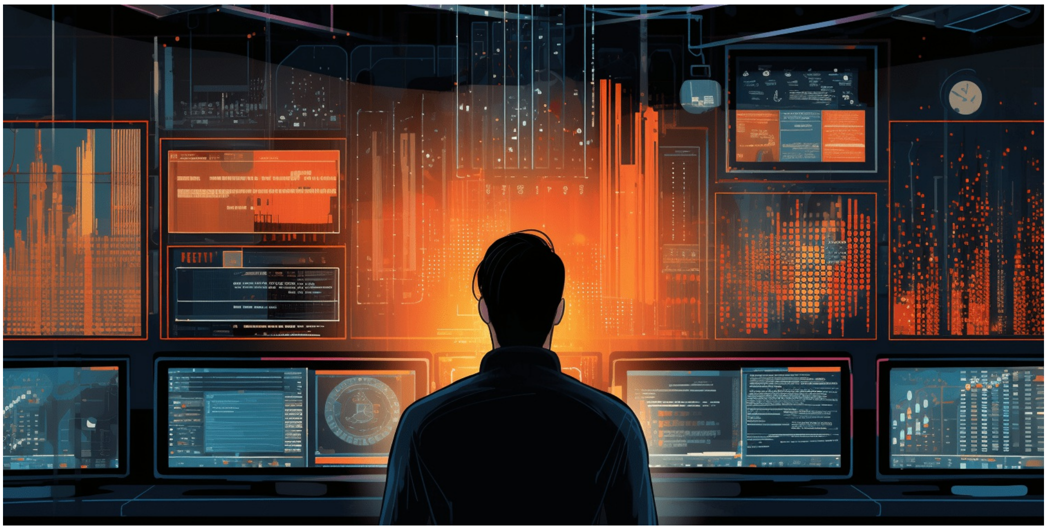

Non-revenue Water Reduction

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Abstract

SCADA systems are essential for water management in smart cities. They provide real-time monitoring, control, early detection of issues, efficiency improvements, enhanced resilience, and data-driven decision support. By leveraging SCADA technology, water utilities can optimize operations, reduce water losses, ensure a reliable supply, and contribute to sustainable water management in smart cities.

Non Revenue Water (NRW) refers to water that is produced and lost before it reaches consumers or generates revenue for water service companies (WSCs). The summary highlights the importance of reducing non-potable water as it leads to increased water availability and revenues for WSCs. This is done by installing flow meters and water pressure measuring devices on the water sources or the entrances and exits of the isolated area, then calculating the amount of water feeding the area and the amount of water accounted for, and from it the amount of non-accountable water can be calculated, and work to reduce it by detecting leakage - Detecting stealth connections and installing water meters that work efficiently. The reduction of commercial losses, which includes issues like inaccurate billing or theft, can significantly improve revenue generation. Similarly, reducing physical/real losses, such as leaks or inefficient distribution systems, allows WSCs to postpone capital investments needed for water source development. To address this issue, departments such as Network Operations, Geographic Information Systems (GIS), Hydraulic Analysis, and the commercial sector must collaborate to estimate and identify the different components contributing to NRW and water loss reduction.

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I. Introduction

Non-revenue water (NRW) loss is among the biggest challenges facing the water industry and the world as reducing (NRW) means the available of more water to be supplied and money. For instance, reducing commercial losses results in improved billing, which is a significant source of new revenue, and Physical/Real Loss reduction allows utilities to postpone capital investments required in water source development schemes.

The NRW level is a key performance indicator for efficiency. For most WSCs, the true level of non-potable water is “underestimated” mainly due to the lack of accurate information and knowledge to correctly determine the level of non-potable water, and due to institutional and political pressures. Reporting low levels of NRW will mask real problems affecting efficient drinking water operation. Therefore, the 'quantification' and 'sizing' of NRW components must be done so that the level of NRW can be 'checked'.

Some reports put the NRW level at 22%; however, this low level of NRW is questionable. Various discussions with drinking water senior management and review of records and field visits concluded that the low levels reported in NRW are due to many factors but are intentional misinformation or, more likely, a lack of accurate information. An audit of the various NRW components should be done, and a more “reliable” and “reliable” NRW standard should be worked out in order to detect real issues affecting the operating efficiency of WSCs. Accordingly, network operations, GIS, hydraulic analysis, and the commercial sector collaborate to estimate and quantify NRW components.

As each component affects the NRW level and the size of each component can be different for each water utility, it is important to ensure the level of each component by conducting an NRW audit. The Non-Revenue Water (NRW) program consists of 5 main components:

1. System Input Volume
2. Billed Authorized Consumption

3. Unbilled Authorized Consumption
4. Apparent / Commercial Losses
5. Real (Physical) Losses (subject of this project / document)

Networks are divided into groups of DMAs (District Metered Area) or large regions called counter zones (DMZs).

