

Quantifying the Mismatch in Smart Water Meter Readings in Muscat Water Distribution Network (DIAM) – Case of Oman

Ibrahim Nasser Khalifa Al-Mamari

MBA, Middle East College

Dr. Maria Teresa Matriano

Faculty/Assistant Professor, Department of Post-Graduate Studies
Middle East College, Oman

ABSTRACT

Purpose: The study is intended to focus on quantifying the mismatch between the consumption data collected on the project site to the estimated reading generated by the system. The mismatch quantification process involves formulating a theoretical mathematical modelling using Bernoulli's equation that will help in reducing the conflicts in mismatch of data between the actual and estimated water consumption readings. **Design / methodology / approach:** The study revolves around basic survey of different journals and articles which relates closely to the topic. There's application of qualitative method in which the results depend on the opinion of the focus group participants. **Findings:** Based on survey results and flow calculations, the flow was compared with the actual discharge measured from the smart meters; mismatch was ensured in the actual discharge at transmission and the discharge at the distribution line at each consumer location. The opinion of the focus group suggests to upgrade the existing system in Diam. **Research limitation / Implications:** A recognizable mismatch was made that influences Diam to create estimated charging. A viable computerized water spillage checking system was consolidated to recognize and annihilate the mismatch. There are recommendations to minimize the estimation system in billing at the water supplier end; and the inclusion of a new technology to quantify the mismatch in the existing system. A SCADA based system to localize the flaw point; and the inclusion of big data analysis in the bill generation software should be implemented. **Originality / value:** There are no previous studies on mismatch quantification process in Oman, and this study would propose a system that would be helpful in finding the causes of mismatch and eradicating them.

Keywords: Diam, Distribution Network, Smart Meters, Estimated Reading, Water Consumption Mismatch, Numerical Modeling

INTRODUCTION

Water is one of the most essential components of life on earth. Every living creature from a micro-organism to human life depends on it in one form or the other for hydration. Almost every activity of nature depends on water as one of its constituents. Thus, a proper allocation of water would require facilitate a appropriate environment for the life to exist. In the recent decades, pollution has been a major issue in almost major locations of the world. The different forms of pollution have impacted the water in terms of quantity, purity and recyclability.

Therefore, with rising pollution levels, the pollution departments of different nations have passed laws to curb pollution and regulate water usage (Nkosi and Odeku, 2015).

The climatic conditions of Oman are totally arid. The Sultanate depends highly on rainfall for its ground water recharge and its freshwater supply. The usage of water for domestic purposes in the Sultanate surged highly in the past couple of decades. In urban areas, the water distribution through pipeline system is in common use when compared to the water distribution methods before 1970 (Al-Ismaily and Probert, 1998). The rapid rise in population, living standards, use of modern technological machinery in agriculture in combination with the scorching climatic conditions of Oman contributes towards the over-drafting and straining of water resources of the country. The Sultanate is also experiencing the intrusion of sea water, increase in salinity and depleting aquifers induce the Government to improve deteriorating water conditions (JMP Report, 2017). Despite the efforts of the ministry for the past two decades to control the water resources and strategies implemented in the field of agriculture, desalination, waste water reclamation and reuse, there appeared a strong indication to monitor the water distribution system as it plays vital role in transporting water to desired location of Oman (Omezzine and Zaibet, 1998).

STATEMENT OF RESEARCH PROBLEM

A public authority named 'Diam' was setup to take the responsibility of providing quality services of water and its supply throughout the Oman Sultanate. The responsibility of the firm also includes the billing and metering of water consumed at customer location in addition to water distribution to the customer. The inevitable factors of improper connection of water meters to distribution pipeline network, consumption data not updated in the meter reading periodically, pressure accumulation, water leakage, drop in pressure are all factors that lead Diam processing erroneous metering data of consumed water in the customer end (Dawoud, 2015). The initiative of Diam in Muscat region, in finding solution to the mismatch problem is to implement Automated Meter Reading (AMR). The AMR method is a smart system that incorporates accurate and automated water reading that replace the conventional metering system and thus reducing the man power. In the transition period and the work in progress period of the installing the system, numerous issues appeared by which the firm was forced to consolidate the data of previous usage and generate a bill accordingly known as estimated reading (Raykar *et al.*, 2015). Flaws existing in metering the water consumption produces a mismatch between water consumption and water supplied. There were flaws registered in metering the water consumption mostly due to faulty meters, flaws in transmission like leakages and pipe wreckages. The study is focused on quantifying the mismatch between the consumption data collected on the project site to the estimated reading generated by the system.

RESEARCH QUESTIONS

1. What are the factors that are influencing mismatch in the water meter reading and how the Diam handles it?
2. How can the mismatch in the water meter reading be estimated?
3. How can the mismatch in the water meter reading be analysed and what are the research tools required for this?
4. How will the mismatch in the water meter reading be quantified and validated?

OBJECTIVES OF THE STUDY

1. Determining the difference in the reading between actual water consumption and estimated reading and thus quantifying the mismatch in Muscat region.
2. Theoretically estimating the mismatch by a flow modeling using Bernoulli's equation and the related estimated reading by the aid of SCADA.
3. Utilizing big data analysis method for critically analyzing the mismatch in water meter reading.
4. Locating the area using SCADA and quantification of relative water consumption

SIGNIFICANCE OF THE STUDY

The project gains importance by its contribution to the society that helps the society to grow economically and socially. The significant factors that the project focuses on are highlighted and is very useful for devising a method, that yields optimal consumption of water, which is a volatile substance in the region. The study also facilitates the consumers to pay for the actual consumption than a high rated estimated consumption. The following are the significant outcomes of the study.

- The initial data if water consumption and supply will be made available in an excel format. Further the collected data will be analyzed and processed to obtain the mismatch information in the suppliers prospective.
- A governing equation for flow modeling is obtained from Bernoulli's equation which will help in quantifying the mismatch theoretically.
- The analysis report prepared would enable the location of mismatch occurring area, as the mismatch calculation is for each and every branched water pipeline. Big data analysis would play a key role in locating the mismatch.
- Finally, the evolved system to quantify the mismatch and compare the actual and theoretical consumptions would be helpful in locating the mismatch. Thus, the system would be helpful in finding the causes of mismatch and eradicating them.

Academe

Smart meters usage in the field of water distribution is an emerging technology. It's technology is to be made aware to the student community, focus more on instrumentation, resource distribution, fluid mechanics, supply chain etc through their curriculum. This work will create an impact among the academicians in introducing the features and requirements of smart meter usage.

Future Researchers

Smart water meter technology as discussed is an emerging trend still in its innovation and stabilizing cycle. Thus, it is prone to technical issues that are operation related. Hence there is a wide scope for future researchers to provide practical solution to the persisting technical issues. Since water distribution deals with operations and management of pipe networking and its managerial elements, widens the scope for future researchers in refining the water distribution system.

The Company

Un-interrupted water distribution is the responsibility of any water distribution organization. This project work would help the engineers, focusing on smart meter transition work to minimize the existing issues like water leakages, water transport losses, unaccounted water supply and so on. By incorporating the quantifying approach validated in this project would be beneficial to the company in managing the water distribution efficiently and in broader prospective to the nation as well.

SCOPE AND LIMITATIONS OF THE STUDY

The 'Public Authority of Water' a public body under the Oman Sultanate Government has proposed the installation of Smart water meters replacing the conventional water meters. The smart water meters are expected to be in constant and uninterrupted communication with the Server, updating it with the periodic consumption data. Towards the end of the billing cycle, a bill is generated according to the data stored for a particular meter identification number, indication the amount of water consumption.

Practically, the water transmission from the main transmission line to the customer branch line is monitored by the SCADA system. On comparing the data received from smart meters with the SCADA data of the respective water branch lines reveal a mismatch of data. The study focuses on quantifying the mismatch would reveal its causes such as water leakages, pressure accumulation, pressure drop. Thus, a possibility of locating a branch line which would possess the above problems could be identified and rectified at the earliest to achieve customer satisfaction and utilizing the water resource without any losses that leads to the wastage of water (Al-Marshudi, 2018). The possible hinderance that may curb the wide practical application, is that system depends on the end user data that is transmitted to the server for bill generation. Often there is a serious network issue that hampers the connectivity of smart water meters to the server. This causes the bill to be generated based on an estimated reading. Although the project aims to quantify this mismatch, for ideal cases, it is demanded that an uninterrupted internet connectivity is required. In the presence of such internet interruptions, it mandates a manual inspection at the consumer location at the project site.

LITERATURE REVIEW

Mismatch Identification In Smart Water Meter Reading

Smart meter technology in the field of water utilities are launched in various cities that vary from medium to large size that continuously monitor the water consumption at the individual customer household level. The method is useful in obtaining information that are spatially high and of temporal resolution that outlines the designing strategies that are tuned to the management of user oriented residential water demands. The paper also evolves the information of future challenges that pose growing population and their demands, climate change that impacts the constrained sources of water supply and are expected to have integrated procedures that support the water demand modeling and its management for supporting the residential water (Cominola *et al.*, 2015). The concept of smart water meter technology should always encompass the dynamic factors such as increasing population, climate change impacting the water supply and its availability and to be incorporated in the demand modeling and management of water distribution.

In parts of France, the smart water meters are installed at free cost and despite this the customers are reluctant in utilizing this technology for its advantage. The factors that influence this state of utilizing are described as the low adaption rate of the technology by focusing on providing information that foster intentions for good. The study is concluded with the results that smart meters are seen as potential barriers in adapting, although respondents are more interested than compared to the number of oppositions to the technology. The adaption rate is low particularly in heavy water consuming customers and the flat renters (Montginoul and Vestier, 2018). Some consumers whose consumption of water is on the higher side, there is a reluctance in the adaption of the smart meter reading.

It is understood that the perception of the consumer of their water usage, frequently do not match the actual usage of water. The study attempts to examine the psycho-social and socio-demographic surveys that stock inventory audits. The end uses of water was categorized for each group as low, medium and high-water user. The socio-demographic variables such as family size and its composition, income, water efficient stock percentage that characterize the self-identified water usage group. It is concluded that the groups either overestimate or underestimate the usage of water and how the corresponding knowledge could be identified to demand management policy and educate the targeted community (Beal *et al.*, 2015). The water consumers are categorized based on the consumption quantity, self-estimation of consumption either over or under by the consumer are considered in the devising of the demand management policy.

