. Trần Văn Thời	5,812
3. Thới Bình	1,152
4. U Minh	2,031
5. Đầm Dơi	1,415
6. Phú Tân	1,638
7. Cái Nước	3,500
8. Ngọc Hiển	1,000
Total design capacity of water supply (m³/d):	**68,948**
Total raw water volume daily (m³/d):	56,020
Total treated water production daily (m³/d):	48,760

Source: Data provided by Cà Mau Water Supply JSC (EE&NRW questionnaire)

The population served in the two provinces amounts to 280,000; however, the service coverage of the utility is unknown. The utility manages approximately 300 km of mains and 70,000 connections. Approximately 67 percent of the network is younger than 21 years. In 2010, 50 percent of the network in Cà Mau city was replaced with funding from Italian aid.

All customers are metered. The nonrevenue water (NRW) at the company level in 2017 was 23 percent.

Table D.18: Customer Base

Service coverage (%)	—
Average liter per capita per day (l/p/d)	113
Population served:	280,000
Total number of customer connections:	69,991
Density of connections (connection/km)	178
Billed volume (m³/year)	13,917,749
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually (%)	10.35

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Total length of transmission pipes (diameter ≥ 300 mm) (km)	5.5
Total length of distribution pipes (diameter = 100–300 mm), excluding service pipes (km)	282
Total length of pipes used over 21 years (km)	95

Source: Data provided by Cà Mau Water Supply JSC (EE&NRW questionnaire)
Note: DMA = district metered area.

3.2 NRW Management

The utility's policy is to follow the NRW targets set in Prime Minister Decision 2147 TTg.

The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the technical and commercial departments in the routine NRW management activities. The approach to NRW management mainly focuses on achieving short-term impact and can be summarized as follows:

- Pressure management[39]
- Timely repair of reported leaks and bursts
- Improved material use
- Improved customer service

The utility is in the process of installing digital metered areas (DMAs). Due to the many boreholes in the supply area, the installation of discrete DMAs is somewhat complicated. In Cà Mau city, 20 DMAs are installed, which covers 50 percent of the network. The water balance (i.e., NRW, apparent and real losses) is not determined on a regular basis.

Table D.19: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	20
DMA coverage%	50%
Connections per DMA	1.96
Monthly water balance in DMA	No
Assessment of apparent and real losses	No
Type of bulk meters	Mech
Data-transfer technology	Data loggers
SCADA	Yes

Source: Data provided by Cà Mau Water Supply JSC (EE&NRW questionnaire)

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition.

3.2.1 Performance of NRW Management in Cà Mau City

The rapid assessment looks into the current NRW situation of the major cities of the utilities, and the NRW performance in Cà Mau city is considered in this section. The reason for the focus on the major cities is that the

39 Inducing very low pressure at the fringes of the network.

impact and viability of a potential performance-based contracting (PBC) NRW program are maximized in a relatively densely populated and big supply area.

Table D.20 presents a summary of the performance of NRW management and an estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 23.5 percent is equivalent to 234 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utilities are performing in various areas of NRW management.

The "top-down" assessment methodology, as developed by the NRW Task Group of the International Water Association (IWA) has been used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.20: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	144,220,000
System input (l/conn/day)	994
Volume billed (l/conn/day)	760
Volume billed domestic (l/conn/day)	679
Per capita billed (l/cap/day)	151
NRW (l/conn/day)	234
NRW calculated (%)	
NRW reported in questionnaire (%)	23.5
Apparent losses	
Average age of domestic meters (years)	9
Contribution of apparent losses to NRW (%)	32
Apparent losses (% of total billed)	10
Real losses	
Pressure in tertiary network (m)	10
Real losses (l/conn/day)	159
Real losses (L/conn/day/m)	16
Technical performance category	C

Source: Data provided by Cà Mau Water Supply JSC (EE&NRW questionnaire)

In Cà Mau city, the contribution of apparent losses to NRW is estimated to be 32 percent. The relatively old age of the domestic water meters contributes considerably to the apparent losses. The utility reports that there is no unbilled authorized consumption, whereas the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is approximately 300,000 cubic meters. Illegal practices are marginally present.

It can be concluded, however, that real losses still largely contribute to the current NRW, which is 159 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[40] The technical performance of the network in Cà Mau City is poor (Category C; see table 2.5 for a description of the categories).

3.2.2 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meters is estimated to be 9 years. That of the big customers is approximately 6.5 years. Class B meters are used. The utility has no structured meter maintenance policy.

Meter reading and billing are automated, using an app on smartphones, allowing a reading error margin of 20 percent. The billing software and server are outsourced to the telecommunications company VNPT. Collection is still carried out manually; only 1 percent of customers pay electronically.

Table D.21: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	No
Meter class	B
Average age (years)	9
Type of meter (big customers)	Mech
Management of customer meter	No
Billing	Automated
Meter reading	Smart phone
Internal audit of billing database	No
Collection	Manual

Source: Data provided by Cà Mau Water Supply JSC (EE&NRW questionnaire)
Note: E/M = electrical and magnetic.

3.2.3 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the relatively young network is poor. Important causes mentioned by the management of the utility are as follows:

- The high temperature of the drinking water promotes rapid degradation of the polyvinyl chloride (PVC) mains
- Ground movement, particularly close to the coast
- Poor workmanship of contractors and project developers

As summarized in table D.22, the management of real losses in Cà Mau city focusses on pressure management and leak repair. The utility does not perform economic analysis to determine the optimum leakage level or comprehensive analysis of leaks/bursts and other historical events for policy purposes. The distribution network data are recorded on drawings. The replacement policy is limited by budget constraints.

In 2016, the utility started to replace the PVC service lines of connections with high-density polyethylene (HDPE) pipes. Approximately 10 percent of the service lines have already been replaced.

40 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

Table D.22: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	No
Budget for repair and minor replacements	Constrained

Source: Data provided by Cà Mau Water Supply JSC (EE&NRW questionnaire)
Note: GIS = geographical information system; Q&P = flow and pressure.

3.2.4 Suggestion made by Utility

Based on a brief exchange of ideas, the utility indicated intended improvements and interventions to enhance the performance of NRW management. In a nutshell, these are as follows:

- Replace PVC mains with HDPE mains (with a replacement rate of 12 kilometers per year over 15 years).
- Upgrade the equipment used for network maintenance.
- Expand the existing SCADA to monitor and report flow and pressure in the network.
- Implement a geographical information system (GIS).

3.3 Energy Efficiency Management

The company's current specific energy consumption for water treatment is 0.39 kilowatt-hours per cubic meter. During the interview, the company confirmed that this represented a reduction from 2003 levels, which were 0.6 to 0.7 kilowatt-hours per cubic meter.

All the company's water treatment plants treat groundwater from boreholes and comprise borehole pumps, pressure filters, and chlorination, making the asset base relatively simple.

The company confirmed that the potential to develop a planned program of energy audits using an independent third party has been under consideration since 2014, but so far, no action has been taken to deliver the program.

Instead, two operational staff (who are dedicated to energy efficiency [EE]) regularly monitor the specific energy consumption at the site level, recording the specific energy for each pump and noting any deviations on a monthly basis (with each individual site being checked annually).

The management of energy consumption is overseen by the utility's central management teams but relies on the site operations personnel for manual collection of the required data.

3.3.1 Performance of EE Management in Cà Mau

Cà Mau has a typical water production volume of 38,959 cubic meters per day and a specific energy consumption for water production of 0.39 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.39 to 0.46 kilowatt-hours per cubic meter.

3.3.2 Approach to EE Management in Cà Mau

Cà Mau utilizes an internal team, comprising two people, to monitor the energy efficiency in each of the eight treatment and distribution networks operated by the company.

In the interview, the company confirmed that the team has sufficient resources to audit each of the pumps on an annual basis and that the data collected by the team are reviewed monthly. The auditing team uses local power monitoring and flow data to assess pump efficiency.

The company recognizes that, in the future, it will be essential to provide energy audit reports to the MoC. However, in the interview, the company commented that no audit reports would be produced until an approved format was received from MoC.

Cà Mau's approach to energy auditing has been graded according to the criteria in table D.23.

Table D.23: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to this grading, Cà Mau's energy-auditing approach achieves a grade of B/C.

3.3.4 Delivery of EE Management (Operational)

The key operational EE measure is the assessment of energy efficiency at the asset level, which is carried out by the internal EE team.

The specific energy of each pump is assessed during the audit, and any changes over typical performance are assessed in more detail. In addition to checking the specific energy of the pumps during site visits, the EE team also confirms the operating point of each pump on its efficiency curve, making adjustments where necessary to maintain pump efficiency.

The water from the pressure filters of the water treatment works (WTW) is passed directly into distribution, creating a risk of poor borehole pump control leading to energy-inefficient operation because the large number of pumps in service must be synchronized to control the pressure in the distribution network. The company utilizes automatic control and monitoring via a SCADA system to ensure EE operation.

The company also ensures that good operational practices are implemented at its sites. There is a particular focus on the operation of large pumps during low-tariff periods, and pressure filter backwashes (which are manually controlled) are also carried out during low-tariff periods when possible.

3.3.5 Delivery of EE Management (Capital)

In the interview, the company confirmed that the majority of energy is consumed by the borehole pumps. Pumps are planned for replacement when they meet the following criteria:

- Consume more than 0.36 kilowatt-hours per cubic meter
- Have an unacceptably high level of breakdowns
- The company confirmed at interview and in the associated questionnaire that although a capital investment budget is available to fund pump replacement, the budget is limited, which may potentially lead to decreased energy efficiency in the future.
- The company has invested extensively in the pump control, and all of the borehole pumps are equipped with variable-speed drives. There has also been some investment in the replacement of older power meters with new smart meters, driven by a desire to improve the accuracy of power monitoring.

The company has not yet invested in renewable energy technologies. However, the company is interested in piloting the use of solar photovoltaic (PV) technology at smaller water treatment plants with a design treatment capacity of 10 to 15 cubic meters per hour.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.24.

Table D.24: General approach to EE

		Cà Mau
General approach to EE management	Specific energy(kWh/m^3)	0.39
	WLC assessments for new equipment	No
	Asset deterioration monitoring	Yes
	Granularity of power metering	Process level
	Peak-tariff avoidance	Yes
	Asset operation	Semiautomatic
	Distribution pressure management	Yes
	Dedicated energy management staff	Yes
	Defined energy strategy	Partial
	Defined EE improvement strategy	Partial
	Capital budget available	Yes, limited
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	Treatment and network
	Renewable energy	Investment planned

Source: Data provided by Bình Dương Water Supply and Sewerage JSC (EE&NRW questionnaire)

Note: EE = energy efficiency; WLC = whole-life cost; "—" = not available.

Report 4: Cần Thơ Water Supply and Sewerage Joint Stock Company

4.1 Cần Thơ

The Cần Thơ Water Supply and Sewerage Joint Stock Company (JSC) manages the water supply in 9 districts in Cần Thơ city (Bình Thủy, Cái Răng, Ninh Kiều, Ô Môn, Phong Dien, Thot Not, Co Do, Thoi Lai and Vinh Thanh). The joint-stock company is owned by the government (64 percent), private investors (34.59 percent), and utility staff (1.41 percent). The Cần Thơ JSC is also a holding company of two subsidiaries: Thốt Nốt Water and the Trà Nóc–Ô Môn Water Supply JSC. The holding company and the two subsidiaries deliver water supply services in different areas of the city.

Cần Thơ is served by two additional urban water utilities: the Cái Răng Water Supply JSC (Cái Răng) and the Cần Thơ 2 Water Supply JSC (Cần Thơ 2). The presence of Cần Thơ 2 and Cái Răng in the city effectively limits growth opportunities for the Cần Thơ JSC because the three utilities effectively compete in a small geographical area with a saturated market.

The design capacity of the water systems of the Cần Thơ JSC and its two subsidiaries is 87,500 cubic meters per day. The actual treated water production amounts to 80,000 cubic meters per day.

Cần Thơ JSC has no legal mandate to provide sanitation services to the public. It has an operation and maintenance (O&M) contract for the wastewater treatment plant. This plant serves mainly the Ninh Kieu district center.

Table D.25: Asset Base

Service coverage (%)	91 (Year 2017)			
Water supply systems	1.	Cần Thơ 1 WTP- 75,000 m³/d		
	2.	Hưng Phú WTP - 10.000 m³/d		
	3.	Bong Vang WTP -2.500 m³/d		
Total design capacity of water supply (m³/d):	87,500			
Pumped supply (% of total):	100			
Gravity supply (% of total):	0			
Supply time (hr/day):	24			
Average supply pressure in water supply system (in DMA)	1. 15 m: Phú Thứ, Tân Phú - Southern Cần Thơ			
	2. 10–12 m: Ninh Kiều district center			
	3. 8–10m: Surrounding area Ninh Kiều			
	4. 5–8m: Phòng Điền district, Mỹ Khánh, Road no. 923			
Total raw water volume daily (m³/d):	~83,000 (Parent company)			
Total design capacity of wastewater treatment (m³/d):	30,000			
Total treated water production daily (m³/d):	~80,000			
Water availability (l/p/d):	180			
Population served (December 2017, parent company)	247,433			

Total number of customer connections:	Total: 60,057 Domestic: 46,545 Administration: 916 Industry: 2,927 Trade: 9,669
Density of connections (connections/km):	117
Billed volume (m^3/year, 2017):	20,594,635
Billed volume of domestic customers (m^3/year, 2017):	Domestic: 13,212,975 Administration: 2,428,965 Industry: 913,014 Trade: 4,039,681
Proportion of water meters installed vs. total connections (%):	100
Proportion of water meters replaced/repaired/checked annually (2017):	Replacement: 6.986 Small repair: 759 Checked: 27.257 (45,39%)
Average age of domestic water meters (years)	5
Type of domestic water meters, velocity or volumetric	Multi jet / velocity
Brand and country of origin of domestic water meters	Baylan, Coma, Zener
Total length of transmission pipes (diameter ≥ 300 mm) (km)	48,223
Total length of distribution pipes (diameter = 63–300 mm), excluding service pipes (km)	511.16
Total length of distribution pipes constructed by project/real estate developers (km)	No figure stated
Total length of pipes used over 21 years (km):	No figure stated

Source: Data provided by Cần Thơ Water Supply and Sewerage JSC (EE&NRW questionnaire)

Note: DMA = district metered area.

Can Tho JSC (Mother company) manage approximately 560 km of mains and 60,067 connections. The coverage of the water supply is 91 percent. The average age of the network is unknown.

4.2 Nonrevenue Water Management

4.2.1 Utility's General Approach

The utility's targets are not completely in line with the targets set in Prime Minister (PM) Decision 2147 TTg, which are as follows:

- 2016: <30 percent
- 2020: <25 percent
- 2030: <15 percent

The current nonrevenue water (Year 2017) level of 29 percent is higher than the 2015 national target. The average level in 2018 is 23.9%. At present, the company has an NRW unit or department.

The approach to NRW management is reactive. Basically, the utility has an appropriate metering and monitoring infrastructure installed in parts of the network, as shown in table D.26. However, the utilities do not compile a complete water balance in the network/district metered areas (DMAs), and the distribution between apparent and real losses is not analyzed and therefore is unknown. The utility does not yet have a comprehensive NRW reduction strategy. The utility's efforts are focused on reducing real losses in the Ninh Kiều district. DMA pilot projects have been implemented in some areas of this district.

The utility has recently hired the Asia Water Network Solutions Corporation (AWNSC) to develop an NRW reduction strategy[41] and help the utility improve its ability to detect leaks. The AWNSC is a subsidiary of the Manila Water Corporation, which is one of Cần Thơ JSC's private shareholders.

Table D.26: NRW management

Item	
NRW unit/department	No
Number of DMAs	42
DMA coverage%	40%
Connections per DMA	1.429
Monthly water balance in DMA	No
Assessment of apparent and real losses	No
Type of bulk meters	E/M
Data-transfer technology	AMR
SCADA	Yes

Source: Data provided by Cần Thơ Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: AMR = automated meter reading; DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition.

4.2.2 Performance of NRW Management in Cần Thơ

Table D.27 presents a summary of the performance of NRW management and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW is approximately 29 percent, which is equivalent to 393 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology, as developed by the NRW Task Group of the International Water Association (IWA), was used to estimate the distribution between apparent (commercial) and real (technical) losses.

41 Assessment report, Water Utility Turnaround Framework Pilot II, March 2018.

Table D.27: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	29,200,000
System input (l/conn/day)	1,333
Volume billed (l/conn/day)	940
Volume billed domestic (l/conn/day)	778
Per capita billed (l/cap/day)	173
NRW (l/conn/day)	393
NRW calculated (%)	29.5
NRW reported in questionnaire (%)	29.0
Apparent losses	
Average age of domestic meters (years)	8
Contribution of apparent losses to NRW (%)	19
Apparent losses (% of total billed)	8
Real losses	
Pressure in tertiary network (m)	12
Real losses (l/conn/day)	317
Real losses (L/conn/day/m)	26
Technical performance category	>D

Note: NRW = nonrevenue water

In Cần Thơ, the contribution of apparent losses to NRW is estimated to be 19 percent. With the information available at this stage, the average age of the domestic meters is estimated to be 8 years. The inaccuracy of the domestic water meters contributes to the apparent losses. The utility and its two subsidiaries do not indicate the existence of unbilled authorized consumption, nor is the annual volume of unbilled unmetered consumption reported (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.). The utility does have a procedure to detect and handle Illegal practices.

It can be concluded that real losses still largely contribute to the current NRW, which is 317 liters per connection per day. The guidelines of the NRW Task Group of the International Water Association (IWA) were used as a reference to assess the technical performance of the network.[42] The technical performance of the network in Cần Thơ is poor (Category D; see table 2.5 for a description of the categories).

4.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meter is estimated to be 8 years. Most likely, class B meters are used. The utilities use electrical and magnetic (E/M) meters for the big customers with automated meter reading (AMR) technology. The utility has implemented a structured meter maintenance policy.

42 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** 2.5 in the text.

Table D.28: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	Yes
Meter class	?
Average age (years)	8
Type of meter (big customers)	E/M
Management of customer meter	Yes
Billing	Manual
Meter reading	Handheld
Internal audit of billing database	?
Collection	Manual

Source: Data provided by Cần Thơ Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: E/M = electrical and magnetic.

Meter reading, billing, and collection are done manually. The administration consolidates readings manually. The printed bills are physically collected by a collector. The utility is piloting an e-billing process (meter reading with an app and collection through banks).

4.2.4 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network in Cần Thơ is poor. The general approach to managing real losses is reactive, with a focus on the repair of visible leaks only. Most efforts seem to be focused on reducing NRW in the Ninh Kiều[43] district given its high population density.

True asset management is yet to be implemented (by Iarc / ArcGis software). A comprehensive analysis of leaks/bursts and other historical events and economic analyses are not carried out for policy (assessment) purposes.

Table D.29: Real loss management practices

Item	
Pressure management	No
Hydraulic model for Q&P management	No
Active leak control	No
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	Yes
Budget for repair and minor replacements	Constrained

Source: Data provided by Cần Thơ Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: GIS = geographical information system; Q&P = flow and pressure.

Currently, the cost of renewal programs for pipelines is not incorporated in the financial plans. The utility has recently initiated an active leak control program with the support of the AWNSC.

43 Assessment report, Water Utility Turnaround Framework Pilot II, March 2018.

4.3 Energy Efficiency Management

4.3.1 Utility's General Approach

The company has set a target energy consumption for water treatment of 0.18 to 0.19 kilowatt-hours per cubic meter, compared with the reported current consumption of 0.21 kilowatt-hours per cubic meter, a reduction of 9 to 14 percent.

An increase in the cost of energy of between 5 and 10 percent is anticipated during the period to 2028, and during the interview, the utility identified this anticipated cost increase as a key driver for energy efficiency (EE) investment. Power costs represent approximately 21 percent of the total operational costs for the company.

Cần Thơ WASSCO has developed a proactive program of EE management based on two key concepts:

- Employment of good operational practices (e.g., tariff management)
- A program of regular third-party energy audits at operational sites

The company has a fixed program of regular energy audits at its water treatment plants. The audits are carried out by an independent third party every 3 years. The outputs of the audits are used to develop asset planning and maintenance programs. The most recent audits were carried out in 2015, with more planned for 2018.

4.3.2 Performance of EE Management in Cần Thơ

Cần Thơ has a typical water production volume of 79,500 cubic meters per day and a specific energy for water production of 0.21 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.36 to 0.53 kilowatt-hours per cubic meter.

4.3.3 Approach to EE Management in Cần Thơ

Cần Thơ utilizes a central energy team to provide overall management of energy efficiency at its three water treatment plants. This central team works with the site operational teams to ensure that EE opportunities are identified and that good practice is shared between the different operations teams. Plant performance is reviewed monthly in this way, and any deviations from historical plant performance are investigated.

At interview, the company confirmed that there was a substantial reliance on the experience of the site operations teams to identify any deterioration in the EE performance of key assets, a process that relies on the operational staff to recognize increases in the power consumption through stringent monitoring of submeters and general awareness of the health of the plant.

Accurate power metering is available only at the site level. There is no accurate submetering at the Motor Control Center level, although ampere meters are available for individual plant items (during external energy audits, large plant items are temporarily sub metered). There is a lack of automatic monitoring; thus, the experience and diligence of site personnel are essential in the management of energy efficiency.

