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SMART WATER METERING IMPLEMENTATION FOR THE CITY OF ANKARA

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Abstract: *Freshwater scarcity in urban centers is a major concern for municipalities. Expanding urbanization and increasing population place pressure on limited resources. Water conservation and effective water use seem to be the only feasible route to avoid impending water crises. This study analyzes water prospects for the city of Ankara. The current situation is evaluated, and issues related to water shortage are discussed. An action plan that focuses on conservation and efficient use of existing resources is presented. The installation of a smart metering system that started in 2019 is also discussed in this study. The benefits of such systems are reviewed from the perspectives of both the customer and the provider.*
Key words: *smart meters, municipal water, water balance, water conservation, water management.*

1. INTRODUCTION

Demand for freshwater has been on the increase in parallel with rapid urbanization. In an urban setting, water demand comes from domestic and industrial needs. Increasing population and expanding industry put pressure on existing water supplies of municipalities. To make matters worse, issues related to climate change aggravate the water shortage problem. To end a deteriorating situation, new resources should be exploited and added to the network. Although this method has been the easiest solution for many years, it is becoming unpopular. Scarcity of new resources and high exploitation costs have changed the focus from exploitation to conservation and efficiency. The very first step of all conservation plans is to prevent waste and encourage the rational utilization of resources.

Figure 1 shows a breakdown of water loss in a municipal system. Physical loss includes anything that is lost in the supply and distribution lines and through evaporation and leakage from storage tanks. Apparent loss is more related to administrative inefficiencies of the system. This category includes inaccuracies in metering and mistakes in billing and accounting. Water theft or illegal use of water, which is the primary factor in water loss in developing countries, also falls into this category.

To minimize the loss in the system and to use water efficiently, municipalities have put various measures into practice. One such measure is effective metering of the water usage. The ASKI (Ankara Water and Sewage Works, a municipality-owned utility company) has recently started to replace mechanical meters with smart ones. The pilot project started with 1000 households in 2019, and it is in the process of expanding to new neighborhoods. In this study, we review and discuss issues related to smart water metering systems and other water efficiency-related issues for Ankara.

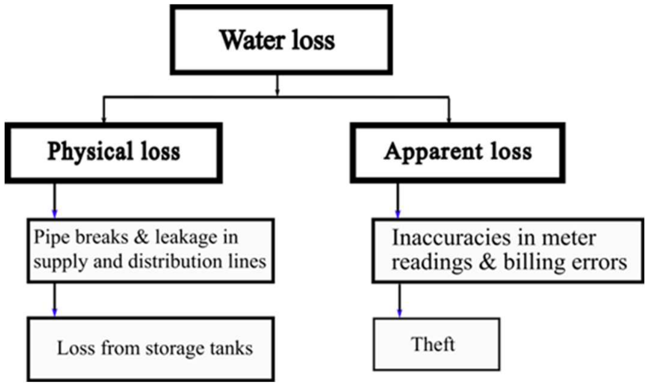

Fig. 1. Water loss causes

2. SMART WATER METERING SYSTEMS

The primary function of the water meter is to record water supplied to a consumer for billing purposes. Effective management of water use requires close monitoring of consumption. The "smart water metering" system has been introduced as part of efforts to manage water resources effectively. These systems have remote access to meters, which makes it possible to download real-time (or near real-time) consumption data for further analysis. In addition to the frequent reading of meters, these systems provide several benefits, such as supply and demand management and leakage detection. All these benefits lead to economic water use [1].

Smart meters function similarly to conventional meters. The major difference is the additional electronic component that has the capability to read and record consumption data. This data can be transferred to a central location for processing. Smart systems are flexible and can be configured in many different ways according to the needs of the utility company. The frequency of recordings and data content can be adjusted as specified by the utility administration [2].

Data collection and analysis of the data can provide information regarding water use patterns. Supplying feedback to customers can lead to behavior changes in water usage. Table 1 summarizes various strategies adopted and their accompanying effect on water usage.

Table 1

The use of smart meters and their effect on water usage

Source	Strategy deployed	Effect on water usage
[3]	With the help of a smart metering system, detailed information is provided to consumers. It is assumed that water usage information and the format in which it is delivered may positively influence customer behavior.	Approximately 8% reduction in water usage after the intervention. Significant increase in water-use awareness. Before the program, only 30% of participants knew their monthly water consumption. This percentage increased to 80% after the intervention.
[4]	Survey previous studies regarding the effect of providing feedback on consumer behavior.	Consumption reduction ranges between 3% and 53.4%. The majority of studies find that providing feedback curbs consumption.
[2]	Digital in-home displays are installed to provide near-live (hourly measurement) information about water consumption. The display also shows a reference number, which is based on average consumption in the community. Figures are adjusted according to the number of people living in the household.	A reduction of 7% to 10% was observed in household water consumption.
[1]	Metering data is monitored and analyzed to detect post-meter leakages. These are leaks from plumbing fixtures or piping systems within the residential property. Dripping taps and leaking toilet cisterns also contribute to post-meter leakages.	Once a post-meter leakage is detected, the homeowner is contacted and informed about the leakage. Most leaks were repaired for less than AUD 200, which led to an 89% reduction in water loss.

