

# **Apparent Water Losses generated by Unauthorised Consumption: Assessment and Corrective Actions**

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# APPARENT WATER LOSSES GENERATED BY UNAUTHORISED CONSUMPTION

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## *Abstract*

*This paper refers to the various kinds of unauthorised consumption: non-registered consumers, unauthorised consumption of registered customers and other types of water theft. It presents the various ways to quantify the loss, to reduce it and to get it under control.*

*The level of unauthorised consumption is not only the consequence of poverty, dishonesty or cultural aspects: it also often results from the laxity of the Water Utility and its poor strategy in terms of social involvement and communication.*

*Relevant solutions are outlined.. Considering the variety of technical and social backgrounds over the world, a wide range of solutions is proposed to assist the practitioner in finding the most adequate solution to his personal issues. It ranges from the usual procedures to improve operation efficiency to the most recent techniques. More stress has been put on those techniques.*

## **1. Definition and basic issue**

There are three categories of unauthorised water consumption:

- Unauthorised consumption by unregistered consumers: These consumers are not registered in utility's customer records: obviously, these customers do not receive any water bills. These connections are often referred to as illegal, unauthorised or clandestine connections. These terms may have a negative impact in terms of communication or in terms of legal involvement. These unregistered connections may have been made by the current operator or by a previous operator. Sometimes, the Water Utility itself may be responsible for the outdated state of its database.
- Unauthorised consumption by registered consumers: These consumers are registered either as active customers that receive a water bill or as inactive customers for whom no volume is billed. These apparent losses may be due to fraud (or any other unauthorized practice), but it may also be the consequence of unsuitable Water Utility's practices.
- Water theft on public distribution network equipment such as hydrants, discharge valves and others

A list of practices that generate apparent losses on either registered or unregistered connections follows. This list is not exhaustive, as human ingenuity has no limit, particularly in this matter. It could be counterproductive to provide a more detailed list.

### **List of frauds (examples)**

#### **Connection-Related Unauthorized Actions**

- Unregistered connection: the customer is not in the utility's database
- Unregistered second connection i.e. one connection is registered and the second one is not.
- Meter by-pass (equivalent to a second connection)
- Unauthorized tapping upstream of the meter (equivalent to a second connection)
- Unauthorized re-activation of a connection that was cancelled in the database
- Unauthorized re-activation of a connection that was cut off (for reasons of non-payment, for example), i.e., the unauthorized reinstatement of customers registered as inactive

#### **Meter-Related Unauthorized Actions**

- Meter by-pass (already mentioned above, as it involved an illegal action performed on the connection itself.)
- Removed meter
- Reversed meter
- Inclined (or twisted) velocity meter
- Meters that are tampered: there are many ways of tampering with a meter, some of which are listed below).

#### **Water Meter Tampering**

- Destruction of the manufacturer's seal: this is not fraud in itself but indicates a likelihood of fraud
- Destruction of the Water Utility's seal
- Broken meter
- Insertion of a needle to stop the counter rollers
- Use of a magnet to slow down the meter's movement
- Disconnection of the counting mechanism from the rotor
- Cut off rotor (or helix), modified turbine
- Insertion of a foreign body to block the rotor

#### **Unauthorized Use of Network Equipment**

- Unauthorized use of public reservoirs
- Unauthorized use of fire hydrants or connections
- Water theft on discharge valves or air valves

#### **Interconnection with a Local Water Source**

- Simultaneous use of network water and water from a private well (or other source): this may conceal a bypass. Such practice may also involve serious health consequences.

#### **Very low revenue areas**

- This refers to the shantytowns and squatter areas (favelas) in Brazil (villas miserias) in Argentina for instance or overcrowded slums and squatter areas in some regions of Asia and Africa. The problem is not only about water.
- In the very low-income areas, the various types of water losses including real and apparent losses are generally closely related and an analytical approach is generally not applicable. Therefore, individual studies, based on a global technical but also sociological approach, need to be carried out in each case.

## **The Water Utility itself as a source of unregistered consumption**

High level of Unauthorised Consumption is not only the responsibility of the dishonest consumers: it is also the consequence of an inappropriate management by the Water Utility.

- Poor practices: new connections are not immediately registered
- Failure in updating the customer database
- Inappropriate policy towards the population
- Inappropriate communication policy
- Internal corruption and mis-management

This latter list shows that the Unauthorised Consumption issue cannot be solved through corrective measures only. The management of the customers needs to be improved to get sustainable results.

Therefore, following sections refer to:

- How to review and assess the situation? There are two components: quantifying the apparent loss and evaluation the running of the customer department of the Water Utility
- How to reduce unauthorised use of water?
- How to make the results sustainable?

## **2. Review and Assessment**

### **2.1. Quantifying unauthorised consumption**

The review and assessment stage aims at quantifying the various types of apparent losses classified as unauthorised consumption.