A second critical aspect of the utility's approach to managing major EE issues is the commissioning of EE audits, as described earlier. The audits are conducted by an independent third party. Due to the lack of reliable submetering on-site, the auditors utilize temporary clamps on power monitors to ensure that the data collected during the audit are accurate.

Cần Thơ provided a partial copy of a recent energy audit for the Cần Thơ 1 water treatment plant, completed in 2015. The audit included a thorough assessment of the energy consumption of all major plant items on-site and was of good quality. Cần Thơ's approach to energy auditing was graded according to the criteria in table D.30.

Table D.30: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as having reached the end of its service life
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least every five years

According to this grading, Cần Thơ's energy-auditing approach achieves a grade of A.

4.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites.

During a brief site visit to the Cần Thơ 1 water treatment plant, the plant manager confirmed that tariff management is carried out to ensure that, where possible, major plant items are not operated during peak-tariff periods.

For example, filter backwashes are delayed until low-tariff periods, and high-lift-pump operation is restricted (within the bounds of the requirement to provide a sufficient pressure and volume of water in distribution) during peak-tariff periods.

A lack of submetering on-site was confirmed, although panel ammeters were available for large plant items such as the high-lift pumps. Ammeters are not as accurate as good-quality submeters but are sufficient to allow a qualitative assessment of energy consumption for a given plant item to be made.

The plant manager was able to confirm that the ammeters are monitored on a daily basis by plant personnel and that the site staff members have sufficient experience to identify periods when asset performance is deteriorating.

4.3.5 Delivery of EE Management (Capital)

Cần Thơ provided a partial copy of a recent energy audit for the Cần Thơ # water treatment plant. The audit included a thorough assessment of the energy consumption of all of the major plant items on-site.

Recommendations were made under the findings of the audit, and these were confirmed to have been implemented by Cần Thơ WASSCO.

The key recommendation, the installation of variable-frequency drives on the Cần Thơ 1 plant's high-lift pumps, was implemented at a cost of 27,176 million Vietnamese dong (D), delivering annual savings of approximately D 41,526 million per annum.

The installation of inverters at other locations was also recommended, at a combined cost of D 28.47 million, with predicted annual savings of D 111 million, and this was implemented by the company.

The company has also made some initial assessments of the potential to install technologies for renewable energy generation (with a focus on solar generation), although no investment decisions have yet been made.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.31.

Table D.31: General approach to EE

		Cần Thơ
General approach to EE management	Specific energy(kWh/m³)	0.21
	WLC assessments for new equipment	No
	Asset deterioration monitoring	Yes
	Granularity of power metering	Site level
	Peak-tariff avoidance	Yes
	Asset operation	Semiautomatic
	Distribution pressure management	Yes
	Dedicated energy management staff	Yes
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	Treatment and network
	Renewable energy	Assessment completed

Source: Data provided by Cần Thơ Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: EE = energy efficiency; WLC = whole-life cost; "—" = not available.

4.3.6 Wastewater Treatment

Cần Thơ is involved in a pilot program whereby the utility manages the operation of a wastewater treatment plant serving an industrial zone and part of the city of Cần Thơ. The plant was of recent construction, having been partially funded by a German bank, with 54 percent of the cost being covered by a loan and 46 percent by domestic capital funds.

The site was not visited, but the information provided by the utility noted that biological treatment at the plant is provided by trickling filters. This technology (and other similar low-energy-consuming processes) are an inherently energy-efficient option for wastewater treatment.

The operational costs for the plant are refunded to the utility from the People's Committee.

However, the company confirmed that no energy audits had been completed at the plant, and there were no plans to complete any at the time of the visit. The current contract structure, where 100 percent of the site's operational costs are refunded to the utility, does not incentivize the utility to improve energy efficiency.

Report 5: Hà Nam Water Supply Joint Stock Company

5.1 General

The Hà Nam Water Supply Joint Stock Company (JSC) is 100 percent privately owned. One individual investor holds 90 percent of the shares.

The utility manages two water supply plants (design capacity = 20,000 cubic meters per day + 50,000 cubic meters per day) in Phủ Lý city. At present, a third water treatment plant in Duy Tiên district is being constructed. In the near future, the total capacity is expected to equal 170,000 cubic meters per day.

The capacity of the water system in the capital of Hà Nam province, Phủ Lý, and three other districts accounts for 100 percent of the total installed design capacity of 70,000 cubic meters per day. The water supply covers the urban, commercial water supply. The utilization rate of the production facilities is less than 60 percent. The facilities are not operating every day due to water quality, energy supply, and other incidents.

The utility also manages the water supply to five industrial zones. The utility does not manage wastewater.

Table D.32: Asset Base

Water supply systems	1. Phủ Lý WTP1: 20,000 m³/day 2. Phủ Lý WTP2: 50,000 m³/day
Total design capacity of water supply (m³/d):	70,000
Total raw water volume daily (m³/d):	73,500
Total design capacity of wastewater treatment (m³/d):	—
Total treated water production daily (m³/d):	40,000

Source: Data provided by Hà Nam Water Supply JSC (EE&NRW questionnaire)
Note: WTP = water treatment plant; — = not available.

The population served in the provinces amounts to 305,328; however, the service coverage of the utility is unknown. The utility manages approximately 340 kilometers of mains and 40,500 connections. The network was first installed in 1978 and was expanded in 1997 and 2002 (Phủ Lý and three other districts).

All customers are metered. The nonrevenue water (NRW) at the company level in 2017 was 27 percent.

Table D.33: Key characteristics

Average liter per capita per day (L/p/d)	Urban = 120 ; Rural = 90
Population served	305,328
Total number of customer connections	40,500
Density of connections (connection/km)	—
Billed volume (million m³/year)	7.7
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually:	Very limited
Total length of transmission pipes (diameter ≥ 300 mm) (km)	87.85
Total length of distribution pipes (diameter = 100–300 mm), excluding service pipes (km)	257.37
Total length of pipes used over 21 years (km):	—

Source: Data provided by Hà Nam Water Supply JSC (EE&NRW questionnaire)
Note: — = not available.

5.2 NRW Management

5.2.1 Utility's General Approach

The utility policy is to follow the NRW targets set in Prime Minister (PM) Decision 2147 TTg. At present, the company does have not an NRW unit or department, nor does it have an NRW management plan.

The approach to NRW management is reactive, lacking an appropriate metering and monitoring infrastructure (see table D.34). The bulk meters are read manually every 3 months. The utility has plans to implement district metered areas (DMAs).

Table D.34: NRW management

Item	
NRW unit/department	No
Number of DMAs	0
DMA coverage%	0
Connections per DMA	N/A
Monthly water balance in DMA	N/A
Assessment of apparent and real losses	No
Type of bulk meters	Mech
Data-transfer technology	N/A
SCADA	No

Source: Data provided by Hà Nam Water Supply JSC (EE&NRW questionnaire)
Note: AMR = automated meter reading; DMA = district metered area; E/M = electrical and magnetic; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

5.2.2 Performance of NRW Management in Province

Table D.25 presents a summary of the performance of NRW management and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 27 percent is equivalent to 267 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology, as developed by the NRW Task Group of the International Water Association (IWA), was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.35: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	14,600,000
System input (l/conn/day)	988
Volume billed (l/conn/day)	721
Volume billed domestic (l/conn/day)	532
Per capita billed (l/cap/day)	118
NRW (l/conn/day)	267
NRW calculated (%)	47.3
NRW reported in questionnaire (%)	27.0

Continued…

Apparent losses	
Average age of domestic meters (years)	15
Contribution of apparent losses to NRW (%)	32
Apparent losses (% of total billed)	12
Real losses	
Pressure in tertiary network (m)	20
Real losses (l/conn/day)	181
Real losses (L/conn/day/m)	9
Technical performance category	B

Source: Data provided by Hà Nam Water Supply JSC (EE&NRW questionnaire)
Note: NRW = nonrevenue water.

The contribution of apparent losses to NRW is estimated to be 32 percent. The old age of the domestic water meters contributes considerably to the apparent losses. The utility reports that there is no unbilled authorized consumption, and the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is not recorded or estimated.

It can be concluded that real losses still largely contribute to the current NRW, which is 181 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[44] The technical performance of the network is reasonable (Category B; see table 2.5 for a description of the categories).[45]

5.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meters is estimated to be 15 years. Class B meters are used. The class of the meters of the big customers, which are not calibrated, is unknown. The utility has no structured meter maintenance policy and reacts based on customer complaints.

Table D.36: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	No
Meter class	B
Average age (years)	15
Type of meter (big customers)	Mech
Management of customer meter	No
Billing	Manual
Meter reading	Manual
Internal audit of billing database	No
Collection	Manual

Source: Data provided by Hà Nam Water Supply JSC (EE&NRW questionnaire)
Note: E/M = electrical and magnetic.

44 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** 2.5 in the text.

45 The NRW level and real losses are possibly underestimated due to noncalibrated old mechanical bulk meters (20 and 16 years of age).

Meter reading, billing, and collection are done manually. The administration consolidates readings manually. The printed bills are collected physically by a collector. Big customers pay through banks.

5.2.4 Management of Real (Physical) Losses

The general approach to managing real losses is reactive, with a focus on the repair of visible leaks only. Currently, a few hundred leaks occur in the network of Hà Nam. The utility has allocated one staff member to repair leaks.

Parallel to the city's project to upgrade sidewalks (started in 2016), the utility repairs or replaces pipes. In 2017, approximately 3 kilometers (1 percent of the total) had been replaced, an additional 2 kilometers were scheduled to be replaced in 2018. True asset management is yet to be implemented. A comprehensive analysis of leaks/bursts and other historical events and economic analyses are not carried out for policy (assessment) purposes. Distribution network data are recorded manually on drawings.

Table D.37: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	No
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	No
Budget for repair and minor replacements	Constrained

Source: Data provided by Hà Nam Water Supply JSC (EE&NRW questionnaire)
Note: GIS = geographical information system; Q&P = flow and pressure.

5.3 Energy Efficiency Management

5.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.49 kilowatt-hours per cubic meter. In the interview, the utility confirmed that the annual targets for energy consumption are based on previous performance and that there are no firm targets to reduce energy consumption. There is also no formal strategy for energy management.

The company's informal strategy for energy management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- Completion of internal energy audits to monitor performance against business plan targets.

Energy audits are carried out by operations personnel; no staff is dedicated to the assessment of energy efficiency (EE).

5.3.2 Performance of EE Management in Hà Nam

Hà Nam has a typical water production volume of 40,000 cubic meters per day and a specific energy consumption for water production of 0.49 kilowatt-hours per cubic meter, which is within the Ministry of Construction (MoC) cost norm of 0.45 to 0.53 kilowatt-hours per cubic meter.

5.3.3 Approach to EE Management in Hà Nam

Hà Nam utilizes internal operational staff to assess energy efficiency at its water treatment plants. Staff from the teams must work in cooperation with the central asset planning staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is assessed monthly, and any discrepancies in EE performance from month to month are identified and investigated. Energy business plans are developed annually, and although there is a general desire to improve energy efficiency year on year, no firm targets for energy consumption have been set. The company does not have a formal EE strategy.

In the interview, the company confirmed that improvements in energy efficiency rely on the experience of the site operations team personnel to identify deviations in power consumption through diligent monitoring of data from the site.

Accurate power metering is available at the site level, with more detailed and accurate submetering available for newer assets.

During the interview and in the returned questionnaire, the company confirmed that with the data available, they feel it is possible to gauge when assets are deteriorating.

Hà Nam's approach to energy auditing was graded according to the criteria in table D.38.

Table D.38: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to this grading, Hà Nam's energy auditing approach achieves a grade of C.

5.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. The key area of focus is on the management of treatment processes to ensure that energy-intensive processes such as filter backwashes are carried out as infrequently as possible. The company reported that tariff management is not carried out.

Of the two water treatment plants operated by the company, one is operated semi automatically, requiring significant operator intervention to maintain energy efficiency, and the other is operated with fully automatic control.

5.3.5 Delivery of EE Management (Capital)

In the interview, the company confirmed that the average age of the pumps in service is 10 years, which is relatively young. A typical service life for a clean water pump would be expected to be in excess of 20 years.

Although the company is reported to be willing to deliver capital investment in energy-saving measures, the water tariff is insufficient to fund additional investment. Pumps are replaced when the specific energy consumption becomes too high, although a threshold level for specific energy consumption was not given by the company. All of the pumps have been equipped with variable-speed drives to improve the flexibility of control and energy efficiency. The company has made no investment in renewable energy technology to date and has no plans to do so.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.39.

Table D.39: General approach to EE

		Hà Nam
General approach to EE management	Specific energy(kWh/m^3)	0.49
	WLC assessments for new equipment	No
	Asset deterioration monitoring	Yes
	Granularity of power metering	Plant Level, Partial
	Peak-tariff avoidance	No
	Asset operation	Automatic/Semiautomatic
	Distribution pressure management	No
	Dedicated energy management staff	No
	Defined energy strategy	No
	Defined EE improvement strategy	No
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	—
	Automated control	—
	Renewable energy	No

Source: Data provided by Hà Nam Water Supply JSC (EE&NRW questionnaire)
Note: EE = energy efficiency; WLC = whole-life cost; "—" = not available.

Report 6: Kiên Giang Water Supply and Drainage Company Limited

6.1 Kiên Giang

The Kiên Giang Water Supply and Drainage Company Limited is a state-owned joint-stock company. The utility manages 12 water supply systems, as listed in table D.40. The capacity of the water systems in the provincial capital and Phú Quốc is the largest, accounting for approximately 70 percent of the total installed design capacity of 104,000 m^3/day. The utilization rate of the production facilities is unknown.

In 2009 the production facilities and network of Rạch Giá were completely replaced and extended in a project funded by the Asian Development Bank (ADB), and the network of Phú Quốc was completely replaced in 2016 in a project funded by the World Bank. Currently, major replacement and extension works are being carried out in Hà Tiên, funded by AusAID. The raw water source is surface water.

Table D.40: Asset and customer base.

Service coverage (%):	**85.2**
Water supply system	Capacity (m^3/d)
1. Rạch Giá Water Treatment Plant	50,000
2. Hà Tiên Water Supply Company	8,000
3. Phú Quốc Water Supply Branch	21,500
4. Tan Hiep Water Supply Station	2,400
5. Hon Chong Water Supply Station	2,000
6. Giồng Riềng Water Supply Station	2,400
7. Kiên Luong Water Supply Station	10,000
8. An Biên Water Supply Station	600
9. Minh Luong Water Supply Station	2,000
10. An Minh Water Supply Station	2,400
11. Tắc Cậu Water Supply Station	2,000
12. Community College Water Supply Station	1,200
Total design capacity of water supply (m^3/d):	104,000
Total raw water volume daily (m^3/d):	no data (raw water meters are still not available)
Total design capacity of wastewater treatment (m^3/d):	Sewerage is not the company's activity
Total treated water production daily (m^3/d):	107,200

Source: Data provided by Lạng Sơn JSC (EE&NRW questionnaire)
Note: "—" = not available.

The utility manages approximately 360 kilometers of mains and 112,302 connections. The age of the networks in Rạch Giá and Phú Quốc is less than 10 years old. The age of the networks in the other 10 water supply systems is unknown.

All customers are metered. The nonrevenue water (NRW) at the company level in 2017 was 24 percent. The NRW in Rạch Giá and Phú Quốc is 30 percent and 12 percent, respectively.

Table D.41: Key characteristics

Average liter per capita per day (l/p/d)	100
Population served	561,510
Total number of customer connections	112,302
Density of connections (connection/km)	16
Billed volume (m^3/year)	28,144,189
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually (number)	Maintained 11,140 Replaced 2,660
Total length of transmission pipes (diameter ≥ 400 mm) (km)	21,972
Total length of distribution pipes (diameter = 100–400 mm), excl service pipes (km):	341,065
Total length of pipes used over 21 years (km)	240

6.2 NRW Management

6.2.1 Utility's General Approach

The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the technical and commercial departments in the routine NRW management activities. The approach to NRW management mainly focuses on achieving short-term impact and can be summarized as follows:

- Smart pressure management,[46] monitored and managed with supervisory control and data acquisition (SCADA)
- Timely repair of reported leaks and bursts
- Improved material use

The utility is in the process of installing district metered areas (DMAs). The DMA coverage in Rạch Giá and Phú Quốc is 100 percent.

Table D.42: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	39
DMA coverage (%)	100
Connections per DMA	1,282
Monthly water balance in DMA	Not done
Assessment of apparent and real losses	Not done
Type of bulk meters	E/M
Data-transfer technology	AMR
SCADA	Yes

Note: AMR = automated meter reading; DMA = district metered area; E/M = electrical and magnetic; NRW = nonrevenue water; SCADA = supervisory control and data acquisition.

46 Inducing very low pressure at the fringes of the network.

6.2.2 Performance of NRW Management in Rạch Giá

The rapid assessment looks into the current NRW situation of the major cities of the utilities, and the NRW performance in Rạch Giá is considered in this section. T The reason for the focus on the major cities is that the impact and viability of a potential performance-based contracting (PBC) NRW program are maximized in a relatively densely populated and big supply area.

Table D.43 presents a summary of the performance of NRW management and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 30 percent is equivalent to 304 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.43: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	18,545,286
System inpt (l/conn/day)	1,016
Volume billed (l/conn/day)	712
Volume billed domestic (l/conn/day)	600
Per capita billed (l/cap/day)	133
NRW (l/conn/day)	304
NRW calculated (%)	
NRW reported in questionnaire (%)	29.9
Apparent losses	
Average age of domestic meters (years)	7
Contribution of apparent losses to NRW (%)	26
Apparent losses (% of total billed)	11
Real losses	
Pressure in tertiary network (m)	9
Real losses (l/conn/day)	226
Real losses (l/conn/day/m)	27
Technical performance category	>D

Note: NRW = nonrevenue water.

In Rạch Giá, the contribution of apparent losses to NRW is estimated to be 26 percent. The average age of the domestic water meters contributes considerably to the apparent losses. The utility reports that there is no unbilled authorized consumption, and the unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is not recorded. Illegal practices are marginally present.

It can be concluded that real losses still largely contribute to the current NRW, which is 226 liters per connection per day. The level of real losses is surprisingly high when considering the young age of the network.

The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[47] The technical performance of the network in Rạch Giá is poor (Category D; see table 2.5 for a description of the categories).

6.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meter is estimated to be 7 years. A third party recalibrates the meters and checks the accuracy (2 to 3 percent accuracy is accepted for reuse of meters). The characteristics of the meters of the big customers are unknown. Class B domestic water meters are used. The utility has no structured meter maintenance policy. Meter reading, billing, and collection are done manually. The bill is brought to the customer.

Table D.44: Commercial management practices.

Item	
Meter coverage (%)	100
Management of customer meter	No
Meter class	B
Average age (years)	7
Type of meter (big customers)	Mechanical
Management of customer meter	No
Billing	Manual
Meter reading	Manual
Internal audit of billing database	No
Collection	Manual

The utility has an active program to address unauthorized consumption (i.e., illegal practices), including public awareness campaigns.

6.2.4 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the relatively young network is poor. Important causes mentioned by the management of the utility are as follows:

- Ground movement and land subsidence due coastal development projects, which affect the polyvinyl chloride (PVC) mains
- Poor workmanship of contractors and project developers (Approximately 50 percent of the current extension to the network is done by real estate developers.)
- Many roadworks, inducing ground movements and direct damage

Table D.45: Real loss management practices.

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes

Continued…

47 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

Analysis of economic leakae level	Yes
Comprehensive analysis of bursts and historical events	No
GIS	No

Note: GIS = geographical information system; Q&P = flow and pressure.

As summarized in table D.45, management of real losses in Rạch Giá focuses on smart pressure management and active leak detection and repair. The utility performs economic analysis to determine the optimum leakage level.

True asset management is still in its infant stage. A comprehensive analysis of leaks/bursts and other historical events is not carried out. Distribution network data are recorded on drawings. The replacement policy is budget driven, which is a constraint.

6.3 Energy Efficiency Management

6.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.38 kilowatt-hours per cubic meter. In the interview, the utility confirmed that there is a target to reduce the specific energy consumption to 0.30 kilowatt-hours per cubic meter wherever possible. However, the expectation is that it will only be possible to actually deliver this level of energy efficiency (EE) at some of the newer plants.

The company's formal strategy for EE management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- The completion of energy audits using internal staff to monitor performance against business plan targets
- The completion of partial energy audits with specialist suppliers (e.g., suppliers of pumps or variable-speed drives) to identify opportunities for energy savings through capital investment

The company's energy-auditing approach relies on the use of internal staff who are dedicated to the monitoring of energy efficiency. The internal audits are completed regularly, but there is no defined frequency.

6.3.2 Performance of EE Management in Kiên Giang

Kiên Giang has a typical water production volume of 74,900 cubic meters per day and a specific energy for water production of 0.38 kilowatt-hours per cubic meter, which is within the Ministry of Construction (MoC) cost norm of 0.36 to 0.52 kilowatt-hours per cubic meter.

6.3.3 Approach to EE Management in Kiên Giang

Kiên Giang utilizes staff working in the central technical department to oversee the management of energy efficiency at its water treatment plants. Dedicated staff work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is audited internally on an ad hoc basis, and any discrepancies in EE performance are identified and investigated. A target of 0.3 kilowatt-hours per cubic meter has been set; however, this target will not be applied to every plant.

In the interview, the company confirmed that improvements in energy efficiency rely on the ability of the technical department and site operations team personnel to identify deviations in power consumption through diligent monitoring of data from the site.

