Exploratory Study on Digitalization of Malaysian Water Services

Prepared By

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Abstract

Water sector around the globe is struggling against many issues, particularly on water demand management and operational efficiency. This is evidence as the average of Non-Revenue Water (NRW) is reported at 35% globally which means more than 1/3 of world treated water are lost during distribution. In Malaysia, while the average is improving at around 33%; one third of its Water Operators has recorded up to 46% of NRW yearly. The new target was set by the Malaysian government to reduce this figure to 31% by 2020.

Funding is the major issue within this sector and as such, water companies have to rely heavily on federal fund to replace aging infrastructure. At the same time, the low water tariff has not been reviewed for years giving financial pressure to the government to provide more subsidies. Operational cost has also increased with more than RM300 Million spent yearly on energy to manage water treatment processes. The efficiency improvement of water services management is therefore imperative, especially in addressing the loss of valuable water resources that is vital for life.

Digitalization and Industrial Revolution 4.0 technology have brought some potential solutions that can improve operational efficiency and consequently help to reduce water loses. The smart water platform, which leverage on ICT technologies can now offer many digital, cyber-physical and analytic solutions (IoT) that will add automation and intelligence in water management and eventually help to improve overall reliability and efficiency in managing a large urban systems.

While the benefits have found many successful use cases in other industries, the adoption of digital and IR4.0 technology within water industries in Malaysia is relatively low compared to other developed countries in the region especially Singapore, Japan and Korea which has triggered our interest in this research.

To benchmark on the success of Seoul in managing water services, we conducted a comparative study and analysis between Malaysian and Seoul water industries to understand the key success factors that have been the catalyst for successful digital adoption in Seoul. To further understand digital adoption within Malaysian context, we conducted variety of engagement programs and deployed several pilot studies to explore how digital solutions are being received by the local water authorities.

This research is conducted in conjunction with Telekom Malaysia's R&D projects mandated to develop new digital solution specific to water industries in Malaysia. A collaboration between Telekom Malaysia and several Water Authorities has allowed us to consistently engage and co-create solutions through several pilot implementation of namely 1) connected infrastructure (IoT) 2) Digital Workforce and 3) Analytics.

In this thesis we will discuss the comparison between Malaysia and Seoul and present some of the results from our pilot study. The main goal here is to share our observation and insights gained from our very own experience enabling a digital transformation for Malaysian Water Utilities. The outcome should be of benefits to the businesses, water authorities, regulators, individual as well as academia interested in some local digital transformation experience.

Introduction:

Water sector is one the critical sectors that is crucial for the people as it deals with the management of basic human necessity which is water resources. Unfortunately, poor performance and inefficiency in managing the infrastructure has led to significant loses in treated water which is referred to as the Non-Revenue Water (NRW).

Non-revenue water is a global issue facing most water operators all over the world. While cities are battling with population growth as the effect of urbanization, infrastructures that are built since last couple of decades are coming towards the end of its functional life. Cities, therefore need to address this issue smartly as infrastructure upgrade will require a huge investment that will hit their pocket badly, especially during this challenging economic condition.

In general, NRW is a term used to measure the efficiency of water service providers which can be obtained by comparing the amount of water that has been billed (distributed) against the amount of water being treated from original sources.

There are many factors contributing to water loses including aging infrastructure, leakages, meter theft, illegal tapping, water quality, inefficient workforce, meter issues and many others that can be categorized as non-physical losses. According to Bill Kingdom et.al (Bill Kingdom, 2006) , utilities, especially in Asian countries are struggling with NRW Reduction because of the following factors:

- Not understanding the problem (magnitude, sources, costs)
- Lack of capacity (insufficient trained staff)
- Inadequate funding to replace infrastructure (pipes; meters)
- Lack of management commitment
- Weak enabling environment and performance incentives

Government of Malaysia has been taking this seriously and set the average target of NRW to 31 % by 2020 (reviewed from original target of 25%). As such, many forms of support have been introduced including the RM500 Million allocated in the form of grant to support the NRW reduction, focusing on the 5 state water operators with the most NRW. In 2016, the Commissioner of Water in Malaysia (SPAN), who is the regulator of water industries, has estimated that as much as RM13 Billion is needed to address NRW. Given the state of NRW in Malaysia, we believe that NRW management needs to be urgently improved, and this can be achieved by hypothetically leveraging and benefitting from a digital platform or smart technology.

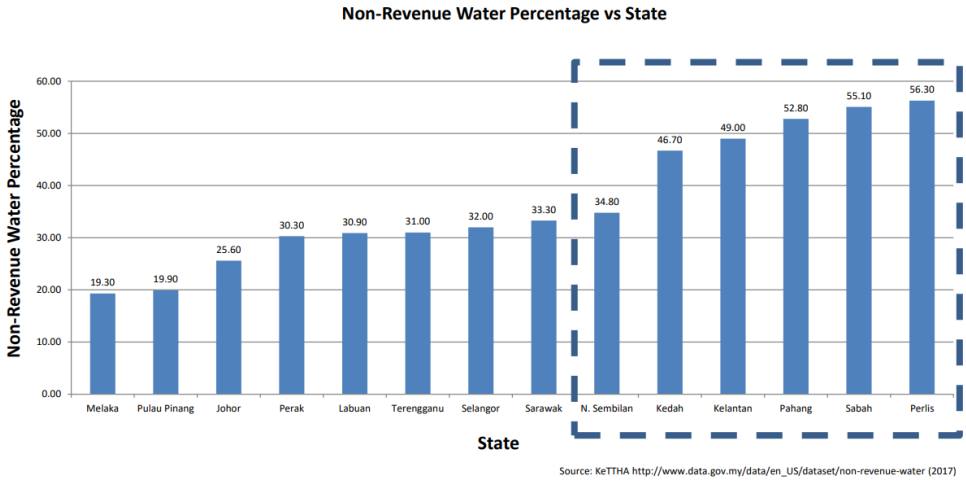

Figure 1: Non-Revenue Water Percentage at all States in 2017

In the recent years, many system Integrators and ICT players in Malaysia have shifted into a more vertical centric solution to further expand their footprint in IR4.0 technologies such as the Internet of Thing (IoT) and Big Data Analytic. The largest telecommunication company in Malaysia, Telekom Malaysia (TM) for example has repositioned itself to become a digital enabler that provides end to end digital solution tailored to different sectors. Telekom Malaysia has started working with various sectors particularly water companies to develop vertical solutions including the IoT sensors and platforms, advance metering infrastructure, workforce management platform as well as big data analytic.

This study is conducted in conjunction with several pilot projects by TM's Innovation (R&D) on IoT and digital workforce solution which have been initiated since 2017. As a custodian for these projects, we have observed and studied the project from the aspect of digital transformation journey which covers stakeholders' engagement, the business challenges, concerns, business models and many others that will be analyzed and reported as part of this thesis deliverables. In summary, the main goal of this research is to address the following problem statement and research questions.

Problem Statement:

Water Authorities in Malaysia are struggling to provide efficient water services to the citizen based on the high Non-Revenue Water recorded from year to year. Most of the state-operated water companies currently suffers from the average of 33% water loses with 5 of 15 water authorities recording up to 46% water loses per year. With the low, review-pending water tariff and lack of citizen awareness on proper water consumption, a continuous financing from the government and innovative governance of water industries are needed to improve the situation. Multiple systems around water management are built in silos, requiring a lot of human operators to manage them separately. With the lack of right infrastructure to extract frequent and near real-time data from the infrastructure, the operators' visibility of the infrastructure is limited and they have to rely on delivering people on site.

At the same time, workforce assignments are still being managed using the paper-based forms, which contributed towards a longer job completion time since documents need to be handed over physically to the assigned vendors. As such, the legacy processes are contributing towards poor productivity and inefficiency of water services which can be potentially improved by

deploying the right digital solution. Huge funding is needed to support NRW reduction projects, which can take years or maybe decades to complete, prompting for the needs to provide some intermediate, cost effective solution. At the same time, institutional and stakeholders' participation are also required to manage NRW efficiently.

Hypothesis

Digitalization seems to be the strategic solution to address the issues in hand as it offers the best opportunity to leverage on the advancement of latest digital technology especially IoT, Cloud Platform, Analytics and AI capabilities. By adopting the IoT for a smarter, connected infrastructure and digitalizing current processes, operators can gain more data from its environment which can be converted to valuable insights for faster decision making and actions.

While the digitalization mainly centered on technology, getting all the actors and stakeholders onboard for the transformation will be the major barrier. As such, a pilot deployment can be one of the approaches that not only can be used for technology sandboxing, but at the same time can be a mean to experimenting social adoption and new policies or governance approach. Through this approach, we aim to explore the adoption of digitalization by the water authorities/operators.

Research Questions

1. What are the differences and similarities based on demographic, political, economic and social background between Malaysia and Seoul that can contribute to success or failure of digital adoption?
2. What are the drivers and challenges unique to both Malaysia and Seoul in terms of water management, and what are the common ones?
3. What is the environment that is needed for a successful digital adoption and in general what can Malaysian water industries learn from Seoul?.
4. Where does Malaysia stands compared to other countries in term of digital readiness?
5. What are the digital or IR4.0 definition, components and critical features?. How do water industries, benefit from digitalization?
6. How do we measure the success or degree of digital adoption or of a smart city for example:
    - Are the citizen/users/workforce digitally connected?
    - Are infrastructure connected (connected water grid?);
    - Are infrastructure for data driven decision making in place?
7. What are examples of digital application, innovation, solution (to be deployed for IR4.0) to fill in the gap and reduce NRW in general?, how would you measure the success? ;
8. What can be the recommendation for the water industries to accelerate the adoption of IR4.0? – ie from the perspective of institution (authority, businesses), technology, people (stakeholders) & process as being learned from Seoul and the Pilot studies ?
9. What can be learnt and observed from pilot experimentation?. What are the unique challenges or barriers and how they were addressed during the pilot deployment?
10. What is the right methodology to approach an organization to embark on digital transformation? Is there any theoretical framework and practical guide towards it?

The Scope

Management of water industries covers a wide array of disciplines, from water resources, waste water management, water treatment, water security, sustainability, water distribution and many others. In this thesis we will cover the water service management aspect that focuses on reducing Non Revenue Water (NRW) or in general, the efficacy of water services. We will investigate how digital and IR4.0 technology can be adopted by the water authorities. The discussion will cover some aspects on technology and its ecosystems, the actors and frameworks needed for digital adoption.

Thesis Impact

The outcome of this thesis will be useful for the stakeholders including the consumers, water operators, businesses, urban planners, regulators and government depending on their roles. Based on our case study on Seoul Water management, stakeholders will be able to understand the requirements, drivers, challenges, gaps and other factors that contribute to the success of new technology adoption. Similarly the case study on Malaysian water industries are discussed in details and extended with a pilot study to investigate how several digital solutions are being deployed and adopted as part of experimentation within local water industries.

Some methodologies and theoretical frameworks could be used for guidance in any real implementation of digital solution. Similarly, various concepts and building blocks of digitalization such as connectivity, platform, artificial intelligence, smart Cities and social aspect of digitalization are discussed and analyzed which can be applicable to any urban infrastructure.

Through the knowledge, experience and recommendation shared in this thesis, local stakeholders will be able to take appropriate approaches or measures to prepare water industries towards digital and IR4.0 technology adoption.

The thesis and its pilot implementation have also indirectly used to prove the value (POV) of the actual digital solutions being developed by Telekom Malaysia which will be further developed as new services applicable to the whole water operators in Malaysia.

Methodology

This study will be conducted as two part researches to address our research questions. The first part will be conducted as a comparative study based on relevant literatures to analyze the demography, structure, environment challenges, gaps and digital initiatives in water management between Malaysia and Seoul. Other relevant work and literature on digital readiness especially related to Malaysia and Seoul are also included to get some basic idea on their current state in relation to the other countries.

The second part will be an exploratory research based on the adoption of Malaysian local water authorities to smart or digital technologies. The observation will be based on several pilot case studies conducted by Telekom Malaysia with several state water authorities to co-develop a new digital water solution. In this study, we aim to contextualize and observe various components including technology, people and process of enabling digital transformation within Malaysia water industries. This also covers the requirement, motivation, challenges and other aspects that we can learn from a series of engagement and observation made throughout this study.

Various approaches and theories such as change management and design thinking methodologies have been conducted in the form of workshops, interviews, site surveys, town hall session and actual onsite deployment using actual infrastructure which are explained in the following section.

Our Approach to the Water Authorities

The vision and mission of the studies are communicated with the participating water authorities. The vision of TM is to jointly develop and evaluate digital solution that will help water authorities to adopt digitalization or smart water governance, particularly towards reducing NRW.

The mission is to enable a connected infrastructure and workforce, while providing some digital platform and tools to prove the concepts, benefits and values of digital technologies in addressing NRW.

Our research took advantage of two research grants and leverage resources from Telekom Malaysia that have been allocated to develop some pilot IoT solutions and workforce management for water industries.

Throughout this study we conducted surveys and engagements with at least 5 from 15 water authorities in Malaysia representing different states. Among them are SAMB (Malacca), Air Selangor, AKSB (Kelantan), SADA (Kedah), and JANS (Sabah) to whom we have presented our proposal to collaborate as a joint Research and Development (R&D) exercise between Telekom and selected water authorities.

Based on the engagement, we have received some positive encouragement from all engaged parties and managed to come to a formal agreement and supports from 3 water authorities namely SAMB, Air Selangor and SADA that will be the candidates for the pilot case study on IoT and workforce management (However, due to time and resource constraint, the full pilot studies are being deployed with SAMB while participating in a smart meter pilot with Air

Selangor). The discussion to replicate similar pilot program is still in progress with SADA and other states-owned water operators which will not be covered in this study.

Strategically, the selected candidates are representing authorities with the lowest, average and highest NRW (SAMB-Melaka at 18-20%, SYABAS-Selangor at 33% and SADA at 48%) but have a strong digital aspiration and support from the top level management. Having that being said, input from all the other authorities are also considered in our study. After receiving formal commitment and invitations from the several Water Authorities, we have conducted the following activities to further our initiatives. The observation and data from the pilot study are analyzed and discussed in the next part of this thesis.

1. **Interviews, Awareness & Workshop**
   i. Our first approach is to have a one to one discussion or interview with Head of Departments (ie IT and Operation) from respective Water authorities. We then seek to engage in a formal discussion with the top management (normally C-level). Following up from C-level engagement, we seek endorsement to organize a design thinking workshop in which relevant personnel (ie experts, users) are invited to gather more input.

   The engagements are made with the following entities:
   a. Syarikat Air Melaka (SAMB)
   b. Syarikat Air Selangor (Air Selangor) & Smart Selangor Director
   c. Syarikat Air Kedah & State Exco
   d. Jabatan Air Negeri Sabah (JANS)
   e. Syarikat Air Kelantan (AKSB)
   f. SPAN / KETTHA – Regulator/Federal Agencies

Figure 2 : Interviews, Workshop and Awareness Program with Water Authorities

Figure 3 : Management Review and Handholding Session

ii. Part of the research and result are aspired from the IGLUS Seoul module attended in 2018. During the 2 weeks program, several engagement and session with researchers, authorities and experts in Seoul Water Management were conducted. Several topics related to this study are also learned through from several sessions on Seoul Water management, ICT policy, smart city framework etc.

iii. Market Research and IoT Spending of water companies for 5 years are being studied to ensure solutions are relevant to the needs and demands of water industries in general

2. Expert Surveys:

i. Expert surveys allow us to gain information from specialists in a field that we are less qualified or knowledge in. Through the **Design Thinking Methodology** workshop, we assigned our researchers and experts to conduct several tracks of discussions. The tracks created are IoT for meter and SCADA, enterprise connectivity, Analytic & Connected Workforce. This interaction allowed us to further understand the pain points, process, current solutions and at the same time allow the participant to discuss the desired improvement of current infrastructure managements

ii. Similarly, several sessions with the experts in Seoul water management are also being held throughout this study.(IGLUS Seoul Module2018)

Figure 4 Photo showing Information Gathering Activities with Subject Matter Experts

***3.* Open-Ended Questions:**

a. The open ended questions are used when engaging target focus group for the first time. In this exercise, we discuss our proposed blueprint and describe pilot scopes and activities initiated with SAMB.

Literature Review

Utilities Landscape and it's Challenges

Water is a one of the most vital elements in our life as it plays big part in social, economy & environment (producing food and keeping sure a balance biological ecosystem)

Having clean and adequate access to the water facilities is a part of United Nations Sustainable Development Goals (SDG). Cora Kammeyer (Kammeyer, 2017) from Pacific institute highlighted some the issues facing water sectors including:

i) Growing water demand and scarcity due population growth which indirectly increase the consumption for agriculture (food production) and manufacturing

ii) Water Pollution : Currently 80% of the untreated wastewater are discharged back to the river or ocean causing pollution that can damage water ecosystem

iii) Access to Safe, Affordable, Sanitation and Hygienic water is still a major issue that is caused by poor distribution infrastructure and governance. In average, the global Non-Revenue Water Ratio is around 35%, which means more than 1/3 of treated water are loss. In some more severe situations, lack of safe and clean water can cause health issues that could possibly lead to death.

iv) Climate change and other resilient challenges such as flood, storm etc are also impacting the water ecosystems and reliability, hence water infrastructure need to be secured and protected.

In general, while many improvement and initiatives are in place, the issues need to be viewed holistically as it implicates many other areas of our lives as quoted by Zaini (Ujang, 2017) :

> "The more water being utilized, the more trees, money and energy required to treat the water. And the more the wastewater generated; the more money and energy required to treat and dispose (recycle) the wastewater"

Zaini (Ujang, 2017) outlined 5 major challenges that need to be addressed by water industries:

I) **Demand Management**: This includes the issues on water efficiency, managing water resources, treatment and distribution to meet the demand (ie litre/capita) of population. The pressure increase as population growth especially as the effect of urbanization.

II) **Water Economy:** This issue centered around the need to prepare for the soft infrastructure or ecosystem that include the workforce, expertise & education while establishing the right policy and legal framework to support the sector.

III) **Water sustainability:** The Challenges referring the issue of Carbon footprint, urban catchment and freshwater extraction.

IV) **Financial Sustainability**: The issue to Ensure systems efficiency, deciding on the right tariff and overall "bankability" of the water industries. Aging infrastructure is one of the main issues facing many cities which can put more pressure on the government's pocket.

The rest of the literature for this thesis will focus on water management which is one of the critical challenges facing government and water industries. We will discuss the efficiency aspect of water management as we explore how digital technology can be used to address this issue.

In general, water management inefficiency can be indicated by the Non-Revenue Water Ratio (NRW). Non-Revenue water is the difference between the volume of water put into a water distribution system and the volume that is billed to customers. In general, it refers to the amount of water loss during the process of distribution. In some countries the term Revenue Water Ratio (RWR) is preferred as a reversed psychological approach that focuses on capturing the useable water rather than measuring the losses.

The Non-Revenue Water is a global issues faced by many countries around the world especially in developing countries at estimated loses around 35% on average and can be as high as 65% in some countries (Thomas, 2019). Malaysia for example has targeted to reduce the NRW to the average of 31% by 2020 from the current average of 35% and one third of the states in Malaysia having more than 46% of water losses.

According the world bank report (Bill Kingdom, 2006) , "More than US$14 billion is lost every year by water utilities around the world—and more than a third of that by water utilities in developing countries . The amount of commercial loses in the developing countries is equivalent to approximately a quarter of the total yearly investment in potable water infrastructure for the entire developing world. If these loses can be avoided, it could provide enough water to service an additional 90 million people who currently lack access to piped water and save an estimated US$1.6 billion per year in production and pumping costs for public utilities".

The report also suggested that, up to US$1.3 billion in additional revenues could be generated each year if 50% of the commercial loss can be avoided.

Where is it being lost from? And Why is it being lost?

Based on the World Bank's report, Non-Revenue Water comprises of three components:

1. **Physical (or real) losses:** The Physical losses are losses contributed by leakages from any part of the system and overflows at the utility's storage tanks. They are caused by poor operations and maintenance, the lack of active leakage control, and poor quality of underground assets.

2. **Commercial (or apparent) losses :** Commercial losses are caused by the error of handling data, largely contributed by meter inaccuracy, loss of data or illegal use water or water theft

3. Unbilled authorized consumption : Unbilled authorized consumption includes water used by the utility for operational purposes, water used for firefighting, and water provided for free to certain consumer groups.

What are the strategies to Address NRW?

According the recommendation by the World Bank Report (WorldBank, 2006) the **Physical loss control strategy** must comprise four main elements:

- Active leakage control: monitoring network flows on a regular basis to identify the occurrence of new leaks earlier so that they can be detected and repaired as soon as possible

• Pipeline and asset management: managing network rehabilitation in an economical manner to reduce the need for corrective maintenance
• Speed and quality of repairs: repairing leaks in a timely and efficient manner (often requiring a thorough shakeup of working practices, organization, and stock keeping of repair materials)
• Pressure management: regulating network pressure through the judicious use of pressure-reducing valves (often an underestimated option for leakage reduction)

On the other hand, the design of a commercial loss reduction strategy will very much depend on local circumstances, but is likely to comprise:

• Improving customer meter accuracy. Ensuring that customer meters are in proper working condition and duly replaced at the end of their useful lives reduces under metering and recourse to estimated billing.
• Improving meter reading and billing. A significant portion of commercial losses comes from mistakes in the meter reading and billing chains, not only because of poor technology and data-handling errors in the office but also because of fraudulent practices on the part of utility staff.
• Detection of illegal connections and water pilferage. Contrary to common belief, a large portion of water stolen from public utilities does not come from poor, marginal urban areas, but rather from large industrial customers and those with political clout and enough resources to bribe utility staff and management.

Allowing illegal connections and such fraudulent behavior is unfair for those in the population who do pay their bills, especially the poor, and works against promoting a culture of good governance. An important point to mention is that a precondition for any NRW reduction strategy is to provide incentives for management and staff of the water utility to deliver on, and maintain, the reduction achieved. This has been the missing feature of most attempts to reduce NRW and is one of the main reasons why utilities.

The long term strategy of reducing NRW involved replacing or upgrading infrastructure which will require a huge investment. At some point, water operators or governments need to make a decision for asset replacement program to replace aging infrastructure. It is therefore important to consider the Economic feasibility (hoi, 2016) prior to designing an NRW improvement project.

Total cost of NRW combines the cost of loss by leakages and cost of the NRW reduction project. In general, the cost of water loss increase gradually over time while the cost of managing NRW will generally be reduced as the NRW scales up. As the result, economic level of NRW can be determined as the minimum total cost (cost of water losses + cost of NRW projects) - refer Figure 5. Operators should use this as reference to decide the needs to invest on NRW projects.

The cost by water loss is originated from physical loss and commercial loss. Physical loss on the other hand is calculated from the operational costs such as labor cost, chemical cost, energy cost while commercial loss is estimated from water tariff and baseline usage.

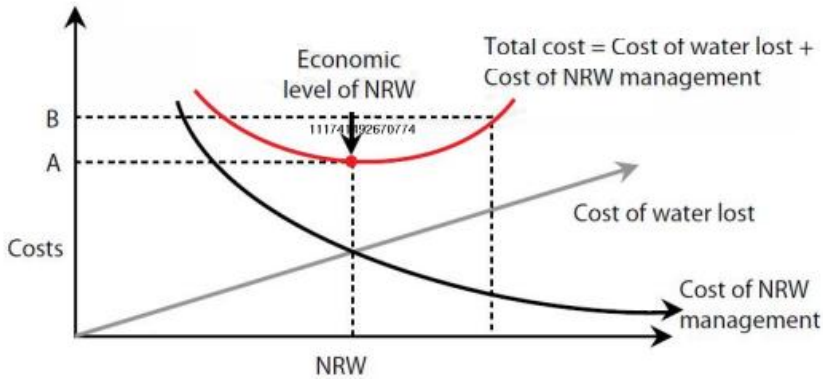

Figure 5 : Graph showing the Economic Level of NRW (hoi, 2016)

The cost for NRW project is defined as the costs used for NRW improvement including costs for labor, equipment and logistic.

Although it depends on the financial and technical conditions of the states government, NRW below 5% is close to the break-even point of investment and revenue and can be considered among the top in the world (ie Seoul.)

Apart from the recommendation above, the strategy needs to be contextualized to local framework (ie financial, legal). (Min, 2011), (Choi I.-C. , 2017) (H Woo, 2005)discussed several strategies in the South Korean context that gives some historical perspective highlighting some government policies that works. Another example is the Strategic document from Malaysian Academy of Science (AcademyofScience, 2015) that covers a wider dimension including Research, Operation, Capacity Building, Green Technology, Planning, Governance, Climate Change and International Collaboration which are documented as a guideline for the government and other stakeholders.

With the advancement of technology, the industries can also take the opportunities from digital technology as highlighted by the experts. Filingger (Filingger, 2019) shared some trends that the sector is heading to, including the IoT technology and Analytic that will be a huge opportunity for industry to tap into. He also emphasized on the need for the smart water infrastructure to interact with the overarching smart cities framework and at the same time include citizen participation as part of the smart agenda. He also advised the importance to pay more attention to cyber security and getting the workforce ready for digital transformation.