Review and assessment consist of two stages: analysis of customer database and field surveys.

#### **1. Detailed analysis of the customer database is a prerequisite for all following actions.**

The presumption of loss or of fraud is established from the analysis of the customer database.

For example:

- Number of customers without meters
- Number of zero consumptions
- Number of abnormally low consumptions
- Number of customers cut-off (for non-payment) who have not asked for a reconnection

With respect to registered customers, visits to a sample of customers at risk will allow the operator to define the percentage of real anomalies that may be associated with each category of customer.

With respect to the unregistered customers - the number of which is sometimes important in some utilities - only appropriate census actions associated with fraud detection and carried out on carefully chosen pilot zones will allow the estimation of the corresponding loss.

#### **2. Then various field surveys can be implemented either in pilot areas or on customers' samples.**

- General census in pilot areas or in sampled areas
- Partial targeted (focused) field surveys in selected areas or fields
- “Walk the line” and “Walk the book” exercises
- Targeted investigations based on preliminary analysis of the database
- Comparison to other utilities customer’s databases (electricity, telephone, taxes, etc.).
- “High risk” consumer’s method
- Self-reporting under an amnesty process.
- Community participation in the fight against illegal connections and frauds.
- Customers’ observatory
- Mapping (GIS) analysis.
- Detection of illegal connections in the case of large consumers.
- Ground penetrating radar (GPR) to detect illegal connections

### **Special cases**

- Specific methods for low-income areas.
- Discontinuous supply.
- Etc.

## **2.2. Mini Pilot Census (simplified procedure)**

A mini pilot census (or field customer survey) will provide a first indication on the importance of possible frauds and other anomalies and disparities, which could exist between the field reality and the technical and customer databases.

The investigations will cover 3% to 5% of the customers that would be selected according to their geographical locations, their types, and their social conditions. It is also necessary to carry out more specific investigations on samples of customers with zero or abnormally low consumptions. Special attention must be paid to samples of customers that are supposed to have been disconnected (cut-off) or having terminated their contract.

The investigations will take into account:

- The address and the customer reference number.
- Description of the supply: number and diameter of the service connections, leaks, illegal connections, etc.
- Information necessary for the edition of bills, position in tariff structure.
- Anomalies or frauds on the meter: by-pass, meter damaged, etc.
- Detailed description of the meter: date of manufacturing, brand, model, technology, nominal diameter, length, nominal flow rate, consumption, etc.

It will be necessary to ensure that the following ratios are found:

- percentage of inactive clients, illegal consumption / total number of inactive customers visited
- percentage of non-registered customers / total number of customers visited
- percentage frauds on the water meters / total number of meters visited
- percentage of anomalies found in the field with respect to the data contained in existing records

On completion of the pilot field customer survey, it will be possible to define the most appropriate type of investigation to be operated through the action plan:

- exhaustive census
- partially localised census
- targeted investigations on one or more different types of anomaly

### **3. Set of corrective actions**

#### **3.1. Improvement of Operational Procedures and Action Plan to Mitigate Apparent Losses**

Depending on circumstances, the objective may be either:

- To stabilize the loss at its current level
- To reduce the loss level.

Depending on the magnitude of the objective, it may be necessary:

- To simply improve the operational procedures of the Water Utility, or
- To formulate a plan of action to mitigate losses.

As previously mentioned, even if the action plan is successful, the existing procedures must be improved in order to ensure preservation over time of the obtained results. Irrespective of the case under consideration, there is a large array of measures that can be utilized. These measures are described in the following paragraphs, and it is the decision-maker's task to choose the most appropriate approach and best suited measures to achieve the goals.

#### **3.2. Sampling Studies and Pilot Studies**

This section describes various actions that may be undertaken to detect and control unauthorised consumption.

In practice, however, actions that were successful in a given context may very well fail in a different context. How do you decide which is the best method to solve your own specific problems?

In some cases, this is easy. In other cases, it is not. If so, the best course is to try out the method in a pilot area or on a sample of consumers.

Three examples based on case studies are presented below to clarify this concept.

##### **Example 1: General Surveys**

Overall survey procedures should always be tested in pilot areas. It would be unwise to reach the end of the survey only to find that the important questions were not asked or that the collected data cannot be reliably processed.

##### **Example 2: Searching for Bypass and Unauthorized Connections**

The rate of commercial losses in X-City was very high. The Water Utility decided to carry out a comprehensive field inspection of all its customers to detect frauds and unauthorized connections. No unauthorized connections were found. After an additional audit, it was discovered that the losses were actually due to illegal agreements concluded between the meter readers and customers, with the complicity of certain IT officials.

