REGULATED INDUSTRIES COMMISSION

Universal Water Metering in Trinidad and Tobago - A Concept Outline

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This paper explores universal water metering as a demand side management measure for water distribution in Trinidad and Tobago.

Consultative Document

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GLOSSARY

AMI - Advanced Metering Infrastructure
AMR - Automatic Meter Reading
ARV - Annual Rateable Value
CO^2 – Carbon Dioxide
GWh – Gigawatt Hours
MGD – Millions of Gallons per Day
Mm^3 – Millions cubic metres
MPU - Ministry of Public Utilities
NRW - Non-Revenue Water
RIC - Regulated Industries Commission
T&TEC - Trinidad and Tobago Electricity Commission
WASA - Water and Sewerage Authority of Trinidad and Tobago

1.0 Background

Since the 1970's, customers of WASA have received an unreliable supply of water. The number of customers connected to the water supply network has grown over the years without a commensurate increase in the size of the transmission and distribution mains. As a consequence, customers often have had to resort to expensive means of coping, such as installing water tanks and pumps, and purchasing private supplies. This situation is primarily the result of a network with inadequate capacity to provide a continuous supply of water to all customers simultaneously, coupled with a flat rate tariff for most customers that is not based on volumetric consumption. This is further exacerbated by the fact that only 4% of customers were metered by 2015[1] (see box 1). Consequently, there are high levels of water consumption and wastage by customers that cannot be accounted for by WASA.

Box 1: Breakdown of WASA's Metered and Unmetered Customers in 2015

Customer Classification	Numbers of Customers		
	Metered	Unmetered	Total
Domestic	10,100	386,118	396,218
Charitable Institution	57	1,842	1,899
Industrial	344	80	424
Commercial	5,405	3,430	8,835
Cottage	744	2,484	3,228
Agricultural	473	700	1,173
(Percentage%)/Total	**(4%) 17,123**	**(96%) 394,654**	**411,777**

Addressing water supply shortages through the use of demand side management measures[2] (which reduce consumption) is considered to be more environmentally and economically prudent than employing supply side management measures[3].

1.1 Purpose of the Document

This paper examines possible approaches to the implementation of universal water metering as a measure to minimise water losses and wastage throughout WASA's network.

1.2 Responding to this Document

In keeping with the RIC's obligation to consult, stakeholders are invited to comment on this document. Responses to the specific questions asked in this document, and any other issues which respondents believe should be considered by the RIC, should be sent in writing by **4:00 p.m. on July 11, 2018** to:

Executive Director
Regulated Industries Commission
Furness House – 1st & 3rd Floors
Cor. Wrightson Road and Independence Square
Port-of-Spain, Trinidad

Postal Address: P.O. Box 1001, Port-of-Spain, Trinidad

Tel. : 1(868) 625-5384; 627-7820; 627-0821; 627-0503
Fax : 1(868) 624-2027
Email : riconsultation@ric.org.tt
Website : www.ric.org.tt

All responses will normally be published on the RIC's website unless there are good reasons why they must remain confidential. Any requests for confidentiality must be indicated. A copy of this document is available from the RIC's website at **www.ric.org.tt.**

2.0 Universal Water Metering

2.1 Introduction

The Regulated Industries Commission (RIC) is responsible for setting price controls for the water and wastewater sector and does so within a regulatory framework that is governed by the Regulated Industries Commission Act No. 26, 1998 (RIC Act). In this regard, the RIC is undertaking a rate review for WASA for the control period 2018-2023. A key element of the review process is to provide incentives to improve the efficiency of the service provider's operations and to reduce its costs.

The Water and Sewerage Authority of Trinidad and Tobago (WASA) is the sole supplier and distributor of pipe borne water in Trinidad and Tobago. In 2015, WASA produced approximately 382 million cubic metres ($382Mm^3$) of water that was distributed to approximately 411,777 customers[4] and reported that approximately 51% of the water captured ($191Mm^3$) was lost due to various factors, such as theft and leakage. The difference between the volume of water supplied and the quantity of water billed to consumers is classified as non-revenue water (NRW), as this water is unaccounted and no revenue is earned from its production and distribution to consumers. It has also been reported that a large percentage of the water lost was due to leaks on customers' premises[5]. Metered consumption ($66Mm^3$) accounted for 17% of the water produced in 2015. Note that this volume of water was consumed by 4% of WASA's customers. WASA provided a scheduled supply of water to approximately 191,500 customers (46.5%) in 2015.

Reducing NRW is important to overall efficiency and financial sustainability of the utility, as it reduces the costs to service customers. The RIC is of the view that a universal water metering programme in Trinidad and Tobago is critical towards reducing WASA's high level of NRW. Over the years, stakeholders in Trinidad and Tobago (the Government, Utility, Regulator and Customers) have discussed water metering as a crucial demand side management measure but it was never implemented as a primary strategy even though WASA had established a Metering Department with a view towards implementing metering at the supply, transmission and distribution levels of its network.

Universal water metering is the installation of meters at the premises of all customers coupled with the implementation of a volumetric tariff structure for the purpose of billing customers for consumption. It

is a fair way of billing customers, as they pay for only what they consume. This in turn facilitates the development of cost reflective tariffs and sends the appropriate price signal to consumers about the value of the commodity. In Trinidad and Tobago, universal water metering has been considered for many years; however, there has been a lack of action due to issues, such as, the associated high capital costs, the magnitude of the project works, the anticipated critical reactions by customers and the potential loss of revenue given existing tariffs and the intermittent supply of water to customers.

2.2 Benefits of Universal Water Metering

Several benefits can be derived from the introduction of a universal water metering program (Declan 1992). These include:

- Conservation of this valuable resource.
- Fairness. Metering is the most equitable way to set tariffs whereby customers pay in relation to their volume of usage and not according to a system that does not correlate to their consumption.
- Reduction of water consumption in the order of 15-50%. This in turn results in:
    - the corresponding reduction in the annual operating and maintenance costs for the water system.
    - the deferment of the capital costs of upgrading and expansion of water production facilities.
    - the deferment of the capital costs of upgrading and expansion of sanitary sewer system facilities.
- Monitoring of water loss, and improved efficiency in water system operation.
- More reliable projection of future upgrade of pumping and storage facilities.
- Reduction in negative environmental impact on watersheds; stream flow during the dry season; capacity of sewage and effluent disposal systems. Existing onsite sewage treatment disposal facilities such as septic tanks and disposal fields can be expected to last longer and require less repairs if indoor water consumption is reduced.

