4 Calidad
Continuidad
Cantidad
Costo

Module 05

# Sanitation Provider Enterprises' Commercial Management Series

## Tools for optimizing metered consumption

PERÚ
Ministerio
de Vivienda, Construcción
y Saneamiento

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REPÚBLICA DEL PERÚ
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Bundesministerium für
wirtschaftliche Zusammenarbeit
und Entwicklung

# Module 5
# Sanitation Provider Enterprises' Commercial Management Series

## Tools for optimizing metered consumption

# Acknowledgements

This work has profited from the invaluable experience of Peru's EPSs, which are engaged in ongoing efforts to improve their own management.

A large part of the contents of this Module was prepared based on the good practices observed in those utilities. We want to thank them for their support in systematizing and documenting those good practices. In particular, we acknowledge the cooperation provided by the following sanitation provider companies (EPSs): SEDACUSCO, EPSASA, SEDAM HUANCAYO, EPS CHAVIN, SEDAHUANUCO and SEDALIB.

The suggestions and recommendations provided here are based on the Rapid Impact Measures Program (Programa de Medidas de Rápido Impacto, PMRI)[1] and the 100,000 Connections Plan[2], sponsored and implemented by GTZ/ PROAGUA. We are also grateful for the dedication of the participating professionals who facilitated the improvement processes at the EPSs.

[1] The PMRI implemented by GTZ/PROAGUA is a group of direct investments, institutional strengthening and political-social management measures aimed at helping service provider companies (EPSs) to improve in a three-year period their services and cash flows, so that in the medium term they will be able to undertake larger financial operations and accomplish their planned investment goals.

[2] The 100,000 Connections Plan is a technical assistance program implemented by ANEPSSA with support from GTZ/PROAGUA. Its objective is to strengthen EPSs' capacities to improve their commercial management by increasing the number of active connections and, thereby, cash flow.

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# Preface

Most Peruvian sanitation provider utilities (EPSs) face serious financial constraints preventing them from growing their business and delivering high quality services to users. Typically, revenues do not cover their costs and even less their investments. This is accounted for by low collections the reasons for which can be grouped under two headings: a) low billing compared to actual consumption of drinking water and generally water use, and b) low bill collection.

To mitigate this problem, GTZ/PROAGUA has proposed a number of commercial management steps to increase EPSs collections without making significantly large investments. One of these steps is to optimize metered consumption, described in this Module. Better meter management should help utilities to bill volumes more closely reflecting actual user consumption.

We trust this contribution from GTZ/PROAGUA will continue in building the commercial capacities of Peruvian sanitation utilities and also to improve micro-metering management.

Lic. Michael Rosenauer, Coordinator
Drinking Water and Sanitation Program
GTZ/PROAGUA

# Introduction

In recent years, sanitation companies (EPS) have invested significantly in gradually expanding the scope of micro-metering. This trend is bound to grow in coming years as it is one of the management goals set for the EPSs in the National Sanitation Plan. Their Optimized Master Plans (PMO is the Spanish acronym) point to a strong increase in micro-metering coverage.

However, efforts to expand the number of meters are marred by neglect of timely maintenance of installed meters; follow up of the consumption recorded in those meters and other management activities that could ensure users are billed for their actual consumption. One example of this neglect is the high average age of micrometers in place.

Such neglect will irremediably increase the percent of unaccounted water and the subsequent low individual EPS billing.

This "Tools for Metered Consumption Management" Module is included in the Commercial Management Modules Series prepared in the framework of the 100,000 Connections Program carried out by ANEPSSA with support from GTZ/PROAGUA. This module provides readers a set of measures allowing monitoring, identifying and correcting metering distortions so that metered consumption will be as close as possible to actual.

The Module is aimed at commercial principally senior management officials from Peruvian sanitation utilities, but also service stewards and workers from the micro-metering and user cadastre departments in Peruvian EPSs.

**Chapter I** provides a quick analysis of the main micro-metering management issues identified at Peruvian EPSs that are a consequence of both internal and external factors.

**Chapter II** provides a number of recommendations for all EPSs to preserve the quality of micro-metering management, with an emphasis on human, material and equipment resources, as well as procedures and good practices.

In **Chapter III,** we provide a quick guide to identify the characteristics of an EPS's micrometers stock through sampling that will contribute significant variables for decision making, including average percent under-registration in m3 and soles, number of operating meters and useful life of the various brands and models of meters installed in the EPSs' jurisdictions.

In **Chapter 4**, we introduce a simple and useful tool to figure out unit consumption averages for groups of facilities with similar consumption patterns (schools, hotels, restaurants, etc.). This tool provides a number of benchmark parameters to identify facilities where there might be over or under consumption registration.

A procedure for the statistical analysis of micrometers' consumption logs is examined in detail in **Chapter 5**. Historical records will allow identifying gradual or sudden changes in meter logs. The steps for each stage of the process, as well as general guidelines for software that will automatically perform the calculations are also shown in this chapter.

Security initiatives and devices to protect meters are examined in **Chapter 6**. This chapter also provides a comparative view of the various types of devices used by EPSs.

**Chapter 7** includes a number of recommendations as regards services provided to the most important users, the so-called large consumers or principal clients.

We expect this Module will be a useful guide for managing the EPSs' meters stock and will contribute to efficient and fair recording of users' consumption.

Finally, it is worthwhile mentioning this publication also seeks to contribute to implementing the Commercial Management Technical Assistance Program sponsored by the Capacity Strengthening System for the Sanitation Sub-sector (SFC is the Spanish acronym)[3]. This technical assistance program builds on the experience gained through the 100,000 Connections Plan. Its main objective is to strengthen EPSs' capacities to improve their commercial management, increase the number of active connections and, thereby, improve cash flows through higher revenues.

[3] The Capacity Strengthening System for the Sanitation sub-sector (SFC in Spanish) operates as a network of government and private organizations seeking to facilitate individual and institutional capacity strengthening and thereby improve the efficiency and effectiveness of water and sanitation service delivery. Its objectives are: i) to contribute to the education, training and specialization of available human resources; ii) to develop the technical and scientific capacities needed to undertake research in alternative appropriate technologies; iii) to strengthen institutional capacities by introducing updated management methods for the various sector organizations; and iv) to promote a culture of water and sanitation through environmental sanitation education.

# 1

# The issues

This chapter provides a brief analysis of the issues identified in Peruvian EPSs as concerns micro-metering management. It describes the issues faced by EPSs as well as the potential consequences of neglecting their solution.

By way of introduction, we present an analysis of desired and undesired effects of implementing micro-metering at sanitation utilities.

## 1.1. Impact of micro-metering in EPSs

Expanding micro-metering is an ongoing task for several reasons.

One is the mandate to meet coverage goals for micro-metering set forth in the **Optimized Master Plans** that are being gradually introduced by EPSs throughout the nation. Meeting these goals demands a large effort to install new meters.

*Fig. 1: Micrometers*

Micro-metering coverage is one of the indicators used by SUNASS to **benchmark** Peruvian EPSs and compare efficiencies among utilities. EPSs' officials must demonstrate, through indicators, their efficiency and good management, to their Boards and shareholders, as well as to users, who constantly demand better service quality.

Finally, EPSs' management policies aim at improving efficiencies and, as the percent of users with micro-metering rises, **unaccounted water should drop**, and thereby continuity of service increase, since users will waste less drinking water.

The above factors drive the gradual but sustained growth in the number of micrometers installed by EPSs across Peru. EPSs expect to create **positive impacts** on their utilities and the users they serve. However, the same pressure creates the risk that EPSs may implement hasty measures without appropriate planning. The resulting **negative consequences** may be a source of frustrated expectations.

### Expected positive effects

One of the positive effects from managing and maintaining micrometers is **fair billing,** both for users and the utility, as users will only be charged for water consumption recorded in the micrometer.

When micrometers are installed, users immediately become alert and act to prevent increases in their monthly bills. They will check and repair their in-house drinking water and sanitary devices fittings, **rationalize consumption** and will use only the necessary amount of water required for daily chores (laundry, washing and personal hygiene) and limit the use of water for tasks like watering gardens.

*Fig. 2: Fixing toilet tank*

EPSs expect this decrease or self-control of consumption by users will improve **continuity of service** indicators as more water will be available to serve the population. Also EPSs will likely need **to produce** less drinking water. A third hypothesis holds that **unaccounted water** will immediately fall as micro-metering expands.

These hypotheses are all valid from a theoretical standpoint. However, it should also be borne in mind that **unaccounted water,** continuity of service and drinking water production indicators are also influenced by many other factors.

Unaccounted water is a consequence not only of losses from under-metering or lack of meters, but also leakages in the distribution network.

Only a comprehensive intervention will reduce unaccounted water, including accurate macro-metering of water delivery to the distribution system and distribution sectorisation that will reveal the distribution of consumption, establishing the water balance to identify the areas with the greatest losses, regulating water pressure, reducing network leaks, replacing old piping, and identifying and reducing clandestine users, to mention just the most important initiatives.

Although it is true that micro-metering is one of the most important factors in reducing unaccounted water, introducing micro-metering in isolation,

without other simultaneous major initiatives, would dilute its beneficial effects, as reflected in other general EPS indicators.

Several initiatives are required to reduce unaccounted water. Micro-metering by itself is not enough.

To improve continuity of service, priority must be placed on installing meters in areas or sectors presently showing large water waste. Presumably, after installing the micrometers, these sectors will consume less water than previously, and thus increase the surplus supply water to improve continuity of service in neighboring areas.

*Figure 3: Drinking water for consumption*

It should be underscored this will be feasible only to the extent complementary measures like sectorisation and efficient operational management are introduced to make the best possible use of additional water resulting from such initiatives. Otherwise, water losses and waste will only be transferred from one sector to another, without resulting in overall benefits for the population or the utilities.

Appropriate and comprehensive water management and subsequent resource optimization may even reduce the need to increase water production and, therefore, will lead to lower operative expenses.

This last consideration becomes all the more important given the dramatic reduction in sources of water for human consumption. Improving water management is necessary not just for simple, technical and economic need but is also an environmental mandate.

## Undesired effects

Unless the necessary preventive measures are taken, some negative effects might dampen the positive effects expected from expanded micro-metering. The **billed volumes** may fall if users consume less than their water allocation before the meters were installed.

This happens frequently because, once micro-metering is introduced, users take extreme

*Figure 4. Drinking water treatment plant*

precautions to rationalize consumption, although gradually consumption will return to more normal levels.

Given such possibility, massive micro-metering installations may not seem a good idea. However, it must be recalled the EPSs' mission is not just to earn profits but also provide an appropriate service and **charge users fairly** for their actual consumption. In the likelihood of such scenario, when figuring out their **PMO** costs, EPSs should consider a choosing between increasing tariffs and reducing production costs. In addition, once micro-metering is introduced, lower consumption in certain areas will increase available water for distribution to other areas that would benefit from improved service continuity.

In a different scenario, **users may react against micro-metering,** fearing higher billing, and in some cases even tamper with or damage meters to reduce consumption records. To prevent or mitigate such behaviors, before meters are installed, EPSs should **inform and educate users** about the benefits of fair billing and issue recommendations to prevent or avoid water waste and losses in their households. An appropriate information and education campaign by utilities will help to mitigate such negative user attitudes and considerably reduce the conflict that may arise from meter installation.

Such preventive measures will reduce tampering but will not cancel the problem completely. EPSs must remain alert to prevent tampering. The main types of meter manipulation are the following:

| Type of manipulation | Brief description |
|---|---|
| Tampering with internal device | Internal meter pieces are tampered with or broken down so the meter will record a significantly lower real consumption and may even totally stop working. |
| Meter destruction | The meter or some of its internal components are fully or partially destroyed to make the meter unusable. This kind of tampering is frequent after the meter has been manipulated to record lower consumption. When meters are broken, the historical averages used for billing will be extremely low. |
| Temporary meter removal | The meter is removed from its box one or two weeks every month far from the EPS's recording dates. |
| Upside down meter | As before, the meter is tampered with by keeping it upside down within the box so readings are backwards. Also the meter is made to read backwards using pressured air. |
| Bypassing | To prevent the meter from recording properly, a piped bypass before the formal connection to the water meter box detours water flow. This type of tampering is frequent among large consumers.<br><br>Alternatively, a household clandestine connection is built parallel to the legal connection. |

Security measures to prevent or reduce the impact of micrometer tampering should be put into practice.

Systematic **meter theft** by criminal organizations is a growing concern for EPSs. Trouble to identify criminals, slow court proceedings and lack of security devices in boxes and meters further compound this issue.

As part of its mission, the micrometer department should underscore the positive impact of micro-metering and take precautions to mitigate negative effects on the utility's economy and efficiency.


*Figure 5. Meter theft reaches the media*

## 1.2. Main EPSs' weaknesses in micro-metering management

This section identifies the main weaknesses found among EPSs. The readers will determine whether they are also present in their own utilities and to what extent.

These weaknesses may appear along the entire micro-metering management chain without officials in charge being fully aware. Below, we describe briefly the most significant weaknesses.

### Lack of an appropriate functional structure and weak work team

- Human resources and their organization within the EPS are the foundation of good management. Potential weaknesses in this respect must be assessed carefully.

- The first consideration is whether the metering department is sufficiently staffed to meet the workload created by the present and projected number of meters.

- In many EPSs that did not enforce micro-metering, no specific metering department has been organized. This function was typically performed by other departments, generally the cadastre division. Despite the significant expansion of micro-metering coverage, the above structure has remained in place and the lack of an appropriate organic structure hampers good management.

- In some EPSs micro-metering management is split. For instance, commercial areas are charged with readings and processing data while meter installation and workshop management are under the responsibility of operations divisions. When this happens, the integrated view of management is blurred by the separation of roles. For instance, maintenance program planning by the operations area may not be synchronized with commercial areas.

- Such organizational weakness worsens when the metering team also lacks the necessary competencies and skills. Ongoing personnel turnover further aggravates this weakness.

### Bad communications with users

– Typically, costumers' commercial complaints increase with micro-metering. They challenge presumed excess billing for water although typically most of these complaints are ungrounded. Inspections of users' sanitary installations usually reveal both visible and occult leaks. Such complaints mainly happen when micrometer installation does not go hand in hand with appropriate communication and information for users about how they should act once the micrometer is installed.

– It is not enough to send the regulatory information brochure. Greater efforts are needed for users to become aware of the benefits of having a micrometer and thereby create a sense of responsibility about the rational use of water.

### Outdated user cadastre

– Properly managing thousands of meters requires truthful, accurate and updated information about meters. Reliable data such as the meters' installation date, serial number, manufacturer, model and capacity should all be recorded in the utility's commercial cadastre.

– A significant management weakness is the lack of appropriate micrometer **data collection**. In turn, this hampers preparing surveys, reports and

planning, and leads to inappropriate decisions caused by lack of needed information.

### IT support

To make good management decisions EPSs must be equipped with IT tools that help them analyze stored data, monitor demand evolution, prepare control reports and identify lacks in processes, and others.

Nevertheless, IT tools may be available but workers may not use them. This happens because those tools were not designed to meet those workers' actual needs or because there are no administrative procedures in place to create a habit of using them in everyday work.

Frequent personnel turnover in the respective departments only aggravates the above-described issues.

### Reading, recording and processing

Meter reading is another area where much inefficiency can be found. Recording is mostly done manually. Technical personnel write down the reading in their logs. This is an initial source of human error that can hardly be avoided.

Figure 6. *Meter reading recorded* on log.

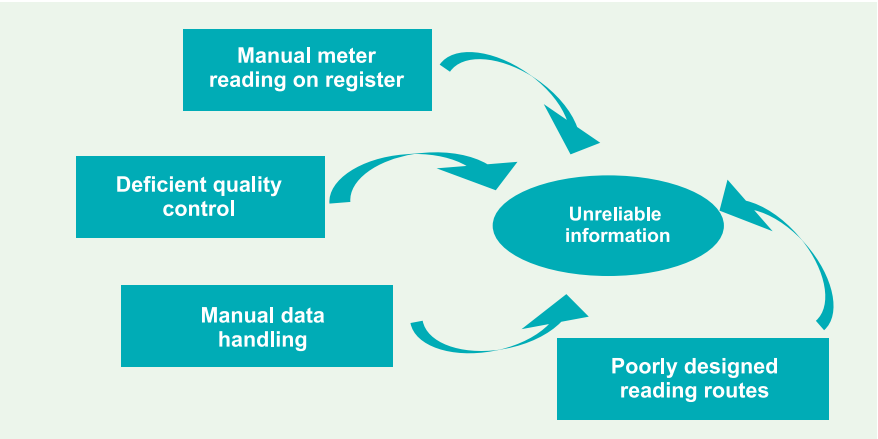
*Figure 7. Entering readings into IT system*

– Lack of appropriate **reading quality controls** by officials in charge leads to complaints and subsequent rebilling. Even when IT tools are available to warn about unusual consumption patterns, no initiatives are taken to check or correct potential anomalies.

– In some EPSs, meter readings are introduced manually into the computer system. Data from the registers is typed by staff in charge of up-taking records, a process not exempt from mistakes.

– Lack of coordination between the cadastre and the metering departments

leads to incompatible and inaccurate cadastre information, when checked against meter reading routes and cadastre codes.




## Meter box and meter safety

– Both the meter boxes and micrometers are poorly protected, in particular in some areas or for certain groups of users. In more extreme cases, safety measures are absolutely lacking. Some of the most remarkable examples of lack of safety include lidless meter boxes, broken lids, easy to open lids and exposed meters without appropriate fixation.

