UNIVERSITÀ DEGLI STUDI DI PALERMO

DICAM

New trends and research perspectives towards a more sustainable environment

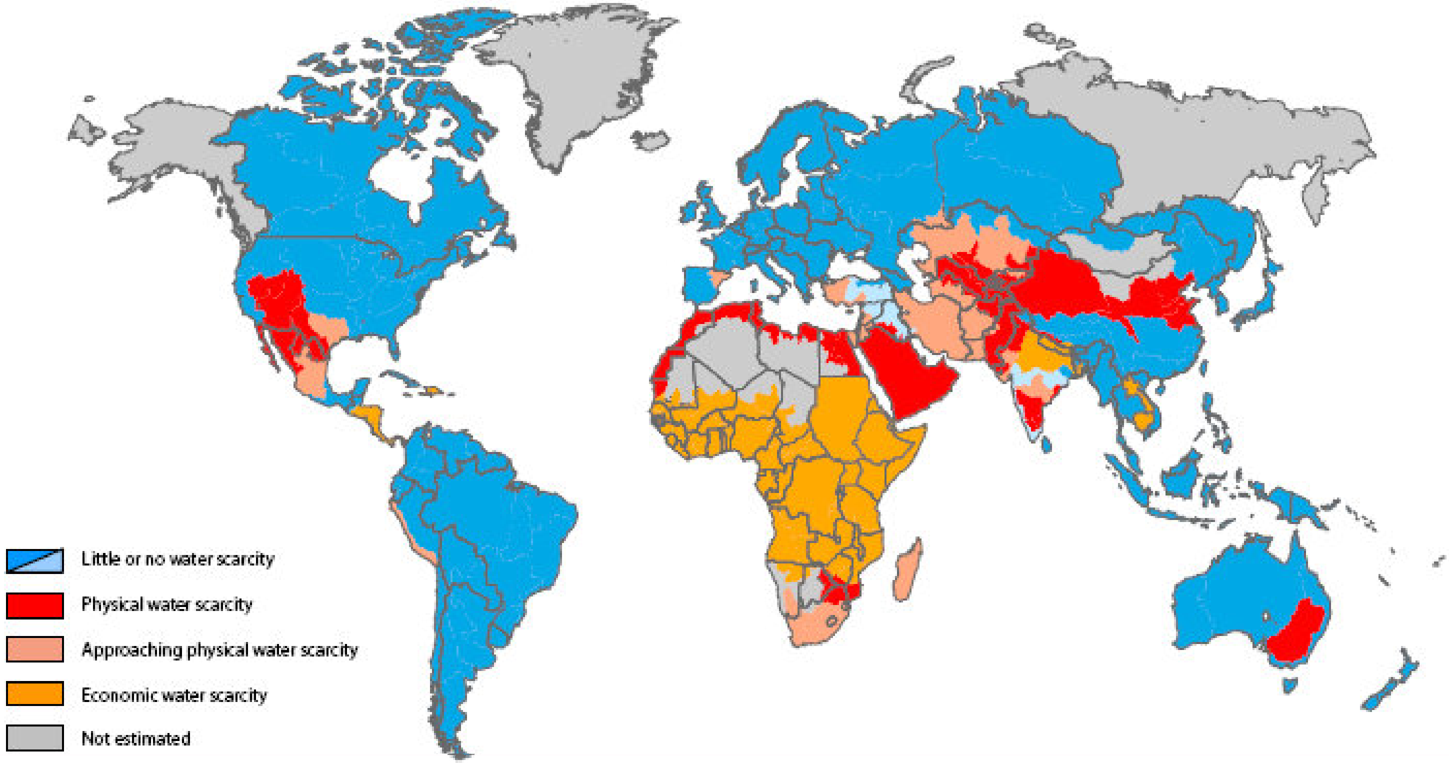
Palermo, 14 March 2014

Water distribution in scarsity condition: the Aquaknight project

Goffredo La Loggia & Vincenza Notaro

INTRODUCTION

1/3 of world population lives in areas affected by water scarcity
(500 millions in urban areas)



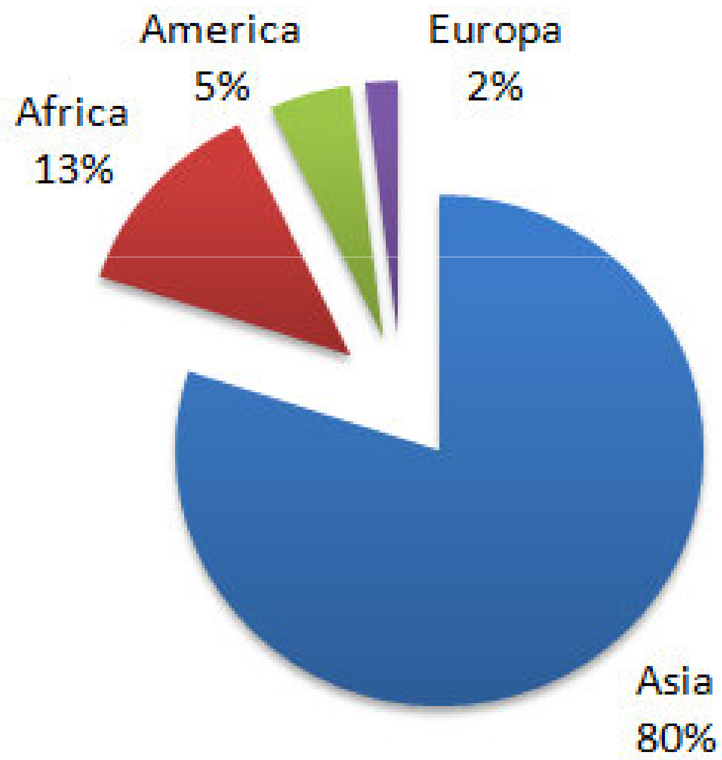
IN THOSE AREAS WATER AVAILABILITY IS LIMITED IN SPACE AND TIME:

SOME AREAS ARE NOT SERVED BY ANY DISTRIBUTION SERVICE OR WATER IS AVAILABLE ONLY FEW HOURS PER DAY OR FEW DAYS PER WEEK.

35% of world population have not access to drinking water (WHO, 2000)

As result:

- population change its habits and put into practice technical measures for coping with water scarcity
- climate and social changes will increase the problem in the future



A WIDESPREAD SOLUTION FOR COPING WITH UNEXPECTED WATER SHORTAGES

INTERMITTENT WATER DISTRIBUTION

The water utility tries to distribute limited water resources as efficiently as possible:

- dividing the entire network into different districts defined by number of users
- supplying each district with a rate of the available volume for fixed periods of time (usually less than 24 hours)

- **Each district is subjected to a cyclical filling and emptying process**
- Users must collect as much water as possible during the service period for covering their needs when supply service is not available

INTERMITTENT WATER DISTRIBUTION

PRO

- ✓ *little financial effort*
- ✓ *reducing background losses*

CONS

- ✘ *water quality problem (pollutant entry, water age)*
- ✘ *inequality in water distribution (water supplied depends on node pressure, filling of the network results in supply lag)*
- ✘ *structural problem due to pressure gradient into network pipes*

It follows that …

User adaptation to intermittent distribution

Users collect water (when the service is available) by means of local reservoirs

Water is then used when the service is not available

Typical skyline in presence of local reservoirs in Sicily

PRO:

