No Revenu Water (NRW) commercial losses

RESULTS OF THE PILOT PROJECT
AQUAKNIGHT

A. M. FOURATI
Projet AQUAKNIGHT

exchange experiences and technologies between countries of the Mediterranean Sea Basin in terms of environmental protection through effective management of water resources by improving the efficiency of distribution networks.

This project has been implemented in five pilot areas under the five water companies of Italy, Cyprus, Egypt, Jordan and Tunisia.

This 3-year project is financed by a donation from the European Union.
Projet AQUAKNIGHT

TUNISIA PILOT PROJECT

For Tunisia the partners are

National Water Distribution Utility (SONEDE)

SONEDE International

IEVP CTMED

Programme funded by the EUROPEAN UNION
Presentation Plan

1. Introduction
2. Water Balance
3. Water meters
4. Reduction of commercial losses
   a) Unbilled unmetered consumption
   b) SONEDE experience steps
   c) Results
5. Conclusion
Introduction

Water loss reduction for sustainable development

“ The term *sustainable development* means nothing less than successful business that facilitates greater prosperity and more equitable opportunities and uses natural resources in a way that preserves them for generations to come. Sustainability requires that economic, technical, social and ecological aspects are considered and various fields and levels of society are linked.”

The *Istanbul Water Consensus (5th World Water Forum, Istanbul, 2009)*
Water loss reduction for sustainable
development

Water losses are an obstacle to sustainability, as the following list of potential impacts shows:

• **Economic impacts:**
  – costs for exploiting, treating and transporting water which is lost on its way to the customer without generating any revenue for the water utility.
  – Pipe bursts and leaks necessitate expensive repair works and may also cause considerable damage to nearby infrastructure.

• **Technical impacts:**
  – leakage leads to reduced coverage of the existing water demand, possibly so much so that the system can no longer operate continuously.
    • Intermittent supply will cause further technical problems by air intruding into the pipes and will tempt customers to install private storage tanks.
Water loss reduction for sustainable development

• **Social impacts:**
  - water losses result in customers being adversely affected by supply failures, such as
    • low pressure,
    • service interruptions and unequal supply,
    • health risks which may arise from the infiltration of sewage and other pollutants into pipe systems under low pressure or intermittent supply.

• **Ecological impacts:**
  - compensating water losses by further increasing water extraction places additional stress on water resources and requires additional energy and thus causes carbon dioxide emissions that could have been avoided.
Political aspects

Many countries already have a water strategy in place and consider water loss reduction to be important. However, its implementation is complex as it requires new forms of sharing responsibilities and a change in traditional consumer behavior.

Water loss reduction is sometimes neglected, even if it presents more economical solutions than exploiting alternative water resources, such as e.g. desalination.
vicious circle

- High water losses
- Lack of reinvestments
- No cost coverage
- Low Tariffs
- Low willingness to pay
- Pour Service

Water Utility
## Water balance

<table>
<thead>
<tr>
<th>System input volume</th>
<th>Authorized consumption</th>
<th>Billed water exported</th>
<th>Revenue water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Billed metered consumption</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Billed unmetered consumption</td>
<td></td>
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<tr>
<td></td>
<td>Unbilled authorized consumption</td>
<td>Unbilled metered consumption</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Unbilled unmetered consumption</td>
<td></td>
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<tr>
<td></td>
<td>Apparent losses</td>
<td>Unauthorized consumption</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Customer meter inaccuracies and data handling errors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water losses</td>
<td>Leakage on transmission and distribution mains</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Real losses</td>
<td>Leakage and overflows at storage tanks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Leakage on service connections up to point of customer meter</td>
<td></td>
</tr>
</tbody>
</table>

### Water losses

- **Apparent losses**: Unauthorized consumption due to customer meter inaccuracies and data handling errors.
- **Real losses**: Leakage on transmission and distribution mains, leakage and overflows at storage tanks, leakage on service connections up to point of customer meter.
The elements of the water balance are defined as:

- **System input volume**: the measured system input to a defined part of the water supply system. In systems with substantial exports of water it is also very important to determine the volume of water supplied (system input volume minus billed water exported).