Traditionally, the metering of water is usually done based for the billing purposes against the water consumption. The advent of smart meters into the market are considered as the integral part of the water management. The study attempts the effect of water metering on water conservation and that metering has a positive impact on water conservation. It is been concluded that the smart meters usage and their integration with the household appliances are increasing with time in the Australian region (Koech, Gyasi-Agyei and Randall, 2018). Smart water meter system enables the conservation of the water at the consumer end.

The study is with respect to Patras in Greece. The city experiences high levels of leakage during the water supply network throughout the city. The system consists of approximately 1000km of water pipes and 134000 customer water meters. The non-revenue water is estimated to be the 55% input volume out of which a considerable volume is termed to be the physical losses. At present, the control of leakage is a passive, thereby it comes to rectification only when it is visible. The water department is in the process of developing a permanent leakage control system in accordance to the terms and conditions of the international water association. The project is designed to consider the initiating the DMAs, pressure management, GIS-based decision support system creation, building up databases through the development of a software intelligence that reports valid information in collaboration with the data warehouse technique, purchasing leak detection equipment and training the department's personnel to operate the pressure management system (Karathanasi and Papageorgakopoulos, 2016). The importance of the leakage detection are to be emphasized in all water distribution network and its upgradation in terms of technology are to be initiated periodically to ensure effective water management.

Water shortage is a significant issue in any heavily populated nations like India. To encounter with such common water shortage issue we can have some smart applications. Smart water metering water piping network is one such solution where water consumption is read through IoT (Internet of Things) applications, expected to be precise. It can monitor water usage and produce utilization report to make restorative moves. This kind of IoT based application improvement is fairly expensive and confounded yet on the off chance that we utilize a structure which can give great stage to gadget network and correspondence with it then things become simple. In this paper the author might wanted to examine pertinence of OSGP (Open SmartGrid Platform) presently known as Grid eXchange Fabric (GXF) for creating brilliant metering of actual water consumption. They have built up an open source Internet of Things stage that is nonexclusive and adaptable. Utilizing this stage, good outcomes are expected to effectively associate, control, and monitor. The juncture can likewise help reenact advancement of Smart Water Metering systems. As an open source, OSGP tends to be utilized for incorporating new applications and gadgets with decreased turnaround time and advancement cost (Mankad, *et al.*, 2020). The concept of Open Smart Grid Platform (OSGP) and its incorporation in smart water metering yields services that are time efficient and cost effective.

Water is a significant thing that is getting scant because of man-made and regular decimation. The Philippines has plentiful water assets however the quick turn of events, anthropogenic exercises, and helpless strategy execution in the nation prompts the crumbling of water quality in its water bodies. Water quality checking (WQM) is a gloomy and expensive cycle that can encroach nations with restricted assets. Then again, arising advances on remote sensor organization, energy reaping, distant detecting, and geographic data framework (GIS) have been the focal point of different explores to accomplish an exact, intermittent, continuous, and ease water quality observing. In this work, the author provides a good review of these empowering advancements and investigated to assess their materialness in the appraisal, the executives, and restoration of tainted water bodies in the Philippine setting. To do this examination, the water quality checking program, existing advancements being utilized, and the difficulties in executing a from one side of the country to the other and far reaching WQM measures were distinguished. At that point, an outline of the subjective condition of the water assets in the nation is looked for to highlight the requirement for more appropriate elective strategies (Burce. M. E. C. *et al.*, 2018). The monitoring of water transportation is to be automated for effective handling and maintainance.

An article reports that the probability of the water consumption will be remembered for the British government's keen metering program has decreased. Subjects talked about incorporate the drives behind the public authority's choice not to incorporate water consumption in the smart metering program for energy showcases, the potential focal points that keen metering can bring to water consumption and their consumers and the difficulties related with actualizing smart metering in the water consumption area.

This paper gives an investigation of the utilization of law to conjure and ensure the interests of least fortunate purchasers of the privatized water industry. It centers upon the presentation of pre-installment gadgets by water organizations and the legitimate activity taken to forestall their utilization. The setting for the examination lies in the privatization of the water business in 1989, one of the last significant acts in 10 years in which the exchange of public endeavors into private proprietorship had gotten one of oneself announced 'lead' arrangements of

progressive Conservative governments. The cases which encompassed the use of the approach to water were recognizable: private possession delivered proficiency, powerful administration, and mindfulness to clients' necessities. Basically, the offer of public resources made advantages for everybody. This article discover the case to be bogus. It considers the social designing function of law in endeavoring to ensure the interests of least fortunate buyers, featuring the assets - individual, network, and political- - which required activation to offer impact to likely cures. It closes by proposing that not exclusively is admittance to the law separated by force and assets, however that consistence with it is additionally intervened by similar disparities.

Influence of Numerical Modeling in Water Monitoring

The recent advances in the smart water technology has improved the monitoring of quality water supply and its distribution. It facilitates the water department to chart consumer patterns of consumption to help them control the water use, active leak targeting and leak detecting capability. The study demonstrates the monitoring of automated meter reading and recorded data that allows the rapid detection of water leakage on the study site (Farah and Shahrour, 2017). Collection of data is enabled through smart meter technology which ensures flawless transportation of water.

The advancements of including sensors, analytical tools aid in the instituting a real-time monitoring and decision system enabling the effective management of network, to ensure that public enjoy a sustainable supply of water in the future generations. The work discusses the five key aspects of distribution system such as asset and leakage management, water quality monitoring, automated meter reading and water conservation and the related challenges, technical gaps and the roadmap to future ('Managing the water distribution network with a Smart Water Grid', 2016). The transmission lines are to be monitored for uninterrupted water supply with the utilization of available technology.

The monitoring and forecast of the water consumption, plays an important role in addition to the billing system and related tariff structure. The study describes the use of a flow meter based on Hall effect sensor. The data collected on daily basis uses it to depict the consumption pattern to both the distributors and the consumers. Forecasting the use of water consumption for future with the application of data analytics, it also comments on the related demand, leakage, asset and water management system (Gosavi, Gawde and Gosavi, 2017). The hall effect sensor technology is used in water distribution and transmission pipeline for structured data handling of water that would help generating appropriate bills.

The flow pattern that varies for residential and non-residential context are reviewed in this paper. The bivariate quality of meters that depends mostly on the number of meters installed and the data temporal resolution demands no generic design approach. To study this phenomenon, a medium to high resolution smart metering system that are comprehensive in nature are used. The medium resolution smart water meters are used for exposing regular, continuous, peak use and diurnal patterns that reflect usage characteristics in a wide range. High resolution meter data are permitted flow pattern at a personal end-use level. Through this method the hydraulic based design co-efficient are determining the poisson rectangular pulse that help in the pattern discovery with implications of automated activity recognition applications. The classification and sitting index was introduced that would classify meter

resolution in terms of their suitable application (Clifford *et al.*, 2018). Smart water meter resolution decides the accurateness of data generation.

Incorporated, measure based mathematical models in hydrology are quickly developing, prodded by novel speculations in numerical material science, propels in computational techniques, bits of knowledge from lab and field tests, and the need to more readily comprehend and anticipate the expected effects of populace, land use, and environmental change on our water assets. At the catchment scale, these reenactment models are ordinarily founded on preservation standards for surface and subsurface water stream and solute transport (e.g., the Richards, shallow water, and shift in weather conditions scattering conditions), and they require vigorous mathematical methods for their goal. Conventional (and still open) challenges in creating solid and proficient models are related with heterogeneity and fluctuation in boundaries and state factors; nonlinearities and scale impacts in cycle elements; and complex or ineffectively realized limit conditions and starting framework states. As catchment displaying enters an exceptionally interdisciplinary period, new difficulties emerge from the need to keep up physical and mathematical consistency in the depiction of numerous cycles that cooperate over a scope of scales and across various compartments of a general framework (Paniconi and Putti, 2015). This paper first gives a verifiable diagram (recent long periods) of a portion of the vital advancements in truly based hydrological demonstrating, stressing how the exchange between hypothesis, tests, and displaying has added to propelling the cutting edge. The second piece of the paper inspects some remarkable issues in incorporated catchment demonstrating from the point of view of ongoing improvements in numerical and computational science.

This work progresses a bound together way to deal with measure based hydrologic demonstrating to empower controlled and precise assessment of numerous model portrayals (speculations) of hydrologic cycles and scaling conduct. Our methodology, which we term the Structure for Unifying Multiple Modeling Alternatives (SUMMA), plans an overall arrangement of preservation conditions, furnishing the adaptability to try different things with various spatial portrayals, diverse transition definitions, distinctive model boundary esteems, and distinctive time venturing plans. In this paper, we present the overall methodology utilized in SUMMA, enumerating the spatial association and model disentanglements, and how various portrayals of different actual cycles can be consolidated inside a solitary displaying structure. We talk about how SUMMA can be utilized to efficiently seek after the strategy for various working speculations in hydrology. Specifically, we examine how SUMMA can help tackle major hydrologic demonstrating difficulties, including characterizing the proper unpredictability of a model, choosing among contending motion definitions, speaking to spatial fluctuation across an order of scales, recognizing possible upgrades in computational productivity and mathematical precision as a feature of the mathematical solver, and improving comprehension of the different wellsprings of model vulnerability (Clark *et al.*, 2015). Central issues: Modeling layout planned utilizing an overall arrangement of preservation conditions Evaluation centers around motion definitions and spatial fluctuation/network Systematic methodology improves model devotion and vulnerability portrayal.

Under the background of water transmission and distribution reform, the profit model of water supplying companies has changed, and the investment in distribution network is facing new constraints. Scientific and reasonable investment scale of distribution network is the key factor

to ensure the operating income and sustainable development of power grid companies. Based on this, this paper comprehensively considers the water distribution network investment capacity and demand of water supplying companies, applies the theory of system dynamics, constructs the decision-making model of water distribution network investment scale considering the constraint of water transmission and distribution price, and puts forward the optimization strategy of water distribution network investment scale under the constraint of water transmission and distribution price. On this basis, a new model is applied to simulate and optimize the investment scale of distribution network in the next water transmission and distribution price supervision period of a provincial water supplying network. The results show that the permitted investment scale of distribution network under the supervision of water transmission and distribution price can meet the investment demand of distribution network to ensure the safe operation of the system, while the investment of public welfare projects should be reasonably planned according to the actual operation of the network (Yuqing Wang *et al.*, 2020). The distribution policy and strategies are critical in water billing system.