## Deficient meter maintenance

– Typically, EPSs only perform corrective maintenance when meters breakdown or there is suspicion of irregularities preventing readings (evidence of tampering, vandalism, blurred meter dials, etc.). **This passive attitude must be avoided.**

*Figure 8. Deteriorated micrometer*

– Few utilities perform preventive maintenance or have procedures in place to predict and correct deficiencies in micrometers or suspect consumption pattern records.

### Poorly planned and scattered renewal of meters or coverage expansion

- Meter renewal is neither sufficient nor timely. Periodical replacement of deteriorated or stolen meters is not planned.

- Meters are not renewed annually for various obstacles. As a result, the devices' age and the number of inoperative meters increase gradually.

- The growing number of meters does to expand service delivery. Frequently, growth has been haphazard without a comprehensive vision that pays attention to issues like macro-metering or sectorisation.

| Inadequate installation priority | Logistic and planning weaknesses |
|---|---|
| Installation of meters in poor continuity and low pressure areas | Tendering documents for metering procurement do not require batch approval testing |
| Meter installation for non-major users | Slow purchase because of other goods and services priorities |
| Meter installation in high-crime areas. | Incomplete metering, lack of accessories, boxes, lids and insufficient labor |

– The election of appropriate meter sizes is not typically based on in-depth or thorough technical analysis. Oftentimes, the meters' technical specifications do not match the type of users for whom they are being purchased.

### Inadequate meter workshops

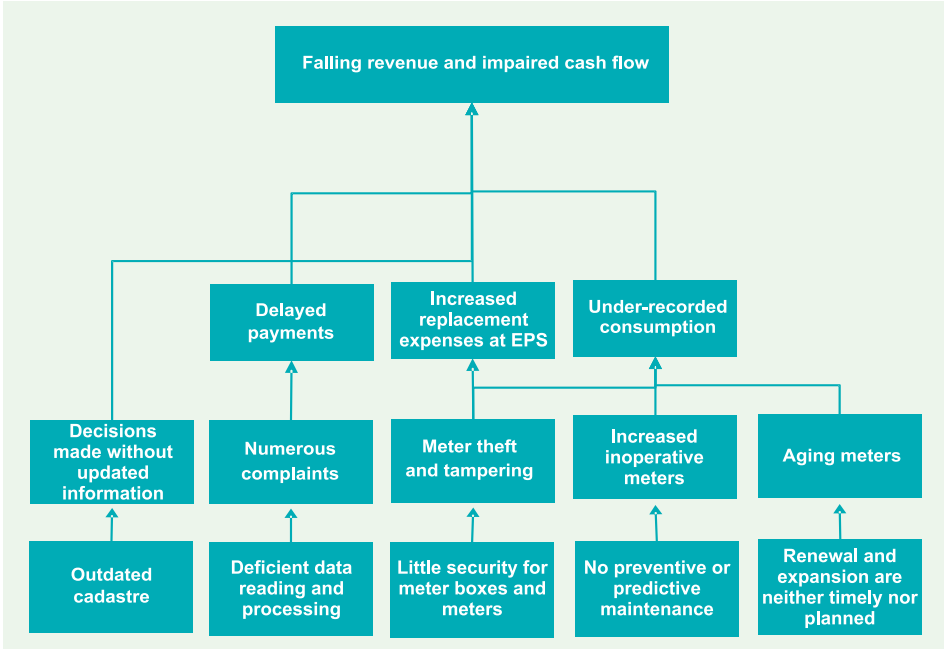
– Because micrometer workshops are not provided with appropriate facilities or equipment, personnel performance suffers. Likewise, if no sufficient and skilled personnel are available, even appropriate equipment will not contribute to optimum workshop operations.

Typical situations in some EPSs

- INDECOPI certification has expired
- No spare parts for maintenance or repairs
- Incomplete tool kit
- Obsolete computers; information not recorded
- Insufficient furniture, cupboards, tables, sinks

## 1.3. Consequences of weak micro-metering management

The weaknesses briefly described in the preceding section have an impact on the EPSs' commercial management. These weaknesses are better portrayed in the following diagram.



A brief explanation of such impacts follows:

- The increase in **average age** is the consequence of inappropriate renewal planning, all of which greatly contributes to increase under-registered volumes.
- Weak meter preventive maintenance results in gradual deterioration of the meter stock, having as a consequence an increase in the number of **inoperative** or malfunctioning **meters.**
- Insufficient security measures open the way for **massive meter theft.**
- This same lack of security, coupled with lack of information and education, result in users **tampering** with meters to modify volume readings.
- As under-registered volumes increase, EPS revenues fall.

In addition to lower revenues, EPSs' cash flow falls because of emerging additional expenses to account for:

- Meter theft or deterioration caused by vandalism or tampering.
- Numerous complaints requiring more customer service, inspection and meter checking expenses.

## MAIN LESSONS. CHAPTER 1. SUMMARY

**Summary**

- Micro-metering may have a positive impact when introduced with a comprehensive view involving both commercial and operative initiatives.
- When metering is introduced in isolation, the expected impacts may become negligible and even counterproductive.
- Meter tampering and theft must be foreseen. This behavior may result from inappropriate communication, information and user education or by vandalism acts.
- Micro-metering management at EPSs shows significant witnesses in human resource management, cadastre organization, and information to users, meter reading gathering and processing, security, maintenance, coverage expansion and poor condition of workshops and metering devices stocks.
- Under-registration from meters is significant, with a subsequent impact on the EPSs' economy.

**Questions**

- Does your EPS show some of the weaknesses described in this chapter?
- What are the causes of such weaknesses?
- What initiatives were taken in the last year to improve micro-metering managing processes?

**Tasks**

- List your EPSs' weaknesses in metering processes
- Determine the causes for each issue and define it accurately
- Analyze the consequences of such weaknesses
- Estimate the likely economic losses created by these issues

**Recommendations**

- Create a work team focusing on management improvements. Appoint a team leader
- Prepare an action plan to overcome the issues related to micro-metering.

# 2

# Comprehensive Micro-metering Management

This chapter describes the processes required for good micro-metering management. The final result should be a comprehensive vision including the tools proposed in this module.

## 2.1 Human team for good micro-metering management

All improvement processes require professionals, technical experts and other resources to ensure the efficient and quality enforcement of programs.

Personnel charged with managing micro-metering processes must be appropriately trained and motivated to perform their job efficiently. Their knowledge must be permanently updated through training courses, internships at other EPSs, and consultancies to strengthen even the least significant activities.

When EPS managers require their micrometer management staff to improve their management indicators, they should also remember that for them to reach their goals, they must be provided with the required tools, materials and resources. Without such logistic support, they will not be able to perform the assigned tasks efficiently and as a consequence the meter stock will suffer, creating significant economic losses to the utility.

### Team functional structure

An appropriate functional structure for the micro-metering management team needs to be put in place to match the needs and size of the meter stock to be managed. An analysis should be made to determine whether the appropriate personnel have been deployed. To do this, functions must be clearly defined for each work position. Also, the manual of procedures should be reviewed and adapted so that individual workers will know precisely what functions they are required to perform, as well as the products to be created and deadlines to meet.

## 2.2 Relationships with users

We have already described the issues that may arise from poor communication with users. We propose here some basic recommendations to improve relations with users and minimize conflict.

Meter installation should run parallel to aggressive information, sensitization and education campaigns targeting users and focusing on micro-metering. This campaign shall promote acceptance by users and thereby prevent a flood of complaints once the new micrometers are installed. An initial task is having users understand and accept micro-metering as the most reliable way

to deliver fair billing, as rates will be charged by actual consumption, just as with other public services like electric energy and telephone communications, for instance.

Utilities must create **confidence** in the metered registration system's dependability and that the EPS will introduce whatever corrective measures are necessary in case of eventual errors.

These information campaigns should underscore the benefits to most residential users because most likely their registered consumption will be lower than the pro rata consumption charged directly without metering. Preferably, this message should target areas where this is expected to happen because of existing poor infrastructure, economic and continuity of service conditions.

Another very important component of such education campaigns is training users to **check their indoor sanitary installations** and repair damages causing drinking water leaks. An indication should always be made of the significant amount of money that must be paid when toilettes are broken down or faucets drip. This will probably help preventing subsequent complaints for excess consumption filed before EPSs.

Dissemination and communication campaigns should be permanent as excess consumption caused by water leaks is an ongoing issue.

## 2.3 Meter stock management processes

We present below the most important micro-metering management processes required for the purpose of this work.

### A. Information recording and updating

An initial effort should help ensure the cadastre system records the following meter data, including:

| Serial number | Capacity |
|---|---|
| ▪ Manufacturer<br>▪ Model<br>▪ Year of installation<br>▪ Supplier | ▪ Diameter<br>▪ Metrological class<br>▪ Type of meter<br>▪ Carcass material |

If not all this information is available or if it is outdated, the data must be

gathered immediately. Meter reading personnel can be useful to this effect. A data gathering form must be prepared and data gathering should start in the following reading cycle. Some additional time should be built in, given the additional workload on field personnel.

Alternatively, this job may be outsourced. The two options should be examined from the viewpoint of their financial convenience.

Updating information is essential to use the analytical tools recommended in this manual.

## B. Meter reading and quality control processes

### Meter reading

Reading micrometers every month is important because good user billing depends critically on good readings.

Quality meter reading will ensure the billed volumes match actual consumption by users and will prevent complaints and additional administrative and field costs resulting from client dissatisfaction.

*Figure 9: Meter reading recorded on log*

To ensure quality readings, the following **human aspects** must be taken into account:

- Personnel charged with meter readings, whether in house or outsourced, must have the physical aptitude, skills and ethical values needed to do their job. They must have good eyesight and be in good physical shape. They must be able to communicate with users, understand instructions, organize their notes, prepare reports and use portable reading devices.
- Honesty is an ethical value of the greatest importance because employees may be tempted to tamper with the devices or alter readings, either on their own initiative or at the request of users.
- In addition, personnel should be committed to do their job efficiently and diligently.

– All the above characteristics must be assessed by the supervisor. Deficiencies must be corrected immediately. In case of repeated error or fraudulent acts, personnel must be replaced without hesitation.
– Training must be permanent. Concepts, procedures and typical cases can be reviewed at workshops where issues can be discussed to arrive at shared solutions.

## Technical considerations to be borne in mind include the following:

– Sequential and coherent **reading routes** depend on the area assigned for metering in close coordination with the cadastre department. Absent or insufficient coordination between these departments will entail enormous time losses, errors and even the inability to read some meters.

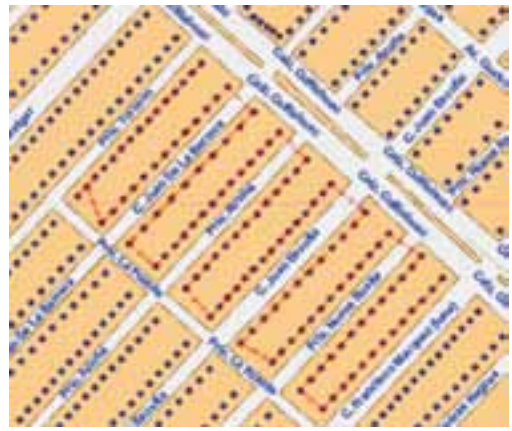


*Figure 10. Example of meter reading route*

– To optimize the personnel's efforts and improve the efficiency and reliability of readings the EPS must introduce, to the extent possible, **electronic reading equipment** for direct recording and thus minimize sources of error. However, before making a decision, a comparative cost analysis is required between the manual procedure and the cost of implementing an electronic system. Clearly, this will also depend on the number of installed meters.

– If the traditional reading procedure remains unchanged, forms should be designed so that field workers can perform the work faster and more efficiently.

Reading routes must be designed following a logical path that increases the workers' productivity. They must be designed to include a certain number of city blocks, connections and meters.

– Likewise, field workers should be provided with appropriate tools to open lids and clean meter dials to ensure correct readings.

## Reading entry and quality control process

This is another stage requiring much efficiency to minimize eventual human error.

The use of electronic means for reading recording allows uploading readings directly into computer systems, thus eliminating typing errors using printed forms.

*Figure 11. Worker entering readings into the commercial computer system*

If no electronic reading devices are available, typed data entries must be validated using algorithms based on average historical records for individual users. This will warn of possible mistakes, both during the process as well as at the end of data entry into the system.

In addition to identifying reading or typing mistakes, these validations allow complying with regulations in force, including criteria for **unusual readings** and gradual billing.

These quality control processes should not be concerned only with identifying and correcting reading or typing mistakes. The sources of these mistakes and the human and technological factors at their origin must also be identified, while measures must be taken to mitigate them in subsequent readings.

## Electronic reading devices and processing

When the number of meters so warrants, using electronic devices for registering data is the best possible option.

Use of these devices introduces immediate validation algorithms to check the records and thus reduces mistakes in data taking.

Additionally, it saves time and effort in entering readings into the commercial information system, resulting in cheaper and more efficient processes than with the manual system.

Several such devices —from the so-called TPLs, up to the state-of-the-art Pocket PC and cellular telephone devices— are available. **Annex 2** provides a brief description of these devices.

## C. Preventive maintenance program

In the previous chapter, we mention most EPSs carry out maintenance operations only when the meters reach the workshops after a commercial complaint, or because the meter has either stopped working or is damaged. In other words, they do only **corrective maintenance.**

Failure to do preventive maintenance results in deteriorated meters and under-registration. As time passes, the volume of under-billed water may rise significantly.

On the other hand, meters may over-record consumption, resulting in financial loss to users. Because of the above reasons, preventive maintenance should be performed regularly with a priority on installed meters and taking into account criteria such as the relative importance of specific clients or statistical variables. To accomplish this goal, we recommend enforcing the following three major criteria:

### Criterion 1: Evolution of consumption over time

This statistical variable identifies strong increases or reductions in specific users' measured consumption over time. It is measured in nuevos soles per month.

This figure is calculated using a linear regression formula for each consumer's historical meter readings or their corresponding averages. **Chapter 4** in this Module looks at this calculation in detail.

Maintenance of those meters showing the highest consumption reductions or increases must be prioritized.

### Criterion 2: Meter age

This variable is measured as the number of years since the meter was first installed. If the meters' age is not recorded in the EPSs' database, the devices' age will be estimated based on its serial number. This number must be immediately updated during the monthly reading cycle.

Maintenance of the oldest meters will be prioritized, as they are more likely to malfunction.

### Criterion 3: Main clients and special cases

The main clients must be subject to preventive maintenance at least once a year, since their bills are large and meters support larger flows.

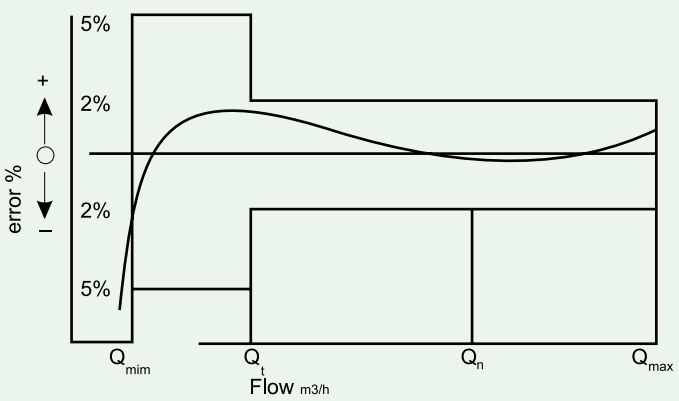
In some cases, maintenance and checks must be more frequent, such as in properties with a history of tampering or when operational problems are frequent in a specific area.

## D. Purchase and installation of micrometers

An appropriate selection process is required when purchasing meters. We provide below some suggestions:

– Proper consideration must be given to the physical and chemical characteristics of water, overall pressure conditions and continuity. These considerations may be included in the terms of reference for tenders. Bidders must declare being aware of these peculiarities and propose appropriate meters.

– The tender documents must include proof of the meters' resistance to wear out. In addition to the standard hydrostatic, charge loss, start-up and initial calibration tests, an **accelerated wear out** test must be required. The purpose of these tests is to ensure the meter will operate within tolerable error margins under various working conditions.




$Q_{max}$ = Maximum flow
$Q_n$ = Permanent flow
$Q_t$ = Transition flow+2%
$Q_{mim}$ = Minimum flow + 5%

– The batch of meters delivered by the winning bidder must be sample tested to ensure they match the bid's requirements. The purchase agreement must include guarantees in case of defective devices.

– Meter boxes, accessories and labor for installation in sufficient amounts must also be planned, after evaluating the meter boxes' condition.

– Together with the meters' purchase, **network air bleed valves** must be purchased and installed. This will help to minimize the number of complaints for excess consumption caused by air entering the meters. As a complementary measure, individual bleed valves may be purchased to be used in specific connections where the presence of air continues to be a problem, despite the network bleed valves having been installed.

– The number of meters to be bought, for each required diameter and capacity class, must be determined carefully.

### When installing meters, we suggest the following:

– Extreme care must be placed in compliance with regulations in force, including notifications within the required deadlines, information to users before installation, initial meter capacity measurement, enforcement of the gradual introduction regime, and others.

– Consideration should be given to the convenience of installing a large number of meters by the utility's in-house personnel, or through a contractor. Attention must be paid to ensuring a quality job, meeting deadlines and determining whether the utility's labor will be in a position to undertake an additional workload to their daily tasks.