Similarly (Mckinsey&Co, 2018), also published a playbook for Digital utilities emphasizing on customer centricity, analytic and digital workforce but add innovation, adoption to cloud and getting used to iT architecture as recommendation for utilities. It also recommended to the leadership to also explore blockchain technology to be part of digital utilities infrastructure.

KPMG (KPMG, 2019) highlighted several emerging trends such as customer's centricity, data driven management and technology competitiveness which need to be heeded by government and businesses. KPMG added that sustainability will be the new mainstream in the market and sees that infrastructure interdependency will be the way forward for creating new opportunities.

Hays (Hays, 2018) also highlighted the same trends toward AI, Innovative project financing, increased in security and converged infrastructure citing Smart Water to play the key roles in the near future.

In summary while the water industries are clouded by the issues of operational efficiency and NRW in particular, utilities should explore the opportunities to embark on digitalization which have a promising prospect. In the next section, we will discuss some details about digitalization, the impact, the component and the adoption of it by industries.

When Physical Meets Digital

The advancement of IT and introduction of Internet in late 90's has changed the way we live and work. Digital services are built on the Internet as the platform that leverage on Internet Protocol (IP) and its global IP addressing, allowing remote access to systems or applications that are connected through the Internet.

More business processes are now being digitalized through online applications which are boosted by the advancement of mobile technology such as smart phones, tablets etc. Digitalization allows manual activities which previously involved physical papers to be converted to equivalent online documents or application. At this moment, more than 90% of government, businesses or consumers applications and services existed online. This includes e-government services such as tax payment, transport registration, medical appointment, e-learning and even e-voting to be done ubiquitously, anytime, anywhere on any devices. Today, digital application has also become the mainstream infrastructure especially in banking, retail and even broadcasting and marketing.

IT and communication technology has matured over time and nowadays, a lot of new advanced platform and tools such as cloud and virtualization, big data analytic, Artificial Intelligence, Virtual Reality etc can be easily accessed as high powered computers and softwares are becoming cheaper and more affordable than before.

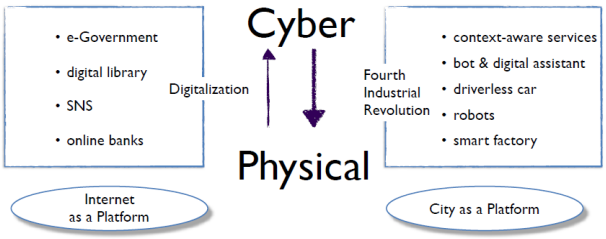

Figure 6 : Digitalization & Fourth Industrial Revolution

From the industrial perspective, the industrial revolution started from Steam Engine Power generation and mechanical automation as early as 1780's that eventually led to the use of mobility in industries in 20th century. In 1950s the introduction of computers and electronic devices have again changed the industrial landscape towards computer-based automation for industrial processing (hence, 3rd Industrial Revolution). Nowadays, the advancement of smaller footprint hardware and more pervasive computing has allowed a more hyper-connected

environment that enabled real-time data to be collected and highly advanced control automation to be performed. The use of robotic and the concept of smart factory are now becoming the new norm, but not limited to the industries, the technology has also found use cases in other physical domains such as self-driving car in transportation, smart energy/water grid and smart meters for utilities as well as smart consumers wearable such as watches, glasses, helmet, gloves etc. for public consumption.

Hence, the fourth industrial Revolution is significantly defined by its cyber-physical features (ie Internet of Thing (IoT)) that allow more physical elements (ie machines, energy, water, vehicles) to co-exist in the digital space and benefit from existing digital services such as cloud computing, Artificial Intelligence and Big Data Analytic.

Other advanced technologies such as virtual reality, drones and 3D printing have also started to hit the industries and will offer a lot of benefits and breakthroughs in many areas including healthcare, logistic, education and many others.

In general, IR4.0 enables Information Technology (IT) and Operational Technology (OT) to converge seamlessly. With a proper network and security design for example, legacy Operational Technology (OT) such as the Industrial Control Systems (ICS/SCADA), Advance Metering Infrastructure (AMI) and industrial remote sensing devices systems can be privately accessed through mobile phone and or any web based console. This means that remote water or power plant for example can be operated online, reducing the needs for manpower deployment and the cost of logistics and transportation. In fact, any response to incidents will be faster and at some extent can be fully automated, creating an opportunity for a fully automated, un-manned facilities (ie with remote supervision) that will increase operational efficiency and reliability.

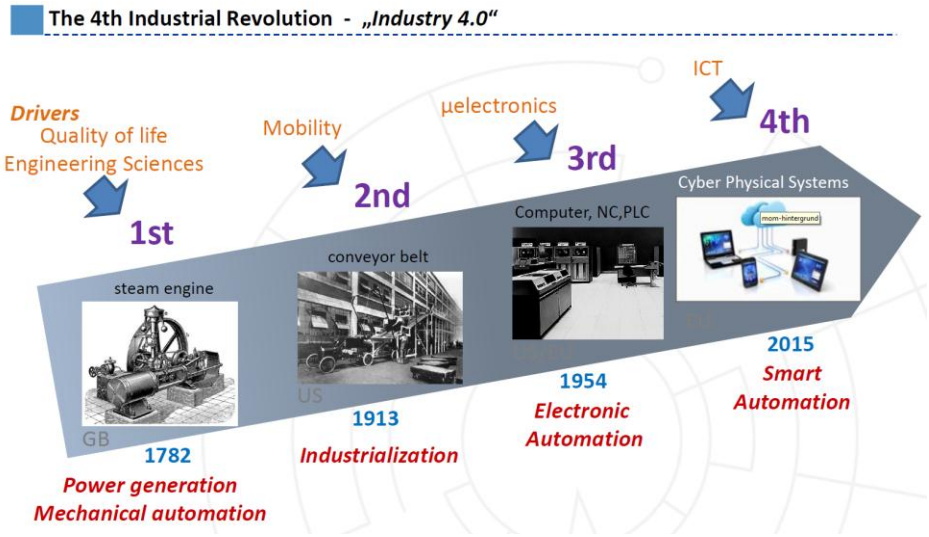

Figure 7 Industrial Revolution and it's Drivers

According to (Lee, 2018), the success of Industrial Revolution 4.0 is attributed to the 4 components of revolution namely Connectivity revolution, Intelligence revolution, Platform Revolution and Social Revolution.

i) The Connectivity Revolution

The main essence of IR4.0 is advancement on connectivity for high speed (for data extensive application) and Low Speed (for lower powered machine to machine) communication. Multiple advanced communication technologies are now available to suit different needs and applications. In the past, wired medium used to be the main mode of communication for high speed and reliable communication but now wireless technology such as WLAN (WIFI) and other cellular technology (23-3G-4G and 5G) are also available as options. (Frost&Sullivan, 2017)

The most recent development on Cellular is 5G which is expected be the key driver for IR4.0 application especially for its high speed and quality. The technology is now pending the standardization but currently has been rolled out as pilot in some countries. The diagram below show the different type of connectivity categorized based on data throughput and range (distance covered) summarized as below:

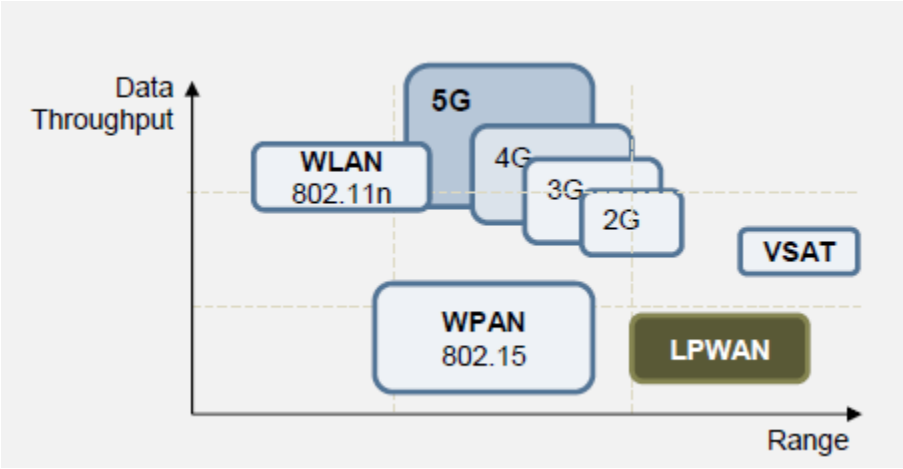

Figure 8 : Wireless Technologies

- 5G- Suitable for IoT and low latency applications
- 4G- Excellent choice for longevity of service, Same base station can offer NB-ioT and LTE-M that can be used for IoT
- 3G- Suitable for high data rates and deployments planned for long duration, for example, 5-8 years
- 2G-Suitable for IoT/M2M devices requiring low data rate. Most effective for most IoT/M2M applications as it is cost effective
- L/S- Reduced connectivity costs helps make M2M more attractive
- N/L-Uses MNO licensed spectrum. Lower connectivity costs than mobile technology

LPWAN on the other hand comprises of the more established but non-cellular-based technologies operating in the unlicensed spectrum, such as Sigfox and LoRa, and the newer cellular-based technologies using licensed spectrum such as NB-IoT, LTE-M, and EC-GSM-IoT. LPWAN networks target low power, wide area IoT services .

While Sigfox and LoRa networks are already being rolled out globally, NB-IoT which was launched in 2017 is starting to get traction. In general, LPWAN networks will be implemented long before 5G networks appear. In conclusion, the combination of high speed and LPWAN contributed towards hyper-connected people, things and machines that will drive IR4.0 further.

ii) Intelligence Revolution

With more machines and mobile devices being connected, more data will be available. But these data can be useful and at the same time can be garbage. Unless it can be turned into meaningful new insights that eventually help to make any decision that can be turned into action. The analogy is similar to using smart watch or wearable to monitor heartbeat. Raw numeric data representing the pulses are passed to the system (normally on mobile phone) which will then, based on certain models, predict activities and present to the users some meaningful visualization and statistic, revealing some hidden behaviors or symptom of medical problem if detected from the pattern of pulses.

Artificial Intelligence algorithms and methods have been around for decades, but lack of affordable computing power has limited their applications towards industries. Nowadays, the high computational power and memories are cheaper and many tools for big data are being developed as open source software allowing AI to be deployed for many different use cases or applications.

iii) Platform Revolution

While connectivity and Intelligence revolution seems to be readily available, platform revolution actually can be crucial and can be the real game changer for any digital application or services that are being developed. Platforms such as Google, Amazon, Uber, AirBnB and many other similar platforms have caused a lot of disruption in today's world, prompting for innovative business model to be developed. Today, Google and Facebook have the largest share of Internet communities which basically allow them to turn themselves into the largest data utility or advertisement exchange platform. Amazon and Alibaba alike, are changing the retail landscape by providing drop-shipping services, which allows products to be delivered directly by manufactures to the end users, hence cutting the cost for warehousing and logistic. Uber and the grab alike, are also challenging many local transportation services which leads to a new regulatory frameworks to be created. In Malaysia for example, several strikes by taxi provider organizations have forced the establishment of the first joint task force between Malaysian Transportation and Communication Commission to co-regulate the services. Similarly with AirBnB, hospitality services can be offered by any property owner at their own time and convenience. Interestingly, the all of the businesses above get to leverage on third parties logistics, fleets or properties without having to invest in any of them.

All digital services mentioned above are some of the examples how Platform, combined with the innovative business model can make the difference between a successful digital service or otherwise. The idea has also led to the concept of City-as-a-Platform that will be discussed in

detail at the end of this section. Generally, it describes the *softwarization* of cities infrastructure on a common digital platform that will unleash many new opportunities and innovation.

iv) Social Revolution

Having digital Platform, Connectivity and intelligence alone will not guarantee a success of a digital service unless the users as the main stakeholders are ready to embrace it. Some examples would be deployment of i-Voting systems in Estonia which have been around since 2005 (Galano, 2019) (Pick, 2018), but only recently managed to record a 45% adoption since 2005. As such, more trust building and awareness programs need to be done by the government. Innovative approaches such as *gamification*, citizen participation, policy and even legal framework need to be in place to increase the chance of successful digital transformation and adoption.

Digital Adoption Around the World

In this section, we will discuss some of digital projects around the world to get some ideas on the pace and traction of digitalization in today's world. In China, the "Internet Plus" policy was introduced to drive "Made in China 2025" vision (Frost&Sullivan, 2017). With the strong research focus and push by the government, China is expected to be the first nation to deploy 5G and other latest technological innovation as more than 200 smart cities are now being developed for the domestic market of 1.3 billion population. Supporting this is Huawei, which is now the world's largest issuer of new international patents with 40% of its 170,000 staff focusing purely on research. Many Industrial IoT solution for example, are already adopted by many manufacturers in China including the use of robot in manufacturing and other sectors.

Similarly in India, the government is pushing to capture 20% of $300 billion global IoT market by 2020. IoT Center of Excellence and hub are established in Andhra and Gujerat and similar to China, the logistic sector has reportedly been benefited from cost reduction of 5%-10% improved 20% on-time deliveries.

South Korea is also one of the earliest to deploy the first 5G for mobility and determined to have 5G trial 2018 Winter Olympic while Japan has also planned for a trial at Summer Olympic 2020. Similarly Australia is getting ready for 5G trial soon but prioritizing on creating the policy framework prior to that.

While the 5G race is set for Korea, China, Japan and even India, New Zealand is taking small steps to leverage on 4G LTE-A Pro for speed and explore LoRa to cater to the existing IoT demand. It plans to learn enough so that it can adapt successfully when 5G comes and scale reliably

The US is looking to leverage on its population to drive the uptake of 5G locally. As the population in developed APAC countries is not nearly as big, use cases will have to be compelling enough to drive 5G.

The vast majority Operators in developing countries will likely deploy 5G after it has gone mass market, that is, post 2020, and network/spectrum sharing may be the way forward. These countries are mostly lack of demand for 5G services especially within lower GDP per capita countries and those with little or no smart city or high tech manufacturing activity. Some

countries have only recently started rolling out 4G networks and will likely enhance it with 4-channel carrier aggregation and massive MIMO to offer a 5G like experience.

While 5G is probably just one aspect of digitalization, the example above should indicate the appetite of some nations when adopting new technology.

The real world examples on application of new digital technology are not hard to gather. In Zhengzhou, China Mobile is using the NB-IoT, to connect three million electric bikes to a management platform designed to reduce theft and accidents (GsmaChina, 2018). China Mobile also provides automated meter reading (AMR) service for electric utilities consists of an NB-IoT connected smart meters, the cloud based OneNET management and application development platform, all supplied by the company, and which can also be deployed in industrial parks and intelligent buildings. China Telecom on the other hand, is planning to use NB-IoT to connect about 1.2 million appliances, such as air conditioners, washing machines and water purifiers in schools and apartments in Beijing, Shanghai, Guangzhou, Shenzhen and Chengdu.

In Valencia, Vodafone and GLOBAL OMNIUM/Aguas de Valencia have been working together to put in place an operating model for the future, and conducting NB-IoT trial with six different manufacturers to assess the properties, performance and battery life of both water meters and local gateway connectors (GsmaValencia, 2017). By using NB-IoT, GLOBAL OMNIUM/Aguas de Valencia is able to take advantage of standardised data gathering and platforms, where the end-to-end management of network operations can be conducted centrally by either the water company or Vodafone themselves.

Sydney Water has successfully deployed smart water project with its in-house Customer Hub that actively interact with citizens to gain valuable insight to deliver better performance. The technology comprises a geo-spatial situational awareness tool (Spatial Hub), online customer portals, automated customer notification and feedback channels, and an Internet of Things (IoT) sensor pilot, simplifying Sydney Water's complex water and wastewater networks, and making identifying and scheduling maintenance simple.

Another example is the Singapore Smart Water Grid Project (Allen, 2012) WaterWiSe platform that covers SCADA integration with sensors to allow water utilities to better understand the behavior of their distribution network and thus improve its operation. The benefits include reduced response time to events, improved operational planning potential and associated efficiency savings.

In Sweden, some of the earliest Smart Metering projects in Europe were done by Connode communication with over 650,000 meters installed in in Sweden, Finland, Norway, the UK and the Netherlands 40+ utilities (Wesberg, 2017). The operator has connected "all" Helsinki Smart Meters 2013 and Wins UK Smart Metering deal with Telefonica. 2-3 million households. They uses wifi mesh communication which could be the best fit technology based on geography demonstrating that options for connecting infrastructure are very diverse, although In our opinion LPWAN could seems be an ideal solution.

In summary, there are already many successful use cases of deploying new technology such as IoT and big data for communication and some take the form of improving current systems such as digitalizing customer interaction and business processes.

The Impact of Digitalization

The impact of digitalization can be seen in many areas of our lives. From city governance aspect, digitalization can help government to engage with its citizen whose active participation will be very vital in any implementation of projects or policies. In Estonia for example i-Voting has been implemented a part of digital government initiatives to encourage more turn out on the polling day. Indirectly, the government can save cost of logistic and deployment of human resource that are normally very extensive on the national polling days (estimated at 50% saving). (Galano, 2019)

City enforcement can also be made more effective, for example, digital surveillance in Seoul has resulted in reduced enforcement officers needed in the cities (Hwang, 2019) (Lee, 2018) Hence the resources such as police and security forces can be channeled to other more demanding tasks.

A lot of government services can also be offered online nowadays, reducing the needs for citizens to spend time at counters and at the same time deliver a more quality and speedy service to citizen (Pick, 2018)

The new approaches in policy making (Moon, 2018) show some trends in leveraging big data technology to understand citizen behaviors through surveys or social observation (Kasdan, 2018). To date there are hundreds of city dashboard initiatives being deployed as a platform to promote a more transparent governance and encourage active citizen participation for example the city dashboard project (CityDashboard, 2017) and city health-dashboard project (CityHealthDashboard, 2017). Many of useful data and information are being shared including city environmental index, happiness index, utilities performance such as energy water and waste statistic, news, weather forecast, announcement, polling as well as city transportation and traffic information.

In addition to this, citizens can socialize and discuss city matters on the platform which city government can monitor and actively analyze to identify any new emerging issue facing the citizen. This has eventually established some new concepts such as urban analytic that uses these open data to study how city and citizen behave. Many governments are also now embarking into open data initiatives to unleash more opportunities that can be delivered with big data technology. (Opendata, 2017)

Healthcare and Education can also benefit from digitalization as better access to quality services can be provided to the remote and rural area with the help of digital platform. Virtual Reality and AI analytic can also provide a new approach for patient diagnostic and help to monitor and track patients effectively. (Jonathan Woetzel, 2018)

Similarly the same impact can also be seen in businesses especially in banking, retail and logistic. (Bowman, 2018) (Catherine Elding, 2018). More banking transaction is expected to be performed online and hence bank can expect to reduce its resources at branches and focus on online activities. Similarly logistic tracking and fleet monitoring can be done online, so resources can be optimized to deliver the best result. In the recent years the use of drones to deliver packages are also being trialed in many cities. In retail, we can also see the impact to the large

hypermarket shifting to online processing as players realized the opportunities of digital platform to increase sales while improving sales operation and planning.

As discussed before, while digitalization is enabled by technology advancement like cloud, AI and analytic, digital platform has paved the ways for some innovative new business models allowing companies like Uber and AirBnB to broker or leverage on other's properties, fleets or asset without directly investing on them.

Apart from the business platform, technology such as blockchain (PwC, 2018) is also being explored for a more secure platform that can be used in finance, smart contract management, energy trading and many others; however success stories are very limited resulting in slow adoption of the platform.

City infrastructure operators require extensive use of workforces to manage and conduct daily infrastructure corrective maintenance such as reading thousands of meters at consumers' premises. Therefore, the city governments are also looking forward to invest in smart water and energy grid to allow distribution automation (KPMG, 2019) (Mckinsey&Co, 2018) which will increase performance of water and energy utilities, however, the pace is subject to many factors that we will analyze in this thesis.

Citizen Mobility can also be improved with the help of digitalization in transport and mobility services (Moon, 2018) (Lee, 2018). One of the examples is the integrated mobility platform that will help to connect various mode of transportation which nowadays includes electronic scooter and bikes. AI has been used to help with the planning and optimization of traffic or ridership such as KL City brain project that uses surveillance infrastructure to help reducing congestion in the city (Wood, 2019).

Agriculture is another area that can benefit from digitalization. A case for example is the Ericsson Corporate Social Responsibility program to regrow mangrove tree along the shore in Selangor as a mean of protecting against sudden rise in water level (The project was later on continued as the first connected-mangrove project) (Ericcson, 2015).

IoT sensors and gateway were installed to collect data such as weather, wind speed, soil acidity, humidity level and many other useful parameters to encourage the growth of mangrove along the area. Despite having all the right parameters, the team was puzzled by the lack of progress and some point the mangrove seeds were being dug out of the soil. This has prompted them to put a new image capturing devices to investigate and later found out that a group of monkeys actually like to take the mangrove seed for their consumption. The information allowed the team to decide to change to a different type of seed that is less favored by the monkeys and eventually allow the mangroves to grow.

The above is of course just a small but meaningful example of how digital technology can also be impactful to environmental sustainability. There are also plenty of researches in agriculture that requires monitoring of environmental parameters and some for diagnosing the symptom of outbreak. Technology such as LPWAN will be useful to help capture all this data in real time and thus allowing quick measures to be taken.

Apart from the impact on business and many sectors, digitalization can also be useful for safety and security. City resilience and security can be increased with the help of digital platform to detect, predict, alert, educate and prepare citizen in facing adverse situation such as flooding, storm earthquake etc. Continuous environmental monitoring and active engagement between government and citizen can therefore make city and its citizen more resilience.

Issues and Challenges

The positive impacts and potential of digitalization are not without any critics or concerns. In some major smart metering initiatives for example, operators are facing citizens who are concern about the health and safety implication of WiFi and 5G to the citizen (Wendrof, 2019). Installation of towers and electromagnetic waves are being associated with high radiation which could be unsafe for the residents. In most of the cases however such claims are normally speculative rather than proven, especially with 5G not being rolled out in the market and lack of real evidence from the use of WIFI in the community. Nevertheless, such participation should be encouraged and more awareness and support needs to be provided to the citizens. The concern could be addressed for example by providing avenues such as local town hall or continuous engagement with local citizen involving experts and other stakeholders.

The other aspects that are being the concern of citizen are the trust, privacy and integrity issue. It goes without saying that data will be generated in volumes with the implementation of smart technology. Data from smart meter (energy and water) can actually be modeled to predict the activities and behavior of consumers in the house (Choi K. Y.). This means, from the trend of data, activities such as bathing, washing clothes, watching TVs etc could be identified. Hence, the issues of privacy and insecurity are being raised, fearing the event when digital infrastructure security are compromised and consequently leading towards information leakages or abuse by people with authorized or non-authorized access. (Wright, 2017)

In the smart metering context, capping or denying citizens' access to the water and energy resources are also seen as violation of basic human rights, which explains why smart features available on smart meters will not be used. Thus, a more delicate approach is needed rather than using the smart technology. Some operators are known to keep low profile on their smart metering project and not discussing it in public but rather addressing and engaging citizen as needed.

AI in particular has triggered a lot of concerns and some have raised the need for AI to be regulated. Like other new ideas, AI raised many questions for example:

- Will AI or machine be accountable of any violation against ethic or regulation(ie autonomous car), in fact in several cases, the progress of autonomous car deployment are halted while waiting for the proper legal framework to be established. (Royakkers, 2018)
- Will the decision of AI be morally or legally correct? For example a classic debate is on Autonomous car that needs to choose between hitting an old woman versus a young girl (given the car needs to decide in seconds to avoid collision). While the decision can involve some empirical calculation, the government or authorities should ideally make such decision from behind the 'veil' (ie no citizen is less worthy than others) (Kasdan, 2018)

- Will AI (or digitalization) displace current workforce with robots and automation, thus making current jobs irrelevant? (i.e less police in city, less bank branches and counters, less field workforce for utilities) (Mueler, 2018). Of course the issue needs to be addressed by proper planning and preparation by the stakeholders. While it is true AI or digitalization will replace jobs, more new jobs could be created (including babysitting automation and in the case of uber, more new jobs are created for public), hence it is the responsibility the government or business to plan for workforce up-skilling or repurposing of resources. Alternatively government can introduce a new robot tax that can benefit the workforce affected.

The other major concern on digitalization is cyber security (JaeSeung, 2017).While AI and digitalization can be used for the benefit of mankind, similar technology can also be used against us. Digitalization can be a double-edged sword, hence it requires every detail risks to be identified, acknowledged, managed and communicated. Similarly, the consequences need to be anticipated and prepared for especially if it can potentially lead to conflicts or disasters (Abburi, 2019).

Adoption & Change Management

Building infrastructure for smart service could be conveniently achieved with the right budget, technology and talents. However, despite all the investment and successful establishment of city's digital infrastructure, it provides no guarantee that the citizen will be adapting to the new changes or actively participate and interact with the new infrastructure (Jonathan Woetzel, 2018).

