Experience and results achieved in introducing District Metered Areas (DMA) and Pressure Management Areas (PMA) at Enia utility (Italy)

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Keywords: Water Balance; DMA; Pressure Management

Abstract

This paper aims to demonstrate that through the practical application of advanced methodologies, a significant improvement in the efficiency of distribution systems is not only feasible, but can also provide an example to encourage other utilities to improve their performance. 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 93% of the total length of the network (4850 km), where the distribution systems were divided into more than 260 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 20% 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. Total length of distribution system is of around 4850 km.

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 implementation of IWA methodology associated to the ongoing water loss management project.

The strategy

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. For this purpose a special software (named StiperzEnia) has been developed by ILMSS Ltd (Allan Lambert) and translated into Italian by Marco Fantozzi.

In addition the analysis of customer meters performance and the definition of a meter replacement programme is actually ongoing.

This ‘holistic’ approach needed the involvement of all Utility staff and training initiatives and workshops have been organized to involve and motivate all personnel.

NRW calculation

The initial step in 2004 has been to do a water audit and to calculate the water balance and PIs for all systems managed by Enìa Reggio Emilia.

The consultant team guided Enìa in converting its water audit into the IWA format, making it the first water utility in Italy to apply this method. Enìa now conducts its water audit on a year schedule. The ILI data set for year 2007 for the systems managed by Enìa Reggio Emilia is shown in following figure.

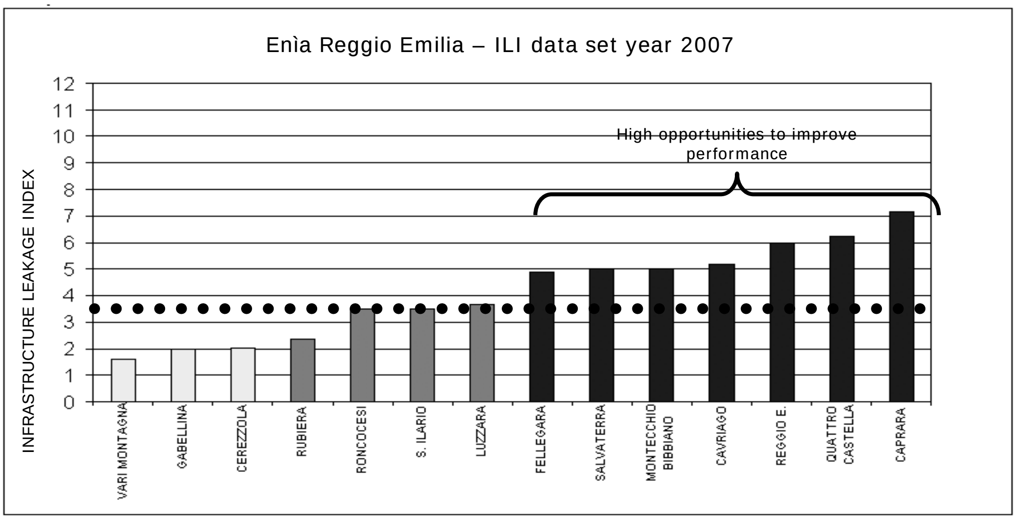


Figure 1.1 Enìa Reggio Emilia ILI data set for year 2007

In Enìa, the IWA water audit now is not only a business practice but also a means by which the regulatory agency (Region Emilia Romagna) can assess the efficiency of water suppliers.

DMA creation and monitoring

The leakage reduction programme has been implemented so far in 4506 km of the network, representing 93% of the total length of the network, where the distribution systems were divided into around 260 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.

