D2.1 Waternomics Methodology

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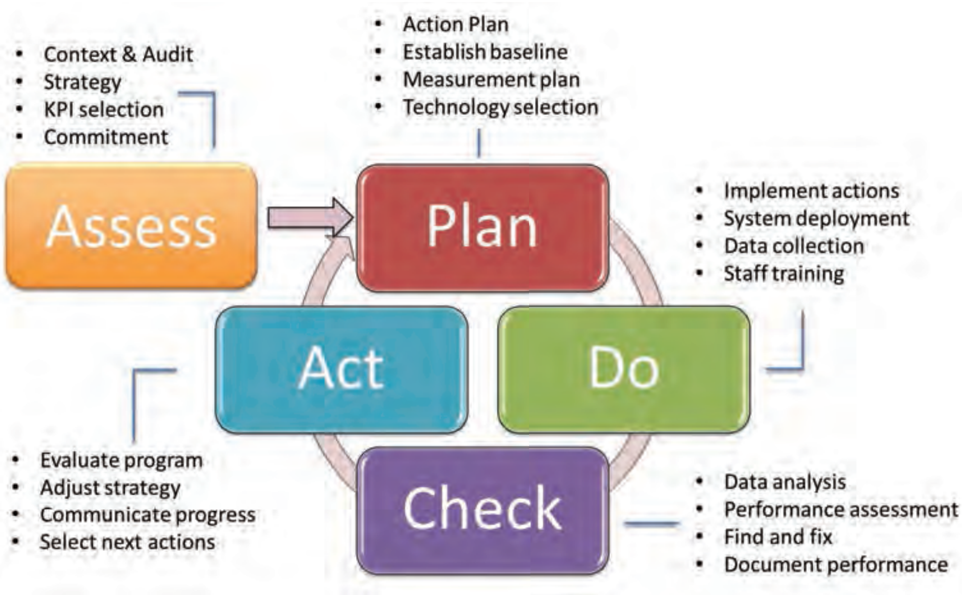
Executive Summary

A lack of information, management and decision support tools that present meaningful and personalized information about usage, price, and availability of water to end users can hinder efforts to manage water as a resource. WATERNOMICS aims to address these issues using innovative information, communication and technology (ICT) tools. The project will develop and introduce ICT as an enabling technology to manage water as a resource, increase end-user conservation awareness and affect behavioral changes, and to avoid waste through leak detection and diagnosis. This report describes the first version of a standards-based methodology for the development and implementation of ICT-enabled water management programs. This methodology will, given constraints, standards, corporate preferences, and key performance indicators (KPIs), provide decision makers and designers with a systematic way to select technologies, measurement points, data collection methods, and data management techniques for ICT-based water management systems.

This reportis divided in the following way:

- Section 2 presents the Waternomics methodology
- Section 3 details several methods developed in the project to help carry out the methodology
- Section 4 provides selected and condensed background information utilized to construct the methodology that may be interesting to researchers in the field. These consist of a review of topic related research projects, a review of the related standards, governance aspects, and best practice examples from water stressed regions.
- Appendices are used provide a fuller set of background information and facilitate the main report being concise.

The developed methodology, which in itself is a new development for the water sector, has five phases: Assess, Plan, Do, Check, Act. These phases are intentionally similar (with the exception of Assess being added as a first step to engage users) to those of ISO50001 (Energy Management Systems). In this way, environmental managers and the organizations, staff and service providers that work with them will immediately recognize the correlation between energy efficiency and the desired outcome of water efficiency.



Waternomics Methodology Overview

Other standards that many stakeholders will recognize include ISO50002 (Energy Audit), IPMVP (measurement and verification planning), and ISO14046 (Water Footprint). In this way, a comprehensive and holistic standards-based approach is established. For each of the phases, the steps to carry out and implement the methodology are provided. The methodology is customised to for the water sector in areas including energy-water relationships, water related KPIs, technology selection tools, rules to design physical measurement frameworks and assessment mechanisms.