Some utilities however, have chosen not to install water meters. The perceived disadvantages of implementing a metering program relate to:

- **Capital Costs.** Initial outlay can be prohibitive, dampening any enthusiasm to carry out metering.
- **Tariff Setting.** For water meters to be worthwhile, the water rates must not be so low as to negate conservative water use. If it is the state's policy/mandate to maintain low water rates, then universal metering will not be successful in promoting the economical use of water.
- **Affordability.** There is a perception that metering is unfair to some customers, as low income with large families may have to pay costs they cannot afford. However, this can be addressed with a proper tariff structure designed to accommodate this category of customer.
- **Societal Reaction.** Customers typically view access to low cost water as a right, thus implementation of metering may result in customer dissatisfaction and critical reaction. This may be an important consideration for the State.

While being mindful of the constraints highlighted above, the implementation of universal water metering to properly account for water usage, in conjunction with cost reflective tariffs, provides opportunities to reduce consumption/demand, thus forestalling the need for high capital expenditure to develop new sources of water[6]. Clearly, the benefits of implementing universal metering appear to more than offset its disadvantages and should therefore be seriously considered.

2.3 Major Considerations

2.3.1 Water Consumption

Historically, universal water metering has led to reduced water consumption when tied to an appropriate pricing regime based on measured use. The following is a summary of consumption change scenarios after metering had been implemented in various jurisdictions:

- South-east England - Research done by the University of Southampton has shown that demand for water decreased by 16.5% after a five-year programme to install nearly 500,000 meters between the years 2011-2016.

- New Zealand - Tauranga City Council achieved an average demand reduction of 25% and a peak day reduction of 30% with the implementation of universal metering and volumetric pricing while the city of Nelson achieved a 37% reduction in peak demand.
- Rostock, Germany - The French company Lyonnaise des Eaux managed to cut consumption by 67% (Markandya, 2004).
- Baltic States - The introduction of higher tariffs led to reductions in demand of around 50% (Markandya, 2004).
- Grenada - While there are no definitive figures, the metering of domestic supply has radically altered the way that the general public perceives and uses water. Water is now valued as a commodity rather than consumed as a right (Krishnarayan, 2002).
- St Vincent and the Grenadines - The Water Authority was able to improve the reliability of its supply because metering led to a reduction in the demand for water, thus allowing it to improve the reliability of its supply in the dry season thereby eliminating water shortages.

2.3.2 Tariffs

Water rates for unmetered users in Trinidad and Tobago are based on the Annual Rateable Value (ARV) of the customer's premises. This is a valuation which is assessed by the State for tax purposes. By applying tariff charges based on the ARV, the charge is seemly oriented towards the customer's ability to pay rather than for the amount of water used (Declan 1992). Consequently, there is no incentive to conserve water.

For utilities that employ metering charges for the volume of water used by the customer, pricing regimes are generally set to incentivise the more efficient consumption of water. This is consistent with the use of metering as a conservation strategy and the global desire to reduce the wastage of water. This however, must be balanced with the customer's ability to pay for water while also ensuring that rates are not set beyond what can be considered a reasonable figure, which is usually an acceptable percentage of a person's monthly income.

2.3.3 Environmental Considerations

Additional demands for water due to increased consumption can have significant adverse effects on the environment. Increased water abstractions from aquifers, rivers and lakes make less water available for wildlife and aquatic life. The construction of new water schemes is no longer viewed favourably especially by environmentalists. The latter submit that proper demand side management is required to reduce demand so that the introduction of large water abstraction schemes can be minimised. The option of metering and the water conservation that is consequently achieved is thus desirable.

2.3.4 Private Sector Participation

Many state run water utilities suffer from low revenues and little capital investment. As such, they can have great difficulty in funding a project, such as universal metering, which can cost hundreds of millions of dollars. Concomitant with this is the constant pressure to improve water service delivery levels. The participation of the private sector in executing metering projects under performance contracts is one option that is currently being considered to deal with this dilemma. Private sector firms while reluctant to provide "over the counter" services to utilities that have not always paid their bills on time are more willing to participate in contracts that are guaranteed by the State and which enable them to be compensated through the revenue streams generated by the operations they are involved in. This approach is also viewed favorably by the State.

There are also benefits for the utility. The private sector firm can meet the initial capital costs thus freeing the utility from sourcing the funding itself. Private sector technological expertise is gained in the particular area and passed on to utility staff. The outsourcing of the project would also be a way of shortening and improving what could be a cumbersome procurement and installation process, and overcoming utility capacity constraints.

2.3.5 Customer Attitudes

Customer attitudes have been mixed about metering. Customers in the United Kingdom who paid high rates due to a high ARV for their properties, and who used small amounts of water, such as couples or elderly persons welcomed metering, as it resulted in lower bills[7]. Anecdotal evidence in Trinidad and

Tobago seems to suggest the same, as a number of customers have reported a reduction in their bills after switching from ATV billing to receiving a metered bill.

Other customers may be suspicious of metering, as they fear higher charges if meters are installed. This may be the case where there is high personal usage for swimming pools and water sprinklers. Where water is considered an entitlement rather than a commodity, customers generally may be reluctant to accept metering, as they perceive it to be an attempt to impose higher tariffs. For example, in Salta province, Argentina there was initial reluctance to metering - consumers refused to accept the installation of meters and there was also meter tampering and protests.[8]

Compulsory metering is also an issue with some communities refusing outright to have such a scheme implemented. In Calgary, Canada for example, the city's proposal for universal metering was defeated on three occasions over a period of 30 years[9]; while representatives in the city of Sacramento, USA have continuously resisted mandated water metering.[10] Public education about the benefits of metering is often a necessary prerequisite for a successful launch of a universal metering programme, as customers are sometimes not amenable to mandatory metering.

In the UK one of the main reasons customers opt for being charged on a volumetric basis is to save money. A water company reported that on average, customers who opted for metering saved over 100 pound sterling (TT$969) per year on their combined water and sewerage bill[11]. While there will always be some consumer opposition to metering, the benefits to be derived by the utility and customers from reduced water consumption is generally much greater than the cost.

2.3.6 Voluntary Customer Participation

A voluntary approach to metering was pursued in the United Kingdom where households were free to choose to have a meter installed at no cost[12]. Those customers also had the option to revert to a flat rate after one year if dissatisfied with cost savings. Under this programme, households had recorded lower consumption levels after metering. Voluntary programmes can support water conservation; however, low uptake can result in higher installation costs due to the purchase of lower quantities of materials and the inability to postpone costly water abstraction projects are major drawbacks.

2.3.7 Feasibility Studies

Feasibility studies must be performed to assess whether a metering programme is worth pursuing as a major undertaking. The typical costs incurred are for the purchase of meters and ancillary materials, installation and maintenance costs as well as the administrative costs inclusive of a public relations campaign. These costs can be weighed against the tangible benefits of metering which include the utility savings from reduced water consumption - deferred costs for water schemes and decreased treatment and distribution costs for both water and wastewater.