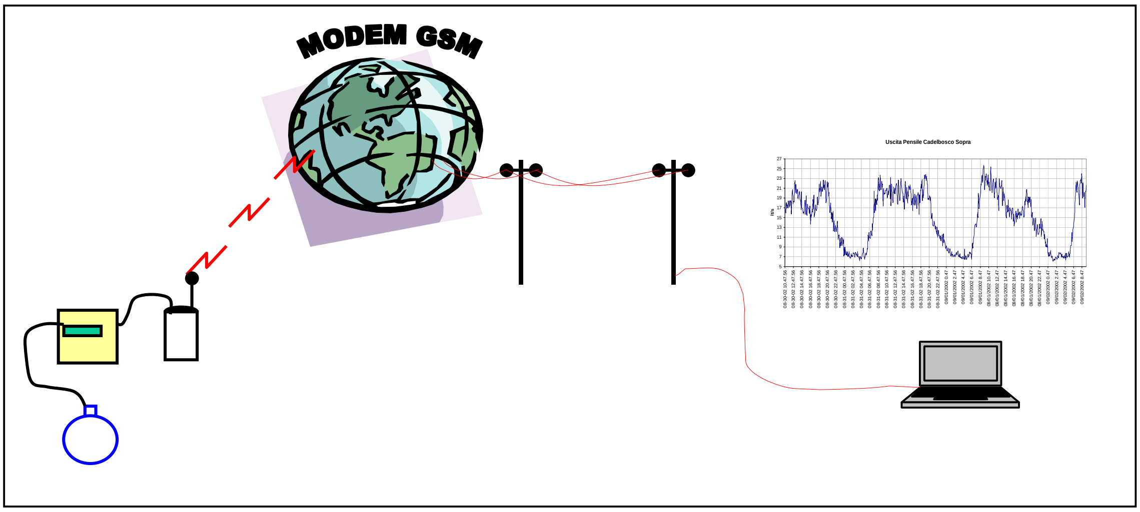


Figure 1.2 Monitoring system of District Metered Areas

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.

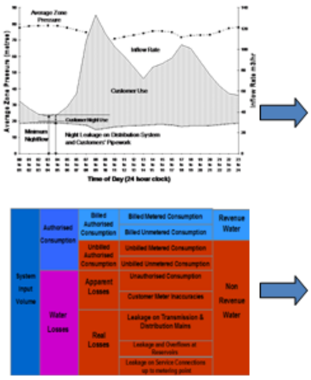
Figure 1.3 Data loggers and building a measurement point

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.

Minimum Night Flow (MNF) analysis and comparison of Real Losses calculated from Night Flows and Water Balance

Enia selected the engineering firm of Marco Fantozzi to implement a methodology to analyse Minimum Night Flow (MNF) profiles and compare Real Losses calculated from Night Flows and Water Balance. The task has been completed by developing StiperzEnia software (LEAKS) customised to accomplish with specific needs of Enìa.

Real Losses calculated from Night Flows and Water Balance and the Best Estimate are shown in following figure for a DMA.



REAL LOSSES CALCULATED FROM MINIMUM NIGHT FLOWS		Beginning 04/03/2004	End 20/02/2005	Days 353
	Estimates >	Lower	Best	Upper
NIGHT LEAKAGE RATE	m3/h	4,87	5,47	6,07
NIGHT DAY FACTOR	Hours/day	17,8	18,7	19,7
REAL LOSSES	m3/day	90,0	102,5	115,0
REAL LOSSES CALCULATED FROM WATER BALANCE		**Beginning** 01/03/2004	**End** 01/03/2005	**Days** 365
	Estimates >	Lower	Best	Upper
REAL LOSSES	m3/day	94,5	101,0	107,6
UARL	m3/day	8,5	9,0	9,5
POTENTIALLY RECOVERABLE REAL LOSSES estimate		**Lower**	**Best**	**Upper**
REAL LOSSES	m3/day	95,8	101,8	107,8

Figure 1.4 StiperzEnia Software comparing Real Losses calculated from Night Flows and Water Balance for a DMA in 2004 and in 2005

In following figure you can see Real Losses calculated from Night Flows and Water Balance, Best Estimate, and comparison with DMA specific Unavoidable Annual Real Losses (UARL) for a single DMA managed by Enìa. The assessed reduction in night Real Losses, from 93 to 45 m3/day is clearly evident.

