Non-Revenue Water and Errors throughout the Data Acquisition Process

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This Paper now acts as Appendix 5 of the free Guidance Notes on Apparent Losses and Water Loss Reduction Planning by Vermersch, Carteado, Rizzo, Johnson, Arregui and Lambert as Paper AppLoss 2016K at http://www.leakssuite.com/guidance-notes-app-loss/

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NRW AND ERRORS THROUGHOUT THE DATA ACQUISITION PROCESS

Summary

In former papers (Johnson, Vermersch, 2010), the authors have used the following dynamic scheme to illustrate the four categories of apparent losses and how these losses and the corrective actions may be responsible for expanding or reducing the level of apparent losses.

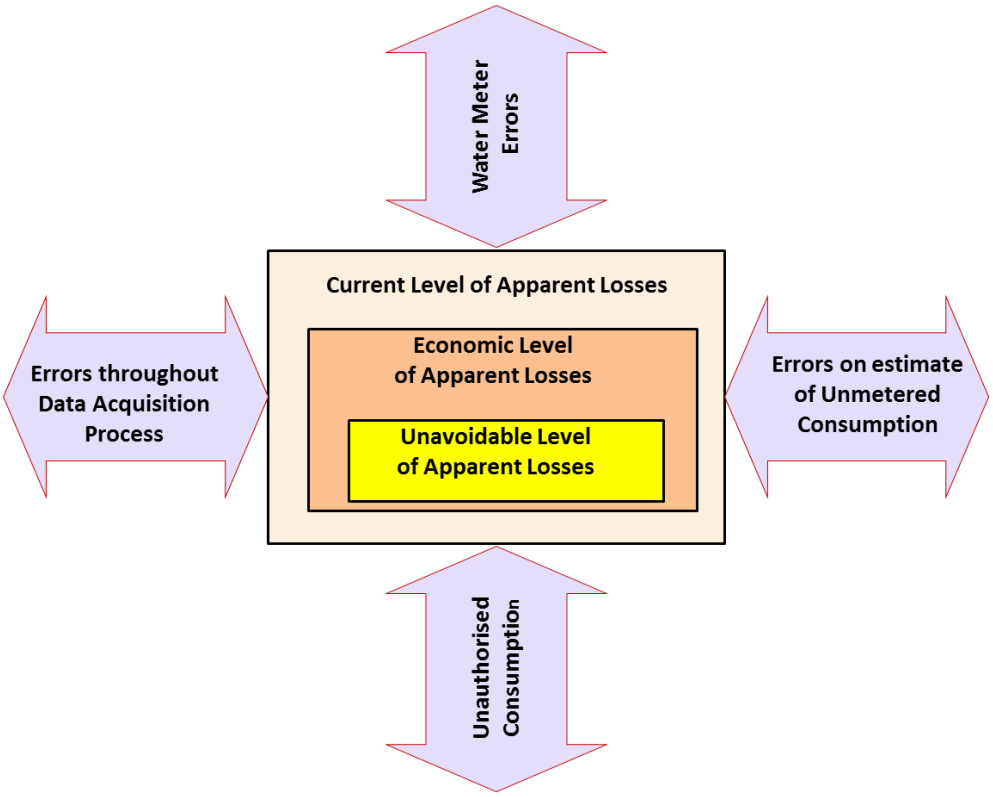

Figure 1 : Dynamic scheme related to Apparent Losses

Table 1 hereafter shows the location of the errors throughout Data Acquisition Process within the Water Balance.

Since 2010, the term 'Unavoidable Annual Apparent Losses' has been changed to 'Reference Level of Apparent Losses', for reasons explained in Section 3 of the Guidance Notes on Apparent Losses and Water Reduction Planning (Vermersch et al, 2016), to which this paper forms Appendix 5).

<table>
<tr><td rowspan="2">Volume from Own Sources (corrected for known errors)</td><td rowspan="5">System Input Volume (corrected for known errors)</td><td rowspan="2">Authorised Consumption</td><td rowspan="2">Billed Authorised Consumption (includes Water Exported)</td><td rowspan="2">Revenue Water</td><td rowspan="2">Billed Metered Consumption</td><td>Billed Water Exported (corrected for known errors)</td><td rowspan="9">Water Supplied</td></tr>
<tr><td>Billed Metered Consumption excluding Water Exported</td></tr>
<tr><td rowspan="3">Water Imported (corrected for known errors)</td><td rowspan="3">Water Losses</td><td rowspan="2">Unbilled Authorised Consumption</td><td rowspan="7">Non-Revenue Water</td><td colspan="2">Billed Unmetered Consumption</td></tr>
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<tr><td colspan="2">Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="2">Apparent (Commercial) Losses</td><td colspan="2">Unauthorised Consumption</td></tr>
<tr><td colspan="2">Customer Metering Errors</td></tr>
<tr><td rowspan="3">Real (Physical) Losses</td><td colspan="2">Errors in Estimate of Unmetered Consumption</td></tr>
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<tr><td colspan="2">Leakage on Service Connections up to point of customer metering</td></tr>
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Table 1 : Water Balance and location of the data errors throughout the data acquisition process.

The reliability of the water balance and the related strategic decision rely on the confidence limit of the assessment and measures that are carried out to establish the balance. Errors in data can be introduced at all stages of the data acquisition process. As a contribution to this important issue, the Paper describes some usual sources of errors and it shows how to minimize them.

A special section is devoted to meter reading procedures. Aspects of data transfer such as the SCADA systems and more recently, Automatic Meter Reading, are also described.

This short document does not pretend to be exhaustive: a full book would not be enough. It merely mentions the most frequent sources of apparent loss related to management of the customers and water meters. The solutions are sometimes simply referred to, as in checklists, leaving the reader the choice of deepening understanding using existing literature and websites.

1. Definition and basic issue

1.1. The Data Acquisition Process and the Data Acquisition Cycle

Apparent water losses are continuous, insidious, and long-term. They generally account for most of the losses in revenue as well as inefficiencies in water management. These losses are due to errors associated with metering, as well as data transfer and data management errors.

Effective management relies on effective measurement, coupled with reliable and accurate data acquisition process and data information transfer.

Errors are introduced to data as it is transferred through a cycle of capture, collection, transmittal, processing, manipulation, representation and application. Johnson (2009) has proposed the Data Acquisition Cycle concept illustrated in Figure 2[1]: this approach shows that any error introduced at any stage of the cycle will have an impact at the following stages.