– Designating a supervisor will help ensure a quality job. A fulltime supervisor may be required when a large number of meters have been installed. Close supervision is even more important when the task has been outsourced.

– Meet all basic technical requirements: appropriate box location and depth, meter boxes and technically adequate accessories.

## E. Criteria to expand the meters' stock

Expanding micro-metering coverage is typically a management goal set forth in the utility's optimized master plan or its strategic plan.

It is always convenient to identify the criteria that will help decide **where to install** the meters that will be purchased regularly.

As a rule of thumb, meters must be installed in those properties where water consumption is presumed to be larger than the respective allocation, either because of the property's size and importance or because water waste is suspected.

This rule allows setting some criteria to prioritize new meter installation:

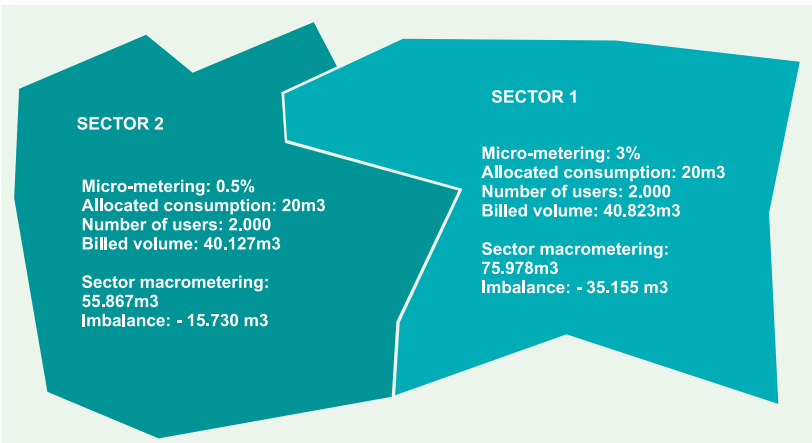
- Areas with good service continuity and pressure. Installation in areas not meeting these characteristics should be ruled out.

- High or intermediate socioeconomic areas where houses are well built, floor areas are large, buildings are numerous or their number is growing, population density is high, etc. No individual property census is required to check these characteristics. Instead, some housing developments or neighborhoods meeting on average these standards may be pre-selected.

- Areas or properties showing inordinate use of water for non-household activities, such as park or farm irrigation, washing facilities, and others.

- Main users, including large schools, hotels, restaurants, markets, slaughterhouses and other types of connections.

- In case of sectorisation and macro-metering of certain operational sectors, priority will be given to those areas with the highest water imbalances between the macro-metered and billed volumes. The following example shows losses are larger in sector 1 than in sector 2. Sector 1 therefore receives a higher priority.




**Water imbalances for two macro-metered operations sectors**

However, it must be borne in mind that the water imbalance in sector 1 may result from grid leads. We must always bear in mind the comprehensive impact of our initiatives. Nor can we expect to solve all problems by just focusing on micro-metering.

## F. Setting up the meters workshop

The meters workshop is indispensable to manage the meters installed by the EPS.

The workshop must be provided with a test bench for meter calibration. The test bench must be certified by INDECOPI. Otherwise, tests performed on the bench will not be valid.

The EPS must determine whether it is best to have its own bench or hire the services of another EPS or an authorized laboratory. The number of bench tests needed to service new meters, returned meters to address user complaints, and for preventive and corrective maintenance must be estimated.


Figure 12. Test bench

The cost of outsourcing meter testing to a third party laboratory must be estimated. If it is significantly cheaper than purchasing, operating and maintaining in-house test bench, the latter option will be discarded.

Such cost analysis must take into account the number of meters for each size class purchased by the EPS. For instance, purchase of a test bench may be justified for testing meters only up to one inch, since larger diameter meters are rare and it makes better economic sense to have them checked by a certified laboratory.

Mandatory bench testing includes the following:

– Inflow measurement for all **new meters** before installation.
– Comparisons of meters in case of **complaints** for excess consumption. This test must be performed within statutory deadlines.
– Measurements for purposes of preventive and corrective **maintenance**.

The following recommendations apply for in-house test benches.

- The meters workshop must be properly **staffed for operation.** Personnel must be competent, skilled and honest since all complaint files related to metering issues will be processed by them. They should be permanent workers if there is a large enough workload. Not only user complaints must be addressed, but also the meters' preventive and corrective servicing.

- Sufficient **tool kits** should be available for meter maintenance and cleaning. Assembly and disassembly of some types of meters require special tools. They must be purchased separately or required from suppliers as part of their tenders.

- **Spare parts** must be available for timely replacement of worn out or broken parts. It must be borne in mind spare parts may not be available for some models. This condition may become a criterion when considering meter replacement.

- **Working areas** must be supplied, including work tables, washing sinks, shelves and cupboards, needed to arrange, clean, maintain and repair meters, and to organize tool kits, spare parts and other workshop implements.

- **Computer hardware and software** should be available to record workshop activities and outcomes. Basic meter data, records of user complaints and maintenance actions carried out by this department should be recorded.

## MAIN LESSONS. CHAPTER 2. SUMMARY

**Summary**

- Micro-metering management involves several processes.
- Metering function organization and personnel must be appropriate.
- It is crucial to put in place a permanent system for educating and communicating with users.
- The automated cadastre must be fed with updated meter information.
- The convenience of using electronic devices for more technical meter readings should be considered.
- Meter maintenance should emphasize prevention.
- Technical guarantees must be required when purchasing meters to ensure quality.
- Meter installation projects should include purchase of boxes, accessories and other necessary materials.
- Both operative and technical criteria must be considered when expanding the meters' stock.
- A good metering workshop requires appropriate facilities, a test bench, tools and personnel.

**Questions**

- Do you think the metering management processes at your EPS are acceptable?
- What do you need to prepare an improvement plan for the micro-metering area?

**Tasks**

- Based on the suggestions presented in this chapter, list the sub-processes needing improvement.
- Determine their present condition and prioritize areas for improvement.
- Identify related activities already approved in the operative plans or approved purchases included in the annual procurement plan.

**Recommendations**

- Prepare a plan to improve micro-metering management and quantify and cost the necessary human, material and equipment resource needs.
- Prepare a presentation of your improvement plan to share it with the commercial and general management departments.

# 3

# Characteristics of Operative Meters

Good micrometer management requires characterizing the meter stock taken account of certain variables.

Characterizing the meter stock means identifying the operative characteristics of meters expressed as a percentage of under- or over-registration.

This chapter discusses the calculation of average under- or over-registration in the meters' stock. This will allow us to answer the following questions:

- What is the average under- or over-registration in the meters' stock?
- What is the percentage of under-recording meters?
- What is the percentage of over-recording meters?

Appropriate sampling will allow us to go even further and determine these same characteristics by age bracket or meter model.

In turn, this will bring to light the meter stocks' operative trends and contribute to its preventive maintenance and decide whether to install new meters.

This chapter presents a simple procedure to undertake such statistically-valid characterization.

## 3.1 Preparing data collection

We have already described the need to have updated information about the meters installed within the EPS's jurisdiction. It is also advisable to have in place a computer system to record the findings from the tests performed in the test bench, both to address users' complaints and as part of the EPS's maintenance program.

It is of outmost importance for this information to be recorded as accurately as possible, so it will provide a sound basis for drawing valid conclusions. Most of this information is kept in physical documents (registers or comparison minutes). Some of these documents are filed in the EPS's archives.

If the EPS does not presently keep a record of this information on a computer system, such system must be urgently implemented. To do so, available information on print format must be reviewed to design a database that will allow using all the existing information.

We must underscore that all the following suggestions require an IT support. Ideally, a module should be included in the commercial computer system. However, it is also possible to record all the data in a spreadsheet.

## 3.2. Meter stock characterization

It is not possible to determine the operational status of each individual meter within the EPS's jurisdiction. Instead, a sample of these meters should be inspected in the field and tested on the bench.

The steps for this analysis are the following:

| | |
|---|---|
| 1 | Defining the analysis strata. |
| 2 | Determining the sample number. |
| 3 | Determining the list of meters to evaluate. |
| 4 | Sampled meters inspection. |
| 5 | Analyzing outcomes. |

### Step I: Defining the analysis strata

Because the meter stock is mixed (including several types, manufacturers and age) and the areas where they are installed are not homogenous either (varying pressure and continuity operating conditions), any analysis must be **stratified.**

Consequently, the outcomes will not be just an average for the entire meter stock, but rather will be drawn for each of the subsets (strata) of the total universe.

Stratification examples

| By operational sector | By meter model |
|---|---|
| Sector 1 | Model a |
| Sector 2 | Model b |
| Sector 3 | Model c |
| Sector 4 | Model d |

The prior definition of strata to be analyzed will help us determine what kind of information we must obtain from each meter. An analysis for each operational sector requires knowing in advance which operational sector each EPS meter belongs to. If our findings refer to each meter model, then we must identify the various meters' manufacturers and models used within the EPS's area of operations.

For instance, we may conduct an analysis using two stratifications simultaneously, although more may be used depending on the diversity of meters' stock.

## Step 2: Determining the sample number

The **sample number** is the number of meters that will be chosen out of the meter stock's total so that findings will be statistically representative.

To determine the **sample number,** ad hoc statistical formulas are used. We present below a simple example that allows determining the number of meters that will be sampled as a function of the utility's total number of meters.

The most simple equation is the following:

**Where:** $$n = \frac{Z^2 \, p \, q \, N}{E^2 \, N + Z^2 \, p \, q}$$

| | |
|---|---|
| **n =** | Sample number (number of meters to evaluate). |
| **N =** | Total number of meters in the EPS or the designated sector. |
| **Z =** | Value of the standardized normal distribution for the selected level of confidence (a value of Z = 1.96 reflects 95% level of confidence). |
| **p =** | Percent incidence of the variable or condition under study. Since we are studying the operational status of meters, "p" will be percent of meters presumably non-operative. If there is no reference number, p = 50%, to determine the largest possible number of samples. |
| **q =** | It is the percent p complement (q = 100% - p). |
| **E =** | Sample error margin. A 5% error margin is acceptable. |

For instance, if we have a total **11, 069** meters, and variables Z = 1.96, p = 0.35, q = 0.65 and E = 0.05, the sample number (number of meters to evaluate) is **n = 339.**

More complex calculations may be performed using more advanced statistical methods to evaluate the meters stock and thus determine the most appropriate stratification.

### Step 3: Determining the list of meters to evaluate

Among all EPS's meters, a random selection will be made until reaching the number of meters determined in the prior step. A random selection does not mean they will be chosen arbitrarily, but rather using an unbiased procedure to choose them.

Some statistical software is available to perform such calculations. However, a computer spreadsheet is an easy way to do the calculations.

In the first place, we enter in a spreadsheet the list of all utility's metered users.

RELACION DE TODOS LOS MEDIDORES DE LA EPS

| IT | CODIGO | L_NOMB | VIA | C_CALL | NUM | N_MEDI | SEC. OPE. | MODELO | FEC_INST |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 01-004-05900 | COLEGIO NACIONAL SAN FRANCISCO | JRN | AYACUCHO | 213 | 0000029874 | 1 | Marca A - Modelo 1 | 14/04/1998 |
| 2 | 01-008-00500 | ESCUELA PRIMARIA DE VARONES | JRN | AYACUCHO | 237 | 0000040531 | 1 | Marca B - Modelo 1 | 30/08/2007 |
| 3 | 01-008-00720 | CANSAHUALA YOLANDA LAZARO | JRN | AYACUCHO | 297 | 0000298356 | 1 | Marca A - Modelo 1 | 16/04/1998 |
| 4 | 01-008-0104[illegible] | CERRUCLA CHAHUAN JULIAN | CAR | AYACUCHO | 232 | 0000037028 | 1 | Marca A - Modelo 1 | 15/05/1998 |
| 5 | 01-012-0040013 | T. MARIO GUTIERREZ | CAR | AYACUCHO | 250 | 0000000000 | 1 | Marca A - Modelo 3 | 23/11/2003 |
| 6 | 01-016-00300 | CASTRO ROMO HILDEBRANDO | CAR | AYACUCHO | 286 | 0000297106 | 1 | Marca C - Modelo U | 12/03/2006 |
| 7 | 01-016-03150 | DIAZ ROMO MAURA | JRN | JUNIN | 123 | 0000029729 | 1 | Marca C - Modelo U | 15/03/2006 |
| 8 | 01-016-05660 | PORRAS LAZO PEDRO | JRN | HUASCAR | 187 | 0000040656 | 1 | Marca A - Modelo 2 | 21/01/2002 |
| 9 | 01-016-06700 | MUDAVITE VERA TEODULO | JRN | ICA | 321 | 0000011111 | 1 | Marca C - Modelo U | 25/03/2006 |
| 10 | 01-016-06860 | QUISPE OBISPO URBANO Y ESPOSA | JRN | ICA | 241 | 0000156838 | 1 | Marca A - Modelo 3 | 21/02/2003 |
| 11 | 01-020-01060 | GRANDE GUTIERREZ VICTOR | JRN | ICA | 463 | 0000041497 | 1 | Marca C - Modelo U | 05/01/2006 |
| 12 | 01-020-01930 | SANCHEZ DIAZ ARCADIO | CAL | PIZARRO | 321 | 0000149588 | 1 | Marca C - Modelo U | 24/05/2006 |
| 13 | 01-020-01940 | MARIN ANGLAS HILDA | CAL | PIZARRO | 345 | 0000149588 | 1 | Marca A - Modelo 1 | 02/03/1998 |
| 14 | 01-020-02010 | MARIN CANSAHUALA CESAR | PLZ | PRINCIPAL | 249 | 0000128910 | 1 | Marca C - Modelo U | 30/10/2006 |
| 15 | 01-020-02030 | ALCANTARA SEVERIANA MERI | CAL | MARAVILLAS | 123 | 0000158376 | 1 | Marca A - Modelo 3 | 04/10/2003 |
| 16 | 01-020-02160 | CONCEJO DISTRITAL ORCOTUNA | CAL | MARAVILLAS | 156 | 0000298677 | 1 | Marca C - Modelo U | 24/05/2006 |
| 17 | 01-020-03300 | LOPEZ QUISPE GLORIA | CAL | MARAVILLAS | 178 | 0003221128 | 1 | Marca C - Modelo U | 28/02/2006 |
| 18 | 01-020-03650 | CHAVEZ JUANA ROJAS DE | PLZ | PRINCIPAL | 249 | 0000064044 | 1 | Marca A - Modelo 1 | 24/06/1998 |
| 19 | 01-020-03760 | CASTRO VACCLCA MOISES | JRN | ALMAGRO | 598 | 0000040552 | 1 | Marca A - Modelo 2 | 09/12/2001 |
| 20 | 01-020-03840 | MESIAS ELESCANO DOMINGO | JRN | ALMAGRO | 432 | 0000000111 | 1 | Marca C - Modelo U | 19/07/2006 |

In a separate sheet, we list items from 1 to 339, the number of meters required for the sample.

MEDIDORES PARA LA MUESTRA

| MUESTRA | ITEM | CODIGO | L_NOMB | VIA | C_CALL | NUM | N_MEDI | SEC. OPE. | MODELO | FEC_INST |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 334 | 331 | | | | | | | | | |
| 335 | 332 | | | | | | | | | |
| 336 | 333 | | | | | | | | | |
| 337 | 334 | | | | | | | | | |
| 338 | 335 | | | | | | | | | |
| 339 | 336 | | | | | | | | | |
| 340 | 337 | | | | | | | | | |
| 341 | 338 | | | | | | | | | |
| 342 | 339 | | | | | | | | | |
| 343 | | | | | | | | | | |
| 344 | | | | | | | | | | |

Now we need to identify each of the 339 sampled meters drawing from the main list of 11,069 meters. This is done using an equation that determines random numbers between 1 and 11,069.

MEDIDORES PARA LA MUESTRA

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | MUESTRA | ITEM | CODIGO | L_NOMB | VIA | C_CALL | NUM | N_MEDI | SEC. OPE. | MODELO | FEC_INST |
| 4 | 1 | 6030 | | | | | | | | | |
| 5 | 2 | 2541 | | | | | | | | | |
| 6 | 3 | 8884 | | | | | | | | | |
| 7 | 4 | 6862 | | | | | | | | | |
| 8 | 5 | 5873 | | | | | | | | | |
| 9 | 6 | 5732 | | | | | | | | | |
| 10 | 7 | 2516 | | | | | | | | | |
| 11 | 8 | 10710 | | | | | | | | | |
| 12 | 9 | 6615 | | | | | | | | | |
| 334 | 331 | 9474 | | | | | | | | | |
| 335 | 332 | 2543 | | | | | | | | | |
| 336 | 333 | 2700 | | | | | | | | | |
| 337 | 334 | 6123 | | | | | | | | | |
| 338 | 335 | 7937 | | | | | | | | | |
| 339 | 336 | 4443 | | | | | | | | | |
| 340 | 337 | 7894 | | | | | | | | | |
| 341 | 338 | 9428 | | | | | | | | | |
| 342 | 339 | 4626 | | | | | | | | | |
| 343 | | | | | | | | | | | |
| 344 | | | | | | | | | | | |

For instance, the previous view shows sample meter number 1 is meter number 6030 from the main list. If by chance, some items are repeated in the sample, those repetitions must be suppressed and replaced by other meters also chosen at random. In addition, the list must include alternate meters for replacement if a given meter from the sample set cannot be checked.