As an example, with the successfully built and tested online Voting infrastructure, to date; Estonia is still struggling to achieve the degree of participation expected (ie only 45% using i-Voting in 2018 since implemented in 2005). Some people are very skeptical to use the systems, especially when there is no obligation of motivation for them to be part of it (Galano, 2019). As such, people are one of the key success factors that need to be considered when developing smart technology or any digital infrastructure. In this section we will briefly focus on literature to discuss theoretical framework that can be used as the guideline for our research.

Innovation life cycle

Innovation life cycle (Rogers, 1971) (Yogks, 2019) is one of the theories that discussed different stage or type of adopters throughout any cycle of innovation. Innovations are not adopted by all individuals in a social system at the same time. Instead, they tend to adopt in a time sequence, and can be classified into adopter categories based upon how long it takes for them to begin using the new idea. Hence, citizen in the cities for example (or water authorities in our case) can be categorized into innovator, early adopter, early majority, late majority and laggards. It is important to understand the distribution of population across all categories so that an appropriate strategies and resources can be designed accordingly.

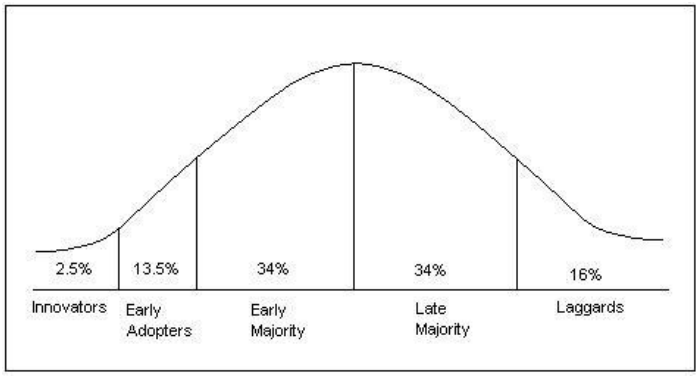

Figure 9 Innovation Life Cycle (Rogers, 1971)

Changes of innovation are driven by a few as small as 2.5% of the total population. At an early stage, the outer community other than the innovators will be the bridge between innovators to the majority of population. This is because the early adopters tend to be integrated into the local social system more than innovators. The early adopters are considered to be localites, versus the cosmopolite innovators. People in the early adopter category seem to have the greatest degree of opinion leadership in most social systems. They provide advice and information sought by other adopters about an innovation. Change agents will seek out early adopters to help speed the diffusion process. The early adopter is usually respected by his or her peers and has a reputation for successful and discrete use of new ideas (Rogers, 1971). In our research for example, it is important to have some of the profiles of water authorities and their leadership who will be the decision makers involved in our projects.

The vast majority of population can be divided into early majority & late majority representing roughly around 68% of population. As these segments have no direct interest on innovation, early majority tend to follow the expert opinion or social leaders (ie early adopters) before deciding to adapt to the new change or technology. Late majority on the other hand will be more cautious but will change their opinion as more and more of the population start to make a shift. As such early adopters can be used to be the influencers to lure more people from early majority segments to join them.

The rest of population might still be skeptical or resisting to commit to any change from what probably has been their comfort state. Addressing the laggards will probably be a tricky business as its could require some wisdom or innovative actions from the administration who at some point, might consider activating a new regulatory framework to enforce the changes, which of course need to undergo many due democratic processes.

As such, the Knoster's model of managing complex change can be referred as a guideline (Razaghi, 2017). The model suggests 5 factors that contributed to the successful change management consisting of vision skill, incentives, resources and action plan.

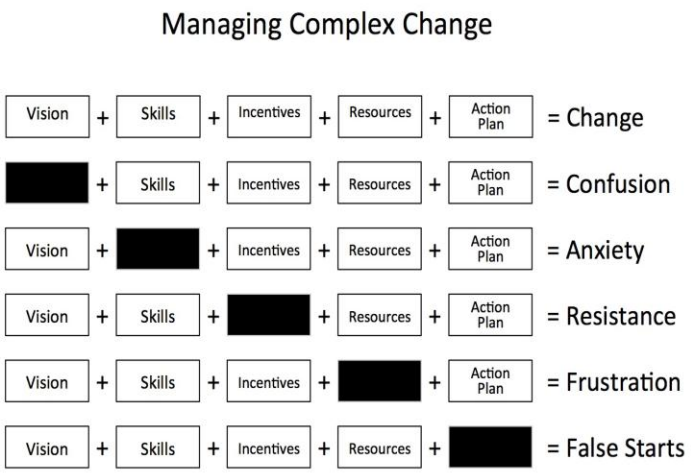

Figure 10 Components for Managing Complex Change

Vision is important, because people whether as a member of an organization or a citizen, need to understand where they are heading with the changes and what should be the end state compared to current status quo. Having a vision for example like "a happy city" will allow the population to relate and feel the needs of the project and therefore approve or even participate in the process. A city without a vision can lead to confusion as many contradicting concepts of city development can co-exist as the city expands.

On the other hand, the changes need to be handled by the right people with the right knowledge and skillset. This will ensure that resources are not wasted to unnecessary activities and valuable time is not wasted to do unproductive tasks. Unskilled workforces would have to spend most of their time learning new things while making important decisions throughout the program. Hence, lack of skillset will lead to anxiety and lack of confidence among not only the workforces but all the stakeholders.

Incentives are also important to lure citizen participation. In most countries for example, water or energy tariff are considered cheap, hence there is little or no motivation for the citizens to change their behavior on utility consumption. This can however be changed with the introduction of innovative digital platform such as smart metering and *gamification* through user mobile application. These platforms will enable city to incentivize consumers for the saving they made against their normal water or energy consumption. This can be done in collaboration with any loyalty points program or any other kind of incentives that can be valuable to consumers. Without motivation, citizen will resist any new changes introduced by the city.

Resources are other very important factors for enabling changes. In many situations, the lack of resources can be the stumbling block that can either slows down the pace or even contributed to the failure of any smart utilities project. The planner therefore needs to plan for the resources that are needed for the project, which includes financial, human resources also time that can be committed by the city to the projects. Failure to do this will result in frustration among various ranks and levels of the people in charge of the project's implementation.

While many cities would have a nice vision and mission on smart cities, the lack of strategic action plan can lead to the wrong start of the project which can cost money and bring down motivation. Action plan can help to identify the strategic and key activities and its success indicators. It shall also provide a clear structure and process that will be crucial in execution of the project. Similarly project timeline should be created and aggressively tracked from any deviation from either time or budget resources.

All in all, these factors or indicators can be used a guideline for our research especially on items to be prepared and discussed with the water authorities as we roll out our pilot projects.

While all the essential components being discussed above could be used in the planning part of the projects, the exploratory research might also need to identify the steps that are needed to accelerate changes. Based on the models from Kotters below, there are 8 steps that generally can be followed.

The first thing first is to establish the sense of urgency and convince the stakeholders on why such changes are important. Smart water project for example can be very crucial as the water authorities are desperate to improve efficiency and optimizing their cost and resources.

As strong guiding team needs to be built consists of all the leaders and or stakeholders that shares the same motivation. Clear vision should be decided so every stakeholders will be on the same page and any changes in direction can be argued if they deviate or not contributing to the vision. This visions are then need to be communicated to all ranks as a form or awareness to get the commitment.

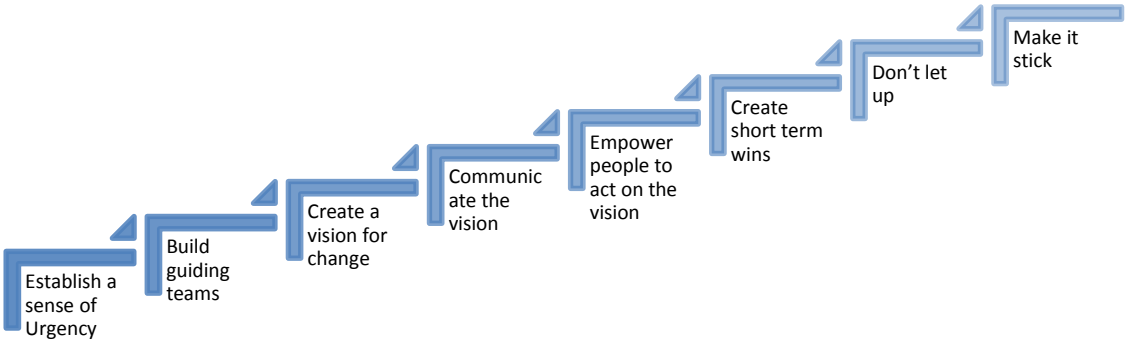

Figure 11 Kotter's 8 Step for Accelerating Change

While the top management could be convinced, the people commitment and participation need to be earned. Thus, empowering people to act will accelerate the change rather than organization or city trying to do all by its own. Some small winnable projects can then be created, aimed towards achieving short term wins that will helps to motivate the creation of more projects and even at the larger scale. The rest of the steps in accelerating change should focus on maintaining the momentum and ensuring a sustained effort towards achieving the long term goal. For this, government or organization can decide on for example to continuously rewarding the people and promoting the effort to gain more supporters which eventually leading towards a new culture and behavior.

Specific to utilities industry, Mckinsey & Company (Mckinsey&Co, 2018) has recently published a report on how utilities can jump-start their digital transformations. According to McKinsey research, the opportunity for incumbents to get ahead of the pack on digitization can be narrow: by the time industries near the 40 percent digitization mark, digital leaders have already secured large market shares. For utilities, these dynamics make it imperative to get digital transformation under way as soon as possible. The consultant has suggested the three steps that can help utilities set a fast pace (as quoted from the report):

1. **Build an executive-led digital mind-set**
   When utility executives adopt digitally savvy behavior, that has a constructive influence on the rest of the organization. Some utility executives we know hold regular meetings with technology executives, venture capitalists, and entrepreneurs so they can keep up with developments in the digital economy and collect ideas to share with their teams. Other key moves are to put a single executive, with a direct reporting line to the CEO, in charge of technology and to encourage the board to devote some of its agenda to technology and the strategic implications of digitization.

2. **Start small, but with big ambitions in mind**
   Since a digital transformation should ultimately cover the entire organization, utility executives sometimes find it hard to decide where to begin. In our experience, it helps to identify a single business domain (such as customer experience, asset operations, or the execution of large projects) where a digital transformation could provide ample value and to begin the transformation there

3. **Make anchor hires to attract digital talent**
   Digital specialists want to work with and learn from people who have a track record of leading teams that envision, develop, and deliver innovative solutions to major business problems. When a utility hires high-caliber digital leaders, this sends a signal to prospective employees that the company recognizes the value of digital technology and appreciates the need for quality people. Anchor hires can also provide digital recruits with compelling reasons to come and work on the utility's digital trans-formation. The senior head of design at one utility, for example, has helped attract new hires by sharing the story of how her team developed a mobile app that made it easier for thousands of line workers to do their jobs well.

Mckinsey's recommendation can be relevant to our research as it can be internalized within our own structure and at the same time recommended to water industry leaders in the preparation of talents for the new digital transformation.

Approach to Innovation- Design thinking

Another aspect of adoption that could be crucial is designing the solution or innovation that actually address the problems or issues organization is struggling to solve. In the past, several models of designing solution adopts waterfall models which involved extensive time spent to build the requirement and designing the final product prior to the actual roll out of the solution.

Design thinking Method on the other hand is a method that allow for agile ways of designing and innovating new solution (Terrar, 2018).

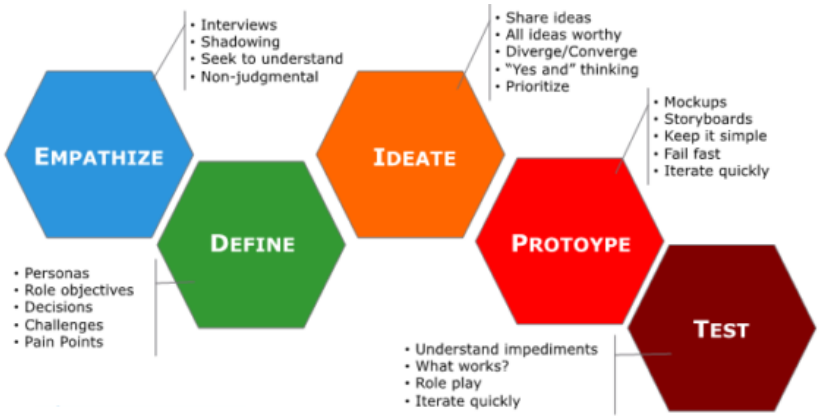

Figure 12 Design Thinking Module (Source :dschool.Stanford.edu)

The classic flow of Design Thinking is to:

- **Empathise** : Involve activities to extract as much information (How, what, where), directly or indirectly from different key stakeholders aimed understand their view, pain points and well as other hidden gestures or observation that are not formally documented. Activities can also include an actual field observation formal interview or story telling approach.

- **Define** (user need and insights) : At this stage , all the information observed above should be defined and properly structured. This includes profiling organizational challenges, personas, pain points, decision needed and many more.

- **Ideate** : At this stage participant will involve in brainstorming session where everyone gets to share ideas and thought without being judged. Every participant should observe and listen while allowing ideas to flow. All ideas shared are worthy and should be taken positively and shall not be judged. The group will then perform the clustering of ideas and prioritizing them which aim to produce a collective decision on ideas or solution, and sometimes lead to a new theme or solution.

- **Prototype** (build to learn) – A prototype is then built to visualize or demonstrate the new idea, it shouldn't be functional but rather it can be in a form of a walkthrough of user journey(considering many possible use case scenario), story board, a mock up model, role playing and etc .

- **Test** (show, don't tell) : The objective of producing prototype is to get early interactive feedback from stakeholders as a form or participatory development through having multiple re-iteration until the satisfied version of prototype has been achieved. The goal is to allow the prototype to 'fail fast' rather than later for example until after complete production of a functional product which at the time, will be too late and costly to fix.

- Start all over and iterate the flow as much as possible : As much possible the steps are repeated until the satisfied version and consensus has been reached.

Design thinking approach would therefore allow a more agile process of extracting ideas and producing prototype for a product. It promotes stakeholder participation and collective decision rather than relying on individual's strength or influence. The method can therefore be useful in our research to help us achieving the solution that really address the problems and at the same time promote co-creation and user participation among all stakeholders. From project implementation perspective this can also be a mean of reducing the risk of rejection or disagreement at the later state of the product life cycle which can be very costly and complex.

The Smart City Paradigm

Before we conclude the literature review, we will briefly look into the smart city paradigm which is one of important topic in urban governance, after all, more than half of world populations are living in the urban areas. It goes without saying that utilities are part of vital city infrastructure that needs to be managed efficiently. Based on several literatures discussed, digitalization needs to be seen holistically rather than independently as it is a platform that integrate multiple interdependent city infrastructures (Hays, 2018) (al, 2012) (Mckinsey&Co, 2018) (KPMG, 2019). As such, any major policies or decisions on utilities infrastructure have some direct or indirect effect on policies of the others (hoi, 2016). For example, while building water infrastructure, planners need to consider the aspect of population and housing, the logistic, security and resiliency, the environmental and ecosystem, businesses and many others.

In fact, with the City-as-a-Platform concept (Bollier, 2016), government can benefit from big data analytic that leverage on multiple sources of data for example from citizen engagement, social media, CRM, population movement, environmental, special events etc. As such, it is imperative for the study on digitalization of water industries to be considered as part of a larger smart city agenda rather than a standalone one.

Smart City Definition

There are many definitions of smart cities currently being used which largely centered on the use of technology, citizen engagement and innovative governance.

Bowerman for example suggested that "Smart Cities" is the urban center of the future, made safe, secure environmentally green, and efficient because all structures - whether for power, water, transportation, etc. are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms (Lee, 2018).

In a smart city report comparing small and medium European cities, the Institute of Regional Science Vienna has defined smart city as a city "well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens." [ViennaSRF, 2016]

The elements of integrated and interdependent infrastructures are the main aspects that have been used which focused on how city should be overarching all the smart components through a centralized digital infrastructure. For example, Hall defined the smart city as :"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges,

tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens." (Hall, 2000)

And similarly the IBM Journals on the foundation of smart cities defines smart cities as:
A city "connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city" (Harrison, 2010)

Think Innovation Research suggested a smart city is about "combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and livability." (Toppeta, 2010)

In general, the use of Smart Computing technologies are seen as the main enablers to make the critical infrastructure components and services of a city, so the city can be managed in a more intelligent, interconnected, and efficient manner.

Nevertheless some definitions puts emphasize on the values of its citizen or vision of cities that they would like to live in for example the Natural Resources Defense Council define it as A city striving to make itself "smarter" (more efficient, sustainable, equitable, and livable) (Nrdc, 2017)

Some emerging discussions are also focusing on the adjective city concept such as green city, City with Soul (Seoul), Happy City, Livable City etc which are the main outcome measured on a city. In this case, while technology and infrastructure are important, the outcome can also be achieved even with less smarter technology such as leveraging on the nature or innovation in governance as well as the citizens participation. The focus of investment here, rather than spent on technology could be prioritized to develop green and social infrastructure as well as promoting citizen participation towards achieving the vision.

Despite of all definitions and philosophies, most of the smart cities are built to support economic growth and to address rapid population growth as the result of urbanization and economic activities. One example is China who is aggressively building hundreds of smart cities to support its economy and population growth (Frost&Sullivan, 2017). Smart city in this case is not the matter of choice but rather a necessity as its will help the city to be more efficient and sustainable. The direct outcome of this can be beneficial to China's economy as its started to produce lots of advance digital components to support IoT and ICT in general, making them to be projected as the first nation to adopt technology such as 5G and to have a more mature and faster development of technology ecosystem to support smart city infrastructure (ie 5G, smart meters and IoT sensors)

However, the planning of smart city should be made in respective context based on the cities' own pace and appetite, taking into account many aspects of readiness, local capabilities and resources while also keeping tab on the other segments of citizen in suburban, rural or village area who are likely to be denied right or access to smart or digital initiatives.

Smart City Index

While the vision and definition that could be adapted by the city varies, smart cities are being benchmarked against the smart cities index or specific metric to measure the improvement of city services. This is useful for the assessment of a city for the funding or risk assessment purposes. Other than governments and city planners, the data will also be useful guide for financial institution and insurance companies, tourism, technology partners that are part of the city ecosystems.

Many smart city indexes have been introduced and become reference by cities for example, the Smart Cities Index by Easypark (EasyPark, 2017); the 2016 Cities in Motion Index by IESE; the Smart Cities Ranking by Juniper Research; or Smart Cities Prospects published by Procedia Computer Science.

We listed below the criteria of Top 50 smart cities government proposed by Eden Strategy Institute (EdenStrategyInstitute, 2018) to understand some of the parameters and values that are being assessed as follows:

VISION	A clear and well-defined strategy to develop a "smart city"
LEADERSHIP	Dedicated City leadership that steers smart city projects
BUDGET	Sufficient funding for smart city projects
FINANCIAL INCENTIVES	Financial incentives to effectively encourage private sector participation (e.g. grants, rebates, subsidies, competitions)
SUPPORT PROGRAMMES	In-kind programmes to encourage private actors to participate (e.g. incubators, events, networks)
TALENTREADINESS	Programmes to equip the city's talent with smart skills
PEOPLECENTRICITY	A sincere, people-first design of the future city
INNOVATION ECOSYSTEMS	A comprehensive range of engaged stakeholders to sustain innovation
SMART POLICIES	A conducive policy environment for smart city development (e.g. data governance, IP protection, urban design)
TRACK RECORD	The government's experience in catalyzing successful smart city initiatives

Figure 13 Smart Cities Index & Parameters

Figure 14 Cities Ranking (Based on Eden Strategy Institute)

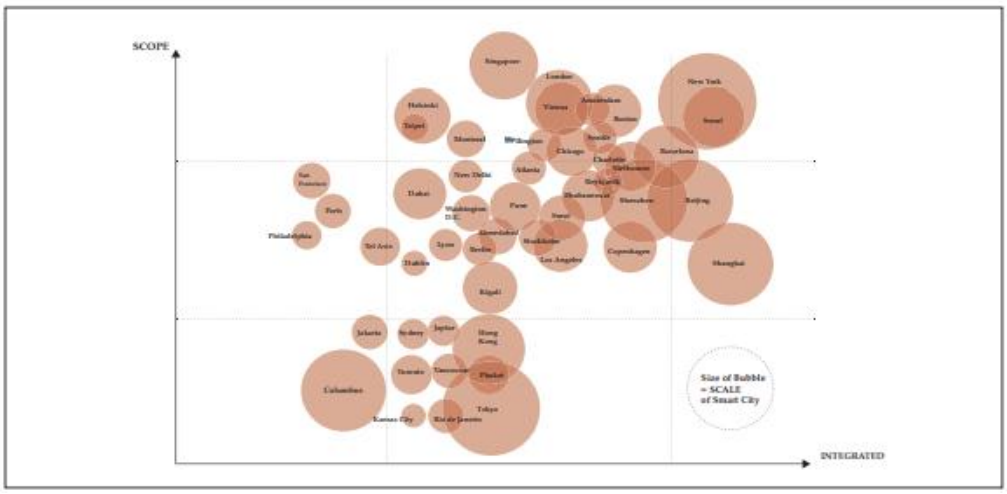

Figure 15 Smart Cities and Scope Covered

Based on the parameters above, the smart cities are being ranked and assessed in various spectrums that is not specific to technology but mostly by measuring conduciveness of environment and soft infrastructure that the cities have established towards realizing smart city initiatives. Vision and leadership probably are among the first that need to be established to drive the initiatives further. The assessment also looks into the capability of the government and some review their budget as well as financial incentive and policies that will demonstrate the government readiness to embark on the smart city journey. Similarly, the support programs are also evaluated as an effort by the government to further drive the implementation of the strategies.

The people elements are important as they are the main stakeholders in making smart city initiative a success. The smart cities programs therefore needs to consider grooming adequate

talents and capabilities to provide a strong innovation ecosystem to sustain the smart city development. People centricity is also important as citizen is the most important stakeholders that smart city is servicing. Although, despite all the capability built, the metric also assess the track record of the government which can increase the confidence or chances of the cities towards realizing their smart city visions.

Smart City as a Platform

The Rise of the "City as a Platform"

Seoul's u-City is among the earliest initiatives by government that leverage on ICT infrastructure to manage and govern a city (Hwang, 2019). Based on the experience of Seoul in developing u-City or (ubiquitous city) in the late 1980s, the concept of u-City has met a static progression that eventually halt the progress of the u-City concept. It was learnt that this can be attributed to the way u-City is being envisioned which look at u-City as a final product. A product is generally seen as a complete system that has all pre-developed components necessary ready to be operational. In the recent decades the smart city concept was coined and then popularized by IBM who was actually campaigning and marketing for "Smarter Cities" to promote ICT and tools developed for urban planning and administration. Smart cities, till now, have been the new paradigm adopted for city administration and some as a state or federal projects.

As discussed above, the definition of smart cities varies and perhaps are still evolving from infrastructure-centric definition (also called smart city 1.0) to a more citizen-centric one (also called smart city 3.0) (Lee, 2018) (PArk, 2018). This trend is also demonstrated through the adoption of adjective city concept such as livable city, happy city etc. In fact smart city 4.0 is said to be more human and environmentally inclusive which include some more holistic values to be adopted.

The concept of city-as-a-platform was introduced in the midst of many definitions and concepts (Bollier, 2016). It describes how smart city can be designed and sustained especially from technological design perspective. This concept has then been eventually adopted in the modern smart city development in South Korea (Lee, 2018). In general, the city-as-a-platform concept leverage on an integrated digital platform to support urban administration which have been made possible with the new advancement in ICT architecture that promote more agile, autonomous, and virtualized systems allowing the city to establish a more sustainable and flexible data driven approach in its management. The concept of *softwarization* of city infrastructure (Finger, 2017) are also being introduced that leads toward new digital services innovation such as meter as a service, urban analytic, mobility as a service, autonomous vehicles, digital citizen ID, citizen engagement etc. (JaeSeung, 2017)

In the essence, City-as-a-Platform is the answer to address the limitation of City-as-a-Product approach as it provides a more flexible city infrastructure that allow many new innovation to thrive while keep expanding its values for the betterment of the cities. As an example, the modern digital design leverage in software systems that are built as modular and smaller systems rather than designed as a large and complex one. The small and modular systems, are built to allow external interaction with other interdependent systems that is enabled by some standard programming protocols to support the interfacing (this is called the Application

Programmable Interface-API). With this development, new software component can be added as the city grow, allowing for a more cost effective and agile development of smart city components and hence allowing the smart cities to evolve rather than being a static final product which has been the lesson learnt from the u-City approach.