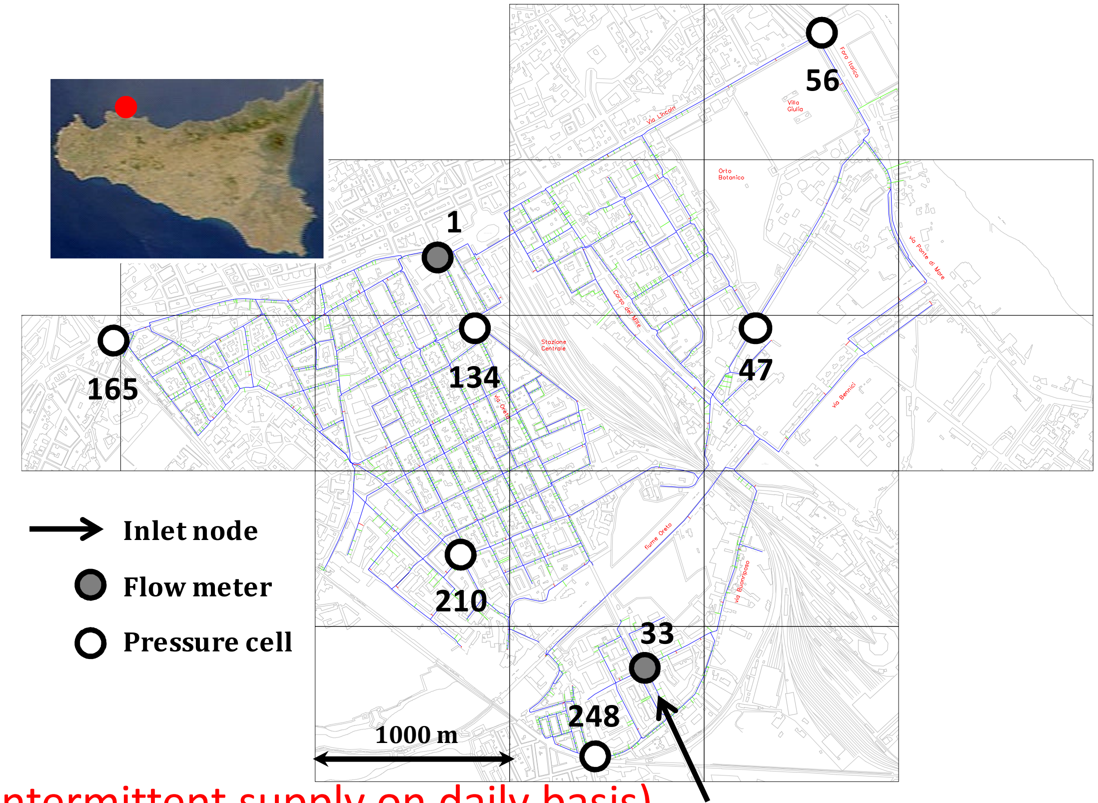
Users vulnerability to unexpected service intermittency is reduced (on the short term)

***CONS*: SYSTEM OPERATING CONDITIONS ARE FAR FROM DESIGN ONES**

- ✘ Node demand depends on node water head and on tank filling and not on actual user consumption
- ✘ Users often over-design their tanks to consider possible higher water consumption
- ✘ The network pressure is often unable to provide a sufficient level of service
- ✘ Flow distribution is inequitable and not homogenous in space and time

The case study: one of 17 supply networks of Palermo (Italy)

Network *Oreto-Station*



Recently rebuilt

Population: 35.000 inhab.

Water demand: 400 l/(inhab.*day)

Network diameters: 110 - 225 mm

Pipes material : PEad

Network extension: 42 km

Network elevation: 3m – 47 m

Network supplied by

2 reservoirs (54 m and 82 m)

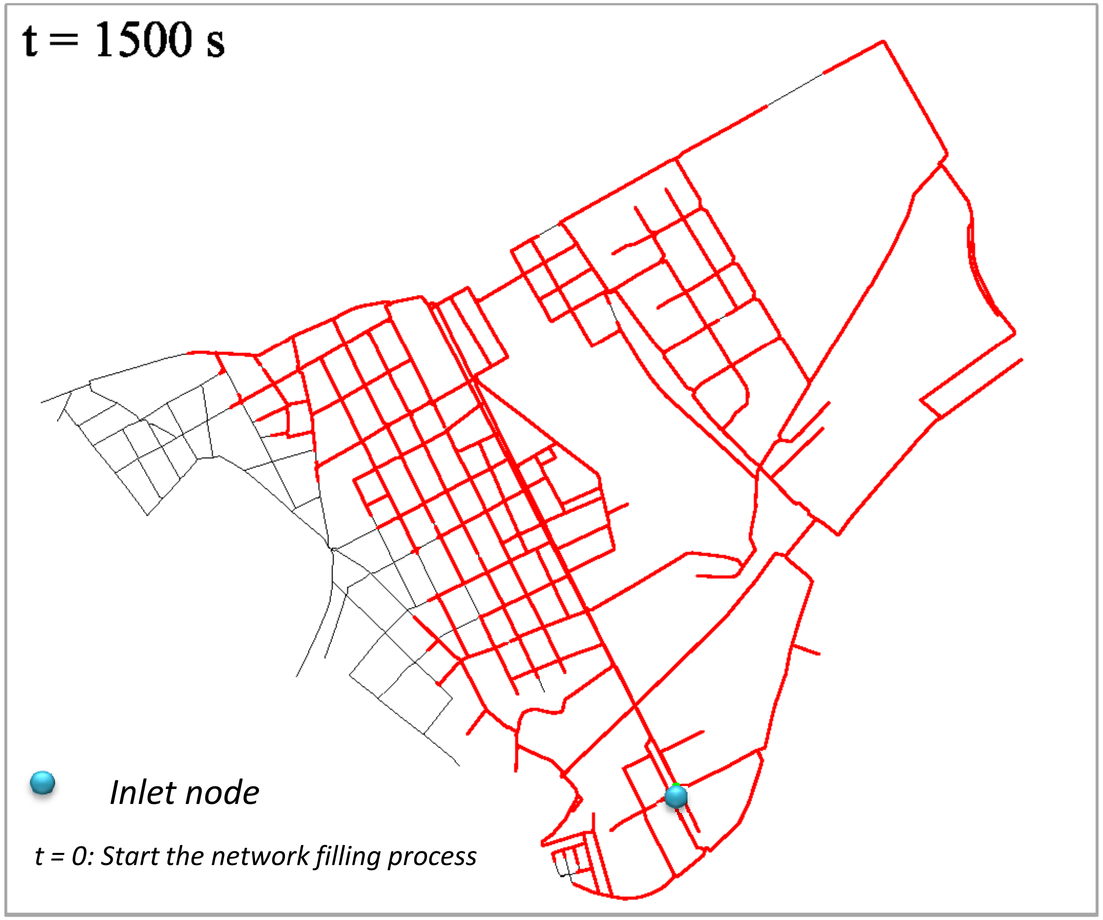
Monitoring period: Jun. - Oct. 2002 (intermittent supply on daily basis)

Data: **hourly flow data** by the two electromagnetic flow meters and

5 min pressure data by the six pressure gauges

DYNAMICS OF PIPE FILLING

The model adequately simulates the network filling process

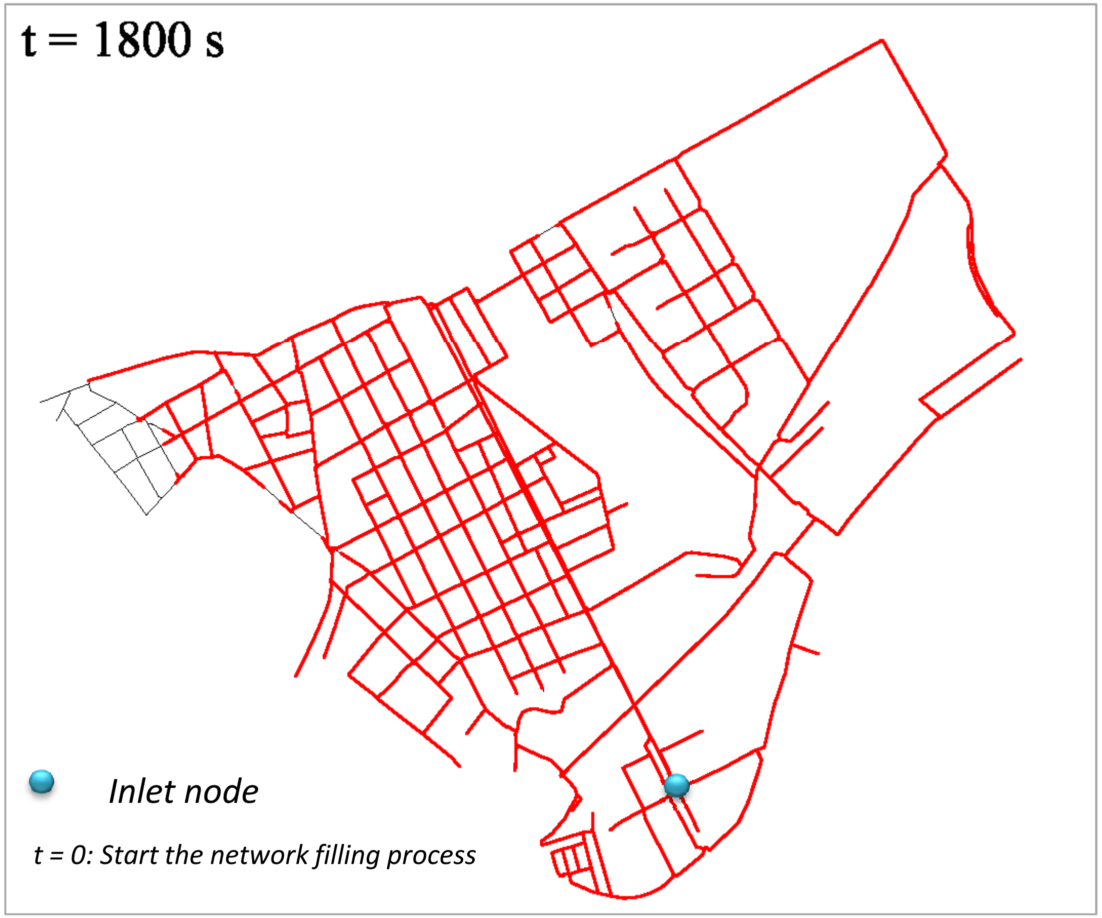


Network mains start filling after the water network is supplied

Initially, each node receives water depending on its distance from the inlet node

