Apparent Losses: Basically, a Utility Management Issue

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Abstract

The authors are the former and current leaders of the Apparent Loss Initiative promoted by the Water Loss Task Force of the IWA. In this paper they present some of the main management concepts that have been developed by the team over the recent years: (i) the dynamics of losses; (ii) the 3-dimension approach for planning of Non Revenue Water (NRW) reduction, and (iii) the concept of optimum level of data:

(i) The Dynamics of Loss shows that working exclusively either on real loss or apparent loss may be a strategic error

(ii) The 3-Dimension Approach shows that special condition are required to meet targets in terms of NRW reduction and to make these targets sustainable when reached

(iii) The search for the Optimum Level of Data is a basic management issue since no efficient management is possible without sufficient and reliable data.

Nowadays, everyone agrees now that the NRW reduction needs to have a holistic approach involving both real and apparent losses. Although the concepts and tools mentioned above may be used in the framework of a comprehensive approach on Non-Revenue Water (NRW) the authors put the stress on the specific topic of the so-called apparent losses, which is very often under estimated and not easily understood. They clearly show that, even when the technical and operational solutions are known, reducing apparent losses and maintaining them at an acceptable level is primarily a management issue.

Keywords: non revenue water; apparent loss; dynamics of losses; change management; data management.

BACK TO BASICS: WATER BALANCE AND APPARENT LOSSES

There is no need to comment on the standard IWA water balance (Alegre et al, 2006) that is now used as a reference in many countries. This balance provides simple definitions of real losses - known as leakage and tank overflow - and apparent losses that may have various causes such as meter errors, estimate of unmetered consumption, unauthorised consumption and errors linked to the data acquisition process.

<table>
<tr><td rowspan="11">System Input Volume</td><td rowspan="4">Authorised consumption</td><td rowspan="2">Billed authorised consumption</td><td>Billed metered consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled authorised consumption</td><td>Unbilled metered consumption</td><td rowspan="9">Non-Revenue Water</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="7">Water losses</td><td rowspan="4">Apparent losses</td><td>Meter Errors</td></tr>
<tr><td>Estimate of unmetered consumption</td></tr>
<tr><td>Unauthorised consumption</td></tr>
<tr><td>Errors linked to Data Acquisition Process</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on transmission and/or distribution mains</td></tr>
<tr><td>Leakage and overflows at transmission and/or distribution storage tanks</td></tr>
<tr><td>Leakage on service connections up to the measurement point</td></tr>
</table>

Figure 1: IWA Water Balance

Paradoxically – and with the risk of creating still more confusion – it can be said that apparent losses are not really water losses: in most cases they relate to real water consumption that generates no revenue. In fact, there is loss in revenue for the utility but there is no loss in volume for the users. Essentially, apparent losses are generated by the metering process, either because the meters generate errors or because some consumption is not metered at all. The case of the unauthorised use of water – either due to unregistered service connection or frauds on registered service connections – is mainly a social and communication issue. It is therefore clear that customer management is a key concept for getting apparent losses under control. Technical and operational solutions are necessary to address the problem but no sustainable results can be met without managerial solutions.

This paper does not provide any exhaustive list of recommendations and tools to get apparent losses under control. The focus is on three specific approaches that have been considered as very interesting and fruitful by the members of the IWA Apparent Loss Initiative.

THE FIRST CONCEPT: DYNAMICS OF LOSSES

The dynamics of water loss is represented by the scheme below (Figure 2). The central ellipse represents the water loss of any system during a certain period of time. The water loss is divided into real losses and apparent losses. The 8 external arrows are the symbols of the causes and related corrective actions that can be used to reduce the losses: (i) leak repair, active leak detection, pressure control, pipe replacement for the real losses and, (ii) meter errors, unauthorised consumption, incorrect estimate of unmetered consumption and errors produced by the data acquisition cycle itself. These arrows are 2-way arrows: oriented toward the centre they represent the components of the action plan to reduce losses itself and contribute to reduce both real and apparent losses; oriented in the opposite external way they contribute to increase real or apparent losses.