What are your views of the need to employ demand management measures in water transmission & distribution sector of Trinidad and Tobago?

What are your views of the benefits, disadvantages and considerations presented with respect to universal water metering?

Are there other issues that should be addressed?

3.0 Trinidad and Tobago Scenario

Based on the benefits associated with water metering and the positive outcomes shown in other jurisdictions, the RIC is of the view that due consideration must be given to the implementation of a universal water metering programme as a demand management measure in Trinidad and Tobago. The RIC notes that some of the main reasons to date for the failure to execute a universal water metering programme throughout the Water Distribution Sector in Trinidad and Tobago are the:

- High initial capital cost.
- High cost to individual customers.
- Intermittent water supply issues.
- Lack of enthusiasm by the political directorate.
- Loss of revenue under current rates and poor quality of service.

Universal metering, as previously discussed, in conjunction with appropriate tariffs can signal to customers the true value of consumed water. Only properly set measured charges can incentivise consumers to economise water usage, since the common tendency is for consumers to relate bills to the amount of water used. Hence, the RIC is of the view that an innovative approach is needed to implement a universal metering strategy in Trinidad and Tobago.

Both manual water meter reading and automatic water meter reading are presently practiced on very small scales in Trinidad and Tobago. Manual water meter reading occurs in various locations and is labour intensive. It is subject to human error and readings are sometimes difficult to carry out when the meters are installed within customers' premises where there is limited/restricted access to the meter. Automatic water meter reading of industrial customers is established in the Point Lisas Industrial Estate. WASA, therefore, has some experience with metering technology in conjunction with the processing of analogue and digital metering data and the generation of bills. This institutional experience would be valuable in the formulation of a universal metering programme.

The following four (4) technical options can be considered with respect to relaying readings from suitably equipped meters to the facility where customers' bills will be generated:

1. Manual system in which meter readers visit each customer's premises to take readings;
2. Reading installed meters programme (based on Remote Meter Reading[13] technology) with mobile devices and relaying the data to WASA for bill processing;
3. Installing standalone Automatic Metering Infrastructure (AMI) for WASA's sole use; and
4. Utilizing the AMI network of the Trinidad and Tobago Electricity Commission (T&TEC) for the transmission of metering data.

The costs for implementing each of the above systems are presented in table 2 and detailed cost computations are presented in Appendix I. It should be noted that use of mobile read or automatically read systems may not totally eliminate manual meter reading, as there may be areas of poor signal strength that will require manual meter readings. The choice of an Automatic Meter Reading (AMR) system will depend on the availability of funding, physical layout of terrain, whether urban or rural communities and customer type. The need for integration of all the different methodologies may have to be considered.

3.1 Implementation Strategy Considerations

Given the constraints listed above, the RIC proposes the following four (4) components as key to implementing universal metering locally:

1. The adoption of a fast track approach.
2. The outsourcing of the metering function as a service to be undertaken by the private sector.
3. The use of an open tendering process for the selection of an optimal number of contractors/companies.
4. The implementation and review of pilot programmes to supplement earlier studies before a full metering programme is rolled out. Pilot studies were carried out several years ago, including the installation of 400 AMR meters for residential customers in Bacolet and Calder Hall, Tobago, and the installation of 8,000 meters nationwide for commercial and industrial customer.

3.1.1 Fast Track Approach

For maximum economic and customer service benefits, the adoption of a fast track approach is highly recommended. With this approach, metering can be implemented throughout Trinidad and Tobago over a period of four to six years versus ten years and longer if traditional approaches and resources are utilized. The main issues arising from a fast track approach include:

i. Impact on revenues

WASA has contended that universal metering will result in a decrease in revenues for the utility and has argued for staggered implementation in order to minimize the impact on revenue. However, while revenues may initially fall, the anticipated reduction in metered customers' water consumption will delay the need for new water sources and the attendant capital and operating costs. Presently, it is projected that approximately TT$107M would be required by WASA for the refurbishment and expansion works to water production facilities[14]. Future net revenues may consequently increase once universal metering is fully deployed and the anticipated behavioural change in consumption is achieved.

ii. Optimum level of metering

The demand for water can be reduced through the installation of meters which results in the inherent benefit of being able to defer water supply expansion costs. Metering is therefore useful in equating demand with supply. The optimal level of metering can be achieved when demand is reduced to current supply levels.

iii. Duration of the installation exercise

Because of the general absence of meters in the water infrastructure network in Trinidad and Tobago, a major effort will be required to install a significant number of meters throughout the country. This includes visits to premises, installation of meters, informing the public of the program and gaining the confidence of customers. It will be beneficial to implement the programme in the shortest possible time rather than over a prolonged period, in order to maintain a high level of public interest and limit the risk of the programme losing momentum and being critically regarded by the public.

Box 2: Experiences gained from metering projects carried out in T&T

Several metering projects have been carried out by the utilities, inclusive of two pilot projects in the water sector and a major AMI project in the electricity sector. The lessons learnt from these projects are:

- The development of a proper Business Case allows for "buy-in" from key stakeholders.
- A thorough examination of the implementation process helps identify the risks involved with execution.
- Pilot projects served to identify issues that were overlooked at the development stage.
- Consumers should be advised to take keen interest in the implementation phase as their engagement helps to facilitate the process and minimize problems.
- Project governance benefited from a greater presence of dedicated project management expertise, definition and execution.
- A comprehensive Communication Strategy should be developed.
- Contract administration procedures should be comprehensive enough to limit negative installation issues.
- Project Accounting has to be more timely and schedule driven.

3.1.2 Outsourcing Project Execution

Employing private contractors to procure, install, maintain and read meters under performance contracts can benefit publicly owned water utilities in the following ways:

- Transferring the initial capital investment costs from the utility and the Government in the case of state owned utilities to the private sector.
- Overcoming operational and manpower limitations within the utility.
- Reducing the time spent to complete a universal metering programme.

- Promoting competition among bidding contractors, which can potentially lower the overall costs for the utility.

Selected contractors can be paid over the duration of the performance contract at a price based on their incurred capital expenditure, contracted operating expense margin and annual costs associated with the number of meters installed on the network. The contractor is thus incentivized to install the contracted number of meters quickly in order to fully benefit from the returns gained when the installed meters relay accurate measurements for billing purposes.