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

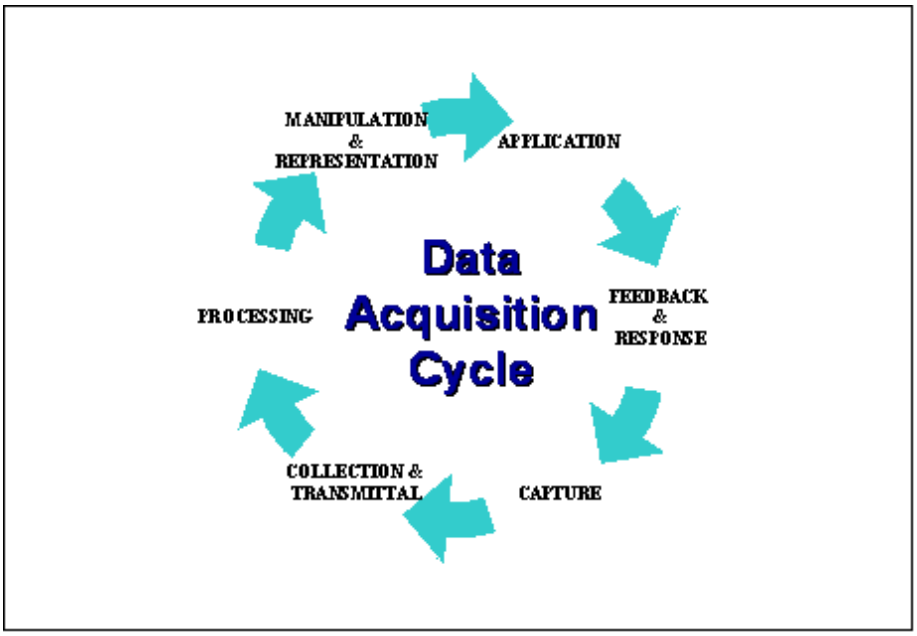

Figure 2 : The Data Acquisition Cycle (Johnson, 2009)

Minimising the errors introduced at the various stages of the cycle illustrated in Figure 2 facilitates the reduction of apparent losses.

The impact that these introduced data errors have on apparent losses are illustrated in Figure 3.

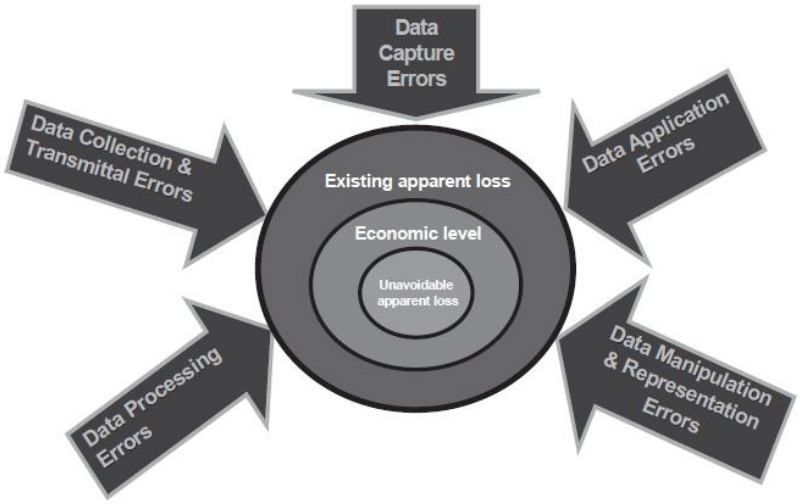

Figure 3 : Minimisation of data errors and apparent water losses (Johnson, 2009)

Examples of how these data errors and hence apparent water losses can be minimised in each stage of the cycle are briefly described as follows:

Capture. The identification of the most suitable sensor for a particular application together with its correct installation and location can minimise measurement errors. Implementation of regular accredited on- and off- site calibration of the sensor facilitates an increase in confidence in the data produced by the sensor.

Collection and Transmittal. Errors usually associated with a manual data collection system can be reduced through the implementation of automatic meter reading (AMR) systems. Insidious (stealth)

errors can be reduced through regular examination of the path along which the data is transferred and converted into different formats. An important long-term consideration in minimising data loss is the life expectancy of the media that contains the data.

Processing. The design and implementation of validation processes that identify and quantify errors in the data also facilitates the reduction of errors in this stage of the cycle.

Manipulation and Representation. Translating and transforming data into a format that is acceptable and understandable to the range of intended users also minimises errors. Processed data that will relay meaning enhances knowledge creation and reduces errors that could possibly arise due to misconceptions and misunderstanding.

Application. The integrated interpretation of data that best replicates future conditions of the various systems associated with water utilities facilitates their decision-making processes. The efficient and effective management and control of data errors enhances the interpretation process.

Feedback and Response. As new water infrastructure is created, implemented and operated new data is generated. There is therefore an evolution of the data originally used as a basis for decision-making at a planning stage to the data subsequently generated by the new water infrastructure. The new data is influenced by the errors in the original data as well as any inaccuracies associated with data transformation processes. The formulation of a revised strategy at the commencement of a new cycle for the acquisition of data facilitates the identification of the set of measures that will minimise measurement errors, optimise decision-making and ultimately ensure the sustainability of water, human, financial and other resources. (Source: Johnson, 2009, footnote 1)

1.2. The Data Acquisition Cycle as an intangible asset

Johnson (2009) has developed a comprehensive reference for the management of non-revenue and revenue water data for urban and rural water authorities. An argument is also presented in the reference that proposes the classification of data as an intangible asset through encouraging its reliable management.

Data are therefore the means by which apparent and real water losses are communicated and comprehended. Errors in the data therefore adversely affect the communication and comprehension processes.

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 data management topic is a very large one. For an overall analysis of this topic one may refer to Johnson EH (2009), Management of Non-revenue and Revenue Water Data (Engineers Media, Australia).

The current guidelines only focus on the most current issues that the practitioners have to address:

- what are the most common sources of errors
- what needs to be analysed at the review an assessment stage
- what are the most common actions to be taken

Due to their importance, special sections are dedicated to water meter reading and automatic meter reading (AMR)

2. Review and Assessment

Some suggested items that need to be considered as part of an audit of the data acquisition process are outlined below.

2.1. Errors in water input data

This point is of paramount importance since it has an essential impact on the reliability of the water balance itself and consequently on the quantification of the various type of losses.

The following items need to be considered and audited:

- Measurement error of the bulk meters that monitor the volume input volumes (and the transferred volumes, if any)
- Procedures for the routine calibration of bulk meters
- Extent of the errors associated with the primary measurement device of the bulk meters
- Extent of the errors associated with the secondary measurement device of the bulk meters
- Reliability of the equipment used for data transfer or remote reading (SCADA for instance)
- Analysis of the interruptions to the remote reading frequency
- Analysis of the procedure used to correct or estimate the data values when equipment is out of order.