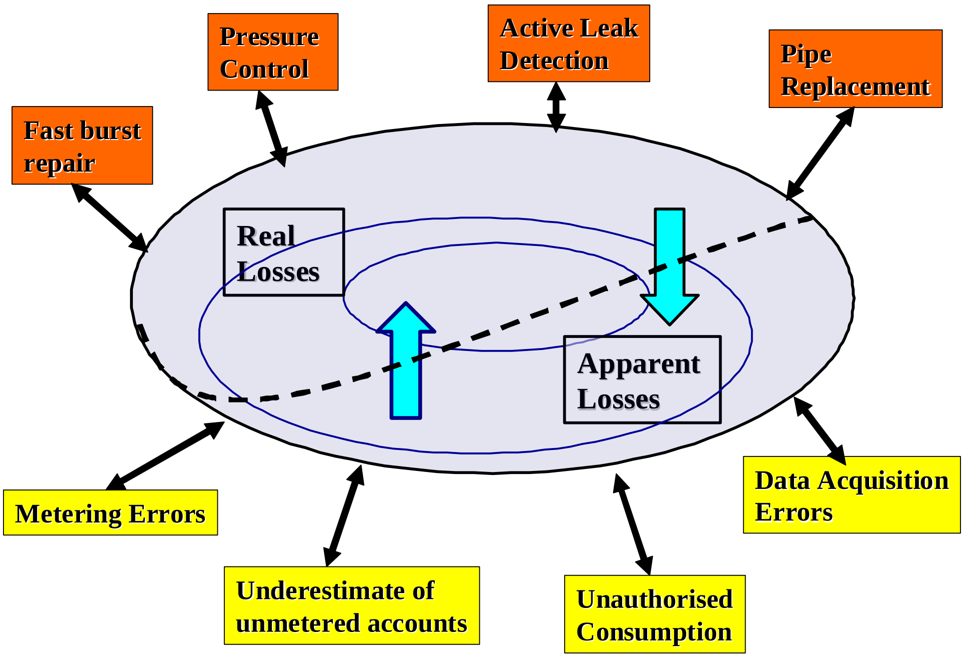

Figure 2: Dynamics of Water Losses

In fact, the dynamics is not so simple. The two additional blue arrows are responsible for moving the boundary between real and apparent losses and they demonstrate the possible migration of real losses into apparent losses or conversely. The lack of consideration of the latter is a frequent cause of failure in the action plans to reduce NRW (Vermersch, 2010). This point is developed hereafter.

The total V_t volume that will be saved in the frame of an action plan during a given period of time is given by the formula.

$$Vt = \sum_{i=1}^{i=n} \left[V_i - (VCRA_i + VEO_i) \right]$$

Where:
The action plan consists in *i* corrective actions numbered from *i*=1 to *i*=n; i also refers to a specific field of activity and related losses.
V_t is the total water saving (or NRW reduction in volume)
V_i is the water saving directly produced by the corrective action *i*
$VCRA_i$ is the natural loss increase generated by the coefficient of return of anomalies in field *i*
VEO_i is the additional loss generated by exceptional occurrences that may occur in the field *i* and amongst which one may find some unexpected loss migration

The formula is an algebraic one; it means that some terms may be negative. It also means that the sum of the negative terms may exceed the sum of the positive terms: this explains the failure of many programmes to reduce NRW: despite many corrective actions the total volumes of savings (Vt) may be nil or even negative. Let us give some examples:

Example 1: Corrective actions should at least compensate the natural rate of rise of the anomalies (Vi > VNRRi)
The overall undermetering due to the aging of the meters will not be reduced if the savings due to the replacement of some old meters does not compensate the "aging loss" generated by the remaining meters.

Example 2: Geographical planning: the gain in one area may be compensated by the losses in other areas
The savings obtained in the pilot areas are lower than the losses generated by the natural rate of rise of leakage in the other sectors of the city. Was it better to use the pilot area approach or to focus first on the metering issue for the whole city? Simple cost-benefit analysis will give the answer.

Example 3: Benefits generated by a given category of actions are hidden by losses in another category
For example, the whole result may be nil or negative because the savings in real loss are compensated by the increase in undermetering losses.

Example 4: When real losses migrates into apparent losses.
This case often happens when not all service connections are metered or when there are significant low income areas that are not under control. Very often, the high level of loss is attributed to leakage and the poor status of the distribution network. The apparent loss issue is underestimated for management or political reasons and the priority is given to leak detection campaign. But the effect is not the expected one: leak repair leads to better pressure of service and increased consumption and wastage by the non-metered customers and in the low income areas. The real losses are automatically transformed into apparent losses by an underestimation of the real customer's consumption without any economical and financial advantage for the utility.

