Introducing Advanced Pressure Management at Enia utility (Italy): experience and results achieved

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Abstract

This paper aims to demonstrate that through the practical application of advanced pressure control methodologies, a significant improvement in the efficiency of distribution systems is feasible and can also provide an example to encourage other utilities to improve their performance.

The advanced pressure management strategy applied by Enia utility (Italy) includes the installation of :

- an advanced system which continuously adjusts and controls the pressure of water going into a DMA so that under all demand levels, low to high, the average zone pressure is kept to the minimum required, consistent with good service;
- a micro-turbine which uses the pressure difference produced by the PRV to produce electric energy and make all monitoring devices installed in the PRV chamber self sufficient in terms of electric supply;
- a monitoring system which allows pressure and flow data to be collected from each DMA or PMA;
- a decision support tool which allows Minimum Night Flow (MNF) profiles to be analysed, in conjunction with pressure profiles recorded by other pressure loggers strategically placed inside the DMA at the average zone point (AZP) and at the critical point (CP), to identify where an intervention with active leakage control is economically justified.

The strategy selected by Enia utility (Italy) in order to address and reduce water leakage within their water distribution systems was to implement District Metered Areas (DMA) and Pressure Management Areas (PMA). Real Losses calculated from Night Flows and Water Balance (each with confidence limits) are compared using a specialist software that provides a more reliable estimate of Real Losses in each DMA, improving overall management of DMAs with an economic intervention calculation for Active Leakage Control. The leakage reduction programme has been implemented so far in more than 94% of the total length of the network (4590 km), where the distribution systems were divided into more than 315 DMAs. DMA creation also allowed a more efficient pressure management. The project since 2001 has obtained more than 16% reduction of the per capita daily inflow and more than 28% reduction in the number of repairs, mainly due to pressure reduction and focused network renewal.

Introduction

Enìa is a municipally owned utility, which serves the provinces of Piacenza, Parma and Reggio Emilia in Northern Italy. Enìa Reggio Emilia is the department serving approximately 515,000 in 45 municipalities in the province of Reggio Emilia.

In 1989, Enìa Reggio Emilia, which has been pioneering water loss management in Italy, started its first project on leak detection and in 1993 initiated a water loss management project including the sectorisation of the distribution system through the establishment of District Metered Areas (DMAs) using enhanced flow metering and SCADA capabilities.

Enìa Reggio Emilia adopted the IWA methodology as best practice in October 2004 and in 2005 the Regulator in Emilia Romagna decided to adopt the IWA methodology as well.

This paper describes the activities and the results achieved by Enìa Reggio Emilia through the introduction of advanced pressure management as part of implementation of IWA methodology.

The pressure management strategy in Enia

The strategy selected by Enìa Reggio Emilia in order to achieve an efficient management of Non Revenue Water was to complete the implementation of District Metered Areas (DMA), introduce calculation of IWA water balance and PIs, optimise Pressure Management, set up of a monitoring system and implement a methodology to analyse Minimum Night Flow (MNF) profiles and compare Real Losses calculated from Night Flows and Water Balance.

In regards to advanced pressure management, various technologies have been introduced to optimise achievable benefits and to allow implementation even in places without availability of electric energy.

DMA creation and monitoring

The leakage reduction programme has been implemented so far in 4590 km of the network, representing 94% of the total length of the network, where the distribution systems were divided into around 315 DMAs.

In some cases, DMA creation also allowed a more efficient pressure management with reduction of average system pressure up to 20%. This methodology is relatively new in Italy, but is now recognised being both appropriate and effective.

To enable efficient control of recoverable losses, DMAs are being used both to identify and reduce recoverable leakage in the short term and then to monitor and control leakage in an ongoing manner.

A sensitive flow measurement device is permanently installed onto the inlet pipes to each DMA and flow and pressure profiles are recorded using data loggers. These profiles are transmitted via GSM to a personal computer in the Enìa control room (see following figures) and allow real time monitoring of each DMA.