DYNAMICS OF PIPE FILLING

The model adequately simulates the network filling process



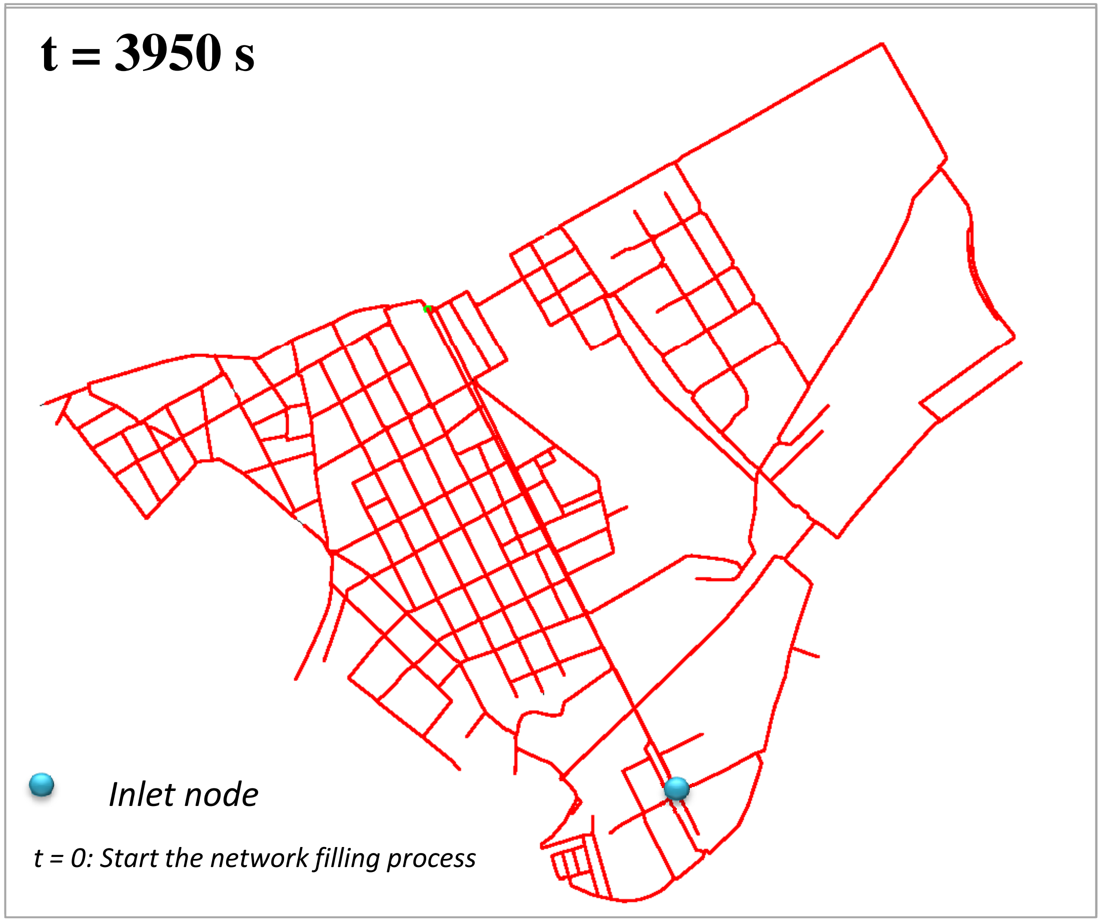
After 30 min the upper part of the network is still empty

Why?

The high consumption of the advantaged users to fill their private tanks at the beginning of service:

- *protracts the filling time of the whole network*
- *generates high head losses in pipes, conveying discharges higher than the design node demand*

The model adequately simulates the network filling process



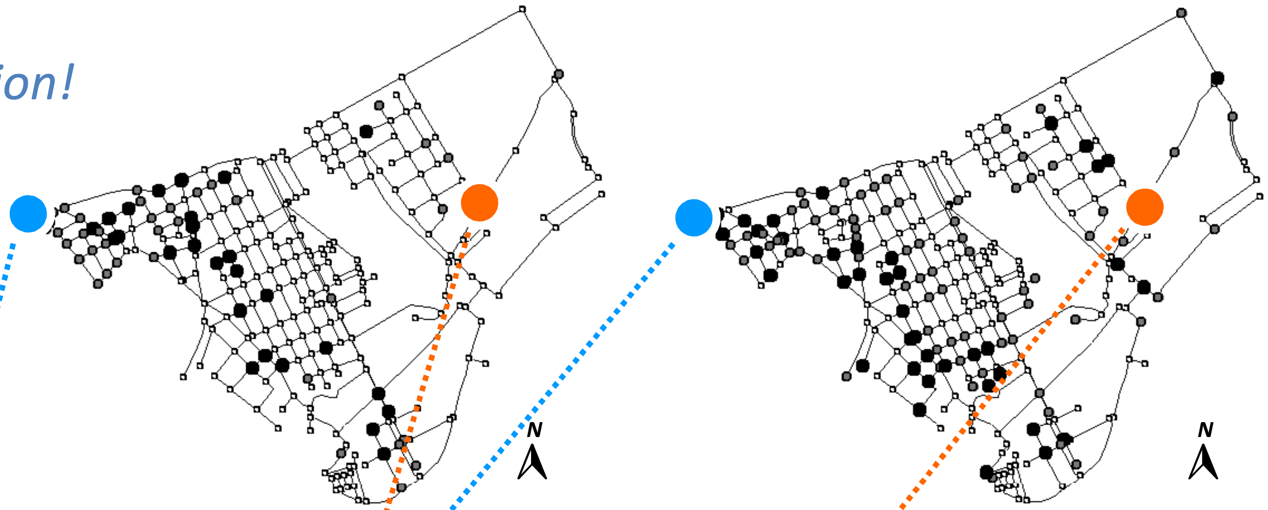
The network is entirely full about 1 hour after water supply begins, but the **pressure levels for several users are still inadequate to allow for private tank supply**

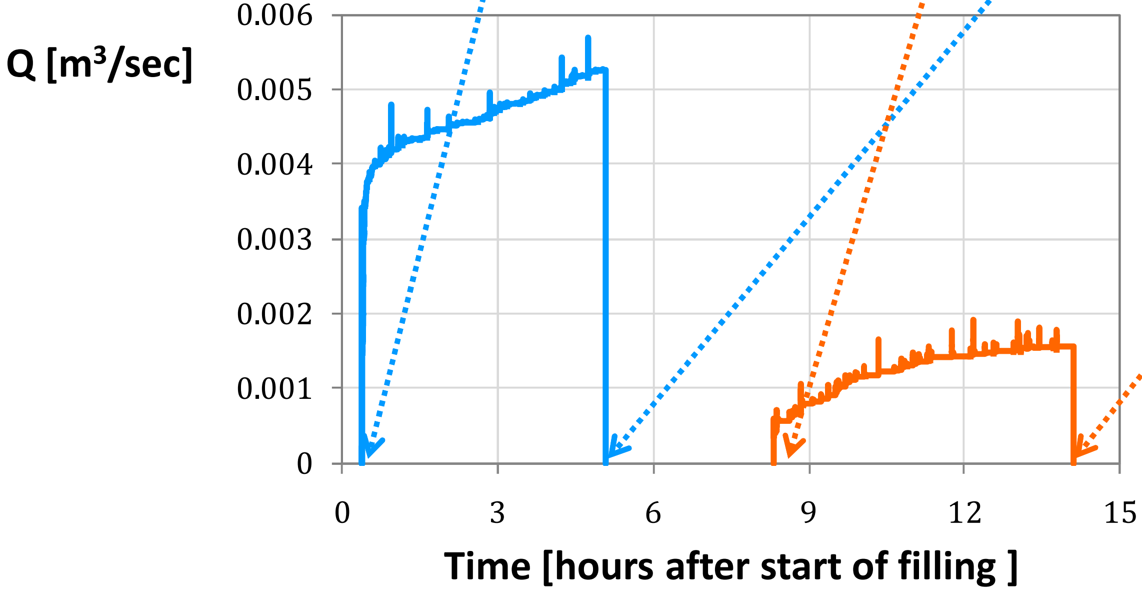
Tanks filling depends on the water head of building roof tanks, related to the combination of average building height and pressure level, so all of the advantaged users are not necessarily in the topographically lower part of the network

INTERMITTENT DISTRIBUTION

Inequality in water distribution!