This list is not exhaustive and the reader is invited to refer to Appendices 1 and 3 of the 2016 Guidance Notes on Apparent Losses and Water Reduction Planning (Vermersch, Carteado, Rizzo, Johnson, Arregui and Lambert, 2016) to which this paper is Appendix 5.

2.2. Customer Meter Reading Errors

This section deals with various aspects of the sources of meter reading errors associated with customer meters and used for generation of water bills.

Usually, this aspect is not considered in the papers and books related to water metering. These documents usually focus on the water meter themselves and their installation and on the way to select the best meters that fit the customer's consumption profiles. However, many cases show that it is useless to have the best meters in the world if these meters are not properly read.

The authors have witnessed very significant cases:

- Good water meters replaced because the poor (or invented) meter reading had influenced the manager
- Meter replacement policy stopped for the same reason: the effect of the meter aging was hidden by poor or invented reading

For these reasons, the authors do not approve the use of water balances where the undermetering due to the meter itself and the reading of the meters are in the same box. They strongly recommend auditing separately the errors due to the meters themselves and the errors due to the meter reading process, which should be classified among the "errors throughout the data acquisition process". The other advantage of such a discrimination is that the corrective actions to minimize both categories of actions are quite different.

In fact, two main categories of errors related to the meter reading process may occur

- Random accidental errors in the meter reading process itself including data transmission and record. Most of them can be detected by the billing software or at the last stage by the customer. Appropriate training and monitoring procedures enable these to be controlled and minimised.
- Systematic errors due to intentional errors: corruption, illegal agreement between the customer and the meter reader, etc. Many solutions may be considered in the frame of the fight against corruption and illegal practices. They range from the assignment of specific meter reading controllers, to the complete elimination of the meter readers in the automatic reading process

(AMR). Other techniques may be considered such as assigning changing meter reading routes to the meter readers or using hand held computers that make the fraud more difficult and minimize the data recording errors.

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Corrective actions are considered in Section 3.

Some specific audits to be carried out

As an alternative to a lengthy discussion on the topic and for brevity, key points have been listed that should be considered when investigating the meter reading issue:

- Meter reading in the Water Utility
- Various kinds of meter readings
- Meter reading Frequency
- Processing anomalies
- Meter reading and communication
- Cultural and legal aspects

1. Meter reading in the Water Utilities

The flow chart shown in Figure 4 indicates the importance of the meter reading process and the revenue collection process for any water utility.

Meter reader's tasks and responsibility are the following:

- To read the meters (meter reading code)
- To detect anomalies (anomaly code)
- To inform customers

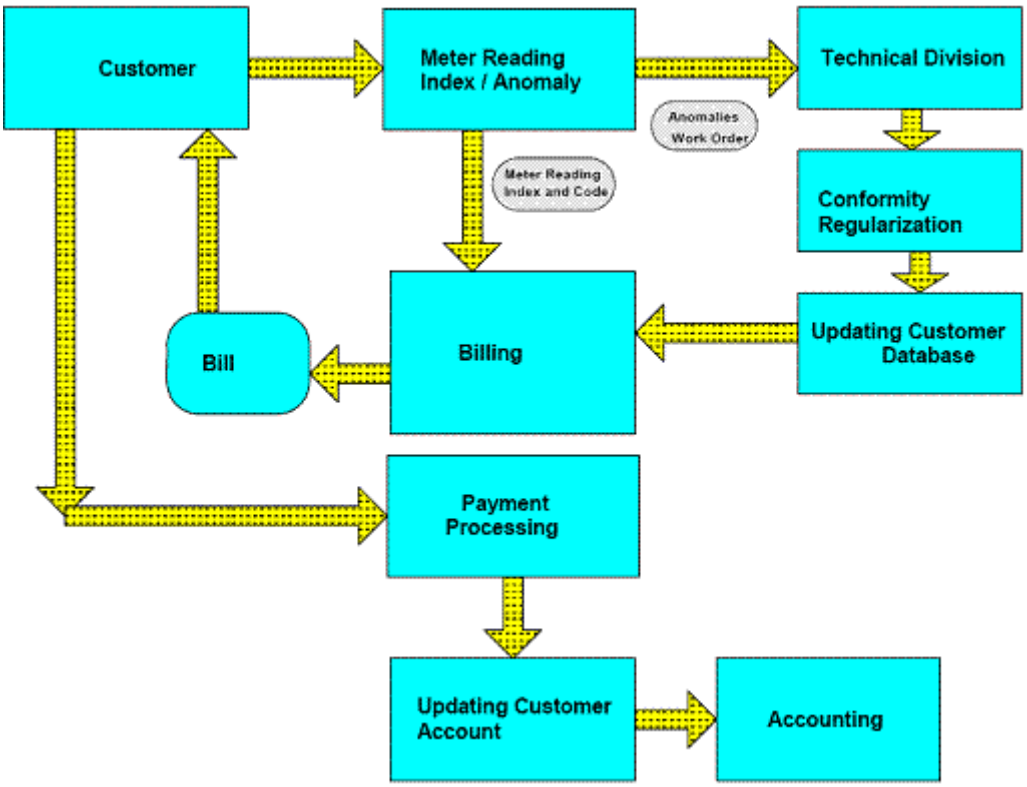


Figure 4 : Meter Reading and Payment Process in the Utility flow chart

2. Methods of meter reading

Various methods of meter reading may be considered:

- Manual reading
- Reading with portable digital assistant (PDA or Hand-held computer)
- Remote reading
- Periodical or rolling meter reading procedures
- In-house reading and out-sourced reading

The stages of the meter reading process include the following:

- Preparation stage: batches and meter reading routes
- Meter reading in the field
- Critical review before billing
- Processing administrative anomalies
- Processing technical anomalies

3. Frequency of meter reading

The frequency of meter readings could be influenced by the following factors:

- Customer mobility
- Customer's agreement (or not) on estimated bills
- Seasonal variation of tariffs (e.g. resort areas)
- Operational cost of meter reading and billing
- Improvement of working capital
- Important: Frequency of billing and frequency of meter reading may be different

The advantages of a more frequent reading are as follows:

- To bill more frequently
- To suit the ability to pay by small customers (important in low income areas)
- For faster detection of anomalies on water meters and house connections
- For faster detection of anomalies on consumption and frauds

Inconvenience of a more frequent reading includes the following:

- High operating cost
- The critical review of the data requires more staff

4. Changing frequency of meter reading

When considering the need to change the frequency of reading and billing (e.g. from monthly to bimonthly) the following items require investigating. The overall benefits require establishing for a comparison of the various alternatives.