Accurate power metering is available at the site level, with some accurate submetering available at the process-element level. In the interview and in the returned questionnaire, the company confirmed that with the data available, it is possible to gauge when assets are deteriorating.

Kiên Giang's approach to energy auditing has been graded according to the criteria in table D.46.

Table D.46: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as having reached the end of its service life
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least every five years

According to this grading, Kiên Giang's energy-auditing approach achieves a grade of A/B.

6.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. For example, there is a program of tariff management to ensure that major energy-consuming assets are not operated during peak-tariff periods. Plant control was reported to be almost entirely manual, therefore relying on the expertise of the site operations personnel to maintain the energy efficiency of the plant.

Historically, there have been significant issues with raw water quality in the province, which has caused operational impacts. The construction of a large reservoir serving the Rạch Giá water treatment plant has significantly reduced the turbidity of the raw water and led to an improvement in the performance of the plant.

There is a rigorous internal training program to ensure that operations personnel are sufficiently skilled to maintain energy-efficient operation. Staff members are subject to an annual competency test, and there are bonuses for good performance, including good EE management.

Following the interview with the company, a brief site visit to the Rạch Giá water treatment plant was completed. During the visit, it was observed that the clarifiers were performing poorly and therefore probably being hydraulically overloaded. This may indicate a requirement for better operational training or may indicate that the plant was being operated outside its design envelope in order to meet high demand. In either case, the poor clarifier performance would lead to more frequent filter backwashing, presenting an additional energy expense at the plant. The automatic filter control had also failed, meaning that EE filter backwashing relied on the diligence of operations staff.

6.3.5 Delivery of EE Management (Capital)

In the interview, the company confirmed that capital funding is available for any EE measures that are identified. The typical period from the initial concept to scheme delivery is 3 months, and any such schemes are expected to deliver a simple payback within 2 years.

Following the interview with the company, a brief site visit to the Rạch Giá water treatment plant was completed. Three new inverter-driven clean water pumps had been installed at the plant, replacing the original pumps, which were in excess of 20 years old and very inefficient. The installation of inverter drives allowed the new pumps to deliver a much greater level of efficiency than the old pumps.Three further pumps remained to be replaced, and the company has plans to do this in the future. The company confirmed that there were similar plans for EE investment at the Hà Tiên water treatment plant, which would again involve the replacement of inefficient and life-expired pumps. A rough analysis of the efficiency of the remaining old pumps was completed, and their efficiency was found to be approximately 60 percent, well below the 80 percent expected of modern pumps.

The company has not yet made an investment in renewable energy technologies. However, there is an ongoing discussion with a supplier of floating solar photovoltaic (PV) equipment, with a view to installing this on the newly constructed Rạch Giá reservoir.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.47.

Table D.47: General approach to EE

		Kiên Giang
General approach to EE management	Specific energy(kWh/m^3)	0.38
	WLC assessments for new equipment	Yes
	Asst deterioration monitoring	Yes
	Granularity of power metering	Process level, Partial
	Peak-tariff avoidance	Yes
	Asset operation	Manual
	Distribution pressure management	Yes
	Dedicated energy management staff	Yes
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	Network
	Renewable energy	Investment Planned

Note: EE = energy efficiency; WLC = whole-life cost; "—" = not available.

Report 7: Lâm Đồng Water Supply and Sewerage Company Limited

7.1 Lâm Đồng

The Lâm Đồng utility is a joint-stock company, of which the government owns 40 percent of the shares. In the near future, the private share will increase. The utility manages eight water supply systems in the provinces of Lâm Đồng, as listed in table D.48. The capacity of the water system in the capital of Lâm Đồng province, Da Lat, accounts for approximately 30 percent of the total installed design capacity of 73,520 cubic meters per day. The utilization rate of the production facilities is 78 percent. The water supply covers the urban, commercial, and rural water supply. The tourist industry is well developed in Da Lat.

The current raw water source is surface and groundwater. The utility purchases 25,000 cubic meters per day for Da Lat (BOT Đan Kia 2 water treatment plant [WTP]; see table D.48). The utility is responsible for wastewater management.

Table D.48: Asset Base

Service coverage (%)	- Da Lat city: 97 - Lộc Thắng town, Bảo Lâm district: 85 - Dinh Van town, Lâm Hà district: 82 - Thạnh Mỹ town, Đơn Dương district: 45 - Dran town, Đơn Dương district: 45 - Đạ Tẻh town, Đạ Tẻh district: 54 - Đam Rông town, Đam Rông district: 32 - Dam Ri town, Đạ Huoai district: 61
Water supply systems and capacity (m³/d)	1. Đan Kia WTP–Suoi Vang (Da Lat city): 25,000 2. Than Tho Lake WTP (Da Lat city): 6,000 3. Đan Kia 2 WTP (Da Lat city): 25,000 *(The company purchases treated water from this WTP to supply Da Lat city)* 4. Dinh Van WTP (Lâm Hà district): 3,000 5. Tân Hà WTP (Lâm Hà district): 2,000 6. Nam Ban WTP (Lâm Hà district): 2,000 7. Đạ Tẻh WTP (Đạ Tẻhdistrict): 2,000 8. D'Ran WTP (Đơn Dương district): 1,500 9. Thạnh Mỹ WTP: designed capacity 900, at present: - Well 1 (Đơn Dương district): 450 - Thạnh Mỹ WTP, Well 2 (Đơn Dương district): 450 10. Đam Rông WTP (Đam Rông district): 500 11. Da M'Ri WTP (Đạ Huoai district): 500 12. Madaguoi WTP (Đạ Huoai district): 1,500 13. Bảo Lâm WTP, Well 1 (Bảo Lâm district): 720 14. Bảo Lâm WTP, Well 2 (Bảo Lâm district): 600 15. Bảo Lâm WTP, Well 3 (Bảo Lâm district): 600 16. Bảo Lâm WTP, Well 4 (Bảo Lâm district): 600 17. Bảo Lâm WTP, Well 5 (Bảo Lâm district): 600 18. Bảo Lâm WTP, Well 6 (Bảo Lâm district): 600 The total design capacity of Bảo Lâm WTP is 3,720
Total design capacity of water supply (m³/d):	73,620
Total raw water volume daily (m³/d):	36,910
List of wastewater treatment systems, Da Lat city (m³/d):	7,775
Total design capacity of wastewater treatment (m³/d):	12,400 (Phase I: 7,400; Phase II: 5,000)
Total treated water production daily (m³/d):	35,537

Note: WTP = water treatment plant.

The population served in the province amounts to 297,000, the service coverage varies in the 12 systems, as presented in table D.48. The utility manages approximately 407 kilometers of mains and 74,089 connections (Da Lat = 58,340). The utility has introduced 46 types of customers. The network in Da Lat originated in 1985 and was extended over the years.

Table D.49: Key characteristics

Average liter per capita per day (l/p/d)	Da Lat: 175; Other districts: 100
Population served	297,000
Total number of customer connections	74,089
Density of connections (connection/km)	64
Billed volume (m³/year)	16,000,000
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually (%)	Replaced 4.15 Repaired 65.86 Checked annually 105.88
Total length of transmission pipes (diameter ≥ 300 mm) (km)	44,521
Total length of distribution pipes (diameter = 100 –300 mm), excluding service pipes (km)	362,337
Total length of pipes used over 21 years (km)	200 (including service pipelines and distribution pipelines)

7.2 Nonrevenue Water Management

7.2.1 Utility's General Approach

The utility policy is to follow the nonrevenue water (NRW) targets set in Prime Minister (PM) Decision 2147 TTg. At present, the company does not have an NRW unit or department or an NRW management plan.

In the past (2003–2005), the company managed to reduce the NRW from 40 percent to 15 percent. Since then, the NRW level has crept up to approximately 27 percent. In the period 2003–2005, the main features of the NRW management strategy were as follows:

- Monitoring day and night, identifying leakages, and fixing the leakages in a timely manner
- Identifying high-pressure points and reducing pressure at these points (with normal valves; the company did not have pressure valves at that time)
- Checking every water meter for accuracy and replacing old meters
- Detecting burst points
- Identifying improper designs and materials
- Identifying illegal connections, which was and still is a major issue in Da Lat

At present, the utility has installed 100 pressure-reducing valves (PRVs) in Da Lat and has plans to install 82 more. Due to the hilly terrain, pressure management in Da Lat is complicated. In the past, the utility used a supervisory control and data acquisition (SCADA) system, which is presently incomplete. The present 63 DMAs and 10 regulators valves are being completed.

Table D.50: NRW management

Item	
NRW unit/department	No
DMAs (number)	61
DMA coverage (%)	N/A
Connections per DMA	N/A
Monthly water balance in DMA	No
Assessment of apparent and real losses	No
Type of bulk meters	Mechanical
Data-transfer technology	N/A
SCADA	No

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition.

7.2.2 Performance of NRW Management in Da Lat

The rapid assessment looks into the current NRW situation of the major cities of the utilities, and the NRW performance in Da Lat is considered in this section. The reason for the focus on the major cities is that the impact and viability of a potential performance-based contracting (PBC) NRW program are maximized in a relatively densely populated and big supply area.

Table D.51 presents a summary of the performance of NRW management and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 27 percent is equivalent to 273 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.51: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	21,170,000
System input (l/conn/day)	1,012
Volume billed (l/conn/day)	739
Volume billed domestic (l/conn/day)	898
Per capita billed (l/cap/day)	199
NRW (l/conn/day)	273
NRW calculated (%)	
NRW reported in questionnaire (%)	27.0
Apparent losses	
Average age of domestic meters (years)	3
Contribution of apparent losses to NRW (%)	25
Apparent losses (% of total billed)	9

Continued…

Real losses	
Pressure in tertiary network (m)	10
Real losses (l/conn/day)	206
Real losses (L/conn/day/m)	21
Technical performance category	D

Note: NRW = nonrevenue water.

In Da Lat, the contribution of apparent losses to NRW is estimated to be 25 percent. The utility has a stringent meter management policy; every 3 years, the (relatively expensive) class C meter is calibrated or replaced. Considering the low tariff, a positive business case for this replacement policy is doubtful, and it is somewhat asymmetric in the whole process of manual meter reading and billing.

The utility reports that there is no unbilled authorized consumption, and the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is unknown. Illegal practices are an issue in Da Lat.

It can be concluded that real losses still largely contribute to the current NRW, which is 200 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[48] The technical performance of the network in Da Lat is poor (Category D; see table 2.5 for a description of the categories).

7.2.3 Management of Apparent (Commercial) Losses

Meter reading, billing, and collection are done manually. The administration consolidates readings manually. The printed bills are collected physically by a collector. The company is piloting an e-billing process (meter reading with an app and collection through banks).

Table D.52: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	Yes
Meter class	C
Average age (years)	3
Type of meter (big customers)	Mechanical
Management of customer meter	Yes
Billing	Manual
Meter reading	Manual
Internal audit of billing database	No
Collection	Manual

The utility has an active program to address unauthorized consumption (i.e., illegal practices).

48 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

7.2.4 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network in Da Lat is poor. The general approach to managing real losses is reactive, with a focus on the repair of visible leaks and pressure management. Currently, 70 percent to 80 percent of 1,500 leaks per year in the province occur in Da Lat.

True asset management is yet to be implemented. A comprehensive analysis of leaks/bursts and other historical events and other economic analyses are not carried out for policy (assessment) purposes. Distribution network data are manually recorded on drawings. The former geographical information system (GIS) application was abandoned in 2008. The present investment does not include investments for NRW management.

Table D.53: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	No
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	No
Budget for repair and minor replacements	Constrained

Note: GIS = geographical information system; Q&P = flow and pressure.

7.3 Energy Efficiency Management

7.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.779 kilowatt-hours per cubic meter. In the interview, the utility confirmed that this has been reduced from historical levels of approximately 0.9 kilowatt-hours per cubic meter through a program of investment in the replacement of older, inefficient pumps and the updating of old starters from star-delta types to soft starters or (at three plants) inverters. There has also been some historical investment in equipment for power-factor correction.

The company's strategy for energy efficiency (EE) management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- The completion of energy audits using internal staff to monitor performance against business plan targets

The company's energy-auditing approach relies on the use of internal staff from the electrical and water technical departments.

7.3.2 Performance of EE Management in Lâm Đồng

Lâm Đồng has a typical water production volume of 60,864m^3/d (from which Da Lat City 53,130 m^3/d), and a specific energy for water production of 0.779kWh/m^3, which is within the MoC cost-norm range of 0.36-0.52kWh/m^3. The high rate of energy consumption caused by the mountainous features of Lam Dong.

7.3.3 Approach to EE Management in Lâm Đồng

Lâm Đồng utilizes staff working in the central Electricity and Water Planning -Technical Departments to oversee the management of energy efficiency at its water treatment plants. Staff members from the teams work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is assessed monthly, and any discrepancies in EE performance from month to month are identified and investigated. As yet, there is no formal EE management strategy and no formal strategy or target for EE improvement.

In the interview, the company confirmed that improvements in energy efficiency rely on the ability of the Planning -Technical Departments and site operations team personnel to identify deviations in power consumption through diligent monitoring of data from the site.

Accurate power metering is available at the site level, but more detailed and accurate submetering is unavailable. In the interview, in the returned questionnaire, and during site visits, the company noted that asset-level submetering using moving-iron ammeters was widely available. The company confirmed that with the data available, it is possible to gauge when assets are deteriorating.

The company's EE audits are carried out internally on an ad hoc basis, with monitoring of energy consumption against the targets set in the business plan for each plant.

Lâm Đồng's approach to energy auditing has been graded according to the criteria in table D.54.

Table D.54: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as having reached the end of its service life
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least every five years

According to the criteria in table D.54, Lâm Đồng's energy-auditing approach achieves a grade of C.

7.3.4 Delivery of EE management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. In particular, careful tariff management is carried out to ensure that high-energy-consuming plant items are not operated during peak-tariff periods.

A site visit to the Đan Kia water treatment plant was completed with the site manager, during which it was clear that the management and operations team at the plant were experienced, highly competent, and gave regular consideration to the energy efficiency of the plant.

A partially translated copy of the Operation and Maintenance manual for the plant was provided, which demonstrated that the operations team frequently assesses the current energy consumed by large plant items against typical levels and reports or investigates deviations.

7.3.5 Delivery of EE Management (Capital)

In the interview and in the subsequent questionnaire, the company confirmed that there is not currently a capital investment budget available for EE-driven improvements, nor is there a clear strategy for the management of EE-driven capital investment.

However, a site visit to the Đan Kia WTP confirmed that EE investment had nevertheless taken place. The following investments had been delivered in 2017:

- Replacement of two power transformers
- Installation of soft starters on nine large raw and clean water pumps
- Installation of equipment for power-factor correction

The company has not yet made any investment in renewable energy technologies, and there are no current plans to do so.

During an energy audit of the Đan Kia WTP, conducted as part of the second World Bank mission, the potential to install solar photovoltaic (PV) technology at the Da Lat wastewater treatment plant was evaluated. The installation of fixed and floating solar PV equipment on the site was found to be potentially commercially viable and recommended in the audit report.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.55.

Table D.55: General approach to EE

		Lâm Đồng
General approach to EE management	Specific energy(kWh/m^3)	0.39
	WLC assessments for new equipment	No
	Asset deterioration monitoring	Yes
	Granularity of power metering	Site level
	Peak-tariff avoidance	Yes
	Asset operation	Automatic
	Distribution pressure management	Partial
	Dedicated energy management staff	Yes
	Defined energy strategy	No
	Defined EE improvement strategy	No
	Capital budget available	Yes, limited
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	Yes
	Soft starters	Yes
	Variable-speed drivers	No
	Automated control	Treatment and network (Partial)
	Renewable energy	No

Note: EE = energy efficiency; WLC = whole-life cost.

7.3.6 Wastewater Treatment

The utility manages the operation of a wastewater treatment plant serving part of the city of Da Lat.

The operational costs for the plant are refunded to the utility from the People's Committee. The plant utilizes a combination of percolating filters and anaerobic filters, a relatively low-energy treatment process compared with alternatives such as suspended growth processes.

There was a high level of automatic control at the plant, in line with modern process design standards, in contrast to the low levels of automatic control seen during site visits to water treatment works during both missions.

Sludge from the plant is composted on site. The utility confirmed that the potential to recover energy from the sludge using anaerobic digestion had been considered but that the volume of sludge available was too small to justify the installation of this type of technology.

The company confirmed that no energy audits had been completed at the plant, although an audit was completed under the scope of the second World Bank mission.

Report 8: Lạng Sơn Water Supply and Drainage Joint Stock Company

8.1 General

The Lạng Sơn Water Supply and Drainage Joint Stock Company (JSC) is 51 percent state owned. The utility manages water supply systems in Lạng Sơn city and in nine districts in the provinces of Lạng Sơn, as listed in table D.56. The capacity of the water system in the capital of Lạng Sơn province accounts for approximately 40 percent of the total installed design capacity of 51,820 cubic meters per day. The utilization rate of the production facilities is 70 percent. The boreholes were constructed 20 years ago, and the two surface water treatment plants were constructed 5 years ago. The Lạng Sơn JSC also manages urban drainage, public lighting, and some plant industry.

Table D.56: Asset Base

Service coverage (%)	25.7
Water supply systems	1. Surface water (2 WTPs): Capacty (m^3/d): 25,108
	2. Groundwater (12 boreholes): Capacity (m^3/d): 26,712
Total design capacity of water supply (m^3/d):	51,820
Total raw water volume daily (m^3/d):	36,851
Total design capacity of wastewater treatment (m^3/d):	5,260
Total treated water production daily (m^3/d):	36,577

Source: Lạng Sơn Water Supply Joint Stock Company
Note: WTP = water treatment plant;

The population served in the province amounts to 185,664, and the service coverage in the province amounts to 26 percent. The utility manages approximately 175 kilometers of mains and 48,416 connections (Lạng Sơn city = 27,000). The average age of the majority of the network in the province is less than 21 years. In Lạng Sơn city, the network was replaced 5-10 years ago.

Table D.57: Key characteristics

Average liter per capita per day (l/p/d)	130
Population served	185,664
Total number of customer connections	46,416
Density of connections (connection/km) (based on total distribution and serviced pies, 345 km, excluding transmission lines in the whole province)	135
Billed volume (m^3/year)	1,206,180
Proportion of water meters installed vs. total connections	100
Proportion of water meters replaced/repaired/checked annually	16.8
Total length of transmission pipes (diameter ≥ 300 mm) (km)	1.87
Total length of distribution pipes (diameter = 100–300 mm), excluding service pipes (km)	173.9
Total length of pipes used over 21 years (km)	0,02

The nonrevenue water (NRW) in the province and in Lạng Sơn city amounts to 37.5 percent. The water balance (i.e., NRW) is based on bulk metering at the surface water intake.

8.2 NRW Management

8.2.1 Utility's General Approach

The utility policy is to follow the NRW targets set in Prime Minister (PM) Decision 2147 TTg. At present, the company had a NRW / Network management unit. The plan of DMAs has been established, but not completed yet.

NRW management uses a reactive approach, lacking appropriate metering and monitoring infrastructure (see table D.58). The nine district metered areas (DMAs) are not yet operational. The bulk meters are read manually.

Table D.58: NRW management

Item	
NRW unit/department	No
Number of DMAs	9
DMA coverage (%)	Unknown
Connections per DMA	3,000
Monthly water balance in DMA	—
Assessment of apparent and real losses	No
Type of bulk meters	Mechanical
Data-transfer technology	—
SCADA	Pilot

Note: DMA = district metered area; NRW = nonrevenue water;
SCADA = supervisory control and data acquisition; "—" = not available.

8.2.2 Performance of NRW Management in Lạng Sơn City

The rapid assessment looks into the current NRW situation of the major cities of the utilities, and the NRW performance in Lạng Sơn city is considered in this section. The reason for the focus on the major cities is that the impact and viability of a potential performance-based contracting (PBC) NRW program are maximized in a relatively densely populated and big supply area.

Table D.59 presents a summary of the performance of NRW management and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 37.5 percent is equivalent to 298 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.59 NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m³/year)	7,838,170
System input (l/conn/day)	795
Volume billed (l/conn/day)	497
Volume billed domestic (l/conn/day)	442
Per capita billed (l/cap/day)	98
NRW (l/conn/day)	298
NRW calculated (%)	
NRW reported in questionnaire (%)	37.5
Apparent losses	
Average age of domestic meters (years)	15
Contribution of apparent losses to NRW (%)	23
Apparent losses (% of total billed)	14
Real losses	
Pressure in tertiary network (m)	13
Real losses (l/conn/day)	230
Real losses (L/conn/day/m)	18
Technical performance category	C

Note: NRW = nonrevenue water.

In Lạng Sơn city, the contribution of apparent losses to NRW is estimated to be 23 percent. The relatively old age of the domestic water meters contributes to the apparent losses (every 5 years commissioning, repair or replacement when customer requested). The utility reports that there is no unbilled authorized consumption, and the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) was not reported in the questionnaire. The utility has no program to manage Illegal practices.

It can be concluded that real losses still largely contribute to the current NRW, which is 230 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[49] The technical performance of the network in Lạng Sơn city is poor (Category C; see table 2.5 for a description of the categories), despite the average age of 5 years.

8.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meters is estimated to be 15 years. Class B meters are used. The mechanical meters of big customers are not calibrated. The age of these meters is unknown. The utility has no structured meter maintenance policy; it responds to complaints and cases of malfunctioning meters.