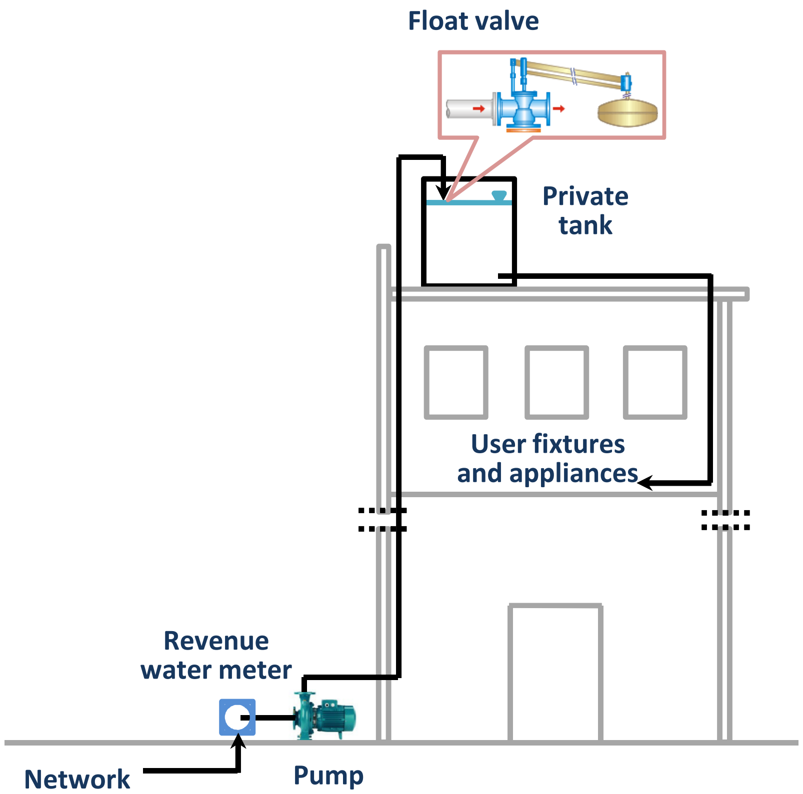
Some users start to be supplied within 1 hour of service and collect the whole daily demand in less than 6 hours, with discharges much higher than the daily average…





… other users in have to wait more than 7 hours to receive water, and complete their daily supply after 14 hours with much lower discharges

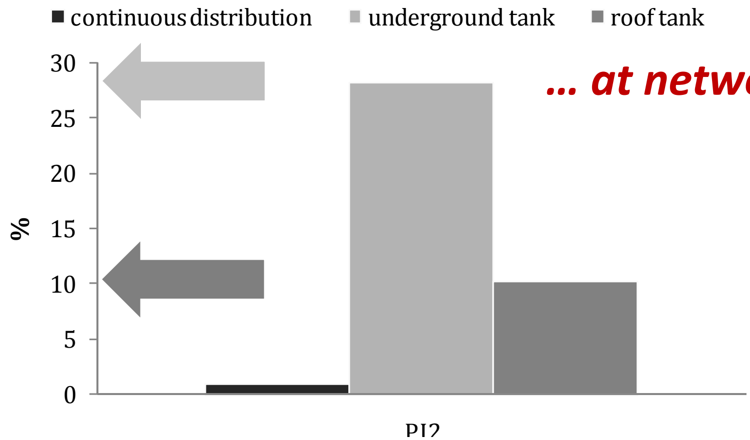
INTERMITTENT DISTRIBUTION: LOCAL PUMPING SYSTEMS



The **presence of private tanks**, that are usually located on the rooftops, and the **high competition among users**, take as a consequence the **introduction of local pumping systems for supplying the tank** also when water head on the network is not sufficient.

Such operational scenario takes a large cost of energy for pumping and a relevant environmental impact connected to energy consumption and the waste of water resources that are often collected overestimating user needs

ENERGY COST ANALYSIS

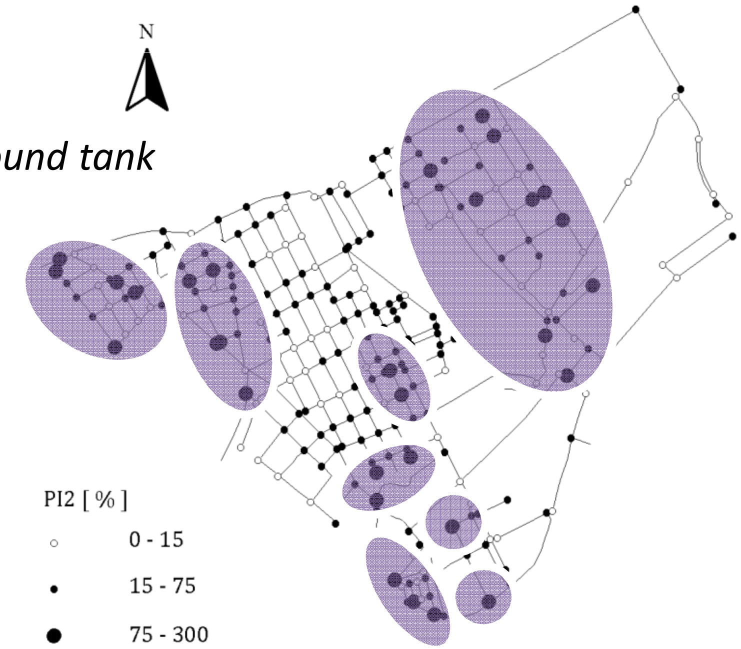


… at network scale

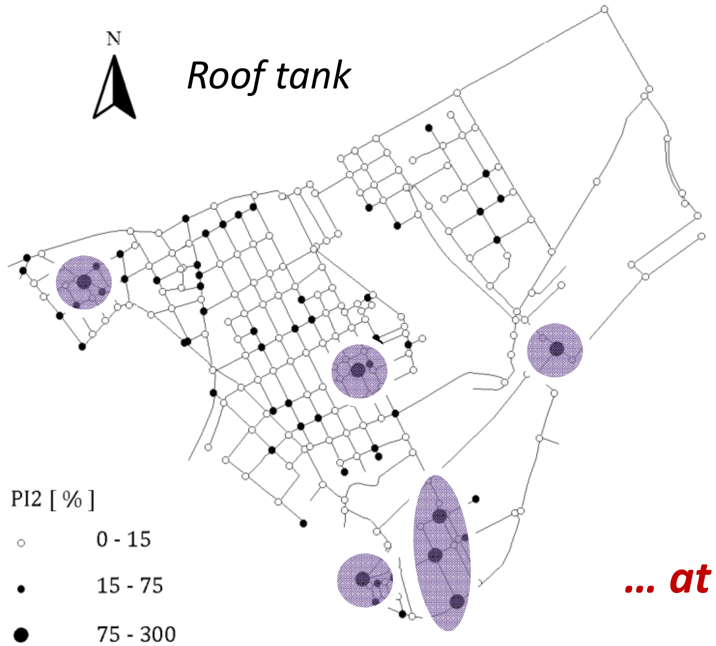
PI2: incidence of the energy cost on the water cubic meter cost [%]

Service intermittency provides inequalities in people access to water resources and in the costs that have to be supported by users

Underground tank



Roof tank



… at node scale

EFFECT OF INTERMITTENCY AND OF PRIVATE TANKS

Due to the cyclical filling and empting and to the presence of private tank pressure in the network and on the user's connections changes rapidly and this behaviour can affect both real and apparent losses

WATER LOSSES = ***Economic Problem*** + ***Environmental Problem***

In Italy water losses can reach values of 30% -70% of the volume supplying the distribution network