- Number of meter readings to be carried out
- Number of meter readers necessary to read the meters for each period
- Cost of the meter reading
- Benefit or loss due to undetected leaks
- Benefit or loss due to undetected fraud
- Losses due to inoperative meters

The following also require investigation/ consideration:

- Technical and logistical aspects
- Impact on cash flows
- Communication campaign

5. **Meter reading and Call Centres**

- Meter reading and billing are usually an important source of data resulting from customer complaints.
- Analyses of the number of calls and types of complaints will assist in improving meter reading and other associated procedures.

6. **Meter Reading and Apparent Losses**

The quality of meter reading has a direct impact on the level of apparent losses. Meter readers should therefore be involved in any apparent losses reduction programmes.

7. **Cultural and legal aspects**

Consideration should be given to national laws and by-laws such as the following:

- Customer's contract
- Customer's regulation
- Details of fines and penalties as stipulated by legislation and regulations.

The following also requires consideration:

- What are the legal rights concerning entrance to a property and dwelling?
- Who is the owner of the meter?
- Do the customers accept bills based on estimated consumption?

Points to be audited through specific performance indicators:

Concerning the meter reading procedures, the following points must be the subject of a specific analysis, or even an audit:

- Quantity of unread meters (why? and since when?)
- Critical analysis of the meter reading procedures
- Control on unread meters (second reading, inspection etc.)
- Missed or omitted meters
- Dishonest meter readers/corrupt meter reading
- Corrections to incorrect meter readings: for instance, a negative meter reading can often introduce errors into the estimating algorithms in the software.
- Under registration generated by the delayed replacement of stopped meters.

Some appropriate techniques

Some techniques that can be used to minimise meter-reading errors are as follows:

- Readings provided by the customer
- Remote meter reading (AMR). This point is described in subsequent text.

2.3. Billing and Accounting errors

This section deals with various aspects of the sources of billing and accounting errors associated with the generation of water bills for customers. Key points that should be considered when investigating this problem are listed hereafter.

1. **General**

The following can be undertaken to identify the causes of billing errors and facilitate the identification of measures to address these anomalies:

- Audit on commercial procedures
- Audit of the billing software
- Audit on security procedures including computer staff ability and level of access authorisation
- Critical analysis of the billing spreadsheets and statistics
- Administrative privileges (if any)

2. Some specific items

Typical sources of errors include the following:

- Erroneous calculation
- Erroneous or misleading algorithms
- Programming errors in the billing software
- Quantity of estimated bills;
- Factors or criteria used for the bill estimation
- Billing corrections. Sometimes corrections, based on a customer's justified request, are manually processed and are not taken into accounts in the final statistics and results: Money is taken into account but relevant volumetric amount of water is not
- Discounts that are manually processed and that are not taken into accounts in the final statistics and results: money is taken into account but relevant volumetric amount of water is not
- Fraud or illegal practise on the customer database or on the computer itself.

3. Set of corrective actions

3.1. Reduction of water input data errors

The determination of the exact magnitude of errors associated with the determination of the volumes of water supplied into the system requires the establishment of an accredited calibration approach (Johnson, 2009).

The comparison between the on-site meter readings and the value provided by the remote reading and/or SCADA System provides a useful measure of the extent of errors introduced into the data acquisition process.

3.2. Meter reading

Improvement of meter reading procedures as well as the use of handheld computers can reduce the errors associated with meter reading. The following interventions / devices could also be considered:

- Improvement in monitoring procedures: no procedure is completely sure, inspection and control always need to be implemented. For instance, some managers believe that they can cancel the meter reading frauds by using hand held computer without providing the former meter index to the meter reader: this is a wrong statement, in the utilities with a high level of corruption, the dishonest meter readers have their own meter reading records.
- Inspection procedures: special team of inspectors in house or outsourced monitoring inspections
- Enhancement of associated GIS/GPS procedures as some types handheld terminals for meter reading have GPS, GSM (mobile communications) and a built-in camera
- Implementation of continuous remote reading (AMR)

3.3. Billing and Accounting

The customer services management must rely on clear procedures that are regularly independently audited, such as for the installation of a meter, meter reading, administrative procedures, billing delivery etc. Anomalies identified can therefore be used as a source for improving the procedures.

The main actions suggested are:

- Periodical critical analysis of the billing spreadsheets and statistics
- Continuous monitoring of the commercial and computer procedures (ISO 9000)
- Continuous monitoring of the computer security procedures (ISO 9000)
- Comparison of billed volumes to delivered volumes on a zone basis
- Establish revenue collection efficiencies
- Establish Return on Assets (ROA) ratio
- Tariff design

4. Description of some specific actions or solutions

4.1. Reduction of signal path errors in data transmission

No system is 100% secure.

The conversion of data into various formats as it follows a path through a telemetry or smart metering system can cause changes to the original signal generated at the sensor. Errors are introduced to data during its conversion into an appropriate format for storage at the outstation or data concentrator unit as well as during further conversions for transmittal and reception at a central base station. These errors can be induced due to the incorrect electronic identification, in the sequence of transmitting, in the transmission and in the conversion of data.

Output signals from water meters are generally converted for transmission and reception by analogue-to-digital (A-to-D) converters. Digital errors can be introduced during this conversion process that result in incorrect negative values, a continuous maximum value and/or extreme changes in consecutive values. Transmission of signals over radio frequencies can be interrupted causing a loss of data resulting in gaps in this data. On-site audits and off-site statistical analysis checks should be carried on a regular basis to identify these anomalies.

Signal path errors can be minimised using the following (Johnson, 2009):

- Synchronised real-time clocks in the outstation/ data concentrator unit;
- Programmable error correcting software algorithms for the outstation/ data concentrator unit;
- Communications software that optimises data transmission;
- Software that ensures outstation/ data concentrator unit only transmit data when interrogated by the central;
- Communications software that have both error detection and correction capabilities.

4.2. Establish meter reading efficiencies

There is a need to establish the extent of the problem and the benchmark for improvement.

Meter reading efficiency is a measure of the extent that the meter readings are correct and has an impact on the determination of billing efficiency.

4.3. Advantages and disadvantages of different meter reading methods

Different methods of reading meters are summarised in Table 2 and generally, the more automated methods are applicable to those countries with higher labour costs and higher water prices.

