Automation with renewable energy to optimize the exploitation of water supply networks in Ninh Thuan province

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Abstract. The research that was conducted on the water supply network of Phan Rang city, Ninh Thuan province, is aimed at using renewable energy to optimize the management and reduce the water loss. The research has conducted DMA (District Metering Area) setup, construction and installation of flow meter and pressure reducing valve chamber for flow and pressure control with active pressure regulation, and the use of hydraulic power generator to generate power at the site. Research results provide management agencies, in particular, water supply companies, with optimal solutions in network management and energy saving, reducing the amount of water loss effectively, thereby increasing revenue and saving clean water - precious resources are gradually depleted.

1 Introduction

Ninh Thuan Water Supply Joint Stock Company manages the water supply network of Phan Rang - Thap Cham city, Ninh Thuan province, with a population of 160,000. The water resource used is the river water and the well water with 3 water treatment plants (WTPs) with total capacity of 61,300m³/day, total length of distribution network is 21,700km and serves for 75,689 people.

The current water supply network in Thap Cham is a round network with total flow managed through the WTPs, with a current water loss ratio of 20%, including invisible loss and visible loss [16]. This research proposes solutions that help Ninh Thuan Water Supply Company manage its water supply network efficiently, save energy and reduce water loss.

The author proposes to divide the water supply network into 15 DMAs, which is a modern management solution [20]. Each district can be independently analyzed using flow meters and pressure transducers to improve system knowledge, to realize the water balance of the area, and to locate water losses. A DMA is a set of nodes enclosed in specified and permanent boundaries defined in order to install the smallest number of metering devices. DMAs identification is commonly realized using an empirical approach based on technical experience [20] even if new methods, survey sound leakage in water supply pipelines

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periodically [21] or graph theoretic and graph partitioning principles used in distributed computing have recently been proposed.

The equipment installed in the DMA for continuous monitoring of flow and pressure makes the water supply company easy to manage. Water supply network management is becoming more and more of a concern in Viet Nam, in the context of clean water resources is increasingly exhausted threatening national clean water security. But mainly on network research, water quality, hydraulic problems and water loss prevention, the equipment management of the water supply network has not been paid much attention while the water equipment is often of high value. In practice, meter, data transmitters (water meters, pressure sensors and dataloggers) installed on the water supply network are mainly installed in underground sites, sometimes flooded difficult to get the power from the electricity where the main power source is the battery installed in the device. Batteries will be depleted after several years of use and must be replaced to ensure stable operation, the cost of replacement batteries often high due to imports from abroad. In this research, the author also recommends the use of hydraulic power generators to generate electricity for on-site consumption, prolong battery life, and save operating and maintenance costs.

The research also proposed a water loss solution for DMA Ngo Quyen, one of the 15 DMAs in Phan Rang - Thap Cham city. In previous researches, the author found that the majority of water losses occurred as mechanical water losses but mainly at the clamp saddle position, service connections [10, 11]. Therefore, to reduce water loss, the study focused on reducing mechanical water losses, regulating the pressure in the DMA based on the partitioning management of the pipe network, such as the PMA (pressure management area) and DMA. PRVs (pressure reducing valves) are installed at the inlet of the PMAs or DMAs and the water pressure inside the zonal network can be regulated by operating the PRVs. To maximize the benefits of pressure management, the installation and operation strategies of PRVs, i.e. quantity, locations and opening adjustment, are optimized [12], when the pressure in the pipeline drops, the water leakage through the hole in the pipeline will decrease [19].

2 Materials and methods

2.1 DMA setup and equipment installation

DMA Ngo Quyen was selected with a pilot scale of 500 connections and did not specify the consumption as well as the leakage rate. DMA is set up by closing the boundary valves and installing the bulk flow meter chamber at the DMA input. This bulk flow meter has a pressure probe and a pressure reducing valve installed at downstream of meter to actively regulate the pressure in the DMA.

Equipment installed in DMA including:

1. Electromagnetic flow meter DN150
 2. Hydroturbine to generate power
 3. Pressure Reducing Valve (PRV) dual setpoint
 4. LS-V Datalogger to archive data (Flow, up- and downstream pressure) and control the PRV
- P1 is upstream pressure, P2 is downstream pressure, P3 is critical point pressure (The critical point is the place in the zone in question (DMA or PMA) at which the lowest supply pressure occurs during the course of the day)
5. LS42 Datalogger to archive pressure at critical point
 6. PCWIN2 SCADA software to store, view and analyze data

Fig. 1. DMA Ngo Quyen.