The concept of city-as-a-platform has been adopted by many cities and vendors who have formed alliance to further strengthen the ecosystem development of the concept. Through International forum called TM Forum (TM_Forum, 2018), some standards and guidelines which are then formalized as a Manifesto, are being developed and adopted by the signing members. By signing this Manifesto, the members have pledged to drive the future by adhering to the following principles when deploying city platforms:

1. City platforms must enable services that improve the quality of life in cities; benefitting residents, the environment, and helping to bridge the digital divide
2. City platforms must bring together both public and private stakeholders in digital ecosystems
3. City platforms must support sharing economy principles and the circular economy agenda
4. City platforms must provide ways for local start-ups and businesses to innovate and thrive
5. City platforms must enforce the privacy and security of confidential data
6. City platforms must inform political decisions and offer mechanisms for residents to make their voices heard
7. City platforms must involve the local government in their governance and curation, and are built and managed by the most competent and merited organisations
8. City platforms must be based on open standards, industry best practices and open APIs to facilitate a vendor neutral approach, with industry agreed architecture models (see below for examples)
9. City platforms must support a common approach to federation of data or services between cities, making it possible for cities of all sizes to take part in the growing data economy
10. City platforms must support the principles of UN Sustainable Development Goal 11: Making cities and human settlements inclusive, safe, resilient and sustainable.

This Manifesto supports the use of Open APIs and common standards, such as those supported by the European Commission's Connecting Europe Facility (CEF) and TM Forum, which offer a direct path to creating an open, flexible and interoperable city platform model. The guidelines and principles outlined will facilitate cities in managing the vast reservoir of data offered by sensor networks, enterprises city agencies and residents. This can be crucial ensuring the success of the cities in adopting the city-as-a-platform concept.

In conclusion, smart water initiatives should also be planned and designed as part of the larger, interoperable urban systems rather than a silo-ed one. However, with the agile infrastructure design and the supporting digital platform, integration of independent systems can be facilitated by the cities that adapt to certain common design principles and guidelines as proposed by the Manifesto. This will allow them to benefit from the strong ecosystems developed by the technology partners; at the same time allowing them learn some best practices from experience of others.

CASE STUDIES

Malaysia

Context

Malaysia's Social, Economic and Political Background

Located in South East Asia (north), Malaysia is divided by South Chinese Sea into Peninsular and West Malaysia (also known as Borneo). The peninsular Malaysia is bordering with Singapore on the South and Thailand on its north.

Malaysia has a tropical rainforest climate with a lot of rainfalls throughout the year especially between October to February each year which makes flooding as one of the potential climate challenges for this country. It is also located slightly off the Pacific Ring of Fire of making it the free of earthquake or volcanoes.

Figure 16 Map of Malaysia and All the States

Malaysia is a multicultural country with population is 32 Million people, with Malay being the dominant ethnic groups (67%) followed by the Chinese (24%) and Indian (7%). There are also other minorities ethnic groups especially in West Malaysia which, together with Malays are categorized as 'Bumiputera' status which grant them certain privilege after the Independence and formation of Malaysia in 1957 and 1963 respectively.

Malaysian GDP grew at an average of 6.5% per annum for almost 50 years (AgentsChap, 2016), contributed by a well diverse sector predominately from its natural resources such as oil and gas, rubber, and in the last decades has been focusing on manufacturing and knowledge economy. Aimed to be the tiger of Asia, Malaysia adopted similar government systems as Westminster in UK, with federal constitutional monarchy consists of 13 states and three federal territories, Election are held every 4 years to elect 222 members of House Representatives and also State Legislative Assembly for every 13 states. With the first past the post systems, the winning coalition will form a cabinet led by a prime minister. The general election in 2018 was significantly historic for Malaysian politic as the ruling parties was defeated for the first time since it took power for over 60 years ago. Under the "New Malaysia" tagline, the opposition now ruling party has committed to a reformed agenda to bring Malaysia at back on track to become the Tiger of Asia with true democratic values.

The smart City Initiatives and Supporting Framework

Smart Cities development is part of the agenda in 11th Malaysia Plan 2016-2020 (Ministry_of_Economic_Affair, 2018) as well as the Industry Forward 4.0 framework currently being drafted (Min_InternalTradeIndustry, 2018). The **Eleventh Malaysia Plan** contains Malaysia's five-year development plan towards realizing the goal of Vision 2020. The concept of a smart city has been introduced with the development of Cyberjaya and Malaysian Super Corridor in 2004. Driven by new knowledge economy, the cities were aspired by the Silicon Valley concept aimed to bring many high tech companies and global talents to be part of Malaysia innovation hub.

To date, the concept of Cyberjaya as smart city has been extended to be a live innovation hub for new technology sandboxing. Neighboring to Cyberjaya is Putrajaya, a modern administrative city that was built towards a Green Government City. Currently, almost all Ministerial headquarters and government agencies are located in Putrajaya. With the wide range of unique architectural design and ecstatic environmental features, Putrajaya has now becoming a popular tourist attraction.

Apart for the two cities, smart city concept has been adopted at the State level with Kuala Lumpur, Selangor and Melaka all coming up with their own smart city blueprints . KL was ranked 105th smartest city among over 500 cities worldwide, Singapore 23rd and Tokyo 27th (2018 Smart Cities Index surveyed by Europe-based EasyPark Group) (EasyPark, 2017)

Digital Adoption and Challenges

Apart from smart city initiatives by City and state government, many of city infrastructure administration such as energy, water, transportation and waste management generally centralized under federal government with some function privatized to local companies. The energy supply sector for example, is being served by a single national energy company, Tenaga Nasional which used to be part of government entity and then turned into Government Link Company.

Under the smart grid and Advanced metering initiatives, the company has in the recent years rolled out a pilot smart meter projects involving more than 300K houses. Similarly, in transportation, effort are being undertaken to provide an integrated transport systems which is currently managed by different operators. Recently the idea of City brain are being introduced in collaboration between Kuala Lumpur Municipal and Alibaba (Wood, 2019), aiming to utilized the AI and the city's surveillance systems to reduce traffic congestion in Kuala Lumpur.

Unfortunately for sectors like water service and waste management, the digital adoption is still lagging behind, as water operators being overwhelmed with issues on basic infrastructure improvement. As such, our studies will include a couple of pilot projects conducted within water industries, in which we aim to investigate the water industries adoption of digital technology.

From telecommunication perspective, Malaysia generally has a good telecommunication infrastructure (Ghani, 2019) with more that 77% broadband penetration nationwide. The

cellular penetration is even greater with more that 143% cellular subscription compared to Malaysia population (31.8Million). LTE network are also widely available with 68% coverage nationwide while the 3G and 2G penetration have been more than 92% overage. This fact suggested that Malaysia is one of the highly connected nations and will be ready for digital adoption.

Water Industry landscape in Malaysia

Malaysia Water services industry has undergone a reformation in 2008 following the enactment of water Services Industrial act 2006 (Nariman, 2017). Prior to this act, each of the 13 states are in charge of water resources, treatment, and distribution which have caused non-standard service level across the nation. There was no uniform legislation governing the water industries and water tariff are not calculated based on standardized principle. This has led to inconsistency even in the use of treatment material for water hygiene.

The reform involved restructuring and centralizing the water management of the state government by establishing SPAN (National Water Services Commission) and PAAB (Water Asset Management Company) with the objective to improve the efficiency of water operators in Peninsular Malaysia including Labuan (Thomas, 2019)

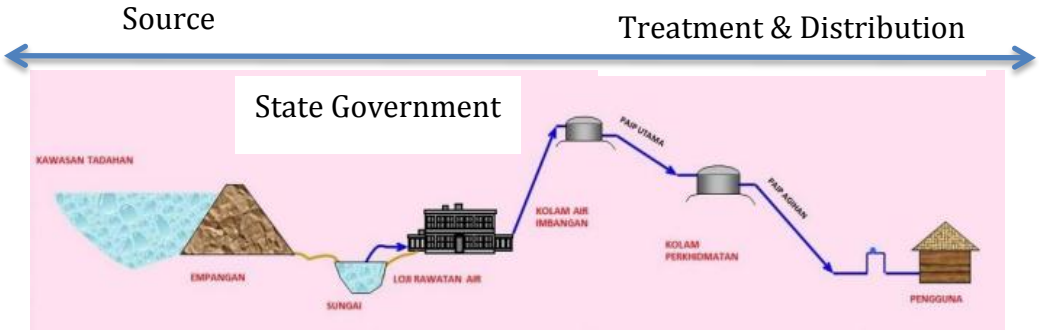

Figure 17 Before Water Industry Reformation 2006

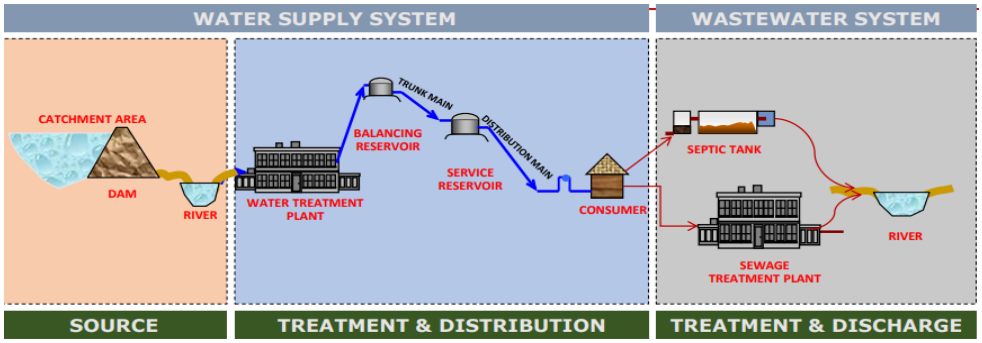

Figure 18 After Water Industries Reformation 2006 and restructuring 2008

State Government	**Federal Government**
(Water Source is under Federal purview - Environmental Department	Ministry of Water, Land & Natural Resources, Malaysia – (Dept. of Irrigation and Drainage) •National Water Resources Commission (SPAN)

With the introduction of the act in 2006 in particular and several other bills introduced, Water Services were then being governed by a single regulatory body. Uniform tariff setting mechanism was formed and there were consistency in product and material standard.

Operational procedures are also regulated. In general, the state government will no longer in charge of the whole supply chain but limited to the water sources as shown in the above diagram. The other actors within Malaysia Water Sectors can be summarized as follows:

Authorities	Scope of Responsibilities
Ministry	Establish Policy Matters regarding Water and Sewerage
State Government	Authority over State water Resources, Abstraction and Catchment
The National Water Resource Council	Coordinate water resources and river basin management
National Water Resource Commission (SPAN)	Regulate water supply and sewerage services for peninsular Malaysia and Labuan

Figure 19 Water Authorities and Responsibilities

Nariman (Nariman, 2017) has conducted a study to empirically measure the efficiency of water service operation before and after the reform. The study has shown that the establishment of SPAN and PAAB has had a small but positive impact on the efficiency of state-owned water operators. Some of the water operators have achieved ISO9000 Quality Standards and also maintained ISO14001 standards for environmental quality, although for some operators, efficiency seems to degrade after the privatization but getting to pick up within 5 years of the new policy. Generally in the long run the reform has shown some positive results.

Part of the reform was also to introduce a new funding mechanism that is based on asset light models. Under this mechanism, water asset will be owned by federal through a water asset holding company (PAAB).

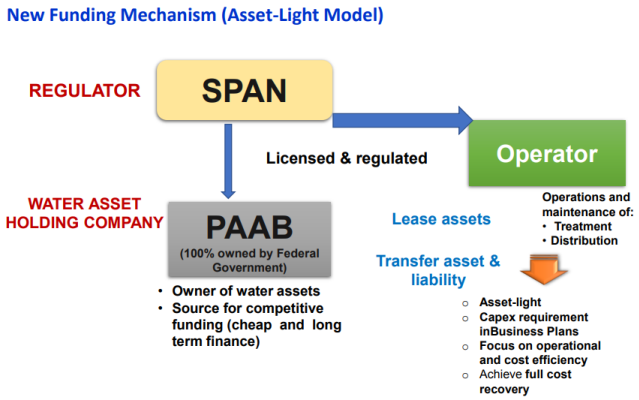

Figure 20: Asset Light Model and Funding Mechanism

Through this restructuring exercise, the operation and maintenance of the water services are done by operators (licensees) that is private, individual or state own companies. To date there are 14 licensees including Labuan that is under the purview of SPAN. Note that for the west Malaysia, there are operated by few states regional water boards which is under State government water department.

The following diagram showed the licensees for all the states in Peninsular Malaysia. Note that in our cases studies, we have conducted the survey and engagement with the following state-own water operators: Air Selangor, SAMB (Melaka), SATU (Terengganu), AKSB (Kelantan), SADA (Kedah) and JANS (Sabah Water Department).

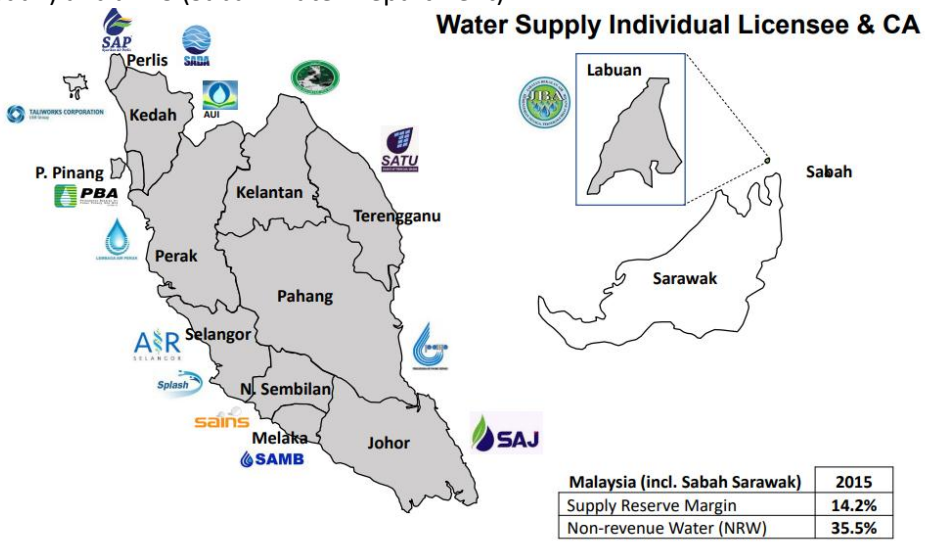

Figure 21 Water Supply Operators (Individual Licensee)

From infrastructure point of view a total of 160km pipe have been installed. Between 1990s - 2017 the length of pipes has increased by 103,359 KM which is 212%, so in average there is an increase of 3,828 KM of pipes. Based on the statistic given, 80,000 km or half of current total water pipes length have been installed prior to 1999. These are the pipes that are above 20% and might be due for replacement as it could potential contributed to leakages and leading to a poor performance of Non-Revenue Water across the country. (Thomas, 2019) (AWGWRM, 2015)

The worst NRW has been recorded is in Perlis at 63%, while 4 of the other states have recorded more than 46% NRW. The current average of NRW is at 33% and the government is setting the target of 31% by 2020.

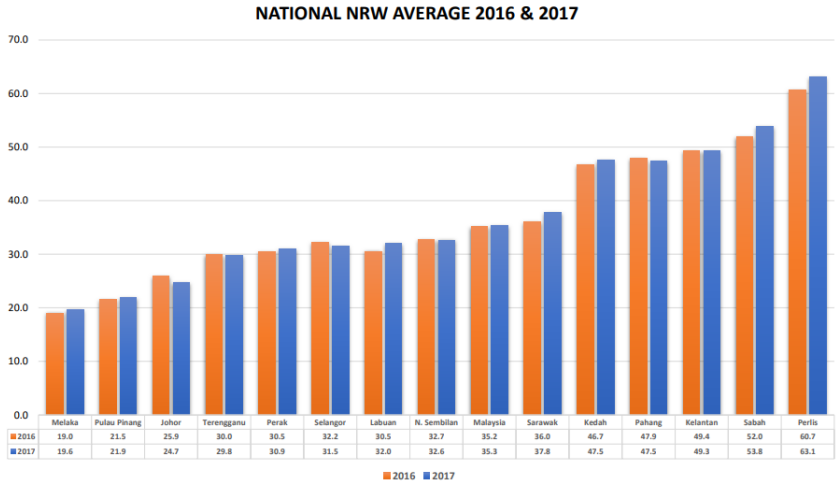

Figure 22 Malaysia NRW Average 2016 and 2017

The federal government has invested more than RM13Billion since last decade to address the issues of infrastructure can be broken down into the following.

- 9th Malaysian Plan – 6.9Bil
- 10th Malaysian Plan – 6.3 B
- 11th Malaysian Plan – 1.8B (2016-2018)

In general the funding was focusing more on the 5 highest NRW states which is Perlis, Sabah, Kelantan, Pahang and Kedah. At current moment we leant that the infrastructure replacement program had taken place in some of the states but not taking into account rebuilding digital infrastructure around it. Note that by definition Non Revenue Water can be contributed by either physical losses or nonphysical loses. The non-physical loses refers to the indirect loses due to longer time to identify, respond and repair as well as in accuracy in data due to manual reading of meters etc.

Water consumption rate is quite high with 209 Litter/day in 2018, compared to UN standard at 160 litter/day and Singapore 140litter/day. As shown in the statistic, Perlis has recorded the second highest water consumption despite having 63% NRW. It also has the least population among the other states and not the central of economic activities.

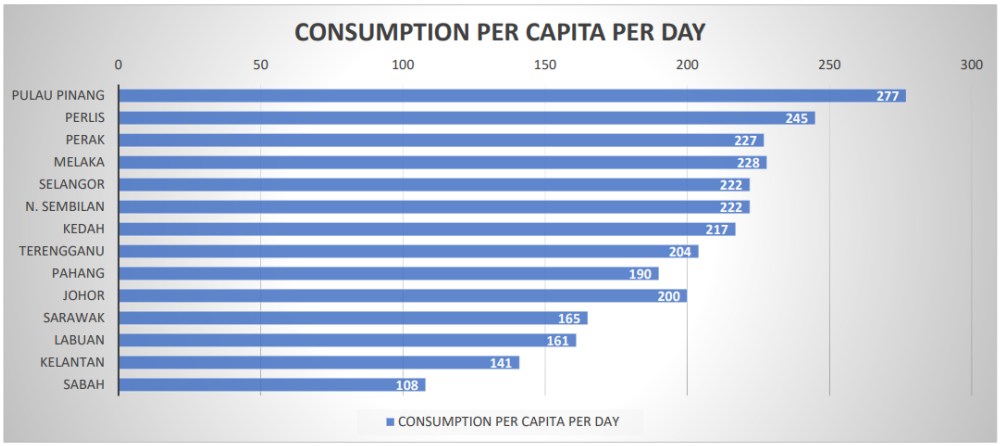

Figure 23 Water Consumption by States

Water Quality in Malaysia is meeting WHO standard. The Malaysian Green Technology Master Plan (2017-2030) has put emphasize on the increase of Revenue Water rather than Non-Revenue Water term as a form of reverse psychology approach. It called for active participation from all water operators and new funding mechanism to "capture revenue".

Despite the positive outcome from the water reform, the whole water industries in Malaysia are still lack of integration especially with the waste water management which is undertaken by different agencies that report to the same Ministry.

Apart from Water supply and Regulatory bodies (ie SPAN), there are other actors the deals with the sewerage(IWK), water source, water asset(PAAB), waste water management (IWK) and research and development (ie NAHRIM) in water industries. However, due to the scope of this study to focus on water services and the impact of digital adoption into the industries, the rest of the water networks will not be discussed in this study.

SEOUL

Context

Seoul's Social, Economic and Political Background

South Korea is located in East Asia on the south part of the Korean peninsula, which is surrounded by the three seas: the Yellow (West) Sea, the South Sea, and the East Sea. The Han River (length of 481.7 km, basin area of 26,018 km^2) is the largest one of South Korea and flows through Seoul (largest population) metropolitan areas including Inchon (third) to the West Sea. Between June and September, there is about 74% of the average yearly precipitation.

As a fast-moving society, Seoul is facing multiple challenges in providing and managing the infrastructure to support the growth of an already highly-dense city. To date, Seoul population has reached 10 Million people which is one-fifth of South Korea's total population of 50 million. The metropolitan area, including Seoul, represents 25 million inhabitants, a situation that leads to many urban challenges for the country, in terms of development

Over the last several decades, the country has enjoyed a high level of economic growth with an average annual rate of the Gross Domestic Products (GDP) of 8.5% (water policy reform South Korea) contributed mainly by the industrial sectors mainly electronic and household goods.

Republic of South Korea adopted the presidential representative democratic republic systems, whereby the President is the head of state, and of a multi-party system. Executive power is exercised by the government while Legislative power is vested in both the government and the National Assembly.

According to the Organization for Economic Cooperation and Development, or OEC, Korean has been listed as one the most educated population in the world with 48.8% of adult aged 24-60 has obtained high education.

Digital Adoption and Challenges

According to Wikipedia, Seoul has been described as the world's "most wired city", ranked first in technology readiness by PwC's *Cities of Opportunity* report. Seoul has a very technologically advanced infrastructure. Seoul is among the world leaders in Internet connectivity which has the world's highest fibre-optic broadband penetration and highest global average internet speeds of 26.1 Mbit/s. Since 2015, Seoul has provided free Wi-Fi access in outdoor spaces through a 47.7 billion won ($44 million) project with Internet access at 10,430 parks, streets and other public places. Internet speeds in some apartment buildings reach up to 52.5Gbit/s with assistance from Nokia, and though the average standard consists of 100 Mbit/s services, providers nationwide are rapidly rolling out 1Gbit/s connections at the equivalent of US$20 per month. In addition, the city is served by the KTX high-speed rail and the Seoul Subway, which provides 4G LTE, WiFi and DMB inside subway cars. 5G will be introduced commercially in March 2019 in Seoul.

Based on the reputation and success story of Seoul Water industry, we have selected Seoul Water service management as our model for local digital water transformation. Having said that, Seoul is still struggling in other issues ie to address its housing issue especially with the rapid growth of population . As a smart city, Seoul has a strong digital and water management policies which is crucial for the sustainability and development of utilities and infrastructure (Nam, 2018).

From social and cultural perspective, Seoul and Malaysian in general have some similarity being part of Asian countries. Seoul is also one of the city understudied as part of IGLUS program during which, the author spent 2 weeks as a study visit to Seoul and has a chance to visit some of the key places, learnt from and engage with the experts and local scholars who have been contributing to the input for this study.

From economic perspective, Seoul metropolitan is the home of electronic industry's giants such as Samsung or LG and has been known as one of the early adopters in technology and ICT application on Urban management. From our literature review, we observed Seoul's transportation, water and waste management are among some of the highly rated services, not only as backed by statistic and international recognition, but can be attributed to successful implementation of key policies and citizen participation in the related issues.

Seoul Water Management, for example, is recording a staggering 96% of Revenue Water and currently aspired to provide tasty and healthy water to its citizen. It is rated as one of the best water in the world and at a very affordable price. Nevertheless, the ratio of population drinking tap water is very low mainly because of spread idea from the 50's that tap water has a bad quality. A current issue related to deceasing plastic usage is to change citizen state of mind concerning tap water.

Seoul Metropolitan Government (SMG) has started to embrace smart city initiatives since the 1980's with the introduction of the ubiquitous city or u-City (Hwang, 2019). With the emergence of new technologies such as High-speed network, mobility, big data, IoT and AI, in particular, Seoul infrastructure management has been adopting ICT in many ways to enhance service delivery. This development has been conducted with strong implication of companies and focus

on resolving concrete problems, such as improving transportation with a huge increase of population in a small amount of time.

Apart from the infrastructure, the highly populated Seoul is struggling to provide innovative policies to encourage citizen participation in decision making. Citizens are becoming more politically active and demanding for inclusivity in making a decision of the city's major projects. The successful implementation of the "One Less Nuclear Power Plan (ONLPP)" for example, demonstrated how different actors and stakeholders were getting involved in the policy proposal and implementation.

While the discussion focused on Seoul as a prominent example of how urban management and ICT technology are extensively embraced, the impact of such heavy reliance on ICT to human and community has raised some new issues. The new generation of the Seoul is starting to embark into work-life balance that seems to be overwhelmed by the aggressive economic development.

The smart City Initiatives and Supporting Framework

The ideas of smart cities have been around since 2004 for Seoul when Korea coined the concept of Ubiquitous City (u-City) (PArk, 2018) (Lee, 2018). Since then, most of the cities being constructed with u-City with around 50 out of 163 cities in Korea has started constructing Ubiquitous City. Among them, 57% are from 33 Seoul Metropolitan Area (19 cities). Hence, Seoul can be seen as pioneer in smart city with numbers of policies and framework being developed to support the development of Smart City.

While many definitions and concepts of smart cities exist, the main discussion is centered around building the smart city as a platform (rather than a product). Many lessons that were learnt from the u-City agenda are being used to enhance the direction of the new smart city initiatives. A smart city is seen as a platform that allows many different city services to 'communicate' with each other. Big Data and AI have played some key roles in this respect especially after Seoul declared the end of AI 'Winter' in the recent years.