The full cost comparisons of outsourcing the installation of a universal metering programme (based on the technology employed) versus WASA conducting the programme in house are presented in Appendix I. Based on the analysis, the net present value of the total capital and operating costs of **outsourcing** the programme is estimated to range between approximately TT$1,517M to TT$1,942 depending on the mode of data transmission. The annual expenditure will correspondingly range between TT$224M and TT$297M. In the event that WASA executes the programme **utilizing its staff**, the net present value of the total capital and operating costs is estimated to range between approximately TT$1,292M to TT$1,648M. The annual expenditure will correspondingly range between TT$189M and TT$255M.

Although the use of external contractors would result in higher annual and total costs, it is projected that the duration of the project implementation would be shortened from approximately ten years to within five years thus bringing about the consequential benefits in a shorter time frame.

3.1.3 Selection of Contractors/Companies

Contracts to supply, install, read and maintain water meters should be awarded in accordance with open tendering procedures[15]. If contractors are employed, Trinidad and Tobago can be divided into at least five (5) service areas with at least one (1) contractor operating in an area. Each contractor/company should comprise of the following parties:

i. A Local Operating Partner (at least 60% of the equity).
ii. A Meter Solutions Provider (A foreign supplier - who can establish Export Finance Credit).

3.1.4 Implementation of a Pilot Programme

It is recommended that a pilot programme be initiated, with the installation of 10,000 to 15,000 meters in various locations that presently receive a continuous supply of water. The geographical spread of the locations would be such as to adequately test the integrity of a prototype meter reading system. The installation of meters should be followed by a study to determine customer satisfaction, changes in utility revenue and consumption. The study will include a survey of customers being performed 6 months after pilot project closeout.

For transparency purposes, it is recommended that one (1) contractor, chosen from at least three bidders, be awarded the contract to purchase, install and read the meters to be installed in the pilot programme. The locations chosen would encompass the different types of customer premises that exist throughout the country; i.e. single dwelling residences, condominium-type residences, apartment buildings and business places.

The main advantages of conducting a pilot programme are:

- It will allow for the assessment of equipment in various field applications. Although metering and data transmission technology has been successfully installed and operated in other jurisdictions, there will be challenges unique to Trinidad and Tobago. Therefore, various issues need to be considered, such as, the specific requirements for different types of customer's installation, terrain, and other geographical features.
- Different implementation strategies can be tested during this stage to determine the optimal way forward for implementation of a full programme.
- It will allow for increased public awareness of the programme and the promotion of the concept of water metering throughout the country.
- The lessons learned will be used to evaluate the feasibility of the different types of metering systems that can be deployed, such as, mobile read meters versus automatically read meters.

Implementation of a full programme should then follow the assessment of the pilot programme.

What are your views on the considerations presented?

Are there any other issues that you believe should be considered for the implementation of a universal metering programme in Trinidad and Tobago?

4.0 Benefit/Cost Analysis of implementing a Universal Metering Programme

The benefits derived from the implementation of a universal water metering programme have been highlighted in Section 3.0 and can be equated to avoided costs, or the incremental savings associated with not having to produce additional units of water or water service. Avoided cost can be used to compare demand management and supply management options and inform the utility as it determines the least-cost alternatives for meeting future water needs.

The following benefits of a universal metering programme can redound in significant avoided costs in Trinidad and Tobago:

- Reduced Consumption – Projected 50% reduction in overconsumption[16]
- Reduced Leakage & Theft – Projected reduction in water losses from 51% to 25% (AMI); to 35% (mobile read); and to 40% (manually read)[17]
- CAPEX Deferral/Avoidance – A number of the scheduled water supply projects would no longer need to be executed
- Carbon Credits – The tradable value of CO^2 reduction due to the elimination of mobile or manually meter reading systems as a result of the implementation of an automatic metering system
- Reduction in Security cost – Lower projected costs for the additional security required for manual or mobile meter readings in high risk locations throughout Trinidad
- Increase in Operational Efficiency – Savings derived from operational improvements

Table 1 shows the estimated net present value of the economic cost savings attributed to the benefits identified above for the various metering system technologies that have been discussed in Section 3.1.2. Detailed computations and assumptions are presented in Appendix I. All metering options provide significant benefits over the life of the universal water metering programme.

Table 1 – NPV (MTT$) of Projected Benefits based on Metering System

Technology Option	Manually Read System	Mobile Read System	WASA AMI System	T&TEC AMI System
NPV (MTT$) of Total Cost Savings	**891**	**1,253**	**2,015**	**2,015**

Table 2 shows the Benefit/Cost Analysis of the implementation of a Universal Metering Programme in Trinidad and Tobago considering the technological and installation options that have been discussed in Section 3. Detailed computations and assumptions are presented in Appendix I.

Table 2 –Benefit/Cost Analysis of the implementation of a Universal Metering Programme

Implementation Option	Mobile Read System		WASA AMI System		T&TEC AMI System	
	Contractor Installed	**WASA Installed**	**Contractor Installed**	**WASA Installed**	**Contractor Installed meters**	**WASA Installed meters**
NPV (MTT$) of Total Costs	1,517	1,292	1,942	1,648	1,532	1,302
NPV (MTT$) of Total Value of Projected Benefits	1,253	1,253	2,015	2,015	2,015	2,015
NPV (MTT$) of Projected Benefits net Costs	**(264)**	**(39)**	**73**	**367**	**483**	**713**
Benefit to Cost Ratio	**0.83**	**0.97**	**1.04**	**1.22**	**1.32**	**1.55**

Based on the estimated benefit to cost ratios in table 2, the cost for the installation of the mobile read system (contractor/in house) outweigh the projected value of derived benefits while the other options are anticipated to redound in overall cost savings for the utility. Therefore, strong consideration can be given to the implementation of a universal metering programme employing AMI technology. The choice as to whether WASA should own an AMI network, which is estimated to cost more than the option to utilize T&TEC's existing AMI network, will depend on factors, such as, the utility's view on reliability and cyber security.

For every cost projection, the overall cost to contract out the installation/operational services versus utilizing WASA's employees was greater. However, this must be weighed along with the fact that outsourcing the metering service to the private sector will ensure that WASA does not have to commit large amounts of financial, human and physical resources to execute a metering programme, thereby, allowing these resources to be utilized for other projects and core business. Furthermore, it is estimated that the implementation phase would be significantly shortened by as much as six (6) years.

Metering as a service performed by the private sector will further allow for contractual agreements to be established that will hold parties accountable for maintaining a high level of performance of the metering system for its useful life. For example, a success read rate could be made a contractual requirement and failure to meet the set read rate could result in penalties being enforced.

It is highly recommended that a pilot project be undertaken, during which time the utility could provide sample bills based on actual readings to metered customers and also disseminate consumption analysis findings to all customers. This data will allow the public to gain an appreciation of the amount of water consumed locally which can be compared to other jurisdictions and also to highlight the need to conserve the consumption of water in applicable cases. This approach will provide the opportunity for early analysis of both the derived benefits, such as, water conservation and the costs incurred to install metering.