Fig. 2. Equipment in Water meter chamber – DMA Ngo Quyen.

After installation of equipment, flow and pressure parameters in the DMA collected in 07 days as follows (from 03-06-2017 to 19-06-2017), the pressure valve in fully open mode

Fig. 3. Curve of Pressure – Flowrate after when pressure valve in fully open mode.

Table 1. Report of Pressure – Flowrate (From 13-06-2017 to 20-06-2017).

	Flow	P1 Presure	P2 Pressure	P3 Pressure
Max	37.32 m3/hr	3.22 bar	3.20 bar	2.79 bar
Min	12.00 m3/hr	1.40 bar	1.42 bar	0.85 bar
Average	26.85 m3/hr	2.14 bar	2.11 bar	1.63 bar
Average per day	644 m3/day			

2.2 Model setup

2.2.1 Hydraulic generator renewable energy

Equipment used.
The research uses turbine-powered generator, the flowgoes through and turn the turbine to generate AC power, via a Hydrocharger and save the enegy in battery as DC power to supply to external devices.

Fig. 4. Hydroturbine hydraulic generatorstructure.

This DMA uses Hydros-pin 6” YOGEV 20W, the power generated and headloss versus flowrate as following:

Fig. 5. Hydros-pin 6” YOGEV 20WProducts Power Output- Power vs Flow-Rate & HeadLoss.

Operating mode of the equipment

The equipment installed bulk meter chamber that requires power include: electromagnetic flowmeter and LS-V Datalogger. In which the electromagnetic flowmeterand LS-V operatecontinuity 24/7, LS-V is set to send data of flow, up- and downstream pressure with interval of every 15 minutes.

Preliminary estimates of energy generated from hydroturbine, with a water flow of 580.86 m3/day (about 24 m3/h). With this flow rate, based on the table, the power generated is about 5W. ISOMAG electromagnetic flowmeter have a power consumption of about 4W, to ensure a stable and reliable metering, the author suggests that the meter be powered directly from the battery and that only the power from the Hydroturbine should be used for LS-V Datalogger.

2.2.2 Adjusting pressure reducing valve to reduce water losses

Pressure-flow results are recorded and displayed as curve plotting using the PCWIN2 SCADA software as follows:

Table 2. Report of Pressure (From 13-06-2017 to 20-06-2017).

	P1 Presure	P2 Pressure	P3 Pressure
Max 02:00 – 04:00 a.m	3.22 bar	3.20 bar	2.79 bar
Min 10:00 – 11:00 a.m	1.42 bar	1.40 bar	0.85 bar
Average	2.14 bar	2.11 bar	1.63 bar

Fig. 6. Curve of Pressure – Flowrate before pressure regulating.

The results of input pressure monitoring and pressure points P1, P2, P3 showed that at low demand hours, pressure P3 was up to 2.79 bar, 1.94 bar higher than the minimum pressure, this was Excessive unnecessary pressure can be cut to reduce the rate of mechanical water loss during night time due to leakage. According to Vietnam standards, pressure requirements at each point of the water supply network must be at least 0.1 bar. The research conducted pilot setting pressure reducing valve in two stages. Pressure control schedule.

Stage 01: (21-06 to 30-06-2017): Maintain downstream pressure at setpoint, Pressure P2 = 1.7 bar.

Table 3. Report of Flow – Pressure (From 23-06-2017 to 30-06-2017).

	Flow	P1 Presure	P2 Pressure	P3 Pressure
Max	38.04 m3/h	3.34 bar	1.93 bar	1.51 bar
Min	10.92 m3/h	0.96 bar	0.96 bar	0.53 bar
Average	24.63 m3/h	2.15 bar	1.66 bar	1.19 bar
Average per day	591 m3/day			

- Stage 02: (01-07 to 29-07-2017): Maintain downstream pressure at dual-setpoint
- High demand 05:00 – 22:00: High pressure (P2 = 1.7 bar)
 - Low demand 22:00 – 05:00: Low pressure (P2 = 0.9 bar)

Table 4. Report of Flow – Pressure (From 15-07-2017 to 22-07-2017).

