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Techno-Economic Study regarding Water Metering System, MOGA, PUNJAB

Draft Report

Submitted to:
Department of Water Supply and Sanitation (DWSS),
Government of Punjab

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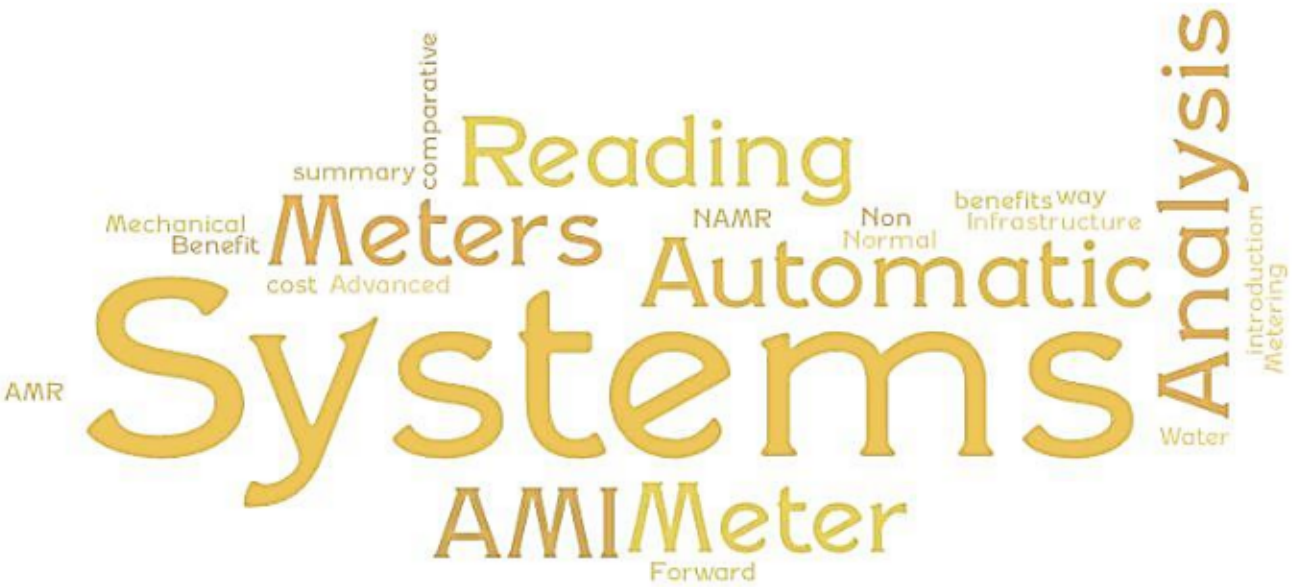

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The State Rural Water Supply and Sanitation Policy 2014 of Punjab has laid out measures to achieve 100% coverage through 24/7 piped and metered individual water supply connections along with the introduction of consumption-based tariffs. The Department of Water Supply and Sanitation (DWSS), Government of Punjab, is responsible for providing potable drinking water to the rural residents of the state of Punjab. The ground water quality in 85 villages of district Moga has deteriorated (Uranium-42, Heavy Metal – 5, Basic Parameters -36 and 2 en-route villages). Hence, to provide clean drinking water to these villages of Moga district, the DWSS has tied up with M/S L&T for the provision of water supply service through a large multi village canal-based surface water supply scheme built using the Private-Public Partnership model. To align with these objectives of providing 24/7 clean drinking water to individual households, and implement consumption-based tariffs for water usage, water meters will be installed in all the piped individual connections of the villages in Moga. In this context, the main objective of this techno-economic study is to recommend the best and cost-effective water metering system to DWSS to be implanted in 85 villages being covered under Surface Large Water Supply Project Moga, Punjab.

In the recent past, public-private partnerships (PPP) models have been successful for the provision of public goods such as water. In the context of water supply systems, the water supply companies started charging consumers on a flat or fixed rate basis irrespective of usage. However, such flat rate tariffs have resulted in water wastages leading to not only huge revenue losses, but also depletion of a precious resource. According to various studies, the proportion of Non-Revenue Water (water supplied by the system but not being charged to customers) varies from 20 percent up to 80 percent of total supply (World Bank, 2014). In the case of the existing DWSS scheme in Moga, the NRW ranges from a low of 7.5% to up to 96% (average NRW of 68%). To decrease non-revenue water and foster a culture of Pay as You Use, water utility companies are introducing metering for individual piped water connections.

For this study, four water meter types are analysed. The costing analysis include costs for Supply and Installation, meter box, spare meters, meter reading, data entry, IT & Billing Works, manpower for O&M, test bench and non-revenue water (NRW) loss. In 2018, the average NRW loss for Moga district is at 68%. By estimating 68% loss in NRW for the normal mechanical meters, the NRW loss amounts to INR 33.33 crores, and the Total cost of implementing normal mechanical water metering system for ten-years amounts to INR 293.6 crores. In the sections below, the NRW loss is calculated at 35% for normal mechanical meters and NAMR systems, 10% for AMR systems, and 5% for AMI systems, respectively. The underlying reason for the reduction in NRW loss percentage is due to system efficiency in identifying the leakage and respective time taken to resolve the leakage issue. The Total cost for the entire package for the normal mechanical meters for ten-years is estimated to be INR 190.5 crores. For Non-Automatic Meter Reading (NAMR) systems, the Total cost for the entire package for ten-years is estimated to be INR 166.42 crores. For Automatic Meter Reading (AMR) systems, the Total cost for the entire

package for ten-years is estimated to be INR 105.65 crores. And, for Advanced Metering Infrastructure (AMI) systems, the Total cost for the entire package for ten-years is estimated to be INR 98.71 crores.

From the analysis it is evident that though AMR and AMI systems have initial cost, in the long-run these meter systems are cost-effective and efficient. With additional capabilities including features of AMR systems, AMI systems have far more benefits than AMRs and other mechanical water meters. The high initial cost of AMI systems will be offset by its value addition and reduction in NRW in five years' period. Long term accuracy and reduction in NRW will be the key factor, which can contribute to increased revenue. As the data can be analysed and graphically represented, AMI systems have high impact in creating consumer awareness among the water users, and at the same time, utility stakeholders can have deep insights on water supply and its conservation efforts.

1. Introduction

The State Rural Water Supply and Sanitation Policy 2014 of Punjab has laid out measures to achieve 100% coverage through 24/7 piped and metered individual water supply connections along with the introduction of consumption-based tariffs. Department of Water Supply and Sanitation (DWSS), Government of Punjab, is responsible for providing potable drinking water to the rural residents of the state of Punjab. Government of Punjab has accorded highest priority to drinking water supply and is implementing various projects to provide its residents with potable water supply. Till now nearly all the 13,559 rural habitations have been provided with potable drinking water supply. Predominantly, source of water supply is ground water.

The ground water quality in most of districts of Punjab has deteriorated. For instance, the rate of decline of groundwater levels is 55 cms. per year from 2009 to 2013 (NITI Aayog, 2018). Consequently, to address this issue, DWSS, Government of Punjab is implementing large surface-water based schemes. One such Large Surface Water Supply Project is being implemented in 85 villages of district Moga where ground water quality has deteriorated (Uranium-42, Heavy Metal – 5, Basic Parameters -36 and 2 en-route villages). To obviate this problem, in some villages community Reverse Osmosis (RO) based water treatment plants have been set. The Work is being executed by M/S. L&T Limited Chennai (Operator) - on Design, Build-Operate and Transfer (DBOT) basis. The project is likely to be commissioned on Aug-2019, after that the Agency will operate and maintain the project for 120 months (10 year).