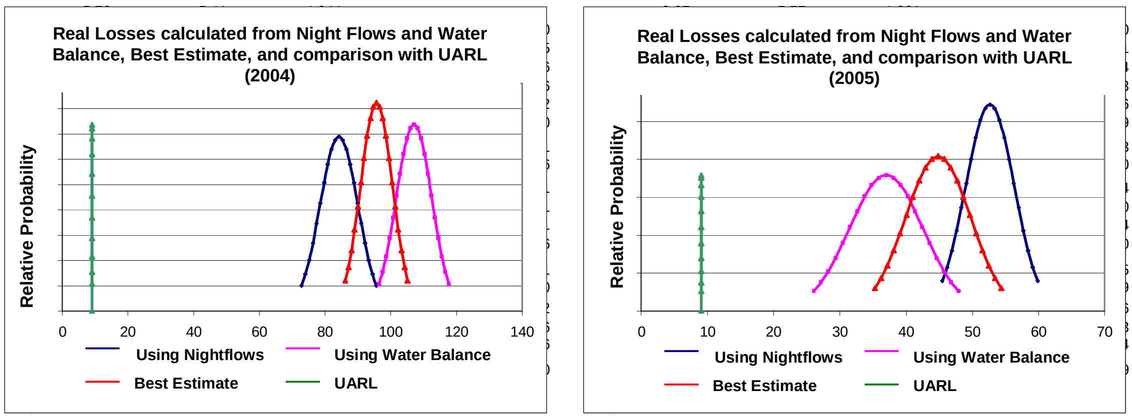
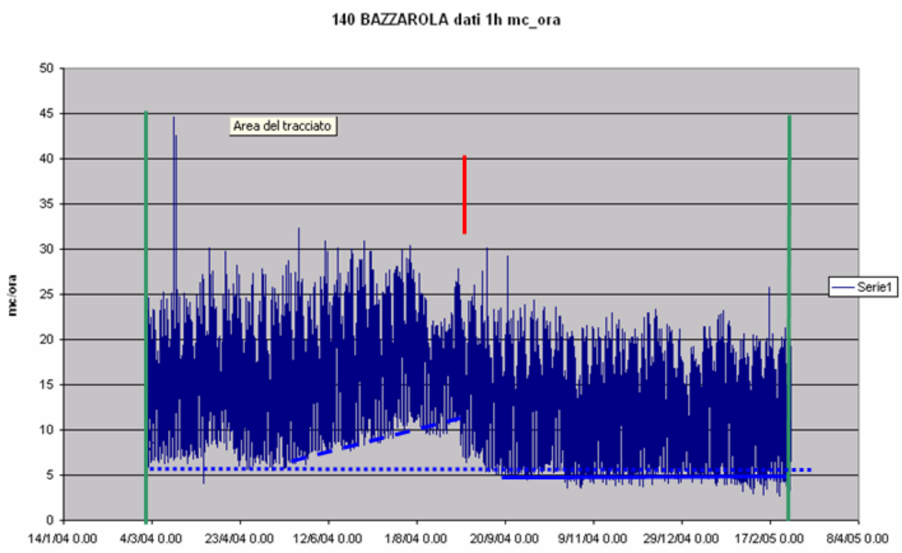


Figure 1.5 StiperzEnia Software comparing Real Losses calculated from Night Flows and Water Balance for a DMA in 2004 and in 2005

Software StiperzEnia, introduced in 2005, has been progressively applied to all existing DMAs, enabling Enìa to quickly identify deficiencies in management of real losses, and likely priorities for action. Two other Italian Utilities now use Stiperzenia (re-named as ANPER software).

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.

As shown in following figure, DMAs with high night flows can then be analysed in detail to reveal burst time and flow rate are quickly identified.



<table>
<tr><td rowspan="4">Suggested colour coding for lines to be added to night flows graph(s)</td><td colspan="2" rowspan="2">Dates when customer meters were read</td><td rowspan="2"></td><td rowspan="4">Average base lines for sequence of night flows</td><td>Easy to define</td><td></td></tr>
<tr><td>Can only be estimated</td><td></td></tr>
<tr><td rowspan="2">Dates when bursts and leaks were repaired</td><td>On mains</td><td></td><td rowspan="2">Average night flow used for comparison with water balance</td><td rowspan="2"></td></tr>
<tr><td>On services</td><td></td></tr>
</table>

Figure 1.6 Pattern of flow analysis for Bazzarola DMA (StiperzEnia Software)

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. After high leakage areas are identified and leakage volume is quantified, the individual leaks are located by acoustic detectors.

Pressure management in Enìa

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

The authors of this paper used the following approach when implementing effective management of system pressures in Enìa:

- 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 (e.g.: PreMOCalcs), 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.