That problem assumes more importance during periods of water scarcity

TYPE OF LEAKAGE

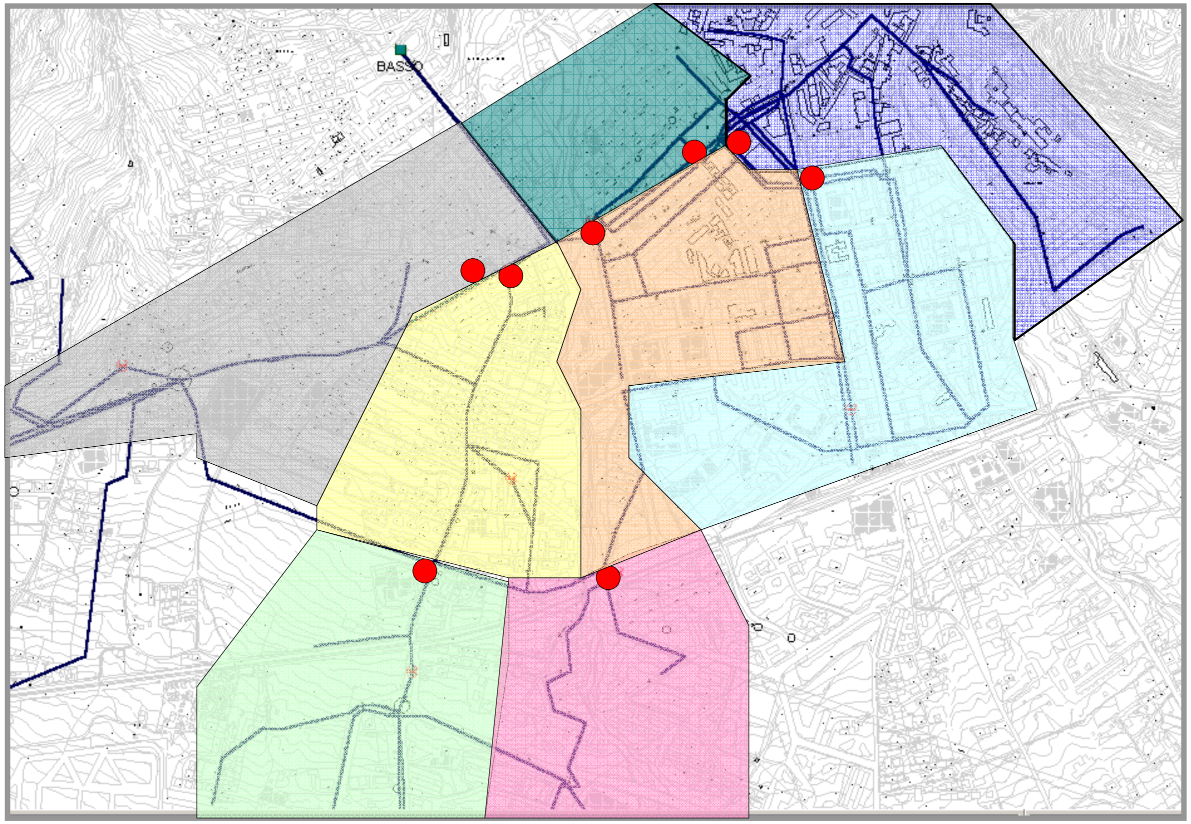
Physical Leakage

- Breaks in mains and service connections
- Background losses (valves, not detectable small leaks)

Apparent Losses

- Unauthorized use
- Illegal Connections
- Errors in meters and/or out of order meters

ACTIVE LEAKAGE CONTROL METHODOLOGY



Permanent sectors

Closed boundary

Single supply pipe

Flow meter on inlet

Quantify leakage in each DMA

Locate leaks

AQUAKNIGHT
OBJECTIVES

1. **Reduce the water losses** of distribution systems and **rationalise demand** in line with the environmental policies of all MED States.

2. **Enhance the capacity of Mediterranean water operators** in Non Revenue Water management by means of Active Leakage Control and improved water metering

3. Validate / Develop **best practices to manage real and apparent water losses in the Mediterranean context**

AQUAKNIGHT
PILOT PROJECTS

Development of **5 parallel pilot projects**:

Alexandria (Egypt)

Aqaba (Jordan)

Tunis (Tunisia)

Lemesos (Cyprus)

Genova (Italy)

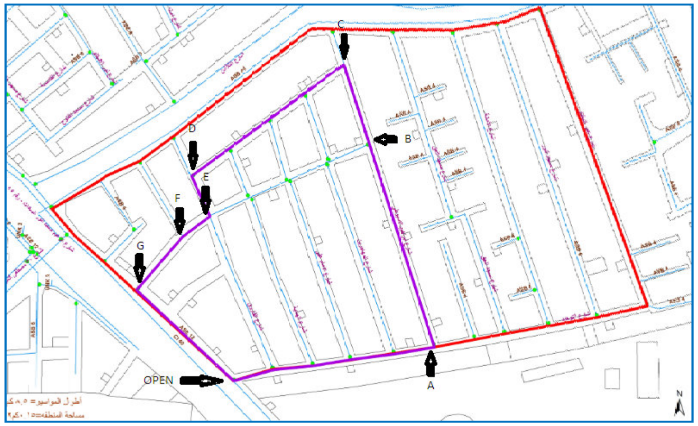
AQUAKNIGHT

PILOT PREPARATORY ACTIVITIES

Selection of the Pilot District Metered Area (1,000-3,000 users)

Set up of the pilot DMA

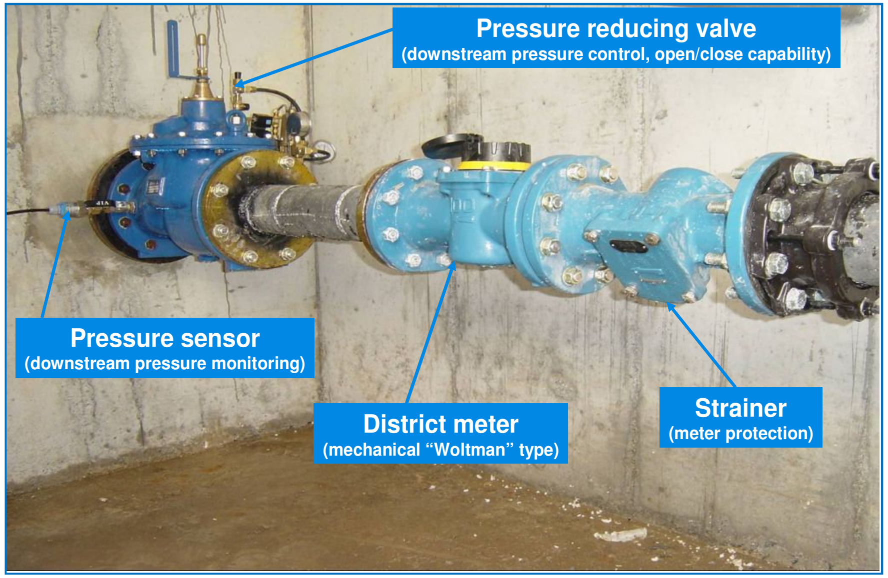
- field surveys and network mapping
- Boundary valve survey aimed at verifying their tightness
- Civil works to install flow meters, repair or replace old valves

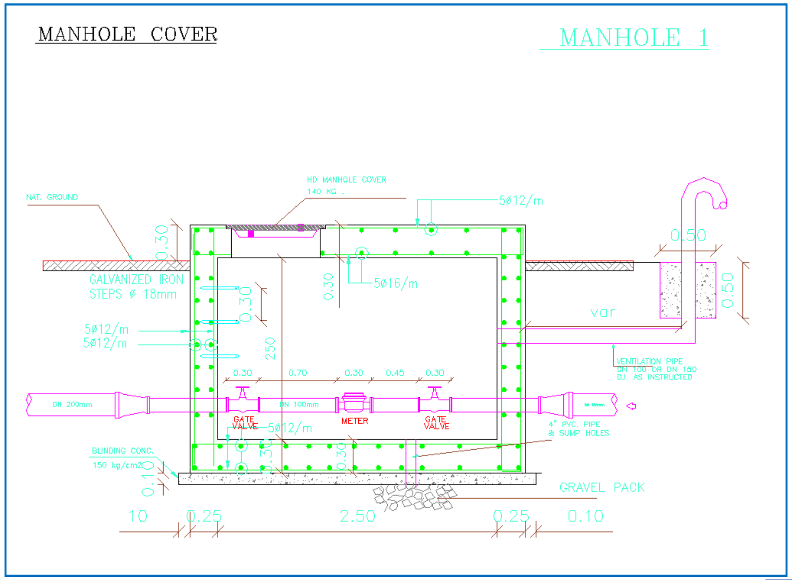


AQUAKNIGHT

PROCUREMENT OF EQUIPMENT

- Procurement of equipment: Flow and pressure monitors, data loggers, AMR, Unaccounted Flow Reducers, leakage detection equipment, PRVs
- Civil works for the construction of chambers to install Flow Meters, PRVs, etc.