The RIC welcomes your views on the consideration of a universal water metering programme in Trinidad and Tobago.

Appendix I - Cost and Benefits Computations (Detailed)

A. Evaluation of outsourcing the installation of mobile read meters versus WASA executing the project works.

Table I.A.1 – Capital Costs (TT$)

	CAPITAL COSTS	Total
1	Cost of 370,599 meters[1] and hardware at US$400 per meter[2]	1,037,677,200
2	Cost of Mobile Reading hardware[3]	2,000,000
3	**Total**	**1,039,677,200**

Table I.A.2 – Cost Projection for Outsourcing Programme Execution (TT$)

	ANNUAL COSTS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total Cost
1	Annual Debt Service for meters and hardware: 9.5% per annum/10 year loan[4]	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	1,652,668,540
2	Annual Maintenance cost at 1% of value of installed meters[5]	2,075,354	4,150,709	6,226,063	$ 8,301,418	10,376,772	10,376,772	10,376,772	10,376,772	10,376,772	10,376,772	83,014,176
3	Annual Debt Service for Mobile Reading hardware: 9.5% per annum/10 years[4]	318,532	318,532	318,532	318,532	318,532	318,532	318,532	318,532	318,532	318,532	3,185,320
4	Annual Operating Costs[6]	7,944,000	7,944,000	7,944,000	7,944,000	7,944,000	6,828,000	6,828,000	6,828,000	6,828,000	6,828,000	73,860,000
5	Field Labour Costs[6]	8,640,000	8,640,000	8,640,000	8,640,000	8,640,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	50,400,000
6	Meter Reads[7]	288,000	576,000	864,000	1,152,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	11,520,000
7	**Sub-total (Sum lines 1-6)**	**184,532,740**	**186,896,095**	**189,259,449**	**191,622,804**	**193,986,158**	**185,670,158**	**185,670,158**	**185,670,158**	**185,670,158**	**185,670,158**	**1,874,648,036**
8	Contingencies (10%)[5]	18,453,274	18,689,609	18,925,945	19,162,280	19,398,616	18,567,016	18,567,016	18,567,016	18,567,016	18,567,016	187,464,804
9	**Sub-Total (Sum lines 7-8)**	**202,986,014**	**205,585,704**	**208,185,394**	**210,785,084**	**213,384,774**	**204,237,174**	**204,237,174**	**204,237,174**	**204,237,174**	**204,237,174**	**2,062,112,840**
10	Oper. margin (10% total annual costs)[5]	20,298,601	20,558,570	20,818,539	21,078,508	21,338,477	20,423,717	20,423,717	20,423,717	20,423,717	20,423,717	206,211,284
11	**Sub-Total (Sum lines 9-10)**	**223,284,616**	**226,144,275**	**229,003,934**	**231,863,592**	**234,723,251**	**224,660,891**	**224,660,891**	**224,660,891**	**224,660,891**	**224,660,891**	**2,268,324,124**
12	Promotional Costs (WASA)[8]	211,000	0	0	0	0	0	0	0	0	0	211,000
13	Bill Processing Costs (WASA)[9]	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	4,320,000
14	**Total (Sum lines 11-13)**	**223,937,616**	**226,576,275**	**229,435,934**	**232,295,592**	**235,155,251**	**226,820,891**	**226,820,891**	**226,820,891**	**226,820,891**	**226,820,891**	**2,272,865,124**
	Net Present Value: Discount rate 8%/annum for 10 years	207,366,232	194,175,868	182,172,132	170,737,260	160,140,726	141,808,521	131,229,156	121,550,161	112,546,446	94,989,200	**1,516,715,702**

Table I.A.3 – Cost Projection for Programme Execution by WASA (TT$)

	ANNUAL COSTS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
1	Annual Debt Service for meters and hardware: 8% per annum/10 years[4]	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	1,546,445,030
2	Annual Maintenance cost at 1% of value of installed meters[5]	2,075,354	2,075,354	3,113,032	4,150,709	5,188,386	6,226,063	7,263,740	8,301,418	9,339,095	10,376,772	58,109,923
3	Annual Debt Service for Mobile Reading HW: 8% per annum/10 yrs[4]	298,059	298,059	298,059	298,059	298,059	298,059	298,059	298,059	298,059	298,059	2,980,590
4	Annual Operating Costs[10]	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	45,720,000
5	Field Labour Cost[10]	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	97,200,000
6	Meter Reads[11]	268,800	537,600	806,400	1,075,200	1,344,000	1,612,800	1,881,600	2,150,400	2,419,200	2,688,000	14,784,000
7	**Sub-total (Sum lines 1-6)**	**171,578,716**	**171,847,516**	**173,153,994**	**174,460,471**	**175,766,948**	**177,073,425**	**178,379,902**	**179,686,380**	**180,992,857**	**182,299,334**	**1,765,239,543**
8	Contingencies (10%)[5]	17,157,872	17,184,752	17,315,399	17,446,047	17,576,695	17,707,343	17,837,990	17,968,638	18,099,286	18,229,933	176,523,954
9	**Sub-Total (Sum lines 7-8)**	**188,736,588**	**189,032,268**	**190,469,393**	**191,906,518**	**193,343,643**	**194,780,768**	**196,217,893**	**197,655,018**	**199,092,142**	**200,529,267**	**1,941,763,498**
10	Promotional Costs (WASA)[8]	221,000	0	0	0	0	0	0	0	0	0	221,000
11	Billing Costs (WASA)[9]	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	4,320,000
12	**Total (Sum lines 9-11)**	**189,389,588**	**189,464,268**	**190,901,393**	**192,338,518**	**193,775,643**	**195,212,768**	**196,649,893**	**198,087,018**	**199,524,142**	**200,961,267**	**1,946,304,498**
	Net Present Value: Discount rate 8%/annum for 10 years	175,374,758	162,370,878	151,575,706	141,368,811	131,961,213	122,984,044	114,646,888	106,966,990	99,762,071	84,805,655	**1,291,817,013**

NOTES for Tables I.A.1, I.A.2 and I.A.3:

1. Customer base of 411,777. Approximate number of customers with connections @ 90% is 370,599.
2. Includes the cost of the meter, transmitting device and installation hardware.
3. Includes the meter reading equipment and hardware to process data.
4. Based on current interest rates.
5. Based on current industry practice.
6. Costs are reduced after the installation of all meters in the fifth year due to a reduction in required human and physical resources.
7. Costs progressively increase with each year of meter installation till full implementation in the fifth year.
8. Promotion of the programme on the television during first six (6) months of rollout.
9. Cost of additional manpower and physical resources to process data.
10. Costs remain constant throughout the entire 10-year period as an equal numbers of meters will be installed annually.
11. Costs progressively increase with each year of meter installation till full implementation in the tenth year.