- **Authorized consumption**: the volume of metered and/or un-metered water taken by registered customers, the water utility and other authorised parties. It includes billed authorised consumption (such as billed metered consumption, billed unmetered consumption and water exported) and unbilled authorised consumption (such as unbilled metered consumption and unbilled unmetered consumption). This part of the water balance also comprises leaks and overflows after the point of customer metering as well as the own requirements of the water utility, e.g. for flushing pipes or filter back-wash.

- **Revenue water** (corresponding to billed authorized consumption): the volume of water successfully delivered and billed to the customer and which thus generates revenue for the water utility.

- **Non-revenue water** (NRW): the volume which remains unbilled and therefore does not generate any revenue for the water utility. It can be expressed as the difference between the system input volume and billed authorized consumption or as the sum of unbilled authorized consumption and water losses.

- **Water losses**: the volume of water lost between the point of supply and the customer meter due to various reasons. It can be expressed as the difference between system input volume and authorised consumption, and consists of apparent and real losses. Apparent losses can be subdivided into unauthorized consumption, meter inaccuracies and data handling errors. Real losses are made up of leakage from transmission and distribution pipes, leakage from service connections and losses from storage tanks.
Water balance

- **Water losses**: the volume of water lost between the point of supply and the customer meter due to various reasons. It can be expressed as the difference between system input volume and authorized consumption, and consists of apparent and real losses. Apparent losses can be subdivided into unauthorized consumption, meter inaccuracies and data handling errors. Real losses are made up of leakage from transmission and distribution pipes, leakage from service connections and losses from storage tanks.

- **Real losses**: are water volumes lost within a given period through all types of leaks, bursts and overflows. Real losses can be classified according to their location within the system and their size and runtime.

- **Apparent losses**: are losses that are not due to physical leaks in the infrastructure, but are caused by other factors. Apparent losses can be grouped into the following categories based on their origin:
  - meter inaccuracies due to broken or incorrect customer and bulk water meters
  - data handling and accounting errors and poor customer accountability in billing systems
  - unauthorized consumption due to water theft and illegal connections.
# Water balance

<table>
<thead>
<tr>
<th>System input volume</th>
<th>Billed authorized consumption</th>
<th>Billed water exported</th>
<th>Revenue water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorized consumption</td>
<td>Billed metered consumption</td>
<td>Billed unmetered consumption</td>
<td>Non-revenue water</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Unbilled authorized consumption</td>
<td>Unbilled metered consumption</td>
<td>Unbilled unmetered consumption</td>
<td></td>
</tr>
<tr>
<td>Water losses</td>
<td>Apparent losses</td>
<td>Unauthorized consumption</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Systematic data handling errors</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Customer meter inaccuracies</td>
<td></td>
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<tr>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
Reduction of commercial losses

Low flow increase the Unbilled unmetered consumption

Using the UFR (Unmeasured Flow Reducer)

To reduce the quantity of small flow unmetered (under starting flow)

Improve Customer meter accuracies

Replacing old meters

To avoid errors due to age of the meter
Water Meter

Values of Q1, Q2, Q3 and Q4

The flowrate characteristics of a water meter shall be defined by the values of Q1, Q2, Q3, and Q4.
Flowrate, Q

• **Permanent flowrate, Q3**
  - The highest flowrate within the rated operating conditions, at which the water meter is required to operate in a satisfactory manner within the maximum permissible error.

• **Overload flowrate, Q4**
  - The highest flowrate, at which a water meter is required to operate, for a short period of time, within its maximum permissible error, whilst maintaining its metrological performance when it is subsequently operated within its rated operating conditions.

• **Transitional flowrate, Q2**
  - Flowrate which occurs between the permanent flowrate Q3, and the minimum flowrate Q1, that divides the flowrate range into two zones, the “upper zone” and the “lower zone”, each characterized by its own maximum permissible error.

• **Minimum flowrate, Q1**
  - The lowest flowrate at which the water meter is required to operate within the maximum permissible error.
Flow Meter
Metrological requirements

A water meter shall be designated by the numerical value of $Q_3$ in m$^3$/h and the ratio $Q_3 / Q_1$.