Citizen and government are now able to communicate on regular basis through digital means. Through OASIS apps, for example, the citizen is actively proposing and discussing city issues that need to be addressed, which will then be taken up by the authorities. Some Policies are also driven by big data, in which, data from hundreds of different systems within the SMG is currently being consolidated to support decision making in urban management.

In the transportation domain, apart from various CCTVs and loop sensors, the city is collecting data from the various infrastructure domains. This includes data from the MET office and from smart transportation card and also from credit card that helps them predict public transport ridership such as current utilization or passenger in public transport. In the night owl bus services on the other hand, the systems uses real time spatial analytic tools to dynamically customize route according to changing night population. (Lee, 2018)

Within the water sector, measurement sensors are used extensively to ensure the water supply quality are preserved to the highest standard (hoi, 2016) (CHOI, 2018) (Choi K. Y.). From the

research on smart water meters deployment, the water companies are able to understand water consumption behaviour, leveraging on the big data technology.

Another domain where technology has been used heavily is in disaster management. With 10% of the city budget allocated for disaster preparation, Seoul has basically equipped and ready for disaster such as typhoon or flood and able to engage with the citizen digitally.

In summary, the data-driven approach by Seoul government has demonstrated some significant success based on the capability in addressing many issues of the city. This can be effectively done with strong institutional support from Seoul Metropolitan Government that oversees all city infrastructures via its digital platform.

Water Industry Landscape in Seoul

Water in Seoul is being managed by Seoul Waterwork, an authority under Seoul Metropolitan Government. The agencies are further divided into the research institute, Water Supply office , Arisu Water and Waterwork Equipment Management Center. Currently, water management in Seoul is considered as world top level with Revenue water as high as 95.7% as of August 2016 (or NRW of 4.3%). The authority currently handling Daily average production of 3.19 million m^3 and deliver water services to more than 10 million people which is about 20% of Korean total population with current water supply rate at 100%.

As of 2015, the total length of the pipe network of Seoul is 13,697 km, i.e., about 1.1 times longer than the diameter of the earth (12,756 km). The most effective way to increase the RWR is to replace the old pipes in the supply network system. The Seoul Water Authority invested budget of 1.7 trillion KW between 1984 and 2013 to replace the 87% (11,221 km) of the old pipes.

The authority has replaced 97% (13,292 km) of the old pipes in 2016 with total budget of 3.3 trillion KW. Remaining 405 km of the old pipes will be replaced until 2018. Although it differs by pipe material and diameter, the life of the pipe asset is generally 30 years10. The replacement of the old pipes has to be a continuous project based on technical and financial consideration. Criteria to determine the old pipe has to be established for the project to be effective. Studies on asset management are required to secure the efficiency of financial investment for RWR increase

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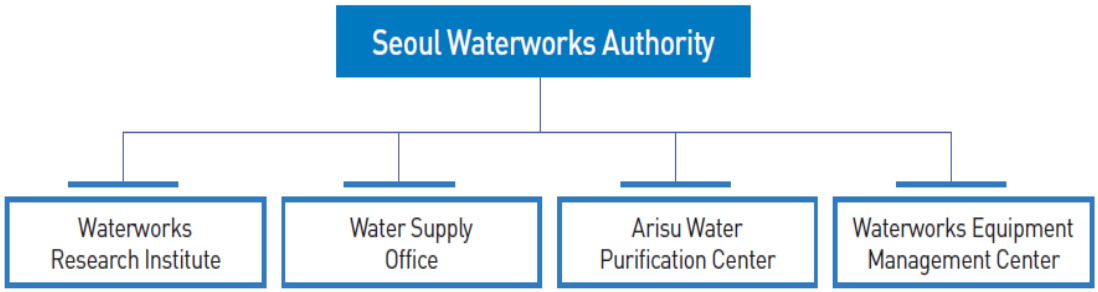

Figure 24S Seoul Waterworks Authority' s Structure

Despite being among the top water service globally, the authority is facing many challenges such as frequent Urban floods, expansion of the capacity of smart water grid facing governance issue due to separated water supply and sewerage service. From social point of view, while the water are claimed to be healthy and safe to drink, there are still strong mistrust of Water Quality among the public.

The water service has been benefiting from strong and innovative water policies especially through the introduction of Policy on the Revenue Water Ratio (RWR) which started with the establishment of Seoul Water Authority, in 1998. The authority then began to roll out plans and project to improve RWR until it reached the world best level. (hoi, 2016)

The main contents of the policy include;

- Launching and operating a dedicated organization for drinking water
- Projects to reduce leakage using scientific and systematic leak detection based on ICT
- Projects to measure night minimum flow
- Projects to replace and rehabilitate old pipes
- Installation of water reservoir system using gravity
- Scientific water management based on water flow monitoring system
- Knowledge sharing programs to improve RWR

RWR improvement was also boosted by the urban regeneration policy. As the city had more of urban regeneration projects, the management on the waterworks system within the project area was managed systematically and intensively since 1999.

The policy on Geographic Information System (GIS) was also contributing towards the RWR improvement project is to reduce water loss in the water supply system. Precise information of location and attributes of water pipes are imperative to increase the RWR. Spatial information using waterworks GIS allow users to manage construction, analyze and predict leakage which can be preemptive management method for the RWR improvement. The urban infrastructure for waterworks system in Seoul has been stabilized decades ago with almost 97% of old and corrosive pipes were replaced and further completed by 2018.

Other Water Policies related with the RWR improvement project are also in place including urban safety, water demand and supply management , pipe network improvement projects (replacement, re (replacement, rehabilitation, and management of old pipes), and investment and budget operation strategies. This is evidence that water governance and management in Seoul is mature and can be a good model for water other water authorities.

Digital Market Outlook and Potential

Before analyzing the state of digital penetration in Seoul and Malaysia, it is important to understand the different challenges in water industries in the context of Seoul and Malaysia. The priority of digital agenda could therefore be highly influenced by these challenges:

Malaysia Challenges for Smart Water Systems:	**Seoul Challenges for the Smart Water System**
• Finance • Technology Ecosystems Support • Awareness & Skillset • Regulation	▪ Regulations ▪ **Climate change** ▪ PPP ▪ Transparency ▪ **Finance**

Figure 25 Smart Water, Challenges in Seoul and Malaysia

Both Malaysia and Seoul shared similar issue on financing as with any other cities or countries in managing city-wide/state-wide utility infrastructure. However, this issue is the top concern in Malaysia compared to Seoul. The financial stability and strong economic growth will probably be the strength of Seoul that allows them to complete more than 96% infrastructure upgrade which will last for the next 30 years. Malaysia authorities on the other hand are struggling keeping the pace with infrastructure upgrade amidst challenging economic challenges.

Regulation is also common concern among the two, but has been top concern in Seoul compared to Malaysia. Having stable and renewed infrastructure in the last few years, Seoul priority would be to maintain the infrastructure by strengthening the operational and strategic policies around the industries. Malaysian Water industries however are still undergoing continuous reform and much handholding effort and coordination need to be done by the federal agencies (SPAN) to improve the situation especially with 1/3 of the water authorities in Malaysia recorded more than 46% of NRW. Based on our engagement with the regulator, while the policies and enforcement exist, it is not feasible to impose for example penalties to any of the violation at current stage.

While Seoul water is managed under Seoul Metropolitan Government, Seoul actually has to deal with municipalities especially on water facilities and jurisdiction. Similarly, business model such as Public Private Partnership (PPP) is also area that Seoul is struggling with. In Malaysia, since the water industry reform, the demarcation of roles and authorities between federal and state territories has been effectively addressed. Under the same initiative, water asset are being transferred to a government owned by a public water asset company while state water companies (as licensed water operator) focus on the operation and maintenance of their respective territories.

Climate change is also another concern in Seoul which, apart from having 4 seasons, is exposed to typhoon and storms especially between July to September each year. During typhoon season for example, will increase the risk of flooding although at some point storms would be effective natural answer to contain the algae bloom outbreak that normally hit the reservoirs and dams (Park, 2018).

As a leading democratic country, digitalization project in Seoul is now moving toward citizen participation as people expect transparency in every aspects of national infrastructure

governance. As the result digitalization of water industries, Seoul need to also include open data and dashboard for public access. This will mean that the government will need to maintain high quality of services of the city water infrastructure.

In contrary, Malaysia is still lacking in term of talent and skillset to support digital water infrastructure but despite that, our observation is that the water operators have enough skilled personnel that have years of experience in traditional water management approach. From technological perspective, since the industries are still new in digital, strong ecosystems and supports are urgently needed as catalyst to digital adoption within Malaysian Water Industries.

Based on a survey exclusively conducted for Telekom Malaysia by IDC, we have also studied several statistic on IoT Maturity Assessment conducted among IoT decision makers in the region.

The Survey shows that South Korean is the highest spender in IoT technology in the region with close to USD 30B IoT spending in 2018 and expected to rise to USD 40B in 2022 . This is highly significant compare to Malaysia which only recorded USD 2.358B in 2018 and expected to double by 2022. Compared to the rest of Asean country, Malaysia is still trailing behind its neighboring countries like Singapore, Thailand, Indonesia, Philippines and Vietnam.

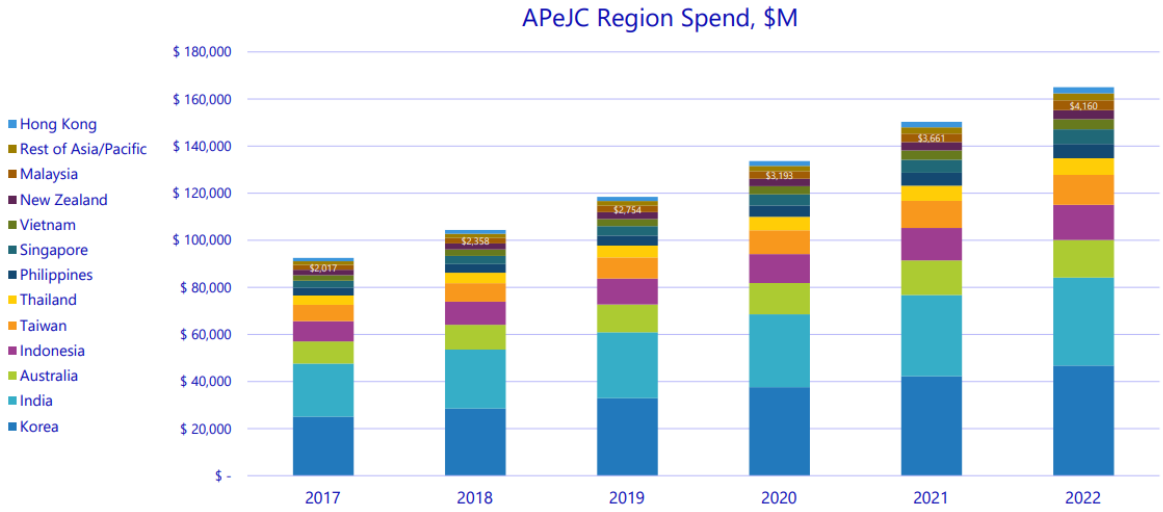

Figure 26 IoT Maturity Assessment 2017 (IDC Research)

From the perspective of IoT related projects surveyed, at least 19% utilities organization has started IoT projects in 2017. The outcome has suggested the utilities sector are looking into project such as Leak Detection (19%), Predictive Underground Line Services (19%), Intelligent Grid management (18%) and Remote Access management (19%). In another word, digitalization is already ongoing in this sector, but based on our engagement with local water authorities, these projects are still conceptual at least locally.

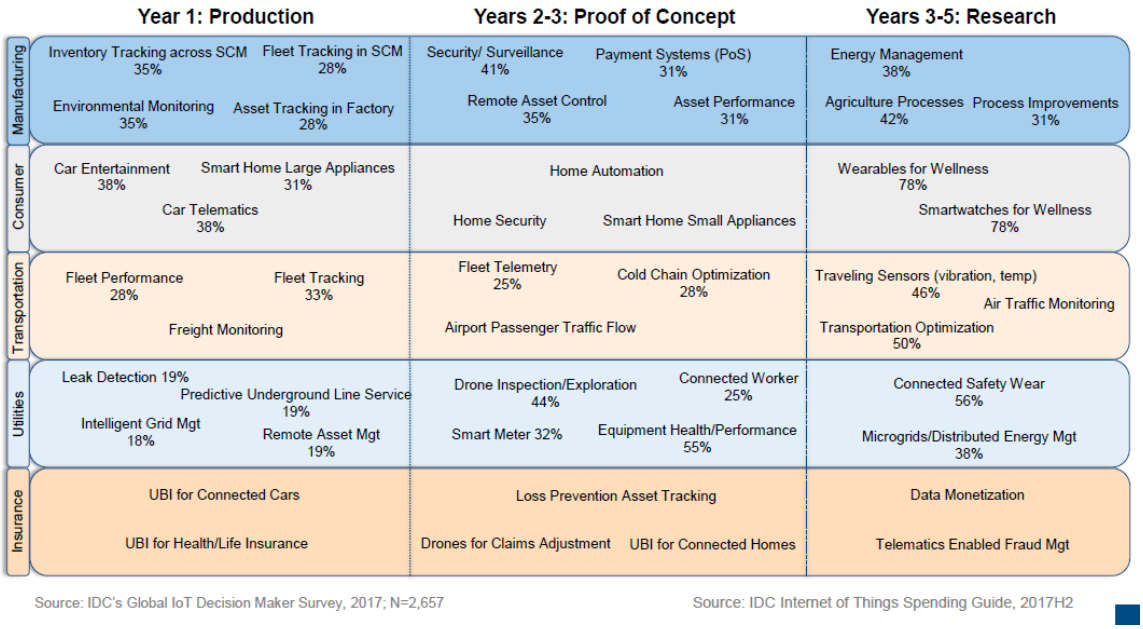

Figure 27 Survey of Smart Water Projects (Source :IDC Survey)

The similar research also indicated that by 2020, the water service operators are also looking into Smart meters (32%), Equipment Health/Performance (55%), Drone Inspection and Exploration(44%) as well as connected Worker (25%). At the same time some research activities have taken place in the area of Microgrid/ Distributed Utility management (36%) as wells Connected Safety Wearable (56%). This shows that most of the water Operators are already investing or looking into digitalizing the water service operation.

Based on our engagement, some local water operators are already working on developing workforce management while there is also ongoing traditional meter (not smart meter) replacement projects being initiated at several states although, in our best knowledge only couple of state water operators (Selangor and Malacca) are currently piloting 100 unit of IoT meters (which Telekom Malaysia is participating until July 2019)

Institutional Readiness

From the institutional perspective, Malaysia is currently at 33% NRW rate which is close to global average. From the tariff perspective Malaysia has among the lowest water tariff which has not being reviewed for decades. In the recent post general election in 2018, after the changes in government, the idea of reviewing water tariff has been mooted and discussed but eventually decided not to be reviewed. As such, the low tariff will continue impacting the industry's financial sustainability at least until the next 2-3 years.

Some critics around the issue are being raised especially when water subsidy being offered to certain segments of consumers, despite lack effort on water education and awareness among citizen to reduce or manage the consumption of already low tariff utilities. Water treatment processes are also associated high consumption of energy that can reach up to RM300Million per year. In south Korea though, water tariff is also relatively low, thanks to the strong economy and the successful RWR policies and project that see the drastic improvement of Seoul water industries with less than 4% NRW in 2018.

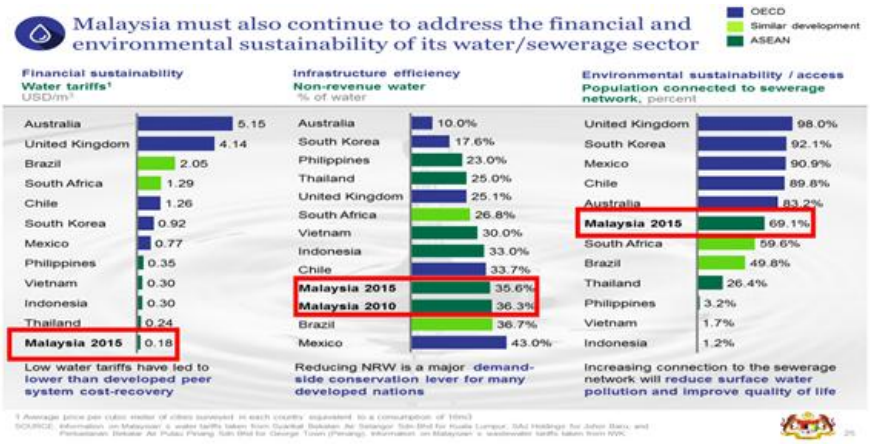

Figure 28 Malaysia's position in Water Financial Sustainability and Infrastructure Efficiency

Technology Readiness

In general Technology such as NB-IoT has penetrated the market since 2016 with many use cases are being implemented in Seoul and other part of the world. Based on our study on Seoul for example, the pilot project implementing NB-IoT and LoRAWAN based smart meters have been deployed and completed in some cities while actual implementation has been rolled out successfully at several cities. Seoul Waterwork has even made the data available for public access in real time as part of their commitment and obligation in the democratic country.

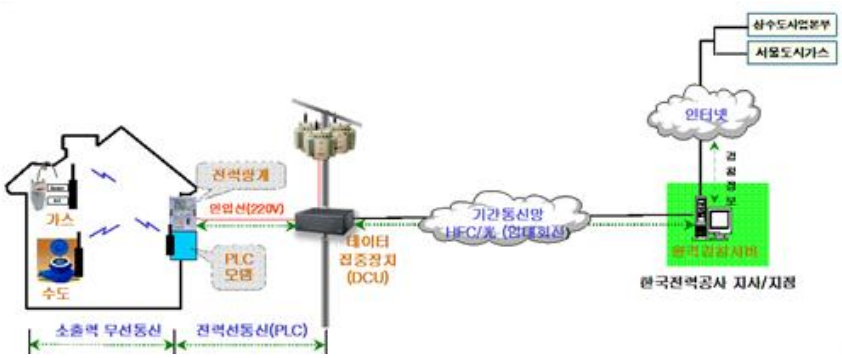

Figure 29 Seoul's Integrated Smart Metering Testbed

Source : Bereau of R& D Seoul Water Institute Seoul Metropolitan Government

Based on our pilot deployment, we reckoned that, within Malaysia, technology such NB-IoT and has been available since 2015 when Telekom Malaysia's R&D established the first NB-IoT lab in the country.

NB-IoT technology operates on a spectrum that is already allocated among the 4G/LTE services providers and it takes only software activation for NB-IoT Services (at base station) to be offered to the users. LoRAWAN on the other hand is more ad-hoc kind of infrastructure and operates on unlicensed band. This means the technology can be offered by a small company or startup by installing the gateway for the IoT access.

However, despite this opportunity, the roll out of LoRAWAN within utilities are limited or unheard of. This can be attributed to the concern over lack of strong standard (such as 3GPP under International Telecommunication Standard) that is normally acquired by telco grade services like NB-IoT. Hence, for critical services like Smart meter a more reliable and better assurance solution is needed.

Apart from that, the technology is perceived as lack certainty in term of sustainability and future readiness, although actually the technology are being supported by a strong alliances of major players or network and equipment vendors around the globe.

Compared to NB-IoT, LoRAWAN is also seen as a more mature option judging from its strong ecosystems supports and numbers of sensors and smart meters available in the market. This means that, other than typical smart metering devices, other peripheral sensors such as GPS, temperature, water level, water quality, crack sensors, motion sensors are relatively more available in the market compared to NB-IoT.

The traction for NB-IoT has probably been hindered by lack of strong ecosystems. NB-IoT meters also (based on our experience) need to be tested with different Service provider's network infrastructure since there are different spectrum allocated by the regulator in Malaysia (ie band 8 and band 5) adding challenge to the already weak NB-IoT ecosystems (at least in Malaysia).

The other aspect of the technology is the strategy of deployment. As seen in the diagram above, a combination of gas, energy and water meter can actually utilize a common gateways or communication medium. However, in Malaysia, such consolidation will be very challenging since all utilities are being managed and operated by independent operators that are likely to build their own infrastructure rather than integrated one. Integrated Smart water system will be ideal approach as it creates economic of scale while silo development by separate entities is a mis-opportunity.

Technology as % of Population				Business Environment	
ICT Spend	IoT Spend	Cloud Spend	Broadband Penetration	Start Up Procedures	Government Effectiveness
Vietnam	Korea	Singapore	Korea	New Zealand	Singapore
HK	China	New Zealand	HK	HK	HK
Singapore	Vietnam	Australia	New Zealand	Australia	New Zealand
Malaysia - 4	Taiwan	HK	Australia	Korea	Australia
New Zealand	Indonesia	Korea	Singapore	Singapore	Taiwan
Thailand	Philippines	Taiwan	Taiwan	Taiwan	Korea
Australia	Thailand	**Malaysia - 7**	China	Thailand	**Malaysia - 7**
Taiwan	India	Thailand	**Malaysia - 8**	**Malaysia - 8**	China
Korea	New Zealand	China	Thailand	Vietnam	Thailand
Philippines	Singapore	Philippines	Vietnam	China	Philippines
China	Australia	India	Philippines	India	India
India	HK	Vietnam	India	Indonesia	Vietnam
Indonesia	**Malaysia - 13**	Indonesia	Indonesia	Philippines	Indonesia

Figure 30 Source : IDC Report on Iot Readiness Index 2017

Based on the IDC survey, Malaysia generally ranked average when relatively compared to the other regional countries surveyed, especially on Cloud spending and Broadband penetration. The business environment and procedures it exercises for startup are also at average rating compared to other, some are which Malaysia can improve by learning from neighboring countries including Korea.

IoT spent is seen as the lowest among all, which suggested that IoT awareness or penetration is still far away from other countries in the region although the spending on ICT is among the highest which suggest that Malaysia is still developing its ICT infrastructure while setting low priority for the IoT implementation

Pilot Study on Technology Adoption by local Water Authorities

The second part of this research will be largely based on pilot studies conducted in collaboration with selected water authorities. Prior to the commissioning of pilot project, we conducted some local survey on the major challenges facing local water authorities to devise some potential solutions and identify the tools or enablers for the delivery of the project. The output has been summarized and used for our initial proposal can be summarized as follows:

Challenges →	Solution →	Enablers

• **NRW :** High non-revenue water due to leaks, water theft, and payment defaulters
• **QUALITY** :Old distribution pipes causing discolouration of treated water
• **INFRA** Old distribution pipes being prone to damages that cause leaks
• **Water tariff** in Malaysia, which is already one of the lowest in Asia, is unlikely to be reduced in the short term
• **Others : (Based on survey)**
  • Compliance (Reporting and data)
  • consumer satisfaction,
  • Decentralized Data and overloaded data from multiple disintegrated systems
	• Water **pollution control** and detection
	• **Leak detection**
	• **Theft Detection**
	• Rainwater harvesting
	• Water **quality monitoring**
	• Advanced **water pipes**
	• Water use **minimisation**
	• **Consumer-centric** mobile application
	• Operational **Efficiency**
	• **Data Management Infrastructure and analytic** (from automatic data ingestion, digestion to visualization and Analytic)
		• Smart Water **Grid**
		• Advance Metering Infrastructure **(AMI) – for Demand Management**
		• Smart **Asset/Fleet** Management
		• Connected **Workforce (Process Digitalization)**
		• **Command Center's Business Insight & Analytic** Dashboard (consumer behavior, prediction, prescription)
		• **Non-Technological**
		  Regulatory Input
		  • Innovative Business Model
		  • Consumer's Behaviour Analytic

Figure 31Mapping Challenges to Solution

In summary, the proposed solutions are mainly concentrated towards a more connected infrastructure, digitalized and connected process and workforce as well as analytic which are also confirming with some of the literature survey on current trend and solution.

The next step is focusing on building a conceptual enterprise architecture to identify key components of the complete digital solution while mapping our resources and capability to fill the gaps. The finding leads to the formulation of Digital Water Framework.

The Digital Water Framework

The solutions to address the NRW in particular are based on the following framework that we have developed to educate the partnering water authorities on digital transformation journey. The understanding of such framework is important in managing stakeholders expectation as well as communicating any requirement related to the framework.