Example 5: When apparent losses migrates into real losses
This example is more or less the opposite of the former one. In some water utility – often in developing countries – there is a high rate of unmetered service connections or default meters installed. Experience shows that their average consumption may be twice or three times higher than the consumption of the actual metered service connections, when there is no water restriction or pressure management. This is generally due to high level of wastage when there is no consumption control. When these non-metered areas are metered there is a dramatic

decrease of consumption, which leads to higher pressure in the pipes and increased flow rate of leakage.

Many additional examples could be provided. This approach is particularly effective in the understanding of the non pressurized networks or in the management of low income areas. It may seems that this approach is very fruitful in the case of utilities presenting high levels of apparent losses but experience shows that it can also been applied by utilities presenting a very low level of loss.

Example 6: Collateral effects in Pressure Control

Pressure control appears as one of the most effective way to control real losses. But pressure reduction generates a change in customer's consumption patterns, mainly at night. Some specific water usages may be affected by the pressure drop. Consequently, pressure control may also produce collateral effects such as a significant reduction in the customers' consumption and related increase in terms of apparent losses induced by lower flows not read by the water meter.

Conclusion on the Dynamics of Losses

Taking into account the dynamics of losses is a basic prerequisite in the elaboration and implementation of action planning for reducing water losses.

THE SECOND CONCEPT: A THREE-DIMENSION APPROACH

The AL Initiative has worked on defining the basic conditions for any NRW reduction program to fail or to be successful. At first it is necessary to define the two basic conditions for a project to be successful: (i) meeting the target in terms of loss reduction and, (ii) making the new target sustainable over time. For instance one would not say that a project is successful if we have reduced the loss from 40% to 35% of the water input over a 2-Year period and that the ratio came back to 40% two years later.

The AL Initiative recommends considering any loss reduction program from a multi-dimensional perspective. Three levels, or dimensions, must be considered: the operational management dimension; the project management dimension; and the change management dimension (Figure 3).

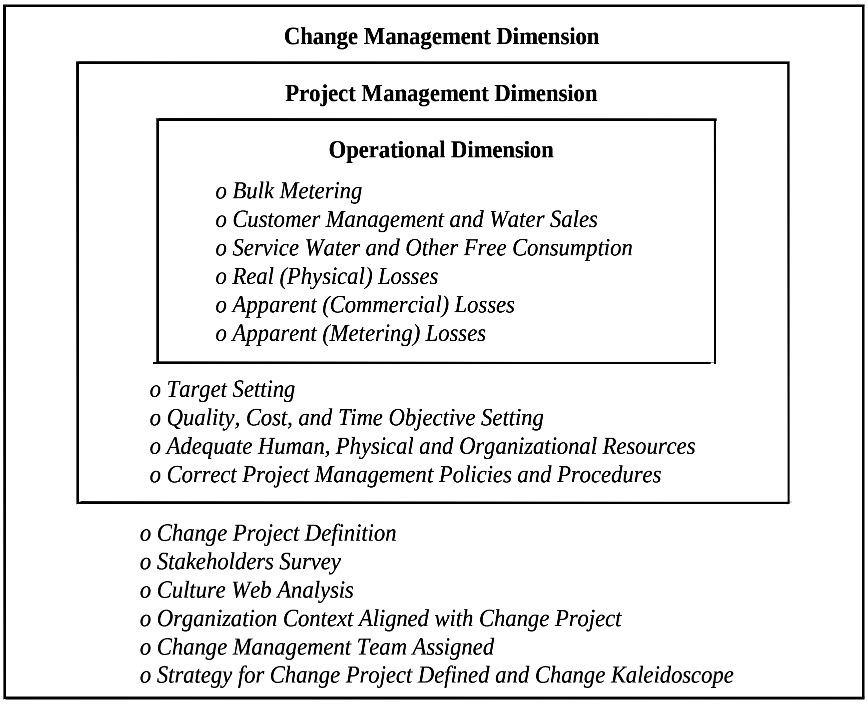

Figure 3: Action Planning Model as a 3-Dimension structure

The Operational Management Dimension

This dimension looks at defining the technical and operational activities that are required to transgress from the current to the targeted water balance, such as accurate bulk metering, optimised water billing, reduction of unbilled authorised consumption, leakage reduction, optimised customer metering, and reduction of unauthorised consumption. These aspects are well known by the practitioners, generally.