Method	Comment
Self-reading by customer and submitted by telephone, letter or internet to water authority.	Requires random auditing and auditing based on credit control reports.
Visual reading and recording of reading in a book.	Each reading has to be manually recorded in the water authority's management system.
Schedules manual reading and recording of reading in a handheld electronic device. The meter reader's route is scheduled and different routes are allocated to different meter readers on a rotational basis.	Readings are downloaded automatically into the water authority's management system. Depending geographical features, 200 to 500 small residential meters can be read a day by a meter reader using this method.
Programmed photo-meter-reading with a special digital camera.	Only recommended if a manual meter reading could be problematic such as in some developing countries. Each reading is manually recorded in the management system.
Program scan-meter-reading with a handheld computer with or without site charging.	Like photo-meter-reading, this method ensures that the meter reader actually visits each meter. Readings are downloaded automatically into an information management system. Maintenance and capital cost are high, nearly twice that of a photo-meter-reading system.
Smart technology reading of end of month reading any day after the end of the month with a hand-held or lap-top computer.	Usually linked into a prepayment volume control metering system. This system facilitates the monitoring of Non-Revenue Water.
Automatic Meter Reading (AMR) while passing the customer's meters and automatically read meter with an electronic hand- held terminal or portable computer.	Can be linked into a volume control prepayment metering system. Has the advantage that the meter reader does not have to enter the customer's property.
Automatic Meter Reading (AMR) from the water authority's office by radio, power cable carrier, telephone cable or mobile phone.	It is a costly form of meter reading but it presents many advantages for the management of the meters and customers. The advantages exceed the simple meter reading aspects and a full analysis need to be carried out.

Table 2 : Different methods for reading meters (Johnson, 2009)

4.4. Meter Lag and Premature Calculation

The water balance and the indicators are calculated for a given period of time, but it is generally unlikely that all water meters are read at the same time. It is usually possible to read the bulk input and output meters at the same time because they are fewer in number than the customers' meters. Customer meter readings are usually carried over a period of several weeks. This meter-reading lag generates some discrepancies in the calculation of the various indicators.

The meter lag may result from the following:

- The billing period, the meter reading period and the production period could be different
- The lengthy duration of the customers' meter reading period.

Also, regulatory and media pressure to publish results means that Utilities sometimes have to complete the water balance before all the relevant data are available and customer meter reading and billing queries are resolved. 'Premature calculation' can also be an additional source of error even in fully metered systems.

Various solutions which can be implemented by a water utility to adjust for this meter reading lag are listed as follows:

- Using approximations without any meter lag corrections such as indicators that are calculated on a 12-month rolling period in order to minimize meter lag effect (see example on Fig 5).
- Sharing the meter reading figures on different water supply periods (see Fig 6)
- Reading the input and output bulk water meters at the weighted centre of the customers' meter-reading period. It can be done by meter reading batch or by meter reading routes.
- Extrapolating the customer consumption values one by one in order to fit with the large meter reading periods: this can be done automatically by some billing software upon request.
- Tailoring more or less sophisticated software to minimise the meter lag effect.
- Using an automatic metering system (AMR) should substantially solve the problem of metering lag since all meters are read simultaneously.

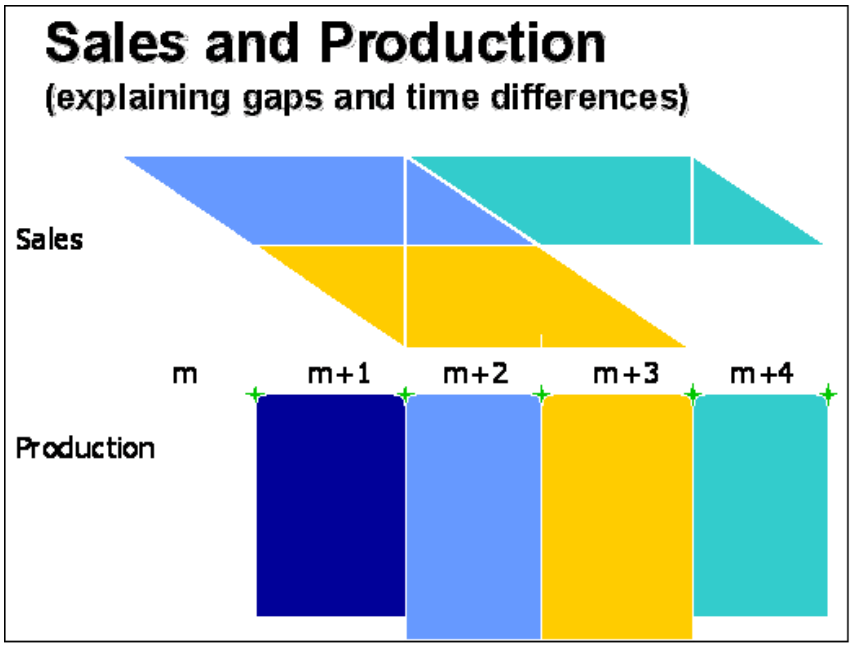


Figure 5 : Meter Reading Lag

Case study 1. A large city in Asia

In this Case Study, some years ago, the contract specified that NRW should be calculated as % of System Input Volume. It is now recognised that there are problems in using this KPI to track changes in Real and Apparent Losses (see Tables 8 and 10 of Section 3 of the Guidance Notes by Vermersch et al, 2016), but Figure 6 provides some general conclusions. On this graph, it is possible to note:

- How the lack of a meter lag adjustment influences the large variability of monthly NRW%
- A 4-month rolling NRW% reduces the effect of meter lag and identifies seasonal trends
- The annual rolling index minimises the influence of lack of meter lag adjustment