ASSUMPTIONS for Tables I.A.1, I.A.2 and I.A.3:

- No standpipe customers will be metered. Standpipe customers at 10% total number.
- Meters will be read on a monthly basis.
- Operating costs include expenditure for: Vehicles; Salaries and Wages; Office space rental; Utilities; Stationery; Insurance.
- US$1= TT$7

B. Evaluation of outsourcing the installation of meters and advanced metering infrastructure versus WASA executing the project works.

Table I.B.1 – Capital Costs (TT$)

	CAPITAL COSTS	Total
1	Cost of 370,599 meters[1] and hardware at US$400 per meter[2]	1,037,677,200
2	Cost of Advanced Meter Infrastructure (AMI) hardware3 at US$125 per meter[3]	324,274,125
3	**Total**	**1,361,951,325**

Table I.B.2 – Cost Projection for Outsourcing Programme Execution (TT$)

	ANNUAL COSTS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total Cost
1	Annual Debt Service for meters and hardware: 9.5% per annum/10 years[4]	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	1,652,668,540
2	Annual Maintenance cost at 1% of value of installed meters and AMI network[5]	2,723,903	5,447,805	8,171,708	10,895,611	10,376,772	13,619,513	13,619,513	13,619,513	13,619,513	13,619,513	105,713,365
3	Annual Debt Service for AMI hardware: 9.5% per annum/10 years[4]	51,645,892	51,645,892	51,645,892	51,645,892	51,645,892	51,645,892	51,645,892	51,645,892	51,645,892	51,645,892	516,458,920
4	Annual Operating Costs[6]	7,944,000	7,944,000	7,944,000	7,944,000	7,944,000	6,828,000	6,828,000	6,828,000	6,828,000	6,828,000	73,860,000
5	Field Labour Cost[6]	8,640,000	8,640,000	8,640,000	8,640,000	8,640,000	1,440,000	1,440,000	1,440,000	1,440,000	1,440,000	50,400,000
6	**Sub-total (Sum lines 1-6)**	**236,220,649**	**238,944,551**	**241,668,454**	**244,392,357**	**243,873,518**	**238,800,259**	**238,800,259**	**238,800,259**	**238,800,259**	**238,800,259**	**2,399,100,825**
7	Contingencies (10%)[5]	23,622,065	23,894,455	24,166,845	24,439,236	24,387,352	23,880,026	23,880,026	23,880,026	23,880,026	23,880,026	239,910,082
8	**Sub-Total (Sum lines 7-8)**	**259,842,714**	**262,839,006**	**265,835,299**	**268,831,592**	**268,260,870**	**262,680,285**	**262,680,285**	**262,680,285**	**262,680,285**	**262,680,285**	**2,639,010,907**
9	Oper. margin (10% total annual costs)[5]	25,984,271	26,283,901	26,583,530	26,883,159	26,826,087	26,268,029	26,268,029	26,268,029	26,268,029	26,268,029	263,901,091
10	**Sub-Total (Sum lines 9-10)**	**285,826,985**	**289,122,907**	**292,418,829**	**295,714,751**	**295,086,957**	**288,948,314**	**288,948,314**	**288,948,314**	**288,948,314**	**288,948,314**	**2,902,911,998**
11	Data Charges (WASA)[7]	113,880	227,760	341,640	455,520	569,400	569,400	569,400	569,400	569,400	569,400	4,555,200
12	Promotional Costs (WASA)[8]	221,000	0	0	0	0	0	0	0	0	0	221,000
13	Bill Processing Costs (WASA)[9]	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	4,320,000
14	**Total (Sum lines 10-13)**	**286,593,865**	**289,782,667**	**293,192,469**	**296,602,271**	**296,088,357**	**289,949,714**	**289,949,714**	**289,949,714**	**289,949,714**	**289,949,714**	**2,912,008,198**
	Net Present Value: Discount rate 8%/annum for 10 years	265,385,919	248,343,746	232,794,820	218,002,669	201,636,171	182,668,320	169,040,683	156,572,845	144,974,857	122,358,779	**1,941,778,809**

Table I.B.3 – Cost Projection for Programme Execution by WASA (TT$)

	ANNUAL COSTS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
1	Annual Debt Service for meters and hardware: 8% per annum/10 years[4]	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	1,546,445,030
2	Annual Maintenance cost at 1% of value of installed meters[5]	2,723,903	2,723,903	4,085,854	5,447,805	6,809,757	8,171,708	9,533,659	10,895,611	12,257,562	13,619,513	76,269,274
3	Annual Debt Service for AMI hardware: 8% per annum/10 years[4]	48,326,407	48,326,407	48,326,407	48,326,407	48,326,407	48,326,407	48,326,407	48,326,407	48,326,407	48,326,407	483,264,070
4	Annual Operating Costs[10]	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	45,720,000
5	Field Labour Cost[10]	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	97,200,000
6	Data Charges[11]	56,940	113,880	170,820	227,760	284,700	341,640	398,580	455,520	512,460	569,400	3,131,700
7	**Sub-total (Sum lines 1-6)**	**220,043,753**	**220,100,693**	**221,519,584**	**222,938,475**	**224,357,367**	**225,776,258**	**227,195,149**	**228,614,041**	**230,032,932**	**231,451,823**	**2,252,030,074**
8	Contingencies (10%)[5]	22,004,375	22,010,069	22,151,958	22,293,848	22,435,737	22,577,626	22,719,515	22,861,404	23,003,293	23,145,182	225,203,007
9	**Sub-Total (Sum lines 7-8)**	**242,048,128**	**242,110,762**	**243,671,542**	**245,232,323**	**246,793,103**	**248,353,884**	**249,914,664**	**251,475,445**	**253,036,225**	**254,597,006**	**2,477,233,082**
10	Promotional Costs (WASA)[8]	221,000	0	0	0	0	0	0	0	0	0	221,000
11	Billing Costs (WASA)[9]	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	4,320,000
12	**Total (Sum lines 9-11)**	**242,701,128**	**242,542,762**	**244,103,542**	**245,664,323**	**247,225,103**	**248,785,884**	**250,346,664**	**251,907,445**	**253,468,225**	**255,029,006**	**2,481,774,082**
	Net Present Value: Discount rate 8%/annum for 10 years	224,741,245	207,859,147	193,818,212	180,563,277	168,360,295	156,735,107	145,952,105	136,030,020	126,734,113	107,622,241	**1,648,415,762**

NOTES for Tables I.B.1, I.B.2 and I.B.3:

1. Customer base of 411,777. Approximate number of customers with connections @ 90% is 370,599.
2. Includes the cost of the receiving devices, transmission network and installation.
3. Includes the meter reading equipment and hardware to process data.
4. Based on current interest rates.
5. Based on current industry practice.
6. Costs are reduced after the installation of all meters in the fifth year due to a reduction in required human and physical resources.
7. Costs progressively increase with each year of meter installation till full implementation in the fifth year.
8. Promotion of the programme on the television during first six (6) months of rollout.
9. Cost of additional manpower and physical resources to process data.
10. Costs remain constant throughout the entire 10-year period as an equal numbers of meters will be installed annually.
11. Costs progressively increase with each year of meter installation till full implementation in the tenth year.