- The values of $Q_3$ shall be chosen from the values that will appear in norms, the following values shall be used:

<table>
<thead>
<tr>
<th>Value</th>
<th>1</th>
<th>1.6</th>
<th>2.5</th>
<th>4</th>
<th>6.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>16</td>
<td>25</td>
<td>40</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>160</td>
<td>250</td>
<td>400</td>
<td>630</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>1600</td>
<td>2500</td>
<td>4000</td>
<td>6300</td>
<td></td>
</tr>
</tbody>
</table>

expressed in m$^3$/h.

The list may be extended to higher or lower values in the series.
The value of the ratio \( Q_3 / Q_1 \) shall be chosen from the following list:

<table>
<thead>
<tr>
<th>10</th>
<th>12.5</th>
<th>16</th>
<th>20</th>
<th>25</th>
<th>31.5</th>
<th>40</th>
<th>50</th>
<th>63</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>125</td>
<td>160</td>
<td>200</td>
<td>250</td>
<td>315</td>
<td>400</td>
<td>500</td>
<td>630</td>
<td>800</td>
</tr>
</tbody>
</table>

The list may be extended to higher values in the series.

The ratio \( Q_2 / Q_1 \) shall be 1.6.

However, for a transitional period of 5 years, \( Q_2 / Q_1 \) may be 2.5, or 4, or 6.3, provided that \( Q_3 / Q_2 > 5 \).

The ratio \( Q_4 / Q_3 \) shall be 1.25.
Courbe de précision de mesure selon la classe métrologique.
Classe R = Q3/Q1
starting flow

This happens down to a limit in which water flow is not capable of moving the sensing element.

This parameter is not defined in any standard and therefore is not officially tested by any manufacturer or metrological institution.
meter inaccuracies

Figure 5. Comparison between the typical error curve of a single jet and a positive displacement meter.
starting flow

The starting flow rate may change depending on several factors. Such as:

- Installation
- Age
- Pressure
- Water Quality (scale-forming water)
meter inaccuracies

Old meter

some consumption is not measured at all because it occurs at a flow rate smaller than the starting flow rate.

the starting flow will increase and the error at low flow will become more negative.
Unbilled unmetered consumption

Every water system has to cope with non-revenue water. Main leaks, theft, tank overflows and unmeasured flow through water meters all contribute to a system’s non-revenue water problem. According to the American Water Works Association (AWWA), 14% of indoor household usage in North America can be attributed to leaks. As residential water meters aren’t designed to register low-flows such as leaks and drips, much of this usage goes un-metered and un-billed.

**THE SOLUTION - THE UNMEASURED-FLOW REDUCER (UFR):**

The UFR captures this low-flow water and forces it through the meter in a way that causes nearly every drop to be registered. Apparent losses are reduced and customers are held accountable for their actual usage.
THE UNMEASURED-FLOW REDUCER (UFR)

HOW THE UFR WORKS
The UFR works by changing the way water flows through the meter at low flow rates. At low flow rates there is not enough energy in the flow to activate the water meter. With the UFR installed, the low linear flows are divided into batches that are forced through the meter at a higher flow rate (see chart below). These higher flows can now be registered by the water meter, reducing apparent losses and increasing revenue.
Experience steps

- Selection of a test zone containing a sample of 59 subscribers.
  - Gravity water supply
- Minimum hill: 10 m
- Maximum hill: 90 m
  - Average pressure: 50 m
  - Age of meters: between 3 and 14 years
  - Nature of pipes: 78% asbestos cement, 22% polyethylene
  - Nature of connections: 100% polyethylene
  - No water fraud
  - No water tanks on the roofs
Experience steps

✓ Verification of the network sealing before the test, through the installation of a data logger on the electromagnetic flowmeter.

Flow monitoring at the inlet of the test zone from 27/03/2013

Minimum Night Flow

MNF = 80 l/h
Experience steps

The reduction of commercial losses is based on the following:

Step 1:
distributed and billed volume without any modification on the network

Step 2:
distributed and billed volume after installation of UFR

Step 3:
distributed and billed volume after replacement of old meters and with UFRs and AMRs

Step 4:
distributed and billed volume after removing UFRs
Experience steps

Results of Step 1

Comparison of distributed volume and billed volume without any modification on the network

- Starting date: 28/03/2013
- Test completion date: 11/04/2013
- Total billed volume: 668,960 m³
- Total distributed volume: 780,033 m³
- Water loss for 14 days: 111,072 m³
Experience steps