II. Implementation

To implement the DMZ, IWSSTA, and Luxor NRW, Hydraulic Analysis, O&M, GIS, and the commercial department's work will include:

- Implementation of the Customer Identification Survey (CIS) of customers to identify commercial losses
- Leak Detection team installed flow meters and pressure sensors to monitor the zone
- Mobile application to transfer the GIS link of the customer meter with the commercial department.
- Satellite Images are used to identify actual physical features in the area.

DMZ equipment includes a few fixed clamp-on Ultrasonic flow meters, a few pressure sensors, and software to receive data from meters. And data transfer units, a monitoring server system, and an updated software system (SCADA Application).

Fig. 1. SCADA Application to monitor water flow and pressure.

Main Devices:

- Flow meters
- Pressure devices
- Panel
- RTU

- SIM cards

The provided diagram showcases the connections between various departments, including DMZ (Districts Metered Zone), the hotline, Hydraulic Modelling, GIS (Geographic Information System), Operation and Maintenance, Research and Development, and Leak Detection departments.

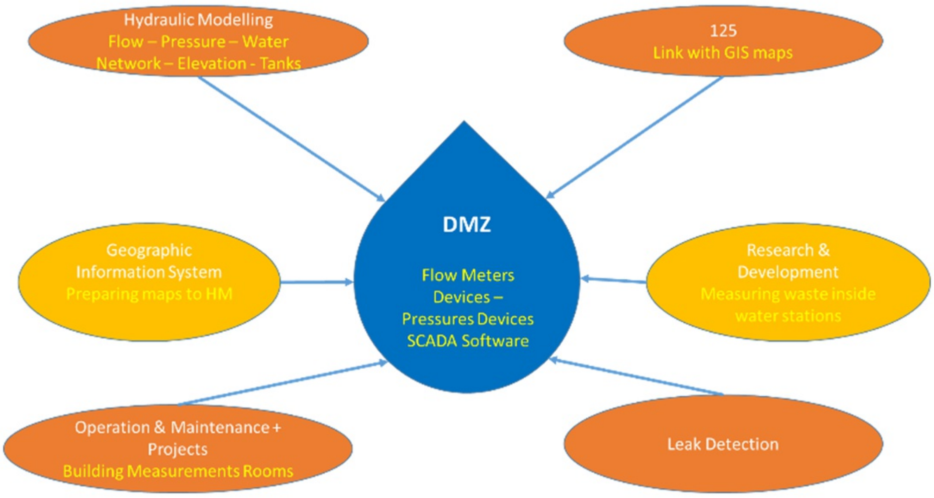

Fig. 2. analysis of data and linking to different departments.

The illustration depicts a network configuration comprising field devices, including Flow Meters and Pressure sensors. These field devices are interconnected with either a PLC (Programmable Logic Controller) or an RTU (Remote Terminal Unit), which in turn is connected to a router. On the server side, there is an additional router responsible for receiving data from the field devices and transmitting it to the server and SCADA system for data storage and analysis.

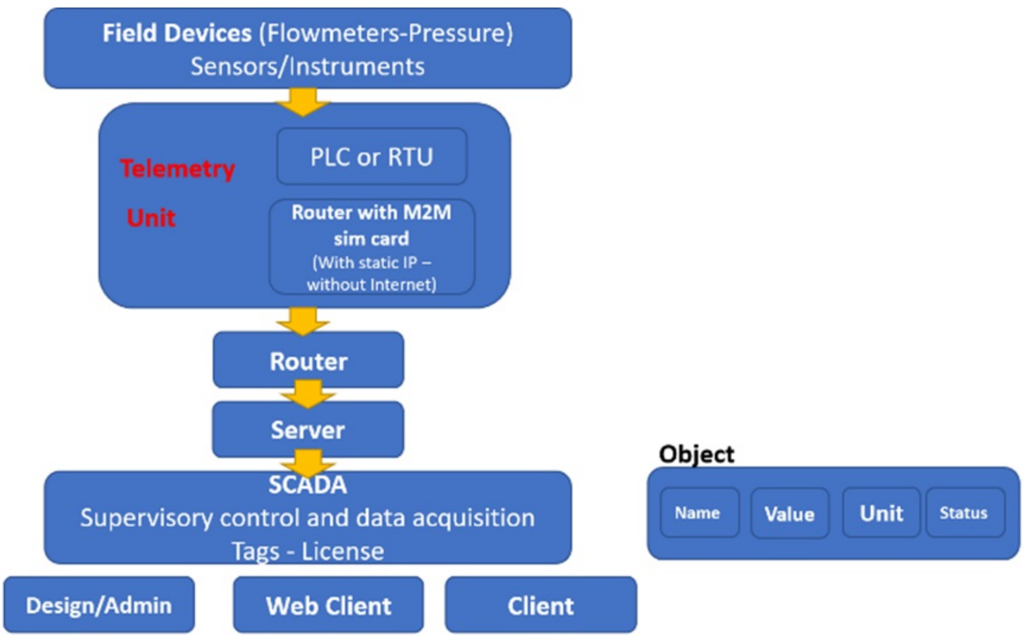

Fig. 3. Flow Chart from Field Devices to SCADA application.