49 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

Table D.60: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	No
Meter class	B
Average age (years)	15
Type of meter (big customers)	Mechanical
Management of customer meter	No
Billing	Manual
Meter reading	Manual
Internal audit of billing database	No
Collection	Manual

Meter reading, billing, and collection are done manually. The administration consolidates readings manually. The printed bills are collected physically by a collector. Institutional customers use e-billing. The utility does not assess the billing data for anomalies.

8.2.4 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network in Lạng Sơn city is poor. The general approach to managing real losses is reactive, with a focus on the repair of visible leaks only and some pressure management. The pressure at a few points is monitored using supervisory control and data acquisition (SCADA). The utility recently implemented active leak detection.

Currently, 1,200 leaks occur in the network of Lạng Sơn city. In 2017, 8 kilometers of mains were replaced.

True asset management is yet to be implemented. A comprehensive analysis of leaks/bursts and other historical events and other economic analyses are not carried out for policy (assessment) purposes. Distribution network data are recorded manually on drawings. The utility is piloting a geographical information system (GIS) application in Lạng Sơn city. The present investment does not include investments for NRW management.

Table D.61: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	Pilot
Budget for repair and minor replacements	Constrained

Note: GIS = geographical information system; Q&P = flow and pressure.

8.3 Energy Efficiency Management

8.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment in whole province is 0.53kWh/m^3, in Lang Son City is 0.49 kWh/m^3. In the interview, the utility confirmed that there are no firm targets to reduce energy consumption, although there is a general desire to deliver energy efficiency (EE) where possible.

The company's energy-auditing approach relies on the use of internal staff from the maintenance department, who are responsible for monitoring the energy efficiency of the company's pumps.

8.3.2 Performance of EE Management in Lạng Sơn

Lạng Sơn has a typical water production volume of 22,800 cubic meters per day and a specific energy consumption for water production of of 0.53kWh/m^3 in whole province and 0.49 kWh/m3 in Lang Son City which is below the Ministry of Construction (MoC) cost norm of 0.43 to 0.52 kilowatt-hours per cubic meter.

8.3.3 Approach to EE Management in Lạng Sơn

Lạng Sơn utilizes staff working in the central maintenance department to oversee the management of energy efficiency at its water treatment plants. Staff members from the teams work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified.

Energy efficiency is assessed on an ad hoc basis, and any discrepancies in EE performance are identified and investigated. In the interview, the company confirmed that EE data are available only at the company level, as opposed to the site or process level, and that there is no formal auditing process.

Lạng Sơn's approach to energy auditing was graded according to the criteria in table D.62.

Table D.62: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as having reached the end of its service life
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least every five years

According to this grading, Lạng Sơn's energy-auditing approach achieves a grade of C/D.

8.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. In particular, tariff management is carried out to ensure that energy-intensive processes are not operated during peak-tariff periods at some sites, although not as part of a defined strategy.

Energy data are available only at the company level, as opposed to the site or asset level.

8.3.5 Delivery of EE Management (Capital)

In the interview, the company confirmed that there has been some relatively limited capital investment in energy efficiency, for example, the installation of inverter control on some of its pumping assets.

The company has no plans to invest in renewable energy technologies.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.63.

Table D.63: General approach to EE

		Lạng Sơn
General approach to EE management	Specific energy (kWh/m^3)	0.41
	WLC assessments for new equipment	—
	Asset deterioration monitoring	—
	Granularity of power metering	Site level, Company Level
	Peak-tariff avoidance	Partial
	Asset operation	Manual
	Distribution pressure management	Partial
	Dedicated energy management staff	No
	Defined energy strategy	No
	Defined EE improvement strategy	No
	Capital budget available	Yes, Limited
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	Network, Partial
	Renewable energy	No

Note: EE = energy efficiency; WLC = whole-life cost; "—" = not available.

Report 9: Long An Water Supply Joint Stock Company

9.1 General

The Long An Water Supply Company is a joint-stock company, of which the state owns 60 percent of the shares. The utility manages five water supply systems in the provinces of Long An, as listed in table D.64. The capacity of the water system in the capital of Long An province accounts for approximately 25 percent of the total installed design capacity of 48,000 m^3/day. The utilization rate of the production facilities is slightly over 100 percent. The water supply covers the urban, industrial, and rural water supply.

The current raw water source is groundwater, which is being depleted. The company is also investing in surface water capacity in three phases (Phase 1: 30,000 cubic meters, Phase 2: 60,000 cubic meters, Phase 3: 120,000 cubic meters).

Table D.64: Asset Base

Service coverage	Tân An city: 70% (mostly domestic water) Other areas such as Thủ Thừa, Bến Lức, Tân Trụ: supply of production water for enterprises and industrial zones	
Water supply systems	1. Tân An Water Treatment Plant	Capacity (m^3/d): 12,000
	2. Binh Anh Water Treatment Plant	Capacity (m^3/d): 15,000
	3. Gò Đền Water Treatment Plant	Capacity (m^3/d): 7,200
	4. Water supply stations at the wards of Tân An city	Capacity (m^3/d): 10,800
	5. Bảo Định surface water treatment facility	Capacity (m^3/d): 3,000
Total design capacity of water supply (m^3/d):	48,000	
Total raw water volume daily (m^3/d):	52,000	
Total design capacity of wastewater treatment (m^3/d):	—	
Total treated water production daily (m^3/d):	50,000	

Source: Data provided by Long An Water Supply JSC (EE&NRW questionnaire)
Note: — = not available.

The population served in the province amounts to 190,000, and the service coverage of the utility is 70 percent. The utility manages approximately 230 kilometers of mains and 22,230 connections. Nearly all of the network is younger than 21 years.

The company applied the World Bank's support ($1 million) to reduce nonrevenue water (NRW) in Tân An city to 21 percent in 8 months. The project consisted of the following investments:

- Rezoning the areas into 14 district metered areas (DMAs)
- Detection of leakage within the zone—500 leakages fixed
- Use of pressure-reducing valves (PRVs) to control pressure
- Installation of district meters to monitor water flows
- Replacement of 10 kilometers of severely corroded distribution pipes in small alleys.

All customers are metered. The NRW at the company level in 2017 was 15 percent.

Table D.65: Key Characteristics

Average liter per capita per day (l/p/d)	Tân An: 140
Population served	190,000
Total number of customer connections	22,230
Density of connections (connection/km)	- Tân An: 100 - Binh Anh–Gò Đền: 25
Billed volume (m^3/year)	42,500
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually (%)	2.5
Total length of transmission pipes (diameter ≥ 300 mm) (km)	40
Total length of distribution pipes (diameter = 100–300 mm), excluding service pipes (km)	230
Total length of pipes used over 21 years (km)	8 (mainly in Tân An city)

9.2 NRW Management

9.2.1 Utility's General Approach

The utility policy is to follow the NRW targets set in Prime Minister (PM) Decision 2147 TTg.

The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the technical and commercial departments in the routine NRW management activities. The approach to NRW management mainly focuses on achieving a short-term impact and can be summarized as follows:

- Pressure management[50]
- Measurement of minimum night flow to enhance leak detection
- Active leak detection
- Timely repair of reported leaks and bursts
- Improved material use

The utility has installed 14 district metered areas (DMAs) in Tân An City. The water balance (i.e., NRW and apparent and real losses) is not determined on a regular basis. A metering infrastructure is installed in Tân An city, as summarized in table D.66. The utility wants to replicate the approach and experiences in Tân An city in the other water supply systems.

Table D.66: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	14
DMA coverage (%)	100
Connections per DMA	1.250
Monthly water balance in DMA	Yes

50 Inducing very low pressure at the fringes of the network.

Assessment of apparent and real losses	No
Type of bulk meters	E/M
Data-transfer technology	AMR
SCADA	Yes

Source: Data provided by Long An Water Supply and Sewerage JSC (EE&NRW questionnaire)
Note: AMR = automated meter reading; DMA = district metered area; E/M = electrical and magnetic; NRW = nonrevenue water; SCADA = supervisory control and data acquisition.

9.2.2 Performance of NRW Management in Tân An City

The rapid assessment looks into the current NRW situation of the major cities of the utilities, and the NRW performance in Long An city is considered in this section. The reason for the focus on the major cities is that the impact and viability of a potential performance-based contracting (PBC) NRW program are maximized in a relatively densely populated and big supply area.

Table D.67 presents a summary of the performance of NRW management in Long An city and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 21.2 percent is equivalent to 276 L/connection/day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.67: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	8,322,000
System input (l/conn/day)	1,303
Volume billed (l/conn/day)	1,027
Volume billed domestic (l/conn/day)	865
Per capita billed (l/cap/day)	192
NRW (l/conn/day)	276
NRW calculated (%)	
NRW reported in questionnaire (%)	21.2
Apparent losses	
Average age of domestic meters (years)	9
Contribution of apparent losses to NRW (%)	36
Apparent losses (% of total billed)	10
Real losses	
Pressure in tertiary network (m)	7.5
Real losses (l/conn/day)	176
Real losses (l/conn/day/m)	23
Technical performance category	D

Note: NRW = nonrevenue water.

In Tân An city, the contribution of apparent losses to NRW is estimated to be 36 percent. The relatively old age of the domestic water meters contributes considerably to the apparent losses. The utility reports that there is no unbilled authorized consumption, and the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is estimated by the utility to be between 2 and 3 percent of the water production. Illegal practices are marginally present.

It can be concluded that real losses still largely contribute to the current NRW, which is 176 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[51] The technical performance of the network in Long An city is poor (Category D; see table 2.5 for a description of the categories).

9.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meters is estimated to be 15 years. That of the big customers is unknown. Class B domestic water meters are used. The utility has no structured meter maintenance policy.

Meter reading and billing are automated, using handhelds, allowing a reading error margin of 30 percent. The billing software and server are managed by the utility. Collection is still carried out manually.

The utility has the ambition to replace the current mechanical domestic water meters with electrical and magnetic (E/M) water meters and implement automated meter reading (AMR) technology.

Table D.68: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	No
Meter class	B
Average age (years)	9
Type of meter (big customers)	E/M
Management of customer meter	No
Billing	Automated
Meter reading	Handheld
Internal audit of billing database	No
Collection	Manual

Note: E/M = electrical and magnetic.

The utility has an active program to address unauthorized consumption (i.e., illegal practices).

9.2.4 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the relatively young network is poor. Important causes mentioned by the management of the utility are as follows:

- Deteriorated tertiary mains in many alleys
- Poor workmanship of contractors and project developers

51 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

Table D.69: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	No
Budget for repair and minor replacements	Constrained

Note: GIS = geographical information system; Q&P = flow and pressure.

True asset management is still in its infant stage. A comprehensive analysis of leaks/bursts and other historical events and other economic analyses are not carried out for policy (assessment) purposes. Distribution network data are recorded manually on drawings. The utility is starting to implement BGIS software. The replacement policy is budget driven, which is a constraint.

9.3 Energy Efficiency Management

9.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.41 kilowatt-hours per cubic meter. In order to manage its energy efficiency, the utility has established a centralized Energy Control Board, with four members, which is responsible for overseeing energy efficiency (EE) at a company level.

The company's strategy for EE management is based on the following key concepts:

- The setting of internal energy consumption targets
- The completion of energy audits using a combination of internal staff and external experts to monitor performance against business plan targets

The Energy Control Board monitors energy consumption for each water treatment plant on a monthly basis and is responsible both for ensuring that any unusual trends are investigated and also for managing the delivery of any EE-driven capital investment.

9.3.2 Performance of EE Management in Long An

Long An has a typical water production volume of 22,800 m^3/d and a specific energy for water production of 0.41 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.43-0.5 kilowatt-hours per cubic meter.

9.3.3 Approach to EE Management in Long An

Long An's EE management is driven centrally by a defined Energy Control Board, comprising four members, with a mandate to manage all EE issues. Staff from the board work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is assessed monthly, and any discrepancies in EE performance from month to month are identified and investigated.

Energy business plans are developed annually, and although there is a general desire to improve energy efficiency year on year, no firm targets for energy consumption have been confirmed by the company. Energy budgets are approved annually at a meeting of the shareholders.

Accurate power metering is available at the site level, but more detailed and accurate submetering is unavailable. However, in the interview and in the returned questionnaire, the company confirmed that with the data available and with the use of independent experts and temporary equipment where required, it is possible to gauge when assets are deteriorating.

The company's EE audits are carried out using a mixture of internal and external staff, and the audit process is to complete a thorough review of the energy efficiency of the plant at the site, process, and asset levels. The audits are currently carried out on an ad hoc basis, although EE data are reviewed monthly.

Long An's approach to energy auditing was graded according to the criteria in table D.70.

Table D.70: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to these criteria, Long An's energy-auditing approach achieves a grade of A/B.

9.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. Predominantly, this includes tariff management to ensure that energy-intensive processes are not operated during peak-tariff periods.

Operations teams also report EE data back to the Energy Control Board on a monthly basis and are required to report and investigate any deviations in energy consumption to the board.

9.3.5 Delivery of EE Management (Capital)

In the interview, the company confirmed that there are a significant number of aging mechanical and electrical assets, specifically pumps, in service and that this is a key concern for the company and a source of inefficiency. The Energy Management Board has been responsible for the delivery of a range of EE- driven capital investment measures, with the following areas of focus:

- A program for the replacement of old raw and clean water pumps at water treatment plants
- A program for the installation of inverter drives for pumps at several water treatment plants, reducing power consumption by 20 percent

The company has piloted the use of solar photovoltaic (PV) technology at the Lợi Bình Nhơn water treatment works, with a total capacity of 22 kilowatts, reducing the energy costs for the plant by 40 percent.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.71.

Table D.71: General approach to EE

		Long An
General approach to EE management	Specific energy(kWh/m^3)	0.41
	WLC assessments for new equipment	Yes
	Asset deterioration monitoring	Yes
	Granularity of power metering	Site level
	Peak-tariff avoidance	Yes
	Asset operation	Automatic
	Distribution pressure management	Partial
	Dedicated energy management staff	Yes
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	—
	Renewable energy	Investment made

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 10: Ninh Bình Water Supply Joint Stock Company

10.1 General

The Ninh Bình utility is a joint-stock company. Not enough quantitative data were provided to allow for a general overview of the water supply system.

10.2 Nonrevenue Water Management

10.2.1 Utility's General Approach

The current nonrevenue water (NRW) level is approximately 40%. In 2013, the NRW in Ninh Binh was 53%.

With the support of the WB project, the NRW has been reduced to 33% within two months. However, as they improved the water pressure, the NRW returns to 38% and now 40%. The utility's NRW targets are compliant with the targets set in Prime Minister (PM) Decision 2147 TTg. The utility's target for 2020 is a reduction of NRW to 18 percent.

The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the technical and commercial departments in the routine NRW management activities. The approach to NRW management mainly focuses on the following areas:

- Pressure management
- Active leak detection
- Timely repair of reported leaks and bursts

Table D.72: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	—
DMA coverage%	—
Connections per DMA	—
Monthly water balance in DMA	—
Assessment of apparent and real losses	No
Type of bulk meters	Mechanical and E/M
Data-transfer technology	—
SCADA	Yes

Note: DMA = district metered area; E/M = electrical and magnetic; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

10.2.2 Performance of NRW Management in Ninh Bình

No quantitative data were provided to allow for an assessment of NRW management.

10.2.3 Management of Apparent (Commercial) Losses

Meter reading, billing, and collection are done manually. Currently, the company is using client management software; it is planned that the company will upgrade and invest in new software based on a geographical information system (GIS).

The utility reports that the annual volume of unbilled metered and unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is not known. The utility does have a procedure to detect and handle illegal practices.

Table D.73: Commercial management practices

Item	
Meter coverage (%)	—
Management of customer meter	Yes
Meter class	—
Average age (years)	—
Type of meter (big customers)	Mechanical and E/M
Billing	Manual
Meter reading	Manual
Internal audit of billing database	—
Collection	Manual

Note: E/M = electrical and magnetic; — = not available.

10.2.4 Management of Real (Physical) Losses

The general approach to managing real losses is to detect and repair leaks, both visible and invisible leaks. The utility has also implemented pressure-management programs. The utility reports that it carries out economic analysis to determine the economic level of leakage. Renewal programs for pipelines and costs are incorporated in the financial plans.

Table D.74: Real loss management practices

Item	
Pressure management	Yes/Partial
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	Yes
Comprehensive analysis of bursts and historical events	No
GIS	Yes
Budget for repair and minor replacements	—

Note: GIS = geographical information system; Q&P = flow and pressure; — = not available.

10.3 Energy Efficiency Management

10.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.27 kilowatt-hours per cubic meter. In the interview, the utility confirmed that the annual targets for energy consumption are based on the company business plan (i.e., on previous performance) and that there are no firm targets to reduce energy consumption, although there is a general strategy to deliver energy efficiency (EE) where possible.

The company's strategy for EE management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- The completion of quarterly assessments using internal staff to monitor EE performance against business plan targets

The company does not have a formal energy-auditing approach but does carry out quarterly assessments of energy consumption and ad hoc reviews of the EE performance of specific plant items using internal staff members.

10.3.2 Performance of EE Management in Ninh Bình

Ninh Bình has a typical water production volume of 33,000 cubic meters per day and a specific energy consumption for water production of 0.27 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.5 to 0.58 kilowatt-hours per cubic meter.

10.3.3 Approach to EE Management in Ninh Bình

Ninh Bình utilizes operations staff to oversee the management of energy efficiency at its water treatment plants. These staff members are required to identify any opportunities to improve energy efficiency.

Energy efficiency is assessed by the central management team on a quarterly basis, and any discrepancies in EE performance from quarter to quarter are identified and investigated. Energy business plans are developed annually, and although there is a general desire to improve energy efficiency, and some capital investment work has been completed to deliver this, no firm targets for energy consumption have been set.

In the interview, the company confirmed that improvements in energy efficiency rely on the ability of the site operations team personnel to identify deviations in power consumption through diligent monitoring of data from the site. Accurate power metering is available at the site level, but more detailed and accurate submetering is unavailable.

The company has not yet completed any EE audits, although it has completed internal cost checking to understand its energy efficiency.

Ninh Bình's approach to energy auditing was graded according to the criteria in table D.75.

Table D.75: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to the criteria in table D.75, Ninh Bình's energy-auditing approach achieves a grade of D.

10.3.4 Delivery of EE Management (Operational)

The company has completed some work to ensure that good operational practices are implemented at its sites, as far as possible. In particular, there has been a significant focus on tariff management, with energy-intensive processes being turned off during peak-tariff periods wherever possible. There are also energy consumption norms for each site, and the performance of the sites against these norms is measured and reported.

10.3.5 Delivery of EE Management (Capital)

The company identified the use of old and life-expired mechanical and electrical assets on-site as a key challenge for energy efficiency. Many of the pumps in service were installed prior to 2002 and are now approaching the end of their asset lives.

The company has completed some work to estimate the capital investment required to replace all of the life-expired mechanical and electrical assets, and the required investment is approximately 20 billion Vietnamese dong (~$865,000). To date, limited capital investment work has been completed, with two obsolete pumps at Ninh Bình water treatment works (WTW) being replaced under a capital investment scheme funded by the World Bank. The company has not made any investment in renewable energy technologies and currently has no plans to do so.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.76.

Table D.76: General approach to EE

		Ninh Bình
General approach to EE management	Specific energy(kWh/m^3)	0.32
	WLC assessments for new equipment	Yes
	Asset deterioration monitoring	Partial
	Granularity of power metering	Site level
	Peak-tariff avoidance	Yes
	Asset operation	Manual
	Distribution pressure management	Yes
	Dedicated energy management staff	No
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes, limited
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	Network
	Renewable energy	No

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 11: Phú Tho Water Supply Joint Stock Company

11.1 General

The Phú Tho utility is a joint-stock company, of which the state owns part of the shares. The utility manages 10 water supply systems in the provinces of Phú Tho, as listed in table D.77. The capacity of the water system in Việt Trì accounts for approximately 50 percent of the total installed design capacity of 119,200 cubic meters per day. The utilization rate of the production facilities is 60 percent. The raw water source is surface water.

The utility is responsible for the operation of two wastewater treatment plants, although these have not yet been commissioned, and flows have not been connected.

Table D.77: Asset Base

Service coverage (%)	90		
Water supply systems and their capacity (m^3/d):	1	Việt Trì WSS: 60,000	2. Phù Ninh WSS: 10,000
	3	Phú Thọ town WSS: 10,000	4. Cẩm Khê WSS: 6,000
	5	Thanh Thủy WSS: 16,000	6. Thanh Sơn WSS: 3,000
	7	Hạ Hòa WSS: 3,000	8. Trung Nghĩa WSS: 7,200
	9	Tân Sơn WSS: 1,500	10. Yên Lập WSS: 2,500
Total design capacity of water supply (m^3/d):	119,200		
Pumped supply (% of total):	100		
Gravity supply (% of total):	0		
Supply time (hr/day):	24		
Average supply pressure in water supply system (in DMA) (m)	1. 30	2. 40	
	3. 50	4. 20	
	5. 35	6. 45	
	7. 29	8. 12 (at the endpoint)	
Total raw water volume daily (m^3/d):	—		
Total treated water production daily (m3/d):	69,840		

Note: DMA = district metered area; WSS = water supply system; — = not available.