Technical Parameters Influencing Water Distribution Management

For ensuring the quality of water distribution services to the customers, it is primary objective to detect, localize and control the leakage instances even before their occur. A comprehensive leakage monitoring covering the aspects such as leakage assessment, detection and control (Gupta and Kulat, 2018).

Another work stress the importance of water leakage management system by throwing light on the scarcity problem of water in the present days. Thus, urges that the water leakage becomes the part of every day activity of each human being. The author of the work proposes that the pressure management is one of the most effective method of controlling leakages in water distribution system. In this work, a leakage function of pressure and pipe length is modeled. Leakage coefficients are calibrated by utilizing the pressure reducing valves to induce pressure fluctuation and developing instances of waterCAD to minimize the leakage effectively by manipulating the Pressure reducing valve settings (Samir *et al.*, 2017). Pressure is a important factor that assists the water flow. For effective flow distribution, the pressure is to be maintained at the optimum.

The article by Rahmat, distinguishes the problem of water leakage in underground pipes as serious problem of permanent loss in comparison with that of pipes on over ground that are visible. The local leak detection is carried out by the fluid mechanics in combination with the kinematic physics based on the flow rate data of water that is obtained using flow sensors of liquid meters and coupled with Arduino UNO microcontroller. Results of the study reveal that the method proposed work in stable condition to locate the leak in a maximum distant limit of 2 meters and determine the possible leak location with flow rates corresponding to 10 liters per minute (Rahmat *et al.*, 2016). The leak detection during the fluid flow in both cases of over and underground pipelines is discussed using the microprocessor setup which could be helpful in devising the leakage monitoring system.

A work on the pipe network monitoring reports that there are numerous difficulties related to the growing context in the field of water supplying system at metropolitan regions which has latest technologies involved infrastructure, requiring improved choice expressively help the water networks and its smartness in accessing the information on flow through the network as

well. An increase of conventional techniques with current ideas is required, for example, calculations on actual water consumption to justify the billing, automated meters and responsive programming for improving the precise control over the flow networking management system. This paper extends an IoT-based model with Deep Learning and robotized test situations, while indicating the viable application and examination of learning procedures on test information in this area. The exploratory model is depicted from the equipment level to the IoT stage in a cutting edge approach utilizing the present status of programming advancement and structures for ongoing information the executives. (Samir *et al.*, 2017). The concept of IoT and robotics are used for the pipeline inspection and managing the flow which would enhance the decision making and automize the process.

An arranging supportive network improves our capacity to utilize water limit extension as a metropolitan development the board methodology. This paper reports the improvement of limit extension demonstrating of water supply as a component of the proceeding with advancement of such an arranging emotionally supportive network (PEGASUS: Planning Environment for Generation and Analysis of Spatial Urban Systems) to join water supply. This framework is planned from the arrangement that land use and improvement drive the interest for foundation and framework can impact the manners by which land is created and utilized. limit extension issues of water supply can be addressed two: 1) ideal control hypothesis, and 2) blended number nonlinear programming (MINLP). Every strategy has its qualities and shortcomings. in this examination the MINLP approach is utilized because of its solidarity of deciding extension measuring and timing all the while. A dynamic organization streamlining model and a water-dispersion network examination model can address the dynamic freedom between water arranging and land use arranging. While the water-appropriation network investigation model assesses the exhibition of generated network options over the long run, the dynamic organization advancement model picks choices to meet extending water needs. Moreover, the client and limit development displaying to-produce options (MGA) can create alternatives. A money saving advantage investigation module utilizing a standardization procedure helps in picking the most efficient among those other options. GIS gives an instrument to assessing the volume of requested water and indicating aftereffects of the limit development models. A Planning support System of Capacity Expansion of Water Supply (PSS/CEWS) gives a structure that encourages organizers, specialists, residents, and leaders in directing intelligible thoughts about water-dispersion network extension. Through the four phases of supply, request, elective age, and assessment, PSS/CEWS coordinates essential arranging, primer plan, and designing plan (Chatterjee, 2017). Organizers and designers can demonstrate their thoughts in form of PCs and speak with each other with on language without utilizing language.

Clean water supply demand in Malang City, East Java, Indonesia urges the public authority of water to improve the automation in water flow network that will obviously benefit the supplier and the consumer as well for the flow metering is mainly focused. It includes limiting the measure of water misfortune dispersed to consumers because of line leakage. Water stream checking and leakage water flow network dependent on the remote sensor organization could be utilized to introduce data on the water stream in a line and to stop a valve if there is a hole. The information at that point could be transported off the worker to be shown on a site. The created water flow network had the option to peruse the water discharge with a normal error estimation of 2.23% of the deliberate all out volume and decide the leakage pipeline with a

leakage estimating breaking point of 30mL/sec. The water pipeline network likewise had a most extreme transmission distance between hubs of 170 meters and it had the option to introduce monitored local information into a site. With a little error esteem and the enormous transmission range, it was normal that the pipeline flaw could be identified sooner and prudent steps could likewise be taken. (Samir *et al.*, 2017). The transportation of water through a long distance is of utmost importance to ensure equal distribution to every consumer. Thus, the data collected at periodic intervals are to be synthesized as required to initiate necessary action.

The sectors such as demand management, customer service, labor optimization and the respective operational efficiency are raised by implementing smart meters. The article provides information on the survey carried out for a couple of years, in accordance with the interviews that were deployed to gauge the penetration depth of the smart water meters and the intelligent project network and the challenges faced by employing this technology. Among the various disadvantages, there has been a misunderstanding and development awareness of the technology as applied to the business case, resulting in the essentiality to be aware of the business drivers and the related goals that are highly contextual to the location such as opportunities for cost avoidance. Moreover, the social drivers of the technology being the customer acceptance and the satisfaction and improved trust and customer's engagement. The evidence collected reveals an increased awareness of digital meters and application of data analytics in the technical working of the concept. It is concluded by the author that many authors commented that the need of the hour be to standardize the definitions related smart water technology that includes devices such as pressure sensors, meter data and water meters that provide information to further guide its strategy and related investments (Beal and Flynn, 2015). The importance of technical parameters of flow are been discussed such that successful flow is enabled through smart water technology.

The policy of water demand management is the discussion topic across the table as a strategy to reduce consumption of water. In the project site of the study, a mixed approach is been deployed including questionnaire for water utility officials, semi-structured interviews and secondary data and information to be reviewed in the identification of successful policies. However, the impact of the water demand management systems are in the field of renovation and maintenance, water saving campaign network that are backed up by the installation of smart meters. It is observed that the consumption are reduced due to awareness created but on the other hand lowering the urban water use by too much may lead to technological and financial challenges faced by the water utilities (Stavenhagen, Buurman and Tortajada, 2018). The opinion of water consumption and its relative causes are been obtained through various data collection methods, and impact of the lack of water resources on the consumption pattern. Thus, the renovation and maintenance of the water transporting infrastructure using smart water meters.

Environmental change and their resultants in the form of shortage of water are turning out to be significant difficulties for nations around the globe. With the approach of Wireless Sensor Networks (WSN) in the most recent decade and a moderately new idea of Internet of Things (IoT), implanted water piping networks engineers are currently chipping away at planning control and mechanization water piping networks that are lower in expense and more economical than the current telemetry water piping networks for its functionalities. An Asian water piping networks and it is incredibly testing to plan a minimal effort installed water piping

networks for observing and control of flow that can keep going for quite a long time. In this paper, it is presented an equipment plan and execution assessment of a keen water metering arrangement. The outcomes show that their equipment configuration is as amazing as the reference configuration, however takes into account extra adaptability both in equipment and in piping networks. The indigenously planned arrangement has a force added proficiency (PAE) of 24.7% that is relied upon to keep going for 351 and 814 days for hubs with and without a force enhancer (PA). Likewise, the outcomes show that a broadband correspondence (434 MHz) over more than 3km can be upheld, which is a significant venturing stone for planning a total inclusion arrangement of huge scope streams (Ahmad, Zahoor, *et al.*, 2017). The concept of water metering and its relative arrangement is simplified to test the impact of the metering on the flow, to emphasize metering phenomenon as an essential part of water flow management.

Water leaks are considered as unusual utilizations of water. It is a test to identify them momentarily however ongoing remote smart water meters offer new open doors for far off observing and controlling of utilizations and breaks. This paper presents a total management that comprises in collection and investigating of water supply and consumption information. This silent apparatus depends on data separated from estimations taken on a private and brought together piece of an assumption by the organization. The author of this paper proposes a conventional methodology which depends on a proper portrayal of water supply and consumption data. It is made of a few models and highlights that are illustrative of very huge datasets. We utilize day by day water load fluctuations and characterize a Minimum Night Flow (MNF) and a Period Without Null Consumption (PWNC). It is accordingly simple for a methodology, i.e., a calculation running in a circle, to manage this interpretation continuously with respect to un accounted water consumption through the water pipeline network. The author expresses a way to deal with distinguish water leaks has been actualized and approved with genuine utilization information from a keen meter introduced in a tertiary structure. The greatest day by day utilization fluctuation in the consumption side is utilized as a commonplace load fluctuation and permits to distinguish huge flaws in the water pipeline networks. Separating the MNF promotion the PWNC from the prompt flow rate of water permits to recognize more modest flaws. The segregation among enormous and little holes depends on whether the common water load bend is surpassed (Boudhaouia, *et al.*, 2018). The concepts of Minimum Night Flow (MNF) and Period Without Null Consumption (PWNC) are incorporated in the process identifying the fluctuation in consumption and in distinguishing huge flaws.