Finally, we will introduce the meters and clients' data for the 339 sampled meters.

MEDIDORES PARA LA MUESTRA

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | MUESTRA | ITEM | CODIGO | L_NOMB | | VIA | C_CALL | NUM | N_MEDI | SEC. OPE. | MODELO | FEC_INST |
| 4 | 1 | 6030 | [illegible] | PEREZ LLALLICO MARIO | | PSJ | LOS CURIDORES | 121 | [illegible] | 1 | Marca A - Modelo 1 | 23/11/2003 |
| 5 | 2 | 2541 | [illegible] | MAGARIÑO DIAZ EUGENIO | | AVI | PAVIMA | 472 | [illegible] | 2 | Marca C - Modelo c | 12/05/2006 |
| 6 | 3 | 8884 | [illegible] | SHIGUIA MEDINO JOSE | | JRN | DIEGO FERRE | 771 | [illegible] | 5 | Marca C - Modelo d | 15/05/2006 |
| 7 | 4 | 6862 | [illegible] | PORRAS DE LA CRUZ BERNARDO | | JRN | CIRCULO | 581 | [illegible] | 4 | Marca A - Modelo 2 | 21/01/2002 |
| 8 | 5 | 5873 | [illegible] | AUTAVILCA MONTES ROMUALDO | | JRN | RUBINA VIEW | 1002 | [illegible] | 1 | Marca C - Modelo d | 25/05/2006 |
| 9 | 6 | 5732 | [illegible] | MACAYO CAJAHUANCA HUMBERTO | | CHL | AMERICA | 151 | [illegible] | 3 | Marca A - Modelo 1 | 14/04/1999 |
| 10 | 7 | 2516 | [illegible] | MERCADO CONDOR EUGENE | | JRN | VELARDE | 153 | [illegible] | 4 | Marca B - Modelo 1 | 03/05/2007 |
| 11 | 8 | 10710 | [illegible] | SANTOS PANGUE MARCELINO | | CAL | LAS PALMAS | 173 | [illegible] | 2 | Marca A - Modelo 1 | 15/06/1999 |
| 12 | 9 | 6615 | [illegible] | CASTRO CUEVA ROMULO | | AVI | AZUCENA | 751 | 1427502 | 3 | Marca A - Modelo 1 | 13/05/1999 |
| 13 | 10 | 6852 | [illegible] | MAHAUANCA CARDENAS RAUL | | JRN | PERALES | 291 | [illegible] | 5 | Marca A - Modelo 1 | 06/10/2003 |
| 334 | 331 | 9474 | [illegible] | ESTRADA RAMOS RAUL | | AVI | SITAS | 1070 | [illegible] | 4 | Marca A - Modelo 1 | 02/05/1999 |
| 335 | 332 | 2543 | [illegible] | PORRAS SEGANO ALBERTO | | AVI | CARLOS DIAZ | 243 | 23456207 | 4 | Marca C - Modelo d | 03/10/2006 |
| 336 | 333 | 2700 | [illegible] | MIGUEL FERNANDEZ HUARTE | | CAL | BARRIETO | 479 | [illegible] | 5 | Marca A - Modelo 1 | 06/10/2003 |
| 337 | 334 | 6123 | [illegible] | SALAZAR BERRIOS EUDEN | | CAL | ESPINOZA | 581 | [illegible] | 4 | Marca C - Modelo d | 24/05/2006 |
| 338 | 335 | 7937 | [illegible] | OLIVERA MATTOS TEODORO J. | | JRN | CAPDEVILA | 129 | [illegible] | 2 | Marca C - Modelo d | 23/02/2006 |
| 339 | 336 | 4443 | [illegible] | MORALES QUISPE HERNAN | | PSJ | PINOS | 171 | [illegible] | 4 | Marca A - Modelo 1 | 24/09/1999 |
| 340 | 337 | 7894 | [illegible] | TELLO CELA CREATA CESAR | | JRN | SANDALES | 551 | [illegible] | 1 | Marca A - Modelo 2 | 09/12/2001 |
| 341 | 338 | 9428 | [illegible] | GUTARRA RUMI MIGUEL | | PRL | ROBLES | 1002 | [illegible] | 6 | Marca C - Modelo d | 14/01/2005 |
| 342 | 339 | 4626 | [illegible] | MEDRO TICSE ALEJANDRINA | | CR | TILO | 371 | [illegible] | 2 | Marca A - Modelo 1 | 13/05/1999 |
| 343 | | | | | | | | | | | | |
| 344 | | | | | | | | | | | | |
| 345 | | | | | | | | | | | | |

Because this is a random list, the sample is expected to be distributed homogenously among the strata selected for our analysis. To ensure such homogenous distribution, we can design a stratified sample. However, this is a complex calculation that is beyond the scope of this manual.

However, we can test our sample distribution by segregating the 339 selected meters by operational sector and model. If we find any of the sectors show very few of the selected meters, we will have to choose some additional ones only for that specific sample stratum so that no stratum will include less than 15 sampled meters.

We show below the sample distribution among strata for operational sectors and meter model:

### Distribution by operational sector

| Operational sector | Total number of meters | Meter sample size | Corrected sample |
|---|---|---|---|
| Sector 1 | 2.345 | 75 | 76 |
| Sector 2 | 1.847 | 52 | 53 |
| Sector 3 | 2.954 | 87 | 88 |
| Sector 4 | 799 | 28 | 29 |
| Sector 5 | 3.124 | 97 | 99 |

### Distribution by meter model

| Meter model | Total number of meters | Meter sample size | Corrected sample |
|---|---|---|---|
| Brand A Model 1 | 953 | 31 | 31 |
| Brand A Model 2 | 4.343 | 141 | 141 |
| Brand A Model 3 | 389 | 9 | 15 |
| Brand B Model 1 | 2.139 | 67 | 67 |
| Brand C Model U | 3.245 | 91 | 91 |

In this case, one of the meter models samples include only 9 meters because there are only 389 meters installed for this model.

Consequently, we chose to increase the sample to 15 meters and select the 6 additionally required meters at random only among meters from this model. This increase the total sample number to **345 meters** (as shown in the above chart as the corrected sample).

### Step 4: Inspecting sampled meters

Each of the selected meters must be subject to a field inspection and **laboratory tests** to determine its operational status and recording accuracy.

Field inspections will determine the physical conditions of the meter, the accessories and the registration box.

The 345 meters shown in the sample list will be taken to the test bench for calibration test and determine the percent under and over registration for each, as appropriate.

### Step 5: Analyzing outcomes

Finally, the findings will be studied to characterize the operative condition and accuracy of meters by brand, model, type and operative sector.

We show below several examples of major findings that result from such analysis:

**Typical finding 1:** Based on field inspections, it may be possible to determine the physical condition of meters, boxes and accessories in each operational sector.

| Operational sector | Total number of meters | Number of sampled meters | % of meters without lids | % of meters broken or without boxes | % of connections requiring accessory replacement |
|---|---|---|---|---|---|
| Sector 1 | 2.345 | 76 | 6,58% | 2,63% | 5,26% |
| Sector 2 | 1.847 | 53 | 5,66% | 1,89% | 3,77% |
| Sector 3 | 2.954 | 88 | 5,68% | 4,55% | 7,95% |
| Sector 4 | 799 | 29 | 10,34% | 6,90% | 17,24% |
| Sector 5 | 3.124 | 99 | 1,01% | 1,01% | 1,01% |

The percentages above result from evaluating a 345-meter sample, but since they are statistically representative, they apply to the entire universe of existing meters.

These findings will be extremely useful to estimate a sufficient number of lids, covers and accessories for renewing the meter stock. A similar sampling can be used for connections where no meter is installed and, thereby, determine the number of materials required for a mass new meters installation.

**Typical finding 2:** It is possible to determine what type of meter is more or less accurate when recording consumption. This information is useful to guide the decisions about maintenance prioritization or replacement of meters. Likewise, it will tell us about total average under registration for the EPS's meter stock.

## Characterization of meters by model

| Meter model | Total number of meters | Number of sampled meters | % of under-recording meters | % of over-recording meters | Average error |
|---|---|---|---|---|---|
| Brand A Model 1 | 953 | 31 | 12,90 % | 0,00 % | - 6,50 % |
| BrandA Model 2 | 4.343 | 141 | 13,48 % | 1,42 % | - 5,79 % |
| Brand A Model 3 | 389 | 15 | 26,67 % | 0,00 % | - 15,17 % |
| Brand B Model 1 | 2.139 | 67 | 31,34 % | 1,49 % | - 17,43 % |
| Brand C Model U | 3.245 | 91 | 20,88 % | 1,1 % | - 12,06 % |
| Average under registration for total meter stock | | | | | - 10,27 % |

The "% **of under-recording meters**" column shows the number of meters that under-register compared to the total sample. Thus, for instance, we have 31 evaluated meters sampled for model 1 in brand A, of which 4 under register below the allowed limits. These 4 meters account for 12.9% of the 31 sampled meters. Because this is a representative sample, the 12.9% figure is valid for all the 953 meters in this group.

The "% **of over-recording meters**" column can be understood similarly.

The "**average error**" column is calculated by averaging out all the errors found in the sampled meters, whether under or over registration. This average, typically negative (under registration), is representative for the entire meter stock.

The average under-registration figure for the meter stock is an important figure because it will allow to determine the amount of unbilled water due to under registration for the entire EPS's jurisdiction.

A similar analysis should be performed for each operational sector.

**Typical finding 3:** Another of the useful outcomes of this type of analysis is that it allows knowing the condition of all meters by taking account of the time elapsed since the date when they were installed to provide meter service. We must underscore that such a calculation requires knowing the installation dates for all meters as properly recorded in the system. Otherwise, this analysis is not possible.

The following table shows the distribution of the 345 sampled meters by age. We then analyze under registration following the procedure described in the prior example.

| Meter age (years) | Total meters | Number of sampled meters | % under-recording meters | % over-recording meters | Average error |
|---|---|---|---|---|---|
| <= 3 | 953 | 31 | 9,68% | 0,00% | - 3,26% |
| >3 ; <=5 | 4.343 | 141 | 28,13% | 1,56% | - 5,15% |
| >5 ; <=8 | 389 | 15 | 33,91% | 1,72% | - 7,51% |
| >8 ; <=10 | 2.139 | 67 | 53,03% | 1,52% | - 22,30% |
| >10 | 3.245 | 91 | 70,00% | 0,00% | - 49,50% |
| Average under registration for total meter stock | | | | | - 10,27 % |

This chart is important because it shows the evaluation of under registration as time goes by. This, in turn, will help us plan for meter replacement in advance.

It will be noticed here that average under registration for the entire meter stock is similar as in the previous example because this is the same sample distributed by an age criterion.

This analysis can even show the behavior of each meter model over time, and thus determines the average expected life under local conditions.

## MAIN LESSONS. CHAPTER 3. SUMMARY

**Summary**

- Data for the meters installed by an EPS should be gathered in an updated database.
- To know the operational status of the meter stock, it is not required to check all meters.
- It is enough to extract a small representative sample.
- This sample will be evaluated in the field and at the test bench to determine its operative status and recording accuracy.
- The behavior of meters will be characterized by operational sector, model and age.
- It is also possible to identify the condition of meter boxes, lids and connection accessories.

**Questions**

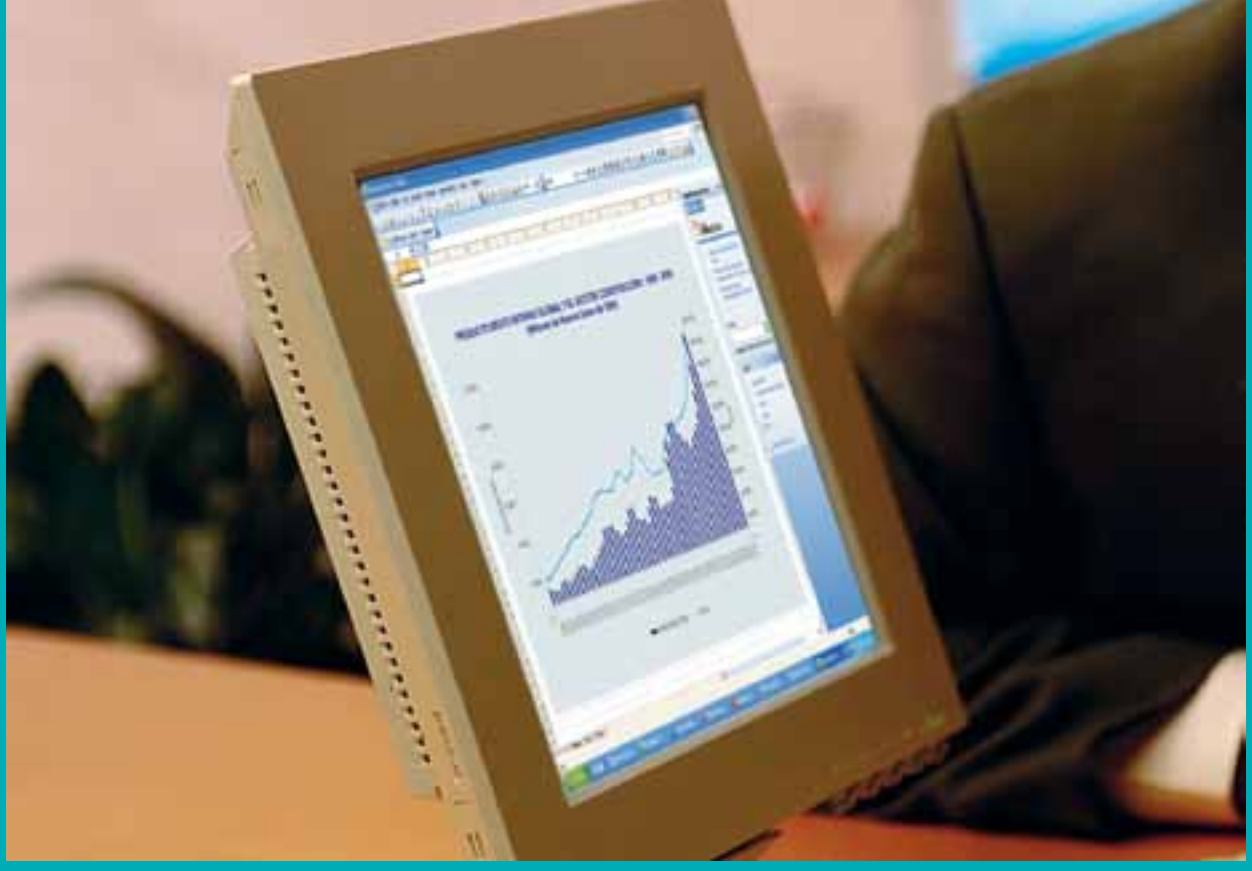
- In what kind of media is meter data stored? Is that information updated? (See chapter 2, item 4)
- Do you know the under registration percentage figure for your meter stock?
- Do you know the average age of your meter stock?

**Tasks**

- Compile meter information in a data processing chart and coordinate with the IT department. Organize a fieldwork session to update and supply complementary information for the chart.
- Prepare a work plan to perform the analysis recommended in this chapter.
- Identify the resources needed to for the characterization exercise.

**Recommendations**

- Information about the meter inventory and the corresponding calibration must be kept by the commercial department.
- If necessary, check with the statistics expert.
- This analysis should be performed once yearly.
- The objectives and characteristics under study may change every year.



# 4

# Analysis of Consumption Patterns by Activity

The purpose of this chapter is to present an analysis model including the variables and criteria to oversee users group by economic activity.

We present a procedure to determine unit consumption parameters by group of clients. With this basis we can identify consumption outliers.

## 4.1 Identifying user groups by shared characteristics

In all EPSs, consumers can be grouped by shared property utilization characteristics. Analyzing these groups reveals the consumption behavior parameters, which will help in making major decisions. To identify these user groups, they must be classified by similar characteristics, for instance, schools, restaurants, hotels, shopping centers.

Oftentimes, the automated cadastre system does not include updated information about use in the EPS's user properties.

An initial effort must be devoted to updating such information in the IT system. Field workers will undertake a rapid data gathering using a pre-designed card where they will enter the selected groups (i.e. schools, restaurants, hotels, etc.) cadastre codes.


*Figure 13: Types of users by property use*

## 4.2 Cross-referencing information with third party institutions

A complementary way to update the user groups list is by cross referencing information with same sector organizations or agencies charged with managing or overseeing those industries. By way of example, the following

chart includes but is not limited to some agencies that may more willingly provide information about user types:

| Data source agency | Type of user | Type of information | Time for paperwork |
|---|---|---|---|
| Regional educational directorates | Public and private schools (pre-school, primary, secondary, institutes, vocational schools) | Name, address, number of classrooms, number of students | One – two weeks |
| Regional tourism directorates | Restaurants | Name, address, number of tables and chairs | One – two weeks |
| | Rated and non-rated lodgings | Name, address, number of beds and rooms | |
| Provincial and district municipalities | Various types of commercial installations | Name, address, business, floor/total area | One – two months |

Once these lists have been obtained, the **cadastre code** under which client has been registered at the EPS **will be identified**. Typically, listings provided by third-party agencies include different company names, owner names and addresses from those recorded in the EPS database. Consequently, this task can hardly be a desktop job.