Results of Step 1

Flow monitoring from 28/03/2013 to 11/04/2013

- V distributed : 780,033 m³
- V billed : 688,960 m³
- Efficiency : Vb / Vd = 85.8%
Experience steps

Results of Step 2

Comparison of distributed volume and billed volume after installation of UFR

- Date of installation of UFR: from 12 to 23/04/2013
- Date of starting the test: 24/04/2013
- Date of achieving the test: 08/05/2013
- Total billed volume: 890,081m³
- Total distributed volume: 1003,252m³
- Water loss for 14 days: 113,171m³
Experience steps

Flow monitoring from 24/04/2013 to 08/05/2013

V distributed: 1003,252 m³
V billed: 890,081 m³
Efficiency: Vb/Vd = 88.7%
Experience steps

✓ Comparison between results of step 1 & step 2

We can see that the installation of UFR has allowed a net gain of 3 points in the network performance of the test zone:

Efficiency without UFR = 85.8%
Efficiency with UFR = 88.7%
Experience steps

✓ Step 3:
Comparison of distributed volume and billed volume after replacement of old meters and with UFRs and AMRs

- Date of replacement of meters: 09/05/2013
- Date of starting the test: 10/05/2013
- Date of achieving the test: 24/05/2013
- Total billed volume: 1059,675m³
- Total distributed volume: 1045,800m³
- Water loss for 14 days: 13,875m³
Experience steps

Flow monitoring from 10/05/2013 to 24/05/2013

- V distributed: 1059,675 m³
- V billed: 1045,800 m³
- Efficiency: \( \frac{V_{\text{billed}}}{V_{\text{distributed}}} = 98.7\% \)
Experience steps

✓ Step 4:

Comparison of distributed volume and billed volume after removing UFRs

- Date of removing UFRs: 30/05/2013
- Date of starting the test: 31/05/2013
- Date of achieving the test: 14/06/2013
- Total billed volume: 1199,276 m³
- Total distributed volume: 1188,000 m³
- Water loss for 14 days: 11,276 m³
Experience steps

Flow monitoring from 10/05/2013 to 24/05/2013

V distributed: 1199,276 m³
V billed: 1188,000 m³
Efficiency: Vb/Vd = 99.1%
## Results

<table>
<thead>
<tr>
<th></th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume distributed</td>
<td>780,033</td>
<td>1003,252</td>
<td>1059,675</td>
<td>1199,276</td>
</tr>
<tr>
<td>Volume billed</td>
<td>668,96</td>
<td>890,081</td>
<td>1045,8</td>
<td>1188</td>
</tr>
<tr>
<td>Losses</td>
<td>111,072</td>
<td>113,171</td>
<td>13,875</td>
<td>11,276</td>
</tr>
<tr>
<td>Efficiency</td>
<td>85,76%</td>
<td>88,72%</td>
<td>98,69%</td>
<td>99,06%</td>
</tr>
<tr>
<td>Starting Date</td>
<td>28 Mars</td>
<td>24 April</td>
<td>10 May</td>
<td>31 May</td>
</tr>
<tr>
<td>End Date</td>
<td>11 April</td>
<td>08/May</td>
<td>24 May</td>
<td>14 Jun</td>
</tr>
<tr>
<td>Number of days</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Losses Efficiency</td>
<td>2,96%</td>
<td>12,93%</td>
<td>13,30%</td>
<td></td>
</tr>
<tr>
<td>Average mid day temp</td>
<td>20</td>
<td>22</td>
<td>25</td>
<td>26</td>
</tr>
</tbody>
</table>

**Step 1**: volumes distributed and billed without any modification of the network

**Step 2**: volumes distributed and billed after the installation of the RFUs

**Step 3**: volumes distributed and billed after the installation of the new meters equipped with AMR while keeping the RFUs

**Step 4**: volumes distributed and billed with the new meters and the AMRs after dismantling the RFUs
Experience steps
Conclusion

• The installation of UFR reduce the unmetered consumption
• The efficiency increase
• New water meter (class D) reduce the unmetered consumption significantly
• The UFR has no effect with new high precision meter, but after some year !!, who knows.?

This results must be confirmed by an other follow up on a long period
The age and the accuracy of the meter are very important, Water Utility should install a buy and changing strategy for her meters.
Thank You for your attention