Smart Meters – Bigdata Analysis and Mismatch Analysis

The rising population level in the region of the US has mandated the deployment of smart meters in the water sector. The concept of sustainability faces several challenges such as increasing water main breaks, decreasing fresh water sources, non-revenue water that are untraceable and ever rising water demands. Big data enables the collection of massive amounts of relevant data from sensors installed to monitor system performance, usage and structural condition. Thus, the use of Internet of Things (IoT) throughout the water supply infrastructure and consumer's usage. The wireless sensor network technologies are connected to IoT to collect both the downstream and upstream data from a myriad of water clients. Down stream data pertains to the water usage and performance data to clients whereas the upstream data corresponds to the SCADA and automated meter readings. Most data will be converged to build a Big data system in which data mining corresponds to local and system performances including

pressure and flow, non-revenue and illegitimate water consumption, locating and quantifying water breaks and losses. It is concluded that the objective of this technology should enable both the utilities and consumers to proactively manage their water usage and achieve higher sustainability levels in water supply (Koo, Piratla and Matthews, 2015). The scope of IoT in operation and management of transmission network is vital.

The rising demand for water supply is a major challenge for many countries across the globe. To enhance the response to these challenges an IPv6 network coupled with IoT design is proposed for real-time water flow metering and quality flow monitoring with the ease of fair billing. The supply versus consumption data is required to create an awareness to curb water wastage and encourage its conservation with the option to intimate the user automatically in case of any leakages. The study also attempts to measure the water quality by using the pH and ORP sensors that are included in the system. The experiment attempts to use CC2538 motes programmed using ContikiOS to monitor the water consumption and enable the wireless communication of data (Anjana *et al.*, 2016). Wireless communication in data transmission future technology in water management system.

The total populace development and climatic changes increase the top demand for water and challenges the scientists for a new methodology to handle this issue as well. This reality powers mankind to make new water the board techniques. Keen urban areas have effectively applied the Internet of Things (IoT) innovation in numerous areas. In addition, Complex Event Processing (CEP) can investigate and deal with big data collections delivered by IoT sensors continuously. Customary business measures are too inflexible in communicating the dynamic conduct of water piping networks. Each execution way should be expressly determined so that the water distribution is perfect and the metering of consumption as well. Then again, explanatory business measures permit execution ways that are not disallowed by the guidelines, giving greater adaptability to water flexibly supervisors. This paper consolidates IoT, CEP, and revelatory cycles to make an incredible, proficient, and adaptable engineering (REFlex Water) to oversee water piping networks system. To the data on the suppliers and consumers has to be perfectly managed to arrive to an exact metering and billing of the actual consumption of water as well. REFlex is a system basically designed with the aid of IoT application where the actual water consumption is the main focus for advanced water metering and billing with regards to water piping network flow. This paper also describes the contribution of REFlex system in managing the flow of water pipeline network engineering and shows its application to a genuine water pipeline network management from a Brazilian district. The author says that the results are promising, and the supervisors from the Brazilian water organization are extending the utilization of REFlex Water to different areas of their water pipeline networking system management (Talari *et al.*, 2017). Big data analysis resolves the complications existing in urban water transmission networks.

The previous 25 years has seen improvement of cutting edge demonstrating approaches, for example, stochastic and specialist based displaying, to reasonably oversee water frameworks within the sight of profound vulnerability and intricacy. In any case, generally very frequently information contributions for these amazing models are inadequate and obsolete, yielding inconsistent outcomes. Headways in sensor and correspondence advancements have took into consideration the omnipresent arrangement of sensors in water assets frameworks and past, giving high-recurrence information. Handling the huge measure of heterogeneous information

gathered is non-unimportant and surpasses the limit of customary information warehousing and preparing approaches. In the previous decade, huge advances have been made in the capacity, conveyance, questioning, and examination of huge information. Numerous apparatuses have been created by PC and information researchers to encourage the control of huge datasets and make pipelines to communicate the information from information stockrooms to computational scientific devices. A nonexclusive structure is introduced to finish the information cycle for a water framework. The information cycle presents a methodology for coordinating high-recurrence information into existing water-related models and investigations, while featuring a portion of the more accommodating information the executive devices. The information apparatuses are useful to settle on manageable choices, which fulfill the goals of a general public. Information investigation conveyance instrument Spark is presented through the illustrative use of coupling high-recurrence request metering information with a water appropriation model (Shafiee, Barker and Rasekh, 2018). By refreshing the model in close to ongoing, the examination is more exact and can uncover genuine misinterpretations.

The advancements of technology have advanced the metering and digital technologies, smart cities therefore have employed various electronic devices on the basis of internet of things, transforming to be smarter cities than before. The work focuses on the comprehensive view of smarter city concepts, its motivations and its applications. Also, it stresses the IoT technologies for smart cities and main components that features a smart city. Practical experiences and the main challenges are discussed in the document (Arasteh *et al.*, 2016). Smart cities governed by IoT, advanced instrumentation and communication.

The invention of smart water meters have paved way for the concept of Internet of Things (IoT) with the equipping the customer location with various electronic devices required to execute the intended purpose and hence enabling the smartness and its applications more accessible. The introduction of the most possible IoT technologies and their capabilities to merge and apply to various smart cities are outlined. The potential applications of smart cities in respect to the technology development in future. Also the practical experiences across the world and the key barriers for its implementation are expressed thoroughly (Talari *et al.*, 2017). The work is the review of smart cities and their different applications, benefits and their advantages.

One among many factors that hinder effective water management are the standardization in monitory and control equipment. The processes of water management are the water distribution, consumption, identification and maintenance. A platform termed as Object linking and embedding for process control unified architecture is an architecture that is independent and service oriented that are commonly used for the logistic and manufacturing sectors. Based on this architecture, a smart water management module is proposed in combination with the Internet of Things with business process co-ordination and decision support systems (Robles *et al.*, 2015). A subsystem interaction architecture is proposed and a detailed description of the physical situation in which the implementation, allowing specific vendor equipment to be managed and inter-operated in the water management context.

Integrating smart systems and related IoT devices such as sensors, actuators in the city play a key role to develop urban services that transform their city digitally smarter. However, these processes generate a large volume of data termed as Big data. Thus, it is challenging in the real-

time applications. The study outlines the effectiveness of utilizing the concept of big data analytics while harvesting the real-time data. Different sensors are deployed for real time data system of the smart city. The proposed architecture and implementation prototype utilizing the Hadoop eco-system in realistic environment with the facility to notify the citizens regarding the real-time traffic information and the respective alerts. There are a number of stages in the system including data generation, collection, aggregation, classification, filtration, preprocessing, computing and finally the decision making. The efficiency of the system is extended by applying the Big data processing tool using Hadoop. Practically implementation of existing smart systems and IoT devices as city data sources are used to develop the smart digital city (Rathore *et al.*, 2018). The system proposed is evaluated in to the efficiency in accordance to the scalability and processing of real-time data.

In Egypt, the flow water flow observing system includes careful physio-compound and natural examinations. Nonetheless, there is as yet an absence of ongoing water flow information that impacts the pressing dynamic cycle. The field securing of such information has still been exorbitant, long and arduous. Accordingly, the author of this paper intends to introduce an ease and work sparing Early Warning water piping network (EWF) for water flow checking of the River bed area of Nile dependent on the Internet of Things (IOT). A recently evolved Prototype was acquainted with screen the in-situ water flow boundaries; velocity, discharge and temperature at a pilot area along the River bed of Nile inside Egypt. Similar boundaries were additionally checked utilizing the present status of-the-craftsmanship multi-test EXO. Then, the two set of information estimations were launched off an ongoing monitoring control community for examination and alignment. The examination results uncovered that there is no critical distinction between the two estimations as per a factual investigation done utilizing the Minitab 16 measurable model. The Root Mean Squared Error (RMSE) values indicated that the blunder rates were acknowledged for the three checked boundaries (Rathore *et al.*, 2018). As needs be, it very well may be inferred that the created Prototype can give a minimal effort early detection of pipe networking information on water flow monitoring. At long last, it is emphatically prescribed to introduce grown continuous water flow monitoring locations as monetary remote hotspots (IoT based) at various vital locales along the River bed side of Nile inside Egypt.

Enormous information assumes a significant part in savvy city. Enormous information investigation is one of the ongoing advances that could upgrade savvy city administrations. It gives significant experiences from enormous volume of information gathered through different sources. The mix of large information and Internet of Things (IoT) upholds metropolitan leaders and offers better types of assistance to the residents. This paper is centered around assessing the effect of large information on the brilliant city. It talks about large information difficulties and advantages, its relationship with web of things, chosen keen city stages and system. Notwithstanding it present huge information applications in shrewd urban communities in Arab Nation (Hafez, H. A. A. 2017). The outcomes outlined that large information examination can give a ton of advantages to keen urban areas and improve the personal satisfaction, regardless of its difficulties that should be tended to.

As the population of the world keeps increasing, restricted resources risk look for approaches to ease our burden on the planet. Modifying customer conduct shows up as an establishment for keen matrices. Project shows the worth accessible from profound investigation of power

fulfillment chronicles, buyers' messages, and blackout alarms, and so on Endeavor mines gigantic organized and unstructured information. More or less, brilliant frameworks bring about a surge of information that should be dissected, for better acclimate to request and give clients greater capacity to dig into their capacity utilization. Basically, keen matrices will progressively have an adaptable information distribution center connected to them. The critical driver for the selection of information the board techniques is unmistakably the need to deal with and break down the a lot of data utilities are currently confronted with. New ways to deal with information reconciliation are disgusting second; Hadoop is truth be told now being utilized by the utility to help deal with the colossal development in information while keeping up intelligibility of the Data Warehouse (Mehenni, *et al.* 2017). In this paper we characterize another Meter Data Management System Architecture archive that contrast with three pioneers MDMS, where we use Map-Reduce programming model for ETL and Parallel DBMS in Query explanations.

Smart city initiatives are often driven by the important role of big data and the evolution of Internet of things. Valuable insights are gained through big data from different sources and integration of this information is made possible through the integrating sensors, identification using radio frequency waves and Bluetooth in the real-world environment using extremely networked services. It is an unexplored area of research the combination of big data and the IoT which would help in discovering new goals and challenges for achieving the goal of future smart cities. The initial challenges are related to the primarily problems related to business and technology enabling cities to actually visualize the vision, principles and demands of the applications of smart cities in the main smart environment characteristics. The big data to analytics in support of the smart cities are discussed in the document, in order to fundamentally change urban population at various levels. A business model of bigdata for smart cities proposed that the business and technological challenges of research are identified (Hashem *et al.*, 2016). The study could always serve as the benchmark for researchers and industries for the progress and development of smart cities in the big data context.