3. A WATER MANAGEMENT SYSTEM FOR THE CITY OF ANKARA

The city of Ankara is the second largest metropolitan center in Turkey (following Istanbul), with a population of 5.6 million [5]. Ankara is located at the center of the high Anatolian Plateau under the influence of continental climate with cold winters, hot summers, and little rainfall. The region has limited resources, and eleven water reservoirs situated around Ankara form the source of water supply for the city. The list of major water reservoirs, with a total capacity of 1764 million cubic meters, is given in Table 2. Water collected from reservoirs is processed in purification centers before being pumped into the distribution networks.

Table 2

List of major reservoirs around Ankara [6]

Reservoir	Volume (million m3)
Çamlıdere	1220.4
Eğrekkaya	112.3
Kesikköprü	95.0
Kurtboğazı	92.0
Others	
Total	1764.0

There are two types of meters currently used in the city. The mechanical meter, calibrated in cubic meters, measures the volume of water used by the customer. An operator reads these meters once a month, and the difference between the two readings is used for the billing. Prepaid-card water meters are also used by many consumers. In this system, the customer purchases water credits in advance. The credits are loaded on a smart card instructing the metering device to allow water usage up to the defined limit. Currently, there are 2.5 million customers in Ankara. Approximately 80% of customers have conventional mechanical meters that must be checked by a reader every month. The remaining 20% use prepaid cards. To read two million meters every month requires many readers. Reading and billing make up the largest expenditure in ASKI's budget. In addition, ASKI still receives many complaints regarding incorrect reading.

Table 3 shows the water balance for ASKI in 2020. Out of 507 million cubic meters of water supplied to the network, only a little over 60% is turned into revenue water. The remaining 40% is lost. The most significant portion of this percentage comes from physical losses in supply and distribution networks. The second, but a smaller portion of the loss, comes from inaccurate meter readings.

The loss at supply and distribution networks is excessive, and measures must be taken to lower the network losses. The second area that needs improvement is the metering of consumers.

3.1. Network Management Strategies

One way of pinpointing network losses is to divide the entire network into multiple sub-networks. Each sub-network has a fixed number of supply points and outlets that are interfaces to other sub-networks. Flow rates and water pressure are monitored at interfaces and other reference points to identify leakages and manage losses.

Table 3

Water balance table for Ankara

<table>
<tr><td rowspan="8">GRAND TOTAL – SYSTEM INPUT 507.52 mil. m3/ year (100%)</td><td rowspan="4">Authorized consumption 313.1 mil. m3/year (61.7%)</td><td rowspan="2">Billed authorized consumption (61.5%)</td><td>Consumption (billed, metered) (61.5%)</td><td rowspan="2">REVE-NUE WATER (61.5%)</td></tr>
<tr><td>Consumption (billed, unmetered) (negligible)</td></tr>
<tr><td rowspan="2">Unbilled authorized consumption (0.2%)</td><td>Consumption (unbilled, metered) (0.2%)</td><td rowspan="6">NON-REVE-NUE WATER (38.5%)</td></tr>
<tr><td>Consumption (unbilled, unmetered) (negligible)</td></tr>
<tr><td rowspan="4">Water losses 194.4 mil m3/year (38.3%)</td><td rowspan="2">Apparent losses (3.6%)</td><td>Unauthorized consumption (0.1%)</td></tr>
<tr><td>Inaccuracies in meter readings (3.5%)</td></tr>
<tr><td rowspan="2">Physical losses (Real losses) (34.7%)</td><td>Loss and leakage in supply (mains) and distribution lines (34.3%)</td></tr>
<tr><td>Loss in storage tanks (0.4%)</td></tr>
</table>

3.2. Potential Benefits for Consumers

In addition to improvements at a network level, there must be measures in the new system to influence customer water-use behavior. Positive influencing can be instituted by using a carrot and stick strategy. Material incentives can encourage customers to change their behavior. Similarly, there can be financial disincentives to force the customer to behave in a desirable way. From a customer perspective, the most significant advantage is a potential reduction in usage costs. Installing smart meters can help in reducing costs in several different ways.

Previous studies have shown that providing detailed feedback about water usage motivates consumers to use less water [2]–[4]. The awareness created by real-time or near real-time information regarding water consumption also led to a reduction in water usage. The level of awareness may depend on many factors including, income, level of education, and environmental consciousness [7].