9,92,289

Moga population

85 villages

Of Moga District facing water quality issues

DWSS tied up with M/S L&T

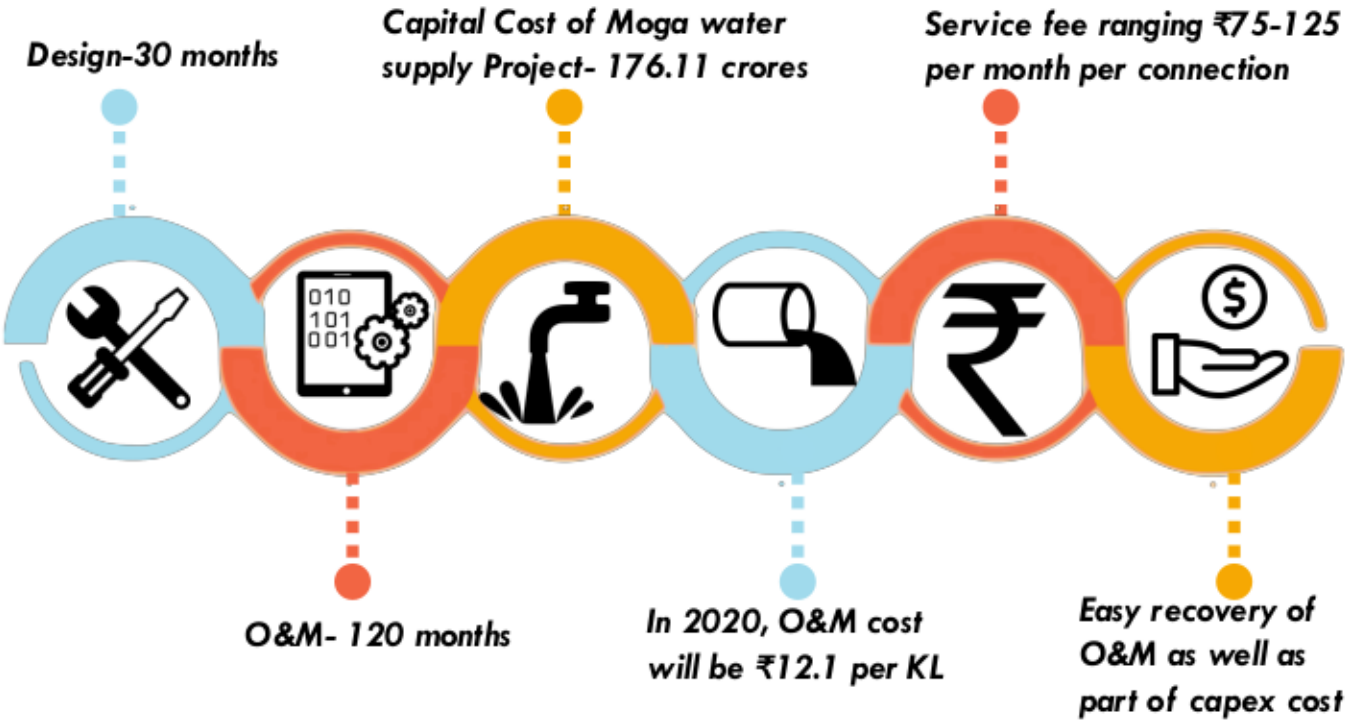
for the provision of clean water supply

A comprehensive tariff fixation and revenue collection mechanism and water metering policy is needed to recover O&M cost as water bills from nearly 60,000 consumers of 85 villages for successful operation and maintenance of surface water supply scheme Moga over the period of 10 years.

DWSS has hired M/S. Deloitte Touche Tohmatsu India LLP (The Consultant) as financial management expert to review the Revenue & Expenditure during the last five years in respect of O&M of Rural water supply schemes in Punjab. The Consultant has submitted its report with analysis on cost and revenue of rural water supply schemes operated and maintained by DWSS and Gram Panchayat Water and Sanitation Committees (GPWSCs), and recommendations on formulating revenue collection and O&M cost recovery. As per the report on Cost Recovery / Tariff Options for the multi-village surface water supply scheme Moga, the consultant has recommended volumetric tariff structure i.e. installing water meters to individual water connections.

Further, to generate enough revenue, reduce revenue loss due to water wastage & non-revenue water and to foster a culture of Pay as You Use robust water metering system is required in 85 villages being covered under Large Surface Water Supply Project, Moga. In this context, the main objective of this techno-economic study is to recommend the best and cost-effective water metering system to DWSS to be implanted in 85 villages being covered under Surface Large Water Supply Project Moga, Punjab.

2. Moga Water Supply Salient Features



The water supply project awarded to L&T will be based on Design, Build, Operate & Maintain and Transfer (DBOMT) covering 85 villages of block Moga-I, Moga-II, Nihal Singh Wala, Moga District. The design and build phase of the project has been defined as 30 months, while the operation & maintenance (O&M) phase has been defined as 120 months. The envisaged capital cost of the Moga water supply project is INR 176.11 crores, while Net Present Value (NPV) of the total O&M price for the ten-year period (discounted at 10% per annum) is INR 32.94 crores, assuming a supply of the minimum requirement of water (15 MLD) in the first year, and an increment of 0.5 MLD over it, every year.

The O&M cost to supply 70 Litres per Capita per Day (lpcd) to the households in the year 2020 works out to INR 12.1 per Kilo Litre (KL). A volumetric tariff assuming fixed service fee ranging between INR 75-125 per connection per month scenario, 40% of the households consume less than 10KL per month, 50% of the households consume between 10KL and 20 KL per month and the remaining 10% consume more than 20 KL per month. Assuming a rate of INR 14 per KL for the 10-20 KL slab and INR 20 per KL for the above 20 KL slab, and with a moderate annual increase of 3%, it is possible to not only recover the full O&M cost but also part of the capex cost. If the excess water produced can be sold at the highest slab rate, then the financials would improve.

3. Why Metering Systems?

In the recent past, public-private partnerships (PPP) models have been successful for the provision of public goods such as water. To ensure continued private sector investment in large scale public sector projects like water supply and sanitation, revenue generation from these PPP projects is crucial for their continued success.

In the context of water supply systems, the water supply companies started charging consumers on a flat or fixed rate basis irrespective of usage. However, such flat rate tariffs have resulted in water wastages leading to not only huge revenue losses, but also depletion of a precious resource. According to various studies, the proportion of Non-Revenue Water (water supplied by the system but not being charged to customers) varies from 20 percent up to 80 percent of total supply (World Bank, 2014). In the case of the existing DWSS scheme in Moga, the NRW ranges from a low of 7.5% to up to 96% (average NRW of 68%). To decrease non-revenue water and foster a culture of Pay as You Use, water utility companies are introducing metering for individual piped water connections.

With the advent of metering systems, information management is easier, and the customer usage trends are identified for providing improved services. It is imperative that customers are aware of usage trends for effective management and conservation. It is equally important that water utilities provide timely and precise information, which can be accessed using user-friendly equipment or means. Having an automated metering system is crucial, as the existing manual processes are automated, operational costs becomes negligible, and accessing real-time data that will enable the performance of the entire utility system. With the help of smart metering systems, leakages are detected and reported with high frequency, thereby enabling quick response time to resolve an issue. One other potential benefit of using metering systems is the change in consumer behaviours towards the water usage patterns. For instance, survey results of Smart Energy GB in 2017 showed that 86% of population have changed their behaviours towards energy usage after the installation of smart meters. The survey report says that eight in ten people have taken effort to consume less energy, and 70% of them are conscious in energy usage after the implementation of smart meters (Bairstow, 2017). In another study conducted on a dozen utility pilot programs in North America and around the globe has shown that direct feedbacks given by In-Home Displays (IHD) have helped consumers to change their behaviour in reducing electricity consumption by about twice the amount (Faruqui, Sergici, & Sharif, April 2010).

4. Types of Water Meters

Four types of water meters are considered for this study. They are:

I. Normal mechanical meters,

II. Non-Automatic Meter Reading (NAMR) systems,

III. Automatic Meter Reading (AMR) systems, and

IV. Advanced Metering Infrastructure (AMI) systems.

Each of these meters are explained in detail in the following sections.

I.

Normal mechanical meters are the mechanical type water meters where readings are to be taken manually for each connection. Major limitations of these normal mechanical meters include easy tampering and reversing the meter readings during most of time of billing period, and there are cases where these meters are removed willfully but reinstalled few days before the intended date of meter readings. Moreover, no backup data can be stored for these meters and it is very cumbersome to do manual readings particularly in large schemes and further to generate bills. For instance, as the number of pipe connections increase, the time taken to complete the readings will increase. As a result, it is difficult to identify leakages on time if any, which will in turn, delay the time to rectify the issue identified. Moreover, increased time delay in resolving the issue would increase the billing cost for the consumer even if it isn't the consumers' fault.

Other implications include the financial burden for the consumer to pay the accumulated water tariffs where the billing period exceeds more than two months, due to manual reading of the piped connections in larger areas. With respect to technical aspects, the life cycle of normal mechanical meters varies between two and three years, and hence long-term accuracy cannot be ensured, thus replacement cost including wear and tear to be considered in the long run. Additionally, these meters that are existing in the market does not come with warranty or guarantee periods, hence the risk is high, though the initial costing of these meters seems to be cheap in the market. Manpower required for taking readings manually is high, thereby increasing the total cost of these normal mechanical meters. As a result, there is loss of revenue and water wastage as well.

II.

Non-Automatic Meter Reading (NAMR) systems are like the normal mechanical meters, but with additional features of IP68 Grade2, and ten-year warranty period covered. As these systems have warranty period, the utilities need not worry about the replacement cost of the meters for a minimum period of ten years.

Automatic Meter Reading (AMR) Systems: To overcome the shortcomings of the mechanical water meters, water utilities across the globe are switching over to Automatic Meter Reading (AMR) systems, where the meter readings can be fetched and recorded automatically in digital format without even entering the premises of the piped connection. Moreover, AMRs cannot be tampered with, as there's back-up data being stored and can detect and record reverse flow thereby ensuring consumer satisfaction, less disputes and consumer awareness in conserving water. As meter readings are automatically recorded, human interface is eliminated, and therefore consumers cannot reduce the consumption in connivance with meter readers. AMRs are enabled with signaling features that can detect willful removal of water meters. Meter readings does not require to enter the houses or premises, therefore enabling safety to the women, children and elders in the family. Though meter readings require manpower to fetch the readings from a certain distance with the help of handheld devices, the efficiency of the readings are high as compared to the normal mechanical water meters, thus reducing the cost of manpower considerably. Bills can be generated automatically by transferring recorded data from handheld devices, and hence bill generations take less time.