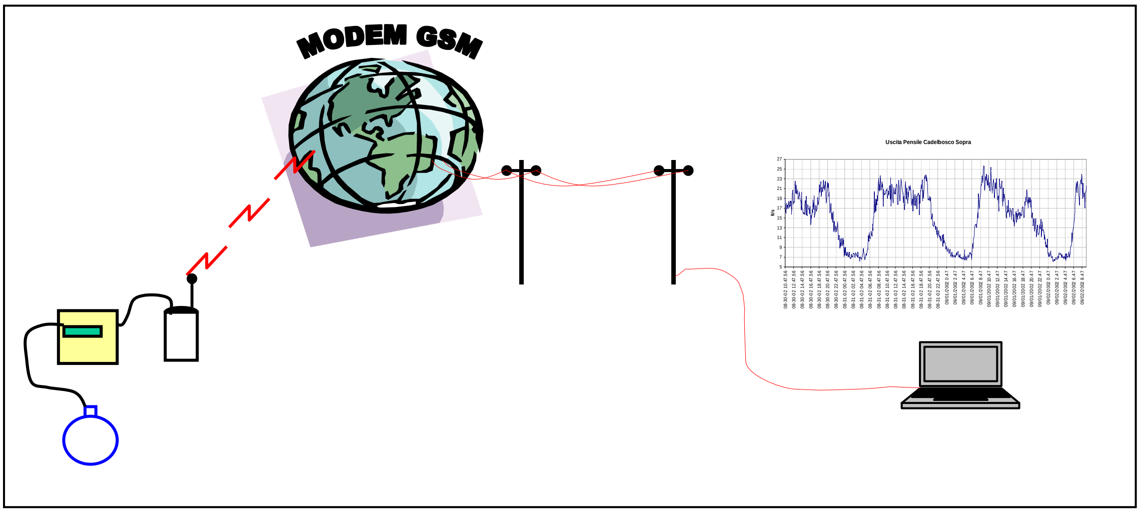

Figure 1.1 Monitoring system of District Metered Areas

For each DMA, Minimum Night Flow (MNF) profiles are analysed, in conjunction with pressure profiles recorded by other pressure loggers strategically placed inside the DMA at the average zone point (AZP) and at the critical point (CP), to identify where an intervention with active leakage control is economically justified.

This methodology allows Enia engineers to prioritize areas of high leakage and to quantify the rate of rise of unreported leaks to be used in payback calculation and in calculation of intervention frequency with active leakage control.

Figure 1.2 Data loggers and a measurement point

After high leakage areas are identified and leakage volume is quantified, the individual leaks are located by step tests and acoustic detectors (leak noise correlators, geophones and noise loggers). Once the DMA has been cleared of detectable leaks, a pressure-dependent baseline flow is determined and the area is monitored to identify when leakage starts to develop again.

A specialised software, introduced in 2005, has been progressively applied to all existing DMAs, enabling Enìa to compare real losses calculated from night flows and water balance, to quickly identify deficiencies in management of real losses, and likely priorities for action. The software is now in use also in other Italian Utilities.

At Enìa, there is now an automated process that determines the average flow rate for each DMA between 3,00 and 4,00 a.m.. Each morning it is possible for each DMA to compare the average night flow rates with established benchmarks and calculate the difference between the benchmark and the most recent night flows.

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Pressure management in Enìa

Pressure Management in Enìa has been progressively implemented from 2004 in District Metered Areas in need for optimisation.

Enia used the following approach when implementing effective management of system pressures in its water systems:

- Step 1: Assess probability of Pressure Management opportunities, based on type of supply (gravity or pumped) and average pressure, according to a basic methodology developed by the authors for international application.
- Step 2: Proceed to investigations and predictions in individual sectors of a system, using best practice methodology.

- Step 3: Identify opportunities for achieving economic management of operating pressures, to reduce frequencies of new leaks, and flow rates of running leaks.
- Step 4: Select what type of pressure management is most appropriate

The most appropriate type of control is determined by the field conditions measured in the above stage.

This process has become much easier to accomplish during 2007, as there are now software packages specially developed by Allan Lambert, that allow the user to process field measurements collected at selected key points (inlet point, average zone point and critical point) and assess probability of pressure management opportunities for each of the three types of basic controls available (Fixed Outlet, Time Based and Flow Modulated). Furthermore it is possible to assess achievable economic benefits in individual sectors of a system and to select what type of pressure management is most appropriate.

Above strategy selected by Enìa has been applied in a number of DMAs in the last few years.