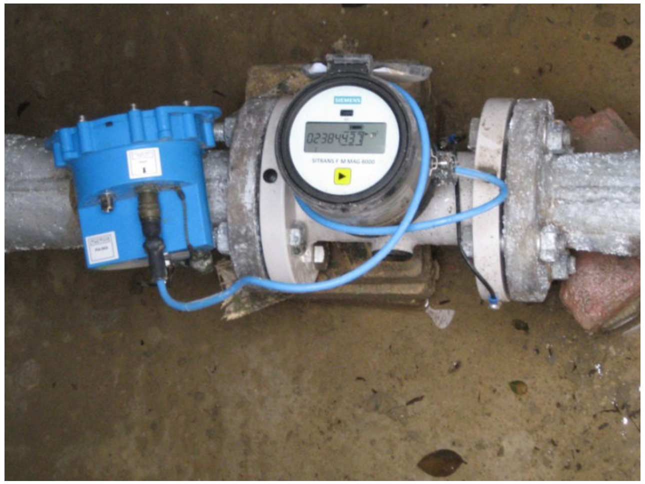


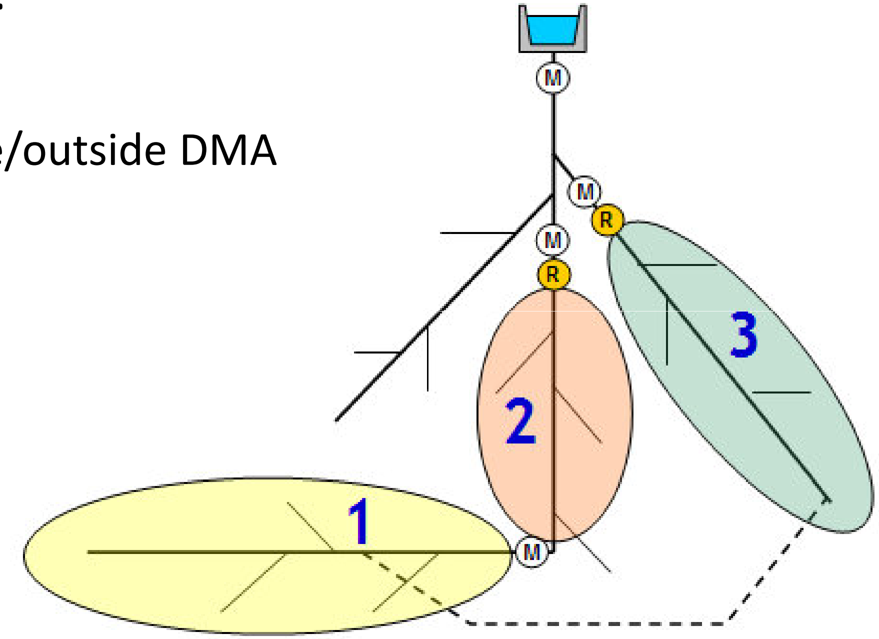


ACTIVE LEAKAGE CONTROL IN PILOT DMA

Verification of the pilot DMA boundaries:

1. Installation of inlet flow meter
2. Installation of pressure meters inside/outside DMA
3. Closure of boundary valves
4. Zero pressure test





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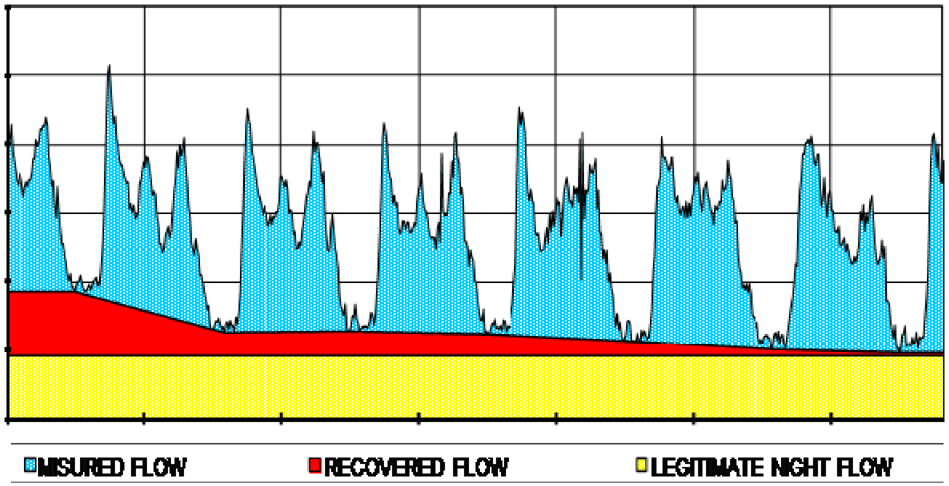
Programme funded by the EUROPEAN UNION

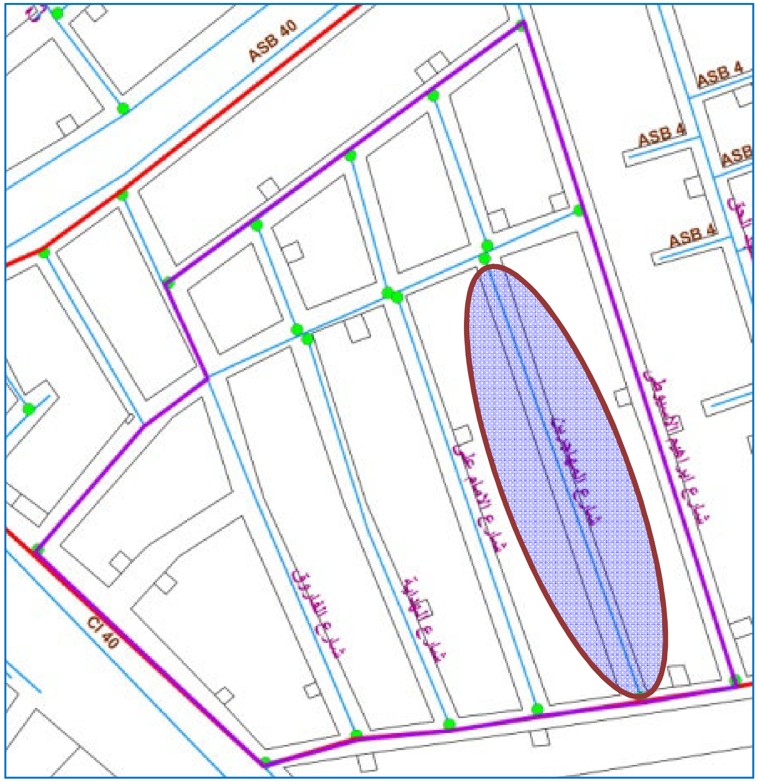
EVALUATION OF REAL LOSSES

- **Leakage pre-location** using sounding, noise logging or step testing
- **Leakage pinpointing** using acoustic equipment (correlator, ground microphone)
- **Continuous monitoring of DMA inlet** during leaks repair to check reduction in MNF



EVALUATION OF COMMERCIAL LOSSES

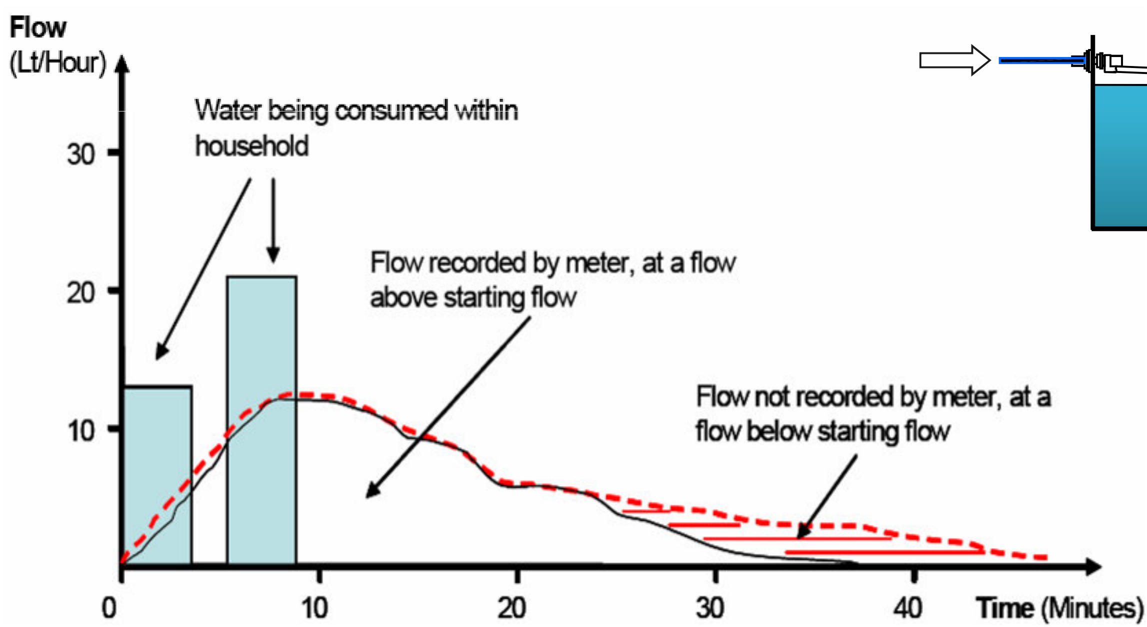
- Creation of a small subdistrict with less than 100 users
- Installation of an accurate inlet flow meter and comparison with accumulated customer meters readings
- Installation of UFRs
- Replacement of customers old meters with new meters incorporating AMR
- Bench testing of old meters at UNIPA's laboratories