Since data is generated and recorded in digitized format, actual water consumption on real time basis can be worked out, and data can be easily analysed for abnormal low consumption patterns. Additionally, volumetric consumption data can be depicted graphically thereby increasing consumer awareness about water consumption. Consumer clarifications regarding high water bills can be done with the help of back-up data and visual representation of daily or even hourly water meter readings. With respect to technical aspects, AMRs have long life with less wear and tear thus ensuring long term accuracy, which in turn, increases revenue. With the help of AMRs, water utilities can take informed decisions by understanding the overall consumption pattern, daily peak demand, and seasonal variations in a population. Even vendors offer prolonged guarantee and support for AMRs. AMRs can help decrease non-revenue water (NRW), which is a major contributor to revenue increase and expenditure reduction. Also, AMRs produce actionable data for both the utility and the end consumer.

Advanced Metering Infrastructure (AMI) systems are the latest in the market and has additional capabilities including features of AMR systems. It is a system where data collection is automated, and two-way communication is possible between the water meter with an IP address and the water utility. In AMI systems, the data collection is done through a chip-based transmitter technology, thus eliminating the need for handheld devices to record data and the manpower, respectively.

AMI systems have the ability to obtain Turn On/Off reads from remote office, thus eliminating the need for manual visits every month. They provide detailed information that will be helpful in answering customer's queries regarding the usage trends. The AMI systems has the ability to run daily leak reports for every customer, and can run zero consumption reports to identify stuck meters. The reports can be even published to the customers for review. These systems can evaluate and monitor conservation efforts by individual account or by desired classification. Daily production and consumption reports can be generated and compared to develop daily water loss reports.

Additionally, the frequency at which the data is recorded is high compared to AMRs, and the frequency can be even controlled and set for different situations and scenarios. Therefore, the NRW loss can be minimized considerably as the leakage identification and resolving process is reduced considerably. Tools like advanced metering infrastructure (AMI) can help achieve the goals of information management, reduction in operational costs, and provide customer with improved services. Using AMI systems, it is possible to compare data of neighbors, between one customer type and another. Comparison can also be made from one customer to the average usage of all the similar customers.

Using AMI systems can help improve the processes involved in managing natural resources demand, in this case, water. One of the salient features of data collected through AMI is to predict the future usage patterns and trends and adjust accordingly the supply and demand equations. When metering systems like AMI are implemented and managed wisely, utility providers can improve their business operations, regulate consumer water usage, and promote sustainable usage of natural resources.

IV.

5. Comparative Analysis of Water Meters

Having studied the features, advantages and disadvantages of different water meters in the previous section, cost-benefit comparison of these water meters would enable utilities to make well informed decisions. Water Metering System shall mean the entire process right from the type of water meters, including communication protocol from meters to base computer(s), fetching/recording meter readings, data capturing, data back-up and its security, computerized bill generation from the data captured/data transfer to, and/or integration with third party website, bill printing and distribution of bills to consumers.

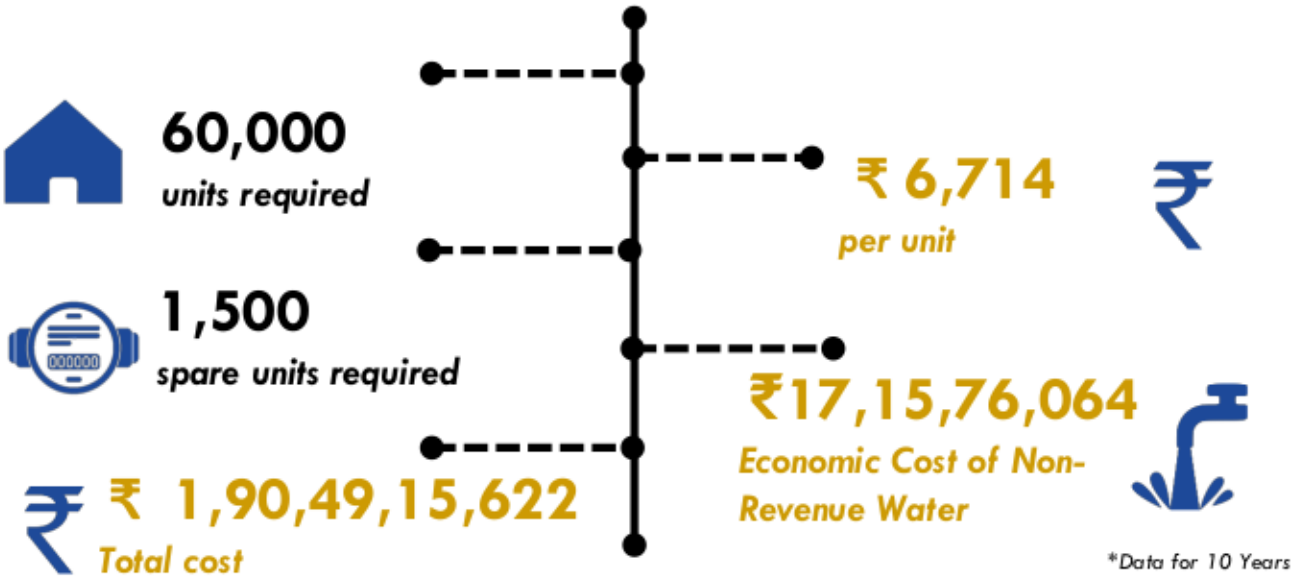
Major benefits can be realised in terms of manpower used for manual meter readings, conversion of manual readings to digital format (data entry) and reduced non-revenue water (NRW) – equivalent to water saving. In 2018, the average NRW loss for Moga district is at 68%. By estimating 68% loss in NRW for the normal mechanical meters, the NRW loss amounts to INR 33.33 crores, and the Total cost of the entire water metering system for ten-years amounts to INR 293.6 crores (see Annexure for details). In the sections below, the NRW loss is calculated at 35% for normal mechanical meters and NAMR systems, 10% for AMR systems, and 5% for AMI systems, respectively. The underlying reason for the reduction in NRW loss percentage is due to system efficiency in identifying the leakage and respective time taken to resolve the leakage issue.

5.1 Cost details of Normal Mechanical Meters

The basic rate for a normal mechanical meter is INR 1286 with additional amount of INR 524 for installation. Since these meters have a guarantee period of two-three years, three replacements are required for a ten-year period. With inflation charges applied at 4%, the unit supply cost of normal mechanical meter amounts to INR 6,714 inclusive of 18% Goods and Services Tax (GST). To read 60,000 connections, 600-man days are required under the assumption that 100 connections are read in a day. In the first year of the connection, unit rate for a man day is fixed at INR 500. Hence for the first year, the metering cost would amount to INR 42.48 lakhs inclusive of GST at 18% on the billing cycle amount (which is number of man-days multiplied by the unit rate for man-days) of INR 3 lakhs. From the second year, the reading cost will go higher by considering 10% increase in the unit rate for a man day. Therefore, at the tenth-year, the metering cost is estimated to be INR 1 core with unit rate for a man day fixed at INR 1,179. Adding all the yearly cost, total meter reading cost for ten-years amounts to INR 6.77 crores.

Upon completion of meter readings, data entry operators are required to convert the manual readings to the digital format. For 60,000 meter readings, under the assumption of 8 data entry operators working for 8 hours in a day, with 1.5 minute per reading, they will be able to enter 300 readings per day including break time. Therefore, for a month of 25 working days, 8 operators would be able to complete the data

entry task of 60,000 meter readings. By calculating INR 10,000 as salary per operator, the monthly expenditure for data entry is estimated to be INR 80,000. Therefore, for the first year, the data entry cost will amount to INR 9.6 lakhs. With 10% increase in their salary every year, the data entry cost for ten-year duration is estimated approximately to be INR 1.53 crores (See Annexure for details).



The daily water demand for Moga district is estimated to be 38.5 Million Litres per Day (MLD). For this analysis, the NRW loss is assumed at 35%, which is nearly half the percentage of the average 68% NRW loss in Moga district with no water meters installed. The NRW loss calculated at 35% for a year at INR 15 per KL is estimated to be 7.28 crores. Therefore, for a ten-year period the NRW loss value amounts to INR 17.16 crores with 10% increase in the estimated NRW value for the subsequent years. The manpower cost for these meters is estimated to be INR 2.13 crores for a year, and for ten-years the cost amounts to INR 21.31 crores.

Table 1: Non-Revenue Water (NRW) Estimation for Normal Meters

Description	Value
Daily Water Demand in MLD	38.5
NRW loss percentage	0.35
NRW Loss per day in ML	13.475
Daily loss in KL	13,475
Yearly loss in KL	48,51,000
Revenue loss @ INR 15 per KL	7,27,65,000

Apart from these costs, there are other costs which includes water meter box (unit cost of INR 514), spare meters (0.25% of total units) for ten-years, IT & Billing Works that includes hardware and software, and test bench cost. For ten-years, the total value of other costs is estimated to be INR 4.48 crores. Therefore, by considering all the cost factors, the Total cost for the entire package for the normal mechanical water metering system for ten-years is estimated to be INR 190.49 crores.