Technologies for advanced pressure management applied in Enia

<u>Advanced pressure controller</u>

In order to further reduce losses, advance pressure management with a self learning algorithm has been introduced in 2009. The aim with this system is to keep the pressure at the critical point (P3) at the target level by modulating the PRV output pressure (P2). The modulation is done by a self learning algorithm that takes into account the head loss between P3 and P2 with regards to the flow and the time. As the head loss in the DMA between the PRV and the critical point changes with changing demand patterns, the output pressure of the PRV (P2) must be continually adjusted in order to achieve this. The equipment used to achieve this are:

- Advanced pilot valve installed at the PRV and controlled by the controller,
- Controller which measures pressure upstream of the PRV (P1), P2 and flow,
- P3 pressure sensor at the critical point.

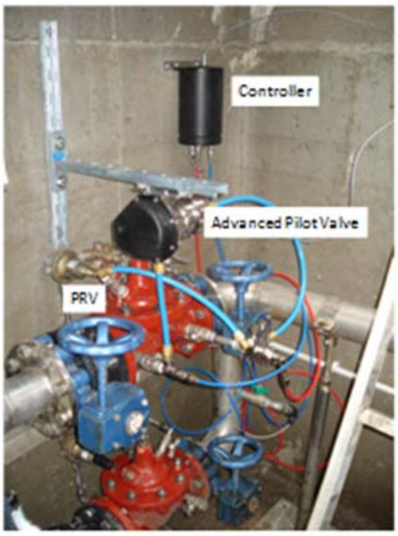

Figure 1.3 Installation of the self learning algorithm system

All the information collected from the controller and the P3 sensor is processed in a sophisticated self learning algorithm in an Open Loop configuration. The algorithm automatically learns the head loss characteristics of the DMA taking into account the minute of the day, the day of the week and the month of the year; and downloads optimised control parameters to the controller every day. The controller communicates with the server once a day using the GSM network. During each communication, the latest pressure and flow data are uploaded to the server and updated control parameters are downloaded to the controller. A sensor at the critical point (P3) also sends the latest pressure data to the server over the GSM network.

The system is standard for all common types of PRVs and easy to install. Once it is installed the system is set up to maintain the previous fixed outlet pressure during two weeks. During these two weeks, the self learning algorithm is learning how the DMA works. After these two, weeks the systems starts to modulate P2 to achieve P3 target. The information of the system is accessed through a user friendly secure web interface.

Micro turbine

One of the problems related to use of data loggers and PRV, specifically in remote locations, is availability of electric energy. As while reducing pressure, PRVs dissipate energy, a device has been recently developed in Pisa (Italy) in collaboration with local water utility to produce energy by using the difference in pressure created by the PRV. This small turbine (12-24 Volts) needs only 8 meters of pressure reduction in order to generate enough energy to supply all equipment for data logging and data transmission usually installed in the chamber. So far 18 micro turbines have been already installed in various locations on Enia water system.

Following figure shows the micro turbine installed in a chamber and relationship between difference in pressure at the PRV (delta P) and Energy produced in watts.

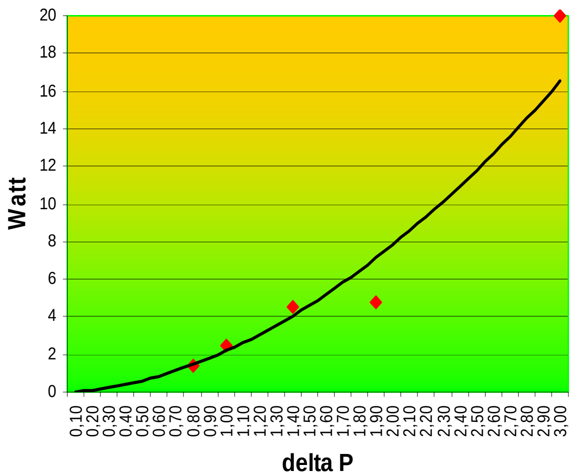

Figure 1.4 Micro turbine and energy produced as a function of delta P.

Results achieved in Coviolo pilot district

Pressure control was introduced in the Coviolo DMA (12,89 km mains, 330 connections) in 2005. The network is quite old and the pipes are in poor condition making pressure control a very effective solution. In Coviolo real losses and bursts frequency have both been reduced by more than 50%. The return of the investment has been estimated in the order of few months.