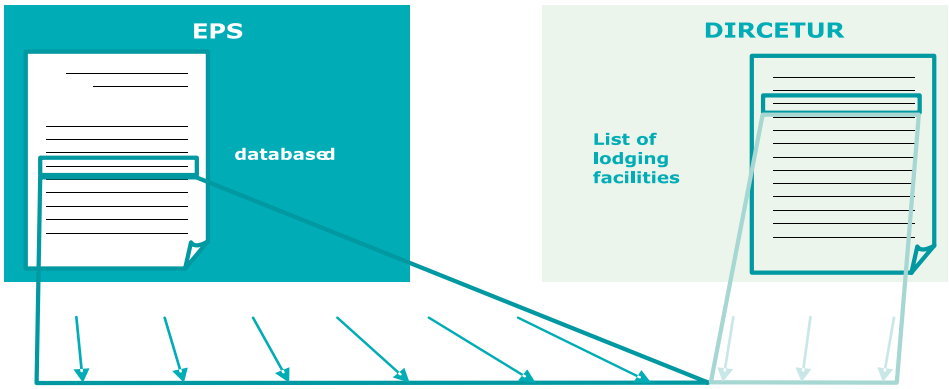
Instead, it will require fieldwork that can be assigned to personnel charged with delivering clients' bills. Because this will be a relatively small number of properties, the entire job should not last longer than one month.

When the cadastre code for each property, as reported by third party agencies, is available, it will be possible to tie this information to the EPS's database information. Cross-referencing all this data will help in updating the properties' cadastre data, mainly their rate categories.

However, the greatest usefulness of this data as regards the issue at hand can be found in the possibility to assess individual groups' consumption.

## 4.3 Consumption evaluation by groups and calculation of unit consumption patterns

Cross-referencing all data should provide us with consumption and billing reports for those properties, to be combined with information about their most relevant features, as for instance number of students, beds, tables, etc., as appropriate.




| Cadastre code | Company name | Address | Volume ( $m^3$ ) | | | | | | | Number of beds | Number of rooms |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | Pro | | |
| 05-123-321456 | Hostal Star | Jr. Grau 123 | 54 | 61 | 58 | 67 | 43 | 53 | 56 | 17 | 9 |
| 06-521-67342 | Hotel Simón | Av. Paz 8321 | 156 | 178 | 181 | 175 | 185 | 176 | 175 | 41 | 28 |
| 09-908-978041 | Hospedaje Azul | Ca. Azul 654 | 73 | 81 | 54 | 77 | 84 | 79 | 75 | 35 | 21 |

We now have enough information to figure out the monthly registered unit consumption. For purposes of our example, we will figure out the unit monthly consumption by bed and room for each of the above lodging establishments. This calculation is possible after having cross-referenced our data.

| Cod. cat. | Company name | Address | Number of beds | Number of rooms | Average consumption | m3/ bed/ month | m3 / room/ month |
|---|---|---|---|---|---|---|---|
| 05-123-321456 | Hostal Star | Jr. Grau 123 | 17 | 9 | 56 | 3.29 | 6.22 |
| 06-521-67342 | Hotel Simón | Av. Paz 8321 | 41 | 28 | 175 | 4.27 | 6.25 |
| 09-908-978041 | Hospedaje Azul | Ca. Azul 654 | 35 | 21 | 75 | 2.14 | 3.57 |

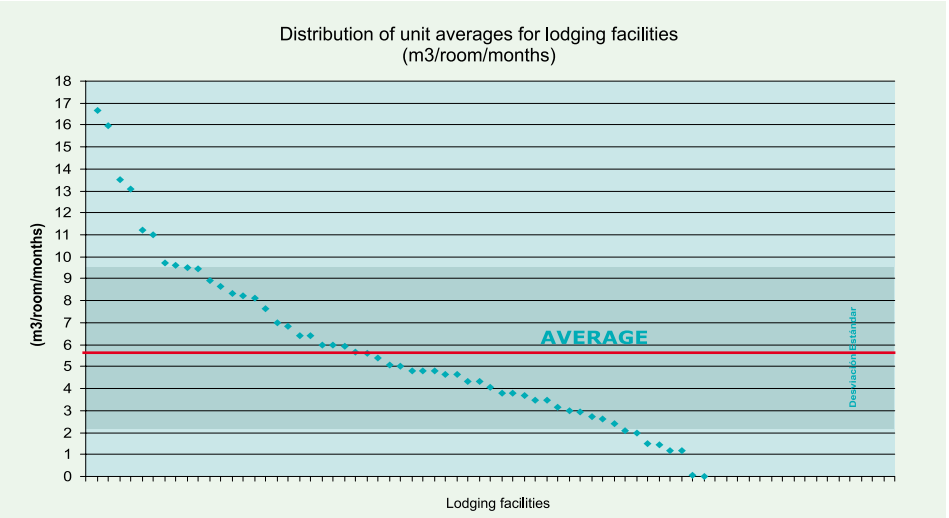
Presumed connection tampering

It is now possible to identify establishments showing a significantly higher or lower average consumption compared to other establishments. These figures do not necessarily reflect anomalous consumption in these properties, but they should warn us about the need for verifying the reasons for such outlier patterns.

In our example, the "Hospedaje Azul" lodging facility shows significantly lower unit consumption than the two other facilities. A field inspection must identify the reasons for such behavior.

The graph below shows another example based on real data for a specific EPS. The graph shows the distribution of average consumption for a group of lodging facilities. The establishments lying below and above the average can be easily identified.

The standard deviation gives us an idea of the group's dispersal. Generally, we advise to inspect the properties whose unit consumption falls outside the range determined by the standard deviation.




Finally, we must carry out the field inspections and, if necessary, laboratory tests for all properties where **unit consumption is low**, and thus determine the reasons for such behavior.

Inspections and identified irregularities

Also, we must focus our efforts on those properties, where **consumption is significantly above** the group average, as this may be caused by improper water usage or leaks from internal sanitation facilities. If so, training and recommendations are needed for those establishments.

## MAIN LESSONS. CHAPTER 4. SUMMARY

**Summary**

- Some user groups show common property characteristics. They include schools, restaurants, hotels and others.
- Some government agencies can provide information about these user groups.
- We can figure out unit average figures for each user group, and so study their consumption behavior.
- As a result, we will identify users with significantly lower or higher than average unit average consumption.
- Although these figures are not final, they warn us about a likely irregularity. Property field inspections are required to discard them.

**Questions**

- Do you know the average volume consumed by schools, hotels and restaurants within your EPS jurisdiction?
- Do you update the user's business or economic activity in the cadastre information?

**Tasks**

- Contact the industry agencies most appropriate to get their list of establishments on a digital format.
- Identify each of the users listed by those sector agencies and match them to the EPS's cadastre code or registration code.
- Identify other user groups, in addition to those mentioned in the example above.

**Recommendations**

- Encourage a cooperation relationship with industry agencies to permanently update user listings.
- Regularly figure out average unit consumption.

# 5

# Consumer Records Analysis

Permanent follow up of meter registration is one of the most important issues discussed in this chapter. Our discussion focuses on introducing IT tools to perform statistical calculations based on each user's consumption record, identify major outliers and warn about potential under- or over-registration.

Once such meters have been identified, they must be evaluated at the workshop performing the necessary tests to determine their operational status.

This analysis is one of the most important tools in determining what meter will be checked annually and be subjected to preventive maintenance. This chapter also shows the procedure and theoretical foundations for doing this analysis as well as some suggested evaluation and control parameters. In addition, it includes recommendations on the components of an IT tool and the initiatives to tap the results.

## 5.1 General considerations and requirements for analysis

The **objective** of analyzing the micrometers' consumption record is to identify and report occurrences leading to the decision to replace under- or over-registering meters for reasons including meter tampering, vandalism, bypassing or because they have exceeded their design useful life.

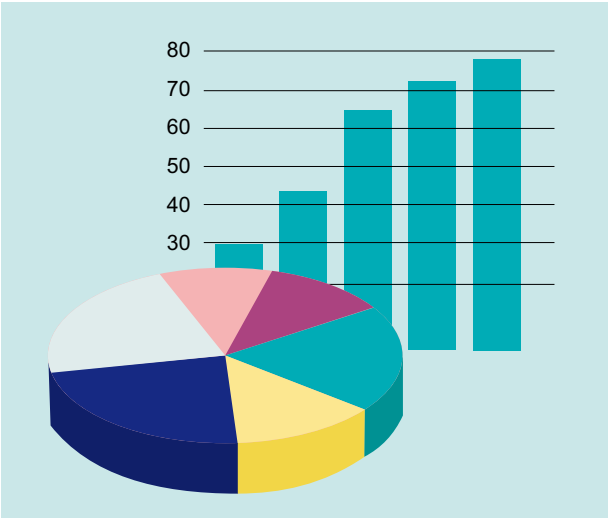



*Figure 14: NT: Caption missing/leyenda ausente*

The recommended analytical procedure was enforced as part of the **100,000 Connections Plan**.[1] It involves calculating a number of statistical variables like **historical averages** and **linear regressions**, based on registered monthly consumptions by reading differences on each meter since the date of installation until the day of analysis.

Calculating these two variables must be performed for each individual meter

Because each individual meter has to be analyzed independently, this analysis requires a **computer module** where the calculations will be performed automatically. Manual calculation is arduous and time consuming, and would render this tool impractical.

[1] 100,000 Connections Plan :A technical assistance program aimed at improving commercial management in Peruvian EPSs. This program is carried out by ANEPSSA PERU (National Peruvian Association of Sanitation Services) with financial support from the German Development Cooperation Services through its Drinking Water and Sewerage Program (GTZ/PROAGUA) from 2005 until 2009.

The following steps must be taken for this analysis:

| | |
|---|---|
| 1 | Preparing a table showing the consumption record. |
| 2 | Design and execute a computer application. |
| 3 | Prioritize meters most likely subject to consumption registration tampering. |
| 4 | Inspect meters in the field. |

## Step 1: Preparing a table showing the consumption record

The first task is to prepare a software table that will be used to calculate the historical average statistical variables and the trend lines for each meter.

*Figure 15: Consumption record*

Some minimal considerations are in line:

- Compile the information from the databases in the **computer commercial system**, including the consumption records for each meter. Check back up copies as required. The more information available, the greater statistical validity of the calculations and, consequently, the greater the more useful they will be for making decisions.
- Because of the above, only meters **at least 2 years old** should be analyzed, to yield statistically valid calculations.
- On the historical records, **correct for re-billed volumes** after quality controls or complaints resolved in the benefits of users. Otherwise, the resulting statistical variables will be strongly distorted and lead to erroneous conclusions about those meters' condition.
- Discard **inconsistent information** from the databases. Examples include records without a cadastre code or billing dates. They will also distort results or make automated statistical analysis unfeasible.
- For the data tables use a specific format that may be used in programming. **Annex 2** provides an example of the software table structure including the recommended data types.

### Step 2: Design and execute a computer application

This analysis requires designing a small software module that will be compatible with the software used by the EPS's commercial information system.

This module should be integrated to the utility's commercial system, so it can be run automatically by micro-metering personnel.

The following basic recommendations should be borne in mind when designing this module:

- Computer programs must be validated to ensure the certainty of calculations.
- The system must operate in an operator-friendly environment.
- It should include options to analyze user groups by geographical areas, rate category, periods, etc.
- It should include reporting filter options by area or cadastre-type variables.
- Filter options should also be included for likely under-registered volume ranges and the corresponding money amounts.
- It should include the ability to export reports in several formats (database or spreadsheets).
- Those reports should include cadastre variables allowing subsequent field inspections.

The purpose of this application is to allow calculations of the following two variables which describe each meter's behavior:

- Trend 1. Consumption average curve
- Trend 2. Linear regression curve

These curves are described by the **y = m x + b** equation. The program should be able to calculate values for **m** (slope) and **b** (constant). Values for **x** are the number of months for each billing period and values for **y** represent the billed volumes for those same periods.

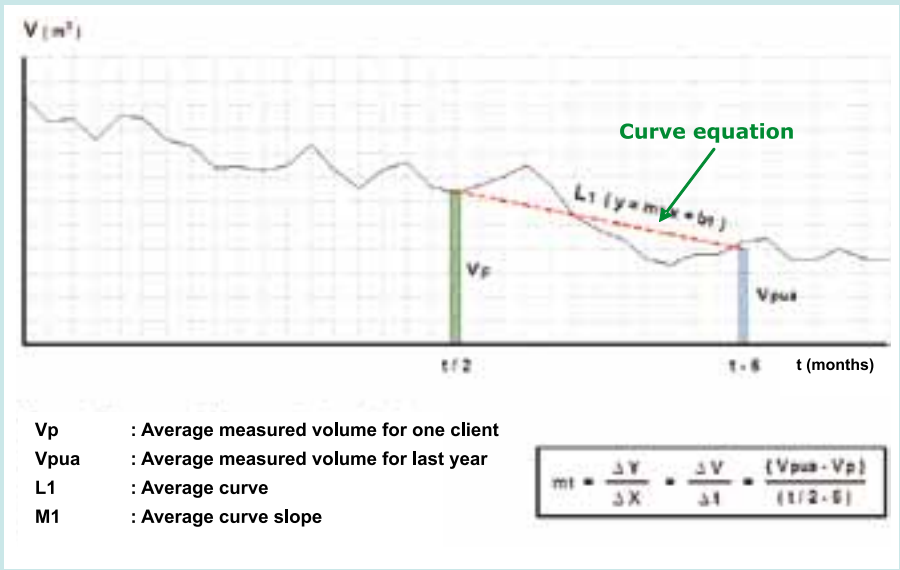
A **negative curve slope** means reveals falling monthly registration for that meter and a higher likelihood of under registration.

## Trend 1: Average consumption

This trend reveals the comparative average consumption for the entire meter period and the average consumption for the most recent 12 months.

The curve between two such points is defined by an equation reflecting the initial trend, based on which it is possible to figure out the curve's slope and the estimated volume of reduction in the current volume compared to average volume.

Behavior trend over the last year.




| | |
|---|---|
| **Vp** | **: Average measured volume for one client** |
| **Vpua** | **: Average measured volume for last year** |
| **L1** | **: Average curve** |
| **M1** | **: Average curve slope** |

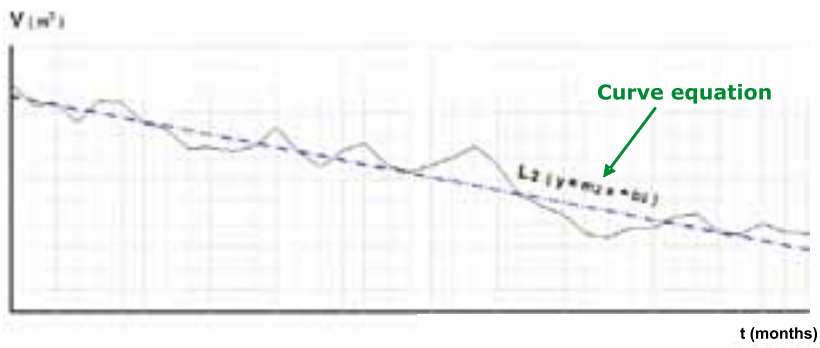
$$m1 = \frac{\Delta V}{\Delta X} = \frac{\Delta V}{\Delta t} = \frac{(Vpua - Vp)}{(t/2 - 6)}$$

## Trend 2: Linear regression

This calculation allows to draw a curve reflecting the evolution of each meter's monthly consumption over the entire registration period. Calculations are based on a statistical equation. Calculation of this statistical equation curve may be automated.

Historical consumption trends

As with the average trend line, we must here also figure out the curve's slope and the estimated lower volume compared to the average volume, as reflected by the curve equation.




Vp : Average measured volume for one client
tp : Average measured volume for last year
L2 : Average curve
m2 : Average curve slope

$$m_2 = \frac{(\Sigma tV - n\,tp\,Vp)}{(\Sigma t^2 - n\,tp^2)} \quad ; \quad b_2 = Vp - m_2\,tp$$

**Equation for "m" and "b" values**

## Example

We describe below a user's consumption record.

- This example is based on a real case in a provincial municipality.
- Measurements were taken from July 2004 until December 2008, when this analysis was performed.

| Periods (month/year) | | Consumption ($m^3$) | Periods (month/year) | | Consumption ($m^3$) |
|---|---|---|---|---|---|
| 072004 | | 524 | 102006 | 22 | 381 |
| 082004 | | 374 | 112006 | 23 | 375 |
| 092004 | | 579 | 122006 | 24 | 467 |
| 102004 | | 524 | 012007 | 25 | 401 |
| 112004 | | 746 | 022007 | 26 | 510 |
| 122004 | | 595 | 032007 | 27 | 589 |
| 012005 | 1 | 612 | 042007 | 28 | 420 |
| 022005 | 2 | 690 | 052007 | 29 | 8 |
| 032005 | 3 | 689 | 062007 | 30 | 6 |
| 042005 | 4 | 720 | 072007 | 31 | 7 |
| 052005 | 5 | 746 | 082007 | 32 | 7 |
| 062005 | 6 | 531 | 092007 | 33 | 8 |
| 072005 | 7 | 574 | 102007 | 34 | 11 |
| 082005 | 8 | 414 | 112007 | 35 | 2 |
| 092005 | 9 | 342 | 122007 | 36 | 3 |
| 102005 | 10 | 398 | 012008 | 37 | 12 |
| 112005 | 11 | 584 | 022008 | 38 | 588 |
| 122005 | 12 | 753 | 032008 | 39 | 16 |
| 012006 | 13 | 585 | 042008 | 40 | 8 |
| 022006 | 14 | 571 | 052008 | 41 | 15 |
| 032006 | 15 | 500 | 062008 | 42 | 34 |
| 042006 | 16 | 370 | 072008 | 43 | 21 |
| 052006 | 17 | 417 | 082008 | 44 | 15 |
| 062006 | 18 | 434 | 092008 | 45 | 29 |
| 072006 | 19 | 193 | 102008 | 46 | 9 |
| 082006 | 20 | 202 | 112008 | 47 | 14 |
| 092006 | 21 | 347 | 122008 | 48 | 18 |

Beginning month of analysis

Last year

As a recommendation, it is better to analyze each meter always taking into account full years, starting with the last available record. For instance, our last record belongs to December 2008. Looking 4 years back, the date to start our analysis is January 2005.