The Project Management Dimension

Genuine project management requires a project champion, a committed team, quantified objectives, time scheduling, resource commitment, and adequate tools and techniques, for the project to be successful. An excellent coordination between the various operational components is absolutely required to avoid any risks generated by the dynamics of water loss as described in the former section.

The Change Management Dimension

This dimension looks at the readiness or willingness of the water utility to really tackle water loss issues. It includes institutional and stakeholder support, a clear mandate, and an established project strategy. Internal organisational changes are very often required to tackle water losses and more specifically apparent losses that are linked to human, social and management issues.

Conclusion on the 3-Dimension Approach

Lack of consideration of the project management dimension and the change management dimension are frequent causes of failure in NRW action planning. It is possible to meet a NRW target in a defined period of time by considering only the first two dimensions. However, sustainability of the results will not be possible without considering the change management dimension; that really is an alignment of the interests of all parties concerned.

The survey of the change management dimension should always be considered as a prerequisite for any NRW reduction program.

THE THIRD CONCEPT: OPTIMUM LEVEL OF DATA

There is a well known statement: “You cannot manage what is not measured”. Effective management relies on effective measurement, coupled with reliable and accurate information transfer.

Errors are generally introduced to the data as it is transferred through a cycle of capture, collection, transmittal, processing, manipulation; representation and application (Johnson, 2009).

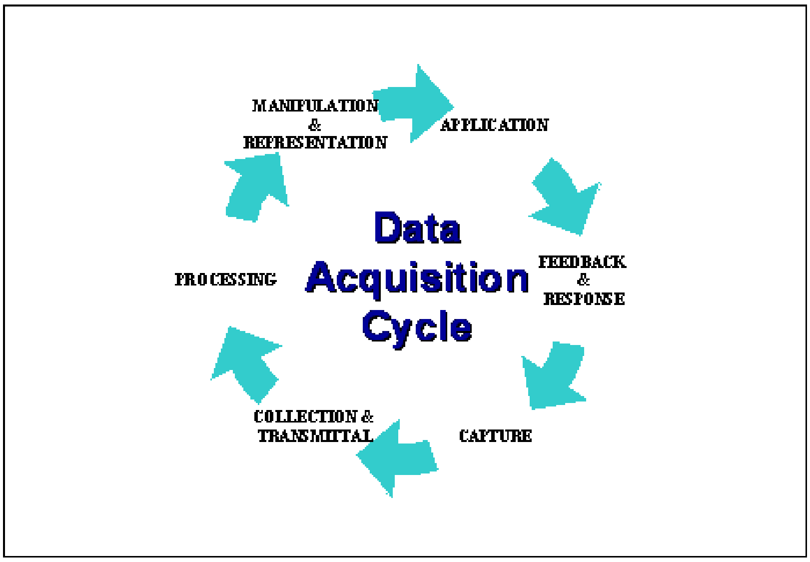

Figure 4 : The Data Acquisition Cycle (Johnson, 2009)

The management of apparent and real water losses requires a significant investment in data management and if this is not undertaken at the outset of a project there is greater risk that the strategies and measures selected may not achieve the optimal results. The level of data available to a water organisation is directly related to the investments – both human and equipment – at the various stages of the data acquisition cycle.

Lack of data or poor quality of data usually results in costly inefficiencies (Figure 5). The optimum investment in terms of data is the one for which the sum of the cost of data and the cost of inefficiencies is the lowest. A formula has been developed and tested with case study data (Johnson, 2009).