ASSUMPTIONS for Tables I.B.1, I.B.2 and I.B.3:

- No standpipe customers will be metered. Standpipe customers at 10% total number.
- Meters will be read on a monthly basis.
- Operating costs include expenditure for: Vehicles; Salaries and Wages; Office space rental; Utilities; Stationery; Insurance.
- US$1= TT$7

C. Evaluation of outsourcing the installation of meters versus WASA executing the project works. (T&TEC AMI System to be used).

Table I.C.1 – Capital Costs (TT$)

	CAPITAL COSTS	Total
1	Cost of 370,599 meters[1] and hardware at US$400 per meter[2]	1,037,677,200
2	**Total**	**1,037,677,200**

Table I.C.2 – Cost Projection for Outsourcing Programme Execution (TT$)

	ANNUAL COSTS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total Cost
1	Annual Debt Service for meters and hardware: 9.5% per annum/10 years[4]	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	165,266,854	1,652,668,540
2	Annual Maintenance cost at 1% of value of installed meters [5]	2,075,354	4,150,709	6,226,063	8,301,418	10,376,772	10,376,772	10,376,772	10,376,772	10,376,772	10,376,772	83,014,176
3	Annual Operating Costs[6]	7,944,000	7,944,000	7,944,000	7,944,000	7,944,000	5,424,000	5,424,000	5,424,000	5,424,000	5,424,000	66,840,000
4	Field Labour Cost[6]	8,640,000	8,640,000	8,640,000	8,640,000	8,640,000	720,000	720,000	720,000	720,000	720,000	46,800,000
5	**Sub-total (Sum lines 1-4)**	**183,926,208**	**186,001,563**	**188,076,917**	**190,152,272**	**192,227,626**	**181,787,626**	**181,787,626**	**181,787,626**	**181,787,626**	**181,787,626**	**1,849,322,716**
6	Contingencies (10%)[5]	18,392,621	18,600,156	18,807,692	19,015,227	19,222,763	18,178,763	18,178,763	18,178,763	18,178,763	18,178,763	184,932,272
7	**Sub-Total (Sum lines 5-6)**	**202,318,829**	**204,601,719**	**206,884,609**	**209,167,499**	**211,450,389**	**199,966,389**	**199,966,389**	**199,966,389**	**199,966,389**	**199,966,389**	**2,034,254,988**
8	Oper. margin (10% total annual costs)[5]	20,231,883	20,460,172	20,688,461	20,916,750	21,145,039	19,996,639	19,996,639	19,996,639	19,996,639	19,996,639	203,425,499
9	**Sub-Total (Sum lines 7-8)**	**222,550,712**	**225,061,891**	**227,573,070**	**230,084,249**	**232,595,427**	**219,963,027**	**219,963,027**	**219,963,027**	**219,963,027**	**219,963,027**	**2,237,680,486**
10	T&TEC Service Charge (WASA)[7]	1,359,096	2,718,192	4,077,288	5,436,384	6,795,480	6,795,480	6,795,480	6,795,480	6,795,480	6,795,480	54,363,840
11	Promotional Costs (WASA)[8]	221,000	0	0	0	0	0	0	0	0	0	221,000
12	Bill Processing Costs (WASA)[9]	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	4,320,000
13	**Total (Sum lines 9-12)**	**224,562,808**	**228,212,083**	**232,082,358**	**235,952,633**	**239,822,907**	**227,190,507**	**227,190,507**	**227,190,507**	**227,190,507**	**227,190,507**	**2,296,585,326**
	Net Present Value: Discount rate 8%/annum for 10 years	207,945,160	195,577,755	184,273,392	173,425,185	163,319,400	143,130,020	132,452,066	122,682,874	113,595,254	95,874,394	**1,532,275,500**

Table I.C.3 – Cost Projection for Programme Execution by WASA (TT$)

	ANNUAL COSTS	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
1	Annual Debt Service for meters and hardware: 8% per annum/10 years[4]	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	154,644,503	1,546,445,030
2	Annual Maintenance cost at 1% of value of installed meters[5]	2,075,354	2,075,354	3,113,032	4,150,709	5,188,386	6,226,063	7,263,740	8,301,418	9,339,095	10,376,772	58,109,923
3	Annual Operating Costs[10]	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	4,572,000	45,720,000
4	Field Labour Cost[10]	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	9,720,000	97,200,000
5	**Sub-total (Sum lines 1-4)**	**171,011,857**	**171,011,857**	**172,049,535**	**173,087,212**	**174,124,889**	**175,162,566**	**176,200,243**	**177,237,921**	**178,275,598**	**179,313,275**	**1,747,474,953**
6	Contingencies (10%)[5]	17,101,186	17,101,186	17,204,953	17,308,721	17,412,489	17,516,257	17,620,024	17,723,792	17,827,560	17,931,328	174,747,495
7	**Sub-Total (Sum lines 5-6)**	**188,113,043**	**188,113,043**	**189,254,488**	**190,395,933**	**191,537,378**	**192,678,823**	**193,820,268**	**194,961,713**	**196,103,158**	**197,244,603**	**1,922,222,449**
8	T&TEC Service Charge (WASA)[7]	679,548	1,359,096	2,038,644	2,718,192	3,397,740	4,077,288	4,756,836	5,436,384	6,115,932	6,795,480	37,375,140
9	Promotional Costs (WASA)[8]	221,000	0	0	0	0	0	0	0	0	0	221,000
10	Billing Costs (WASA)[9]	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	432,000	4,320,000
11	**Total (Sum lines 7-10)**	**189,445,591**	**189,904,139**	**191,725,132**	**193,546,125**	**195,367,118**	**197,188,111**	**199,009,104**	**200,830,097**	**202,651,090**	**204,472,083**	**1,964,138,589**
	Net Present Value: Discount rate 8%/annum for 10 years	175,426,617	162,747,847	152,229,755	142,256,402	133,045,007	124,228,510	116,022,308	108,448,252	101,325,545	86,287,219	**1,302,017,462**

NOTES for Tables I.C.1, I.C.2 and I.C.3:

1. Customer base of 411,777. Approximate number of customers with connections @ 90% is 370,599.
2. Includes the cost of the receiving devices, transmission network and installation.
3. Includes the meter reading equipment and hardware to process data.
4. Based on current interest rates.
5. Based on current industry practice.
6. Costs are reduced after the installation of all meters in the fifth year due to a reduction in required human and physical resources.
7. Costs progressively increase with each year of meter installation till full implementation in the fifth year.
8. Promotion of the programme on the television during first six (6) months of rollout.
9. Cost of additional manpower and physical resources to process data.
10. Costs remain constant throughout the entire 10-year period as an equal numbers of meters will be installed annually.