Enìa applied the methodology in a number of DMAs in the last few years including the following examples:

- Brescello DMA, where the network is quite old and deteriorated, flow modulated pressure control were used to maintain pressure between 20 and 27 metres according to flow and fire fighting requirements. In Brescello (26 km mains, 998 conn.) real losses have been reduced by 14% and bursts frequency has been reduced by 33% from 51 bursts/year (around 2 main break/km/year) to 34 bursts/year. Pressure management enabled to get great results with limited investment, but to achieve acceptable performance of the system, active leakage control and selected replacement of connections and mains is now been implemented to further reduce losses and bursts frequency.
- Quattrocastella water system is a large pumped system (145 km mains) which was characterised by excess pressure and high bursts frequency. Inlet pressure has been reduced by 12,5% from 50 to 43,7 metres and frequency of bursts has been reduced by more than 40% as shown in following figure.

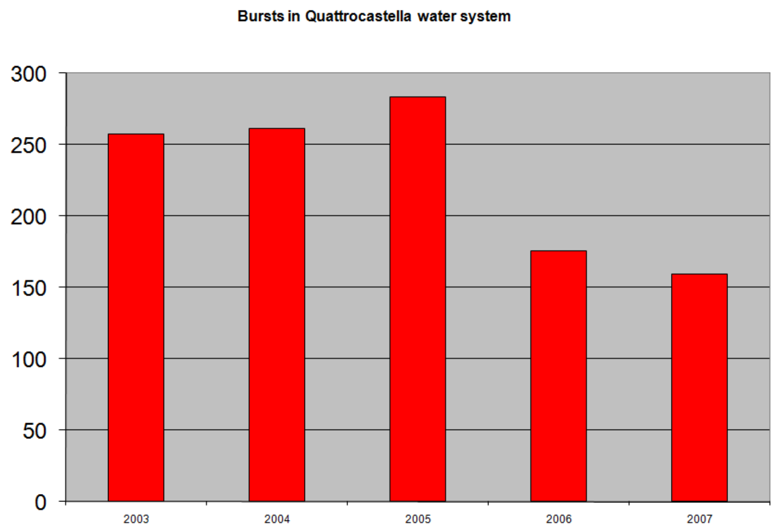


Figure 1.7 Bursts in Quattrocastella water system

The return of the investment in pressure management in both the described cases has been in the order of only a few months, encouraging Enìa to extend the analysis to all water systems and implementation of pressure management in all DMAs where it is proven to be convenient.

Results and Discussion

In Enìa Reggio Emilia, because of the implementation of the NRW program from 1999 to 2008, the ILI for the whole system decreased from 3,9 in 2005 to 3,0 in 2008. The ILI trend from 2005 till 2008 for the whole system managed by Enìa Reggio Emilia is shown in the following figure.

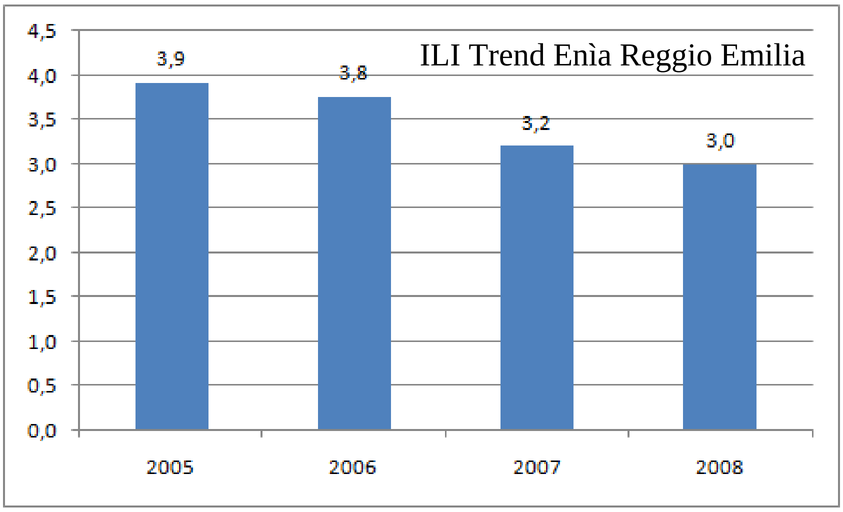


Figura 1.8 ILI data set for Reggio Emilia province from 2005 to 2008

Furthermore, water consumption in Enìa Reggio Emilia, from 1999 to 2008, dropped by 16%, from 113 to 94 mc per capita per year as shown below.