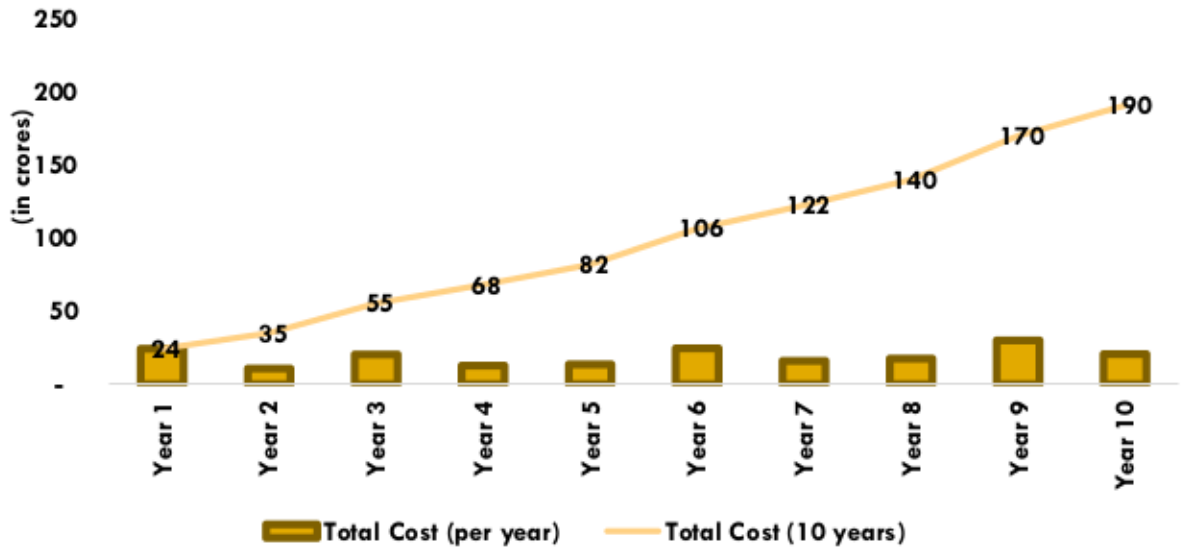


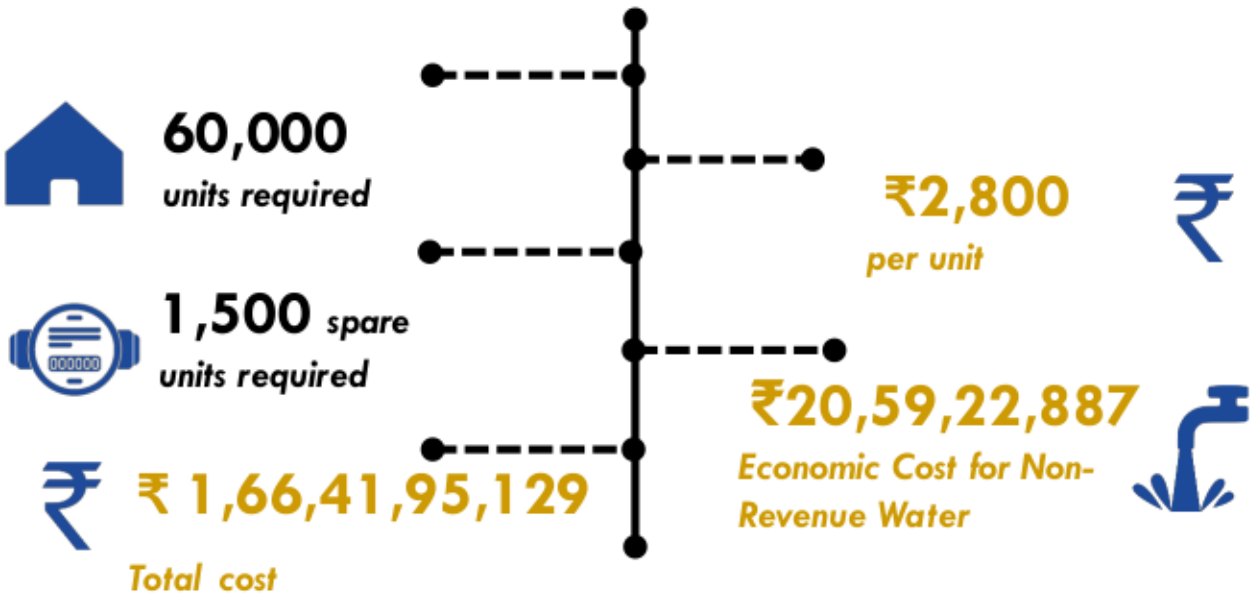
Figure1: Yearly Costing trend in Normal Meters

5.2 Cost details of NAMR Systems

The basic rate for a NAMR system is INR 1,500 with additional amount of INR 1,000 for installation. Therefore, the unit supply cost of NAMR systems amounts to INR 2,800 inclusive of 18% Goods and Services Tax (GST) and 2% packaging charges. These meters have a guarantee period of ten years. To read 60,000 connections, 600-man days are required under the assumption that 100 connections are read in a day. In the first year of the connection, unit rate for a man day is fixed at INR 500. Hence for the first year, the metering cost would amount to INR 42.48 lakhs inclusive of GST at 18% on the billing cycle amount of INR 3,00,000. From the second year, the reading cost will go higher by considering 10% increase in the unit rate for a man day. Therefore, at the tenth-year, the metering cost is estimated to be INR 1 crore with unit rate for a man day fixed at INR 1,179. Adding all the yearly cost, total meter reading cost for ten-years amounts to INR 6.77 crores.

Upon completion of meter readings, data entry operators are required to convert the manual readings to the digital format. For 60,000 meter readings, under the assumption of 8 data entry operators working for 8 hours in a day, with 1.5 minute per reading, they will be able to enter 300 readings per day including break time. Therefore, for a month of 25 working days, 8 operators would be able to complete the data entry task

of 60,000 meter readings. By calculating INR 10,000 as salary per operator, the monthly expenditure for data entry is estimated to be INR 80,000. Therefore, for the first year, the data entry cost will amount to INR 9.6 lakhs. With 10% increase in their salary every year, the data entry cost for ten-year duration is estimated approximately to be INR 1.53 crores (See Annexure for details).



The daily water demand for Moga district is estimated to be 38.5 Million Litres per Day (MLD). For this analysis, the NRW loss is assumed at 35%, which is nearly half the percentage of the average 68% NRW loss in Moga district with no water meters installed. The NRW loss calculated at 35% for a year at INR 15 per KL is estimated to be 7.28 crores. Therefore, for a ten-year period the NRW loss value amounts to INR 17.16 crores with 10% increase in the estimated NRW value for the subsequent years. The manpower cost for these meters is estimated to be INR 2.13 crores for a year, and for ten-years the cost amounts to INR 21.31 crores.

Table 2: Non-Revenue Water (NRW) Estimation for NAMR Systems

Description	Value
Daily Water Demand in MLD	38.5
NRW loss percentage	35%
NRW Loss per day in ML	13.475
Daily loss in KL	13,475
Yearly loss in KL	48,51,000
Revenue loss @ INR 15 per KL	7,27,65,000

Apart from these costs, there are other costs which includes water meter box (unit cost of INR 514), spare meters (0.25% of total units) for ten-years, IT & Billing Works that includes hardware and software, and test bench cost. For ten-years, the total value of other costs is estimated to be INR 4.48 crores. Therefore, by considering all the cost factors, the Total cost for the entire package for the NAMR water metering systems for ten-years is estimated to be INR 166.42 crores.