A. *Methodology*

To support water companies in the implementation of DMZ, the methodology will be as follows:

1. *Establish a criterion for selecting and prioritizing the DMZs at the Governorate*
2. *The field survey will apply a mobile application connected to the GIS in order to identify the customer and the location of the meter. This information will also be connected with the commercial department, hot lines, and any other related departments*
3. *Specification of equipment such as flow meters and other instrumentation will include a market search of the newest communication techniques, and technology development*
4. *Determine the final hydraulic model and GIS maps for DMZs*
5. *Prepare GIS maps for stations (zone inlets and outlets)*
6. *Field verification to check if GIS map matches and/or is suitable for the as-built conditions*
7. *Field staff will use computer templates with internet connections to send signals for the GIS and commercial departments*
8. *Use of satellite images*
9. *Train field personnel on the mobile application and how to download satellite images.*

B. *Activities and Tasks*

1. *Team formulation from contribution departments (i.e. NRW, Network O&M, Hydraulic Analysis, Commercial, and GIS)*
2. *Orientation of the team on the program's mission, goals, and purpose*
3. *Selection of a pilot zone using the water balance technique and GIS mapping technology according to a designed criterion.*
4. *On-the-job training for the contributed departments.*
5. *Database development by conducting a field survey of connections / customers using a survey team consisting of (GIS, water network, meter readers, billing, and collectors).*
6. *Update customer database, which includes comprehensive data on connections, customers, meters, and update the database from the information collected during the field surveys. The output is an updated map including connections, water pipes route, pipes diameter and material, customer name and number, consumption classification (residential, commercial, industrial), meter condition and diameter, etc.).*
7. *On-the-job technical training for the leak detection staff: Training on the use of modern leak detection equipment and measuring devices in order to take an accurate measurement of flow and pressure.*
8. *Conduct flow and pressure measurements in the pilot zone.*
9. *Commercial losses intervention such as replacement of malfunctioned meters, dealing with illegal connections, updating meter reading, and other commercial issues with "government" customers (i.e. installing meters for*

governmental facilities, clubs, religious buildings, hospitals, schools, etc.)

10. *Conduct a leak detection survey.*
11. *Allocate the discovered leaks on the GIS map.*
12. *Conduct repairs for the discovered leaks by the water network team.*
13. *Conduct flow and pressure measurements in the pilot area after the repair of the discovered leaks in the network.*
14. *Analysis of the physical and commercial data.*
15. *Reporting and recommendations.*

III. Results and Discussion

A. *Data Display and Charts*

1. *The status of the connection is required to be clarified in that the connection exists or does not exist.*
2. *View signal status exit in the flow meter and pressure sensors from malfunction or no malfunction or problem with the device.*
3. *Buttons required to open reports and charts directly.*
4. *The* program interface needs to be reprogrammed so that there are multiple screens, especially each Plant on which the feeder stations of this branch are shown on maps instead of the view of the stations in *one* table.

B*. Historical Data Display*

1. *Data monitored for all signals, including call status and warning signals, are required to be shown.*
2. *They must be saved and linked to a special database like an SQL database.*
3. *Where the data that has already been shown monitoring is the basis for the work of different reports, data analysis, and generating charts.*

C. Display Trends for the Measured Data

1. *Showing the changes in measured values for the periods prior to all signals is required to illustrate changes in the values measured for previous periods, for easy identification of different operating patterns of stations and how long it changes over time throughout the day.*
2. *View an analysis of curve values according to the duration to be displayed on the curve.*
3. *Report Generation*
4. *Reports are required for all signals, including the status of the connection, which is one of the main functions.*
5. *There are different types of reports to be created, including the daily report - showing the total behavior and average pressures per hour daily.*
6. *The monthly report also shows total behaviors and average pressures per day, as well as the annual report.*

In table 1, you can see that in the year 2021, after using SCADA systems, the %NRW decreased

Table 1. NRW In District Metered Zones

% NRW	District Metered Zones				
	DMZ 1	*DMZ 2*	*DMZ 3*	*DMZ 4*	*DMZ 5*
FY2020	26%	35%	21%	36%	29%
FY2021	25%	27%	27%	36%	28%
FY2022	21%	22%	24%	29%	27%