The population served in the province amounts to 769,045, and the service coverage of the utility is 90 percent. The utility manages approximately 458 kilometers of mains and 126,528 connections. The age of the complete network is younger than 21 years. All customers are metered. The nonrevenue water (NRW) at the company level in 2017 was reported to be 18 percent.

Table D.78: Key Characteristics

Average liter per capita per day (l/p/d)	53
Population served (number)	769,045
Total number of customer connections	126,528 58,563 1,174
Number of new connections per year, made by water company	115,849
Number of new connections per year, made by project/real estate developer	8,677
Number of other connections	2,002
Density of connections (connection/km)	—

Billed volume (m^3/year)	21,704,008	
Billed volume of domestic customers (m^3/year)	14,829,204 14,504,963 8,924,588	
Proportion of water meters installed vs. total connections (%)	100	
Proportion of water meters replaced/repaired/checked annually (%)	20	
Average age of domestic water meters	5 years	
Type of domestic water meters, velocity or volumetric meters	volumetric	
Brand or country of origin of domestic water meters	French	Quantity: 68,509
	Malaysia	Quantity: 41,093
	Turkey	Quantity: 2,007
	Thai	Quantity: 2,804
	Germany	Quantity: 5,522
	Italy	Quantity: 2,977
	South Korea	Quantity: 1,216
	Other	Quantity: 2,400
Total length of transmission pipes (diameter ≥ 300 mm) (km)	56.4	
Total length of distribution pipes (diameter = 63–300 mm), excluding service pipes (km)	401.4	
Total length of distribution pipes constructed by project/real estate developers (km)	457.8	
Total length of pipes used over 21 years (km)	0	

11.2 Nonrevenue Water Management

11.2.1 Utility's General Approach

The current NRW level is approximately 18 percent, which is lower than the 2015 national target. Based on the available data on the volumes distributed and billed, the NRW level of 14.9 percent was calculated. The utility's NRW targets are much more stringent than targets set in Prime Minister (PM) Decision 2147 TTg. The utility's targets are as follows:

- 2017–2021: reduction of NRW to 10 percent
- 2021–2025: reduction of NRW to below 10 percent and sustainable maintenance of the proportion

The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the technical and commercial departments in the routine NRW management activities. The approach to NRW management mainly focuses on the following areas:

- Pressure management
- Active leak detection
- Timely repair of reported leaks and bursts
- Improved material use
- Improved customer service

The utility has installed 100 district metered areas (DMAs), which cover 60 percent of the network. The utility determines the water balance in the DMAs on a regular basis (i.e., assessment of NRW). It is unknown whether apparent and real losses are analyzed.

Table D.79: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	100
DMA coverage%	60
Connections per DMA	1.265
Monthly water balance in DMA	Yes
Assessment of apparent and real losses	No
Type of bulk meters	E/M
Data-transfer technology	—
SCADA	Yes

Note: DMA = district metered area; E/M = electrical and magnetic; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

11.2.2 Performance of NRW Management

Table D.80 presents a summary of the performance of NRW management and the estimated distribution between real and apparent losses. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. Based on data provided, the calculated NRW is 14.9 percent, which is higher than the reported NRW level of 18 percent. The calculated NRW is equivalent to 99 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.80: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	25,491,600
System input (l/conn/day)	552
Volume billed (l/conn/day)	470
Volume billed domestic (l/conn/day)	344
Per capita billed (l/cap/day)	76
NRW (l/conn/day)	99
NRW calculated (%)	14.9
NRW reported in questionnaire (%)	18.0
Apparent losses	
Average age of domestic meters (years)	5
Contribution of apparent losses to NRW (%)	34
Apparent losses (% of total billed)	6

Real losses	
Pressure in tertiary network (m)	25
Real losses (l/conn/day)	66
Real losses (L/conn/day/m)	3
Technical performance category	A

Note: NRW = nonrevenue water.

The contribution of apparent losses to NRW is estimated to be 34 percent, which is normal considering the low NRW level. With the information available at this stage, the average age of domestic meter is estimated to be 5 years.

The utility reports that there is no annual volume of unbilled metered consumption. The annual volume of unbilled unmetered consumption reported (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is not included in the NRW calculation. The utility does have a procedure to detect and handle illegal practices.

It can be concluded that real losses contribute marginally to the current NRW, which is 66 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[52] The technical performance of the network in Phú Tho is good (Category A; see table 2.5 for a description of the categories). Further reduction efforts are only needed if there is a shortage of water.

11.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meters is estimated to be 5 years. Most likely, class B meters are used. The utility uses electrical and magnetic (E/M) meters for the big customers. The technology used to transfer data is not clear. The utility has implemented a structured meter maintenance policy.

Table D.81: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	Yes
Meter class	B
Average age (years)	5
Type of meter (big customers)	E/M
Management of customer meter	Yes
Billing	Manual
Meter reading	Smart phone
Internal audit of billing database	No
Collection	—

Note: E/M = electrical and magnetic; — = not available.

The meter reading and billing process is automated. It is unknown if e-billing for domestic customers is implemented.

52 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

11.2.4. Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network in Phú Tho is good. The general approach to managing real losses is to detect and repair leaks, both visible and invisible leaks. The utility has also implemented pressure-management programs.

The utility has implemented an asset management plan. It is unclear if this plan is incorporated in the financial plan. Details are not available, such as whether comprehensive analysis of leaks/bursts and other historical events or other economic analyses are carried out for policy (assessment) purposes. Assets are recorded in excel spreadsheet.

Table D.82: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	No
Budget for repair and minor replacements	—

Note: GIS = geographical information system; Q&P = flow and pressure.

11.3 Energy Efficiency Management

11.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.41 kilowatt-hours per cubic meter. In the interview, the utility confirmed that the specific energy consumption for some plants has been reduced to 0.33 kilowatt-hours per cubic meter, with the highest energy consumption for any of the plants being 0.47 kilowatt-hours per cubic meter.

The company's formal strategy for energy efficiency (EE) management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- The completion of energy audits using internal staff to monitor performance against business plan targets
- The completion of energy audits using external expertise in the future

The internal audits are completed regularly, but there is no defined frequency. An EE audit was completed by an external third part in 2017; however, the utility found that the quality of the audit was insufficient, and no further work was completed. The company plans to develop a detailed program for further third-party audits in the future.

10.3.2. Performance of EE Management in Phú Tho

Phú Tho has a typical water production volume of 62,100 cubic meters per day and a specific energy consumption for water production of 0.41 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.43 to 0.52 kilowatt-hours per cubic meter.

11.3.3 Approach to EE Management in Phú Tho

Phú Tho utilizes staff working in the central offices to oversee the management of energy efficiency at its water treatment plants. Dedicated staff work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams. Energy efficiency is audited internally on an ad hoc basis, and any discrepancies in EE performance are identified and investigated.

In 2017 the utility commissioned an independent third party to complete an EE audit at one of its plants. However, the company was dissatisfied with the quality of the audit and plans to commission a new program of third-party audits.

In the interview, the company confirmed that improvements in energy efficiency rely on the ability of the site operations team personnel to identify deviations in power consumption through diligent monitoring of data from the site. The utility also confirmed that there has been a significant internal focus on improving energy efficiency since (approximately) 2015. Accurate power metering is available at the site level, with basic moving-iron Motor Control Center or asset-level submeters available on-site.

Phú Tho's approach to energy auditing was graded according to the criteria in table D.83.

Table D.83: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to the criteria in table D.83, Phú Tho's energy-auditing approach achieves a grade of C.

11.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. For example, there is a program for tariff management to ensure that major energy-consuming assets are not operated during peak-tariff periods.

Plant control was reported to be almost entirely manual, therefore relying on the expertise of the site operations personnel to maintain the energy efficiency of the plant. In the interview, the utility expressed a desire to invest in improved process automation in the future, although no investment had yet been made.

Following the interview with the company, a brief site visit to the Việt Trì water treatment plant was completed. The plant was observed to be well operated, but it relies on the diligence of the operations team to ensure that the plant operates in an energy-efficient manner. Very little automation was in use.

11.3.5 Delivery of EE Management (Capital)

In the interview, the company confirmed that some capital funding is available for any EE measures that are identified, although the availability of capital was recognized as a potential limiting factor in future investment. The company confirmed that although no company-wide EE strategy exists yet, some ad hoc EE-driven investments had been delivered. For example, two service reservoirs of 2,000 cubic meters were constructed in the cities of Phú Tho and Phú Ninh to allow tariff management to take place. The company also confirmed that an investment in variable-speed drives for large pumps had also been made, although no details were provided.

Following the interview with the company, a brief site visit to the Việt Trì water treatment plant was completed. The raw water pumping station had been reconstructed to allow continued abstraction from the adjacent Lo River, the level of which had fallen significantly following the construction of the original raw water pumping station. At the clear water pumping station, three of the five pumps had been retrofitted with variable-speed drives, which had allowed the plant to significantly reduce its energy consumption.

The company has not yet made any investments in renewable energy technologies and currently has no plans to do so.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.84.

Table D.84: General approach to EE

		Phú Tho
General approach to EE management	Specific energy(kWh/m^3)	0.35
	WLC assessments for new equipment	Yes
	Asset deterioration monitoring	Yes
	Granularity of power metering	Process level
	Peak-tariff avoidance	Yes
	Asset operation	Automatic
	Distribution pressure management	Yes
	Dedicated energy management staff	Yes
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	—
	Soft starters	Yes
	Variable-speed drivers	Yes
	Automated control	Treatment and network
	Renewable energy	Investment planned

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

11.3.6 Wastewater Treatment

The utility manages the operation of two wastewater treatment plants, constructed around 2017 and not yet commissioned due to the lack of connection to the mains-drainage scheme required to allow the plants to receive flows. The reason for this lack of connection is a shortfall in capital funding for the scheme to construct the mains-drainage assets associated with the plants.

One plant was briefly visited during the course of the mission. The plant utilizes conventional activated sludge reactors, which is a relatively energy-intensive treatment process compared with alternatives such as fixed film processes.

There appeared to be a high level of automatic control at the plant, in line with modern process design standards, in contrast to the low levels of automatic control seen during site visits to water treatment works during both missions.

The operational costs for the plants will be refunded to the utility from the People's Committee. The utility collects a 10 percent "environmental protection tax," which is a tariff on the water bill, on behalf of the People's Committee. This tax is not specifically to cover the operational costs of the wastewater treatment plant, which are accounted for separately.

Report 12: Quảng Nam Water Supply and Drainage Joint Stock Company

12.1. General

The Quảng Nam Water Supply and Drainage Joint Stock Company (JSC) is 100 percent privately owned. The utility manages eight water supply systems in the provinces of Quảng Nam, as listed in table D.85. The capacity of the water system in the capital of Quảng Nam province, Tam Kỳ, accounts for approximately 60 percent of the total installed design capacity of 57,500 cubic meters per day. The water supply covers the urban, commercial, and rural water supply. The tourism industry is well developed in Hội An.

The actual production (65,000 cubic meters per day) exceeds the design capacity. Future expansion in Hội An (an additional 10,000 cubic meters per day) is planned, and three treatment plants in Dien Nan, Điện Ngọc, and Núi Thành are being constructed (total = 30,000 cubic meters per day). By 2019 the total capacity will reach 100,000 cubic meters per day. The current raw water source is surface water.

The utility is not responsible for wastewater management. The Quảng Nam JSC is also active in the hotel, food, and trade sector and real estate and infrastructure development.

Table D.85: Asset Base

Plant	Capacity(m³/d)
1. Tam Kỳ Water Treatment Plant	35,000
2. Duy Xuyên Water Treatment Plant	3,000
3. Núi Thành Water Treatment Plant	8,000
4. Dien Ban Water Treatment Plant	4,500
5. Hội An Water Treatment Plant	21,000
6. Kham Duc Water Treatment Plant	2,000
7. Thăng Bình Water Treatment Plant	3,500
8. Nam Giang Water Treatment Plant	1,000
9. Phú Ninh Water Treatment Plant	1,000
Total design capacity of water supply (m³/d):	57,500
Total raw water volume daily (m³/d):	65,000
Total design capacity of wastewater treatment (m³/d): —	
Total treated water production daily (m³/d): —	

Source: Data provided by Quảng Nam Water Supply and Drainage JSC (EE&NRW questionnaire)
Note: — = not available.

The population served in the province is 280,000, and the service coverage in the province is 62 percent. The utility manages approximately 991 kilometers of mains and 55,621 connections (Tam Kỳ = 19,081). The average age of the majority of the network in Tam Kỳ is less than 21 years. In 1997 the network was completely replaced, and in 2014 the network was substantially extended.

Table D.86: Key Characteristics

Average liter per capita per day (l/p/d)	120
Population served	280,000
Total number of customer connections	55,621
Density of connections (connection/km)	—
Billed volume (m³/year)	1,206,180
Proportion of water meters installed vs. total connections (%)	100

Proportion of water meters replaced/repaired/checked annually (%)	25
Total length of transmission pipes (diameter ≥ 300 mm) (km)	450
Total length of distribution pipes (diameter = 100–300 mm), excluding service pipes (km)	541
Total length of pipes used over 21 years (km)	46

12.2 Nonrevenue Water Management

12.2.1 Utility's General Approach

The utility's policy is to follow the NRW targets set in Prime Minister (PM) Decision 2147 TTg. At present, the company does not have an NRW unit or department or an NRW management plan. NRW management uses a reactive approach, lacking an appropriate metering and monitoring infrastructure (see table D.87). The bulk meters are read manually.

Table D.87: NRW management

Item	
NRW unit/department	No
Number of DMAs	0
DMA coverage (%)	0
Connections per DMA	—
Monthly water balance in DMA	—
Assessment of apparent and real losses	No
Type of bulk meters	Mechanical
Data-transfer technology	Manual
SCADA	No

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

12.2.2 Performance of NRW Management in Tam Kỳ

The rapid assessment looks into the current NRW situation of the major cities of the utilities, and the NRW performance in Tam Kỳ is considered in this section. The reason for the focus on the major cities is that the impact and viability of a potential performance-based contracting (PBC) NRW program are maximized in a relatively densely populated and big supply area.

Table D.88 presents a summary of the performance of NRW management in Tam Kỳ. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 22 percent is equivalent to 229 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.88: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	7,264,939
System input (l/conn/day)	1,043
Volume billed (l/conn/day)	814
Volume billed domestic (l/conn/day)	514
Per capita billed (l/cap/day)	114
NRW (l/conn/day)	229
NRW calculated (%)	
NRW reported in questionnaire (%)	22.0
Apparent losses	
Average age of domestic meters (years)	8
Contribution of apparent losses to NRW (%)	36
Apparent losses (% of total billed)	10
Real losses	
Pressure in tertiary network (m)	13
Real losses (l/conn/day)	146
Real losses (l/conn/day/m)	12
Technical performance category	C

In Tam Kỳ city, the contribution of apparent losses to NRW is estimated to be 36 percent. The relatively old age of the domestic water meters contributes to the apparent losses. The utility reports that there is no unbilled authorized consumption, and the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) was not reported on the questionnaire, nor was the presence or management of illegal practices.

It can be concluded that real losses still largely contribute to the current NRW, which is 146 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[53] The technical performance of the network in Tam Kỳ city is poor (Category C; see table 2.5 for a description of the categories).

12.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meter is estimated to be 8 years. The mechanical meters of big customers are not calibrated. Class B meter are used. The utility has no structured meter maintenance policy.

Table D.89: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	No
Meter class	B
Average age (years)	8
Type of meter (big customers)	Mechanical

53 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

Management of customer meter	No
Billing	Manual
Meter reading	Manual
Internal audit of billing database	No
Collection	Manual

Meter reading, billing, and collection are done manually. The administration consolidates readings manually. The printed bills are collected physically by a collector. The company is piloting an e-billing process (meter reading with an app and collection through banks); 75 percent of customers in the business center of Tam Kỳ pay through banks.

12.2.4 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network in Tam Kỳ is poor; see also table D.90. The general approach to managing real losses is reactive, with a focus on the repair of visible leaks only. Currently, 1,500 leaks occur in the network of Tam Kỳ.

True asset management is yet to be implemented. A comprehensive analysis of leaks/bursts and other historical events and other economic analyses are not carried out for policy (assessment) purposes. Distribution network data are recorded manually on drawings. The former geographical information system (GIS) application was abandoned in 2008. The present investment does not include investments for nonrevenue water (NRW) management.

Table D.90: Real loss management practices

Item	
Pressure management	No
Hydraulic model for Q&P management	No
Active leak control	No
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	No

Note: GIS = geographical information system; Q&P = flow and pressure.

12.3 Energy Efficiency Management

12.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.29 kilowatt-hours per cubic meter. The company's strategy for energy efficiency (EE) management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- The completion of energy audits using internal staff to monitor performance against business plan targets

The internal audits are completed regularly. There is no defined frequency, but reviews are completed approximately monthly. The company plans to develop a detailed program for further third-party audits in the future; however, this has not yet been completed.

During the interview, it was apparent that energy efficiency is currently a relatively low priority in Quảng Nam.

12.3.2 Performance of EE Management in Quảng Nam

Quảng Nam has a typical water production volume of 19,904 cubic meters per day and a specific energy for water production of 0.29 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.43 to 0.63 kilowatt-hours per cubic meter.

12.3.3 Approach to EE Management in Quảng Nam

Quảng Nam utilizes staff working in the central offices to oversee the management of energy efficiency at its water treatment plants. Staff work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is audited internally on an ad hoc basis, and any discrepancies in EE performance are identified and investigated. This process is generally carried out monthly. The company plans to organize a program of third-party audits in the future; however, no work has been completed on this yet. Quảng Nam's approach to energy auditing was graded according to the criteria in table D.91.

Table D.91: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to this grading, Quảng Nam's energy-auditing approach achieves a grade of C.

12.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. Some work to carry out tariff management, to ensure that major energy-consuming assets are not operated during peak-tariff periods, has been completed in a localized (as opposed to strategic) fashion. The company plans to develop a strategy for tariff management in the future.

12.3.5 Delivery of EE Management (Capital)

During the interview, the company confirmed that some EE-driven capital investment has been completed, with all of the pumps in the utility's water treatment and distribution systems being equipped with variable-speed drives.

The company has not yet made any investment in renewable energy technologies. There are plans to install a turbine for energy recovery in the future; however, no work has yet been completed. The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.92.

Table D.92: General approach to EE

		Quảng Nam
General approach to EE management	Specific energy(kWh/m^3)	0.29
	WLC assessments for new equipment	—
	Asset deterioration monitoring	—
	Granularity of power metering	—
	Peak-tariff avoidance	—
	Asset operation	—
	Distribution pressure management	—
	Dedicated energy management staff	No
	Defined energy strategy	—
	Defined EE improvement strategy	—
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	—
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	—
	Renewable energy	Investment planned

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 13: Saigon Water Supply Corporation (SAWACO)

13.1 General

The Saigon Water Supply Corporation (SAWACO), a joint-stock company (JSC), manages the water supply in Hoc Chi Minh City (HCMC). SAWACO is a state-owned JSC and is a holding company of 6 subsidiaries—the distribution JSCs in all districts of HCMC, two branches, the water production and transmission enterprise.

SAWACO provided limited information and the information for Gia Định which was requested was not provided separately.

Table D.93: Asset Base

Service coverage (%)	100
Total design capacity of water supply (m^3/d):	—
Pumped supply (% of total):	—
Gravity supply (% of total):	—
Supply time (hrs/day):	24
Average supply pressure in water supply system (in DMA):	—
Total raw water volume daily (m^3/d):	—
Total treated water production daily (m^3/d):	—

Note: DMA = district metered area; — = not available.

The number of households served in the province is 1,523,377, and the service coverage of the utility is 100 percent. The utility manages approximately 7,800 kilometers of mains and 1,378,023 connections. Nearly all of the network (92 percent) has an age of younger than 21 years.

Table D.94: Key Characteristics

Supply, average liter per capita per day (l/p/d, 2017)	144
Population served (households)	1,988,000
Total number of customer connections (in billing system by the end of 2017) Total connections in biggest WSS - Chợ Lớn WSS JSC - Trung An WSS JSC Domestic connections in biggest WSS: - Chợ Lớn WSS - Trung An WSS	1,378,023 275,947 308,781 185,172 212,285
Number of new connections per year, made by water company	—
Number of new connections per year, made by project/real estate developer	—
Number of other connections	263,782
Density of connections (connection/km)	—
Billed volume (m^3/year)	—

Billed volume of domestic customers, 2017 data (m³/year): Total billed volume in biggest WSS (m³/year): - Chợ Lớn WSS - Trung An WSS Billed volume of domestic customers in biggest WSS (m³/year): - Chợ Lớn WSS - Trung An WSS	343,649,437 96,351,685 47,614,829 67,537,685 44,564,875	
Proportion of water meters installed vs. total connections (%)	100	
Proportion of water meters replaced/repaired/checked annually (%, 2017)	17.73	
Average age of domestic water meters (Years)	5	
Type of domestic water meters, velocity or volumetric meters	Volumetric and velocity	
Brand and country of origin of domestic water meters	G. Kent	Quantity: —
	Actaris	Quantity: —
	Others	Quantity: —
Total length of transmission pipes (diameter ≥ 300 mm) (km)	600	
Total length of distribution pipes (diameter = 63–300 mm), excluding service pipes (km)	7,184	
Total length of distribution pipes constructed by project/real estate developers (km)		
Total length of pipes used over 21 years (km)	559	

Note: JSC – joint-stock company; WSS = water supply station; — = not available.