With smart meters, flexible billing cycles can be implemented easily. Flexibility in billing allows customers to budget their expenses accordingly. Both billing date and frequency of billing can be selected by the customer.

Smart meters can be a valuable tool for detecting in-house leakages. With hourly meter readings, the water company can detect any water usage abnormality and warn the user. Early detection not only saves customers from high bills but also prevents more severe property damage [8].

3.3. Potential Benefits for the Water Utility Company

Digitizing meters can help utility companies to reduce reading costs. With mechanical meters, a meter reader must physically gain access to the meter. This is a time-consuming process, and it is prone to mistakes. With smart meters, manual reading is eliminated, and any cost reduction associated with manual reading results in saving for the utility company.

There are two broad categories for smart reading. The first category is called walk-by or drive-by reading. When a reading device is within a certain proximity to the meter, the data transfer is activated automatically. For some systems, the reader has to touch the meter with a reading probe for data transfer. For others, a traveling van with an installed meter reading device is able to collect reading data from nearby meters. The second category includes an automated system with a network structure to allow continuous access to meters.

Automated reading systems need a substantial initial investment, but two benefits can assist companies to cut costs in the long run. First, there is a reduction in staff costs related to meter reading. Second, complaints about inaccurate reading and high bills decline with the automatic meter reading. One study reports that, after implementing the advanced metering system, the number of high-bill inspections per month declined, from anywhere between 300 to 400 to under twenty [9].

Accurate and frequent data collection from the meters creates a data repository that can be leveraged to extract actionable insight regarding operations and marketing. Demand and supply management strategies can be developed to match water supply and demand effectively. With the help of historical data, more reliable forecasts for water demand can be generated. Accurate forecasts are crucial for running operations smoothly, as many operational functions, for example, a pumping schedule, depend on demand forecast. Any deviation from the forecasted consumption can be used to pinpoint anomalies such as system faults, leakages, and theft [10]–[12]

4. ROAD MAP FOR FUTURE ACTIONS

Our proposed action plan that specifies concrete measures for efficient water administration is based on three components. The first component is the future demand. The city of Ankara has been growing since it became the capital of modern Turkey in 1923. The population growth, fueled by internal migration, has been higher than the national average. Although migration has slowed down in recent years, the annual growth is expected to be between 1.5% to 2.0% in the next 10 to 20 years [13]. The second component of the action plan is related to existing water infrastructure. In the past, Ankara has experienced periods of sudden expansions in urban development. Unfortunately, most of this urban growth was not supported by an accompanying infrastructure development to sustain the growth. The lack and absence of enforcement of construction rules and regulations exacerbated the flaws in the infrastructure. One obvious evidence of this neglected infrastructure is given in Table 3. The non-revenue water, that is, the water lost or unaccounted for, amounts to 38.5 percent of the total pumped into the system. We think that this is an extremely high rate, considering the fact that the acceptable ratio is less than 10% [14]. The water infrastructure of Ankara urgently needs repair and replacement. The third component of the road map is sustainability. This is particularly important, considering the geography of Ankara. The central Anatolian Plateau, where Ankara is located, has limited water resources. From the south and southeast, Ankara is surrounded by the Konya Closed Basin. This basin covers a large portion of central Anatolia, with a salt lake in the center [15]. Almost the entire water supply for Ankara comes from streams to the north and northwest. The new water development areas extend to the Gerede region, 150 km northwest of Ankara. This area is also the boundary for freshwater resources of large population centers in the Marmara region. Thus, Ankara has already reached the limits of its new water development resources.