To further improve performance of the system, the next step has been the introduction of advanced pressure management to maintain pressure between 20 and 23 metres at the critical point according to flow and fire fighting requirements.

The results obtained with the self learning algorithm advance pressure management where very positive and very close to what was expected from a theoretical point of achievement. In general terms, during the time where target P3 was set up at 23 meters, the system generated a 13,8% reduction in pressure and a 15,3% reduction in leakage. During the period in which P3 target was established at 23 m during the day and 20 m during the night, the system achieved a 15,3% reduction in pressure and a 16,7% reduction in leakage.

The data before and after the implementation of the pressure management system are shown in the following table where, as an initial assumption, night consumption has been considered constant.

Table 1: Coviolo data

	BEFORE	AFTER	
	P2 at 33 m	P3 target at 23 m	P3 target at 23 m day / 20 m night
Time Period	24th Feb – 7th March	19th March – 1st April	3-7th April
MNF (m3/h)	5,04	4,608	4,5
HTD factor	22,35	24,2	26,5
Leakage	43,8	37,1	36,5
AZP	32,6	28,1	27,6
Max AZP	35,4	29,6	26,5
Leak reduction		6,7	7,3
AZP reduction		4,5	5,0
Leak reduction		15,3%	16,7%
AZP reduction		13,8%	15,3%

Also we can see from the graph below how the self learning algorithm system always maintains the pressure above the target level with a variation of 1,5 m above the target P3. Also the system was very positive in responding to different target levels for P3 during the night and the day.

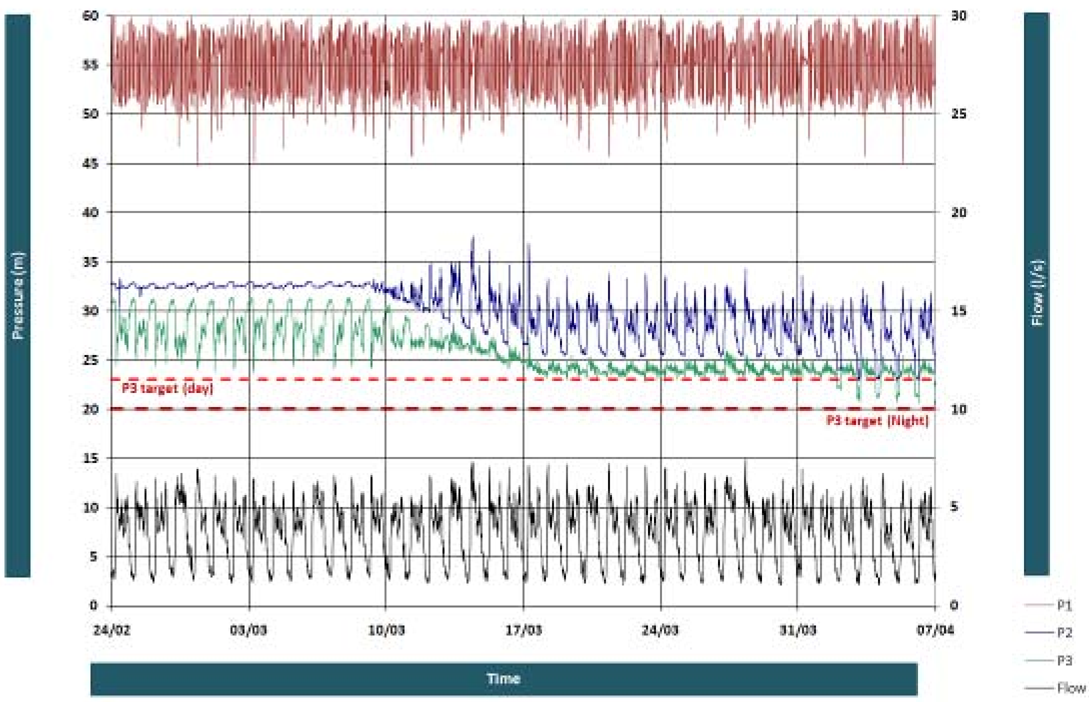

Figure 1.4: Pressure and flow in Coviolo dma

The following graph illustrates the recorded flow related head loss between the PRV outlet and critical point. It can be seen that pressure losses of up to 11m have been recorded. The graph illustrates the classic increase in the variability of pressure difference with flow.