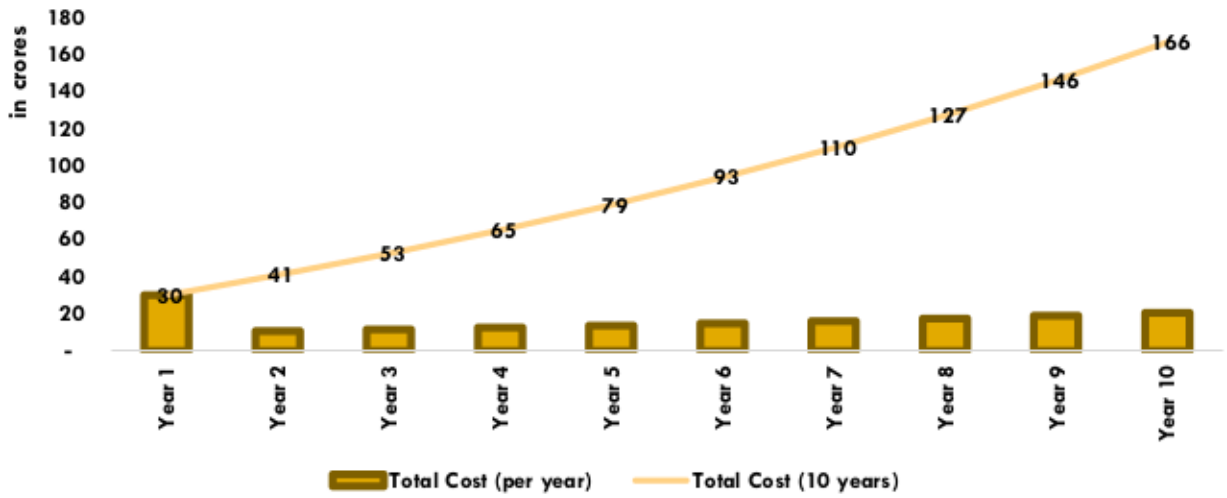
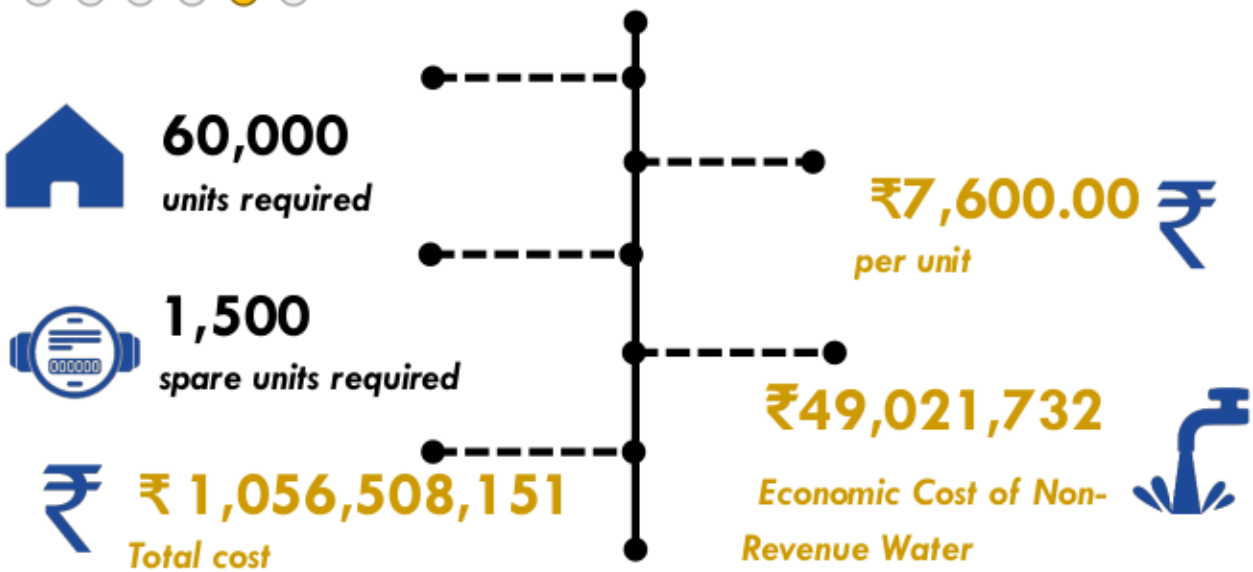


Figure2: Yearly Costing trend NAMR

5.3 Cost details of AMR Systems

The basic rate for an AMR system is INR 5,500 with an additional installation cost of INR 1,000. Therefore, the unit supply cost of AMR systems amounts to INR 7,600 inclusive of 18% Goods and Services Tax (GST) and 2% packaging charges. Since readings are collected with the help of handheld devices, to read 60,000 connections, only 75-man days are required under the assumption that 800 connections are read in a day. In the first year of the connection, unit rate for a man day is fixed at INR 500. Hence for the first year, the metering cost would amount to INR 5.31 lakhs inclusive of GST at 18% on the billing cycle amount of INR 37,500. From the second year, the reading cost will go higher by considering 10% increase in the unit rate for a man day. Therefore, at the tenth-year, the metering cost is estimated to be INR 12.52 lakhs with unit rate for a man day fixed at INR 1,179. Adding all the yearly cost, total meter reading cost for ten-years amounts to INR 84.63 lakhs.

In the AMR systems, data entry is eliminated as the data collected through handheld devices can feed the digitised data into the computer servers. (see Annexure for details).



The daily water demand for Moga district is estimated to be 38.5 Million Litres per Day (MLD). For this analysis, the NRW loss is assumed at 10%, by considering the efficiency of AMR systems in detecting leakages. The NRW loss calculated at 10% for a year at INR 15 per KL is estimated to be 2.07 crores. Therefore, for a ten-year period the NRW loss value amounts to INR 4.9 crores with 10% increase in the estimated NRW value for the subsequent years. The manpower cost for these meters is estimated to be INR 2.13 crores for a year, and for ten-years the cost amounts to INR 21.31 crores.

Table 3: Non-Revenue Water (NRW) Estimation for AMR Meters

Description	Value
Daily Water Demand in MLD	38.5
NRW loss percentage	10%
NRW Loss per day in ML	3.85
Daily loss in KL	3,850
Yearly loss in KL	13,86,000
Revenue loss @ INR 15 per KL	2,07,90,000

Apart from these costs, there are other costs that are common across the four water meters. These other costs include water meter box (unit cost of INR 514), spare meters (0.25% of total units) for ten-years, IT & Billing Works that includes hardware and software, and test bench cost. For ten-years, the total value of other costs is estimated to be INR 4.48 crores. Therefore, by considering all the cost factors, the Total cost for the entire package for the AMR water metering systems for ten-years is estimated to be INR 105.65 crores.

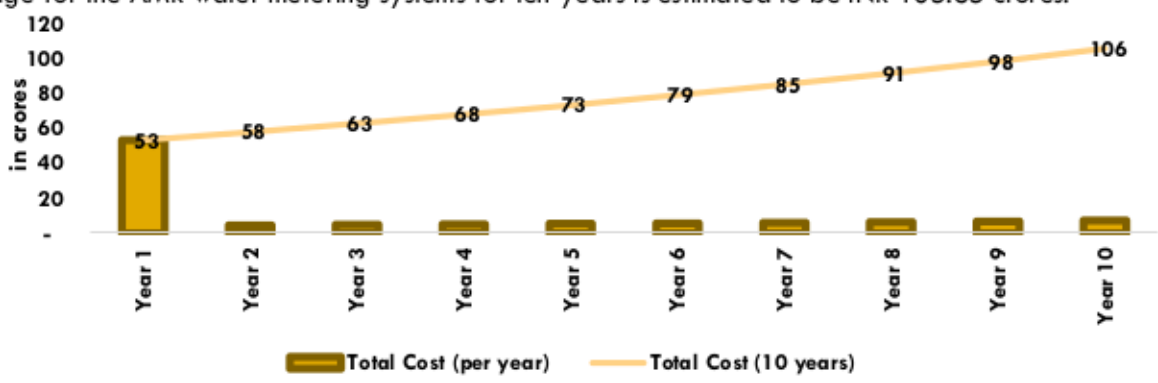
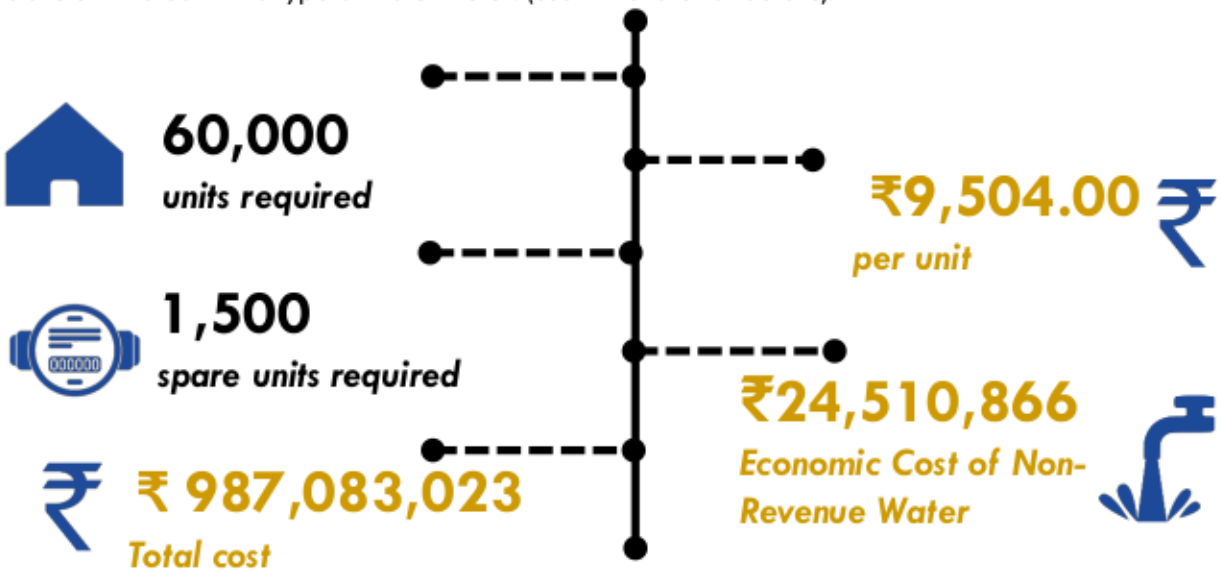


Figure3: Yearly Costing trend AMR

5.4 Cost details of AMI Systems

The basic rate for an AMI system is INR 7,207 with an additional installation cost of INR 1,000. Therefore, the unit supply cost of AMI systems amounts to INR 9,504 inclusive of 18% Goods and Services Tax (GST). Since readings are automated and fed to the server at high frequency, meter reading costs and data entry costs are eliminated in this type of water meter. (see Annexure for details).