D. *SCADA systems*

1. *SCADA (Supervisory Control and Data Acquisition) systems play a crucial role in the water management of smart cities. Here are some key points highlighting the importance of SCADA systems in water management:*
2. *Real-time Monitoring and Control: SCADA systems provide real-time monitoring and control capabilities, allowing water utility operators to remotely monitor and manage various components of the water supply and distribution system. This includes monitoring water quality, pressure levels, flow rates, reservoir levels, and pumping stations. Real-time data helps operators make informed decisions and take timely actions to ensure an efficient and reliable water supply.*
3. *Early Detection of Issues: SCADA systems enable the early detection of issues or anomalies within the water infrastructure. By continuously monitoring the system, operators can identify leaks, pressure variations, equipment malfunctions, or other abnormalities. Early detection allows for prompt maintenance and repair, minimizing the impact on water supply and reducing water losses.*
4. *Improved Efficiency and Resource Optimization: SCADA systems provide insights into water usage patterns, consumption trends, and demand forecasts. This information helps optimize water distribution, identify areas of high usage or potential wastage, and implement demand management strategies. By improving operational efficiency and resource allocation, SCADA systems contribute to reduced water losses, energy savings, and cost optimization.*
5. *Enhanced Resilience and Disaster Response: SCADA systems improve the resilience of water infrastructure in smart cities. They allow for better preparedness and response during emergencies or natural disasters by providing real-time situational awareness. Operators can quickly identify affected areas, reroute water supply, or take appropriate measures to maintain essential services.*
6. *Data Analysis and Decision Support: SCADA systems generate vast amounts of data, which can be analyzed to gain insights and support decision-making. Advanced analytics techniques can help identify patterns, predict system behavior, and optimize water management strategies. Data-driven decision-making enables proactive maintenance, improved asset management, and long-term planning for water infrastructure.*

In the following figure, the main functions should exist in the SCADA application (Graphics, Historical data, alarms, trends, reports, and security)

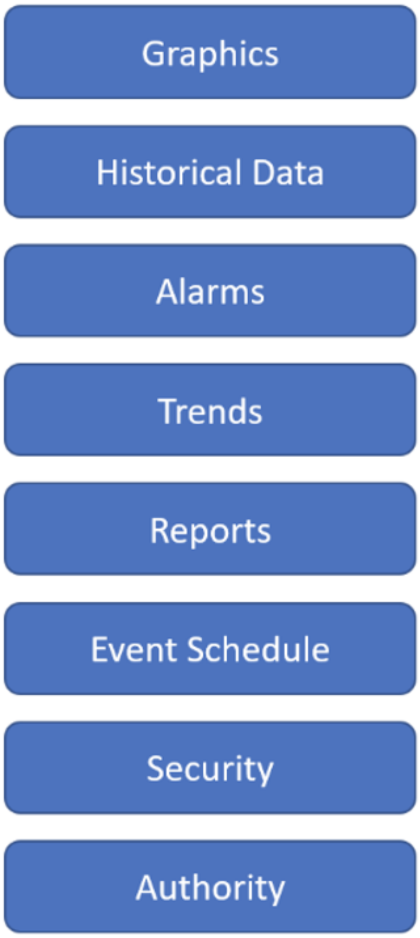

Fig. 4. Main functions in SCADA application.

IV. Conclusion

A study was conducted for the western region of Esna for the months of April and May of the year 2021 before the installation of the meters, and the year 2022 after the installation of the meters, and the following was noted:

Total water production to the west of Isna in the month of April - year 2021 = 2,092,181 Cubic meters (source - Luxor Water Company). The total water production for western Isna in the month of April - year 2022 = 1956020 Cubic meters (source - SCADA system). Among them, the productivity account was reduced in the month of April to about 7%.

Total water production for western Isna in May, 2021 = 2120272 cubic meters (source - Luxor Water Company). Total water production for western Isna in May, 2022 = 1834355 cubic meters (source – SCADA system). Among them, the productivity account was reduced in May to about 13%.

This is reflected in the calculation of the percentage of losses and non-accountable water, and that these calculations will be more accurate after installing the devices and operating the SCADA system better than calculating them before

May		April		2022	2022	2021	2021
%		%		May	April	May	April
-13%		-7%		1,834,355	1,956,020	2,120,272	2,092,181

Table 2. Results In West Isnah

Recommendations

1. Expanding the scope of DMZ and SCADA to cover all other governorates
2. Training on SCADA and maintaining devices is very important to increase skills
3. Providing the necessary devices (flow meters and pressures) to cover DMZ in all other governorates.
4. The integration of artificial intelligence (AI) and machine learning (ML) is going to provide better insights into SCADA network activity and enable more efficient responses to potential threats.
5. Increased use of IoT (Internet of Things) devices and sensors within SCADA networks is going to generate large amounts of data which can be analyzed using big data analytics tools.

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