ASSUMPTIONS for Tables I.C.1, I.C.2 and I.C.3:

- No standpipe customers will be metered. Standpipe customers at 10% total number.
- Meters will be read on a monthly basis.
- Operating costs include expenditure for: Vehicles; Salaries and Wages; Office space rental; Utilities; Stationery; Insurance.
- US$1= TT$7

D. Evaluation of the Economic Value of the Projected Benefits derived from a Universal Metering Programme.

Table I.D.1 – Net Present Values of Projected Benefits (TT$) US$1=TT$7

Benefit / Technology Option	Manually Read System[1]	Mobile Read System[2]	WASA AMI System[3]	T&TEC AMI System[3]
Reduced Consumption	111,423,550	222,847,100	557,117,750	557,117,750
Reduced Leakage & Theft	250,134,500	363,832,000	591,227,000	591,227,000
CAPEX Avoidance[4]	529,634,797	642,323,052	751,255,031	751,255,031
Carbon Credits	28,166.81	30,934	33,608	33,608
Reduction in High Risk Areas Security cost[5]	0	1,418,550	2,026,500	2,026,500
Increase in Operational Efficiency	0	22,739,500	113,697,500	113,697,500
NPV ($) of Total Value from Projected Benefits	**891,221,014**	**1,253,191,135**	**2,015,357,389**	**2,015,357,389**

NOTES for Table I.D.1:

1. Benefits of **Manually Read System** are: *Reduction in consumption by 10%; Reduction in leakage and theft from 51% to 40%.*
2. Benefits of **Mobile Read System** are: *Reduction in consumption by 20%; Reduction in leakage and theft from 51% to 35%.*
3. Benefits of **AMI System** are: *Reduction in consumption by 50%; Reduction in leakage and theft from 51% to 25%.*
4. Based on projected water supply projects for 2018-2023 that can be avoided.
5. Security Costs include the hire of National Police; Special Contractors; Media Promotion and the establishment of a Special Security Unit.

ASSUMPTIONS for Table I.D.1:

- WASA uses 216 GWh of electricity per year. Total water supplied by WASA per annum is estimated at 382 MGD.
- Water supply system, including Desalination, consumes 6% of electricity produced in Trinidad and Tobago.
- Total Electricity produced in Trinidad and Tobago in 2011 is 8,773 GWh.
- Trinidad & Tobago has annual CO^2 emissions of 47,781 thousand metric tons[18]. Power generation accounts for 28% of CO^2 emissions.
- Carbon credit of $10 per ton[19].
- Desalination produces 12% of total water production.
- WASA's operational cost per cubic meter for water production is $0.8900. This is used as a proxy for the marginal cost of water production.
- Metering will result in an improved operational efficiency equivalent to a 5% reduction in operating cost.
- WASA incurs similar cost to T&TEC and metering results in 20% reduction in visits to area with use of new technology.

End Notes:

[1] Source: Water and Sewerage Authority of Trinidad and Tobago's data submission to the RIC, 2016.
[2] Demand side management measures include increased educational awareness, the use of water efficiency devices, regulations and restrictions during periods of intense aridity, water metering, pricing regimes and water conservation tools such as leakage prevention.
[3] Supply side management measures include increasing the quantity of water supplied with new source works/ new storage schemes and/or scheduling the existing available supply of water to customers.
[4] Source: Water and Sewerage Authority of Trinidad and Tobago's data submission to the RIC, 2016.
[5] Genivar, Pilot Leakage Management Program Review, 2008.
[6] Supply side benefits of metering (when tied to an appropriate pricing regime) include the reduction of water abstractions and the deferment of expensive investments in water system facilities such as impounding reservoirs
[7] See Department for Environment, Food and Rural Affairs (DEFRA), London, England 'The Independent Review of Charging for Household Water and Sewerage Services – Final Report' 2009.
[8] See David Feldman, 'Integrated water management and environmental justice – public acceptability and fairness in adopting water innovations.' 2011, Water Science and Technology: Water Supply Apr 2011, 11 (2) 135-141.
[9] See 'Water Use Efficiency Committee (WUEC, 2001) Final Report'
[10] See L.L. Dale et al, 'Water Supply Management – Trends in California Water Metering: A Preliminary Analysis' 2003.
[11] See Department for Environment, Food and Rural Affairs (DEFRA), London, England 'The Independent Review of Charging for Household Water and Sewerage Services – Final Report' 2009.
[12] See Department for Environment, Food and Rural Affairs (DEFRA), London, England 'The Independent Review of Charging for Household Water and Sewerage Services – Final Report' 2009.
[13] Data is passed via radio frequency from the meter to a mobile unit (a hand held logger or unit aboard a vehicle).
[14] Source: Water and Sewerage Authority of Trinidad and Tobago's data submission to the RIC, 2016.
[15] Open tendering is a preferred competitive public procurement method used for acquiring goods, services and infrastructure works. It is executed in accordance with established procedures set out in the procurement guidelines and detailed in standard bidding documents.
[16] Consumption refers to the amount of water that is used by consumers, as opposed to water loss in the system outside of the customer's premises. Metering typically results in a reduction of 20-30% in consumption for a continuous water supply system. It is projected to be much higher for an intermittent water supply system because of the use of customer storage and water quality issues.
[17] AMI provides real-time data for faster detection of leaks and losses thus allowing for better control and management. A reasonable level of water loss for a water utility in a developing country using a manual system is 23-25%, according to the World Bank. It is assumed that the AMI system would be able to provide at least this level of performance improvement for WASA. Mobile and manual read systems provide information at a slower rate and afford slower response by the utility, hence the lower projected performance improvements.
[18] United Nations Statistics Division, Millennium Development Goals indicators: Carbon dioxide emissions (CO^2) 2009
[19] Carbon Trade Exchange, *Carbon Trade Exchange Calculator*, London, UK, http://www.ctxglobal.com/