This procedure will cancel out the likely impact of seasonal consumption variations, which may be considerable in some EPSs' jurisdictions (more water is consumed in summer than in winter).

## Average consumer trend line

This curve is defined by the link between the general average point and the average for the most recent year:

| | |
|---|---|
| General average | Vp = 305 m3<br>(graphically located on month 24, half way along the total 48 months) |
| Most recent year average | Vpua = 64.5 m3<br>(graphically located on month 42, the sixth month in the most recent year) |
| m<br>(curve slope) | m = (64.5 – 305) / (42 – 24)<br>m = 13.36 |
| b (curve constant) | b = 64.5 – (-13.36 x 42)<br>b = 625.72 |
| Average curve | Y = 13.36 X + 625.72 |

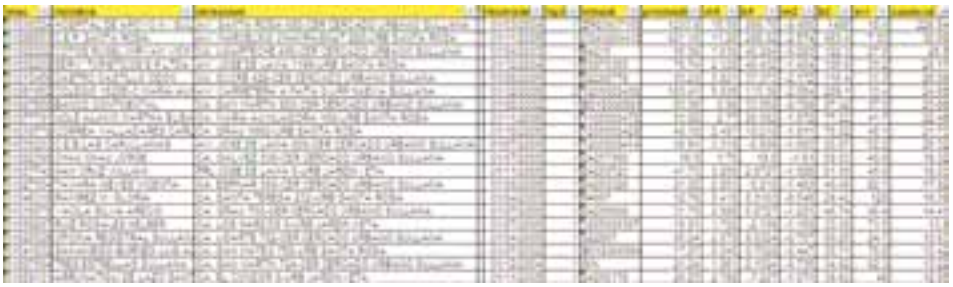
## Linear regression trend line

Results from the statistical equations are as follows:

| | |
|---|---|
| m<br>(curve slope) | m= -15,73 |
| b (curve constant) | b = 690,36 |
| Average curve | Y = -15,73 X + 690,36 |

This analysis is performed for each installed meter within the EPS's jurisdiction. An average trend line and another linear regression curve trend are defined for each meter.

In this example, ml and bl are the average trend line slope and constant, while m2 and b2 are the linear regression trend line corresponding slope and constant.



### Step 3: Prioritize meters most likely subject to consumption registration tampering

So far, we have found the values for the **line equations** for each of the existing meters. It is not very beneficial cost-wise to perform a bench test for all meters. **Therefore, we must identify those meters that must be evaluated as a priority.**

When setting our priorities, we will take into account the value of the curves' slopes, as calculated from the consumption average and the linear regression.

Negative slopes reveal falling consumption over time. The greater the negative value of the slope, the stronger the reduction. Graphically, a negative slope is recognized when the curve falls from left to right, since consumption plotted on the left belong to older periods, whereas more recent periods are graphed to the right.

What meters should we prioritize?
We prioritize those meters showing the steepest negative or positive slopes, as those reflect a stronger change in the consumption trend over time.

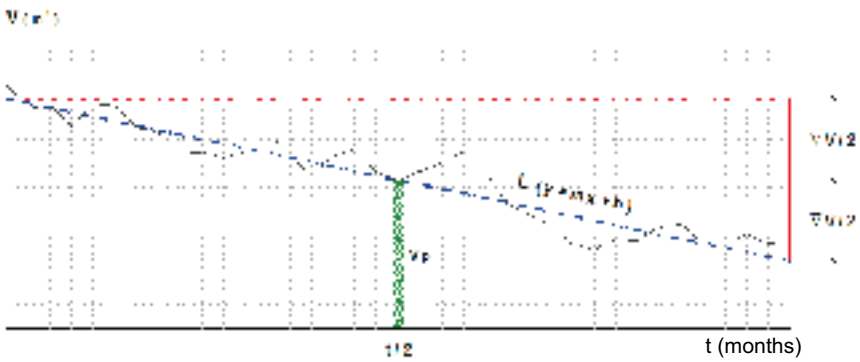
When calculating the slopes of the curves for each meter, we may run into the following cases:

| Case | Average curve slope | Linear regression curve slope | Likely under-registration | Likely over-registration | Selected curve (under-registration) | Selected curve (over-registration) |
|---|---|---|---|---|---|---|
| 1 | Negative | Negative | High | None | Regression | - |
| 2 | Positive | Negative | Intermediate | Low | Regression | Average |
| 3 | Negative | Positive | Low | Intermediate | Average | Regression |
| 4 | Positive | Positive | None | High | - | Regression |

The **selected slope** columns point to the most representative curve for each case, which will be used in calculating the likely under or over registered volume.

## Calculation of probable under- or over-registered volumes

The last step in our statistical calculations consists in determining the estimated probable under registration amount for each meter in nuevos soles currency. This volume is calculated using the **chosen** curve equation, shown in the previous graph.




**Vp:** Average measured volume for one client
**L:** Chosen trend line
**VV/2:** Average volume reduction over study period

We recommend estimating the likely under- or over-registered volume as a difference between the initial volumes and the average volume along the chosen curve. We do not recommend making this calculation as the difference with the final volume to provide an extra safety margin, taking into account that these data are only probability figures.

For purposes of our example:

- Both slopes were negative, so this is **case 1** (high probability of under registration)

- The chosen curve for volume calculations is the linear regression curve:
  **Y = 15.73 X + 690.36**
  Let's recall **X** represents months while
  **Y** stands for volumes.

- The initial curve point is month 0 (X = 0)
  Initial volume = 15.73 (0) + 690.36
  **Initial volume = 690.36**

- The midpoint of the curve is month 24 (X = 24)
  Average volume = 15.73 (24) + 690.36
  **Average volume = 312.84**

- **Volume differential = - 377.52**
  In other words, consumption has fallen by 377.52 m3 since the meter was installed.

This volume differential may be conveniently expressed in nuevos soles currency, to match each user's cadastre variables (rate category, type of service, unites of utilization).

Preparing the listing

Now we are in a position to prepare a listing for all evaluated meters and rank them by resulting volume differential in ascending order, so that in the initial positions we will have the most negative ones (those where consumptions have decreased the most) and at the bottom the positive volumes (those where consumption has increased the most).

| | G | H | I | J | HV |
|---|---|---|---|---|---|
| 2 | SUC | NOMBRE | DIRECCION | RESALDO | DIF_VOL |
| 3 | 10074134 | FUERZA AEREA DEL PERU-ALA AEREA 6 | AV. LOS COCOS 0-UR GRAU | 25 | -201.82 |
| 4 | 10569426 | E.S.S.A.L U.D. | AV. INDEPENDENCIA 0-UR MIRAFLORES - LADO NORTE | 20 | -170.04 |
| 5 | 10070021 | FUERZA AEREA DEL PERU-ALA AEREA 6 | AV. BOLOGNESI 1000-CER CERCADO URBANO | 25 | -130.00 |
| 6 | 10247746 | CUMPA ARCE JOSE | AV. FORTUNATO CHIRICHIGNO 0-UR SAN EDUARDO (1) | 10 | -79.59 |
| 7 | 10246234 | BORMEISTER SEMINARIO NILS | AV. SAN RAMON 0-UR EL CHIPE - ZONA 1 | 10 | -39.71 |
| 8 | 10023326 | UNIVERSIDAD TECNOLOGICA DEL PERU | JR. CALLAO 640-CER CERCADO URBANO | 40 | -32.67 |
| 9 | 10003520 | TERMINAL PESQUERO "JOSE OLAYA" S. | AV. PANAMERICANA NORTE 0-PZ1 ZONA IND. ANTIGUA | 31 | -31.90 |
| 10 | 10010220 | EL CHALAN S.A.C. | CA. TACNA 526-CER CERCADO URBANO | 30 | -29.44 |
| 11 | 10010033 | EMP SERV POST DEL PERU | CA. LIBERTAD 910-CER CERCADO URBANO | 25 | -28.97 |
| 12 | 10027245 | ASOC PROPIETAR. EDIFICIO LOS TAMA | CA. LIMA SUR 865-CER CERCADO URBANO | 10 | -28.78 |
| 13 | 10010396 | FONDOS DE EMPLEADOS BANCO DE LA | CA. TACNA 697-CER CERCADO URBANO | 30 | -28.47 |
| 14 | 10569806 | COL SN IGNACIO DE LOYOLA | AV. INDEPENDENCIA 0-UR MIRAFLORES - LADO NORTE | 20 | -21.97 |
| 15 | 10044115 | LLACSAHUACHE CORDOVA ROSARIO | CA. 0-AH. LA MOLINA | 50 | -21.66 |
| 16 | 09630635 | ROBERT MALE LOUIS RENE | 0-UR LOS COCOS - EL CHIPE | 10 | -20.01 |
| 17 | 10030943 | MUNICIPALIDAD PROVINCIAL DE PIURA | AV. CIRCUNVALACION 330-CER CERCADO URBANO | 10 | -19.40 |
| 18 | 10026749 | CMAC PIURA S.A. | JR. AYACUCHO 353-CER CERCADO URBANO | 30 | -17.67 |
| 19 | 06753167 | CARLOS ALONSO CONSTRUCT.E INMOBI | AV. LAS GARDENIAS 0-UR SANTA MARIA DEL PINAR II | 20 | -16.49 |
| 20 | 10850670 | BOZA FERNANDEZ HECTOR | AV. JOSE OLAYA 359-UR MIRAFLORES LADO SUR | 20 | -16.25 |
| 21 | 09779467 | MUNICIPALIDAD PROVINCIAL DE PIURA | CA. LIBERTAD 331-CER CERCADO URBANO | 11 | -15.21 |
| 22 | 06748516 | CONSTRUCC E INMOBILIARIA MIRAFLOR | 0-UR MIRAFLORES - LADO NORTE | 200 | -15.18 |
| 23 | 10247235 | RENATE FISCHER | AV. FORTUNATO CHIRICHIGNO 0-UR SAN EDUARDO (1) | 10 | -15.18 |

This example shows part of a listing, including registration codes, numbers, client name and address, meter reading and the volume differential calculated through our analysis. The list includes other fields such as meter number and additional client information to facilitate field identification.

Usefulness of the list

This listing is among the most important tools in selecting meters for the annual preventive maintenance program. To do so, the **volume differential** variable can be weighted with other variables, such as meter age and tampering records. Because of its importance, this analysis should be made at least once a year.

### Step 4: Inspect meters in the field

We must bear in mind the procedure to create variables for predicting under and over registration will yield probabilistic outcomes. In other words, these are not conclusive results. We must do fieldwork to identify the reasons for a specific meter's strong consumption reduction or increase. These reasons may be any of the following:

- Under or over registration because of deteriorated meters.
- Under registration resulting from meter tampering.
- Bypasses or clandestine connections.
- Removal or upside down positioning of meter by users.
- Reduction or increasing consumption for new property use or other justifiable reasons.

Recommended subsequent fieldwork should include the following tasks:

- **Field inspection of all selected meters**
  This inspection will allow recording the external aspect of the meter, box and accessories. It should allow to identify some evidence of degradation or manipulation.

  The connection owner will be informed before the meter is removed for maintenance, pursuant to regulations in force.

  Likewise, during this stage, it is useful to ensure whether the use of the property has changed, so as to warrant the consumption differential. This would render removing the meter unnecessarily.

- **Entry capacity assessment**
  Removed meters will be taken to the workshop meters for inspection.

  At the workshop, each meter will be measured for capacity to determine the corresponding under or over registration.

- **Inspection of internal meter clockwork**
  All meters, including regularly operating ones, will be subject to this inspection, excepting those older than 5 years, which will be automatically discarded.

  This review aims at determining the internal mechanical condition of meters and replacing the entire kit as required, and to clean up the devices.

- **Exit meter capacity assessment**
  After maintenance, the meter will be subject to an exit capacity measurement. In case of irregular condition, the meter will be discarded immediately.

- **Reinstallation or replacement of meter**
  Meters showing normal exit capacity measurement figures will be reinstalled. Discarded meters will be replaced.

## MAIN LESSONS. CHAPTER 5. SUMMARY

**Summary**

- A statistical consumption analysis allows us determining meters showing strong consumption decrease or increase trends.
- A computer table must be prepared showing all meters' consumption history, drawing on the information from the EPS' commercial computer system.
- If the EPS does not have the necessary software, an information module must be prepared to do the statistical calculations automatically for all meters. Otherwise, recommendations on this chapter may not be put into practice usefully.
- The result will be a listing of meters showing the strongest consumption reductions or increases throughout their recorded life. This will allow to prioritize the most salient cases.
- Finally, the prioritized meters will be field and bench tested.
- This analysis must be done periodically using appropriate software so it will become a tool to identify meters for preventive maintenance and tampering detection.

**Questions**

- Does your EPS have a consumption history for all users?
- On what media are they available?
- Since what year is user consumption information available?
- Does your EPS do any calculation resembling the methods shown in this chapter?

**Tasks**

- Compile consumption registry information for all users and as old as possible.
- Prepare a computer table using this data.
- Coordinate with the IT department preparing an automated module to perform the necessary computations.

**Recommendations**

- Run this analysis periodically (at least once a year).
- If there is no IT expert at the EPS, consider outsourcing the table and the software module.
- Closely monitor scheduling of field visits, workshop meter inspections and device replacements.

# 6

# Security Devices

All water provider utilities (EPSs) are concerned because of the high incidence of meter theft, as well as manipulation by the users themselves. They undertake many initiatives to prevent this occurrence.

This chapter reviews this issue and its consequences for EPSs, and also includes recommendations to reduce the scope of this problem. Finally, it compares the devices available and compiles the most important security measures put in place by service providers, as well as those devices' individual advantages

## 6.1 Incidence of meter theft and tampering

Meter theft is one of the most serious issues faced by EPSs and drinking water service users in Peru. Mass meter theft is a consequence of those devices' high prices in the black market for copper, a metal used in manufacturing meters.

Frequent press reports have highlighted the alarming growth of this issue.

In addition, scant security measures by EPSs facilitate the criminal acts of meter thieves.

Meter theft affects the economy of both EPSs and users.

*Figure 16: Example of meters stolen to sell their copper components*

| Damage to EPSs | Damage to users |
|---|---|
| ▪ EPSs pay for replacement of the first meter stolen. | ▪ Users must pay for replacement devices in subsequent thefts. |
| ▪ Debe reponer los daños en el marco y tapa de la caja porta medidor. | ▪ Service is interrupted because of theft. |
| ▪ If the meter is not replaced within the statutory deadline, the EPS must bill the lowest amount between the allocated rate and the historical average. | ▪ Lack of meter results in huge water waste. |

Meter theft is difficult to detect as it mostly takes place at night or outside the EPSs work schedule. In some cases, criminals were caught red-handed by police or security forces, but the utilities' legal departments failed to undertake legal actions leading to their prosecution and punishment.

Lack of security measures also has another worrying and harmful consequence for utilities, as is meter tampering by users to modify registered consumption and reduce payments for consumed water.

## 6.2. Initiatives to mitigate meter theft and tampering

The above-described situation forces EPSs to introduce rapid and effective measures to reduce meter theft and tampering.

Need to invest in security measures

The most important and obvious measure to be undertaken is **the mass installation of security devices** to provide meters with physical protection. Such measures range from box, frame and lid securing devices, through devices to protect meters from manipulation.

Other initiatives worth considering include using **plastic meters,** instead of conventional copper or bronze devices, given that these latter materials are the reason for meter theft. These meters are available in the local market by several suppliers and meet metrological quality standards.

Bringing criminals caught red-handed before court is a very effective deterrent. These legal actions must be undertaken immediately and if required to speed up court proceedings and provide strong legal arguments, may warrant hiring external legal counsel.

See Art. 96 in the Quality Regulations for Sanitation Services providers (RCD 011-2007-SUNASS-CD)

Punishment to users who manipulate meters should also be widely advertised by EPSs to discourage such practices and reduce their incidence. Peruvian regulations allow for recovery of under-recorded consumption, and even more so if evidence of meter tampering can be produced.

## 6.3 Security devices used by EPSs

Several meter security devices are available locally while some utilities have designed their own security components. We discuss some such devices below.

*Figure 17: Meter with security seal*

## Security seal

This device shows when the meter has been tampered with. However, it does not prevent theft. They come in several shapes and the simplest ones are pre-installed in new meters.

Other seals include metal straps placed at one or both ends of the meter to attach it to the PVC connection and thus prevent their removal. However, they are easily tampered with.

## Metal anchorings

Used by many EPSs because they can be easily installed and provide strong protection to theft and tampering.

The model on the top right photograph was designed by EPSA S.A. – Ayacucho and is manufactured by local blacksmiths.

The other models shown in the photographs on the right are supplied by local manufacturers. Because better quality materials are used, they are also more expensive.

The purpose of these devices is to attach the meter by strapping it with a metal ring. The device must be anchored in a concrete slab in the lower section of the box using the vertical anchors provided.