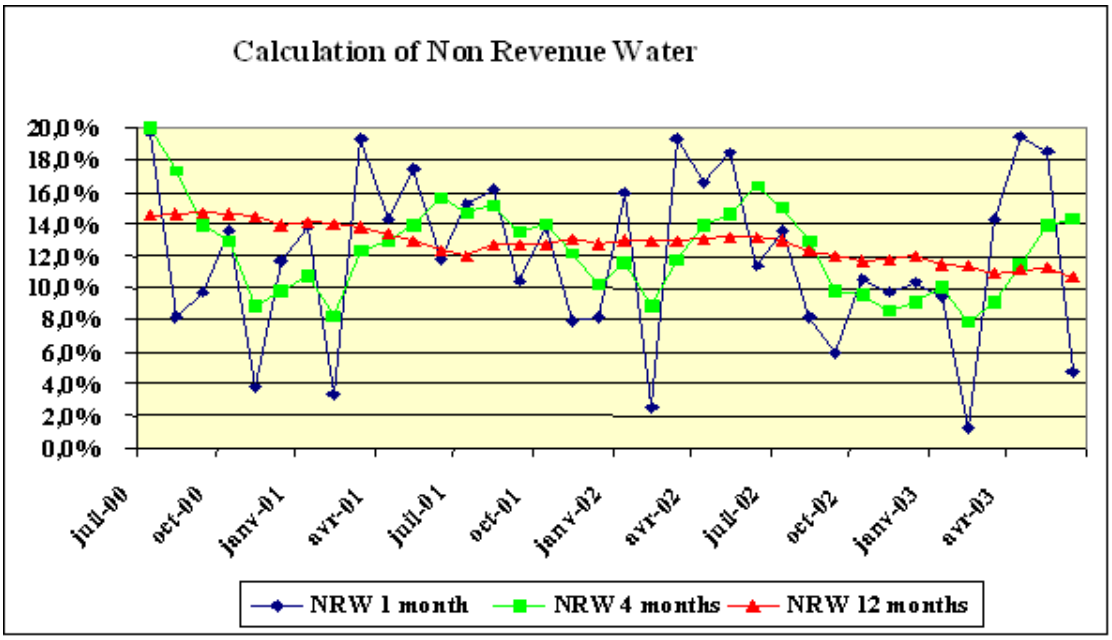
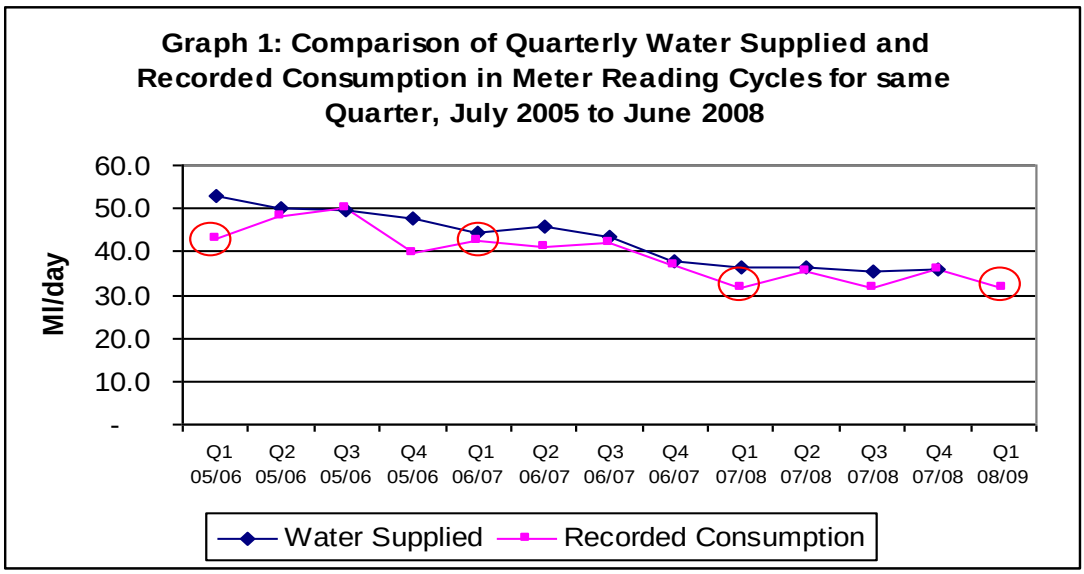


Figure 6 : Meter lag - Monthly calculation of NRW on monthly, quarterly and yearly period

Many utilities compare a monthly index to the index of the former month. The graph shows that this procedure is quite inappropriate, and an annual rolling period is necessary if no meter lag correction is applied. In this Case Study, it was established that apparent losses due to meter under-registration were high, but due to a meter replacement program, the NRW% continued to decrease down to 8%.

Case study 2. Australia

The following graphs show an example from an Australian Utility with a quarterly meter reading and billing cycle, during a multi-year drought event in which restrictions were placed on consumption. Graph 1 compares the quarterly volumes of Water Supplied (upper line) and Recorded Metered Consumption (lower line) in Ml/day. Quarterly NRW – the difference between the lines – varies from 10 Ml/d to 0 Ml/d (or even slightly negative value in one case), if no meter lag adjustment is applied.



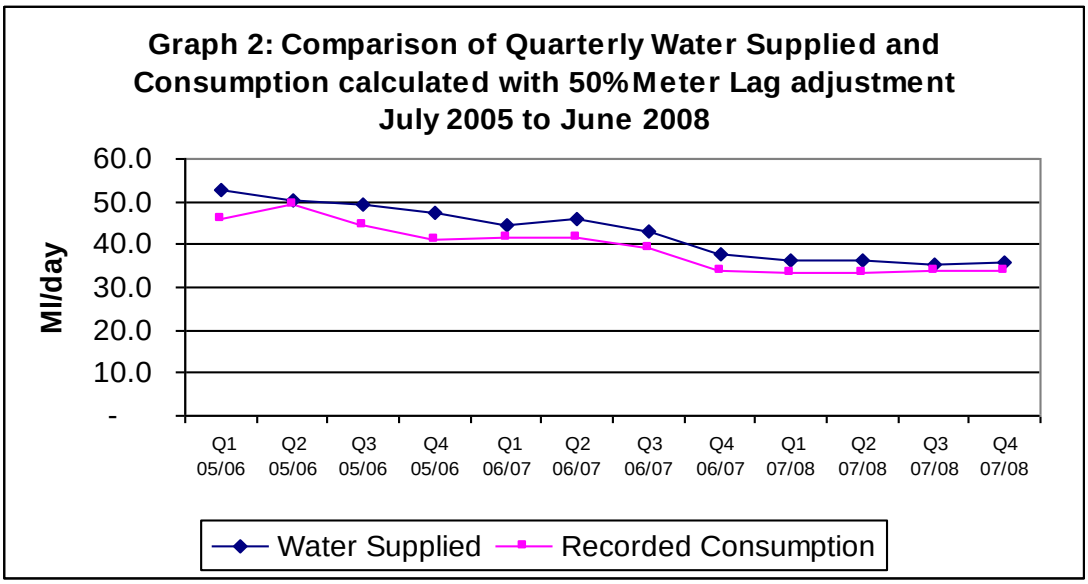


Figure 7 : Meter Lag Adjustments (source: A. Lambert)

In Graph 2, a simple meter lag adjustment has been made by attributing 50% of the metered consumption in each cycle to the previous cycle. The variation in quarterly NRW becomes much reduced and follows a more consistent trend. The annual NRW trend with meter lag adjustment is 3.7 Ml/d in 2005/06, 2.7 Ml/d in 2006/7, and 1.6 Ml/d in 2007/08.

4.5. Under registration generated by the delayed replacement of stopped meters

Manual meter reading is generally carried out on a monthly, bimonthly or quarterly basis. Stopped meters are therefore easily identified and replaced through implementation of correct organisational procedures.

When most meters are read every six months or once a year, as it is common in Europe, it is unlikely that stopped meters will be detected within this lengthy meter reading cycle.

A suggested compromise for the latter situation would be to implement monthly reading of all large consumers that represent approximately more than 50% of the volume of water sales.

The other solution is to implement the Automatic Meter Reading.