The daily water demand for Moga district is estimated to be 38.5 Million Litres per Day (MLD). For this analysis, the NRW loss is assumed at 5%, by considering the efficiency of AMI systems over AMR systems in detecting leakages. The NRW loss calculated at 10% for a year at INR 15 per KL is estimated to be 1.03 crores. Therefore, for a ten-year period the NRW loss value amounts to INR 2.45 crores with 10% increase in the estimated NRW value for the subsequent years. The manpower cost for these meters is estimated to be INR 2.06 crores for a year, and for ten-years the cost amounts to INR 20.06 crores.

Table 4: Non-Revenue Water (NRW) Estimation for AMI Systems

Description	Value
Daily Water Demand in MLD	38.5
NRW loss percentage	0.05
NRW Loss per day in ML	1.925
Daily loss in KL	1,925
Yearly loss in KL	6,93,000
Revenue loss @ INR 15 per KL	1,03,95,000

Apart from these costs, there are other costs that are common across the four water meters. These other costs include water meter box (unit cost of INR 514), spare meters (0.25% of total units) for ten-years, IT & Billing Works that includes hardware and software, and test bench cost. For ten-years, the total value of other costs is estimated to be INR 5.06 crores. Therefore, by considering all the cost factors, the Total cost for the entire package for the AMI water metering systems for ten-years is estimated to be INR 98.71 crores.

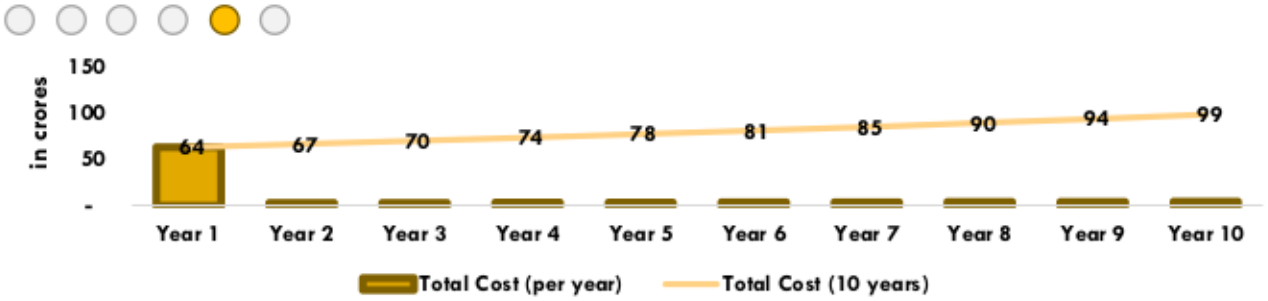


Figure 4: Yearly Costing trend AMI

5.5 Comparative Analysis

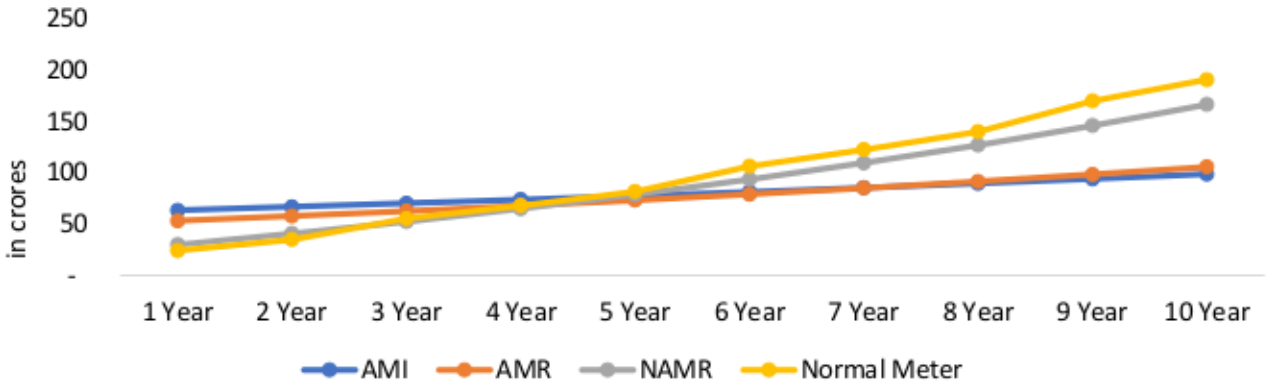


Figure 5: Break-even chart of Water Meter Types

The comparative analysis of four water meter types has shown that, at the fifth year, break-even will be achieved by the AMI systems, even though it has high initial cost (Figure 5).

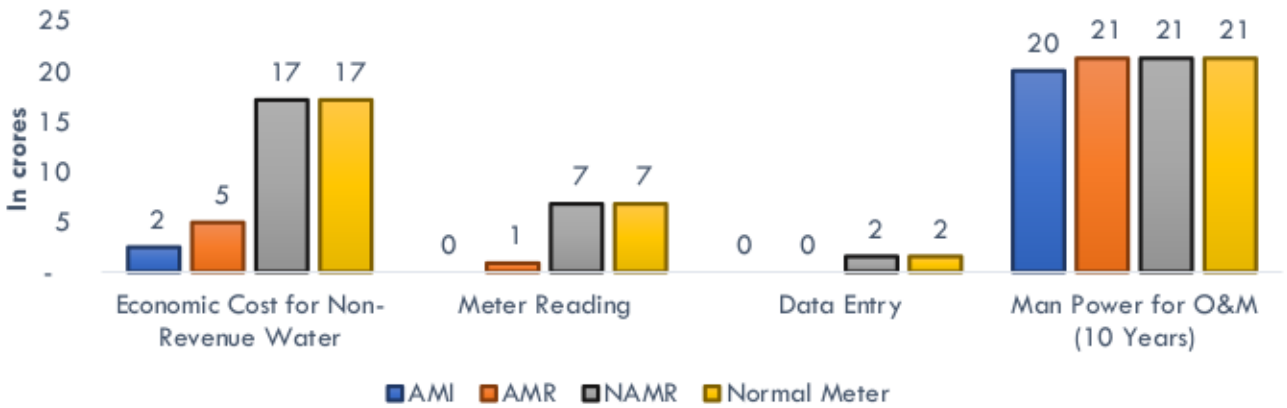


Figure 6: Comparative Analysis of Water Meter Types

From (Figure 6), it is seen that normal mechanical meters and NAMR systems have high manpower cost for O&M equivalent to 21.31 crores and high NRW loss amounting to INR 17.16 crores. Additionally, these meters have meter reading cost of 6.77 crores, and data entry cost of 1.53 crores, respectively.

Whereas, in case of AMR systems, though the manpower for O&M cost is like normal meters, the meter reading cost has reduced considerably to 84.63 lakhs from 6.77 crores, and no data entry cost for ten-year period. And the NRW loss comes down to 4.9 crores. Similarly, for AMI systems, though the manpower for O&M cost is equivalent to 20.06 crores, there is no cost for meter reading and data entry. With respect to NRW loss, it is 2.45 crores for ten-year period when compared to high NRW loss of other water meter types. Therefore, from the comparative analysis of these water meter types, it is evident that AMI water metering systems with total cost amounting to 98.71 crores for ten-years period, are cost-effective in the long run and has far more benefits than other water metering systems.

5.6 Benefits of AMI Systems

1

Variable Pricing Structures

AMI enables price structures to better align to customer usage – so those consuming energy at peak times are charged more.

2

Improved Data Quality

Automated, remote data collection streamlines the back office processing for billing, asset management and outage management.

3

Shorter Billing Cycle

Replacing the traditional meter reading with AMI shortens the billing process by reducing the time and the number of steps between consumer usage and bill distribution.

4

Reduced Load In Call Centers

Accurate remote data collection and interactive voice response (IVR) technology can replace long hold times with instant, automated information.

5

Customer Intelligence

AMI technology offers valuable insight into customer usage, including consumption behavior, effects of external variables and outages. data, etc.

6

Revenue Protection

AMI data can be used effectively to reduce theft. Load profiling can identify "strange" usage patterns (e.g. zero usage on weekends).

7

New Revenue Streams

AMI provides opportunities to turn knowledge into a competitive advantage. Energy and water providers need to look beyond their traditional roles as a conduit for utilities in order to generate new revenue streams.

6. Conclusion

It is evident that water meter types play a major role in financial sustainability, revenue collection, overall consumer satisfaction and successful functioning of a water supply system over its intended life span. Meters are the cash registers of a water supply utility. Since water meters are the essential component in a water supply project, cheap initial cost should not be the only criteria for the installation of water meter types. The water meters should have proper quality with appropriate technology, vendor's guarantee, digitization of data, automation of the collection process, efficient and robust meter reading, and effective bill generation aspects for a longer duration. Some of the major conclusions include the following. Meters with lesser initial cost may not be cost effective over the period of its lifespan due to factors such as wear and tear of the equipment, inflation charges applied if the meters must be replaced within limited period, etc.