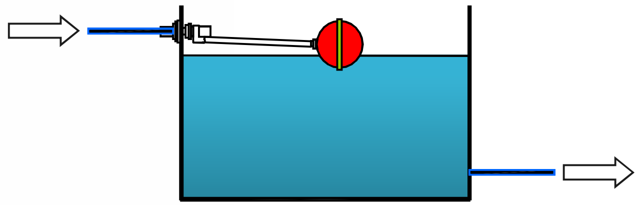


EFFECT OF PRIVATE TANKS

ASSESSMENT OF IMPACTS OF PRIVATE TANKS ON METER UNDER-READING

- **Private tanks modify the demand profile of typical domestic users.**
  - The float valve in the tank dampens the instantaneous water demand and reduces the flow rate passing through the meter.
  - Slow closure of the float valve induces flow rates lower than the meter starting flow

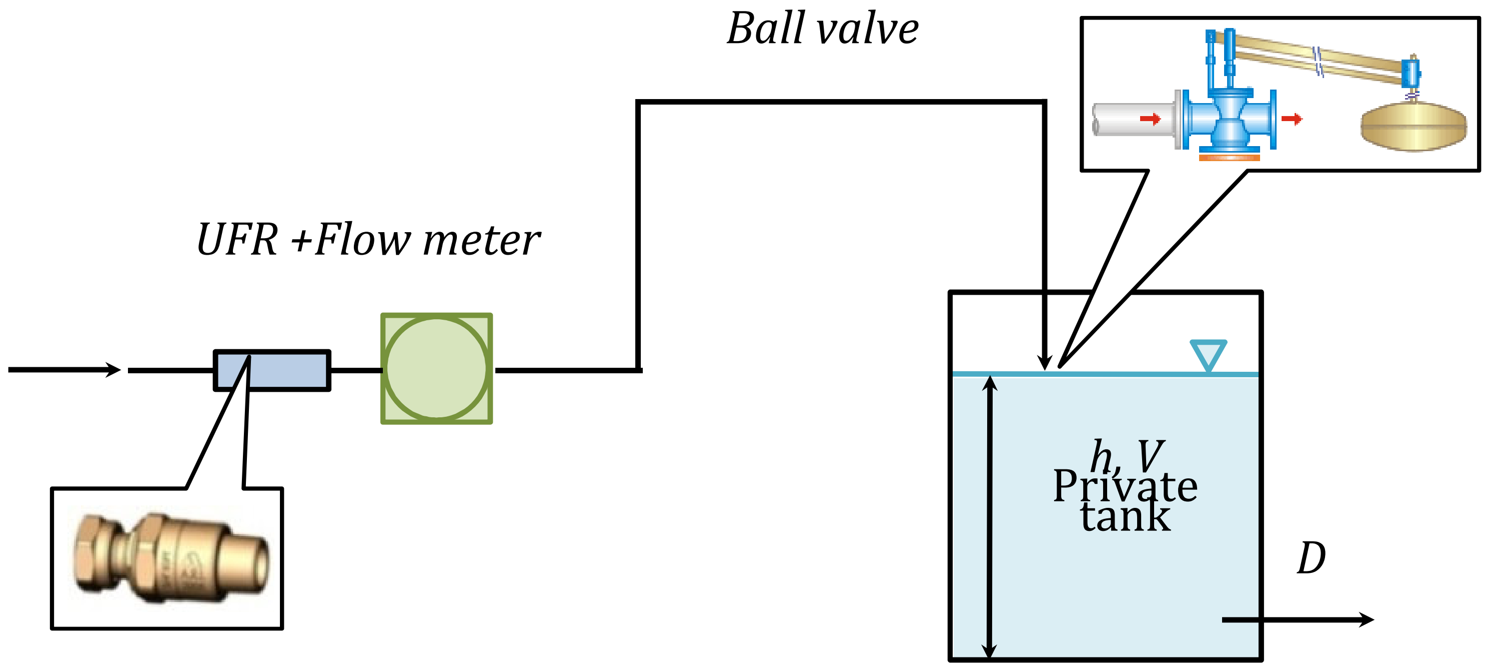




Rizzo and Cilia (2005)

EVALUATION OF COMMERCIAL LOSSES

ASSESSMENT OF IMPACTS OF UFR ON METER UNDER-READING



UNIPA's LABORATORY TEST BENCH

The accuracy of the selected meters was tested by the UNIPA's laboratory test bench

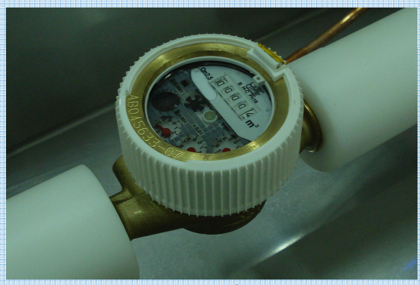
The test bench is a weight calibration device compliant with the ISO 4064:2005 standard

- **a water supply system** (mains, 1 unpressurised tank, 2 pumps);
- **a test section** in which the meter is placed;
- **4 flow meters** to establish the approximate flow rates at which the meter is tested;
- **2 pneumatic and automatic gate valves**;
- **2 pressure gauges** to measure the pressure upstream and downstream the tested meter;
- **1 vacuum gauge**;
- **2 calibrated tanks,** each placed on a precision electronic balance;
- **1 temperature sensor**
- **1 a control panel**

UNIPA's LABORATORY TEST BENCH

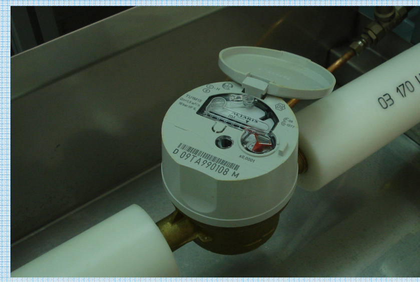
Laboratory experiments were carried out in UNIPA laboratory in order:

- to estimate metering error curves for different flow meters classes and ages
- to find a direct link between meter age, network pressure and the apparent losses caused by the incapability of the meter to accurately measure the volume passing through it at low flow rates

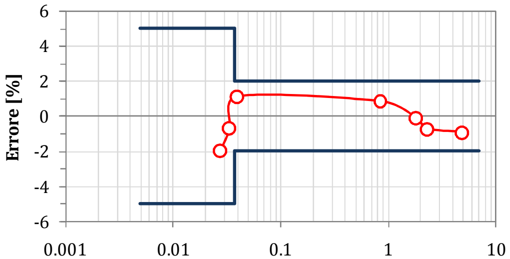


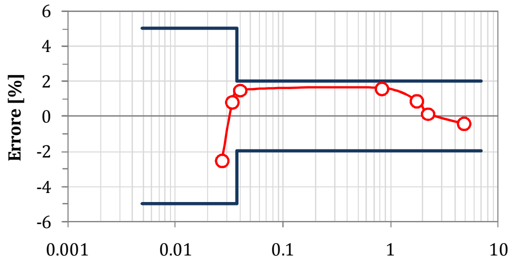
Class C; Q_3 = 2.5 m³/h; DN 20 mm

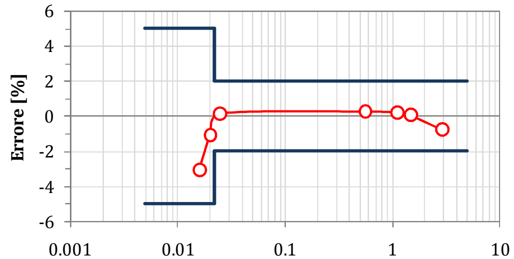
Class C; Q_3 = 2.5 m³/h; DN 20 mm



Class C; Q_3 = 1.5 m³/h; DN 13 mm







aqua knight

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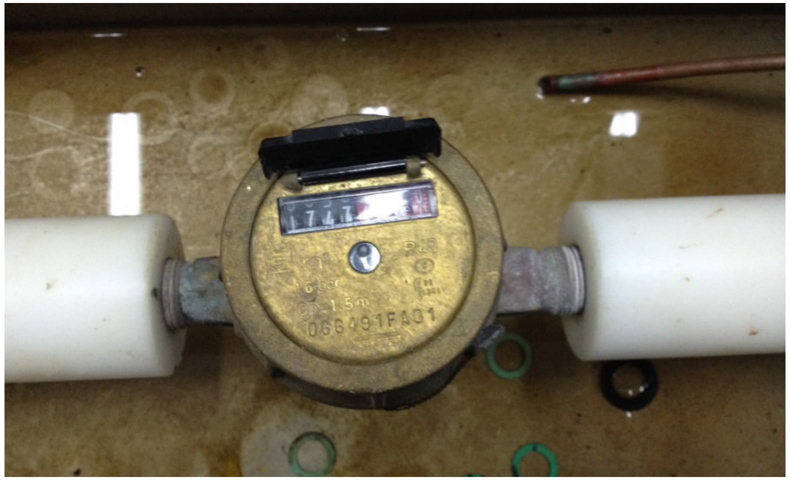
UNIPA'S LABORATORY TEST BENCH