The field inspection was very costly and had no financial benefit whatsoever. It would have been preferable to initially test this field inspection on several pilot areas. The Water Utility would have reached the same conclusion and would have solved the problem at a much lower cost!

##### **Example 3: Search for Illegal ReconNECTIONS**

The Water Utility of Y- City carried out a multi-purpose survey in pilot areas. One of the objectives was to identify apparent losses and their causes. It became apparent that a small percentage of the losses were due to clients who had been cut off for non-payment and had illegally reconnected. Accordingly, it was decided to visit 500 customers who had been cut off for several months for non-payment: it was

discovered that 50% of these consumers had illegally reconnected and therefore were using water without receiving any billing. It turned out that this fraud was one of the major sources of apparent loss in that city. The investigation continued and the cut-off procedures for non-payment were completely changed. This example shows that field inspections on well-defined targets can produce highly significant results.

### **3.3. Methods and Tools**

The following paragraphs present several methods and tools. However, based on the conclusions of former paragraphs, it is recommended never to embark on expensive solutions before previously testing them in pilot areas or on well-defined samples of consumers.

This section discusses the following issues:

- General methods: general or partial surveys, targeted investigations based on a preliminary analysis of the database or pilot studies.
- Specific tools, such as Cartographic Modelling GIS and Ground Penetrating Radar (GPR) systems.

#### **Customer Census and Field Customer's Surveys**

##### **(i) Comprehensive overall survey (or customer census)**

The most widely used and comprehensive method - even though not necessarily the most cost effective one - is a complete census of the consumers that can detect all technical and administrative irregularities and update the customer records.

It is obvious, however, that a comprehensive survey of consumers cannot have this unique objective. Performance of an exhaustive survey is a costly operation. Accordingly, it should aim not only to detect unauthorized connections and frauds but also to record in the customer database any other information that may be useful for commercial management. It must also provide better knowledge of consumers and their installations in order to improve the service, while adjusting individual rates for service according to the appropriate consumer category and applicable rate structure.

Conversely, it happens sometimes that the customer census only aims at the updating of the customer database and is not even related to the systematic investigation and control of fraud. This is unwise. Very often, the extra costs involved in systematic investigation and control of fraud are greatly offset in a few months following the survey, if anomalies are immediately regularised as soon as detected. .

Performance of a survey involves the following phases:

##### **Preparatory Phase**

- Analysis of available data and diagnosis of the operation of the commercial departments
- Geographical, urban and socio-economic analysis of the Utility's area of operations
- Definition of a more or less comprehensive survey file, depending on the type of required results
- Definition of the utilized means: human resources and equipment, survey and control procedures
- Definition of one area (or preferably several areas with different characteristics) to test the methodology and carry out an initial evaluation of results
- Informing the target population and performing a pilot survey
- Correction of detected irregularities by the competent departments
- Critical analysis of the results obtained in the pilot areas
- Critical analysis of corrective actions to enable meeting the needs of the general survey
- Modification of survey procedure and redefinition of quality control procedures as necessary

##### **Execution Phase**

- Population information (communication) campaign
- Extension of the survey in accordance with the conclusions of the pilot survey
- Simultaneous implementation of corrective actions defined and tested in the preparatory phase
- Quality control.
- Statistical control (weekly and monthly) of results: detected irregularities, corrective actions
- General outcome of the survey: physical, cost effectiveness and financial outcome

### **Post Evaluation Phase**

- Analysis of the survey's lessons for improving the organization of customer management departments
- Need to organize site visits to ensure the continuity of the implemented corrective actions over time
- Evaluation of the Rate of Return of the corrected anomalies
- Performance indicators may be used during the post-evaluation phase

These general procedures have been well drilled on many projects but require adaptation to individual circumstances.

#### **(ii) Partial or Targeted Surveys**

To avoid costly surveys, more focus-oriented surveys are sometimes utilized

- Survey of a statistically representative sample covering say, 2.5% to 10% of the total city population.
- Selective survey of areas with conspicuous presence of unauthorized connections.
- Inspection of "high-risk" users starting with preliminary signs of fraud or unauthorized consumption based on an analysis of consumptions records, such as zero or abnormally low consumption rates, significant and inexplicable variations in consumption, etc.

Such an operation does not yield the general advantages of a general survey, but its cost effectiveness is generally much higher than that of a general survey, if only for the windfalls of detected, unauthorized connections and various other types of fraud.

The general survey is usually justified only when the customer database is greatly out-dated.

Survey of a representative sample of the customer database consists in detailed analysis of various areas that are representative of the different types of housing, urban planning or consumers. If the sample is defined according to sound statistical principles, the rate of fraud and unauthorized connections may be extrapolated to the entire city population.

The sampling study and results of the partial survey may serve as a decision-making basis to determine the required strategy:

- Expand the survey to the entire city population, or
- Carry out the survey in specific geographical areas only, or
- Carry out the survey among specific categories of customers only.