13.2 Nonrevenue Water Management

13.2.1 Utility's General Approach

The utility has developed and issued a plan for nonrevenue water (NRW) reduction from 2015 to 2020 (Plan No. 2348/ĐA-TCT-KTCN, dated November 5, 2016), which is used to provide direction for the operation and a roadmap for the NRW reduction of the corporation. The utility is now developing a plan for NRW reduction for 2018–2022 that aims to reduce the NRW proportion to 18.5 percent by 2022.

The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the technical and commercial departments in the routine NRW management activities. The approach to NRW management mainly focuses on the following areas:

- Management: institutional and capacity strengthening
- Techniques: visible and invisible NRW reduction
- Communications: social mobilization
- Finance

The utility has installed 200 district metered areas (DMAs), which cover 100 percent of the network. It is unknown if the utility determines the water balance in the DMAs on a regular basis (i.e., assessment of NRW and apparent and real losses).

Table D.95: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	600
DMA coverage%	—
Connections per DMA	2.297
Monthly water balance in DMA	No
Assessment of apparent and real losses	No
Type of bulk meters	—
Data-transfer technology	Data loggers
SCADA	Yes

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

13.2.2 Performance of NRW Management

Table D.96 presents a summary of the performance of NRW management and the estimated distribution between real and apparent losses at the holding level. The levels of NRW and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The reported NRW level is 23 percent, which is equivalent to 206 liters per connection per day.

The system input of 890 liters per connection per day is calculated on the basis of the total volume billed and the reported NRW of 23.2 percent. The calculated system input of SAWACO is substantially lower than those of Bình Dương and Cần Thơ.

The volume of nondomestic water billed accounts for 30 percent of the total billed. The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight into the distribution between these two NRW components gives a firm indication of how well the utility is performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.96: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	447,460,204
System input (l/conn/day)	890
Volume billed (l/conn/day)	683
Volume billed domestic (l/conn/day)	715
Per capita billed (l/cap/day)	159
NRW (l/conn/day)	206
NRW calculated (%)	
NRW reported in questionnaire (%)	23.2
Apparent losses	
Average age of domestic meters (years)	6
Contribution of apparent losses to NRW (%)	23
Apparent losses (% of total billed)	7

Real losses	
Pressure in tertiary network (m)	15
Real losses (l/conn/day)	159
Real losses (l/conn/day/m)	11
Technical performance category	C

Note: NRW = nonrevenue water.

The contribution of apparent losses to NRW is estimated to be 23 percent. With the information available at this stage, the average age of the domestic meters is reported to be 5.6 years. The inaccuracy of the domestic water meters contributes to the apparent losses. The utility reports that the amount of unbilled authorized consumption and unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is negligible. The utility does have a procedure to detect and handle illegal practices.

It can be concluded that real losses still largely contribute to the current NRW, which is 159 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network.[54] The technical performance of the network is poor[55] (Category C; see table 2.5 for a description of the categories).

13.2.3. Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire, the average age of the domestic water meters is reported to be 5.6 years. Most likely, class B meters are used. The utilities use electrical and magnetic (E/M) and mechanical meters for the big customers, along with automated meter reading (AMR) technology. The utility has implemented a structured meter maintenance policy.

Table D.97: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	Yes
Meter class	B
Average age (years)	5,6
Type of meter (big customers)	Mechanical and E/M
Management of customer meter	Yes
Billing	Automated
Meter reading	Handheld/Smart phone
Internal audit of billing database	—
Collection	Manual

Note: E/M = electrical and magnetic; — = not available.

The meter reading and billing process is automated. It is unknown if e-billing for domestic customers is implemented.

13.3.4. Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network is poor. The general approach to managing real losses is reactive, with a focus on the detection and repair of invisible and visible leaks. SAWACO applies

54 The level of real losses per meter water pressure was calculated and used to determine the technical performance category, as presented in **Error! Reference source not found.** in the text.

55 An average pressure in the tertiary network of 15 m is assumed.

active pressure management in some parts of the secondary and tertiary network. The utility does manage flows and pressures in the transmission system.

It is not clear if true asset management is implemented, based on a comprehensive analysis of leaks/bursts and other historical events and other economic analyses. The utility plan incorporates a replacement project in the annual financial plan.

Table D.98: Real loss management practices

Item	
Pressure management	Yes/No
Hydraulic model for Q&P management	Yes/No
Active leak control	Yes
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	—
GIS	Yes
Budget for repair and minor replacements	—

Note: GIS = geographical information system; Q&P = flow and pressure; — = not available.

13.3 Energy Efficiency Management

13.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.38 kilowatt-hours per cubic meter. To manage its energy efficiency (EE), the utility has established a centralized team to oversee energy efficiency throughout the company.

Since 2008, the company's strategy for EE management has been based on the following key concepts:

- The setting of internal energy consumption targets
- The completion of energy audits using a combination of internal staff and external experts to monitor performance against business plan targets, completed annually with monthly reviews

The management team monitors energy consumption for each water treatment plant on a monthly basis and is responsible for both ensuring that any unusual trends are investigated and also for managing the delivery of any EE-driven capital investment. Historically, external auditors (most recently, an EE auditing company based in the Netherlands) have been employed to improve the company's EE situation.

13.3.2 Performance of EE Management at SAWACO

SAWACO has a typical water production volume of 182,500 cubic meters per day and a specific energy for water production of 0.38 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.42 to 0.52 kilowatt-hours per cubic meter.

13.3.3 Approach to EE Management at SAWACO

SAWACO's EE management is driven by a central management team. Staff members from the team work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is assessed monthly, and any discrepancies in EE performance from month to month are identified and investigated. Additionally, detailed energy audits are completed annually, generally by internal staff but also sometimes by external consultants.

Energy business plans are developed annually, and although there is a general desire to improve energy efficiency year on year, no firm targets for energy consumption have been confirmed by the company.

The company has confirmed that some accurate submetering is also available at the asset level.

The company confirmed that with the data available, and with the use of independent experts and temporary equipment where required, it is possible to gauge when assets are deteriorating. Operational staff members are responsible for regular monitoring and assessment of individual assets. The data from the staff are held locally and centrally and are used to make asset-planning decisions regarding the replacement or renewal of assets.

The company's EE audits are carried out using a mixture of internal and external staff, and the audit process involves a thorough review of the energy efficiency of the plant at the site, process, and asset levels. The audits are currently carried out on an annual basis, although EE data are reviewed monthly.

SAWACO's approach to energy auditing was graded according to the criteria in table D.99.

Table D.99: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to the criteria in table D.99, SAWACO's energy-auditing approach achieves a grade of A.

13.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. Predominantly, this includes tariff management to ensure that energy-intensive processes are not operated during peak-tariff periods.

Operations teams also report EE data back to the head office on a monthly basis and are required to report and investigate any deviations in energy consumption.

13.3.5 Delivery of EE Management (Capital)

During the interview, the company confirmed that there are a significant number of aging mechanical and electrical assets, specifically pumps, in service and that this is a key concern for the company and a source of inefficiency.

At the time of the interview, the company noted that a recent energy audit had identified that the replacement of a number of inefficient pumps would be beneficial in terms of energy efficiency. However, the investment had not yet been completed, and the company stated that this was due to the complexity of obtaining approval for capital investment from all parties within SAWACO. The issue of obtaining approval for capital investment was described by the company as "very complex." The company does, however, have measures in place to allow capital investment to be made in energy efficiency measures.

The company has not invested in any renewable energy technology and currently has no active plans to do so, although it continues to monitor the potential to do so.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.100.

Table D.100: General approach to EE

		Sawaco
General approach to EE management	Specific energy(kWh/m^3)	0.32
	WLC assessments for new equipment	Yes
	Asset deterioration monitoring	Yes
	Granularity of power metering	Site level, Process level (Partial)
	Peak-tariff avoidance	Yes
	Asset operation	Automatic (Partial), Semiautomatic
	Distribution pressure management	Yes
	Dedicated energy management staff	Yes
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	—
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	—
	Automated control	Treatment and network
	Renewable energy	No, assessment ongoing

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 14 Thanh Hóa Water Supply Company

14.1 General

The Thanh Hóa utility is a joint-stock company, of which the state owns part of the shares. Because of the lack of information, it is unclear which proportion. Also, no quantitative data were provided to allow for an overview of the general water supply system.

14.2 Nonrevenue Water Management

14.2.1 Utility's General Approach

The current nonrevenue water (NRW) level is approximately 30.4 percent. The utility's NRW targets were not presented. The utility has installed an NRW unit, which assists management in formulating NRW management strategies and supports the technical and commercial departments in the routine NRW management activities. The approach to NRW management mainly focuses on the following areas:

- Pressure management
- Active leak detection
- Timely repair of reported leaks and bursts

Table D.101: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	0
DMA coverage%	0
Connections per DMA	—
Monthly water balance in DMA	—
Assessment of apparent and real losses	No
Type of bulk meters	—
Data-transfer technology	—
SCADA	Yes

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

14.2.2 Performance of NRW Management in Thanh Hóa

No quantitative data were provided on NRW management.

14.2.3 Management of Apparent (Commercial) Losses

Meter reading, billing, and collection are done manually. The utility reports that there is no annual volume of unbilled metered consumption. Unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.) is reported to be between 2 and 4 percent of the total production. The utility does have a procedure to detect and handle illegal practices.

Table D.102: Commercial management practices

Item	
Meter coverage (%)	—
Management of customer meter	Yes
Meter class	—
Average age (years)	—
Type of meter (big customers)	—
Management of customer meter	—
Billing	Manual
Meter reading	Manual
Internal audit of billing database	—
Collection	—

Note: — = not available.

14.2.4 Management of Real (Physical) Losses

The general approach to managing real losses is to detect and repair leaks, both visible and invisible leaks. The utility has also implemented pressure-management programs. The utility reports that it carries out economic analysis to determine the economic level of leakage. Renewal programs for pipelines and costs are incorporated in the financial plans.

Table D.103: Real loss management practices

Item	
Pressure management	Yes?
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	Yes
Comprehensive analysis of bursts and historical events	No?
GIS	No
Budget for repair and minor replacements	—

Note: GIS = geographical information system; Q&P = flow and pressure; — = not available.

14.3 Energy Efficiency Management

14.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.25 kilowatt-hours per cubic meter. The company's strategy for energy efficiency (EE) management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- The completion of energy audits using internal staff to monitor performance against business plan targets

The internal audits are completed monthly. Some audits have been completed by third-party consultants on an ad hoc basis.

14.3.2 Performance of EE Management in Thanh Hóa

Thanh Hóa has a typical water production volume of 90,000 cubic meters per day and a specific energy for water production of 0.25 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.36 to 0.52 kilowatt-hours per cubic meter.

14.3.3 Approach to EE Management in Thanh Hóa

Thanh Hóa utilizes staff working in the central offices to oversee the management of energy efficiency at its water treatment plants. Staff members work in cooperation with the local operational staff to ensure that any opportunities to improve energy efficiency are identified and that good practice is shared between different operations teams.

Energy efficiency is audited internally on a monthly basis, and any discrepancies in EE performance are identified and investigated. In addition, the company utilizes third-party consultants to audit specific areas on an ad hoc basis. Thanh Hóa's approach to energy auditing was graded according to the criteria in table D.104.

Table D.104: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to the criteria in table D.104, Thanh Hóa's energy-auditing approach achieves a grade of B/C.

14.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. Tariff management is not currently carried out. The company does not operate any water treatment plants but is responsible for the distribution of treated water.

Since 2005, there has been a significant focus in the company on improving the skills of the operations teams, in order to ensure that the utility's equipment (which is operated manually) is run as efficiently as possible.

In 2005, the company changed from a state-owned to a sole-member company. During the transition period, some of the older, lower-skilled workers were offered retirement. In 2016, the company changed to a joint-stock company, and a further tranche of the employees retired. Subsequently, the remaining staff members were offered extensive training to raise their skill levels. This has led to the development of a young, skilled demographic within the utility's operational teams. The restructuring was carried out with the assistance of funding from the state, with 2 billion Vietnamese dong being made available.

The company also has a system of performance-based bonus payments for employees who are able to deliver EE savings.

14.3.5 Delivery of EE Management (Capital)

In the interview, the company confirmed that some EE-driven capital investment has been completed, with some of the pumps in the utility's water distribution systems being equipped with variable-speed drives. The details of the investment were not provided, but the company confirmed that EE savings in excess of 30 percent had been achieved following the installation of the new drives.

The company has not yet made any investment in renewable energy technologies and has no plans to do so. In the interview, the utility confirmed that the potential to install renewable technology had been explored but that the return on investment was not sufficient to justify the investment.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.105.

Table D.105: General approach to EE

		Thanh Hóa
General approach to EE management	Specific energy(kWh/m^3)	0.32
	WLC assessments for new equipment	Yes
	Asset deterioration monitoring	Yes
	Granularity of power metering	Site level/Process level
	Peak-tariff avoidance	No
	Asset operation	Manual
	Distribution pressure management	Yes
	Dedicated energy management staff	No
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes
EE interventions confirmed as completed	Equipment replacement	—
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	—
	Renewable energy	No, assessment completed

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 15: VIWACO

15.1 General

VIWACO is a joint-stock company, of which the state owns part of the shares. No quantitative data were provided to allow for an overview of the general water supply system.

15.2 Nonrevenue Water Management

15.2.1 Utility's General Approach

The current nonrevenue water (NRW) level was not provided by the company but based on a sector report from the association of water and sewerage companies it is 57%. The utility has set a target for the reduction of NRW to 14.5 percent in 2020.

In 2018, company management decided to assign a specialized department to carry out research and propose a specific plan for NRW. The utility does not have an NRW master project. Annual rehabilitation plans are formulated, aimed at reducing the NRW for specific district metered areas (DMAs) after monitoring and assessing the NRW.

Table D.106: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	—
DMA coverage%	—
Connections per DMA	—
Monthly water balance in DMA	Yes
Assessment of apparent and real losses	No
Type of bulk meters	E/M
Data-transfer technology	AMR?
SCADA	Yes

Note: AMR = automated meter reading; DMA = district metered area; E/M = electrical and magnetic; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

The utility reports a lack of input meters in some areas, and upstream pressure also makes it impossible to isolate DMAs; hence, the data for some DMAs are not correct.

15.2.2 Performance of NRW Management at VIWACO

No quantitative data were provided on NRW management.

15.2.3 Management of Apparent (Commercial) Losses

Meter reading, billing, and collection are done manually. The meter readers use handhelds. The company is planning to implement e-billing, with Internet banking or centralized payment.

Customer meters are tested or calibrated on request or periodically.

Table D.107: Commercial management practices

Item	
Meter coverage (%)	—
Management of customer meter	Yes
Meter class	—
Average age (years)	—
Type of meter (big customers)	E/M?
Management of customer meter	—
Billing	Manual
Meter reading	Handheld
Internal audit of billing database	—
Collection	—

Note: E/M = electrical and magnetic; — = not available.

15.2.4. Management of Real (Physical) LOSSES

The general approach to managing real losses is to detect and repair leaks, both visible and invisible leaks. The supervisory control and data acquisition (SCADA) system generates reports indicating anomalies in DMAs. The utility reports that it does not carry out economic analysis to determine the economic level of leakage. Leakage reports are uploaded into a geographical information system (GIS).

The utility has also implemented pressure-management programs. Renewal programs for pipelines and costs are incorporated in the financial plans.

Table D.108: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	Yes
GIS	Yes
Budget for repair and minor replacements	—

Note: GIS = geographical information system; Q&P = flow and pressure; — = not available.

15.3 Energy Efficiency Management

15.3.1 Utility's General Approach

VIWACO is a water distribution company. It does not carry out any water treatment of its own, instead purchasing treated water under pressure from the Song Da water supply company. VIWACO then further pressurizes the water being passed into distribution using a system of 12 water booster pumps. The company did not report a specific energy cost.

The company's strategy for energy efficiency (EE) management is based on the following key concepts:

- The setting of internal energy consumption targets based on historical energy consumption
- The completion of energy audits using internal staff to monitor performance against business plan targets

The internal audits are completed monthly or on an ad hoc basis. In addition, VIWACO is investing in SCADA monitoring for the distribution network to improve pressure management and ensure that pumps are used as efficiently as possible.

15.3.2 Performance of EE Management at VIWACO

VIWACO did not report an EE benchmarking figure because it completes no treatment. Based on the annual energy consumption and distribution figures provided by VIWACO and an assumed weighted average power tariff of 1,660 Vietnamese dong per kilowatt-hour, it is estimated that the specific energy for distribution in VIWACO is approximately 0.016 kilowatt-hours per cubic meter. VIWACO distributes approximately 202,000 cubic meters of water per day.

15.3.3 Approach to EE Management at VIWACO

VIWACO utilizes staff working in the central offices to oversee the management of energy efficiency at its distribution booster stations, with a significant reliance on automatic control using a centralized SCADA system.

Energy efficiency is audited internally on a monthly basis, and any discrepancies in EE performance are identified and investigated. VIWACO's approach to energy auditing was graded according to the criteria in table D.109.

Table D.109: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to the criteria in table D.109, VIWACO's energy-auditing approach achieves a grade of B/C.

15.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, as far as possible. Tariff management is currently carried out. The company does not operate any water treatment plants but is responsible for the distribution of treated water, and there is a focus on minimization of the operation of booster stations throughout the network to ensure energy-efficient operation. Operation of the distribution network is substantially automated, with centralized monitoring and control using a SCADA system.

During the interview, the company reported that there have been problems with the pressure of the supply from the Song Da water treatment plant. The pressure in the delivery main from the Song Da plant dropped from

3.5 bar in 2009 to 1.0 bar in 2018. Capital investment at the Song Da plant in 2018 is expected to increase the pressure to approximately 2.0 bar. The decrease in pressure from Song Da has led VIWACO to incur additional energy costs for its high-lift pumping stations. VIWACO confirmed that there are also seasonal variations in the pressure from Son Da, which can further exacerbate the problem.

To reduce its levels of NRW, VIWACO has reduced the pressure in its distribution network, although this has led to low pressures to the extent that many residents of Hanoi have installed their own booster pumps to create sufficient pressure for their needs. Although the booster pumps are very small (typically around 0.2 kilowatts) and run intermittently, the 140,000 connections served by VIWACO could lead to substantial energy consumption from these pumps.

15.3.5 Delivery of EE Management (Capital)

In the interview, the company confirmed that some EE-driven capital investment has been completed, with some of the pumps in the utility's water distribution systems being equipped with variable-speed drives. The details of the investment were not provided.

The company has not yet made any investment in renewable energy technologies and has no firm plans to do so. In the interview, the utility expressed some interest in the use of small-scale solar photovoltaic (PV) technology to replace batteries in its network flow meters and other instruments. This approach has previously been explored by VIWACO, but its practicality is limited, and the cost is relatively high.

The company's general approach to EE management, as discussed in the interview and in the associated questionnaire, is summarized in table D.110.

Table D.110: General approach to EE

		VIWACO
General approach to EE management	Specific energy(kWh/m^3)	~0.016(Distribution only, est.)
	WLC assessments for new equipment	Yes
	Asset deterioration monitoring	Yes
	Granularity of power metering	Site level (Distribution only)
	Peak-tariff avoidance	Yes
	Asset operation	Automatic
	Distribution pressure management	Yes
	Dedicated energy management staff	Yes
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	No
EE interventions confirmed as completed	Equipment replacement	—
	Power-factor correction	—
	Soft starters	—
	Variable-speed drivers	Yes
	Automated control	Network
	Renewable energy	No, assessment completed

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 16: Bạc Liêu

16.1 General

The Bạc Liêu JS water and Sewerage Company is a Joint stock company of which the state owns 2% of the shares. The utility provides (piped) water services in Bạc Liêu City only The utility does not manage waste water.

The utility manages 3 water supply systems with 2 production facilities in the city of Bạc Liêu, as listed in the table below. The total installed design capacity is 22,000 m^3/d. The utilization rate of the production facilities is 90%.

The raw water source is groundwater. The design capacity of the 2 production-facilities is 10,000 and 12,000 m^3/d.

Table D.111: Asset Base

Service coverage (%)	95
Total design capacity of water supply (m^3/d):	22,000
Pumped supply (% of total):	100
Gravity supply (% of total):	0
Supply time (hrs/day):	24
Average supply pressure in water supply system (in DMA):	Area 1 – 20m Area 2 – 15m Area 3 – 8m
Total raw water volume daily (m^3/d):	21,500
Total treated water production daily (m^3/d):	20,000

Note: DMA = district metered area; — = not available.

The utility manages about 620 km of mains and 27,751 connections in Bạc Liêu City. The whole network has an age of younger than 21 years. The average age of the domestic water meter is estimated to be 18 years.