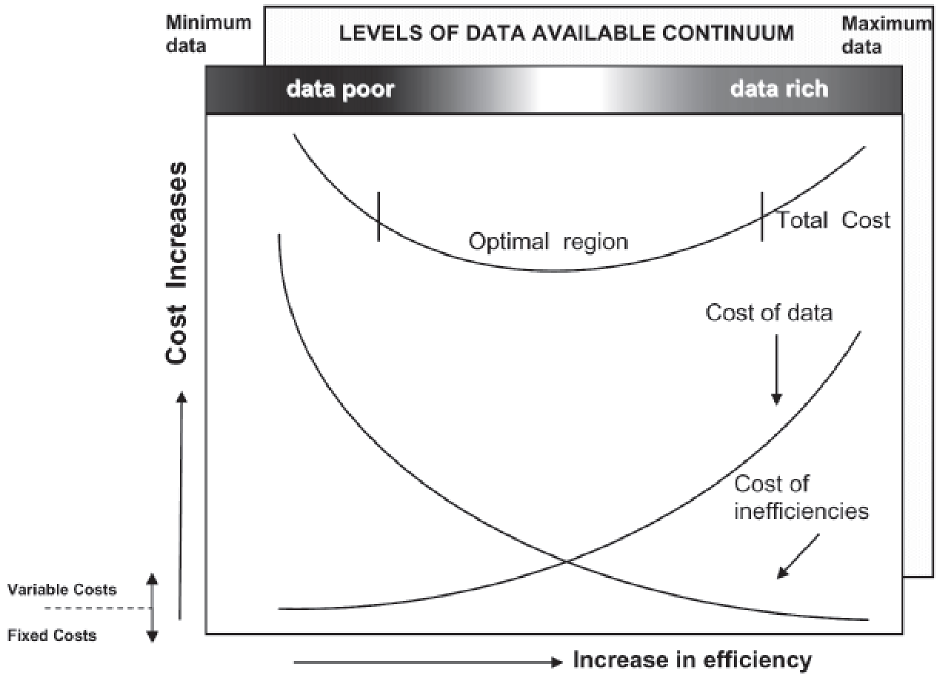

Figure 5 : Optimizing level of data - Economic threshold (Johnson, 2009)

Conclusion on the Optimum Level of Data

Creating an effective data system should be considered as an investment for any water utility and the internal rate of return of this investment can be calculated as for any other kind of investment.

One of the main applications of the above principles in the water utilities is the meter reading process (for both production/transfer meters and customers' meters) and the customer management (including Automatic Meter Reading techniques and Customer Information System). The data optimisation theory can be applied to analysis of a portion or to the whole Data Acquisition Cycle.

OTHER MANAGEMENT APPROACHES AND TOOLS

The Apparent Loss Initiative has also developed some concepts, approaches and tools focusing on apparent losses, implementation of NRW reduction action planning and management aspects. They are just mentioned here and the readers will find more details and explanations in the IWA Guidance Notes on Apparent Losses that should be available soon.

Action planning structure

A comprehensive action plan to reduce and control NRW should comprise 7 components: volume input metering, customer management and billing, control of authorised unbilled consumption, reduction of real losses, reduction of metering losses, reduction of unauthorised use and organisational and institutional aspects including change management (Carteado, 2006). The following figure shows a pie-chart water balance and the categories of actions related to each sector of the water balance

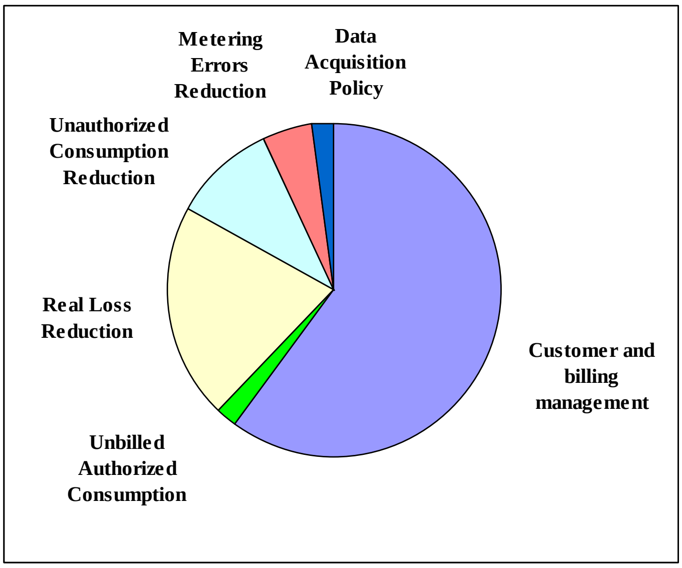

Figure 6 : Structure of an action plan

Stakeholder grid

The success of an action plan depends on the way the Utility is managed but also on the way to deal with its stakeholders. Stakeholders are plotted onto a grid on the basis of their attitude to change and their degree of influence. An example of a stakeholders' grid for a water utility is described below:

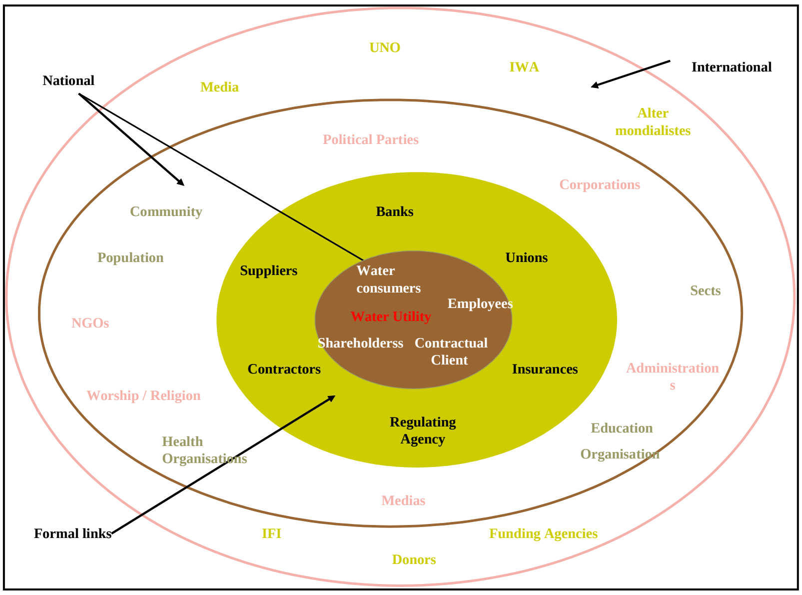

Figure 7 : The Stakeholders' Grid
(Source: adapted from Braïlowsky, 2007)

The utility and its shareholders, employees and customers constitute the core of the stakeholder grid. The second ring relates to the stakeholders that are formally linked to the utility such as the regulating agency, banks, suppliers, contractors, insurances, union, etc. The third ring relates to national bodies and organisations with no formal links (but continuous formal interaction) to the utility such as political bodies, communities, institutions, NGOs, and so on. The fourth ring relates to international stakeholders.

Kaleidoscope of Change

Since the level of loss in any water utility is the result of various factors including the corporate culture and the management of the utility, the Change is a basic condition to get losses under control. In the former sections the change was presented as the 3rd dimension or the 7th component of any action plan. The kaleidoscope enables the managers to consider the various points to be surveyed for designing, promoting and implementing the change in any water utility (Vermersch, Rizzo, 2008).

Once the organization's culture is understood, one can move on to utilize the change kaleidoscope to design a context-sensitive change project within the organisation.

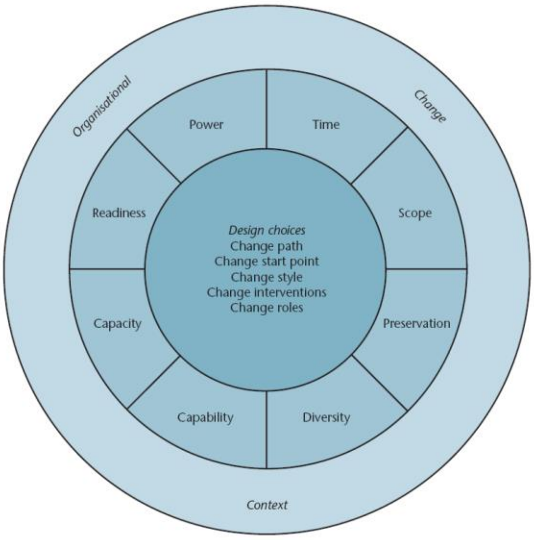

Figure 8 : The Change Kaleidoscope
(Source adapted from Balogun and Hope Hailey (1999)

CONCLUSIONS AND PERSPECTIVES

It is rather common to say that good management is a prerequisite for any utility to implement a successful action plan to reduce and control water losses. But this is still more evident in the case of the apparent losses since apparent loss is less a matter of techniques than a matter of human and social behaviour within and outside the utility.

The authors expect that the consideration of the concepts and approaches described above gives consultants and practitioners a more comprehensive understanding of the water loss processes and provides adequate tools to get them under control.

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