#### **Targeted Surveys: High-Risk Customers**

Site inspection of consumers with abnormally low consumption or large fluctuations in demand is not strictly speaking part of a survey. This method may be utilized as soon as customer management has become computerized. The computer retrieves all the domestic consumers meeting certain criteria, such as zero consumption or consumption below 5 m<sup>3</sup> per month per residential unit.

Inspection is also carried out at sites of industrial or public consumers whose consumption does not match their actual operation, such as hotels, service stations, etc.

### **3.4. Specific methods**

The following methods and procedures may be used independently or in the frame of field customers' survey.

#### **Information Campaigns**

Any field customer survey - or census - needs to be preceded by a large public information campaign. This information campaign should be well designed, with the help of local communication experts. The survey will be successful only if it can secure the full support of the population and public authorities.

#### **Cartographic Analysis**

There are numerous methods based on existing cartographic data. Sometimes photogrammetric plotting based on recent aerial photographs may be necessary. Indeed, in developing countries characterized by rapid demographic growth, maps of city outskirts, often accommodating a fast-growing low-income population, become quickly outdated. These are also the areas most difficult to control, which encourages the spread of unauthorized connections.

Recent cartographic data may be used in different ways:

For a general preliminary analysis, a comparison of existing network plans and spatial maps of properties of authorised customers provides:

- Support for the organization of field surveys as described above.
- Support for the identification of non-billed or incorrectly billed buildings.

In most South American countries, there are also large-scale plans or sketch maps of housing compounds (known as "manzanas" in Argentina and Colombia, or "quadras" in Brazil). These plans also indicate the plots serving as the basis for geographical coding of subscribers (for municipal services or for the water supply utility). Colouring the plots corresponding to the registered customers on a housing compound's plan leaves white patches corresponding either to potential customers who are not yet receiving the service or to unauthorized consumers.

It is recommended to use a Geographic Information System (GIS) for more convenient, flexible, comprehensive and consistent data processing.

#### **Detection of Illegal Connections of Large Consumers**

Systematic campaigns targeting large consumers, whether industrial or other, enable location of unknown connections, which is a common problem when such consumers have enjoyed some form of impunity for a lengthy period.

Case studies:

In Buenos Aires, in the past, large consumers were usually not billed according to metered consumption but based on a series of parameters that were not related to actual consumption. It was therefore perfectly legitimate either for the consumer to request additional connections if the first one was inadequate, because of increasing needs or due to other factors, such as lower pressure in the network. When it was later decided to install meters at sites of all industrial, commercial and public consumers, the Water Utility was faced with the need to register all the actual supply points of each consumer. Sometimes, the consumer was not even aware of the number of water connections it was using.

In Casablanca, the large consumers were granted differential rates according to whether the water was intended for domestic use or industrial processes. In addition, some fire protection systems are granted another special rate. Logically, therefore, there should be three types of distinctive connections. It can be easily understood that in the absence of effective control, interconnections of these different networks were often made, either for reasons of technical convenience or to benefit from rates that are more favourable.

Different types of investigations may be applied in such cases:

- Analysis of consumption and follow-up monitoring of each customer
- Use of plausibility or consistency criteria, depending on the type of commercial activity (consumption per room for hotels, consumption per ton of output for industrial units, etc.)
- Technical inspection of all large consumers
- Systematic search for all supply points by means of an appropriate piping detector

Even though these are neither clandestine connections nor frauds, the surveys of large consumers should generally be accompanied by a diagnostic audit of metering devices. It is well known that an oversized meter cannot measure small flow rates (or measures them poorly), usually causing highly significant under-billing. In fact, from the customer relations viewpoint, it is preferable to launch a meter auditing and rehabilitation campaign, taking advantage of it to search for frauds or other possible irregularities.

### **Local Informants and Reporting**

In European culture, it is not common for the systematic and open use of informants or reporting as standard management tools. This reaction is often related to specific historical memories. In other cultures, however, this prejudice does not exist. On the contrary, denouncing a defrauder is considered proof of good citizenship: "If your neighbour takes advantage of an illegal connection, you will be the one to bear his water costs by paying higher fees....".

In some countries, the "good conduct" campaigns run by government companies relying on informants and reporting have produced very good results.

### **Simultaneous Detection of Non-visible Leaks and Unauthorized Connections**

During a campaign for the detection of non-visible leaks whether using a leakage detector or a leak noise correlator, an open connection produces approximately the same signal as a leak. If well organized, the campaigns for detection of invisible leaks may also enable the detection of unauthorized connections.

### **Ground Penetrating Radar System (GPR)**

GPR detects underground piping irrespective of the material that was utilized. The first GPR devices did not have sufficiently high capabilities, but the technology has improved and, under certain conditions, it enables detecting unauthorized connections.