It is equally important that water utilities provide timely and precise information, which can be accessed using user-friendly equipment or means. Having an automated metering system is crucial, as the existing manual processes are automated, operational costs becomes negligible, and accessing real-time data that will enable the performance of the entire utility system. Metering systems are successful when they are installed, operated and maintained by the vendor right from procurement to publishing (P2P) of bills and bill distribution over a longer duration of about ten years. With consumer grievance redressal mechanisms, it is highly predictable that metering systems will be successful.

AMI systems have far more benefits than AMRs and other mechanical water meters. The high initial cost of AMI systems will be offset by its value addition and reduction in NRW in five years' period. Long term accuracy and reduction in NRW will be the key factor, which can contribute to increased revenue. As the data can be analysed and graphically represented, AMI systems have high impact in creating consumer awareness among the water users, and at the same time, utility stakeholders can have deep insights on water supply and its conservation efforts.

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Annexure

Annexure 1: NRW of Moga District-2018

Sr	Scheme name	Block	Source	Op By	LPCD	Sanctioned Load	Pump Hrs ACTUAL from SDE	Discharge of pump in LPH	Daily water production (in KL)	Private conn	HH size	Daily Revenue water (KL)	Daily NRW (in KL)	%age of NRW
	1	2	3	4	5	6		9	10=(9*8)/1000	11	12	13	14	15
1	Bambiha Bhai (TW1345)	Bagha Purana	TW	DWSS	70	11.27	5	41800	209	215	5.28	79	130	61.98
2	Budh Singh Wala (TW14312)	Bagha Purana	TW	DWSS	70	9.85	8.50	40500	344	186	5.27	68.62	276	80.07
3	Gholia Khurd (TW16159)	Bagha Purana	CANAL	DWSS	70	22.66	4	86000	344	362	5.23	132.53	211	61.47
4	Kotla Mehar Singh (TW3244)	Bagha Purana	TW	DWSS	70	5.83	7	49500	347	206	5.3	76.43	270	77.94
5	Saho Ke (TW4436)	Bagha Purana	TW	DWSS	70	11.51	5	40800	204	238	4.61	76.80	127	62.35
6	Sangatpura (TW4505)	Bagha Purana	TW	DWSS	70	15.72	4	42400	170	187	5.45	71.34	98	57.94
7	Thraj (TW4871)	Bagha Purana	TW	DWSS	70	17.48	4	83000	332	348	5.34	130.08	202	60.82
1	Bagge (TW10065)	Dharamkot	TW	DWSS	40	6.25	4	8600	34	36	5.6	8.06	26	76.56
2	Bhaini (TW10066)	Dharamkot	TW	DWSS	40	6.54	2	50000	100	65	5.2	13.52	86	86.48
3	Bhinder Kalan (TW10055)	Dharamkot	TW	DWSS	40	12.07	5	27500	138	115	5.15	23.69	114	82.77
4	Bhinder Khurd (TW10056)	Dharamkot	TW	DWSS	40	11.77	5	13500	68	140	5.11	28.62	39	57.61
5	Ch Kanian Kalan (TW15029)	Dharamkot	TW	DWSS	40	4.85	6	15000	90	63	5.58	14.06	76	84.38
6	Chak Singh Pura (TW10073)	Dharamkot	TW	DWSS	40	5.81	2	**4500**	9	44	4.73	8.32	1	7.50
7	Chugha Kalan (TW10067)	Dharamkot	TW	DWSS	40	7.54	8	30500	244	150	5.01	30.06	214	87.68
8	Chuhar Chak (TW2022)	Dharamkot	TW	DWSS	40	5.87	8	22500	180	146	5.01	29.26	151	83.75
9	Daya Kalan & Danu Wala (TW2120)	Dharamkot	TW	DWSS	40	9.98	6	**13650**	82	143	5.36	30.66	51	62.57
10	Dholle Wala (TW10068)	Dharamkot	TW	DWSS	40	12.34	4	28000	112	97	5	19.40	93	82.68
11	Fatehgarh Panjtoor (TW2353)	Dharamkot	TW	DWSS	70	13.47	8	42000	336	509	5.55	197.75	138	41.15
12	Ferozewal Mangal Singh (TW10069)	Dharamkot	TW	DWSS	40	9.28	2	29000	58	215	5.14	44.20	14	23.79
13	Galoti (TW16116)	Dharamkot	TW	DWSS	40	11	5	44000	220	159	5.3	33.71	186	84.68
14	Janer (TW10071)-A	Dharamkot	TW	DWSS	40	5.8	3	34500	104	133	5.26	27.98	76	72.96
	Janer (TW10071)-B		TW	DWSS	40	7.8	2	34500	69	133	5.26	27.98	41	59.44
16	Kadar Wala (TW10075)	Dharamkot	TW	DWSS	40	11.95	4	25500	102	35	5.18	7.25	95	92.89
17	Kanwan (TW10074)	Dharamkot	TW	DWSS	40	9.65	3.50	25000	88	107	4.9	20.97	67	76.03
18	Karyal (TW7542)	Dharamkot	TW	DWSS	40	9.74	5	45000	225	215	5.2	44.72	180	80.12
19	Kot Ise Khan (TW3207)-A	Dharamkot	TW	DWSS	40	37.8	5	41800	209	268	5.65	60.57	148	71.02
20	Kot Ise Khan (TW3207)-B		TW	DWSS	40	17.16	5	41800	209	268	5.65	60.57	148	71.02
21	Kot Sadar Khan (TW10079)	Dharamkot	TW	DWSS	40	11.27	2.50	**17350**	43	169	5.35	36.17	7	16.62
22	Mander Kalan (HP3624)	Dharamkot	TW	DWSS	40	6.75	4	16000	64	31	5.01	6.21	58	90.29
23	Masitan (TW10078)	Dharamkot	TW	DWSS	40	15.43	6	53000	318	138	5.6	30.91	287	90.28
24	Mauj Garh (TW3695)	Dharamkot	TW	DWSS	40	11.14	4	43000	172	90	5.79	20.84	151	87.88
25	Nihal Garh (TW10081)	Dharamkot	TW	DWSS	40	14.92	2	16800	34	25	4.91	4.91	29	85.39
26	Raniala (TW10082)	Dharamkot	TW	DWSS	40	9.8	4	37700	151	144	5.11	29.43	121	80.48
27	Rerhwan (TW10061)	Dharamkot	TW	DWSS	40	5.67	6	11000	66	165	5.46	36.04	30	45.40
28	Talwandi Mallian (TW4790)	Dharamkot	TW	DWSS	40	16.32	3	58000	174	326	5.05	65.85	108	62.15
1	Ajit Wal (TW1099)-A	Moga-I	TW	DWSS	70	14.21	7	87500	613	428	5.16	154.59	458	74.76
	Ajit Wal (TW1099)-B		TW	DWSS	70	15.42	7	87500	613	428	5.16	154.59	458	74.76
2	Budh Singh Wala (TW1751)	Moga-I	TW	DWSS	70	6.17	8	23000	184	218	5.1	77.83	106	57.70
3	Butter Kalan (TW7564)	Moga-I	TW	DWSS	40	15.02	7	**68193**	477	78	5.6	17.47	460	96.34
4	Dosanj (TW2307)	Moga-I	TW	DWSS	70	10.22	8	30000	240	187	5.36	70.16	170	70.77
5	Mallian Wala (TW3548)-A	Moga-I	TW	DWSS	70	3.73	8	31000	248	284	5.13	101.98	146	58.88
	Mallian Wala (TW3548)-B		TW	DWSS	70	5.97	8	31000	248	284	5.13	101.98	146	58.88
6	Mehna (TW3734)	Moga-I	TW	DWSS	70	13.62	6	77000	462	446	4.9	152.98	309	66.89
7	Nathuwala Jadid (TW10004)	Moga-I	TW	DWSS	40	15.38	8	**13600**	109	216	5.6	48.38	60	55.53
8	Ramu Wala Kalan (TW4295)-A	Moga-I	TW	DWSS	70	9.32	6	38200	229	72	5.44	27.42	202	88.04
	Ramu Wala Kalan (TW4295)-B		TW	DWSS	70	9.82	8	38200	306	72	5.44	27.42	278	91.03
9	Takhan Wadh (TW9997)	Moga-I	TW	DWSS	40	15.05	5	**25200**	126	215	4.93	42.40	84	66.35
1	Bukan Wala (TW1765)	Moga-II	TW	DWSS	70	8.84	12	11500	138	167	5.05	59.03	79	57.22
2	Chotta Ghar (TW2008)	Moga-II	CANAL	DWSS	70	22.19	5	**14010**	70	67	5.24	24.58	45	64.92
3	Dagru (TW2058)	Moga-II	TW	DWSS	70	8.76	11	47500	523	218	5.59	85.30	437	83.67
4	Daulatpura Niwan (TW2113)	Moga-II	TW	DWSS	70	12.49	6	46200	277	541	5.47	207.15	70	25.27
5	Kore Wala Kalan (TW3190)	Moga-II	TW	DWSS	70	9.91	6	17300	104	61	5.72	24.42	79	76.47
6	Maheshari (TW3481)	Moga-II	TW	DWSS	70	5.84	6	42000	252	201	5.19	73.02	179	71.02
7	Saffu Wala (TW4421)	Moga-II	TW	DWSS	70	18.97	8	52000	416	247	6.7	115.84	300	72.15
1	Bir Rau Ke (TW1698)	Nihal Singh Wala	TW	DWSS	70	6.75	8	39000	312	195	5.31	72.48	240	76.77
2	Didare Wala (TW2285)	Nihal Singh Wala	TW	DWSS	70	4.20	7	23900	167	306	5.48	117.38	50	29.84
							317	**2057503**	651200	**10802**	**296**	**3353**	**8406**	68