Table D.112: Asset Base

Supply, average liter per capita per day (l/p/d, 2017)	110
Population served (households)	140,000
Total number of customer connections (in billing system by the end of 2017) Total connections in biggest WSS Domestic connections in biggest WSS: *(the utility manages only one water supply system for Bạc Liêu City)*	 27,751 24,633
Number of new connections per year, made by water company	-
Number of new connections per year, made by project/real estate developer	-
Number of other connections	-
Density of connections (connection/km)	12
Billed volume (m^3/year)	6,891,069

Billed volume of domestic customers, 2017 data (m³/year): Total billed volume in biggest WSS (m³/year):	- 6,891,069	
Proportion of water meters installed vs. total connections (%)	100	
Proportion of water meters replaced/repaired/checked annually (%, 2017)	13%/year (approx.) of which: Replaced: 3.8% Repaired: 1.68% Visually checked: 6.9%	
Average age of domestic water meters (Years)	5 (estimated)	
Type of domestic water meters, velocity or volumetric meters	Volumetric	
Brand and country of origin of domestic water meters	G. Kent	Quantity: —
	Actaris	Quantity: —
(Meters are B class, manufactured in Malaysia, China, Thailand, Italy)	Others	Quantity: 100%.
Total length of transmission pipes (diameter ≥ 300 mm) (km)	350	
Total length of distribution pipes (diameter = 63–300 mm), excluding service pipes (km)	D63: 154 D110: 61,602 D160: 32,395 D200: 1,804 D300: 4,112	
Total length of distribution pipes constructed by project/real estate developers (km)	In the past, a number of pipelines were constructed by project developers, then handed over to Bạc Liêu. All pipelines are now operated by the water utility.	
Total length of pipes used over 21 years (km)	All pipes are <21 years old.	

Note: JSC – joint-stock company; WSS = water supply station; — = not available.

16.2 NRW Management

16.2.1 Utility's General Approach

The utility's policy is to follow at least the NRW targets, set in Prime Minister (PM) Decision 2147 TTg. The Utility has installed a NRW unit. The utility plans to reduce the NRW level to less than 12% in 2020 and less than 10% in 2030.

The utility's key approach to NRW management mainly focuses on achieving a short term impact in Bạc Liêu City. The main activities can be summarized as follows:

- Pressure management[56]
- Timely repair of reported leaks and bursts
- Active Leak Detection

The utility has no DMAs installed yet. Water balance, i.e. NRW, apparent and real loses are not determined on a regular basis. Electromagnetic bulk meters are installed, whereas the utility is in the process of rolling out SCADA for data transfers.

Table D.113: NRW Management

Item	
NRW unit/department	Yes
Number of DMAs	0
DMA coverage (%)	0
Connections per DMA	—
Monthly water balance in DMA	—
Assessment of apparent and real losses	No
Type of bulk meters	E/M
Data-transfer technology	Partly AMR
SCADA	Yes

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

16.2.2 Performance of NRW Management in Bạc Liêu Province

The rapid assessment looks into the current NRW situation of the major cities of the utilities, and the NRW performance in Bạc Liêu is considered in this section. The reason for the focus on the major cities is that the impact and viability of a potential performance-based contracting (PBC) NRW program are maximized in a relatively densely populated and big supply area.

Table D114 presents a summary of the performance of NRW-management in Bạc Liêu. The levels of NRW, and real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 11 percent, which is equivalent to 84 liters per connection per day, is very low.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight in the distribution between these two NRW-components gives a firm indication how well the utilities are performing in various areas of NRW-management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

56 inducing very low pressure at the fringes of the network

Table D.114: NRW Management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year**)**	7,300,000
System input (l/conn/day)	759
Volume billed (l/conn/day)	680
Volume billed domestic (l/conn/day)	495
Per capita billed (l/cap/day)	110
NRW (l/conn/day)	84
NRW calculated (%)	
NRW reported in questionnaire (%)	11
Apparent losses	
Average age of domestic meters (years)	18
Contribution of apparent losses to NRW (%)	95
Apparent losses (% of total billed)	12
Real losses	
Pressure in tertiary network (m)	24
Real losses (l/conn/day)	4
Real losses (l/conn/day/m)	0
Technical performance category	A

In Bạc Liêu city, the contribution of apparent losses to NRW is estimated to be 36 percent. The estimated average age of the domestic water meters of 18 years contributes considerably to the apparent losses. There is no data available of unbilled authorized consumption, nor of the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.). There is no information available on how Illegal practices are managed.

The high level of apparent losses (95 percent of the total NRW) implies a unrealistic low level of real losses, i.e. 4 liters per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network[57]. Considering the average system pressure of 24 meters, the technical performance of the network in Bạc Liêu Province is exceptionally good (Category A; see table 2.5 for a description of the categories). This is considered not to be realistic as it is estimated that the quality of asset management is basic, see also paragraph 2.4.

16.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire the average age of the domestic water meter is estimated to be 18 years. The average age of the big customer meters is not reported. Class B meters are used. The utility has a meter maintenance policy implemented.

Table D.115 Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	Yes
Meter class	B

57 The level of Real losses per meter water pressure is calculated and referred to technical performance category as presented in **Error! Reference source not found.**

Average age (years)	18
Type of meter (big customers)	-
Management of customer meter	Yes
Billing	Manual
Meter reading	Manual
Internal audit of billing database	Yes
Collection	Manual/Bank

Meter reading and billing are carried out manually. Payment can be made at banks or collected directly.

16.2.4 Management of Real (physical) Losses

As mentioned previously, the technical performance of the network in Bạc Liêu city is A; see also table D.116. The management of real losses focusses on pressure management and leak detection and repair. Pressure settings are semi-automatically and manually generated without the use of a hydraulic model of the network.

The utility does not carry out quantitative nor qualitative analysis to determine the optimum leakage level, nor are records kept of leaks/bursts and other historical events. The utility is in the process to start implementing GIS. Most probably data on the distribution network is still recorded on drawings.

Table D.116 Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	No
Comprehensive analysis of bursts and historical events	No
GIS	No

Note: GIS = geographical information system; Q&P = flow and pressure.

16.3 Energy Efficiency Management

16.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.2 kilowatt-hours per cubic meter. Via questionnaire, the utility confirmed there are currently no firm targets to reduce energy consumption.

There is no defined strategy for the management of energy efficiency at present. No energy efficiency audits have yet been completed, and there are no personnel dedicated to the management of energy efficiency issues.

Operational staff are required to carry out general assessments of energy efficiency as part of their typical duties on site. Peak tariff avoidance has been implemented.

16.3.2 Performance of EE Management in Bạc Liêu

Bạc Liêu has a typical water production volume of 22,000 cubic meters per day, and a specific energy for water production of 0.2 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.43 to 0.53 kilowatt-hours per cubic meter.

16.3.3 Approach to EE management in Bạc Liêu

Bạc Liêu utilises staff working in the Operation and Maintenance Department to oversee the management of energy efficiency at its water treatment plants. Local operational staff are tasked with ensuring that opportunities to improve energy efficiency are identified and implemented where possible.

Energy efficiency is not assessed on a formal basis, with no defined energy efficiency strategy, no energy auditing programme, and no personnel dedicated to the management of energy efficiency issues. No firm targets for energy consumption have been set, and the company does not have a formal energy efficiency strategy.

Borehole pumping stations are equipped with energy submetering at site level, and water treatment works are metered at works level. Data from these meters is collected on a daily basis, with Operational staff collating the data and looking for any discrepancies. In the returned questionnaire, the company confirmed that, with the data available, it is possible to gauge when assets are deteriorating. Bạc Liêu's approach to energy auditing was graded according to the criteria in table D.117.

Table D.117: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to this grading, Bạc Liêu's energy auditing approach achieves a grade of C/D.

16.3.4 Delivery of EE Management (Operational)

The company ensures that good operational practices are implemented at its sites, where possible. The company has two water treatment systems. This small number of systems should make the future delivery of detailed audits straightforward.

Although the specific energy for water production and distribution is low compared with MoC cost norms, the monitoring of energy efficiency appears to be relatively ad-hoc in nature, being reliant on the vigilance of Operations team personnel, and no programme of energy efficiency audits or improvements has been developed.

16.3.5 Delivery of EE Management (Capital)

In their returned questionnaire, the company confirmed that, while funding is available for small scale maintenance investment, capital funding for larger investments driven by energy efficiency is not. However, there has been historic investment in both new assets and the retrofitting of new EE assets to original equipment. The historic investment has included:

- Variable speed drives.
- Soft starters.
- Power factor correction.

When installing new equipment, whole life costs are not currently assessed. This presents the risk that proper consideration may not be given to the energy efficiency impact of any newly installed assets.

The company has also made some investment in renewable energy, with the installation of solar panels (30kW capacity) at one site.

Plant control is a combination of manual and automated control. There is a SCADA system which has capacity to manage up to three water treatment plants and some areas of the distribution network, although its implementation has been limited.

The company's general approach to energy efficiency management, as discussed at interview and in the associated questionnaire, is summarised in table D.118.

Table D.118: General approach to EE

		Bạc Liêu
General approach to EE management	Specific energy(kWh/m^3)	0.2
	WLC assessments for new equipment	No
	Asset deterioration monitoring	No
	Granularity of power metering	Site Level
	Peak-tariff avoidance	Yes
	Asset operation	Manual / Automatic
	Distribution pressure management	Yes
	Dedicated energy management staff	No
	Defined energy strategy	No
	Defined EE improvement strategy	No
	Capital budget available	No
EE interventions confirmed as completed	Equipment replacement	—
	Power-factor correction	Yes
	Soft starters	Yes
	Variable-speed drivers	Yes
	Automated control	Network, limited
	Renewable energy	Investment made

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 17: Hậu Giang Water and Sewerage Joint Stock Company

17.1 General

The Hậu Giang JS water and Sewerage Joint Stock Company (JSC) is 49 percent state owned. The utility provides (piped) water services in 3 towns, 5 district towns and 3 communes. The utility does not manage waste water. The utility's organization consists of 7 branches.

The utility manages 11 water supply systems in the provinces Hậu Giang, as listed in the table below. he capacity of the water system in Vị Thanh, the capital of Hậu Giang province, accounts for about 50 percent of the total installed design capacity of 23,600 cubic meters per day. Bulk water is supplied by a private enterprise, which amounts to 10,000 cubic meters per day. The utilization rate of the production facilities is 100 percent.

The raw water source is surface water. The capacity of the 11 production-facilities ranges between 300 and 11,000 cubic meters per day.

Table D.119: Asset Base

Plant	Capacity(m^3/d)
Vị Thanh Water Treatment Plant	11,000
Ngã Bảy Water Treatment Plant	5,000
Water Treatment Plant	2,000
Một Ngàn Water Treatment Plant	500
Water Treatment Plant	500
Cây Dương Water Treatment Plant	1,000
Cái Tắc Water Treatment Plant	1,000
Đồng Phú Water Treatment Plant	1,300
Tân Bình Water Treatment Plant	1,000
Bung Tau Water Treatment Plant	500
Lương tâm Water Treatment Plant	300
Total design capacity of water supply (m^3/d):	24,100
Total raw water volume daily (m^3/d):	4,490*
Total design capacity of wastewater treatment (m^3/d):	—
Total treated water production daily (m^3/d):	—

Source: Data provided by Quảng Nam Water Supply and Drainage JSC (EE&NRW questionnaire)
Note: — = not available.
*Including 10,000 cubic meters supplied by a third party

The population served in the provinces amounts to 315,594, which is about 40 percent of the 2016 population of the whole province (766,000). However, the service coverage reported by the utility is much lower.

The utility manages about 775 km of mains and 53,000 connections. A summary of connections for each water supply system is not available. The age profile of the network is unknown.

All customers are metered. The NRW at company level in 2017 is 19.5 percent.

Table D.120: Key Characteristics

Average liter per capita per day (l/p/d)	83
Population served	315,594
Total number of customer connections	52,599
Density of connections (connection/km)	68.5
Billed volume (m^3/year)	9,841,420
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually (%)	16.7
Total length of transmission pipes (diameter ≥ 300 mm) (km)	8.1
Total length of distribution pipes (diameter = 100–300 mm), excluding service pipes (km)	768
Total length of pipes used over 21 years (km)	-

17.2 Nonrevenue Water Management

17.2.1 Utility's General Approach

The utility policy is to follow the NRW targets, set in Prime Minister Decision 2147 TTg. The Utility has installed a NRW unit, which assists the management to formulate NRW management strategies and supports the technical and commercial departments in the routine NRW management activities.

The key approach to NRW management mainly focuses on achieving short term impact in Vị Thanh City and Ngã Bảy Town. The main activities can be summarized as follows:

- Pressure management[58]
- Timely repair of reported leaks and bursts

The utility has no DMAs installed yet. Water balance, i.e. NRW, apparent and real loses are not determined on a regular basis. The technology of bulk meters and data transfers are up to date.

Table D.121: NRW management

Item	
NRW unit/department	Yes
Number of DMAs	0
DMA coverage (%)	0
Connections per DMA	-
Monthly water balance in DMA	-
Assessment of apparent and real losses	No
Type of bulk meters	Electrical / Mechanical
Data-transfer technology	AMR
SCADA	Yes

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

58 inducing very low pressure at the fringes of the network

17.2.2 Performance of NRW Management in Hậu Giang Province

The rapid assessment look into the current NRW situation of the major cities of the utilities. The NRW performance within Hậu Giang province is considered in this section.

Table D.122 presents a summary is presented of the performance of NRW management in Hậu Giang. The levels of NRW, real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 19.5 percent is equivalent to 124 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight in the distribution between these two NRW components gives a firm indication how well the utilities are performing in various areas of NRW management.

The "top-down" assessment methodology developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.122: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year)	8,796,500
System input (l/conn/day)	637
Volume billed (l/conn/day)	513
Volume billed domestic (l/conn/day)	376
Per capita billed (l/cap/day)	83
NRW (l/conn/day)	124
NRW calculated (%)	19.5
NRW reported in questionnaire (%)	19.5
Apparent losses	
Average age of domestic meters (years)	7
Contribution of apparent losses to NRW (%)	30
Apparent losses (% of total billed)	7
Real losses	
Pressure in tertiary network (m)	15
Real losses (l/conn/day)	87
Real losses (l/conn/day/m)	6
Technical performance category	B

The contribution of apparent losses to NRW is estimated to be 30 percent. The average age of the domestic water meters contributes considerably to the apparent losses. There is no data available of unbilled authorized consumption, nor of the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.). There is no information available on how Illegal practices are managed.

It can be concluded however, that real losses contribute largely to the current NRW, which is 87 litres per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network[59]. Considering the estimated (moderate) average system pressure of 15

59 The level of Real losses per meter water pressure is calculated and referred to technical performance category as presented in **Error! Reference source not found.**

meters, the technical performance of the networks in Hậu Giang province is good (Category B; see table 2.5 for a description of the categories).

17.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire the average age of the domestic water meter is estimated to be 7 years. Class B meter are used. The average age of the big customer meters is not reported. The utility has a meter maintenance policy implemented, based on default replacement frequency.

Table D.123: Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	Yes
Meter class	B?
Average age (years)	7
Type of meter (big customers)	Electrical/Mechanical
Management of customer meter	Yes
Billing	Automated
Meter reading	Manual
Internal audit of billing database	Yes
Collection	Manual/Bank

Meter reading is carried out manually. The billing is automated using SMS methodology. Payment can be made via SMS and at banks.

17.2.4 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network is good; see also table D123.

The general approach to managing real losses focusses on pressure management and leak repair. A hydraulic model of the important networks is used to evaluate the impact of pressure management. Pressure settings are automated via SCADA.

The utility reports carrying out economic analysis to determine the optimum leakage level. The utility records comprehensive analysis of leaks/bursts and other historical events. However, the utility has no GIS, data on the distribution network is probably recorded on drawings.

Table D.124 Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	Yes
Active leak control	Yes
Analysis of economic leakage level	Yes
Comprehensive analysis of bursts and historical events	Yes?
GIS	No

Note: GIS = geographical information system; Q&P = flow and pressure.

17.3 Energy Efficiency Management

17.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.18 kilowatt-hours per cubic meter. Via questionnaire, the utility confirmed that the target energy consumption is 11 percent lower than 2018 levels, 0.15 kilowatt-hours per cubic meter, and it is intended that this improvement will be delivered by 2020. There are currently no plans for further reductions beyond 2020. A defined energy efficiency has been developed by the company, in order to deliver the targeted energy efficiency improvements.

No formal energy efficiency audits have yet been completed, and there are no personnel dedicated to the management of energy efficiency issues.

Peak tariff avoidance has been implemented and there is an ongoing programme of energy efficiency investment.

17.3.2 Performance of EE Management in Hậu Giang

Hậu Giang has a typical water production volume of 33,485 cubic meters per day, and a specific energy for water production of 0.18 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.45 to 0.53kilowatt-hours per cubic meter. Raw water is abstracted from the Mekong River.

17.3.3 Approach to EE Management in Hậu Giang

Hậu Giang does not have any dedicated staff responsible for the management of energy efficiency. Local operational staff will be essential in ensuring that opportunities to improve energy efficiency are identified and implemented where possible and that the targeted energy efficiency improvements are delivered.

Energy efficiency is not assessed through a formal programme of energy efficiency audits. However there is a defined energy efficiency strategy, with firm targets for energy efficiency improvements being set.

Accurate power metering is available at site level, but more detailed accurate submetering is unavailable. In the returned questionnaire, the company confirmed that, with the data available, it is possible to gauge when assets are deteriorating.

Hậu Giang's approach to energy auditing has been graded according to the criteria in the table below.

Table D.125: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site
C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to this grading, Hậu Giang's energy auditing approach achieves a grade of C.

17.3.4 Delivery of EE Management (Operational)

With no dedicated energy management personnel, the company is reliant on ensuring that good operational practices are implemented at its sites, where possible in order to maintain energy efficiency. The company has eleven water treatment systems, which require the future delivery of detailed audits to be targeted initially at larger sites.

General good operational practices such as monitoring for asset deterioration and peak tariff avoidance, are carried out.

Although the specific energy for water production and distribution is already low compared with MoC cost norms, the company has set itself targets for energy efficiency improvements in 2019/20, which are likely to be stretching. These are likely to be substantially delivered through a programme of capital investment.

17.3.5 Delivery of EE Management (Capital)

In their returned questionnaire, the company confirmed that capital funding for relatively large investments driven by energy efficiency is available. There is an ongoing programme of capital investment in energy efficiency measures, including:

- Replacement of life expired or inefficient assets.
- Variable speed drives.
- Soft starters.
- Power factor correction.

When installing any new equipment, whole life costs are assessed, which should ensure that the due consideration is given to the energy efficiency of new assets.

The company has not yet made any investment in renewable energy and no plans to do so have been identified.

Treatment plant control is partially automated, and there is a SCADA system for management of the distribution network, which provides for automatic pressure control.

The company's general approach to energy efficiency management, as discussed in the returned questionnaire, is summarised in table D.126.

Table D.126: General approach to EE

		Hậu Giang
General approach to EE management	Specific energy(kWh/m^3)	0.18
	WLC assessments for new equipment	Yes
	Asset deterioration monitoring	Yes
	Granularity of power metering	Site level
	Peak-tariff avoidance	Yes
	Asset operation	Manual
	Distribution pressure management	Yes
	Dedicated energy management staff	No
	Defined energy strategy	Yes
	Defined EE improvement strategy	Yes
	Capital budget available	Yes

EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	Yes
	Soft starters	Yes
	Variable-speed drivers	Yes
	Automated control	Network Only
	Renewable energy	No

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Report 18: Sóc Trăng Water and Sewerage Joint Stock Company

18.1 General

The Sóc Trăng Water and Sewerage Joint Stock Company is a Joint stock company of which the state owns 49 percent of the shares. The utility provides (piped) water services in Sóc Trăng City, 3 towns, 7 district towns and 1 commune, basically in the urban areas. The utility does not manage waste water.

The utility manages 11 water supply systems with 22 production facilities in the province of Sóc Trăng, as listed in table D.127. The total installed design capacity is 76,600 cubic meters per day. The utilization rate of the production facilities is 78 percent.

The raw water source is groundwater. The capacity of the 22 production facilities range between 1,000 and 14,000 cubic meters per day.

Table D.127: Asset Base

Plant	Capacity(m³/d)
1. Nguyễn Chí Thanh Water Treatment Plant	14,000
2. An Nghiệp Water Treatment Plant	10,000
3. Dist. No. 8 Water Treatment Plant	4,000
4. Phu Loi Division	8,000
5. Dist. No. 7 Water Treatment Plant	2,000
6. Sung Dinh Water Treatment Plant	3,000
7. Mỹ Xuyên Division	4,000
8. Mỹ Xuyên 2 Water Treatment Plant	2,000
9. Vĩnh Châu Division	3,000
10. Hai Ngu Water Treatment Plant	3,000
11. Long Phú Division	3,000
Mỹ Tú Division Water Treatment Plant	2,000
Lịch Hội Thượng Division	2,400
Trần Đề Division	2,000
Đại Ngãi Division	2,000
Long Đức Water Treatment Plant	2,000
Kế Sách Division	1,000
Kế Sách Training School Water Treatment Plant	2,000
Hưng Lợi Water Treatment Plant	
Thạnh Trị Division	3,000
Ngã Năm Division	2,000
Phong Nẫm Water Treatment Plant	1,000
Total design capacity of water supply (m^3/d):	76,000
Total raw water volume daily (m^3/d):	63,000
Total design capacity of wastewater treatment (m^3/d): —	
Total treated water production daily (m^3/d): 60,000	

Continued…

The population served in the province is 380,000, and the service coverage in the province is 86 percent. All customers are metered. The NRW at company level in 2017 is 15.4 percent. The utility manages about 918 kilometers of mains and 84,254 connections. About 50 percent of the customer connections is in the capital of the Province (Sóc Trăng City). Approximately 10 percent of the network is older than 21 years. The average age of the domestic water meter is 20 years.