In particular, the pipeline must not be laid too underground, which is usually the case with unauthorized connections, and the soil resistivity must be adequate.

### **Specific Methods for Low-Income Areas**

The methods implemented in low- and very low-income areas are very specific. They should include social elements and should promote effective community participation via local associations. This

issue was discussed in detail in the booklet entitled ‘Alternative Solutions for Water and Waste Management in Areas with Poor Financial Resources’ (see reference in 1998)

The issue of poor areas management is related to the following characteristics:

- Very often, the authorities do not wish to formally acknowledge settlements, avoiding the official recognition granted by the public utilities.
- The safety of personnel and equipment is not guaranteed, making it difficult to perform maintenance, billing and collection operations.
- It is practically impossible to create or update customer records.
- Billing procedures are inadequate.
- The entire setup is precarious (residents, populations, consumption) so that the assessment of tasks is impossible.

Irrespective of the situation, it can be imagined that detection of unauthorized connections and frauds is an impossible feat in an environment such as the above, as in many cases the entire area is not registered in the customer database.

The problem, therefore, is not defining the means for detection of unauthorized consumers and frauds, but rather defining a consistent management policy.

### **Comparison with Other Utilities’ Customer Databases (electricity, telephone, etc.)**

This method requires agreements between the various utilities. Such comparison is easier to achieve when the respective utilities use GIS systems.

## **4. Sustainability: Long-Range Preservation of Achieved Results**

The measures discussed above will enable keeping the situation under control during the first months after the operation. However, in order to ensure long-lasting results, the underlying causes must be dealt with and permanent control mechanisms must be established.

The prerequisite is the general improvement of the customer management

### **4.1. Improving customer management**

#### **Prerequisite: Avoid Laxity**

On the customer side, dishonesty or cultural patterns may explain the unauthorised use of water; on the Utility side, laxity is the main cause.

In some developing countries, the rate of apparent loss due to unauthorised use of water is extremely high. The initial reaction is often to justify this loss by the cultural context. It is true that the cultural context in relation to water supply is sometimes of great importance. This is the case in countries where water is scarce, but also in countries where water is found in abundance.

A second reaction is to explain the high level of unauthorised consumption by the high water rates in relation to the low income of the population. There is always a grain of truth in this approach. It is clear that differential water rates must be applied, to provide water access to all population strata. However, this approach in itself cannot account for unauthorised consumption either: very often, there are more defrauders in the rich neighbourhoods than in the poor ones.

Similar findings may be stated in developed Water Utility, even if the amplitude of the issue is smaller.

In fact, a very poor situation in terms of apparent losses is typically explained by years of laxity in management and by a lack of enforcement resulting in the near-impunity of defrauders. When such a

situation had been going on for years, reversing the trend may be very difficult. When the downturn in the situation is recent, it is relatively easy to define the conditions and actions to mitigate the loss and keep it under control.

First and foremost, the operator must not admit any laxity. The rules must be strictly enforced and consumers must be fully aware of this. The image of the Water Utility will benefit if users come to understand that it is the good customers who will foot the bill for defrauders and bad payers.

### **What are the conditions to be met?**

The water utilities that perform well in terms of apparent losses consistently meet the same prerequisites:

- A clear legal environment.
- Good communication with consumers.
- Effective organization to combat apparent losses.
- Personnel training and incentive policy.
- Clear metering policy

Any Water Utility that is in critical condition in terms of apparent losses should strive to meet these prerequisites and improve its situation. However, even after the action plan to mitigate commercial losses has been successfully implemented, these prerequisites must be maintained to ensure long-lasting results.

#### **Legal and Contractual Regulation**

The subscription contract binding the consumer and the Water Utility must clearly indicate the consumer's obligations as well as the penalties and fines to which he becomes liable in the event of fraud. Looking for frauds is useless if the Utility do not know when a fraud is discovered.

Penalties must be sufficiently high to have a deterrent effect on potential defrauders. In some countries, the penalties are so low that it is worthwhile for defrauders to assume the risk. Such a policy has no benefit whatsoever; it entails both an increase in frauds and an increase in operational costs.

If no contract or general regulatory document between the consumer and the Water Utility exists, it is strongly recommended to establish such a document and to have it ratified by the competent authorities. In the meantime, a legal expert should be asked to summarize the country's legal provisions with respect to thefts of water and frauds. The structure of the legal system in force in the country must also be studied.

#### **Communication with the consumers and information campaign**

In many cases, launching an information campaign can help combat apparent losses. This is particularly important if it is decided to perform a consumer survey or other specific activity for the detection of frauds or other illegal consumption.

A good information campaign inherently produces good results by enabling the reduction of on-site operations that are always very costly. Several examples are presented below.