4.6. Automatic Meter Reading (AMR)

4.6.1. General (source Wikipedia, Feb.2009)

AMR

Automatic meter reading, or AMR, is the technology of automatically collecting data from water meter or energy metering devices (water, gas, and electricity) and transferring that data to a central database for billing and/or analysing. This reduces labour costs, and in the case of estimates, billing can be based on actual consumption rather than on an estimate based on previous consumption. It also gives the customer better control of their use of energy, gas or water consumption. AMR technologies

include handheld, mobile and network technologies based on telephony platforms (wired and wireless), radio frequency (RF), or power line transmission

Advanced AMR and AMI

Originally AMR devices just collected meter readings electronically and matched them with accounts. As technology has advanced, additional data could then be captured, stored, and transmitted to the main computer, and often the metering devices could be controlled remotely. This can include events alarms such as tamper, leak detection, low battery, or reverse flow. Many AMR devices can also capture interval data, and log meter events.

Advanced Metering Infrastructure, or AMI, is the new term coined to represent the networking technology of fixed network meter systems that go beyond AMR into remote utility management. The meters in an AMI system are often referred to as smart meters, since they often can use collected data based on programmed logic.

Advantages of AMR systems include:

- Increased efficiencies: the complexities and inefficiencies of manual systems are substantially eliminated.
- Accelerated and accurate billing.
- Tamper notification: on-line monitoring of all meters that immediately identifies operating problems that usually cause apparent water losses. e.g. undetected stopped meters)
- With the meter data being readily available, more flexible billing cycles would be available to the customers instead of following the standard utility read cycles.
- Reduced labour cost as a result of automating reads, connections and disconnections
- System has the flexibility to adjust for reading cycles, adjustments to tariff and changes in tenancies.
- Cultural change: the ability of tenants and landlords alike to be able to view water consumption data via the Internet has social, environmental and economic benefits. These benefits are evident by changes in consumer behaviour in conserving the usage of water.

However, AMR is just a tool and the advantaged cited will be effective only if the tool is correctly used.

4.6.2. AMR SCHEME

The data is transmitted from the meter to radio data collector (network node) via a data concentrator. The data is then transmitted to a central database at the billing office from the data concentrator utilising radio or GPRS technology.

Following text and pictures have been extracted from a case study presented by Suez-Environment at the 4th IWA Conference in Vienna in September 2008.

The three main components of the AMR system are the transmitter, the receiver and the software.

Meter module and transmitter

The initial target of the meter module is to collect information from “AMR ready” or “Smart” water meters. Meters modules are designed to offer compatibility with the full range of any water meters offering new “Inductive Detection” compatibility. A dedicated identification shall be proposed in order to clearly recognise compatible meters.

There are different types of solutions depending on VHF availability or not: VHF meter module, SL meter module and L (antenna) transmitter, SL GSM gateway.
SL GSM Gateway collects data from meters or sensors through a serial link communication port and sends periodically this information towards an information system through the GSM wireless network.

The Meter Module transmits on request sophisticated pre-calculated metering information, like ID, index, flow rates, alarms, status, etc.…

Pulse frame: Meter module stores and sends periodically index: network metering or sub metering.

Monitoring frame: The Meter module also stores monitoring information like backflow index, calculates minimum number of positive turns detected during fix periods (this value helps to indicate leak) or number of direction change.

Receiver

The receiver collects frames received thru antennas (up to 3 antennas per receiver) and sends periodically this information towards an information system through the GSM wireless network.

Software

The AMR software (SITR on the scheme) collects data for:

- installation,
- supervision (data acquisition),
  - AMR software requests
  - Infrastructure for anomaly detection
  - Infrastructure for programmed or on demand reports
- consumption analysis,
- billing

Overall schemes

Example of AMR are illustrated in Figures 7, 8 and 9.

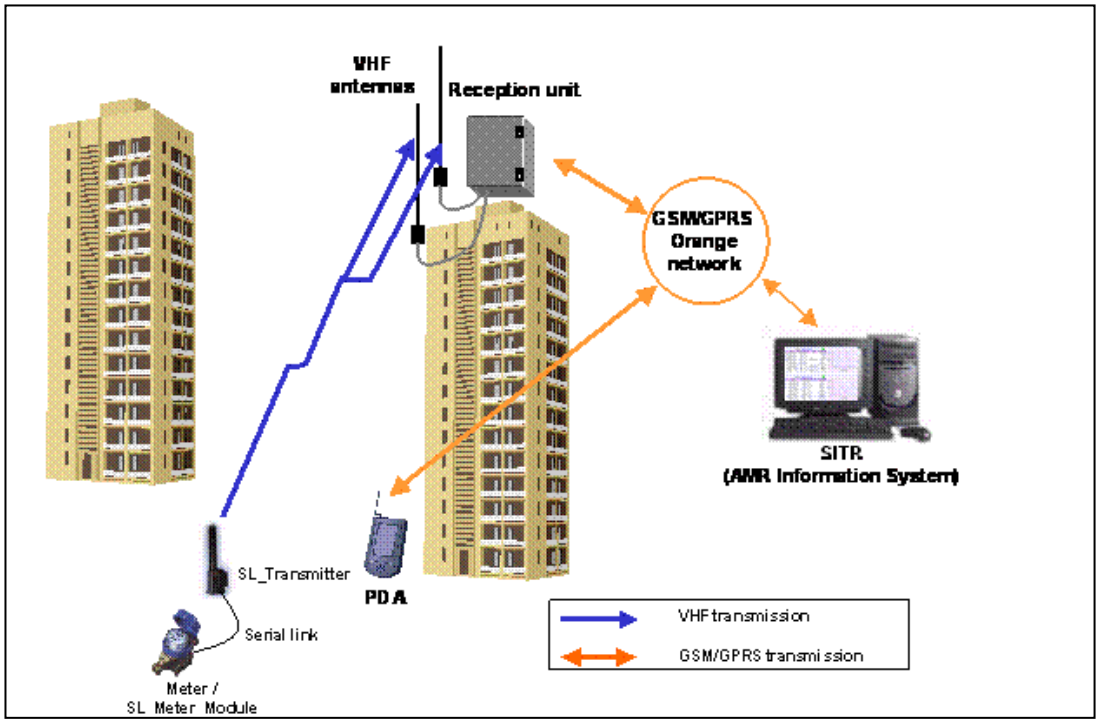


Figure 8 : AMR scheme 1 (Source: Suez-Environnement, Vienna 2008)