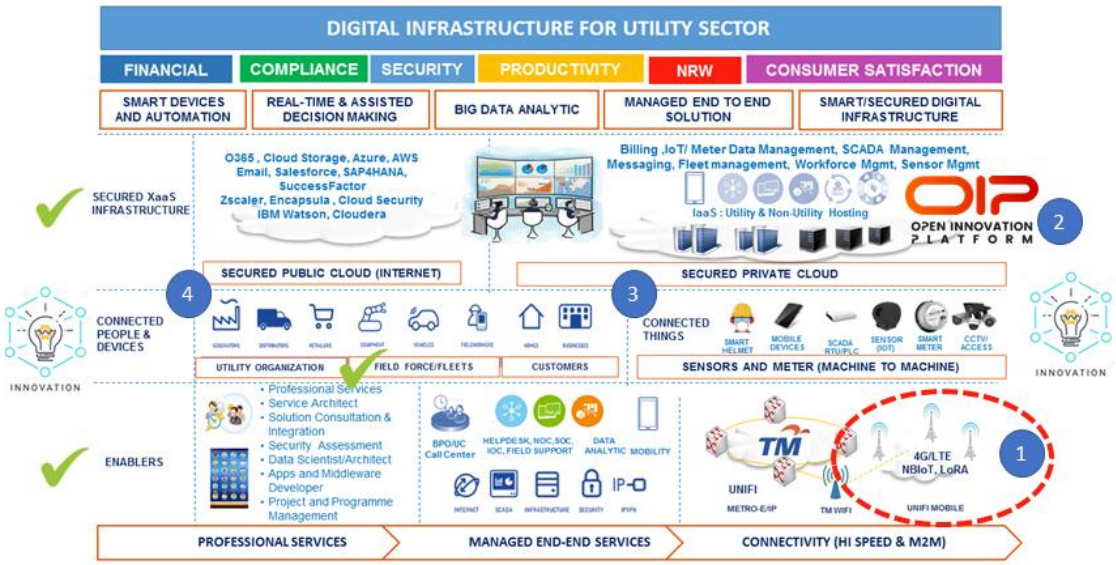

Figure 32 TM's Digital Water Framework

The framework explains the whole digital architecture that form a building blocks towards achieving certain business goals of water industries such as addressing NRW, improving customer satisfaction, increasing productivity and meeting compliance and financial requirement. We emphasized that the digital infrastructure need to be built on connected platform in which Telekom will play role of providing necessary means of communication whether in the form of wire or unwired medium. Secondly a centralized data platform needs to be built at the other end of the infrastructure, which can be in the form of virtual cloud infrastructure that are equipped with facilities for data management and analytic. We have proposed the development of an Open Innovation platform that will be able to support multiple use cases including IoT data management, big data analytic and dashboarding that can be used for solution development.

The role of the participating partners are therefore is in providing the specification and requirement on relevant sensory devices such as smart meters and other mobility applications and devices to be used as part of daily activities (ie workforce management). In this case, since the workforce management is currently operating on physical paper form, a new digital platform and application for workforce are introduced to deliver the same business process as in the manual one.

As the result of our consultation with participating partners, we have agreed for pilot deployment to contain the following digital components :

1. Connected Thing (ie IoT Meter, Water Quality and level sensor) at selected water treatment plants and houses)

2. Workforce Management Apps and Tablets (20 units covering the workforce within Region of Jasin in Malacca)
3. Analytic Platform are being agreed and planned to include CRM data, social Media data and new data from workforce management and IoT data management.

The following timeline indicates the actual timeline agreed with the water authorities to deliver the 3 research projects namely workforce management (FORCE), IoT (SWIMS) and Analytic (BIS + Analytic)

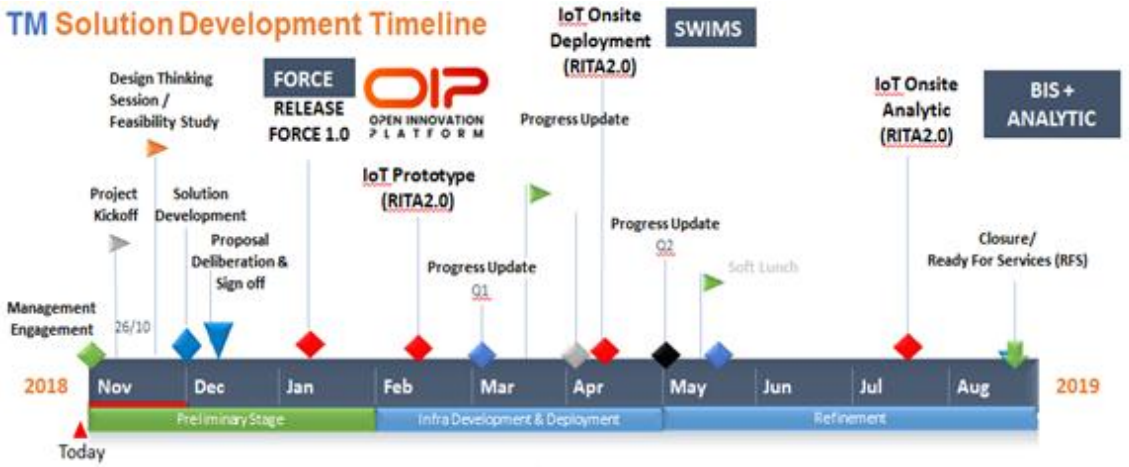

Figure 33 Pilot Project Timeline

A letter of Offer and Letter of Intent were being exchanged between the Telekom and State Water Authorities that formally agreed on the commitment and responsibilities as stated below:

TM's Responsibility	Water Authorities Responsibility
• To provide Research & Development Resources including developers, project managers, engineers, researcher and organize relevant activities • To provide Basic Infrastructure for Pilot implementation Including Connectivity(ie sim card), Tablet, Mobile Application and Cloud infrastructure • **To provide Platform** Dashboard,System including backup, front end interface and other hardware and software requirement • To Provide IoT devices and data management. This include smart meters, water quality/level sensor IoT Management/Operation Dashboard • To provide Analytic/Business Insight (Dashboard) integration with current systems.	• To provide Signed Letter of Intent Sign (as agreement to participate in Pilot Programme for Workforce, IoT for NRW and Analytic) • To actively participate Knowledge Sharing activities organized throughout the programme • To Participate Design Thinking Workshop & Field Study organized • To co-develop Product Development Journey & Evaluation • To advise on Business Model Development and Proposal if necessary.

Figure 34 Responsibility Matrix

The simulation IoT testbed has been successfully established at TM's R& D lab in April 2019 and actual devices are being installed from May 2019 to August 2019 for the assessment by water operators

Figure 35 Water Testbed Deployed at TM's R&D

Photo in fig. 35 showing an end to end Internet of Water Testbed for showcasing and experimentation.

The participating water authorities have been brought to visit the lab as part of validation and progress report deliverables (Fig 36).

Figure 36Visit By Water Athorities to the Testbed

For our Pilot Study IoT meters are also installed on actual user premises since April 2019 and will be completing in July 2019. During the technical compliance test, our proposed solutions have successfully met the compliance criteria set by the water authorities (ie battery duration, stress

test of 96% communication reliability apart from urdergoing physical stress test by placing meters in various condition ; under water, under soil and in the metal closure) - Fig 37

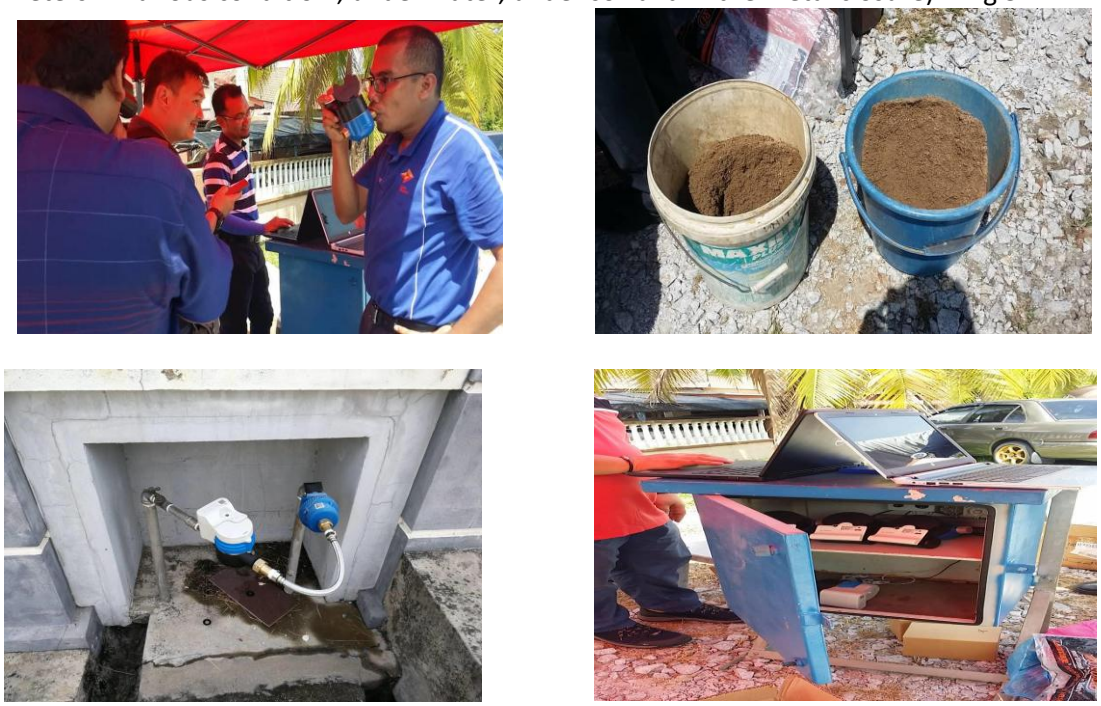

Figure 37 Field Smart Meter Test for Pilot of 100 Houses

Note that while the full deployment of onsite IoT for meters, water level, water quality and IoT analytic might yet to be completed at this point, most of the planning, simulation work and key engagement activities (surveys, workshop, training, awareness, visits) have been completed and will be enough to cover some observation on the digital adoption for water industries.

In the meantime, the pilot study on Digital Workforce management has been fully completed for 2 consecutive months and entering pilot closure stage in July 2019. For the Pilot deployment of Connected People Apps/Tablet, we have delivered mobile Application and 10 loaner units of Tablet for the new workforce Management.

Figure 38 On Field Deployment of Smart Workforce

Similarly for analytic, data was gathered form existing CRM systems which are then added with data from social media as well as the new IoT and workforce management dashboard as part of

deployment of Business Insight & Analytic. The result have been presented during monthly management meeting update.

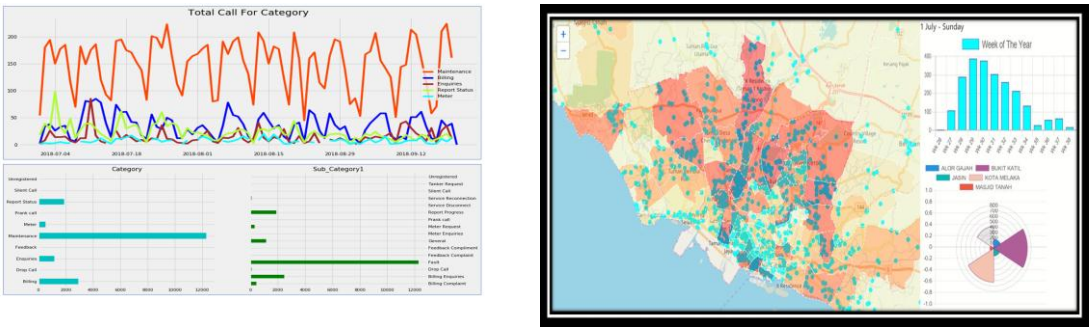

Figure 39 Analytic Result from visualizing data from CRM, Social Media, Workforce and IoT

In general, the **p**ilot study has been successfully delivered and running for the past 2 months and pending the closure of pilot activities. This pilot study is a small scale preliminary study conducted to allow us to evaluate the solution feasibility, project resources (time & cost), the challenges and basically to understand how the end to end digital solution can be delivered successfully.

For the context of our thesis, we have observed beyond technological infrastructure and look into the adoption of the digital solution by the water authorities. As such some of the background data obtained can be summarized as follows which we will discuss and analyze in the next section:

Challenges & Concern on Digital	**AIR Selangor (Selangor)**	**SADA (Kedah)**	**SAMB (Malacca)**	**JANS (Sabah)**	**AKSB (Kelantan)**
State Contribution to National GDP(2017)	**23%**	**3.3%**	**3.1%**	**6.8%**	**1.8%**
GDP growth(2017)	**7.1%**	**5.0%**	**8.1%**	**8.2%**	**5.0%**
Population	**6.38M**	**2.16M**	**0.91M**	**3.87M**	**1.83%**
NRW 2017	**32%**	**47.5%**	**18%**	**53.2%**	**49.3%**
Technology Awareness	**High** (management and Working level have and understand digital vision). Smart meter Pilot project has also been initiated	**Medium** Hi and mid level management have experience understand vision	**High** (Management and Working level have and understand digital vision and participate	**Medium-** Management level understand the vision and looking forward to embark on digital journey	**Medium-** Management understand the vision and looking forward to embark on digital journey but at this point in the

			in pilot)		midst of structuring
Leadership engagement/ buy in	COO/Relevant management, State Smart City Director	CEO/COO and higher management	CEO/COO and all higher management and working level	Head of IT and Corporate	CEO and higher management
Motivation/ Drivers	Smart Selangor Initiatives, Economic	State's NRW reduction program.	Leadership aspiration, Smart Melaka	Unknown until further engagement	NRW reduction
Top Concerns	Reliability, Compliance customer expectation	Sustainability, Reliability, Bad experience with Smart meter (over 2G/3G)	Efficiency, Business Model, Opex, infra readiness, skillset, Business Insight	Institutional Support, Bureaucracy, stringent structural rules	Scattered population, Low water supply coverage
Ongoing IoT Project	100 unit pilot NB-IoT meters for Smart Sepang	Remote meter reading using 2G	Pilot for SCADA IoT, Smart Meter (10 units, Water Quality/Level (selected Plants)	NA	NA
Category	Potential Early adopter	Early Majority	Early Adopter	Late majority due to institutional barriers	Uncertain due to changes in leadership

Figure 40 Observation Notes on Water Authorities

Platform Requirement & Challenges

One of the key infrastructure of our pilot project is the data management platform that is known as the Open innovation Platform. OIP is developed as a cloud-based rapid development platform that enables provider- consumer ecosystem for digital innovation by leveraging services including data hub, smart service hub, IoT management, service marketplace, analytics and many more.

In general, the platform is developed as an open concept to allow collaboration between internal resources and external ones. This can potentially help to boost innovation culture in the company while encouraging co-creation of services. Through this platform, developers, providers, partners, researcher to co-develop new solution from time to time by recycling or leveraging on existing software modules, tools, workflow, code to allow speedy development and testing of new systems. The concept of OIP is represented in the following diagram:

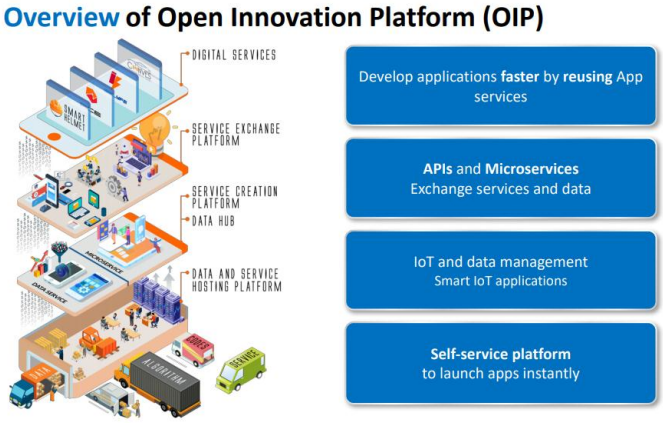

Figure 41 Open Innovation Platform (OIP)

In the context of our pilot project, OIP allows customers and its (in housed or outsourced) developers to co-create and connect to many other micro-services and templates from TM such as map, IoT dashboard, IoT adapters, Analytic, billing and Payment Gateway, Social Media, TM mobile call data record, TM geocoding, Telephone directory, CRM, security intelligence, vulnerability management database, reputational database and many more. Most importantly the services will be hosted on a carrier grade service provider infrastructure which is supported by our local team of experts and workforce which will be a huge factor that will help water authorities to accelerate digital transformation. The overall benefits can be summarized as follows :

- **Collaboration :**The platform provides Ecosystem to Co-develop new services using agile software development methodology by leveraging on ready templates and modules such as analytic, payment gateway, dashboards and IoT connectors to create a new digital service
- **Speed :** The platform allows developers to deliver new services at faster rate through resource (ie code and module) recycling avoiding the need to build infrastructure from scratch as being done traditionally (which is normally quite static and need longer change management process). This concept is especially useful for piloting new digital services before such as Advanced Metering Project.
- **Cost to Serve:** OIP is a one stop platform for sharing variety of APIs for creating new innovative applications which can also be a marketplace offering free and premium tools. This means, the cost to provide hardware, software, network and other essential infrastructure can be greatly reduced as the result of hardware and software consolidation. The model also allow for competitive software or service acquisition which traditionally done by sole developer with short or long term contract which could be risky investment by water utilities.
- **Security and Scalability :** By utilizing cloud based services and platform such as OIP, Water Utilities can focus on its core business while OIP cloud providers take care all investment on IT infrastructure, security and scalability. This will also include retaining high turnover experts and talents (ie in the area of security, data management and analytic) which could be a burden especially when IT is not the core business of water utilities. Additionally Data will be also be secured in a cloud facility while maintaining data sovereignty (keeping data local) which could be crucial given for local regulatory compliance.

ANALYSIS & DISCUSSION

In our Literature Review we begin by studying landscape of utilities sector highlighting some main challenges of the industries and went into specific issue which is the water management efficiency. We narrowed down our survey to understand further about Non-Revenue Water especially their causes and strategies in addressing issues. We then established our core hypothesis to suggest that the poor NRW performance can be significantly improved by adopting digitalization on infrastructure and the operational process.

Our discussion was then shifted towards understanding current landscape of digital technology and Industrial 4.0, giving some background of IT and industrial revolution from historical perspective. We then surveyed a list of digital initiatives around the globes to understand its pervasiveness before studying impact it has brought to different spectrum of our lives. As digital adoption is the main focus of our research, we also surveyed some theoretical framework on managing change and dealing with people in general.

However, learning from our literature, we have to conclude that digitalization need to be seen as an interoperable system rather than a standalone one, and thus should be integrated with other element of cities infrastructure. This has brought our attention to cover some key aspects of smart cities especially the concept of City-as-a-Platform to further expand our study of digital adoption.

Based on all the input from the literature we then begin to look into specific context of Seoul and Malaysia, deliberating more about the water industries and digital landscape which will be analyzed in this section.

The later part in this section is dedicated to the sharing and analyzing our observation from running several pilot projects with the local water authorities. We will exclusively discuss various aspects including technology, institution and people readiness specific to the context of this Project before concluding the thesis.

CASE OF MALAYSIA

Malaysia, like Korea is aspired be one of the digital nations and has been relying on digital economy as the future endeavors of Malaysian economy.

From the infrastructure perspective, Malaysia has among the highest statistic on broadband penetration, thanks to the national broadband and fiberization plan which begin in 2008 and completed recently (2018). The country is now going into the new phase of National Connectivity Plan that will significantly include 5G as part of the converged national infrastructure.

Although current Internet performance is seen as average by the speed comparison, falling behind countries like Korean and Singapore, this however, is still satisfying as the country is aiming towards higher rate of penetration rather than performance. This means that resources and efforts are spent into widening the coverage of Internet access rather that increasing the

speed. Furthermore, most of the development of physical infrastructure is being pressured on the Government Linked Company.

However, broadband competitions are recently being boosted by the implementation of Mandatory Standard Access Pricing (MSAP) that seen the new government enforcing on cutting down the price of broadband to half while doubling the speed. The new policy has introduced new competitions into the market which can be seen as an effort towards open market competition.

Apart from that, Malaysia has always at the frontline of new technologies and recently has been organizing 5G showcases for future technology and application. Internet of Thing and Big Data are being the point of discussion by the government and enterprises across all sectors, however the actual implementation and real applications use cases are still lacking.

In transportation sector, the Kuala Lumpur Municipal Council has recently launched its collaboration with Ali Baba in the City Brain project that aim to reduce traffic congestion in KL by using AI and CCTV feeds around Kuala Lumpur. In the energy sector, the national energy company has already initiated 2 pilot smart meter projects involving more than 300 thousands houses in Malacca, which are still in progress. The company has also initiated its smart grid and distribution automation project, but will grow steadily with aging infrastructure replacement program that will be done in stages.

In the water industries, the first smart meter project based on NB-IoT was announced in Sepang, a small region within the Selangor State. Similarly in other state, the idea of smart water distribution, IoT and Analytic are currently being promoted by the author and his team at Telekom Malaysia. In another area especially in e-government, the use of digital technology are picking up but in the other sectors, the development are noticeable but not in a large scale.

From social point of view, Malaysian has one of the most largest user based in mobile spaces with 140% mobile phone ownership against population are recorded. However, despite of the technology savvy citizens, the adoption among enterprises are still lacking. In general, organizations are bogged down with solving legacy problems and reluctant to invest in new technologies such as IoT and decided to be the market followers rather than early adopter. As such, businesses and digital service enablers need to drive the growth together through co-invention and collaboration. Furthermore, local markets are also skeptical of the new technology as the impact has not been proven in the local sectors.

CASE OF SEOUL

As a leading exporter of digital household goods and electrical equipment, Seoul has built a strong digital infrastructure and institutional support that cut across many domains and industries. Technological advancement has been synonymous to Seoul which can be significantly seen from its vibrant city and people.

From our literature survey, Seoul was among the first nation to ever try the concept digital city (also known as) ubiquitous city (u-City) since the late 1980s. Since then, Seoul has been developing a lot of policies and legislative framework around ICT and Smart city. The city has

been piloting and successfully deployed some advanced digital infrastructures, including AI and Big data analytic across different sectors such TOPIS project (transportation) and OASIS project (citizen engagement). The Internet of Water systems are also in place to monitor the end to end infrastructure for water supply and distribution. The city went extra mile in sharing its real time data with the citizen through the citizen's apps and public websites. Current focus of the smart cities in Seoul is on citizen's engagement and wellbeing, as being demonstrated by the city's commitment in producing healthy and tasty water.

The success of such projects, other than backed by its financial strength can be attributed to the strong support from the government. Seoul Metropolitan Government has effectively exercised its central power to all the sectors within the city in order to get a project running. Also, with overwhelming high number of successful digital projects, the city has developed local talents with experience in all aspect of the projects.

From social point of view, Seoul inhabitants are known as one of the most educated nations basing on the numbers of University graduates. Education is highly valued in the culture where children will spend hours in schools or tuitions, to ensure they will perform well academically. As such, job competition is high and has put the pressure on the young generation.

Being a developed nation, Seoul citizen lives in a fast and vibrant environment with digital element in almost all aspect of life. They are known as early adopters and as such, any new technologies will be openly welcomed by the people. Not only that, while the notion of smart cities are lauded by many, Seoul can boast itself with a list of successful actual real world realization of digital projects covering various sectors.

Comparative Analysis Of Seoul And Malaysia

According to IDC surveys Malaysia is ranked 9th in IoT maturity Index, trailing with 3.2 Billion spending in 2020 behind other ASEAN countries. South Korea has been ranked the first based on IoT maturity index with of more than 30 Billion in 2020, followed by Singapore, New Zealand, Australia , Hong Kong , Taiwan and China.

Figure 42 IoT Readiness Ranking (Source IDC)

While both nations are aspired to be at the frontier of technological advancement, Seoul has set itself as the leader in smart city deployment. We can summarize the comparative details between Seoul and Malaysia as follows:

1. **Financial Strength**: One the obvious strength can be measured in it high GDP which has been the important driver for the success of Smart city or smart water projects. In retrospect, the smart city has been the driver for economic growth for Seoul as it tries to address rapid urbanization issue.
2. **Maturity :** Seoul has shown years of experience and persistency in pursuing smart city projects which can be traced back to the development of u-City in 1980s, In Malaysia, while having some similar project in Cyberjaya and Putrajaya, the smart city concept has been changing from the earlier knowledge economy hub to innovation hub in the late 2008.
3. **Culture:** Seoul's citizens are culturally very competitive people with number of graduates recorded are among the highest compared to other nations. The citizens of Seoul are mostly knowledgeable and therefore more open to new technology than others. In contrary, Malaysian culture are quite laid back, and are still struggling to increase education standard.
4. **Social** : Digital Technology is part of social and daily life of the people living in Seoul, being the producers and exporters of electronic and smart electrical goods. They are also avid consumers of technology who will fit early adopter's profile. In comparison, the Malaysian economy is more diversified and are not focused only around digital innovation although, Malaysian general public are known as technological savvy citizen. In some sectors such as water, digitalization is yet to be adopted.
5. **Institutional :** From Institutional point of view, Smart city development projects in Seoul have enjoyed the supports by the government which can be seen from numbers of ICT policies and framework being developed, which is also backed by financial stability. From Malaysian perspective, while the government has shown its support and commitment, they are still lacking in implementation strategy and coordination. One example is city's adoption to City as Platform concept which is almost unheard of.
6. **Governance :** From structural point of view, Seoul Metropolitan Government exercise central power to coordinate and accelerate digital adoption. In Malaysia various sectors such as transportation, water, energy, environment, urban are disintegrated and managed by independent agencies creating bureaucracy barriers.
7. **Practicality :** While there are many cities actually announcing large scale digital project, Seoul and other city like Japan and Singapore have been successful in deploying some actual city-wide project for example TOPIS for transportation and OASIS of citizen engagement. Many of the mega digital projects in Malaysia however are still conceptual and lack real success stories.
8. **Talent :** Having embraced digital culture, Seoul has developed a strong talent ecosystems and resources who have been involved in smart cities since the concept of u-City are being introduced. Talent shortage especially in IoT and Big Data are still the main issue to be addressed in Malaysia and might require some time to develop.