#### **Water Utility Organization for Mitigation of Commercial Losses**

The organization of the Water Utility for mitigation of commercial losses depends on the Utility size and the magnitude of problem.

- In small utilities, the Customer Department handles detection and settlement of commercial losses: sometimes two or three persons are enough.
- Large utilities sometimes have a specialized department, which may have up to 50 persons.

Then some cases are presented to serve as source of inspiration.

- Creation of a Consumption Control Centre for systematic detection of unauthorized connections and frauds.
- Creation of a Large Consumers Control Department, including a fraud-detection function.
- Creation of Public Relations Department specializing in low-income areas (such as the favelas of Brazil).

It should be noted that the Customer Relations Department (or Unit) must often operate in coordination with the Distribution Department (or Unit), which has the capability to detect unauthorized connections or with the Metering Department (or Unit), which defines the metering policy. The scope of this coordination depends on the size of the Utility.

Quite often, an NRW Steering Committee should be established to enable the various participants to coordinate their actions with respect to real losses, apparent losses and metering losses.

- **Training and Incentive Program**

When apparent losses are particularly high all Water Utility personnel must be involved in the effort against apparent losses.

Under normal circumstances, the personnel in charge of detection and control of real and apparent losses must undergo specialized training. However, training alone is usually not sufficient. Personnel should also feel motivated. There are many ways to increase motivation of personnel.

- **Metering Policy**

The Water Utility's metering policy must be very clear and should be contained in a reference document.

## **4.2. Creation of a Consumption Control Centre for Systematic Detection of Unauthorized Connections and Frauds**

This is a case study. It refers to a Consumption Control Centre (CCC) project that was successfully implemented in South America

The project consisted of several phases:

- Launching an information campaign (“good conduct”) in the media.
- Establishment of a specialized department (the CCC), “to assist users in solving local water supply problems”.
- General pardon for users who declare unauthorized connections or frauds within a specific period of time, such as three months\*.
- After this period, initiation of a field inspection or survey intended among others to detect unauthorized connections and frauds (bypass, meter tampering, etc.).
- Enforcement of a punitive policy based on clear control and legal procedures.

(\*) In some places, population mobility is very high. Accordingly, a user may be unaware of a fraud committed by a previous owner or tenant. Therefore, during the period of grace, the user could ask the CCC to come and check for frauds that were “committed by a previous tenant”. After the period of grace, the Water Utility recommends that tenants carry out an inspection of the sanitary facility (free of charge) prior to moving into a new home.

### **4.3. Establishment of a Large Consumers' Control Department Including a Fraud-Detection Function**

Large consumers account for a major share of billing. Pareto Law (20% of customers account for 80% of billing) is not always applicable due to the predominant type of customers in a particular water utility. However, the customers/billing ABC curve sometimes reveals highly significant ratios of this magnitude.

The large consumers cannot be treated like everybody else and require customized treatment. In certain cities, in the absence of adequate treatment, industrial consumers leave the Water Utility and outfit themselves with independent installations (which is not always against the law).

Large consumers therefore must receive high-quality service. On the other hand, they must be subjected to ongoing control: monitoring of consumption variations, fraud detection, installation of meters of appropriate size, etc.

### **4.4. Creation of a Specific Public Relations Unit for Low-Income Areas**

Specific actions to be conducted in very low-income areas have been extensively discussed above. In a small operation with a relatively small number of such areas, the problem should be handled by the Customer Department.

Taking into account the magnitude of the measures to be implemented - as well as the cultural aspects that must be understood in order to pursue them - it may be advisable to establish a specialized Public Relations Department, perhaps within the Sales Division, for very low-income areas: relations with community associations, churches, sports clubs and various non-governmental organizations (NGOs).

### **4.5. Utility Personnel Incentives and Involvement in Fraud Detection Programs**

In the first phase, agents, who for years took advantage of a system based on more or less generalized corruption, must be eliminated from the very outset. In a second phase, the "meter reading" function must be reorganized.

A primary question is: should meter reading be performed by Utility personnel or should it be subcontracted? In many cases, the meter reader is the only interface between customer and Utility. Is it wise to entrust this responsibility to an outsider who is also probably very poorly paid? Will he resist the temptation to "round off" his monthly wages by entering into illegal agreements with certain consumers? It is well known that in certain countries this practice is quite widespread. Would not it be preferable to have utility-paid readers who the Utility can trust and who participate in the search for unauthorized connections and frauds? Of course, this would involve appropriate training and an adequate financial incentive.

### **4.6. Development of Communication Programs with the Public**

#### **Public Relations Unit**

The first errors due to poor understanding of the psychological, cultural and political realities of its adoptive country may be costly. Such examples abound. Therefore, it is recommended that a new operator or a consultant set up at very outset an effective Public Relations Department, which relies on competent national advisers in the field of public relations and communications media.