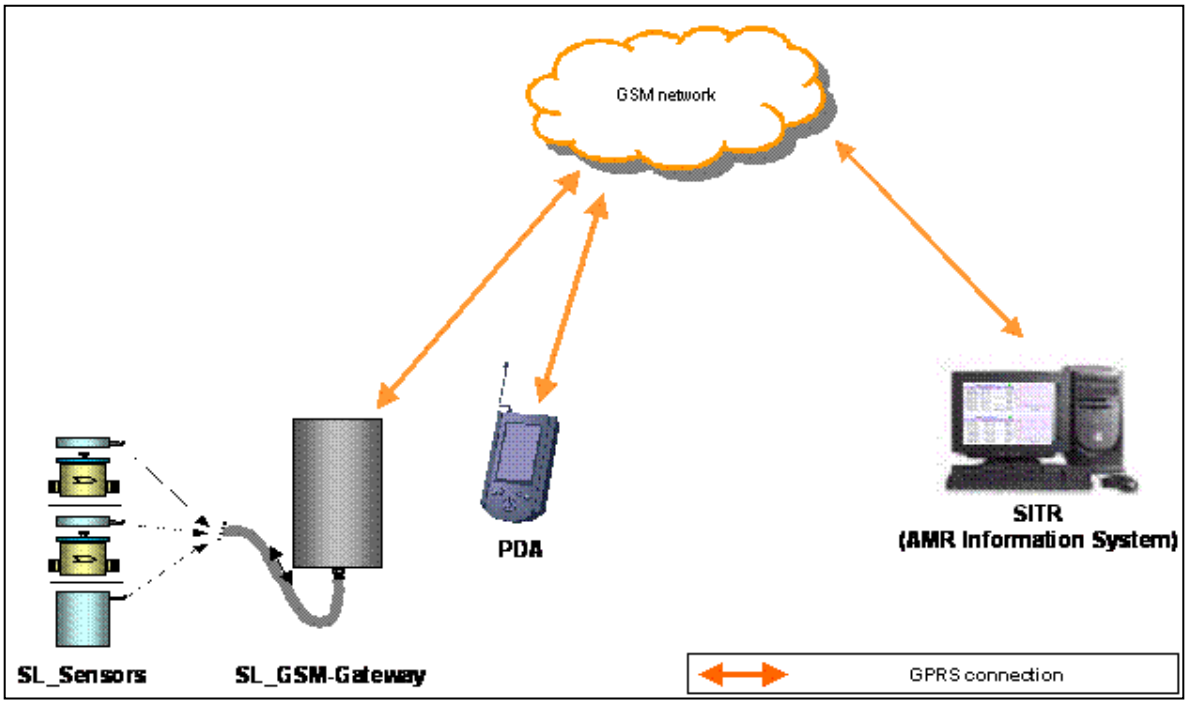


Figure 9 : AMR Scheme 2 (Source: Suez-Environnement, Vienna 2008)

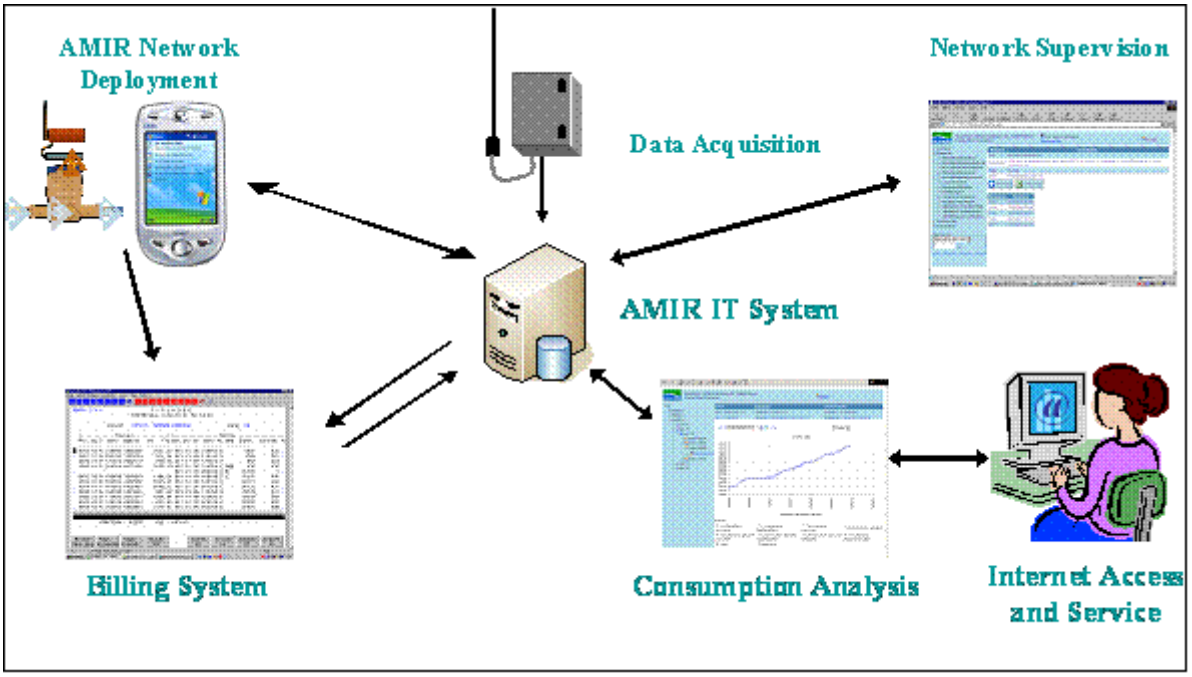


Figure 10 : Integrated AMR IT System (Source: Suez-Environnement, IWA, Vienna 2008)

4.6.3. AMR - POSSIBLE CAUSES FOR FAILURE

This section refers to the possible errors caused by the data acquisition system itself. AMR systems need to take into account the possible causes of failure, identify how to minimize the effects of these failures and provision of automatic error detection.

Metering accuracy

The metering module has to be accurate and the associate equipment compatible with each other. An example of errors introduced due to the pulse duration being too short for maximum capacity of the meter.

Simultaneous receipt of transmissions

Two frames (set of data) could be received at the same time by the same antenna resulting in a loss of data. This could be the result of the collision of data transmitted by two different meters. There is also a risk of interference due to an inadequate broadcast bandwidth.
Solution to this problem is the application of time-stamped data or/and recuperation of the data on another receptor.

Computer software

The software must have the following features:

- Decode the frame
- Check the quality of data
- Manage the redundancy

4.6.4. AMR AND FIGHT AGAINST APPARENT LOSSES

The right management of AMR may enable:

- Rapid detection of meter reading anomalies such as stopped meters,
- Rapid detection of sudden changes in the customer consumption profile such as higher probability of fraud or tampering
- Rapid detection of meter under sizing (or over sizing) due to a sudden and permanent change in the water consumption of a large consumer.
- Cancelation of the meter lag or meter reading lag effect

AMR may facilitate conducting the following surveys:

- DMA consumption patterns
- Minimum night flow measurement
- Loss per DMA
- Customers habits

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