The concepts of smart homes and smart cities could become a reality by internet of things (IoT). The smart homes are the building blocks for smart cities for decades. The smart homes have been largely supported by the invasion of computer in the homes recently. The paper discusses the major requirements through the recent survey in transforming a home into smart homes. The recommendations are made by the specific quality of SH building blocks (Hui, Sherratt and Sánchez, 2017). Water distribution for smart homes through computerized devices builds smart cities.

The emerging paradigm of IoT is focused in connecting devices, objects with each other to the internet to be controlled and activated by the users. IoT is expected to become the basic utility of homes such that the quality of life is improved. There are quite a handful of challenges that the confidentiality, authenticity is taken into account. The data sensing integrity is collected and exchanged by the IoT objects making homes vulnerable to security attacks, thus evaluating the homes to be insecure. The authors tries to deploy the concept of operationally critical threat, asset and vulnerability evaluation methodology, also termed as OCTAVE allegro to access the risks of smart homes. The method focuses on the assets in considering different containers of information such as the digital databases, papers and mental sources through humans. By this the work tries to highlight different security threats that the IoT based smart homes possess

under cover to the home inhabitants and the different approaches are proposed in resolving the risks identified. Research findings are based as the foundation for improving the security requirements of homes based on IoT (Ali and Awad, 2018). This paper also brings to light the ill effects that the smart metering could bring about to the home inhabitants. Therefore, a balance is to be struck to maintain life-technology balance.

RESEARCH METHODOLOGY

Research Design

Descriptive research is utilized to depict the nature of the work that is done to determine an issue. It would be valuable in factual investigation of the work being finished. The result of this would be thinking out the need for the perceptions and the implication of the finding too. Here in this work, an enlightening poll is set up to comprehend the confound in actual and estimated water utilization from the customer and provider also. The mismatch intensity, the economical effect on both purchaser and provider side, the explanations behind the mismatch, impact on smart metering framework, will be the segments of the survey. With the well prepared poll a decent arrangement is procured with the point by point overview report. The overview investigation report will give the factors to be considered in planning a mathematical model and a computerized leakage monitoring gadget too.

Exploratory Design of Research

This cycle is carried out for an examination issue with less investigations directed on it and thus the researcher has no previous information or references. Numerous multiple times these sorts of research work are casual and unstructured also. It fills in as an instrument at the beginning phase of the research which upgrades a theoretical thought for the research issue. In this work since less research were made on metering the actual utilization of water with smart meters, a theoretical thought is expected to unequivocally uphold the research process. A mathematical model and a computerized water leakage monitoring gadget would incredibly help the researcher in deciding the mismatch in water utilization, thus to annihilate the assessment technique followed any place the information is not updated or not read.

RESEARCH METHODS

In this research study the essential information source is focus group, to apply cooperation system in recognizable proof of basic issues in the Oman market. The technique helps the members in imparting their insights and experience about water distribution and related services in Oman, helping the member participants to give opinions and related experience towards improving the guidelines managing water distribution services dependent on member considerations.

This kind of logical examination is named as quantitative research. It causes the research ideology to be communicated as far as numbers (Kothari 2015). Along these lines, the aftereffects of this sort of research are numeric information (Choy 2015). The instruments utilized in this research type are poll or any gear that upholds information assortment measure on mathematical basis (Gunaydin and McCusker 2015). In 2018, Berger added a survey study, content investigation and experiments as apparatuses of quantitative research. Be that as it may, this exploration type is effective in numerical, however it does exclude the logical detail. It utilizes close-finished inquiries in contrast with the open-finished inquiries utilized in subjective research type. The inquiries are quantifiable and the yield will be in numbers and

measurable structure (Creswell and Creswell 2017). In 2018, Berger definite that quantitative as a phrasing starting from latin word quantities, which depicts how extraordinary, the number of, how much. Questions that start with 'how' are relied upon to yield answers as numbers. The information assembled in this research type are portrayed as organized information. It is expected that in this kind of exploration, the data assortment includes a huge sample size of population and the information is displayed as tables, diagrams and figures. For productive examination, a product code is utilized in the investigation of information and communicating to their connections between the information that are communicated as a particular form. (Riff et al. 2019). In this research work quantitative exploration technique is applied by poll dispersion in estimating and organizing the issues of the work market and the fulfillment level among members as result of center gathering strategy.

Research Instruments

Research instrument device refer to the instruments used to gather information, for example, poll paper, Online survey, mobile interviewing framework, Personal Interviewing framework, Case studies, Checklists and Observations. For Online poll, Google forms survey would be utilized. Survey through google forms is endorsed for the normal inspecting size would be greater. The information gathered will be put away in an information base in a excel format. MS Excel is utilized to store, handle, measure the information as it is easy to understand and reliable to the researcher. Examination will be directed with the gathered information utilizing a Big data analysis program called Pentaho for it is ease of use and commonality to the scientist. The examined information is interpreted to measure and gauge the mismatch utilizing formulae in the excel sheet. An sample size of 1000 for each zone will be taken. 4 zones of muscat districts will be chosen for the investigation. Random sampling procedure will be utilized for the limited population and a cluster sampling received for large range of population. Random sampling is accomplished for a sample size, determined utilizing the accompanying formulae.

$$\text{Necessary Sample Size} = \frac{(\text{Z-score})^2 \times \text{StdDev} \times (1-\text{StdDev})}{(\text{margin of error})^2}$$

Collection Techniques

A bunch of poll is prepared in view of valid response and to direct review arrangement among the customers and suppliers utilizing individual in-home study and online overview techniques with chose factors on smart water meter readings. Four zones in Muscat district are chosen for the overview and the sample sizes are determined for the chose zones dependent on random and cluster examining procedures. Questionnaire is set up to obtain the information on smart water meters, water utilization, estimated reading, costing data, the mismatch, etc. These information are gathered face to face and utilizing on the web review also. These all are done at consumer end. The gathered information are put away safe in an information base in an Excel record design. Formulae are utilized in the Excel document to appraise the confuse in the water meter utilization. This jumble is then approved with a mathematical model created to show up the hypothetical utilization of water to estimate and gauge the mismatch. In light of the hypothetical displaying results a hypothetical leakage detection system is created utilizing the information base saved in the Excel design. From consumer side, water utilization information

is gathered utilizing SCADA framework, utilized in all the Diam control rooms to control and screen the progression of water through transmission organizations.

Information Analysis Techniques and Models

The information on utilization of water collected through survey and the information collected on inventory of water from SCADA will be examined in Pentaho, a Big Data Analysis programming. The information will be deciphered utilizing Eulerian formulae in an Excel record where the information are put away. In light of the aftereffects of the large information investigation a hypothetical leakage monitoring framework will be planned utilizing Bernoulli's conditional equation in the Excel design where the information are stored. Finally, the mismatch in the water meter reading will effectively be evaluated, examined and eradicated utilizing hypothetically planned computerized leakage detection system. The consequences of the research will be interpreted to decide the actual and estimated information from consumer and supplier viewpoint and to evolve a system in evaluating the mismatch.

Data Source – Primary

Information considered as essential are spinning around the water utilization information extracted from survey review, investigation and SCADA. Overview is led as questionnaire survey focusing on the exactness utilizing Personal interaction in the event of individual collaboration and Google Forms should be an occurrence of Online connection. Microsoft Excel organization to keep an information based management of utilization of water from Automated Meter Reading (AMR) information. SCADA the Supervisory Control And Data Acquisition framework to enroll and control the water supply structure of Diam. This would be a vital information in assessing and approving the mismatch in the water utilization. Information separated from the customer and supply closures will be large enough to investigate, so Pentaho a Big Data Analysis Tool is utilized in examining various information got for research.

Secondary Information Sources

Secondary information sources are the information based on administration. In this task, the mismatch is assessed through information examination as a whole and assessed actually with the assistance of a mathematical model and a hypothetical Automated Leakage Monitoring framework. Notwithstanding that critical stream information from leakage observing group, Diam will also be received for the approval reason whenever required.

Population, Sampling Technique and Sample Size

Random sampling is a sampling strategy where each example has an equivalent likelihood of being picked. An example picked randomly is intended to be an impartial portrayal of the complete population. On the off chance that for certain reasons, the example doesn't speak to the population, the variety is known as a sampling error.

Population Size

Below is the calculation based on the standards that are expecting to pick a 95% certainty level, .5 standard deviation, and a room for give and take (certainty timespan/ - 5%.

$$((1.96)^2 \times .5(.5)) / (.05)^2$$

$$(3.8416 \times .25) / .0025$$

$$.9604 / .0025$$

$$384.16$$

385 respondents are required

For the calculated sample size, online google forms was used as the research equipment to collect the consumer satisfaction information. Thus, for this sample size, the data were collected as primary and secondary data. The primary data corresponds to the responses of the survey, data from SCADA and the smart meter reading. Whereas the secondary sources of data pertain to the location of the mismatch obtained through the results of analyzing the primary sources of data. Data analysis was initially planned to be carried out through a big data analysis tool expecting a large quantum of data. Due to the present covid-19 restrictions, the primary data sources such as smart meter and SCADA couldn't be registered. Hence with an assumed 30 readings, the analysis was performed using excel calculations.

The typical results of a subjective substance investigation coordinated as referenced above is a lot of thoughts, (for instance, "Motivation," "Character characteristics," "Self-question," "Work related weight," and "Burnout issue"). These don't stay singular, regardless. They summarize in mental terms the way wherein the individuals in the gatherings conceptualized the substance being talked about across the table.

DATA ANALYSIS

Water Distribution Systems

The infrastructure of distribution network is by and large the significant resource of a water utility. It is additionally characterized the water circulation framework is that "counting all water utility segments for the dissemination of completed or consumable water by methods for gravity storage or pumps however distributing department to registered clients or other consumers, including appropriation equalizing capacity." These frameworks should likewise have the option to distribute water to non-consumable utilizations, for example, fire mitigation and water system to support agricultural and landscaping sectors.

The infrastructure of distribution is considered generally considering to be inclusive of pipes, valves, storage tanks, reservoirs, pumps, meters, fixtures, and other hydraulic appurtenances that connect treatment plants or supply from the well to taps of the consumers. The qualities, general support prerequisites, and alluring highlights of the essential network parts in a water distribution network are to be taken into account.