The Water Utility must maintain permanent relations with the most influential communications media.

## **Opinion Surveys**

It is not sufficient to communicate with the customers via the media. Consumer opinion of the provided service is also important.

The indicators determined by the Sales Division (number of complaints, repair response time, etc.) represent the first approach. Performance of periodic opinion surveys is important as well.

These activities seem to be quite distant from our main subject, which is combating fraud and unauthorized connections. However, they are not quite as remote as might appear. In fact, it is indispensable that cultural responses be gradually modified and the public's confidence gained in order to be able to intensify the efforts against fraud with general support.

## **4.7. Social Empowerment**

It may be useful to mention the concept of Community Empowerment that is issued from the former Community Participation Programme concept and that is often useful in many low and medium income countries. Community Empowerment techniques have been developed a lot during the last 15 years by some water utilities and they appear to be a very powerful tool for managing water supply in rural area and in very low-income urban areas.

Community Empowerment consists of a set of supporting measures and actions aiming at:

- Making sure that a water supply project (including water charges) fits the population demand and that the population has been involved in the various stages of the project.
- Developing necessary relations between the stakeholders to work together and formalizing this relationship under contracts or agreements where necessary.
- Making sure that all the conditions are met under the project to establish sustainable water services.
- Strengthening the capacity of the communities that are – or will be – involved in the implementation of the project and the management of the water services.

Community empowerment allows the best possible interaction between the stakeholders in order to increase the benefit of each of them. This optimisation of the overall benefit for each stakeholder - in economic, financial and social areas - is the best criteria for success. In particular, it guarantees the complete involvement of each stakeholder in order to make the project sustainable.

Community Empowerment involves well trained staff capable of elaborating strategies that fit to each community, to create or adapt appropriate analyse tools, to train the communities and to liaise for technical and socio-economical reasons. Community Empowerment implies a real cultural change for both the consumers and the water operators.

## **4.8 Technology**

The following techniques may be utilized either because they contribute to improve management, and consequently, lead to a reduction in the possibility of fraud or because they enable detection of existing frauds.

- High performance and user-friendly customer management system enabling easy formulation of queries and monitoring consumption patterns and irregularities according to categories of consumers
- GIS system in conjunction with a customer management system enabling easy identification of non-serviced plots
- Computerized water meter reading system, such as DPA
- Clear meter sealing policy, utilization of tamper-proof seals.

- Noise correlation equipment
- Piping detection devices
- Inviolable valves on house connections
- GPR for detection of unauthorized connections.
- Pre-payment water meters
- Data loggers.

## **5. Miscellaneous**

Some useful aspects relating to the occurrence and measures required to address unauthorised consumption are provided in this section.

### ***GIS and PDAs***

The use of portable PDA complete with access to the GIS database (indicating known meter positions and readings) together with pipe location techniques (and pilot holes, etc.) can be an effective approach to finding unauthorised connections.

Portable GPS units are relatively inexpensive and are accurate to within a metre (m) after subsequent office satellite corrections are made.

### ***Analysis of Data***

Continuous analysis of consumption via KPIs, statistical and trend analysis is recommended, as is a continuous audit of customer and meter data. Commercial processes should be reviewed for weaknesses e.g. meter change advices, approval of estimated readings, processing of consumption adjustments etc.

### ***Construction Methods and Specifications***

Pipeline construction methods such as the use of special pipe materials and soil backfill additives can be specified to discourage making illegal connections.

Illegal connections into pipes can be minimised by implementing various design, specification and construction standards. Although these measures will minimise illegal connections they probably still require other non-technical solutions such as social and political interventions to address the problem. The higher the operating pressure of large bulk water supply pipelines the greater are the dangers of illegally tapping into the pipeline and hence there is a tendency to discourage this type of activity. Air release valve and scour valve installations on large bulk supply pipelines require securing through integrated lockable maintenance hole (M/H) access covers, as these are usual targets for illegal connections on high-pressure pipelines. Other related engineering design and economic issues must also be considered before increasing the operating pressure within pipelines.

Smaller, non-metallic and low-pressure water reticulation network pipelines are more susceptible to illegal connections. An increase in pressure will result in higher leak flow rates and burst frequency real losses and pressure limitations of internal plumbing within buildings will limit maximum operating pressures. However, depending upon the extent of the economic implications, burying pipelines in soil strengthened with admixtures could have some impact on discouraging the practice of illegal connections.

### ***Metered Standpipes***

Metered standpipes that are available from water authority of metered standpipes for contractors to use when using water from hydrants. Specialized metered hydrants operated by the utility enable to get this specific consumption under control.

In many countries, hydrant for domestic used are metered and operated by an operator (water vendor) who his contracted by the Utility.