Impact of Digitalizing Water Industries

Water is the most vital element of our lives, hence, any effort to protect and preserve this invaluable resources are of similar importance. Digitalization of water industries is one of them. The impacts and benefits of digitalization in water industries are multifold. As per our discussion above, aging infrastructure remains the main challenges of a city. While many cities have embarked on smart cities program, they are still burdened with piles of current infrastructure issue especially in providing basic infrastructure requirement.

In our opinion, Digitalization can help to address various aspects of water management as listed below:

1. Workforce management - Traditional Workforce management is dealing with physical paper form which will take around 2-4 hours of processing. Adopting digital technology can help to reduce processing time which is crucial in reducing NRW during leakages

2. Productivity – Real time infrastructure monitoring and automated workforce scheduling can help in better mobilization of resources and assets around field. This will help to increase productivity and efficiency of water operators.

3. Security and Safety - Safeguarding and securing vital water resources and distribution infrastructure is paramount importance. With help of Internet of Things and the remote sensing devices, more data on water quality can be retrieved in real time, which can also mean saving lives during any severe water contamination incidents. Currently sample needs to be taken manually and brought to the lab for testing.

4. Demand Supply Management- One of the limitations of current water management is the lack of ability to predict the demand and variable trend of usage. This is due to limitation in data collection from the metering infrastructure. With the help of IoT metering, more data can be delivered at lower cost using low powered sensors which will give better infrastructure visibility and data granularity.

5. Saving Energy - One of the indirect cost in water management can be attributed to the energy consumption especially during water treatment processes. Energy is wasted during the treatment as more chemical and other water treatments materials are applied without the tuning to the actual demand. The use of sensors and IoT meters can help to optimize this process in real time and save energy.

6. Cost Reduction and Revenue Generation - With the advanced features of ie smart metering facilities, operators can provide extra services to the real estates or property owner, for example, by providing automated or remote water control and monitoring of meters at AirBNB premises or smart buildings. Smart meter will also save the needs to hire new meter readers to cover new properties.

7. Behaviour and Citizen Education - Another good aspect of applying smart metering infrastructure to domestic users is the ability to understand more about user behavior. By introducing gamification and user's mobile application, consumers can be actively engaged, and some reward and recognition scheme can be introduced to educate on the proper use of water resources.

8. Data driven Policy and Strategic Planning- Devising policy such as setting up new tariff rate or developing legislative framework requires detail study on its current situation and the impact of the changes. With digitalization initiatives, data can be retrieved from infrastructure in a more real time manner, allowing authority to engage and perform necessary study (or sandboxing) before new regulatory standard or policies can be implemented.

9. Integrated decision making using City as Platform - Integrating data from water sector with other city infrastructure can unleash new big data analytic opportunity. For example by listening from social media, citizen conversations and complaints can be detected even before the actually reach the formal channel. This will allow water operators to be more proactive in their service.

Digital Adoption by Local Water Industries

While the above analysis focused on the literature studies on Seoul, Malaysia and global digital adoption in general, this section will be dedicated to analyzing our observation on the actual experience collaborating, engaging, influencing, planning and implementing digital projects with the local water authorities.

In general, we have received overwhelming responses from all the water authorities initially engaged during the course of this study. Multiple visits were made to at least 3 water authorities (out of 7) who were keen to explore potential collaboration with Telekom Malaysia. Based on the engagement, while digital transformation were generally welcomed, certain concerns such as bureaucracy and hierarchy, ongoing organizational restructuring, bad past experience and prioritization of other projects are among the factors limiting them to commit and collaborate in digital transformation initiatives.

In theory, there is no standard ways of measuring adoption although some of the some of the literature has suggested some methods to measure smart city readiness, taking several parameters such as:

- Share of urban resident using digital tech to participate in decision making (Should reach 60%)
- Share of entities managing housing using automated dispatching systems (should be 15%)
- Share of Residential building connected to automated systems for consumption

We will however analyze the state of local adoption or readiness from multiple spectrums such as technologies and ecosystems, institutional readiness and people spectrum which is the core aspect of technological adoption. At the end of this section, we will then explore some of theoretical frameworks on change management and accelerating change to deal with the people.

Technology and Ecosystems

From our engagement, we learnt that the main motivation of digital adoption lies on its ability to solve real business problems regardless of underlying solution or technology used. As such,

while there are many advanced technology centered around AI, Big Data and IoT, the technological jargons should be transparent to the end users. Businesses or organizations are more concern about addressing their business requirements and goals more than the technology to be acquired. As such, technology should be seen as an enabler to solve the problems rather than the goal itself.

Non-Revenue Water for example is a measure of the difference between water being treated versus the water being billed. While the calculation of the water loss seems to be straight forward (ie finding the difference between the accumulated data from the treatment plants versus the billing systems), finding, identifying and breaking down the numbers to different root causes can be complex.

Water losses can attributed to physical and commercial losses and some are due to non-commercial use such are garden watering and for the use for public goods such as hospital, firefighting and so on. In the case of physical losses, solution such as IoT sensors could be used. Similarly, to address commercial losses some of the strategies like deploying advance metering infrastructure and anti-theft IoT sensors can also be considered.

Having said that, commercial losses might require thorough auditing of data sources, including billing and other data management systems since inaccuracy in reading any of these parameters can also contribute to commercial loss. Therefore, it is very hard to establish the ground truth about Non Revenue Water accuracy. However, significant NRW contributors can be identified and addressed, so NRW solution should focus in finding the weakest link and closing the gap rather than trying to try tightening every loose links.

It is also worth to mention that, IoT deployment is not a silver bullet as utilities assets or city infrastructures are very sparsely located. As such, IoT deployment alone might not suffice and needs to be integrated with existing SCADA monitoring infrastructure in order to gather a more meaningful data for analytic and decision making purposes.

IoT Readiness

In general, IoT readiness can be divided into two components, the end devices (sensors or meters) and the communication.

IoT Communication

While the Malaysian government is lauding the potential of 5G and its benefits for future digital infrastructure, we argued that the current existing technology (NB-IoT and LoRAWAN) are underexplored. NB-IoT in particular has been readily available on Telco's 4G networks since 2016 but lack of push from market has halted the progression of the technology into local industries. In our opinion this is a loss of opportunity for many sectors especially for the utilities industries.

5G undoubtedly will make a big impact in the future but currently it has not being standardized and officially rolled out. Developed country like Malaysia should not fall into the 5G race trap that is currently pursued by developed countries, Korea included. 4G infrastructures in Malaysia are still expanding, so focus should be given to aggressively monetizing existing infrastructure to expedite the Return of Investment (ROI). From end users' point of view, underlying technology is their least concern compared to working digital solution that will solve their urgent problems.

As discussed in the literature review, the other IoT communications that we have explored is the LoRAWAN technology. Compared to the regulated NB-IoT network, LoRAWAN is unregulated and hence can be installed by any licensed or unlicensed users or providers. LoRAWAN users also enjoyed the largely available LoRAWAN end points ecosystems and supports from consortiums of alliance and technology partners.

Despite the differences, both NB-IoT and LoRaWAN technology are actually complementary and both could be crucial to address different type of topology and density of devices within the project area. High rise buildings for example are more dense in nature and thus, it might be more cost effective to deploy LoRAWAN rather than NB-IoT .

The other competitive advantage between NB-IoT and LoRAWAN is in the aspect of assurance and technology sustainability. Compared to LoRAWAN, NB-IoT is built over carrier grade infrastructure and communication protocol that complies with the open 3GPP and International Telecommunication Union (ITU-T) Standard. Hence, NB-IoT will be natural choices for advance metering infrastructure projects where certain regulatory requirements need to be met.

Having said that, other operational use such as monitoring environmental data may not subject to any regulatory compliance, thus may still leveraging on LoRAWAN. Hence, from our perspective as system integrator, it is best to offer both options to provide a more agnostic solutions.

IoT Devices

The other components of IoT are the IoT devices and the ecosystems that will support them. Having IoT communication infrastructure alone might not be sufficient if the right devices and ecosystems are not available.

The dilemma faced by the IoT communication providers is on whether to build infrastructure of wait for the right volume of demand, which means more use cases and applications are needed. Since the use cases are limited, activating NB-IoT might not be feasible as the providers need to pay for activation license to vendors along with regulatory fees. As such, network providers and devices manufacturers need to work together to establish their own ecosystems support rather than working in silo. In our pilot studies we have worked with more than 6 manufacturers of smart meters to be tested with or network infrastructure.

In our observation, the lack of ecosystems support, institutional drivers and lack of market traction could be the barriers for IoT adoption among local water utilities. Small volume IoT use cases might not be cost effective as the infrastructure providers will need to pay for activation fee to the vendor as well as the regulator. Here is where, regulator can play its role to lessen the burden of operators. The ideal environment for such technology to grow is when multiple use cases co-exist (ie combining various smart city infrastructure, utility, consumers, agricultural). This requires a smart collaboration between providers, regulator, and players in different sectors. Similarly regulator and government can facilitate this by providing avenue for collaboration.

The other argument by water authorities is that the IoT infrastructure is already in place and as such there is no need to adapt to IoT. This is in our opinion, a misconception of IoT and it real

values. Current SCADA infrastructure and remote metering normally leverages on 2G or 3G technology and works similar to IoT but, the real advantages are significant. Hence, we have to explain the differences between existing technology and IoT using the following parameters:

Features	Current	IoT Benefit
Example Devices	Offline Meter & probe	IoT (Connected) Meter, Sensors
Systems	SCADA/PLC/ICS (protocol dependent)	SCADA + IoT Meter, IoT Sensor (protocol agnostic)
Energy Requirement	High Energy consumption	Battery up to 10-15 yrs
Communication	3G/Radio/Satellite	LPWAN (LoRA, NBIoT)
Data Transaction	Sim card, usage based, limited sensor	1:1000 ++ gateway:sensors; always on
Data Collected	Limited to Water Flow, Level, Quality and predefined SCADA features	Greater additional Range of sensors ecosystems
Example	Flow meter, pressure meter, water quality	Water pressure, flows, levels, Leaks, Tilt meter, gyro meter, volumes and usage, Crack Sensor, Humidity, Crack monitor, GPS, water/air quality
Application	Special built function	Customizable for Asset Management, Monitoring, workforce mgmt, Energy Saving, Smart Light, Smart Access, Security etc
Deployment Model	Built As part of Infra	Innovation, Retrofit

Figure 43 Comparing Legacy Meters to IoT

In general, 2G and 3G SCADA metering infrastructure and sensory devices are built for voice and data transmission rather than machine to machine communication. As such, the legacy devices , while able to send more data, requires high power devices, larger in hardware footprint and can be as expensive as a typical mobile phone or mobile. The pricing and tariff are also designed for limited data transfer (ie once a day) and might not enough to present the detail trending of hourly or even within minutes of interval. .

IoT on the other hand relies on Low Power Wide Area network Technology (LPWAN), which means sensor devices are specially designed to send very small machine data at more regular interval. This can be achieved since devices are optimized for low power usage and data transmission allowing operator to collect more granular data transmission, hence, providers can enjoy more data points in a days and even by hourly or minutes. The tariff is also designed to address the small data requirement and similarly being optimized at the infrastructure end (base station). Due to its low power consumption and form factor, IoT sensors are relatively cheaper than the legacy 2G/3G modems.

Most importantly, in our opinion, while legacy SCADA allows only proprietary data sources such as from SCADA flow meter , water quality and water level, specific purposed IoT sensors can be installed to allow new data to be collected and new innovative applications to be deployed. In the current IoT devices market for example, the sensors are not limited to meters but also, vibration sensors (that allow tracking of potential bursting pipe), Crack sensor (to monitor the severity of crack on infrastructure), Tilt meter (allow measure of structure angular deviation from its standing position) and many others. Furthermore additional water level, water quality and water flow meter can be added at any point without any needs to be connected to the limited SCADA input/output interfaces.

Digital Workforce

The challenges of deploying digital workforce are mostly related to developing software specification and engaging with multiple stakeholders with different requirement and interest. The specification stage however managed to be mediated as we use agile design thinking methodology that basically promotes multiple stakeholders participation.

The other challenges are attributed to the needs for continuous engagement in the form of workshop, training, onsite support and handholding exercise need to be conducted to a team of planners and front liners working on the field. This requires extensive resources in term of effort and time, but successfully completed through the support from the research grant. While the digital software, hardware and necessary handholding programs are in place, our main challenge is in proving the value of the solution and its benefits toward realizing the goal of water authority's management, particularly in demonstrating how the solution can help reducing NRW and increase productivity and efficiency.

The assessment is important as regardless of all the efforts and resources extensively dedicated for the project, the management of water authority will only look at the outcome of the projects. As such we have identified several parameters to be measured for the proof of Value of this project as follows:

No	Item	Description	Detail(s)
1	Benchmark months	The report will use data from the pilot trial and compared with the following months	✓ Feb 2019 ✓ March 2019
2	Performance Indicator	Activity Type to be tracked as Performance Indicator is IC01 -Investigate customer call	✓ Average Handling Time (AHT) of IC01 ✓ Numbers of IC01 Activity
		Optional performance tracking on Non-Revenue Water (NRW) improvement	Activity Category – LEAKAGE

Figure 44 Parameters for Digital Workforce Performance

In general, while there is a long list of elements affecting NRW, we need to identify specific parameters for NRW achievement that can be measured. Some of the parameters include Average Handling Time (AHT), Ticket Created and Resolved and indirectly calculate the NRW saving based on certain mathematical assumption.

We also introduced the auto-creation (of ticket) and observed the improvement compared to the normal ticket creation activities. Note that while the repair work activities could be of the

same nature compared to before (without digital workforce), most of the time are wasted for administrative purposes, largely attributed to the manual paper based processing. As such, the assumption is that the time to repair can be significantly reduced if the time to process and resolve the incident can be reduced.

The reading was taken for the month of February and March and the results can be summarized as follows

1. Through automated ticket creation, the system managed to reduce the average monthly time taken from 1 day 1 hours (manual) to 7 Hours (automated) which represent 72% improvement of current process. As such the planners and manager will be less burdened with forms and paperwork on their day by day reporting activities.
2. Based on the diagram below, in week 3, the system are facing an average of 2 hours surge for its weekly job, however the pending job resolution time are significantly reduced in week 4 after the automated ticket creation are introduced.
3. We also calculate the amount of water saved by the reduction of repair time using the following assumption (input based on estimate by water authority):

    a. Total Allowable Water leakage set to a benchmark of allowable 24hours repair time (expected completion) : 6,600m3 (throughout the pilot project)
    b. Estimate of Water being saved due to early completion (compared against expected completion of 24hours) **: 3982 m3** (for 262 ticket created completed below 24 hours)
    c. Estimate of water saved/wasted (in the category of delayed repair work above 24hours-120 ticket created but repair delayed beyond allowable 24 hours) : **-706m3**
    d. Estimated Total water saved during pilot period (b+c) = **3982m3 + (-706)m3** = **3276m3**
    e. Comparing the total water saved versus the benchmark 24hours resolution time, we have seen a saving of 3276m3 water compared to 6,600m3 expected waste from the leakage. This represent **49%** of water saved by earlier completion of repair works.

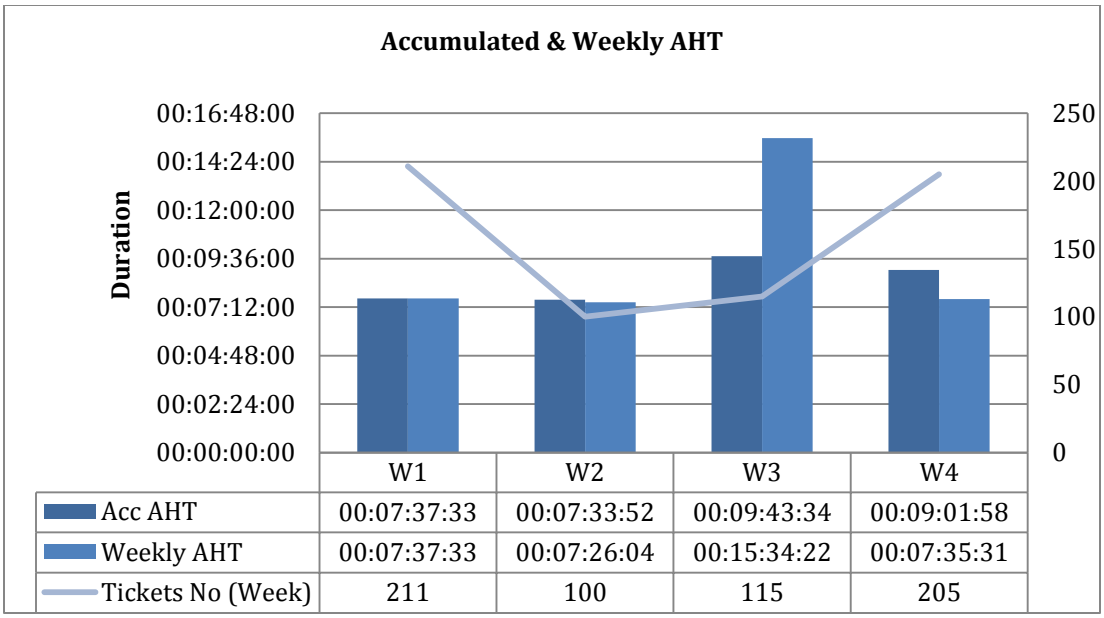

Figure 45 Average Handling Time (AHT) Improvement

In summary, based on our pilot study, digital platform used has contributed towards improving NRW performance by up to 49%. Indirectly this is also a saving on human resource, time and cost of operation which can be translated from the improve time to create and process ticket or handling of incident.

The Platform

Apart from digital solution offered (IoT and Digital workforce), the other core component of the digital solution is the platform that centrally manage and process of data for visualization or analytic purposes. Platform is an important element of the solutions as it delivers and produces the final data output such as dashboard, statistic and meaningful insight that will be valuable for water authorities to make strategic decision and track their operational or business performance.

Virtualized cloud infrastructure underlying the implementation of platform, can be crucial element that can help address the economic barriers for digital adoption. With the cloud-based platform, the cost of hardware and software can be consolidated and distributed among other water utilities adopting similar solution. Thus, an Open Innovation Platform (OIP) is developed to be the common platform to be leveraged by multiple organizations.

The concern over platform is largely attributed to the whether organization is ready for cloud adoption or would choose to develop their on-premise application, which would be costly. The other concern is with regard to data sovereignty of cloud providers. Most of public services such as utilities companies are subject to regulatory compliance which requires data to reside within the national border of the country. As such regulatory and compliance need to be considered when designing the digital solution.

From our observation, most of device manufacturers (ie smart meter) do not have control over the data or platform provided which are located outside the country. Hence some locally hosted platforms need to be established. Our strategy is to develop a platform that is open to any providers, manufacturers and even to different type of LPWAN (LoRA or NB-IoT). For our pilot program we have tested the following smart meters and NB-IoT providers with our own OIP platform.

Manufacturers	NB-IoT Network Provider	IoT Platform
GCI	TM Unifi Mobile (Band-5)	OIP (successful)
	Celcom (Band-8)	
	DiGi (Band-8)	
George Kent	TM Unifi Mobile (Band-5)	UK Platform **
Laison	TM Unifi Mobile (Band-5)	China platform **
Delta Perdana	TM Unifi Mobile (Band-5)	China platform **
IAM Wonderware	TM Unifi Mobile (Band-5)	OIP (successful)
TFP Solutions	To test on 18 Apr.	OIP (commitment) **

Figure 46 Manufactures and Platform Testing

Based on the experiment above, the integration of data into our platform has been successfully conducted with several manufacturers while we continue having engagement with the rest of the providers who are committed in co-developing solution with us (leveraging on TM's NB-IoT connectivity and Platform). Some of the challenges that we are facing is to convince meter manufacturers to collaborate in the testing, as most of the manufacturers are using different NB-IoT spectrum which only compatible with other NB-IoT provider. This has been addressed by offering access our local platform and technical support by our strong R&D team and experts.

Our concern though is on the future sustainability services that can be provided through the platform. This include the maintenance of software and features to be enhanced for the next 5 or may 10 years ahead, which requires some further development on the business and operating model. The platform needs to be attractive as it will be competing with global players.

Hence we believe that open platform can be a solution through which we should maintain as a network, platform and device agnostic which will be key value proposition for the local market. Going beyond utilities, the platform should also be an exchange hub for many other sources of data from different domain such as telecom data, GIS, social media, and other urban infrastructure data.

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Big Data Analytic

Based on our engagement with the top management of water industries, some of the leaders are already exposed to the future digital technology and have some visions towards a fully automated water operation. While the fully automated and real time analytic might seems to be far from reality, we have proposed that the latter might not necessarily needed at this point. Big data analytic project can always leverage on data from the past which can be used as dataset.

The top leaders are well aware on the importance of having proper and enough data collection and have offered us access to SCADA systems and other systems. This is crucial, since, IoT project alone will not be able to provide all data required, especially when deployed at the small pilot scale. Data from the existing systems such as SCADA would be very important in delivering meaningful insights and outcome.

In our initial deliverables we are able to demonstrate using visualization software, some of data analytic result from Customer Relationship Management (CRM) , Social Media, IoT (pilot) and workforce(pilot).

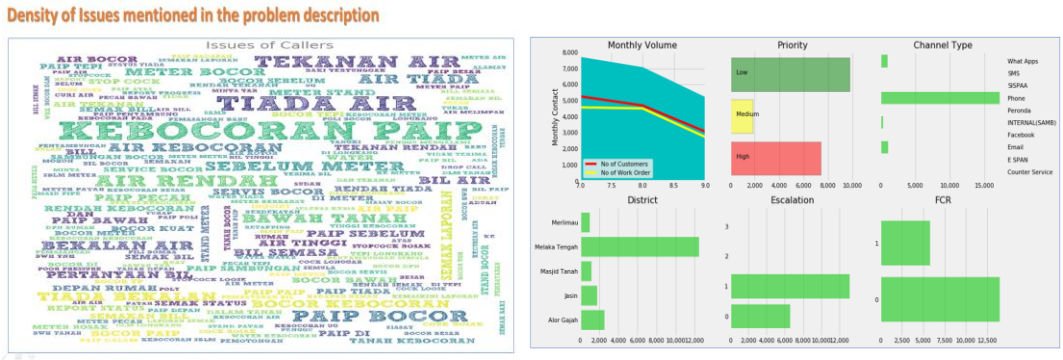

Figure 47: Analytic Dashboarding

While the projects are still ongoing, some of the initial discussion has allowed us to develop some roadmap for the data analytic and potential Minimum Viable Product (data product) that we can work with across the water operator infrastructure.

Key Business Drivers	Compliance/Strategic	Operational Efficiency		Customers Satisfaction
Goals (Theme)	Smart Enterprise	Smart Plant/Digital Twin	Smart Grid	Smart Meter/Smart Consumer
Functions	Corporate/ Business	Energy Generation/ Water Treatment Plant(Reservoire)	Transmission/ Distribution	Consumer/Retail
Analytic Requirement	Financial / Supply Chain	Asset Management/	Water/Energy Quality	Meter data/Demand

(Top 3)		Performance optimization & Automation		Management
	CIS/BI/Command Center	Secured Infrastructure	Water/Energy Leakages/Theft	Consumer Behaviour Analytic
	NRW Reporting	Smart Workforce/Vendor/Fleet		Sentiment Analytic
Main Analytic Requirement	**NON REVENUE WATER MANAGEMENT**			
Key Enablers	MIS, OSS, Billing Systems & Existing Systems	SCADA Monitoring, IoT Sensors/communication & OIP, Digital		Advance Metering Infrastructure, Digital Platform
	BD Infrastructure , BD Analytic Platform & Professional Services (Data Scientist/Architect/Engineer + SME)			
Data Sources	Billing/Financial Data/Operational Data/Consumer Data	SCADA/IoT Sensors / Fleet/Force data	SCADA/IoT Sensors /Fleet/Force data	CRM/Social Media/Meter Data/Consumer Apps

Figure 48 Potential Big Data Opportunities for Water Industries

From the above analysis on technological challenges and adoption we can summarize that technology readiness for IoT and digital infrastructure are high. However, the lack of push from the market has caused the technology remain only within the testbed of R&D lab since 2015. From our observation, both of pilot projects being studied here are among the first effort in pushing IoT and digital technology into other industries.

The local players are new in IoT space and digital enabler such as telecommunication companies need to actively explore partnership with the other industrial players (ie smart meter manufacturer) who might not be aware of the new digital capabilities or have lack of talent and capability that can help to drive the adoption of new technology.

Challenges around network, devices and platform can be attributed towards building a strong local ecosystem. From our perspective, positioning our agnostic platform and network as well as leveraging on a strong research and development support will be the key proposition to the market.

Big data analytic however should not be limited to water industries, in fact there are more opportunity to look at city data as integrated utilities. For example, data from water industries can be studied in relation to city housing infrastructure, social media, demographic, income status, citizen behaviors, green infrastructure and may more.