Pipes

The frameworks of lines that transport water from the source, (for example, a treatment plant) to the client are frequently classified from biggest to littlest as transmission or trunk mains, conveyance mains, administration lines, and reason plumbing. Transmission or trunk mains for the most part pass on a lot of water over significant distances, for example, from a treatment office to a capacity tank inside the dissemination framework. Appropriation mains are ordinarily more modest in distance across than the transmission mains and by and large follow the city roads. Administration lines convey water from the circulation principle to the structure or property being served. Administration lines can be of any size contingent upon how much water is needed to serve a specific client and are estimated so the utility's plan pressure is kept up at the client's property for the ideal streams. Reason plumbing alludes to the funneling inside a structure or home that circulates water to the point of utilization. In reason plumbing the line widths are normally similarly little, prompting a more prominent surface-to-volume proportion than in other dissemination framework pipes.

The three prerequisites for a line incorporate its capacity to convey the amount of water needed, to oppose all outer and inner powers following up on it, and to be solid and have a long life. The materials regularly used to achieve these objectives today are flexible iron, pre-focused on cement, polyvinyl chloride (PVC), strengthened plastic, and steel. Previously, unlined cast iron and asbestos concrete lines were much of the time introduced in dispersion frameworks, and hence are significant segments of existing frameworks (see Figure 1-2). Transmission mains are often 24 inches (61 cm) in measurement or more noteworthy, double reason mains (which are utilized for both transmission and conveyance) are ordinarily 16–20 inches (40.6–50.8 cm) in width, and dissemination mains are generally 4–12 inches (10.0–30.5 cm) in distance across. Administration lines and reason plumbing might be of practically any material and are generally 1 inch (2.54 cm) in distance across or more modest (Panguluri et al., 2015).

It should be noticed that this report considers administration lines and reason plumbing to be important for the circulation framework, and it considers the impacts of administration lines and reason plumbing on drinking water quality. In the event that reason plumbing is incorporated, the figure for complete dissemination framework length would increment from very nearly 1 million miles (Grigg, 2005b) to more prominent than 6 million miles (Edwards et al., 2016). Reason plumbing and administration lines have longer home occasions, more stagnation, lower stream conditions, and raised temperatures contrasted with the fundamental appropriation framework (Berger et al., 2015). Incorporation of reason plumbing and administration lines in the meaning of a public water supply circulation framework isn't normal as a result of their variable proprietorship, which at last influences who assumes liability for their upkeep. Most drinking water utilities and administrative bodies just assume liability for the water conveyed to the control stop, which by and large catches just a segment of the administration line. The part of the administration line not leveled out of the utility and the entirety of the reason plumbing are completely the structure proprietor's duty.

Pipe Network Configurations

The two essential setups for most water appropriation frameworks are the branch and network/circle (see Figure 5.1). A branch framework is like that of a tree limb, in which more modest lines branch off bigger lines all through the administration region, with the end goal that the water can take just a single pathway from the source to the consumer. This kind of framework is most much of the time utilized in country territories. A lattice/circled framework, which comprises of associated pipe circles all through the region to be served, is the most generally utilized setup in huge metropolitan zones. In this sort of framework there are a few pathways that the water can follow from the source to the purchaser. Circled frameworks give a serious level of unwavering quality should a line break happen in light of the fact that the break can be segregated with little effect on customers outside the quick region. Likewise, by keeping water moving circulation lessens a portion of the issues related with water stagnation, for example, unfavorable responses with the line dividers, and it builds putting out fire ability. Nonetheless, circulation can be impasses, particularly in rural regions like parkways, and have related water quality issues. Most frameworks are a mix of both circulated and divided pipelines.

Smart Water Meters

A Smart water meter is a norm or customary water meter, and on a very basic level plays out a similar capacity. Be that as it may, to make it 'Smart', the meter is connected to a gadget that

permits nonstop electronic perusing, stockpiling, show and move of water utilization information (Figure 1). The sum or assortment, and recurrence of logging furthermore, move of information got relies upon how the water meter has been designed (Cole and Stewart 2015). The average time period storage and capacity for private smart water meters is hourly. The water meter appeared in Figure 1 is a mechanical meter which is ordinarily utilized for private water metering. In the extremely late past, completely incorporated ultrasonic (electronic) shrewd water meters have opened up in Australia. These meters have inbuilt correspondence frameworks for example, the NB-IoT (Narrowband Internet of Things), and are viewed as the up-and-coming age of Smart water meters. Smart water meters are essentially apparatuses used to gauge water use, and in this way, all alone can't impact water utilization designs. Or maybe, it is the high recurrence (and goal) data from them that is utilized to make the fitting choices on utilization. Various investigations that have been attempted (for example Doolan 2015) have shown that data gave by Smart water meters can achieve social change in clients which may prompt decrease or effective water utilization. A few studies have endeavored to measure these advantages, and indicated that outcomes in utilization is feasible.

DATA COLLECTION

In order to carry out the research in an effective method and obtain satisfying results of the study, it is required to collect the relevant data for the research from the field and validate it for its fairness and originality. Therefore, an inclusive format of the data required is formulated using the MS excel, for ease of handling the information and interpreting it. In the context of the study to quantify the mismatch of estimated and actual meter readings, a locality with around thirty houses who receive services from Diam are taken into consideration for our study and thus the sample size of the research is 30. Also, there is a survey questionnaire circulated to these consumers, in which their insights on various aspects regarding Diam are collected in reference to the research objectives, that are discussed later in the chapter.

The technical data collection available from the sample populated is organized and relative calculations are done for the information available. The various parameters that are required for analyzing the mismatch for each consumer is listed below.

- Pipe Diameter
- Pipe Length
- Discharge measured
- Velocity
- Pump head
- Water Density
- Frictional loss
- Minor loss
- Pressure difference
- Discharge at transmission
- Distarge actual

Pipe Diameter (D)

By choosing an adequate pipe diameter for the planned flow rate, the framework will have greatest productivity. As the pipe diameter increases, the expense of the pipe also increases yet the pressure drop decreases, so that less effort is needed to pump the fluid. The net outcome is

that there is a base expense as showed in the net present worth. The adequate diameter relating to this expense is known as the economic pipe diameter. It is measured in meters (m). In this study, there are two types of pipes namely transmission pipe and the distribution pipes and thus its relative pipe diameters are taken into consideration.

Pipe Length (L)

Friction pushes against the stream, bringing about pressure drop as the pipe length increments. Pipe length likewise factors in fittings, which increment the "length" contributing to the condition. As discussed, with the increase in length, the discharge of water to the respective consumer locations decrease and thus there is a lack of supply to these consumer locations. Thus, a demand for appropriate water pumping arises, to cater to the needs of the distant location consumers. The length is measured in meters (m).

Discharge Measured

The measure of liquid passing a part of a stream in unit time is known as the discharge. In the event that v is the mean speed and A is the cross section of the pipe, the discharge Q is characterized by $Q = Av$ which is known as volume flow rate. Discharge is also expressed as mass flow rate M .

$$\text{Mass flow rate, } M = \rho Q.$$

Flow Velocity

At low speeds the entire flow across a pipe is laminar and the liquid slides over itself. As the velocity turns out to be turbulent, swirls begin to frame and cross the liquid layers. A progress from laminar to turbulent is developed. At still higher velocities the flow in the center of the line gets turbulent with whirling swirls all through. As flow velocity increases, pressure drops additionally increases and effectiveness is decreased. The overall general guideline is to keep a velocity under 5 ft/s (1.5 m/s).

Pump Head

The pump head of a water pump is a proportion of the intensity of a pump. The more prominent the pump head, the more noteworthy the pressure that the pump can create. This measurement is estimated in meters (or feet) and is determined by putting a pipe on a pump's discharge and estimating the greatest height to which it can pump water.

Water Density

The density of a material is characterized as its mass per unit volume. It's an estimation of how firmly matter is stuffed together. The density of a substance can be clarified as the connection between the mass of the substance and volume it takes up.

The density of a liquid influences its viscosity. Fluids with more mass per unit volume are viscous and require more energy to move them and shear less without any problem. A temperature rise decreases the thickness and density of fluids.

Frictional Loss

In fluid flow, friction loss (or skin friction) is the loss of pressure or "head" that happens in pipeline or pipe flow because of the impact of the fluid's thickness close to the outside of the

pipeline or channel. The contact loss in uniform, straight segments of line, known as "significant loss", is brought about by the impacts of thickness, the development of fluid particles against one another or against the (conceivably harsh) mass of the line. Losses due to friction is a critical monetary concern any place fluids are made to flow, regardless of whether totally encased in a pipeline or conduit, or with a surface open to the air.

Minor Loss

Minor losses in line flow are a significant part in ascertaining the flow, pressure, or energy decrease in funneling frameworks. Fluid traveling through lines conveys force and energy because of the powers following up on it, for example, pressure and gravity. Frictional and minor losses in lines are major contributing elements.

Pressure Difference

At the point when fluid flows through a pipe there will be a pressure drop that happens because of resistance offered to flow. There may likewise be a pressure pick up/loss due an adjustment in rise between the beginning and end of the pipe.

Discharge at Transmission

It is the mass flow rate measured at the beginning, before entering the distribution lines. This discharge is the rate at which the water is received from the storage for distribution.

Actual Discharge

It is the mass flow rate measured at the consumer location. The value might be constant or varies with respect to the length of the pipe. This value is compared with its immediate previous various to identify, if there is any mismatch present.

SURVEY ANALYSIS

Any existing real time project during its transition would mandate a survey of the respective consumers, in order to describe the existing problem and its intensity. A survey that is executed with appropriate questions to obtain the required information would be useful to the researcher to direct the project towards a fruitful solution. Here in this research, the survey is conducted with the intention of being beneficial to the society and the nation, socially and economically. The questions in the survey questionnaire, are based on the research objectives. Based on the research objectives, there are five questions framed, to obtain the insights from the sample population of the research. The survey questionnaire was circulated with the help of google forms to obtain corresponding responses. The number of respondents for the research counted is 385 calculated to fulfill the random sampling conditions. The questions were based on the satisfaction that scaled from 1 to be unsatisfactory and 5 to be the most satisfied with the opinion. The questions framed on each objective were to obtain the respondents opinion on the services and the billing obtained from Diam, the water management board in Oman.