Annexure

Annexure 2: Cost Analysis of Water Meter Types

1. AMI Water Meters										
Description	Supply and Installation of AMI Meters	Water Meter Box	Spare meters (10 years)	IT & Billing Works (Hardware + Software)	Man Power for O&M (10 Years)	Test Bench	Economic Cost for Non-Revenue Water (NRW)	Total Cost (per year)	Total Cost (10 years)	
Quantity	60000	60000	1500	1		1				
Unit	Nos.	Nos.	Nos.	Package		Nos.				
Rate	9504.26	514	9504.26	3383775		2000000				
1st Year Cost	570255600	30840000	1425639	338377.5	20067772.9	2000000	10395000	635322389.4	635322389.4	
2nd Year Cost	0	0	1425639	338377.5	20067772.9	0	11434500	33266289.4	668588678.8	
3rd Year Cost	0	0	1425639	338377.5	20067772.9	0	12577950	34409739.4	702998418.2	
4th Year Cost	0	0	1425639	338377.5	20067772.9	0	13835745	35667534.4	738665952.6	
5th Year Cost	0	0	1425639	338377.5	20067772.9	0	15219319.5	37051108.9	775717061.5	
6th Year Cost	0	0	1425639	338377.5	20067772.9	0	16741251.45	38573040.85	814290102.4	
7th Year Cost	0	0	1425639	338377.5	20067772.9	0	18415376.6	40247166	854537268.3	
8th Year Cost	0	0	1425639	338377.5	20067772.9	0	20256914.25	42088703.65	896625972	
9th Year Cost	0	0	1425639	338377.5	20067772.9	0	22282605.68	44114395.08	940740367.1	
10th Year Cost	0	0	1425639	338377.5	20067772.9	0	24510866.25	46342655.65	987083022.7	
Total Amount	570255600	30840000	14256390	3383775	200677729	2000000			987083022.7	

2. AMR Water Meters										
Description	Supply and Installation of AMR Meters	Water Meter Box	Spare meters (10 Years)	Meter Reading	IT & Billing Works (Hardware + Software)	Man Power for O&M (10 Years)	Test Bench	Economic Cost for Non-Revenue Water (NRW)	Total Cost (per year)	Total Cost (10 years)
Quantity	60000	60000	1500	60000	1		1			
Unit	Nos.	Nos.	Nos.	Nos.	Package		Nos.			
Rate	7600	514	7600		3383775		2000000			
1st Year Cost	456000000	30840000	1140000	531000	338377.5	21308254.6	2000000	20790000	532947632.1	532947632.1
2nd Year Cost	0	0	1140000	584100	338377.5	21308254.6	0	22869000	46239732.1	579187364.2
3rd Year Cost	0	0	1140000	642510	338377.5	21308254.6	0	25155900	48585042.1	627772406.3
4th Year Cost	0	0	1140000	706761	338377.5	21308254.6	0	27671490	51164883.1	678937289.4
5th Year Cost	0	0	1140000	777437.1	338377.5	21308254.6	0	30438639	54002708.2	732939997.6
6th Year Cost	0	0	1140000	855180.81	338377.5	21308254.6	0	33482502.9	57124315.81	790064313.4
7th Year Cost	0	0	1140000	940698.891	338377.5	21308254.6	0	36830753.19	60558084.18	850622397.6
8th Year Cost	0	0	1140000	1034768.78	338377.5	21308254.6	0	40513828.51	64335229.39	914957627
9th Year Cost	0	0	1140000	1138245.658	338377.5	21308254.6	0	44565211.36	68490089.12	983447716.1
10th Year Cost	0	0	1140000	1252070.224	338377.5	21308254.6	0	49021732.5	73060484.82	1056508151
Total Amount	456000000	30840000	11400000	8462772.463	3383775	213082546	2000000			1056508151

3. NAMR Water Meters (Compatible IP68 Grade)											
Description	Supply and Installation of NAMR Meters	Water Meter Box	Spare meters (10 Years)	Meter Reading	Data Entry (after Meter Reading)	IT & Billing Works (Hardware + Software)	Man Power for O&M (10 Years)	Test Bench	Economic Cost for Non-Revenue Water	Total Cost (per year)	Total Cost (10 years)
Quantity	60000	60000	1500	60000	nos	1		1			
Unit	Nos.	Nos.	Nos.	Nos.	Man Days	Package		Nos.			
Rate	2800	514	2800			3383775		2000000			
1st Year Cost	168000000	30840000	4200000	4248000	960000	338377.5	21308254.6	2000000	72765000	300879632.1	300879632.1
2nd Year Cost	0	0	4200000	4672800	1056000	338377.5	21308254.6	0	80041500	107836932.1	408716564.2
3rd Year Cost	0	0	4200000	5140080	1161600	338377.5	21308254.6	0	88045650	116413962.1	525130526.3
4th Year Cost	0	0	4200000	5654088	1277760	338377.5	21308254.6	0	96850215	125848695.1	650979221.4
5th Year Cost	0	0	4200000	6219496.8	1405536	338377.5	21308254.6	0	106535236.5	136226901.4	787206122.8
6th Year Cost	0	0	4200000	6841446.48	1546089.6	338377.5	21308254.6	0	117188760.2	147642928.3	934849051.1
7th Year Cost	0	0	4200000	7525591.128	1700698.56	338377.5	21308254.6	0	128907636.2	160200558	1095049609
8th Year Cost	0	0	4200000	8278150.241	1870768.416	338377.5	21308254.6	0	141798399.8	174013950.5	1269063560
9th Year Cost	0	0	4200000	9105965.265	2057845.258	338377.5	21308254.6	0	155978239.8	189208682.4	1458272242
10th Year Cost	0	0	4200000	10016561.79	2263629.783	338377.5	21308254.6	0	171576063.7	205922887.4	1664195129
Total Amount	168000000	30840000	42000000	67702179.71	15299927.62	3383775	213082546	2000000			1664195129

4. Normal Mechanical Water Meters											
Description	Supply Cost	Water Meter Box	Spare meters (10 years)	Meter Reading	Data Entry (after Meter Reading)	IT & Billing Works (Hardware + Software)	Man Power for O&M (10 Years)	Test Bench	Economic Cost for Non-Revenue Water	Total Cost (per year)	Total Cost (10 years)
Quantity	60000	60000	1500	60000	nos	1		1			
Unit	Nos.	Nos.	Nos.	Nos.	Man Days	Package		Nos.			
Rate	6714.154353	514	6714.154353			3383775		2000000			
1st Year Cost	108600000	30840000	10071231.53	4248000	960000	338377.5	21308254.6	2000000	72765000	242066755.3	242066755.3
2nd Year Cost	0	0	10071231.53	4672800	1056000	338377.5	21308254.6	0	80041500	108424055.3	350490810.5
3rd Year Cost	86794506.24	0	10071231.53	5140080	1161600	338377.5	21308254.6	0	88045650	203795591.5	554286402
4th Year Cost	0	0	10071231.53	5654088	1277760	338377.5	21308254.6	0	96850215	126435818.3	680722220.3
5th Year Cost	0	0	10071231.53	6219496.8	1405536	338377.5	21308254.6	0	106535236.5	136814024.6	817536244.8
6th Year Cost	97632015.47	0	10071231.53	6841446.48	1546089.6	338377.5	21308254.6	0	117188760.2	245862067	1063398312
7th Year Cost	0	0	10071231.53	7525591.128	1700698.56	338377.5	21308254.6	0	128907636.2	160787681.1	1224185993
8th Year Cost	0	0	10071231.53	8278150.241	1870768.416	338377.5	21308254.6	0	141798399.8	174601073.7	1398787067
9th Year Cost	109822739.4	0	10071231.53	9105965.265	2057845.258	338377.5	21308254.6	0	155978239.8	299618545	1698405612
10th Year Cost	0	0	10071231.53	10016561.79	2263629.783	338377.5	21308254.6	0	171576063.7	206510010.6	1904915622
Amount	402849261.2	30840000	100712315.3	67702179.71	15299927.62	3383775	213082546	2000000			1904915622

***The basic rate of different water meter types have been given by the Department of Water Supply and Sanitation (DWSS), Government of Punjab after careful consideration from the vendors in the market and from previous water meter projects across the country.*