Table D.128: Key Characteristics

Average liter per capita per day (l/p/d)	133.8
Population served	380,000
Total number of customer connections	84,254
Density of connections (connection/km)	92
Billed volume (m^3/year)	18,522,222
Proportion of water meters installed vs. total connections (%)	100
Proportion of water meters replaced/repaired/checked annually (%)	5%*
Total length of transmission pipes (diameter ≥ 300 mm) (km)	2,664
Total length of distribution pipes (diameter = 100–300 mm), excluding service pipes (km)	915,617
Total length of pipes used over 21 years (km)	99,519

* There is no data on each component. The total proportion of meter replacement is 5% per year

18.2 Nonrevenue Water Management

18.2.1 Utility's General Approach

The utility's policy is to follow at least the NRW targets, set in Prime Minister Decision 2147 TTg. The utility indicates to reduce the NRW level to less than 15 percent. The company has not yet installed a NRW unit.

The key approach to NRW management mainly focuses on achieving short term impact in Sóc Trăng City. The main activities can be summarized as follows:

- Pressure management[60]
- Timely repair of reported leaks and bursts

The utility has no DMAs installed yet. Water balance, i.e. NRW, apparent and real losses are not determined on a regular basis. Conventional technology of bulk meters and data transfers are used, i.e. mechanical meters and manual reading and transfer of meter records.

Table D.129: NRW management

Item	
NRW unit/department	No
Number of DMAs	0
DMA coverage (%)	0
Connections per DMA	-
Monthly water balance in DMA	-
Assessment of apparent and real losses	No

60 inducing very low pressure at the fringes of the network

Type of bulk meters	Mechanical
Data-transfer technology	Manual
SCADA	No

Note: DMA = district metered area; NRW = nonrevenue water; SCADA = supervisory control and data acquisition; — = not available.

18.2.2 Performance of NRW Management in Sóc Trăng Province

In table D.130, a summary is presented of the performance of NRW-management and an estimated distribution between real and apparent losses. The levels of NRW, real and apparent losses are presented in liters per connection per day, showing the actual volume of distributed water not billed. The current NRW of 15.4 percent is equivalent to 110 liters per connection per day.

The rapid assessment is based on an estimation of the distribution between apparent (commercial) and real (technical) losses. The insight in the distribution between these two NRW components gives a firm indication how well the utilities are performing in various areas of NRW management.

The "top-down" assessment methodology, developed by the NRW Task Group of the International Water Association (IWA) was used to estimate the distribution between apparent (commercial) and real (technical) losses.

Table D.130: NRW management

System input, volume billed, and NRW levels	
System input (average daily production x 365) (m^3/year**)**	21,900,000
System input (l/conn/day)	712
Volume billed (l/conn/day)	602
Volume billed domestic (l/conn/day)	458
Per capita billed (l/cap/day)	102
NRW (l/conn/day)	110
NRW calculated (%)	15.4
NRW reported in questionnaire (%)	15.4
Apparent losses	
Average age of domestic meters (years)	20
Contribution of apparent losses to NRW (%)	75
Apparent losses (% of total billed)	14
Real losses	
Pressure in tertiary network (m)	15
Real losses (l/conn/day)	27
Real losses (l/conn/day/m)	2
Technical performance category	A

The contribution of apparent losses to NRW is estimated to be 75 percent. The estimated average age of the domestic water meters of 20 years contributes considerably to the apparent losses. There is no data available of unbilled authorized consumption, nor of the annual volume of unbilled unmetered consumption (firefighting, flushing mains and sewers, street cleaning, internal utility use, etc.). There is no information available on how Illegal practices are managed.

The high level of apparent losses (75 percent of the total NRW) implies a very low level of real losses, i.e. 27 litres per connection per day. The guidelines of the NRW Task Group of the IWA were used as a reference to assess the technical performance of the network[61]. Considering the average system pressure of 15 m, the technical performance of the network in Sóc Trăng Province is exceptionally good (Category A; see table 2.5 for a description of the categories). This is considered not to be realistic as it is estimated that the quality of asset management is basic.

18.2.3 Management of Apparent (Commercial) Losses

Based on the interview and information from the questionnaire the average age of the domestic water meter is estimated to be 20 years. Class B meters are used. The average age of the big customer meters is not reported. The utility has no meter maintenance policy implemented.

Meter reading is carried out manually. The billing is done manually. Payment can be done at banks or are collected directly.

Table D.131 Commercial management practices

Item	
Meter coverage (%)	100
Management of customer meter	Yes
Meter class	B?
Average age (years)	20
Type of meter (big customers)	Mechanical
Management of customer meter	Yes
Billing	Manual
Meter reading	Manual
Internal audit of billing database	No
Collection	Manual/Bank

18.2.4 Management of Real (Physical) Losses

As mentioned previously, the technical performance of the network is remarkably good, (Category A).

As summarized in table D.132, real losses management focusses on pressure management and leak repair. Pressure settings are manually generated without the use of a hydraulic model of the network.

The utility reports carrying out first preliminary quantitative and qualitative analysis to determine the optimum leakage level. This analysis is carried out without evaluating records of leaks/bursts and other historical events. The utility does not use a GIS, and it is likely that data on the distribution network is recorded on drawings.

Table D.132: Real loss management practices

Item	
Pressure management	Yes
Hydraulic model for Q&P management	No
Active leak control	Yes
Analysis of economic leakage level	Yes?

61 The level of Real losses per meter water pressure is calculated and referred to technical performance category

Comprehensive analysis of bursts and historical events	No
GIS	No

Note: GIS = geographical information system; Q&P = flow and pressure.

18.3 Energy Efficiency Management

18.3.1 Utility's General Approach

The company's current specific energy consumption for water treatment is 0.369kWh/m^3. Via questionnaire, the utility confirmed that there are no firm targets to improve on this figure.

A defined energy efficiency has not yet been developed by the company, and no formal energy efficiency audits have yet been completed. There are no personnel dedicated to the management of energy efficiency issues.

Peak tariff avoidance has not been implemented, although some capital investment interventions have been completed.

18.3.2 Performance of EE Management in Sóc Trăng

Sóc Trăng has a typical water production volume of 60,000 cubic meters per day, and a specific energy for water production of 0.369 kilowatt-hours per cubic meter, which is below the Ministry of Construction (MoC) cost norm of 0.43 to 0.52 kilowatt-hours per cubic meter.

18.3.3 Approach to EE Management Sóc Trăng

Sóc Trăng does not have any dedicated staff responsible for the management of energy efficiency. Local operational staff will therefore be essential in ensuring that opportunities to improve energy efficiency are identified and implemented where possible.

Energy efficiency is not assessed through any formal programme of energy efficiency audits and there is no defined energy efficiency strategy. There are no personnel dedicated to the management of energy efficiency issues, although staff from the Planning-Technical-Material division are tasked with day to day EE management in addition to other duties.

Accurate power metering is available at site level, but more detailed accurate submetering is unavailable. In the returned questionnaire, the company confirmed that, with the data available, it is possible to gauge when assets are deteriorating.

Sóc Trăng's approach to energy auditing has been graded according to the criteria in table D.133.

Table D.133: Quality Grade for Energy Efficiency Auditing Approaches

Grade	Process
D	No process for auditing of energy efficiency, limited understanding or collection of energy efficiency data
C	Internal assessment of energy consumption for individual plants on a regular basis (often monthly), with the energy consumption of the plant compared with historical values and any changes noted and investigated on-site

Continued…

C	Detailed audits conducted on-site by an equipment supplier, usually on an ad hoc basis when a piece of equipment has been identified as being life-expired
B	Outline audits conducted on the basis of a walk-around inspection of the plant by suitably experienced internal utility staff, at least annually
A	Detailed audits with extensive and detailed inspection of individual assets, conducted either by an independent external auditor or by suitably experienced internal staff, at least 5 years

According to this grading, Sóc Trăng's energy-auditing approach achieves a grade of C/D.

18.3.4 Delivery of EE Management (Operational)

With no dedicated energy management personnel, the company is reliant on ensuring that good operational practices are implemented at its sites, where possible in order to maintain energy efficiency. The company has twenty-two water treatment systems, which will require the future delivery of detailed audits to be targeted initially at larger sites.

Monitoring for asset deterioration is carried out, however peak tariff avoidance is not.

18.3.5 Delivery of EE Management (Capital)

In their returned questionnaire, the company confirmed that capital funding for relatively large investments driven by energy efficiency is not available.

Some energy efficiency measures have previously been completed, including:

- Replacement of life expired or inefficient assets.
- Variable speed drives.
- Soft starters.
- Power factor correction.
- Installation of automated control systems.

These measures were a combination of investment in completely new sites and retrofitting of EE management assets to old equipment.

The company has confirmed that some investment has been made in renewable energy, with a focus on the installation of solar PV equipment at three water treatment works (treating 2-3,000m^3/d). Where this investment has been completed, the solar plant is estimated by the company to contribute around 20-30 percent of the power required to operate the plants.

When installing any new equipment, whole life costs are not currently assessed, which may prevent due consideration from being given to the energy efficiency impact of newly installed assets.

Treatment plant control is partially automated. There is no SCADA system for management of the distribution network or treatment operations.

The company's general approach to energy efficiency management, as discussed in the returned questionnaire, is summarised in table D.134.

Table D.134: General approach to EE

		Sóc Trăng
General approach to EE management	Specific energy(kWh/m^3)	0.369
	WLC assessments for new equipment	No
	Asset deterioration monitoring	Yes
	Granularity of power metering	Site level
	Peak-tariff avoidance	No
	Asset operation	Manual/automatic
	Distribution pressure management	Yes (manual)
	Dedicated energy management staff	No
	Defined energy strategy	No
	Defined EE improvement strategy	No
	Capital budget available	No
EE interventions confirmed as completed	Equipment replacement	Yes
	Power-factor correction	Yes
	Soft starters	Yes
	Variable-speed drivers	Yes
	Automated control	Yes
	Renewable energy	Investment made

Note: EE = energy efficiency; WLC = whole-life cost; — = not available.

Appendix E

Activities done so far under the National Non-revenue Water Program:

Pursuent to the contents and tasks of program implementation under Decision No. 2147/QD-TTg, summarizing the implementation of the Program on some of the following contents:

1. Activities of Ministries and Central agencies:

Reviewing legal framework:

Review and evaluate the implementation status of the orientations for development of water supply in Vietnam's urban centers and industrial parks up to 2025, and a vision towards 2050 (Decision No. 1929/QD-TTg dated November 20, 2009 of Prime Minister) and Circular 08/2012/TT-BXD dated November 21, 2012 guiding the implementation of safe water supply in localities, serving as a basis for submission to the Prime Minister for approval of the adjustments to the development orientations for water supply for urban areas and industrial parks through 2025, with a vision toward 2050 in Decision No. 2502/QD-TTg dated December 22, 2016; National Programme on Ensuring the Supply of Safe Water in the period 2016 - 2025 in Decision No. 1566/QD-TTg dated August 9, 2016.

Review, amend and supplement legal documents, standards, technical codes and economic and technical norms related to water supply; review and evaluate the implementation of the Decree No. 117/2007/ND-CP dated 11/7/2007 on the production, supply and consumption of clean water and Decree No. 124/2011/ND-CP dated 28/12/2011 on amending and supplementing a number of articles of Decree No. 117/2007/ND-CP.

Review and evaluate the implementation of the Joint Circular No. 75/2012/TTLT-BTC-BXD-BNNPTNT dated May 15, 2012 between the Ministry of Finance - Ministry of Construction - Ministry of Agriculture and Rural Development guiding principles and method of determination and competence to decide water consumption price in the urban areas, industrial zones and rural areas; Summary of local water prices. To date, most provincial and cities' People's Committees under central authority have adjusted clean water tariffs. Average water prices in localities range from VND 6,000 to 7,500/m3. The issued clean water tariff gradually reflects the principle of correct, adequate estimations, and is adjusted in accordance with the changes in production and business costs.

Consolidating the Program implementation structure

Addition of more functions and duties relating to safe water supply assurance to the National Program Steering Committee to mitigate NRW by 2025 and rename it to National Steering Committee for Water Supply Security and Prevent Non-revenue Water (hereinafter referred to as the Program Steering Committee); Enhance the Program Steering Committee by adding members from the Ministry of Health and consolidating the operation regulations of the Steering Committee;

Review and development plans to implement the Program's activities in each phase, including specific tasks for each activity.

Monitoring and evaluating the implementation status of non-revenue water program:

Organize interdisciplinary working delegations to inspect and urge in some provinces in the North, Central and South regions with the head delegates from of the Ministry of Construction and participating members being the representatives of the Ministry of Planning and Investment and the Ministry of Agriculture and Rural Development, Ministry of Science and Technology, Vietnam Development Bank, Ministry of Natural Resources and Environment, and some experts in the field of water supply.

Assess the demands and develop plans for capacity building of water supply utilities in the fight against non-revenue water; in which, summarizes the status of system operation management of water supply utilities, organizational structure, the training needs for the non-revenue water program.

Implement public awareness raising campaign:

Implement communication activities via the mass media to raise public awareness about economical water consumption and water supply works protection, including: (1) Building and issuing digital news bulletins 1,2,3,4 giving information about Program activities. Each issue was published about 250 books, and sent to the relevant agencies/units of the relevant ministries; provincial People's Committees, Construction Departments and water supply utilities nationwide; (2) The website of the Administration of Technical Infrastructure (http://www.ati.gov.vn) regularly updates the Program activities, information on technological advances in the production of water equipment, new projects and solutions in the legal documents.

Improve the management capacity of local authorities, water utilities in non-revenue water mitigation:

Successfully organize 6 seminars on implementing the program with different themes in all North, Central and South regions with a total of 700 attendants. Delegates were from the central and local authorities, international organizations, businesses operating in the water sector, consulting organizations, scientific research and training institutes. The seminars brought about various and diverse content contributing to capacity building in the non-revenue water management, public awareness raising in water saving.

The contents of the seminars are: (1) Experience sharing in reducing non-revenue water ratio among water supply utilities; (2) Solutions against non-revenue water; (3) Water supply equipment in the fight against non-revenue water, improving the efficiency of water equipment, assets, pipes and devices; (4) Application of information technology in operation management, asset management and water supply system management.

International collaboration in non-revenue water management:

- Collaborate with the Water and Sanitation Program in small towns in Vietnam to organize workshops for sharing experiences in the fight against non-revenue water, Finland Water Forum; review the contents of the Draft Law on clean water supply.
- Cooperate with the World Health Organization in the implementation of the Water Safety Plan; research and develop a National Program for water safety plan.

- Cooperate with the Ministry of Foreign Affairs of Denmark to develop the content of the non-revenue water mitigation project and set up pilot projects on non-revenue water management in some typical cities.

2. Activities of Provincial and Local People's committees:

- The provincial and cities' People's Committees have instructed water agencies and utilities to develop plans to mitigate non-revenue water in the period of 2017-2020 according to the objectives of the Program. The main contents of the plan include: establishing or consolidating the operation of the Steering Committee for water safety plan and the non-revenue water mitigation at the provincial level (currently the provincial steering committees for water safety and non-revenue water mitigation have been newly established or consolidated in about 46/63 localities, and there are more than 14/63 localities issuing regulations on organization and operation of the Steering Committees); organize and coordinate the implementation of the Program.
- The Provincial Steering Committee for Water Safety and Non-revenue Water organizes annual meeting to review the results of non-revenue water mitigation and the develop plan of the following years. The Committee also directs and urges water supply utilities to prepare and implement water safety plan to reduce the non-revenue water ratio.
- The Provincial and Cities' People's Committees instruct the Department of Construction and the water supply utilities to participate in seminars, conferences to share experiences, and improve the implementation capacity to carry out solutions against non-revenue water.
- Based on local conditions, mechanisms and policies have been issued to mobilize investment capital for network construction, improvement and network management projects in the form of socialization.
- To inspect and supervise the implementation of projects in the locality; evaluate quality, progress, efficiency and periodically report to the Ministry of Construction.

3. Activities of Water utilities

- The water supply utilities in the provinces have actively built a roadmap to reduce the non-revenue water ratio; develop plans and activities to implement the Program at the enterprise; organize water safety plan and non-revenue water mitigation, concentrating on: Completing the organizational structure of water supply utility, ensuring there is management units to implement non-revenue water mitigation activities; training plan, capacity building for employees; technical solutions on network zoning, equipping with software and management and investment devices, replacing and improving the pipeline network; carrying out propaganda to raise community awareness.
- In addition, in recent years with the policy of socializing the water supply industry, many domestic and foreign enterprises and individuals have invested in constructing water supply systems in the forms of BOO, BOT and BT. Many water supply companies have used their own capital and borrowed capital to invest in building a highly efficient water supply system such as Thua Thien - Hue Water Supply Joint Stock Company, Ba Ria-Vung Tau Water Supply Joint Stock Company and Binh Duong Water and Environment Joint Stock Company, Hai Duong Clean Water Joint Stock Company ...

Appendix F

Case Study: Water Pumping Station Efficiency Improvements

Pumping of water, both through the treatment process and in the distribution network, is the single biggest factor affecting energy consumption in the potable water sector. This section outlines the findings and recommendations of one section of an energy efficiency audit completed at a large water treatment works in Vietnam.

The raw water pumping station at the site is equipped with five dry well mounted centrifugal pumps. Raw water from the lake is drawn into the station's wet well via a trash screen to remove large objects. The abstraction depth can be manually adjusted by the Operations team to control the raw water quality.

The pumps date from 1984. Originally they were driven via line shaft and equipped with star delta starters. More recently, the line shaft was removed to improve the reliability of the plant. The original motors were replaced with 75kW close coupled motors, and the star delta starters were abandoned and replaced with soft starters to improve energy efficiency. The pumps have a rated capacity of 450m^3/h at 30m head.

The pumping station consumes around 18.5% of the power for the plant. The main drives are:

- Raw water pumps 1-5, 75kW.
- Vacuum priming pumps 1-2, 2.2kW.
- Sump pump 1.75kW.
- Surge vessel pump 0.55kW.

During the audit, pumps 1,2 and 5 were running. The running currents as displayed on the soft start were noted. Based on the design pump flow rates, delivery head, and other information gathered during the site visit, the pump efficiency was estimated. The key information on drives in this section of the plant is summarised below.

Table 3.13: Summary information for main drives at water pumping station

Name	Starter Type	Motor Power (kW)	Motor Rated Current (Amp)	Voltage (v)	φ	Speed (RPM)	Measured Current (Amps)	Motor Load Factor	Est. Motor Efficiency (%)	Required Hydraulic Power (kW)	η
#1 Raw Water Pump	Soft Start	75	140	400	0.89	1470	102	0.73	91	39.2	0.62
#2 Raw Water Pump	Soft Start	75	140	400	0.89	1470	98	0.70	91	39.2	0.65
#3 Raw Water Pump	Soft Start	75	140	400	0.89	1470	-	-	-	-	-
#4 Raw Water Pump	Soft Start	75	140	400	0.89	1470	-	-	-	-	-
#5 Raw Water Pump	Soft Start	75	140	400	0.89	1470	109	0.78	91	39.2	0.58

The estimated efficiency of the pumps was around 60%, which is below the typical efficiency expected of large modern centrifugal pumps, typically around 80-85%.

While the removal of the original line shaft and installation of soft starts (in place of the original star delta starters) reduced wear and tear on the pumps and offered an increased energy efficiency, the pumps had been in service for over thirty years and replacement was identified as beneficial for energy efficiency.

In order to allow an outline assessment of the potential savings that could be made from the installation of new pumps, a recommendation for replacement pumps was taken from a major manufacturer of centrifugal pumps.

Based on the information gathered during the audit, the manufacturer recommended the following replacement pump:

- 55kW IE2 motor, 3ph, 400v.
- Flow at 31m head 450m3/h.

At the design duty point, the combined efficiency of this pump and motor would be around 81% and each pump would consume around 48kW, representing a saving of around 19.4kW over the current running pump running currents.

Based on a design throughput of 25,000m^3/d, the pumping station would require around 2.3 pumps running on average, equivalent to around 20,238 running hours per annum. Therefore, the annual power saving from the installation of new pumps would be around 393.4MWh/a. Assuming a calculated average power tariff of $0.07 (1,660VND) per kWh, this equates to annual energy savings of around $28,086 (653M VND) per annum.

The indicative installed cost for the replacement pumps is around $20,000 (1.4Bn VND) per unit. Since three of the five pumps in the RWPS are required to run as duty, three could be replaced in order to ensure that any capital investment offered the best possible return on investment, with the remaining original pumps being retained as standby units.

On this basis, the financial aspects of a notional capital investment scheme were favourable, with a 20 year NPV of $352,033 (8.187Bn VND, based on a 3.52% discount rate), and a simple payback period of 2.1 years.

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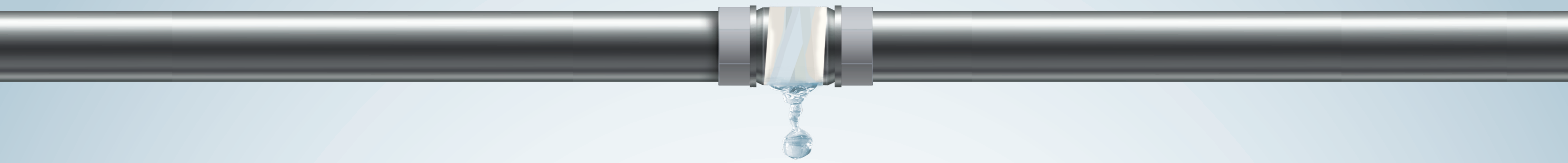

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