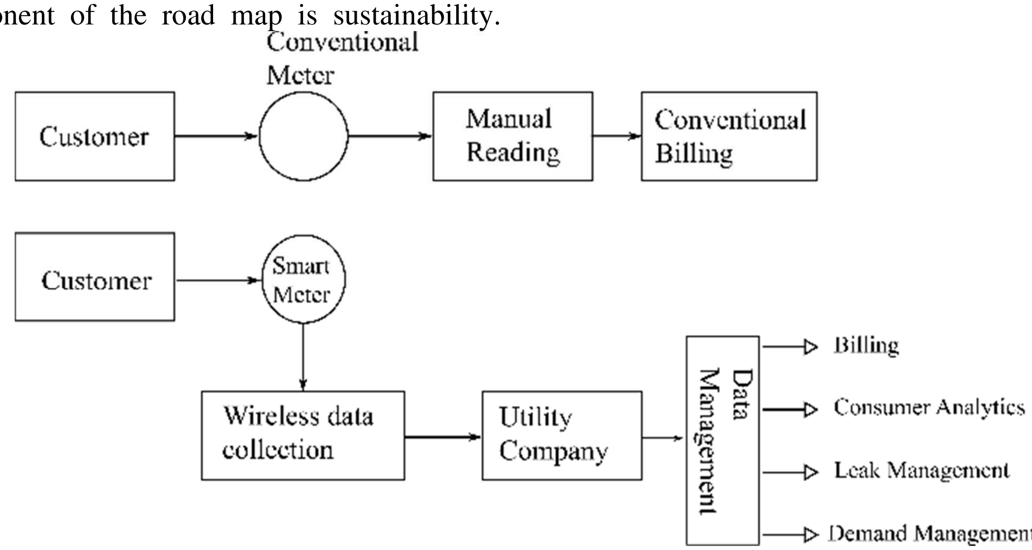

Fig. 2. Diagram comparing the conventional system to the proposed smart system

For Ankara, effective use of existing resources is the only viable alternative as a water management strategy. The diagram for the new strategy is given in Figure 2. Our strategy can be expressed in terms of the following concrete measures:

1. **Establishing District Metered Areas.**

The simple divide-and-conquer strategy is the basis of the district metered area (DMA) concept. The entire network is split into sub-networks so that each component can be monitored and analyzed independently.
There is a fixed number of interchange points for inflow and outflow of water between sub-networks. The checkpoints are monitored and controlled for water pressure, velocity, and flow rate.
For Ankara, establishing DMAs will be particularly beneficial as the city's water network compromises patchworks of infrastructure built at different times. Old neighborhoods of the city with aging infrastructure must be isolated for closed monitoring and data collection.

2. **Expanding the Installation of Smart Meters.**

The city of Ankara started the installation of smart meters in July 2019 [16]. The pilot project with 100 households soon expanded to 1000 customers. The new system is integrated with

advanced metering infrastructure that includes smart meters and a communication network. Since the new system allows two-way information exchange between the ASKI and customers, it offers various new services that were not previously available.
The connecting and disconnecting service, which usually requires an on-site visit by the technical crew, can now be performed remotely.
Due to the heavy winter conditions in the city, freezing of meters is a serious concern. An SMS message will be sent to customers when the water temperature becomes close to the freezing point.
These extras add value to the new system, which benefits both the consumer and the utility company.

3. Alerting of Leaks.

Due to their fast data acquisition capabilities, smart meters can be used to monitor detailed water consumption. Repeated and abnormal readings at inactive hours could be a sign of leakage. In such circumstances, the homeowner can be warned about the problem before it becomes a major issue.

4. Offering Flexible Billing.

Because of instant access to meters, the utility company can use flexible cut-off dates for water bills.
Customers can select the billing cycle that best fits their budgeting strategy.
Since everything is done automatically, this does not result in any additional overheads for the water company.

5. Customer Analytics

Availability of detailed consumption data can provide new business opportunities for the utility company. One apparent area is customer segmentation that categorizes customers according to their consumption behavior.
This can help water companies to introduce new "products" targeted at specific groups. Price, consumption quantity, and calendar (i.e., time of the day or day of the week) can be used as a basis in defining products. Instead of having a constant price, a variable pricing policy can be offered to customers based on quantity and consumption time.
Detailed data can also help utilities to manage the water demand actively. Multiple cyclical factors drive water demand.
In addition to hourly fluctuation, total daily demand can change from one day to the next. Estimating the expected demand correctly and deploying appropriate demand management policies will help utilities to optimize their operations.

5. CONCLUSION

Providing safe and steady freshwater to residents has become a challenging task for municipalities.

On the one hand, water demand has been on the increase due to urban development and population growth.

On the other hand, water resources are limited, and for many municipalities, adding new resources is either too expensive or totally out of the question, as there are no new resources available.

The city of Ankara, with extremely few potential water resources and a growing population, must deal with this challenging issue.

This study reviews options and discusses the viability of proposed solutions. An action plan covering conservation and effective water usage is proposed. The action plan aims to eliminate loss in the distribution network and create awareness of water consumption.

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IMPLEMENTAREA CONTORIZĂRII INTELIGENTE A APEI PENTRU ORAȘUL ANKARA

Rezumat: Lipsa de apă dulce în centrele urbane este o preocupare majoră pentru municipalități. Extinderea urbanizării și creșterea populației exercită presiune asupra resurselor limitate. Conservarea apei și utilizarea eficientă a apei par a fi singura cale fezabilă pentru a evita crizele iminente ale apei. Acest studiu analizează perspectivele legate de apă pentru orașul Ankara. Se evaluează situația actuală și se discută probleme legate de deficitul de apă. Este prezentat un plan de acțiune care se concentrează pe conservarea și utilizarea eficientă a resurselor existente. Instalarea unui sistem de contorizare inteligentă care a început în 2019 este, de asemenea, discutată în acest studiu. Beneficiile unor astfel de sisteme sunt revizuite atât din perspectiva clientului, cât și a furnizorului.

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