Due to the enduring global pandemic COVID-19 and its new normal restrictions, the survey is executed through the circulation of a google form with the appropriate survey questions. However, though the researcher circulated the survey questionnaire among 400 consumers in the region of Al-Khuwair, only 25 responses was obtained. The results and discussions are made below.

RESPONDENTS

All the respondents are Omani nationals and for majority, income slab varies from 1000-2000 OMR.

Responses on Smart Water Meter Reading Mismatch

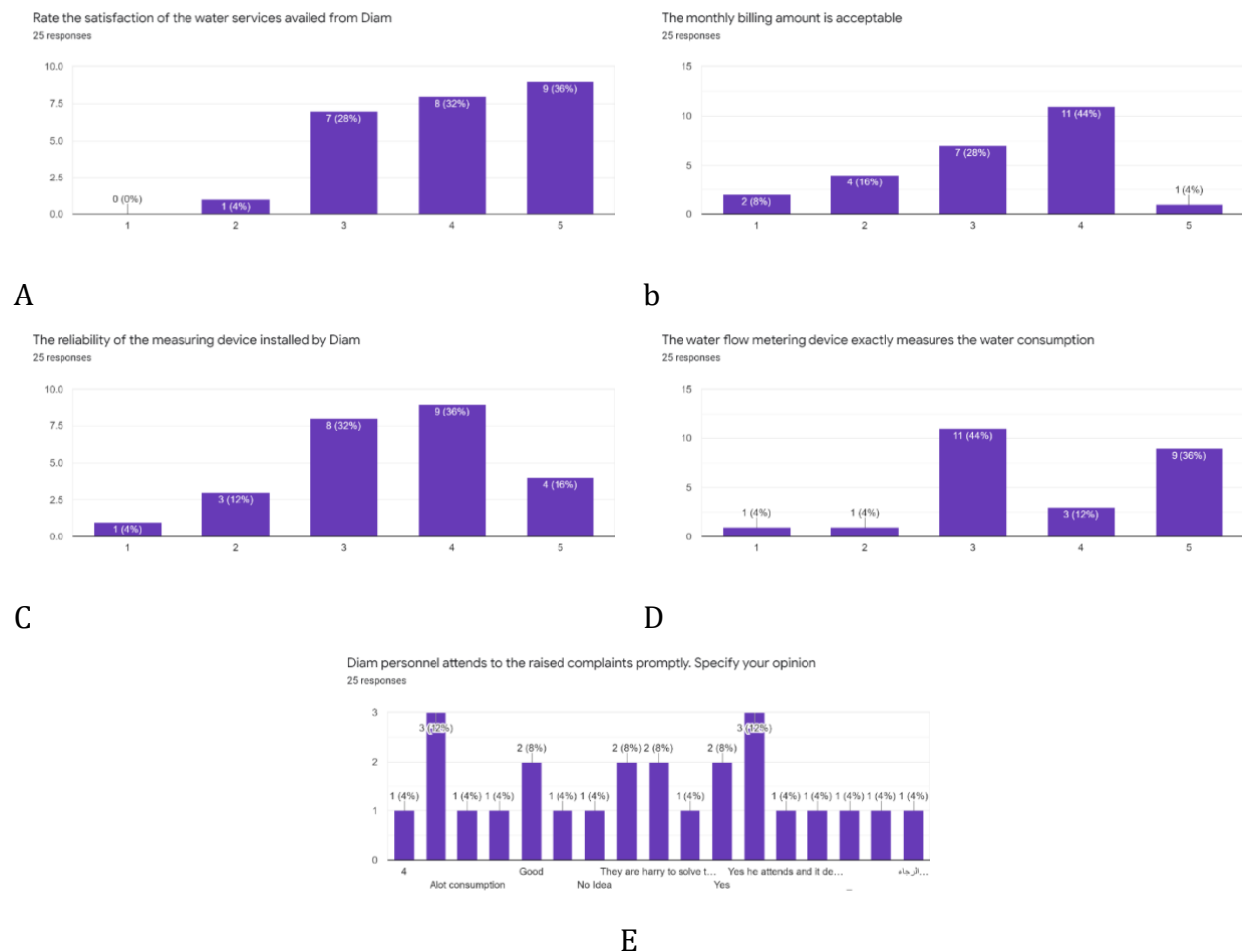


Figure 1.0. Smart water meter reading mismatch.

The smart water meters are installed at the consumer's location, intending to receive precise information on water consumption. These are majorly depending on the internet connectivity, as the devices work on IoT principles. The graph cluster shown in figure 1.0 (a-e) represents that the objective of smart water meter installations are partially fulfilled. The respondents who expressed their complete satisfaction on their monthly meter billing amounted to just 1%. Thus it is evident that there is adverse opinion on the water billing caused by the meter reading mismatch.

Responses on Introducing a New Theoretical Solution of Smart Water Meter Reading

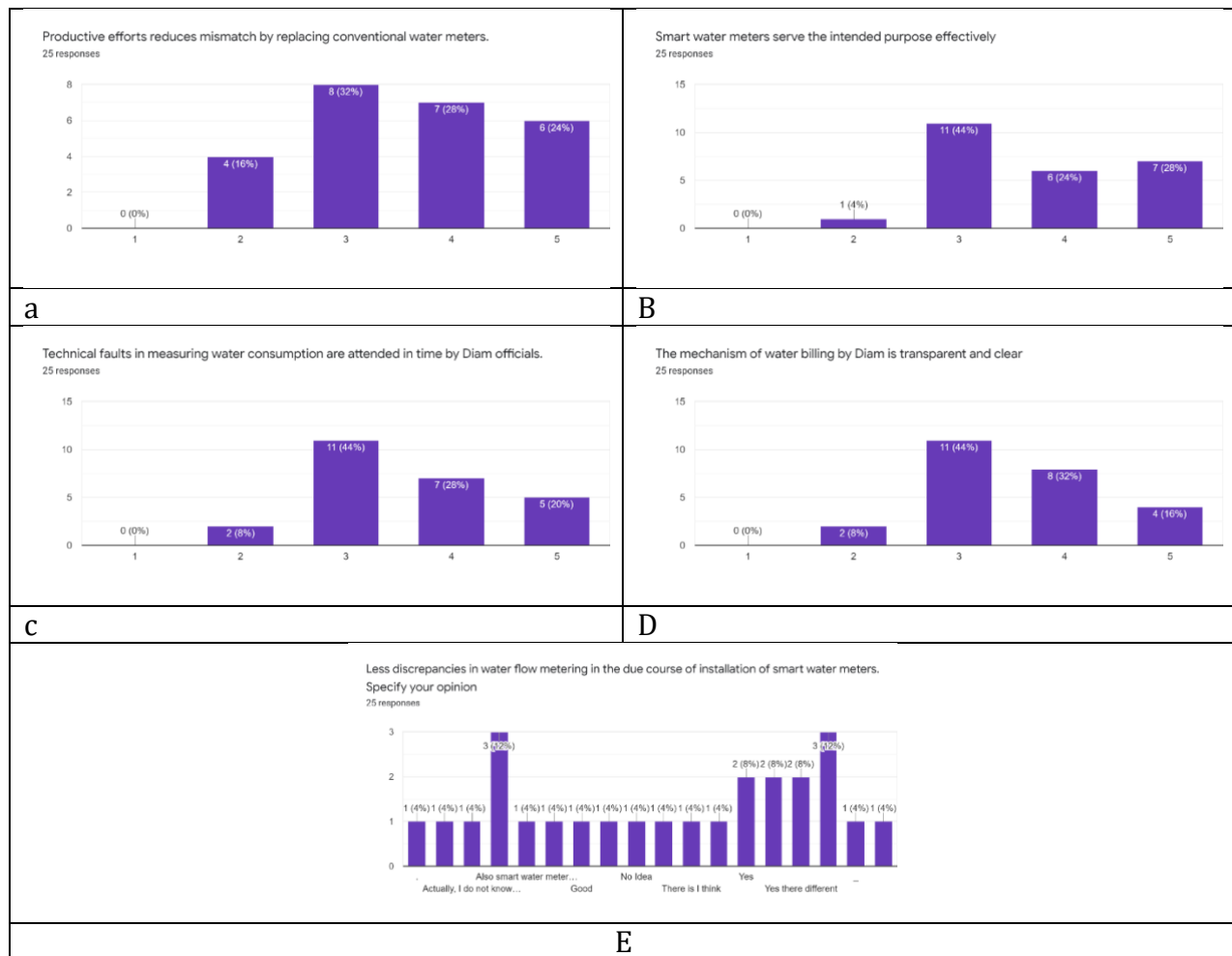


Figure 2.0. Respondent's responses – New theoretical solution of smart water meter reading.

Researches on smart metering are gaining momentum. The willingness to receive a technologically improved method of water metering is appreciated by majority of the respondents (44%) as shown in the figure 2 (a-e). In this project a numerical modelling of the flow from transmission line to the consumer's location in which smart meters are installed is carried out based on the survey.

Responses on SCADA Information in Mismatch Analysis of Smart Water Meter Reading

As the number of consumers are on constant rise, the number of smart water meters installed are also increasing. Thus, the flow modelling becomes complicated and large volumes of data are generated. However, the analysis and monitoring of this data is cumbersome and mandates a certain level of intelligence to be incorporated. Therefore, an adequate solution is expected to be obtained from effective data mining. Forty-four percent of respondents agreed to incorporate some types of analogy that would minimize the reading mismatch. In this study, as based on respondents' view, a big data analysis was intended, but due to the pandemic crises, the analysis is curtailed to an MS excel based analysis.

Quantification and locating the point of mismatch in the smart water readings

The role of the smart meters installed are to provide exact consumption data that enables an accurate bill generation. At present, in practice, there is a mismatch in the metering reading that gives rise to a bill with estimated reading based on the past consumption data. Therefore, the respondents to a large extent agreed that a systematic quantification of the mismatch is to be enabled by the Diam department such that the concept of estimated reading is minimized.

Data Analysis

The actual discharge data is obtained, compiled and a graph is plotted for different consumer locations. The sample size available in the research field is 30 consumers. Thus, the data collected are the pipe diameter (1.2E-02) meters, the pipe length various across the 30 consumer sites, starting its first discharge in the distribution line at a length of 40 meters and increases by 20 meters for every consumer location with the last consumer location at 620 meters away from the transmission pipeline. Each customer location is fitted with a smart water meter to measure the discharge at the consumer location and transmit the reading to the Diam servers periodically to formulate the billing database with respect to the respective meter identity number. The table below shows the respective discharge readings, measured at the consumer locations.