TUNIS DMA

OLD METERs- Volumetric – Multijet – Class C



NEW AMR METERs – Multijet- R200

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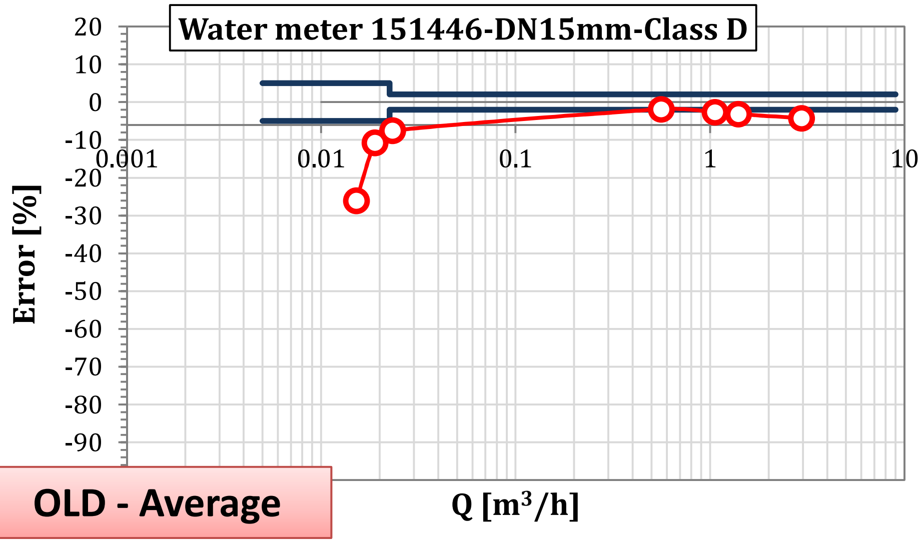
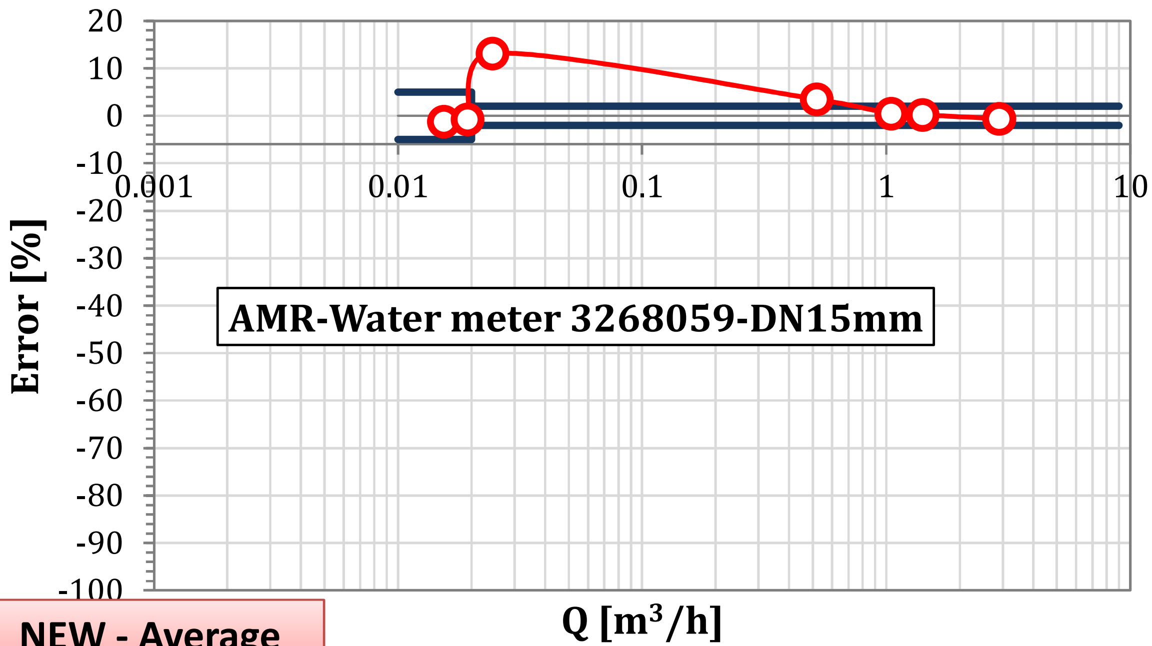
UNIPA's LABORATORY TEST BENCH



OLD - Average

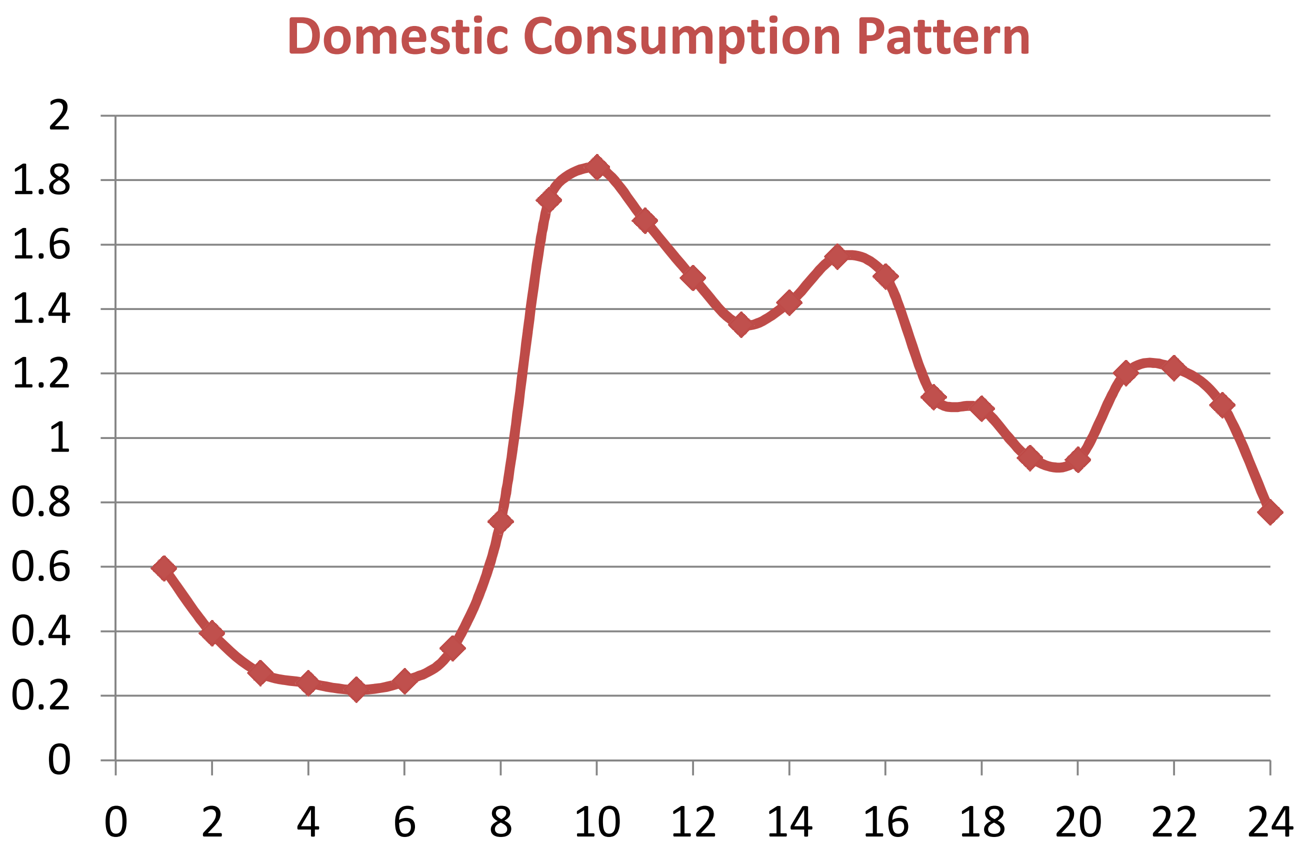


NEW - Average

TUNIS DMA

Customer Night Use Estimate

Unipa is working in the determination of customer demand patterns and legitimate night use by customers



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Thanks for your attention

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