	Flow	P1 Presure	P2 Pressure	P3 Pressure
Max	36.48 m3/h	3.07 bar	1.93 bar	1.47 bar
Min	6.48 m3/h	1.38 bar	0.55 bar	0.16 bar
Average	23.04 m3/h	2.08 bar	1.48 bar	1.02 bar
Average per day	553 m3/day			

The LS-V Datalogger controls the 3-way solenoid valve on the pressure reducing valve to switch between high pressure and low pressure mode. The chart below shows the pressure correlation before and after two modes of pressure regulation.

Fig. 7. Curve of pressure before and after pressure regulating.

3 Results

Hydraulic generator renewable energy. Based on the average daily flow, monitoring Hydroturbine parameters from 29/05/2017 to 06/06/2017, the electricity generated by the flow as follows:

Table 5. Power generated and consumed of Hydroturbine.

Date	Gernerator Power (W)	Power consumption (W)
29/05/2017	0.807	0.017
30/05/2017	0.773	0.016
31/05/2017	0.898	0.016
01/06/2017	0.699	0.016
02/06/2017	0.728	0.016
03/06/2017	0.831	0.017
04/06/2017	0.737	0.017
05/06/2017	0.733	0.017
06/06/2017	0.748	0.059

Calculated results show that the Hydroturbine Device generates enough power to supply the LS-V Datalogger with continuous and stable operation.

Regulate pressure in DMA

Comparing the average daily flow after 02 stages of pressure regulating

- Stage 1: Average daily flow reducing from 644 m3/day -> 591 m3/day: Save 53.0 m3/day (8.2 %)
- Stage 2: Average daily flow reducing from 644 m3/day -> 553 m3/day: Save91.0 m3/day (14.1 %)

Fig. 8. Curve of Pressure – Flowrate before and after pressure regulating.

The curve above shows that the minimum night flow has decreased after pressure regulation

Comparing the minimum flow during off-peak periods before and during the pressure regulating, it was found that reducing the off-peak pressure from 2.11 bar (before pressure control) to 1.7 bar and 0.9 bar (during automatic pressure regulating) would reduce flow through bulk meter 8.2% and 14.1% of DMA total flow. This reduced flow is the loss of water that is reduced by regulating the pressure in the DMA.

4 Conclusions

Hydraulic generator renewable energy.

The Ngo Quyen DMA has a small scale, with a small supply of water so that the generated electricity is just enough to operate the LS-V datalogger. But when installed in the pipe with enough flowrate or large pipelines, installed on by-pass to limit the pressure loss on the main tube, at 6 "diameter, the generated power can be up to 20W for the flow rate of 150m3/h. Electricity can be used for severla devices at the same time with fully calculated power.

Fig. 9. Hydroturbine provided power with a 4" Swing unit for 20"-diameter pipes right near the reservoir.

In above picture, the unit was installed using a 4" bypass and the partial closing of a valve so that a minimum of 20-30 m³ per hour flow through the bypass and spin the turbine. The power is produced to operate a MOSCAD® controller.

Therefore, the hydraulic power generation is renewable energy solutions that can be applied on wide variety of water supply network, in many installation conditions and different size pipe. When installing it should be noted that the pressure loss when passing through the mini generator, this pressure loss can be very high with low pressure places, affecting the pressure of water users.

Regulate pressure in DMA

Active pressure regulation at input according to critical points needs to be rapidly deployed on a large scale. However, when implementing pressure regulation to critical point, it is necessary to consider the most appropriate thresholds for each District Metering Area (DMA), based on the characteristics of consumption and time pattern of main water user in water supply area. Qualitative and quantitative determination of losses in each water supply area should be carried out before implementation the solutions to reduce water loss [28, 29].

This is necessary, because in a situation where the water supply network is severely degraded, leakage prevention by leak detection does not solve the problem of new leakage points after repairing. When regulating low pressure, the flow through the customer meter is also reduced. Therefore, it is necessary to study the correlation between water pressure and demand of customers when implementing regulation. If calculated, maintaining a sufficient pressure for living needs will help to save the water used in the tap. This will reduce the burden of water supply to water treatment plants.

The Ninh Thuan Water Supply Company also noted previously in the DMAs behind DMA Ngo Quyen (after crossing the Thong Nhat Bridge) the pressure was usually very low, but after the installation of the pressure regulator, pressure increased. This shows that pressure regulation not only reduces water loss, but also transfers excess pressure at DMA Ngo Quyen to lower pressure areas, which increases the quality of water supply services.

Fig. 10. DMA Ngo Quyen and around area.

Next research direction

In the next research, the author will study the correlation in terms of pressure between DMAs in a water supply area after pressure reducing valve installation.

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