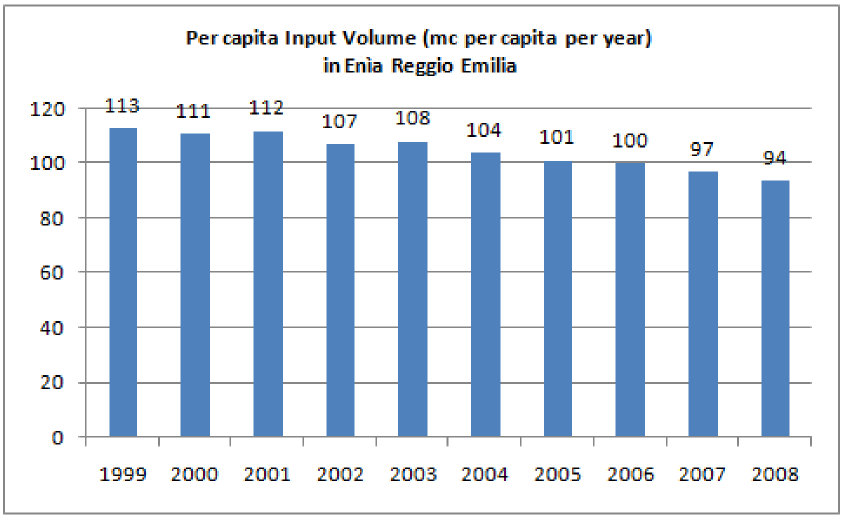


Figure 1.9 Reduction in per capita input volume.

In addition a 20% reduction in the number of repairs, mainly due to pressure reduction and selected rehabilitation has been achieved, as shown below.

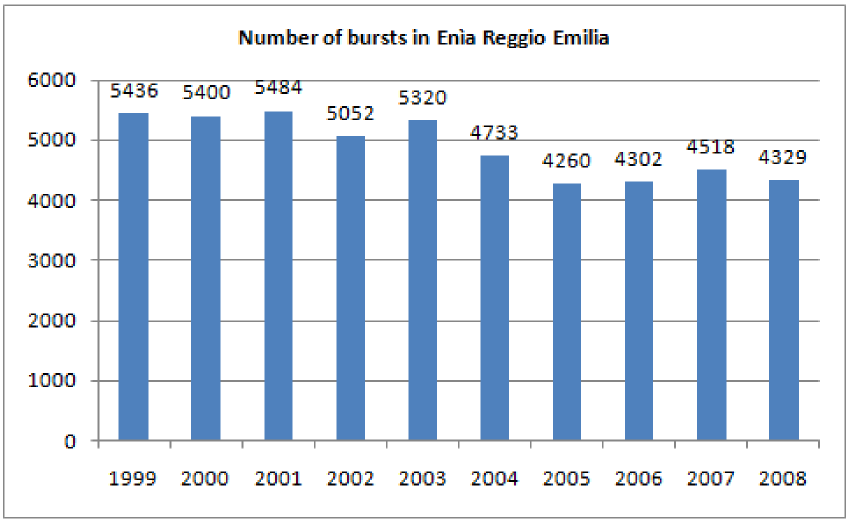


Figure 1.10 reduction in number of bursts

This paper demonstrates that through the practical application of IWA methodologies, the NRW management is feasible as well as a significant improvement in the efficiency of distribution systems.

Main lessons which can be learnt from Enìa NRW project are:

- Leak detection is only one of the many water loss management strategies that can be adopted;
- The first step in water loss management is the application of IWA methodology and calculation of IWA best practice water balance and performance indicators;
- To manage Non Revenue Water, an 'holistic' approach is needed with involvement of all Utility staff;
- Initiatives based on Training workshops and educational softwares can significantly speed up the application of the methods;
- By introduction of DMAs and Pressure Management significant reduction of Real Losses and of Frequency of Bursts can be achieved;
- The use of specialist software can enable to quickly identify deficiencies in management of real losses, and likely priorities for action;
- Apparent Losses have also to be accurately considered. In the case of Enìa the analysis of customer meters performance, the definition of a meter replacement programme and the field test of UFR (Unmeasured Flow Reducer) are activities actually ongoing, to be completed in 2009.

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.

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