### **Lifeline Tariff**

The allowance for a free initial 'lifeline' volume that provides an initial volume of water free for essential human consumption will reduce the theft of water for survival

### **Flow and Volume Control Devices**

Flow control devices such as lockable three way shut-trickle-full flow ball valves or orifice washer installed at connection point are useful to limit losses due to unauthorised connections.

Flow control devices facilitate water demand management at the point of delivery to the user. Non-pressure- compensated flow control devices deliver water at different flow rates depending on the supply pressure in the reticulation system. Pressure- compensated flow control devices allow a user to take water at the same flow rate as supply pressure if the reticulation system varies).

Non-pressure compensating devices are generally used as temporary flow limiting measure in response to non-payment of water bills. These devices can either be a simple orifice inserted into the pipe or a lockable ball valve. The latter device does not require removal after receipt of payment and can be reused in the event of any future non-payments.

Pressure-compensated flow control devices are either installed in association with on-site break-pressure storage tanks and float valves with constant head outlet or with an in-line flow-sustaining valve. These devices are generally used for permanent installations that limit the supply volume to what the customers can financially afford and to ensure the reticulation system operates within pre-defined hydraulic criteria/standards.

Volume control devices include pre-paid metering systems consisting of electronic systems linked to meters and solenoid valves.

## **References**

Suez / Lyonnaise des Eaux (1998) Alternative Solutions for Water and Waste Management in Areas with Poor Financial Resources. *Nanterre France, Suez-Lyonnaise des Eaux*

Carteado F, Vermersch M, (2002) LYSA's method for reduction and control of Non-Revenue Water in water distribution networks. *SINO FRENCH News Letter*

Rizzo A, Thornton J, (2002) Apparent Losses: How Low Can You Go? *IWA Conference. Lemesos, Cyprus. (2002)*

Farley M, Trow S (2003) Losses in Water Distribution Networks, A Practitioner's Guide to Assessment, Monitoring and Control. *IWA Publishing*

Djerrari F and Vermersch M (2004), Reduction of Non-Revenue Water in the Drinking Water System of Casablanca - A global and coordinated approach for the reduction and control of losses, *IWA proceedings – Marrakech 2004*

Vermersch M (2005) The Reduction and Control of Non-Revenue Water - *UNESCO-IHE Institute for Water Education, Delft, The Netherlands - International Masters Programme in Water Management - Specialisation in Water Services Management – Suez-Environnement contribution..*

Carteado F, Vermersch M, (2006) The « Water Loss Circle »: a global approach and an integrated method to reduce and control water losses in the water distribution systems. « *Ingeniería Sanitaria y Ambiental* », *AIDIS n°84, January - February 2006.*

Alegre H, Baptista JM, Cabrera Jr. E, Cubillo F, Duarte P, Merkel W, Parena R (2006) Performance Indicators for Water Supply Services (Second Edition). *IWA publishing*

Ek Sonn Chan, Vaughan, Patrick (2007) - Phnom Penh Water Supply Authority - From a devastated Water Utility to a Model Water Utility, *Water Operator Partnership, Den Haag November 2007*

Chastain-Howley A, Wallestein D (2007) Using an AMR System to Aid in the evaluation of Water Losses: A Small DMA Case Study, an Easy Bay Municipal Utility District, USA *IWA WaterLoss 2007, Bucharest, Proceedings*

Rizzo A, Vermersch M (2007) Apparent Water Loss Control: The Way Forward. *IWA Water 21, August 2007 and IWA WaterLoss 2007, Bucharest, Proceedings.*

Rizzo A, Vermersch M (2007) Action Planning Model to Control for Non-Revenue Water. *IWA WaterLoss 2007 Bucharest, Proceedings.*

Rizzo A, Vermersch M (2008) Action Planning Model to Control For Non-Revenue Water. *IWA Water 21 – April 2008*

Liemberger R (2008) – The Non-Revenue Water Challenge in Low and Middle Income Countries *IWA Water 21, June 2008*

Parena R (2008) Tariffs, billing and metering. *Second IWA Utilities Conference: European Conference of Water and Sanitation Service. Proceedings*

Braïlowsky A (2008) - Social empowerment, Multi-stakeholders dialogue and Institutional Capacity Building, *IWA ASTEE Paris 2008*

Franquelo M.H. (2009) A local case in Malaga – Spain: Consumers Association and the Water Supply Company. *Second IWA Utilities Conference: European Conference of Water and Sanitation Service. Proceedings*

Rizzo A, Vermersch M (2009) Change Management as an Indispensable Component when Planning for NRW Control. *IWA – Water 21 – February 2009.*

Johnson EH (2009) Management of Non-revenue and Revenue Water Data. Second Edition. *Engineers Media. NSW Australia*

IWA Leakage - Halifax (2005-2014) – Halifax Water's Water Loss Journey - use of bulk water fill station to reduce apparent loss or theft