All these models are riveted.

*Figure 18: Meters with metal anchorings*

## Dados de concreto.

These are used mainly because of their low cost.

To protect the meter or meter accessories, several types of material covers are put in place before pouring the concrete slab.

Removing the concrete is a significant deterrent for criminals or tampering users. However, utility workers face the same difficulty when removing meters for calibration in the test workshop.

*Figure 19: Meters with concrete dowels*

*Figure 20: Polyester box*

## Reinforced polyester boxes

These meter boxes have been successful in deterring box lids theft. The material used in manufacturing these lids has no black market value, compared to wrought or galvanized iron metal lids.

These lids are provided with a magnetic key lock not widely available for sale.

## 6.4. Advantages and disadvantages of various security devices

| COMPONENT | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| Security seal  | ▪ Very low cost<br>▪ Evidence of tampering | ▪ Does not protect against theft or vandalism<br>▪ Easy to purchase in black market for replacement |
| Metal anchoring  | ▪ Easy meter removal for maintenance or calibration<br>▪ Evidence of tampering<br>▪ Easy to install<br>▪ May be manufactured locally<br>▪ Does not impair meter carcass or connecting accessories | ▪ El acero puede ser cortado con una cizalla aunque con cierta dificultad. |
| Concrete dowels  | ▪ Impossible to manipulate or steal meter without breaking dowel. Evidence of fracture.<br>▪ Breaking dowel takes time and requires using noisy tools (hammer).<br>▪ Easy to install by utility workers.<br>▪ Low cost. | ▪ May damage connection accessories and meter carcass.<br>▪ Dowel must be broken to remove meter for maintenance and calibration, and then replaced.<br>▪ Hammering for breaking dowel may damage meter's internal mechanism. |
| Polyester box  | ▪ Magnetic key lock difficult to copy.<br>▪ Resistance to breaking.<br>▪ Security device in addition to above. | ▪ Relatively high cost.<br>▪ Initial effort to replace existing boxes. |

In case of doubt, when choosing the appropriate device, the utility may test a small number (50 each) of devices before making a final decision.

## MAIN LESSONS. CHAPTER 6. SUMMARY

**Summary**

- All EPSs face meter theft and tampering issues.
- Meters are stolen to sell metal carcasses in the black market.
- Tampering aims at reducing the consumed volume record.
- Security measures are required.
- Investing in security devices is sustainable and necessary.

**Questions**

- How many meters were stolen from your EPS in the last 12 months?
- What security measures has your EPS tested?

**Tasks**

- Identify individual areas with highest theft and tampering rates.
- Compare several local market quotations for security devices.
- Prepare security plan together with the national police, citizen security brigades or municipal guards in your community.

**Recommendations**

- Install 50 security devices of each type.
- Evaluate their individual performance before deciding on a mass installation.

# 7

# Servicing major clients

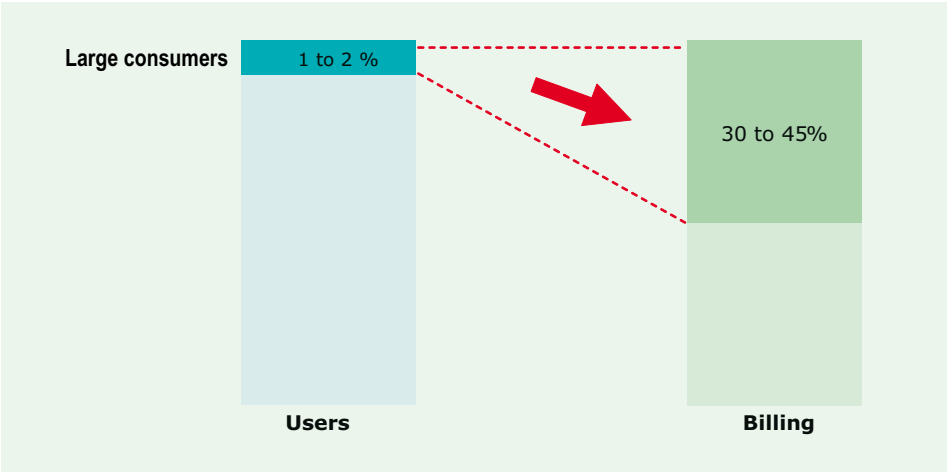
Although this is not an issue exclusively related to metering, in this chapter we provide some recommendations to monitor the EPSs' group of main users, who contribute a significant portion of the utilities¿ revenues.

The purpose of this chapter is to show that the recommended measures may be easily enforced, regardless of the EPS's size and, thereby, increase billed consumption from these users.

## 7.1. Importance of focusing initiatives on the main customers

One of the most important processes in micro-metering management is to direct large-scale and specific initiatives to those users who are the utility's **main customers.**

This group of users, also called large consumers, is made up by a small group who account for 1% to 2% of total consumers, but who because of the metered volume and billed amounts regularly contribute between 30% and 40% of the EPS' total billing.




It is important to correctly **identify** this small group of users to ensure they contribute to the EPS's billing proportionally to their actual consumption. Consequently, all such users must necessarily be provided with an operative **micrometer**.

The significant billing percentage from this small group of users makes it not only necessary but also highly profitable to introduce additional control efforts, such as additional personnel, equipment and technology.

## 7.2. Setting up a work team

The decision to introduce follow-up and control procedures focusing on the main customers requires allocating such tasks to designated officials.

For **small or medium-size utilities**, where the number of main clients is not too large, it will suffice such role to the utility official most closely related to such issues. This official may be the cadastre or metering department head.

However, in **larger EPSs**, it is worthwhile setting up a **work team** exclusively charged with following up and overseeing the main customers. This work team should be staffed by at least two workers, i.e. an analyst and a technical expert. The number of workers designated for this task will be decided by each EPS after performing a cost-benefit analysis taking into account the size of the operation. From the organizational viewpoint, this team should report to the function department charged with cadastres or metering.

*Figure 21: The work team should be provided with the necessary tools to do their job*

The **analyst**, who may also be responsible for the main clients group, should be able to permanently evaluate users using IT tools.

The technical expert will be charged with inspections, notifications, follow-up of outliers readings, complaints and any other field activities connected to the large users group.

## 7.3. Criteria to create the main clients group

An initial task is to determine the number of users who will belong to this group, and then choose them.

How many and who?

To determine the users that should be regarded as main clients, an initial listing of all EPS users must be prepared, in **descending orde**r of historical average billing (last six valid bills).

List of users by order of historical average billing

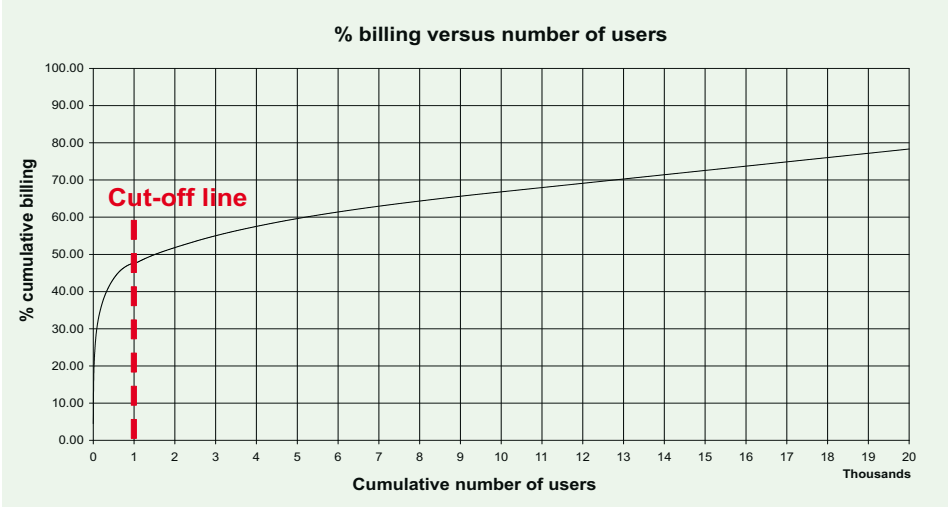
| It | Code | Last name and name | Average consumption $m^3$ | Average billing S/. | % share of cumulative billing |
|---|---|---|---|---|---|
| 1 | 1051502313 | CERVECERÍAS NACIONALES S.A.A. | 34.735 | 75,384,69 | 4,51 |
| 2 | 1032000211 | CORPORACIÓN HOTELERA S.A. | 2.377 | 44,017,81 | 7,14 |
| 3 | 1043100010 | CIA CERVECERA DEL OCCIDENTE | 1.908 | 40,528,63 | 9,56 |
| 4 | 1051502313 | PERÚ TERMINALES S.A. | 2.506 | 26,293,77 | 11,13 |
| 5 | 1032000211 | CIA CERVECERA DEL OCCIDENTE | 1.266 | 24,415,44 | 12,59 |
| 6 | 1043100010 | EMBOTELLADORA PERUANA S.A. | 7.893 | 15,466,35 | 13,52 |
| 7 | 1051502313 | PERÚ TERMINALES S.A. | 1.265 | 13,802,80 | 14,34 |
| 8 | 1032000211 | HOSPITAL REGIONAL I.P.S.S. | 1.108 | 11,770,68 | 15,05 |
| 9 | 1043100010 | HOSPITAL REG. CENTRO DE S. | 1.002 | 11,746,55 | 15,75 |
| 10 | 1051502313 | MINERA EL ORO S.R. LTDA. | 986 | 10,565,56 | 16,38 |

This chart may be complemented by general user and connection cadastre data. It may also be **graphed** with the cumulative number of users on the vertical axis and cumulative billing in the horizontal axis.

This graph will show the importance of users as regards billing and allows determining a cut-off line to choose the main clients. When the curve **slopes steeply** (first user segment) signifies a significant increase in billing for each user. Once the curve flattens out, users in that segment are no longer contributing a significant amount to billing.

In the following example, we graph the top 20 thousand users for an EPS with 55 thousand clients in total. The first one thousand users (2% of the total) contribute 47% of total billing. This is the **cut-off line** to choose the main clients.

Graph. Cumulative billing by number of users




In this group of pre-selected users, some have meters and others don't. Because this short listing is based on average billing, a non-metered user may be classified in a lower than appropriate rate category and, therefore, because of low billing, will not be included in the target priority group.

To address this issue, we suggest using the **average unit consumption** by like group for metered properties, as described in **chapter 4**.

Such unit average consumption may be extrapolated to similar though non-metered properties and thus figure out the likely measured volume. This will allow to identify **potential main customers** not selected when the historical average billing method was used.

List maintenance

This analysis for identifying the group of main customers should not be static. Instead, it must be revised periodically to determine whether new users may join this group or if other users who were formerly main customers, have changed their demand parameters and should be removed from this group.

## 7.4. Measure 1: Installing, maintaining and renewing micrometers

Micro-metering all clients

All users included in the main clients group must be provided with the right kind of consumption **meter**, meeting their individual characteristics. Moreover, these meters must be

fully operational. To ensure this is so, the utility should set as a **priority initiatives** to install new meters, provide preventive maintenance and replace below standard meters.

Mantenimiento preventivo

All micrometers have a **limited useful life** because of internal component wear out, which leads to registration errors (mostly under registration). Such errors are initially imperceptible or fall within established error parameters. However, after using them for 5 years, micrometers start recording erroneous readings, exceeding allowable parameters.

As a result, all meters in this group must be provided preventive maintenance at least **once yearly** for timely identification of anomalous meter functioning and to prevent the resulting altered consumption.

However, for the main customers with large monthly consumption volumes, a recording mistake, even if within allowable figures, may translate into a major economic error. In case of under recording, this may create significant annual economic losses that may exceed by as much two or three times the cost of replacing the meter. On the contrary, excess registrations are a significant source of losses to users.

Renewing micrometers

As a result, it is not only necessary, but fully warranted **to replace micrometers** for this group of users much more frequently than for regular users, and preferably after **the third year** of installation.

## 7.5. Measure 2: More frequent control readings

Micrometer readings are carried out once monthly following the billing cycle. Verification readings are performed only for quality control.
Micrometers are not checked during the rest of the month and, therefore, users who know the regular reading dates may be tempted to tamper with meters' records by removing or inverting meters temporarily.

To prevent these likely events, we recommend **increasing the frequency of readings** for main clients' meters. The frequency will depend on the main clients' importance and may be even daily for users with the highest consumption or those with a track record of tampering. For less important users, there should be at least two additional monthly readings.

Frequency of control readings by consumption range

| It | Consumption range | Frequency |
|---|---|---|
| 1 | ≥ a 1.000 $m^3$ | daily |
| 2 | ≥ a 500 $m^3$ y < 1.000 $m^3$ | Twice weekly |
| 3 | ≥ a 200 $m^3$ y < 500 $m^3$ | Once weekly |
| 4 | < 200 $m^3$ | Twice monthly |

Ranges and frequencies are provided only by way of reference. Each EPS will determine them based on its users' structure.

For higher ranges, it may be required to have the reading form signed by a representative of a client to reduce the possibility of subsequent complaints.

## 7.6. Measure 3: Differential quality control readings

The work team charged with serving the main customers must do its best to ensure such users' billing matches the latter's actual consumption.

For this purpose, it is of utmost importance to ensure meter readings were taken correctly. Preferably, readings' quality control must be performed directly by the team in charge, who will also run all the field checks, as required.

## 7.7. Measure 4: Collection management and individual customer service

**Collection management**

Because of their importance, the main clients' accounts must be checked carefully. Because many large customers have special personnel charged with service payments, the EPS's work team must compile a **directory** of all such clients' personnel (i.e. managers, administrators, accountants, treasurers, etc.). This will allow close coordination and cooperation to smooth out paperwork. This measure aims at preventing main clients from attaching a low priority to utility payments' services when they must rank payments among various suppliers or obligations.

**Distribution of bills and notifications**

Distribution of bills and notifications should always be accompanied by a reception slip signed by the addressee. Personnel charged with distributing bills must be directly supervised by the work team and, if the number of users so requires, may be outsourced with an external message delivery service.

These users are most likely to rely on legal counseling when filing complaints for utility services. In turn, EPSs must be ready to provide robust defense arguments within the existing legal and regulatory arrangements to protect the utility's interests. Otherwise, complaint cases may be lost due to mere formalities (such as failure to admit requirements, send reports or document cases, etc.) that would eventually lead to significant billing losses.

Additionally, the utility's public relations department should pay special attention to the main customers by sending them greetings, invitations to events or congratulations on special dates, to create a friendly atmosphere among these users.

## 7.8. Regular users

It should be underscored that the above recommendations do not in any way imply failing to meet the utility's obligations towards regular users who make up the vast majority of clients. Any EPS should provide quality and efficient service to all its users and a friendly treatment when they require attention to their requests or complaints.

## MAIN LESSONS. CHAPTER 7. SUMMARY

**Summary**

- All EPSs must identify a small group of users or clients who account for a high percentage of the utility's total billing.
- Every possible effort should be made through specific tasks for careful monitoring of those clients.
- Such additional efforts should be commissioned to a special work team in charge.
- Priority should be given to installing meters among the main customers.
- Several monthly readings are required to avoid and prevent tampering.
- Collections and communications management should be personalized.

**Questions**

- Does your EPS have a special group serving main customers?
- How many main customers are there?
- Has this users' list been updated recently?
- What specific activities does the EPS organize concerning such user group?

**Tasks**

- Determine the percentage of total billing generated by your EPS's main customers.
- Determine whether some of these users show very low average consumption.
- Update your main customers list and, if not available, identify and list them.

**Recommendations**

- Prepare a work plan to serve this group of customers, including the staffing and logistic requirements.
- If no resources are available immediately, introduce the recommended measures gradually to demonstrate their effectiveness.

# Annexes


| | |
|---|---|
| Annex 1 | Description of electronic reading devices |
| Annex 2 | Computer-based table for historical consumption analysis. An example |
| Annex 3 | Module planning |

## ANNEX 1:
## Description of electronic reading devices

This brief annex describes how electronic reading devices operate, as well as their advantages and disadvantages.

Several such devices are available in the local market. The most used at present are pocket PCs and cellular telephone sets.

They are all portable electronic devices with the capacity to store information and interact with device users in a programming environment. They are available in several models, brands and capacities.

*Figure 22: Example of a pocket PC electronic device*

The process includes programming the **device** so it can store daily reading data. For fieldwork, they provide an environment where readings are recorded following each reading path order.

Readings are stored in the device's memory and downloaded to a computer at the end of the day's work through a physical port (serial port or USB) or a wireless connection.

*Figure 23: Electronic device with data storage capacity*

This procedure saves typing time compared to when readings were transcribed from printed forms.

The device's software automatically validates each reading by comparing it to the last reading and the historical average.

In case of inconsistencies, a warning flashes on the screen requiring the operator to check the reading. This procedure saves considerable time previously required in screening readings and managing inconsistencies.

The wireless application protocol or WAP is a complementary protocol using Internet standards that allow cellular phones to browse the Web. WAP

technology allows any WAP cellular telephone to access Internet information and to perform Internet-based transactions, such as data transfers.

Some differences among technologies must be taken into account in this general framework. We will first highlight the advantages and disadvantages of pocket PC devices and WAP protocol-based cellular devices.