Institutional Infrastructure

Based on the literature we have found that the success of Seoul can be attributed to the strong institutional support in the form of financial and strategic direction. This can be seen from consistent and continuous agenda of smart city since the introduction of u-City in1980's. The city also benefits from s supportive government and its structure that help to push agenda such as City-as-as-Platform into reality which has been demonstrated through successful project implementation such as TOPIS and OASIS which integrates with other urban data such as payment gateway, weather, transportation etc.

Malaysia on the other hand, also has a strong support from government and regulator, demonstrated through the inclusion of smart city agenda in some important budget planning, apart from having its own policy framework on industrial Forward 4.0. This is also true for some states and municipal level governments, where smart city agenda is also included in the local budget and strategic roadmap.

While the vision and appetite are strong, Malaysia is still lacking in sustainable planning and integrated action-oriented blueprint that will ensure the concept such as City-As-Platform can be realized. Many of digital urban infrastructure projects unfortunately are implemented in silo and as such serve only particular sector or states at a time. In fact the City-as-a-Platform concept is not fully adopted as common principle in the smart city strategy.

From the business side, there is also need for more avenues for collaboration and co-creation. Digital enablers need to be more proactive to drive co-development projects with the industries. As such digitalization project requires a new innovative business model to be explored which could be in the form of IoT leasing, meter as services model or perhaps profit sharing model.

Most of the utility companies are still playing wait and see game and not prioritizing digital transformation due to lack of success stories in the local market. For this reason, they will likely take a small step and involved with a small scale pilot project with minimum investment. It is therefore important for service providers to consider some investment on pilot projects to prove the value of their solution before entering into commercialization.

The platform and network need to be agnostic enough to allow competitive pricing within the ecosystems. As such utilities can choose any providers or manufacturers that can offer the best SLA and not subjected to any lock in by particular vendors, manufacturers or service providers.

The regulator can also plays some active part in coordinating and providing seed funding to facilitate proof or Values or pilot projects. To encourage use or IoT for example NBIoT infrastructure the regulators could waive some amount of regulatory fee and provide avenue industry collaboration.

In general, we would like to emphasize on the need for the strong ecosystems and supports. Apart from smart metering, IoT market has much more potential in other use cases such as smart city waste management, smart light, smart environment etc. While the providers and people are ready, poor ecosystems support could limit the growth of IoT market. As such, government, academic institution and businesses need to provide conducive environment and strong eco-systems to support the growth of digital solution such as IoT.

People's Adoption

Based on our engagement, we found that people are the most important and challenging elements to be dealt with. As such resources including human and financial resources need to be invested to support the activities.

While digitalization is often associated with technology, the term itself is actually referring to a change of culture or people's behavior or in other words, it is more of a people thing rather than technology. Digitalization refers to the culture of using digital technology to conduct day to day business or daily activities. Based on our pilot study, we conclude that while digital infrastructure is in place, getting buy-ins from stakeholders remain as the major challenges. We have spent a considerable amount of time engaging with stakeholders from getting approval, conducting awareness program, workshop, field survey, testing and so on. Our journey starts by engaging with 7 water authorities where we shared our knowledge on digitalization and proposed utility blueprint to be discussed. We also published our own info-graphic to the local newspaper to create awareness to the public (Fig.49)

We have used the design thinking methodology to help us extract this information from various ranks of people working in the organization. These activities allow us to understand every step of customer operation journey, capturing their pain points and understanding their motivation and goals of their tasks. Although a similar journey can be expected from every organization, the challenges, perception and experience on new technology could sometimes vary. Some of the organizations we met for example have some bad experience in piloting smart solution which we found are the case of bad project management. Having that being said, we received full support and commitment from our partners who were very excited about the collaboration and embarking on digital transformation.

Even prior to deciding on candidates for partnership, we have gone into a series of discussion which require us to do some profiling of the potential water authorities, understanding their motivation and deciding on the most likely authorities to work with. Going through the adoption life cycle, we have identified that SAMB and Air Selangor are the potential early adopters based on their strong institutional support, clear smart city agenda and strong leadership leading the organization.

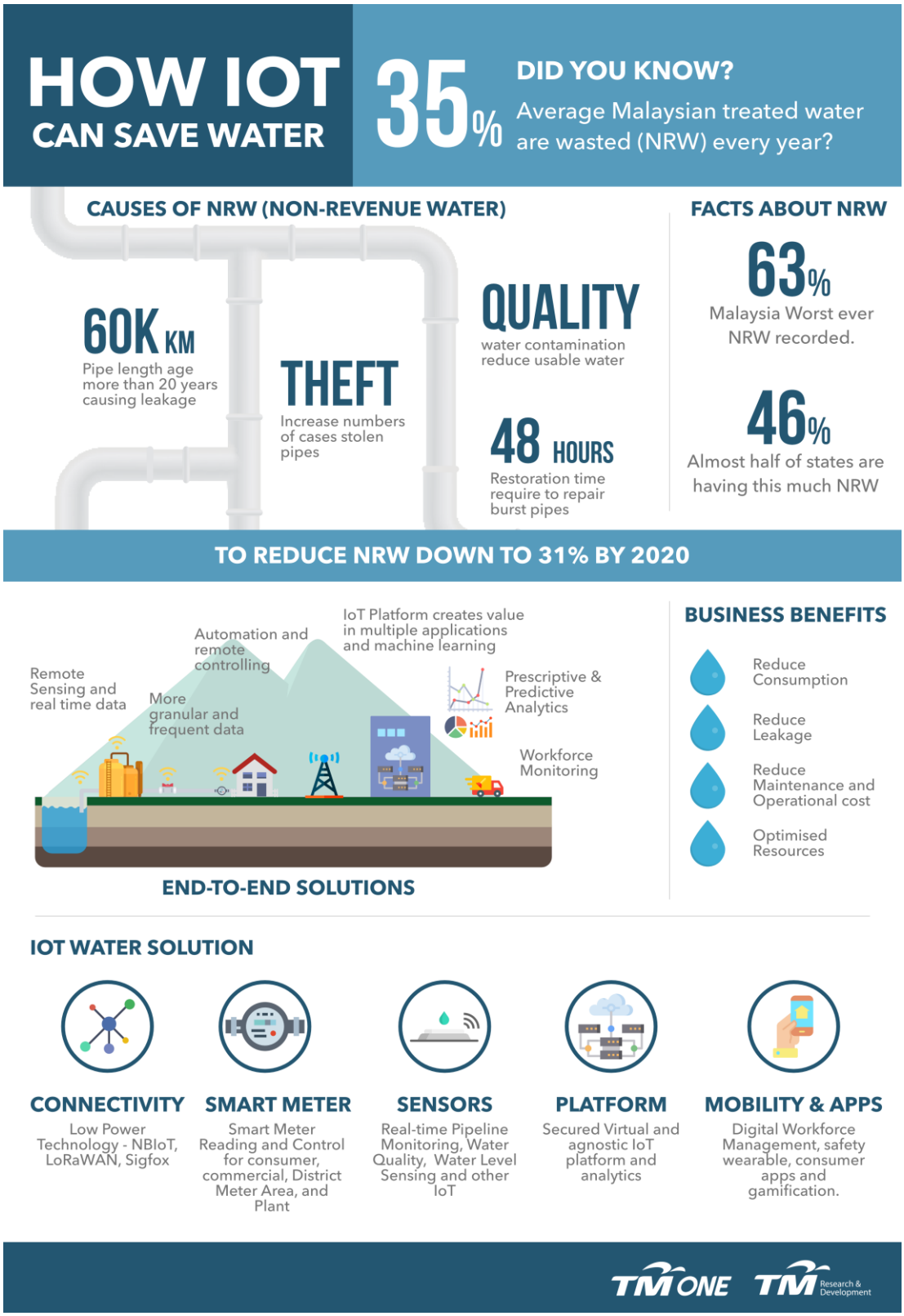

Figure 49 Infographic draft proposed for the Edge, to be published July 2019.

Strong and visionary leadership are also key to our progress as we encountered various leaders with different styles of decision making. This requires us to sometimes engage beyond the rank of leadership to make sure our proposal is accepted.

Addressing the concern at the working level is also important. Some of the stakeholders are skeptical about the new changes, fearing that digitalization will lead to the loss of jobs or making them irrelevant. It is also important to create awareness on the role of digitalization and preparation towards it as some of the workforces might need reskilling at some point of the journey.

The knowledge around business and operational aspects are important. Therefore, talents and champions need to be identified to support the program. The stakeholders also need be convinced that both providers and the water authorities are equally important hence they should have the sense of ownership that will drive the project further.

The main message to be communicated with the stakeholders should firstly address the pain points and helping stakeholders to deliver their business goals. This includes for example demonstrating the saving or reduction of time to repair or perhaps show how some new revenue can be generated as the result of deploying digital solution. The success of a proposal therefore relies on the ability to proof the value of solution rather than having advanced technology.

Apart from the observation we employed Kotter's 8 step model of accelerating change that can be summarized as follows :

Establish a sense of Urgency	The project vision and mission is established with reduction of Non Revenue Water as objective, Some current state financial implication and analysis are conducted and goals are set to meet the timeline set by regulator to achieve certain NRW Target.
Build guiding teams	Project Structure and Team are established with endorsement from the management of water authorities. Generally, the CEO of both companies will be overseeing the projects
Create a vision for change	Blueprint and Roadmap towards reducing NRW is established. This include the introduction of digital workforce, IoT platform as well as Analytic platform with some expected and measurable outcome
Communicate the vision	Stakeholders engagement sessions are conducted with various rank. The handholding program includes Design Thinking workshop, progress reports, field visits, field deployment and testing as well as other formal management meetings
Empower people to act on the vision	The main approach is to Co-Create solution to address current KPI and business goals, with TM (the providers) as enabling partners
Create short term wins	The project entered into Pilot deployment and implementation involving real sites and real people, The aim of the pilot is to establish a Proof of Value of the solution before it goes into production and long term use. The pilot scope is designed to be sizable and is able to meet the budget allocated from the grant.

Don't let up	While technology piloting is in progress, the team works on Innovating Business Models that will plan to Lower entrance Barrier to adopt to the new technology. This includes bundling with current existing services for an extended contract and other models to be established. In the meantime, engagements with the regulators are made to explore other models and opportunities.
Make it stick	In order for the solution to be sustained, the solution is properly productized, this means that Support systems & Assurance are established and long term products and ecosystems roadmap are being developed.

Figure 50 Mapping Adoption Strategy to 8 Steps Kotters Accelerating Change Model

Managing change and influencing water authorities to enter into collaboration or starting a digital journey proved to be challenging. Based on the theory of managing complex change by Knoster, we realized that managing complex change requires clear vision, skills, incentives, resources and action plan, missing any them will result in confusion, anxiety, resistance, frustration and false start. We can summarized our approach mapped to Knoster' s theory as follows :

Vision	The projects are based on clear vision of reducing NRW by adopting digitalization. Blueprints and Roadmaps are drafted towards achieving the vision.
Skills	Both organization (Service Provider and Water Utilities) have experts and strong capabilities in both worlds (telecommunication and water industries), as such co-creation project provides avenue for talents to be gathered to solve common problems.
Incentive	The project is driven by the common goals to reduce NRW which will be the main agenda for water organization. Success of the project will lead to reduction of NRW and improve productivity and financial performance of the organization. From a service provider's perspective, the project will be a pioneering services that can be replicated to other organization
Resources	We managed to secure resources (financial, developers, researchers, project managers) and entered into agreement for the partner (water authorities) to provide resources at their end.
Action Plan	We have established proper project structure, action plan, timelines as well as regular project progress meetings and reports that have been committed by both parties

Figure 51 Mapping Pilot Activities to Knoster's Model for Change

In general, our observations can be concluded as follows :

- For a successful IoT project, it is important to gain commitment from top leadership giving priority for people and budget
- A successful IoT project demands the creation of strong ecosystem and partnerships: It takes a village to do the jobs, and a single organization might not have the talent and resources to do all the tasks.

- Reskilling / Upskilling the Organization for Digital Transformation are important as some of the jobs might be replaced by digital tools and automation. It is therefore the role of organization to plan for the transformation journey
- Redefine ROI Criteria for a Digital World : It is challenging just to convince the organization to embark on digital journey without addressing the current financial and business situation, as such innovative business model and collaboration approach need to be jointly established (ie the collaboration can work towards sharing of revenue or from the saving it made from a successful digital project implementation).

Conclusion

The main themes of our analysis on digital adoption have been focusing on technological, institutional and people factors. In the recent years, technology like connectivity, platform and intelligence have been revolutionized and have become more pervasive and affordable, paving the ways for the advance technology such as big data, virtual reality, AI and cloud computing to gain traction within industries. This has created a hyper-connected world, that allows digitalization or "*softwarization*" of city infrastructure and indirectly leading towards data-driven governance and automation.

Institutional support are also key as we learnt that despite the technology readiness, lack of market push has been the reason of why IoT projects are hardly making it's ways to the real world. As such, the government and enterprises need to play a more proactive role in pushing digital platforms to the industries, ideally by providing the environment and support such as financial, avenue and regulatory framework and coordination to accelerate digital adoption. However, it is also crucial to gain stakeholders' commitments and create a sense of ownership among them, which can be achieved through active involvement during development and the deployment of digital initiatives.

In this thesis we presented and discussed some of the results of our study on digitalization of water industries in Malaysia and Seoul, Korea. While there are many similarities in the aspects of technology readiness, strong government supports and culture, there are other relatively significant features that contribute towards the success of many digitalization initiatives within Seoul water industries. This includes the strong financial support from the government and their consistency in driving a comprehensive smart city framework based on the city-as-platform approach. The effective governance structure under Seoul Metropolitan Government has also allowed coordination of a complex interdependent project to be conducted across many agencies, which we found lacking in the Malaysian environment. From a social perspective, we found that the education level and strong digital culture are among the main social drivers that help to develop a knowledgeable and open-minded society that always wanted to be at the forefront of new technology.

Apart from the comparative study, we also explored and observed the adoption of digital technology among the Malaysian water industries during the deployment of digital workforce management and IoT (smart meter, water level, water quality, SCADA) pilot projects. Some of the key observations are documented in this thesis which includes the challenges, gaps and how we have addressed them throughout the pilot program.

To create technology awareness among the local industries, the concept and values of IoT (such as LPWAN), platform and analytic need to be effectively conveyed during our initial engagements as we were faced with concerns around the technical design, reliability, cloud adoption and security, some of which were shaped by the bad experience or failure of the past projects. This is apart from other non-technological elements such as the budget constraints, return on investment, asset ownership, data sovereignty, business model as well as regulatory issues that altogether could be seen as potential barriers for adoption. However, in our opinion, these concerns can be potentially addressed by adopting an open architecture that is built upon an agile, interoperable and agnostic network and platform. By doing that, we can provide a more flexible business and operating model that suits the requirements whether for business or regulatory compliance purposes. The cloud technology for example, allows the systems to be rapidly prototyped and complete systems to be virtually developed without upfront investment on hardware. Ultimately, digitalization project should be outcome driven rather than project driven (ie focus on amount of water saved regardless of the technology). Hence, the solution needs to focus on delivering values rather than pushing on specific underlying technology and implementation.

As a conclusion to our research, we have made the following recommendations for future research and deliberate some detail actions to be considered by respective stakeholders.

Research Limitations and Recommendations for Future Research:

- Due to limited resource and to leverage on our field study opportunity in Seoul, we have confined the scope of this study to only cover Malaysia and Seoul water industries. There could be other working models like in the Netherland, USA, UK or any other countries which could be a potential references of a successful water management.

- On the same note, while digitalization can be applied across many different industries or projects, we should have been more thorough in our surveys and focus towards smart water projects. One of the examples is to make a comparative study among different digitalization projects that have been deployed specifically within water industries.

- Similarly, towards the completion of this study, we realized that digitalization is more about human rather than technology, hence, we would recommend for the future research to give more focus on this aspect. It would be interesting for example to investigate how different digital projects deal with people and its stakeholders or what are the institutional approach that contributes towards the success of the projects. For a more specific example, researchers could survey some of the innovative methods to incentivize people and what are among the effective one.

- From the literature surveys and observations, we also realized that digital adoption could be time consuming, prompting for the needs to extend the resources to sustain the project in the long run. This has been the case with i-Voting in Estonia that took almost 14 years to increase the adoption from 0 to 45%. Future research could help to answer whether there is any “timeline” for digital adoption and what sort of challenges, solutions and results to be expected. These are important as organizations or governments need to be able to measure the success and justify the investment for the resource allocation.

- Understanding people's behavior is equally important as having technology that works. From our studies and visit, we learnt that other elements such as historical, cultural and spatial factors can also shape the citizen's behavior towards digital adoption, and as such having solution that fit the local context is of paramount important. Approaches that have been proven and successfully applied towards other culture or society would not necessarily work in others.

Despite Malaysian high aspiration to be at the frontline of digitalization, according to IDC research the IoT traction in Malaysia by 2020 is projected to be less than 3.2Billion, trailing behind most Asean countries especially Seoul at 40Billion which indicate low projection of IoT adoption. Our recommendations for respective stakeholders are as follow:

Recommendation to Regulator and Government

- Technology such as NBIoT has been around for several years now but still struggling to hit the industries due to the lack market push, awareness and poor local ecosystems support for IoT devices, sensors and meters and platform. The focus should therefore be given to promote and support solution development and innovation to unravel the values of existing technology and utilize existing infrastructure rather than rushing into advanced technology ie 5G (which will take years to deploy and mature). In fact, Malaysia could enter into the same vicious cycle and fail to tap the value of technology if the above circumstances are not addressed effectively. One suggestion is to look into certain fee exemption or introducing seed grant funding to encourage more pilot implementation especially for critical infrastructure such as water, transport and other city infrastructure. This could help to promote and create traction by experiencing the value of the solution before investing in scale development.

- The government needs to look into a holistic institutional support and ensure soft infrastructure such as talent development, future workforce, local knowledge, legal framework, implementation blueprint, ecosystem development, industry coordination and funding support are in place. Learning from Seoul, Malaysia needs to start creating some small winnable digital projects (ie in the case of IoT) to build up its own experience and momentum, but this will only be possible if the proper hard and soft infrastructure are in place.

- While there are already few independent smart city initiatives by federal, state and municipal government, the government should promote a common smart cities framework such as the City-as-a-Platform Manifesto that will facilitate integration and promote interoperability while strengthening digital ecosystems. City planners and other infrastructure operators should be aware about the importance of such approach and learn from Seoul's u-City projects.

- We also recommend coordinating industrial collaboration focusing on solving critical issues such as NRW in water industries, traffic congestion, safety and security as well as others. Smart technology should be seen as an opportunity for the government to save costs and increase efficiency especially in managing city infrastructure that relies on government funding. Smart Water Infrastructure for example should be seen as an

opportunity to increase reliability and performance of critical city infrastructure while saving taxpayers' money from being wasted as the result of poor infrastructure governance and inefficiency.

- Since the physical and digital worlds are converging, different industry regulators should start to work together to improve certain overlapping area. For example, the smart meters deployment currently requires assessment and certification from 2 bodies (for metering devices and communication). While complying with the standards and regulation are important, regulators can seek ways to shorten the time and cost of undergoing these processes. A similar scenario has actually taken place before between transportation and communication commissions who were working on co-regulating local Uber/Grab services.

Recommendation to Businesses and Industries

- Digitalization is not a silver bullet or a single solution product but rather a multiple approach solutions comprises of technology and its ecosystems (platform, analytic, connectivity etc). Most organizations need to see the outcome of digitalization rather that an output of it. As such, A Proof of Values (rather than a proof of concept) would be a common practice as it could increase the chances of adoption by water authorities especially when prior successful use cases are lacking.

- Digitalization has caused a lot of disruptions in the industries (Uber, AirBnB), hence, businesses need to innovate some flexible model to keep up with the competition. Digitalization project is expected to solve business problems and create new value regardless of underlying technology. This will allow the customers to reinvest or relocate their resources (ie financial, people) out of the saving or profits it makes as the result of digitalization. Innovative business model should also be able to address different business challenges and budgets and ideally should introduce very minimal barrier to allow adoption to take place. One example is the revenue sharing model or meter as a service program.

- Businesses especially the digital enablers, need to be more proactive in driving digitalization in other industries by creating opportunity for co-creation. Water industries for example are overwhelmed with many operational issues and lack of resources to look into digital development. Apart from addressing talent and knowledge divide between the two industries, co-creation will create a sense of ownership to ensure both parties commitment in providing all necessary resources for digitalization.

- Businesses need to also be proactive in creating a strong ecosystem to support digitalization ie by establishing smart collaboration between device manufacturers, platform and network providers, as well as developers. Lack of ecosystems support could be one of the factors that can discourage adoption of technology

- It is imperative to realize that adoption, in the end, is about people rather than technology. We therefore emphasize the need to look into Investment and planning of resources to handle stakeholders and workforce involved in digital transformation. This

is crucial since the key success factors for any digitalization are highly dependent on users. The concerns on digitalization at the working level such as the fear of job displacement as the result of digitalization need to be addressed as it can create resistance from the users.

- We also learnt that strong leadership can make a difference and will be the key to the success of our project. Transformation Leaders and early adopters should be identified prior to the start of the project and consequently involved in strategic planning and digital transformation programs to ensure continous supports from the managements.

- The technology, network and platform should also embrace an Open framework to allow better opportunity for collaboration. In our case, building an Open Agnostic Platform for example has allowed us to collaborate with many vendors and network providers so we can focus on delivering the data and the values of the solution regardless of the underlying technology. Utilities infrastructure for example, is highly sparse and would require extensive network coverage and extensive support that will be hard to achieve without strategic collaboration and strong ecosystem.

- Large organizations should also leverage on Innovation and R&D as the new digital solutions could need some advanced level support, especially in producing big data analytic that requires an advance understanding of modeling and statistic. Similarly, integrating multiple software and hardware element within a common ecosystem might require some advance tuning or tweaking. As an example, we have engaged with several smart meters manufacturers to conduct some interoperability tests between NBIoT devices, platform and network infrastructure which at some points lead to component change in NB-IoT communication module by the meter suppliers.

- Smart Collaboration should also extend beyond the utilities and look into a more holistic governance of a city. This will create new opportunities such as urban analytic that can benefit from co-relating data from various city infrastructures such as e-government, citizen engagement, telecommunication, urban planning, environmental data as well as social media

Recommendation to Citizen and Society

People and citizen play crucial roles in digitalization as being demonstrated in many cases such as i-Voting. Ignoring this will result in risk of digital initiatives being abandoned or failure to address the original issue it is designed for. As such we generally recommend that resources for digital adoption to be planned along with the technology. While most of the initiatives are normally seen as directive from authority and organization, their actions will require active participation from the users which we can summarize as follow:

- Citizens should educate themselves and families on the importance of water and its eco-systems that need to be protected, preserved and sustained. The effort can also be organized through civil society or relevant NGO
- Citizen should also be responsible consumers and ensure proper usage of the valuable treated water. This includes using separate resources for gardening, car washing, pools

and many others that does not require treated water. From our understanding more than half of yearly operating budget of the water authorities are coming for the electricity supply to support the water treatment processes.

- The improvement of water industries demands the support from the citizens who naturally will be resisting to any change especially in increasing water tariff. While government is pressured to maintain the long review-overdue water tariff, it should be noted that there are huge imbalances in Malaysians' monthly water utility spendings compared to others such as electricity, broadband, transportation or even entertainment. As such citizen should at least be aware of the situation and prepare for any necessary changes in the future.
- People need to exercise their rights as the citizens by actively participating in any new policy or decision making process by the government especially when embarking on new technology. In the case of 5G for example, society, probably through local NGO can lead the engagement with government and technology partners to get some understanding on the risk and impact of the technology to their everyday live.
- Active participation also prompted for active action especially in safeguarding or protecting utilities assets and infrastructure. Vandalism, meter theft and illegal water tapping for example are among the factors contributing to NRW and discouraging water authorities from adopting digital solution. These activities can be curbed and prevented with the help from the local society or citizens. Maintaining the geographically sparse utilities infrastructure requires extensive human resources and can be facilitated by technology and citizen participation.
- Lastly, citizens should be resilient and anticipate any changes as the result of digitalization. As such, citizen should independently prepare themselves as future workforce and citizen ie by continuous learning and up-skilling, while keeping abreast with all the changes happening around them. Parents should also ensure that the younger generation will also be ready to face the unpredictable future.

In continuation to this project, our next action is to share the results and findings of the projects with federal authorities and regulators and explore some opportunities that can be implemented at national level. As highlighted, regulators and governments involvement are also crucial in supporting the digital transformation agenda for the water industries.

Finally we recommend that digitalization of water and any other industries to be integrated as part of the bigger smart cities framework. This will give visibility of the city's digital infrastructure that will be useful for soft and hard infrastructure planning and operation while unlocking other opportunity such as big data analytic and automation that will further enhance city efficiency, sustainability and resilience. Ultimately, people should be able to feel the differences and appreciate the values of digitalization which should be reflected into improvement of life and wellbeing.

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