Points	Discharge measured in scada in m/s	Discharge Actual (m/s)
1	2.00E-01	0.00E+00
2	1.95E-01	5.00E-03
3	1.90E-01	1.00E-02
4	1.85E-01	1.50E-02
5	1.80E-01	2.00E-02
6	1.75E-01	2.50E-02
7	0.00E+00	2.00E-01
8	1.65E-01	3.50E-02
9	1.60E-01	4.00E-02
10	1.55E-01	4.50E-02
11	1.50E-01	5.00E-02
12	1.45E-01	5.50E-02
13	1.40E-01	6.00E-02
14	1.35E-01	6.50E-02
15	0.00E+00	2.00E-01
16	1.25E-01	7.50E-02
17	1.20E-01	8.00E-02
18	1.15E-01	8.50E-02
19	1.10E-01	9.00E-02
20	1.05E-01	9.50E-02
21	1.00E-01	1.00E-01
22	9.50E-02	1.05E-01
23	0.00E+00	2.00E-01
24	8.50E-02	1.15E-01
25	8.00E-02	1.20E-01
26	7.50E-02	1.25E-01
27	7.00E-02	1.30E-01
28	6.50E-02	1.35E-01
29	6.00E-02	1.40E-01
30	5.50E-02	1.45E-01

The water distribution is regulated and monitored by a computerized intelligent system called SCADA, operated by Diam. The discharge values generated by the SCADA system is compared with the smart water meter readings, that are observed in the respective individual meters in the consumer location. The following graph is plotted with the data available. The graph plotted with two curves, the red curve representing the discharge values, recorded according to SCADA system and the blue curve representing the actual discharge values observed on the individual meters. On observing the curves there are steep deviations in the meter readings of meters with the identification numbers of 7, 15, 23 respectively.

The SCADA reading is measured starting at the transmission line outlet, following the discharge ported to each consumer outlet is measured and updated in the database system. While the smart water meters transmit the water consumption data to be updated in the database system and compared with the SCADA reading values. As discussed, on observing the corresponding SCADA reading for the meter ids 7, 15, 23 is '0' indicating the malfunctioning of the smart water meter. Therefore, an estimated meter reading would be generated for the successive billing cycle indicating a clear mismatch. Thus, the location of mismatch is now could be easily identified and the inspection of the locations of the corresponding meters by Diam personnel could reveal the actual issue and essential rectification could be administered.

CONCLUSIONS AND RECOMMENDATIONS

Present Day Challenges

Diam, the public department for water is in the establishment of smart water metering gadgets in the Muscat Governate. As of July 2020, there are generally around 90000 meters introduced in the Governate. It is focused to accomplish the introducing 270000 keen meters toward the finish of 2021, as a second stage of undertaking with a cost assessment of R025 million and by joining forces with private areas. Smart meters are introduced for expanded precision in perusing the water utilization and robotized information transmission from the meter to the servers of Diam. All the more frequently the motivation behind establishment of smart meters does not satisfy the event of exactness in the water utilization. For this situation the Diam depends on estimated reading, a value assessed by the database dependent on past utilization of water.

Diam is working seriously to consolidate the smart meters in refreshing the utilization on hourly basis, that guides in the monitoring of utilization and in the event of any inward spillages. The primary favorable position of the smart meter helps in reducing estimated readings gives indication when there is an unexpected spillage issue at the consumer end. By this, a track of support and breakdown are upkept and utilized for follow up tasks. However, because of network breakdown and absence of periodical updates of the water utilization information, the Diam offers estimated readings to the consumers and this estimated value creates a lot of burden for the estimated reading, on observation regularly peruses higher than the real utilization.

Smart water meters used in the distribution system, encounters a problem due to poor internet connectivity which hinders in transmitting the accurate water consumption data, resulting with an estimation system. The billing is found to be random, irrespective of the actual water consumption. Subsequently, this system affects the water providers if the actual consumption is higher than the estimated value and the consumer in the event of actual is lower than the estimated value. To resolve this issue an initiative was taken through this project to quantify the mismatch between actual and the estimated reading.

This was achieved through the research objectives such as receiving consumer's opinion on the smart meter issues, new theoretical modeling of the flow, to estimate the actual water consumption, analyze the data received from smart meters and the SCADA system, to predict the flaw occurring point and quantify the mismatch. The following describes the execution of research objectives of this project.

The project was initiated through a survey questionnaire that intends to grasp on the reaction and accurate information of the participants that directs a study among the consumers, utilizing online overview strategies with the help of google forms in recognizing the necessary factors of smart water meters. Random and cluster sampling strategies are utilized in the recognized zones of the Muscat locale for which the sampling size are determined.

The factors in the survey guarantee the assortment of information regarding the water meters, water utilization, estimated reading, billing data, etc which are done at the client site. Based on which a numerical flow modeling was carried out to theoretically calculate the mismatch between the actual and estimated meter reading with the help of the SCADA system.

Due to Pandemic situation, the survey responses received are short of the calculated sampling size. The available responses reveal that resolving the issues in smart meter data transmission would be solved by quantifying the mismatch. Considering the lesser responses big data analysis was ruled out. Thus information database of the gathered information is arranged in the excel file and the mismatch is thus determined. To approve this mismatch, the methodology of mathematical model is utilized to produce the hypothetical water utilization to gauge the mismatch. The supplier water utilization information is assorted through the SCADA framework, utilized in all Diam control rooms. The outcomes are then interpreted to decide the actual and estimated information from the client and supplier end, advancing a technique to evaluate the mismatch. The algorithm used to estimate the mismatch enhances even the localizing the point at which the mismatch occurs.

RESEARCH FINDINGS AND CONCLUSIONS

From the survey results, it could be inferred that just 1% of the total respondents expressed their complete satisfaction on the monthly billing amount. While the remaining respondents expressed their partial and complete dissatisfaction.

It is observed that approximately 50% of the respondents expressed their opinion to accept the inclusion of new improved technology to quantify the mismatch in the existing system. Also, the result reflects that 44% of the respondents agree to incorporate an analogy to minimize the reading mismatch. While 60% of respondents feel that the quantification and locating the mismatch would help resolve estimated system of water meter reading.

The Numerical modelling based on Bernoulli's equation carried out in this project, eventually estimated a mismatch existing in the flow and water network. The new algorithm used to locate the flaw point served the purpose and located exactly that are discussed briefly in the analysis chapter.

RECOMMENDATIONS

The recommendations of the researchers based on his work are

- Efforts to minimize the estimation system in billing at the water supplier end to be initiated.
- Inclusion of a new technology to quantify the mismatch in the existing system.
- A SCADA based system to localize the flaw point is insisted.
- Big Data Analysis to be included in the bill generation software

References

- Agar, J. W. M. *et al.* (2009) 'Using water wisely: New, affordable, and essential water conservation practices for facility and home hemodialysis', *Hemodialysis International*. doi: 10.1111/j.1542-4758.2009.00332.x
- Al-Ismaily, H. and Probert, D. (1998) 'Water-resource facilities and management strategy for Oman', *Applied Energy*. doi: 10.1016/S0306-2619(98)00026-9
- Al-Marshudi, A. S. (2008) 'Economic instruments for water management in the Sultanate of Oman', *Water International*. doi: 10.1080/02508060802256138
- Beal, C. *et al.* (2011) 'Using smart meters to identify social and technological impacts on residential water consumption', *Water Science and Technology: Water Supply*. doi: 10.2166/ws.2011.088
- Boyle, T. *et al.* (2013) 'Intelligent metering for urban water: A review', *Water (Switzerland)*. doi: 10.3390/w5031052
- Clifford, E. *et al.* (2018) 'Flow-Signature Analysis of Water Consumption in Nonresidential Building Water Networks Using High-Resolution and Medium-Resolution Smart Meter Data: Two Case Studies', *Water Resources Research*. doi: 10.1002/2017WR020639
- Dawoud, M. A. (2011) 'Water import and transfer versus desalination in arid regions: GCC countries case study', *Desalination and Water Treatment*. doi: 10.5004/dwt.2011.2156
- Farah, E. and Shahrour, I. (2017) 'Smart water for leakage detection: Feedback about the use of automated meter reading technology', in *2017 Sensors Networks Smart and Emerging Technologies, SENSET 2017*. doi: 10.1109/SENSET.2017.8125061
- Joint Monitoring Programme (JMP) report, 2017, 'Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and Sustainable Development Goal Baselines', United Nations Children's Fund and the World Health Organization
- Joshi, D. S. A. *et al.* (2016) 'IoT Based Smart Energy Meter', *Bonfring International Journal of Research in Communication Engineering*. doi: 10.9756/bijrce.8209
- Kabeer Yousuf, (2019). Article on more users to get smart water meters in Sultanate of Oman. Oman Observer
- Karathanasi, I. and Papageorgakopoulos, C. (2016) 'Development of a Leakage Control System at the Water Supply Network of the City of Patras', in *Procedia Engineering*. doi: 10.1016/j.proeng.2016.11.100
- Mahmood, A., Aamir, M. and Anis, M. I. (2008) 'Design and implementation of AMR smart grid system', in *2008 IEEE Electrical Power and Energy Conference - Energy Innovation*. doi: 10.1109/EPC.2008.4763340
- Nkosi, B. R. and Odeku, K. O. (2014) 'A comparative perspective of water pollution control', *Mediterranean Journal of Social Sciences*. doi: 10.5901/mjss.2014.v5n23p2600
- Omezzine, A. and Zaibet, L. (1998) 'Management of modern irrigation systems in Oman: Allocative vs. irrigation efficiency', *Agricultural Water Management*. doi: 10.1016/S0378-3774(98)00045-6
- Raykar, M. M. *et al.* (2015) 'Automated Water Billing with Detection and Control of Water Leakage using Flow Conservation', *International Journal of Engineering and Research*
- Vanderzee, M. *et al.* (2015) 'SCADA: Supervisory Control and Data Acquisition', in *Oil and Gas Pipelines: Integrity and Safety Handbook*. doi: 10.1002/9781119019213.ch02