Finally, we show a combined option that may be of interest as it taps on the main advantages of each of the two above-described options.

| Device | Advantages | Disadvantages |
|---|---|---|
| POCKET PC  | ▪ Flexible and functional programming environment<br>▪ Touch tone screen: includes pointer<br>▪ PC downloads using either USB cable or wireless connection.<br>▪ May manage images. | ▪ High initial upfront investment cost<br>▪ Because they are highly sophisticated, these devices are a temptation to thieves.<br>▪ Low resistance to impact due to sensitive components.<br>▪ Skilled programmers required to support and maintain process. |
| WAP protocol cellular telephones  | ▪ Low device cost<br>▪ Strong resistance to impacts and blows<br>▪ May send information directly from the mobile device to any site with telephone coverage. | ▪ Basic, though sufficient, programming environment and presentation.<br>▪ Typically, suppliers sell the application's source code, creating a relation of dependence.<br>▪ Transmission from the mobile set using the WAP protocol carries a relatively steep monthly cost. |
| Direct discharge cellular  | ▪ Low cost device.<br>▪ Manages its own source code and it may be used for other purposes outside reading cycles.<br>▪ May download data using either USB cable or wireless connection without paying WAP rates. | ▪ Basic, though sufficient, programming environment and presentation<br>▪ Skilled programmers required to support and maintain process |

## ANNEX 2:
## Computer-based table for historical consumption analysis. An example

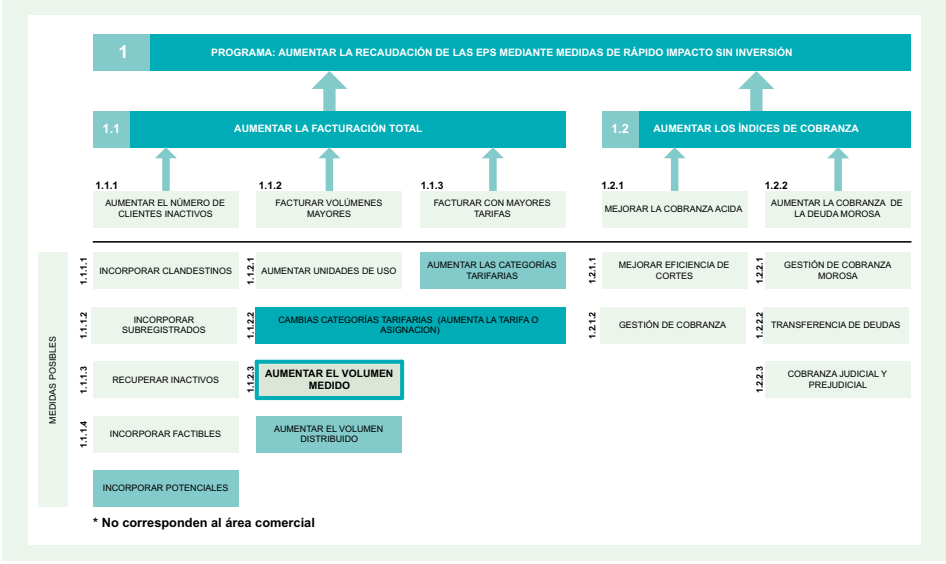
| Nº | Field | Description | Data type | Size |
|---|---|---|---|---|
| 1 | clicodfac | Registration or supply code | Character | 11 |
| 2 | codcat | Cadastre code (sequential, if more characters are needed, expand field size) | Character | 13 |
| 3 | nombreclie | Name of customer | Character | 40 |
| 4 | calle | Street | Character | 94 |
| 5 | preurba | Housing development code | Number | 3 |
| 6 | urbdes | Housing development name | Character | 30 |
| 7 | localidad | Name of locality | Character | 10 |
| 8 | loccod | Locality code | Number | 2 |
| 9 | codesclte | Customer status code | Number | 1 |
| 10 | codestcod | Water connection status ("Situation" in SICI) | Number | 1 |
| 11 | condestad | Sewerage connection status ("Situation" in SICI) | Number | 1 |
| 12 | codtipser | Service type code (typically 1 = water + sewerage ; 2 = only water and 3 = only sewerage | Number | 1 |
| 13 | tarifa | User rate category (for first use unit) | Character | 3 |
| 14 | conmed | Meter installed or not ("S" for yes or "N" for No) | Charácter | 1 |
| 15 | tipovolfac | Type of billing (for example "L" for volume read, "P" for average, "A" for allocation | Character | 1 |
| 16 | periodo | Billing period (for ex. January 2008 = "200801") | Charácter | 6 |
| 17 | facciccod | Billing cycle code (attach code definition in separate table) | Number | 2 |
| 18 | diamedcod | Meter diameter (mm) | Number | 2 |
| 19 | medcodygo | Meter number | Character | 10 |
| 20 | medestcod | Meter condition code (attach definition table) (Otherwise leave field blank) | Number | 1 |
| 21 | medmarcodx | Meter brand code (attach definition table) | Number | 2 |
| 22 | medtipcodx | Meter type code (attach definition table) | Number | 1 |

| N° | Field | Description | Data type | Size |
|---|---|---|---|---|
| 23 | medfecins | Meter installation date | Date | 8 |
| 24 | feclec | Reading date | Date | 8 |
| 25 | lecact | Present reading | Number | 10 |
| 26 | lecant | Last reading | Number | 10 |
| 27 | medobscod | Reading remarks code (attach code definition in separate table) | Number | 2 |
| 28 | volfac | Billed volume | Number | 12 |
| 29 | volmed | Read volume | Number | 10 |
| 30 | asignado | Allocated volume by category (metered or not metered) | Number | 8 |
| 31 | volmin | Minimum volume with meter | Number | 8 |
| 32 | clifacini | Beginning billing date | Date | 8 |
| 33 | clifecing | Customer entry date | Date | 8 |

# ANNEX 3:
# Module planning

## Module: Meter consumption optimization tools

### I. Module location in program: measurement tree




### Definition of target groups:

| | |
|---|---|
| Main target group | ▪ Commercial department<br>▪ Metering division<br>▪ Cadastre division |
| Collateral target groups | ▪ IT division<br>▪ Operations division |

### General objective definition

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|---|---|
| Module | Tools for optimizing metered consumption |
| Module general objective | EPS metering area heads introduce measures to increase average metered volumes and reduce volume under registration. |

## Definition of partial goals and documenting structure

| Objectives | Document outline |
|---|---|
| | Preface<br><br>Introduction |
| Determining the EPS's issues in micro-metering management | I. The issues<br><br>1. Impact of micro-metering on EPSs.<br>2. Main EPSs' weaknesses in micro-metering management.<br>3. Consequences of weak micro-metering management |
| Identifying the main processes in micro-metering comprehensive management | 2. Comprehensive micro-metering management<br><br>1. Human team for good micro-metering management<br>2. Relationships with users<br>3. Meter stock management processes<br>a. Information recording and updating<br>b. Meter reading and quality control processes<br>c. Preventive maintenance program<br>d. Purchase and installation of micrometers<br>e. Criteria to expand the meters' stock<br>f. Setting up the meters workshop |
| Determining the characteristics of meter stock's behavior | 3. Characteristics of operative meters<br><br>1. Preparing data collection<br>2. Meter stock characterization |

| Objectives | Document outline |
|---|---|
| Determining parameters to identify possible tampering with measured consumption | 4. Analysis of consumption patterns by activity<br><br>1. Identifying user groups by common characteristics<br>2. Cross referring information with third party institutions<br>3. Consumption evaluation by groups and calculation of unit consumption patterns<br><br>5. Consumer records analysis<br><br>1. General considerations and requirements for analysis<br>2. Steps required for analysis<br>Step 1: Preparing a table showing the consumption record<br>Step 2: Design and execute a computer application<br>Step 3: Prioritize meters most likely subject to consumption registration tampering<br>Step 4: Inspect meters in the field |
| Determining security mechanisms to prevent tampering and theft | 6. Security devices<br><br>1. Incidence of meter theft and manipulation<br>2. Initiatives to mitigate meter theft and tampering<br>3. Security devices used by EPSs<br>4. Advantages and disadvantages of various security devices |

| Objectives | Document outline |
| --- | --- |
| Determining special service procedures for important users | 7. Main Customer Service<br><br>1. Importance of focusing initiatives on the main customers<br>2. Setting up a steward work team<br>3. Criteria to create the main clients group<br>4. Measure 1: Installing, maintaining and renewing micrometers<br>5. Measure 2: More frequent control readings<br>6. Measure 3: Differential quality control readings<br>7. Measure 4: Collection management and individual customer service |

# Glossary

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|---|---|
| Unaccounted water | The difference between the volume of water produced by the EPS utility and the water effectively billed to users. Measured in cubic meters. |
| Calibration | Exact evaluation of a micrometer's accuracy performed by a certified test bench. |
| Algorithm | A number of sequential logical steps followed in preparing computer software. |
| Benchmark | A set of management indicators applied by Peruvian EPSs as published by SUNASS. |
| Flow | The quotient of volume of water flowing through the meter for a given period of time. |
| Cadastre | A set of graphic, number and alphanumeric data identifying an EPS user and its connections. |
| Continuity | Indicator measuring the number of average hours of drinking water supply service delivered by an EPS. |
| Comparison | Technical procedure to determine the accuracy of a drinking water meter in compliance with metrological standards in force. |
| Consumption | Volume of water consumed in a given period of time. |
| Measured consumption | Difference between two meter readings. |
| Average consumption | Arithmetical mean of a number of consumption readings for specific billing periods for a given connection. Generally, computed from at least 6 meter consumption figures. |
| Metering analysis | Consistency analysis of meter readings above, below the regular average. |

| | |
|---|---|
| Standard deviation | A statistical measure of dispersion for a set of variable figures. |
| Meter | Device used to measure and record the cumulative volume of water supplied through a household connection. |
| Optimized Master Plan | EPS management document setting out the plans and programs for a planning horizon to accomplish management efficiency and meet user's requirements. |
| 100,000 Connections Plan | A technical assistance program implemented by ANEPSSA with GTZ/PROAGUA support. Its objective is to strengthen EPSs' capacities to improve commercial management by increasing active connections and cash flow. |
| Production | Total volume of drinking water delivered by an EPS to the distribution network in the locations within its jurisdiction. |
| Weighing | Emphasizing some variables of a set of data to give them more importance in the final result when computing the common factor. |

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# Acronyms and initials

| | | |
|---|---|---|
| ANEPSSA | Asociación Nacional de Entidades Prestadoras de Servicios de Saneamiento | National Association of Sanitation Services Provider Entities |
| DIRCETUR | Dirección Regional de Comercio y Turismo | Regional Trade and Tourism Directorate |
| EPS | Entidad Prestadora de Servicios de Saneamiento | Sanitation Services Provider Entity |
| GTZ | Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH | German Technical Cooperation |
| INDECOPI | Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual | National Institute for the Defense of Competition and the Protection of Intellectual Property |
| $M^3$ | Metro cúbico | Cubic meter |
| PROAGUA | Programa de Agua Potable y Alcantarillado | Drinking Water and Sanitation Program |
| PMO | Plan Maestro Optimizado | Optimized Master Plan |
| PMRI | Programa de Medidas de Rápido Impacto | Rapid Impact Measures Program |
| SUNASS | Superintendencia Nacional de Servicios de Saneamiento | National Superintendence of Sanitation Services |
| WAP | Protocolo de aplicaciones inalámbricas | Wireless Application Protocol |

# VMCS – DNS

Peru's sanitation agencies are under the Ministry for Housing, Construction and Sanitation (MVCS is the Spanish acronym). This is the governing state agency for sanitation service issues and it operates through the Vice-Ministry for Construction and Sanitation (VMCS in Spanish) and the National Sanitation Directorate (DNS). VMCS is the government agency charged with designing and adopting general sanitation policies pursuant to the guidelines set forth by the Minister. DNS is the line body charged with preparing the policy guidelines, plans, programs and regulations concerning basic sanitation services.

In addition, there are other bodies and organizations that also perform functions indirectly related to this mandate, such as the Ministry of Economy and Finance, the National Superintendence of Sanitation Services (SUNASS), the Environmental Health General Directorate (DIGESA), the local and regional governments, grassroots organizations, the water and sanitation utilities and several international cooperation agencies.

## GENERAL OBJECTIVE

To contribute to expanding the coverage and improving the quality and sustainability of drinking water, sewerage, waste water treatment and excreta disposal services.

MVCS is the governing authority for sanitation policy and as such it has set itself the objective of expanding coverage, assuring system sustainability and improving the quality of sanitation services by accomplishing economic and business efficiency and protecting the environment and people's health. To accomplish such general objective, it has identified the following specific goals:

## SPECIFIC GOALS

1 . Modernizing the sanitation industry's management.
2. Enhancing service sustainability.
3. Improving service quality.
4. Making service suppliers financially viable.
5. Expanding access to services.

## STRATEGIC GUIDELINES

- To improve the industry's legal and institutional framework.
- To strengthen the providers' capacities to accomplish effective decentralization.
- To make the best possible use of the sector's (DNS-PARSSA-PRONASAR, and other agencies and organizations) internal capacities to expand local capacities and reach decentralization goals.
- To improve the service suppliers' management capacities by, among other tools, introducing management contract schemes in these utilities.
- To funnel investment resources through the Sanitation Social Investment Fund – INVERSAN.
- To involve the private sector in this industry's management and investment projects.

# GTZ/PROAGUA

| | |
|---|---|
| Technical cooperation agreement signed between Germany and Peru. | Political agreements governing the support provided by German Technical Cooperation. |
| Technical Cooperation Agency: GTZ | Delivery of technical assistance, advice and training. |
| Financial Cooperation Agency: KfW | Investment financing for water and sanitation infrastructure |
| Counterparty: VMCS-DNS | General coordination of programs supported by KfW and GTZ. |
| Implementing bodies: 12 sanitation services supplier utilities (EPS) | Stewards for individual project implementation |
| Life of present phase: 2008 – 2011 | |

## GTZ/PROAGUA OBJECTIVE

Contributing to ensure sustainability of water and sanitation services in selected cities pursuant to this industry's policy framework.

## GOALS SUPPORTED BY GTZ/PROAGUA

1. Increasing drinking water and sanitation service coverage.
2. Increasing drinking water and sanitation service quality.
3. Enhancing service delivery efficiencies.

## COMPONENTS

### 1. Improving framework conditions in the sanitation sector.

- Improving governance in water and sanitation services.
- Fostering economic incentives for sustainable sanitation.

### 2. Water and Sanitation Training Program

- Strengthening this industry's training structures.
- Improving management skills and technical knowledge for industry staff.

### 3. Rapid Impact Measures Program (PMRI in Spanish)

- Improving the EPSs' economic and financial standing.
- Improving the coverage, quality and continuity of drinking water services.

# ANEPSSA

The National Association of Sanitation Service Provider Entities (ANEPSSA PERU is the Spanish acronym) is a non-profit civil society organization governed by Peru's Civil Code and its own bylaws. It brings together all recognized sanitation service provider entities (EPS) of Peru. Its main objective is to strengthen the sanitation industry by improving EPS's management for the benefit of Peruvians.

## MISSION

To promote excellence in management of sanitation services delivered by its members through training, coordination, cooperation and experience and knowledge exchanges and thereby contribute to improving the people's quality of living.

## VISION

The Association will be recognized as sanitation industry's key actors and related institutions as an efficient and effective organization focused on meeting its associates and the population's needs.

## INSTITUTIONAL VALUES

- Team work
- Transparent management
- Continued improvement of service quality
- Equity and solidarity
- Contributions from its members
- Consistent management and acceptance of regulations

## STRATEGIC OBJECTIVES

- Improving the Association's management
- Improving coordination with government agencies with an emphasis on regulatory and standardization issues
- Increasing its membership
- Improving relations between its members and users
- Providing training and technical skills to its members
- Promoting experience and knowledge exchanges among its members and with sister organizations

## ACTION LINES

- Proposal of and participation in regulatory improvement efforts
- Support to human resource and management development within EPSs
- Strengthening the Association's management unit

## SANITATION PROVIDER ENTERPRISES' COMMERCIAL MANAGEMENT SERIES

- MODULE N°1 CADASTRAL DYNAMIC UPDATING
- MODULE N°2 MASSIVE CLANDESTINE USER REGULARIZATION
- MODULE N°3 SALE OF NEW CONNECTIONS
- MODULE N°4 PAST-DUE COLLECTION AND EFFECTIVE CUT-OFF MANAGEMENT
- MODULE N°5 TOOLS FOR OPTIMIZING METERED CONSUMPTION

**Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH**
Prolongación Arenales 801
Lima 18 - Perú
Telephone (511) 422-9067
gtz-peru@gtz.de
www.gtz.de

Please send requests and enquiries to:

**Programa de Agua Potable y Alcantarillado (PROAGUA)**
Av. Los Incas 172, Piso 5 - El Olivar
San Isidro - Lima 27
Telephone (51-1) 222-0779 / 222-0990
lima@proagua-gtz.org.pe
www.proagua-gtz.org.pe

**GTZ/PROAGUA Coordinator:**
Michael Rosenauer

**Prepared by:**
Teony Alva

**Content review:**
Carmen Zegarra
Stefan Ziemendorff

**Style correction:**
Marta Miyashiro

**Layout:**
Manuel Rosas

**Publications official:**
Roberto Yogui

**First edition:**
Lima. July 2009

**Printing:**
Servicios Gráficos JMD S.R.L
Av. José Gálvez 1549 – Lince

National Library of Peru Registration Number
2009 – 08539

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ANEPSSA PERU
Asociación Nacional de Entidades Prestadoras de Servicio de Saneamiento del Perú