This reduction in pressure had no influence on consumer's standard of service for water supply.

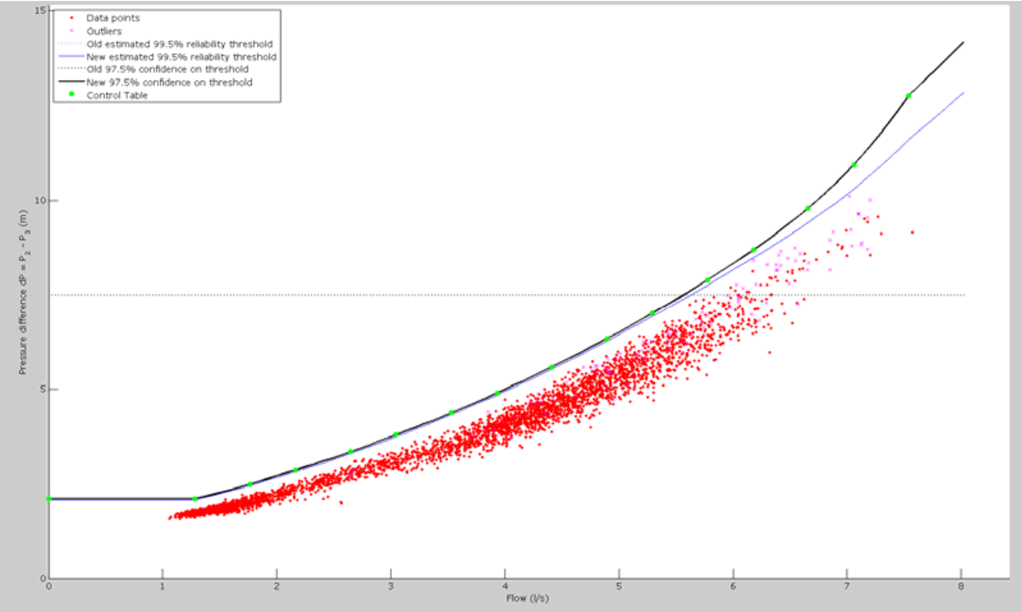

Figure 1.5: Recorded flow related pressure between the PRV outlet and critical point in Coviolo dma

Results and Discussion

The benefits achieved to date with pressure management implementation according to above methodology include: reduction of leakage rate, reduction of bursts frequency, reduction of time of response in case of leakage, optimized reduction of pressure according to real live data, reduced energy consumption, etc..

In the city of Reggio Emilia, the PM program, in the last four years (from 2004 to 2009) had a major role in obtaining:

- more than 13% reduction of the per capita daily inflow,
- more than 28% reduction in the number of bursts,
- more than 16% reduction in per capita consumption (from 113 to 94 mc per capita per year).

This paper demonstrates that through the implementation of advanced pressure management methodologies, a significant improvement in the efficiency of distribution systems is feasible.

The main lessons which can be learnt from Enìa pressure management project are:

- The first step in water loss management is the application of IWA methodology and calculation of IWA best practice water balance and performance indicators;
- By introduction of DMAs and Pressure Management significant reduction of Real Losses and of Frequency of Bursts can be achieved;

- By introduction of advanced technologies for Pressure Management further reduction of Real Losses and of Frequency of Bursts can be achieved, even compared with already existing pressure management solutions. In Coviolo dma a 13,8% reduction in pressure generated a 15,59% reduction in leakage;
- Micro turbines allow the implementation of pressure management solutions even in sites where electric energy is not available or very expensive to get;
- The use of specialist software gives the ability to monitor and analyse night flows, to calculate leakage components, to quickly quantify in advance achievable benefits of pressure management and therefore to justify implementation off advanced pressure management options;

Results achieved are encouraging Enìa to extend the analysis to all water systems and implementation of pressure management in all DMAs where it is proven to be effective.

The example of Enìa is like a champion in Italy, encouraging other utilities in the country to implement or further extend the use of IWA approach and application of advanced pressure management solutions.

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