The desired outcome of the Waternomics methodologyis that decision makers and end users at the community, corporate or home levels have a framework, set of tools, and references that enable them to take action towards water efficiency measures and to enact water management programs. The methodology is customizable to the needs of different end users and as such the report packages phases and activities to carry out the methodology into a number of discreet, concise and accessible summary briefs. In the project itself, the methodology is implemented in four pilots and the refined version of the methodology that incorporates lessons learned from pilot activities will be available later in the project as a report entitled Deliverable 6.2(Integrated Outcome: Methodology, Software & Data Management and Analysis Components) at the conclusion of the project in early 2017.

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Introduction

The goal of Waternomics is to explore how ICT can help households, businesses and municipalities with reducing their consumption and losses of water in the framework of a water management program. A key component of the Waternomics project aims at collecting water consumption and contextual information from different sources to be used for effective data analytics to drive decision making that optimises water consumption: e.g., planning, adjustments and predictions and to raise user awareness of water consumption (Curry et.al. 2014). In doing this, it is important to develop a common standards-based framework with which to plan, implement and assess Water Efficiency Measures.

To this end, a key outcome of the work carried out in the project work package developing this work (WP2) consists of designing the first version of Waternomics methodologyand the tools, techniques and methods to put it into action. The methodology is standards-based and implements best practices and approved guidelines from the energy sector where efficiencyefforts have received greater attention. Intended attributes of the methodology are that it is simple, able to be useful across the home, business and community levels, and can be integrated into existing resource management programs (typically energy) already in place at host organizations. Coupled with ICT in the form of sensors, meters and the project water information system, the methodology provides decision makers with the knowledge to enact and implement a water management program and to realize subsequent water efficiencies.

Within the Waternomics project, the methodology is developed, tested and then refined. In specific, it is developed before pilot activities (this report). It is then implemented at the pilots (home, business, community) where feedback and lessons learned will be captured and integrated into a final version of the methodology to be available near project completion in a future reportentitled Deliverable 6.2 – Waternomics Integrated Outcome (Methodology, Software & Data Management and Analysis Components).

1.1 Work Package2 (WP2)Objectives

WP2 conducts knowledge transfer from water conservation programs worldwide, previous and ongoing research, water and energy standards, consortium knowledge and targeted stakeholder expertise to develop a systematic and standards-based methodology for the design of ICT-enabled water management systems. The objectives of WP2 are:

- To screen existing methodologies and knowledge from other sectors, projects, and international efforts
- To conduct methodology development
- Given key performance indicators (KPIs), constraints, and priorities, to determine what minimal data sets enable the collection of the required data for analysis
- To provide rational for the selection and prioritization of technological options
- To apply the methodology to define the physical measurement framework for the pilot activities

The work of this WP relies on the expertise and field experience of the consortium partners as well as input elicited through the key stakeholder workshop and existing standardized methodologies. Through this, the WP produces as output the methodology and its first implementation to the Waternomics pilots for the definition of their physical measurement frameworks in a separate

report (D2.2).

1.2 Purpose and Target Group of the Deliverable

This report outlines the research and development conducted within tasks in WP2 namely; Task 2.1 (Water Governance – Methodology background and Knowledge Transfer),Task 2.2 (Methodology Design), and Task 2.3 (Specification of Minimal Data Sets to capture Explicit Relationships). Through this, the report provides a set of knowledge, tools and references related to water efficiency and water management. Use of the developed methodology provides a standard-based pathway that can lead to both organizational change (management procedures) and individual change (behaviour change) and serve as a manual or guideline on how to get started.

The main target groups for this deliverable are:

- Organizational environmental/water managers
- Water consumers in various domains (domestic, community and corporate)
- Water services companies
- Water operational managers

In developing and presenting the work, it is a deliberate choice to be "standards-based." In this way, we believe it will be possible to align with concepts and terminology that high replication-potential decision makers are already familiar with. It is also a deliberate choice to provide a set of tools and references to help implement the methodology. As is often the case, frameworks and methodologies are general so that they can be adopted, adapted and applied to a wide range of stakeholders. Without tools and references to assist implementation, there can be a gap between overarching procedural steps and the actions required to accomplish them.

1.3 Relations to other Activities in the Project

WATERNOMICS is organized in eight different WPs as shown in Figure 1.

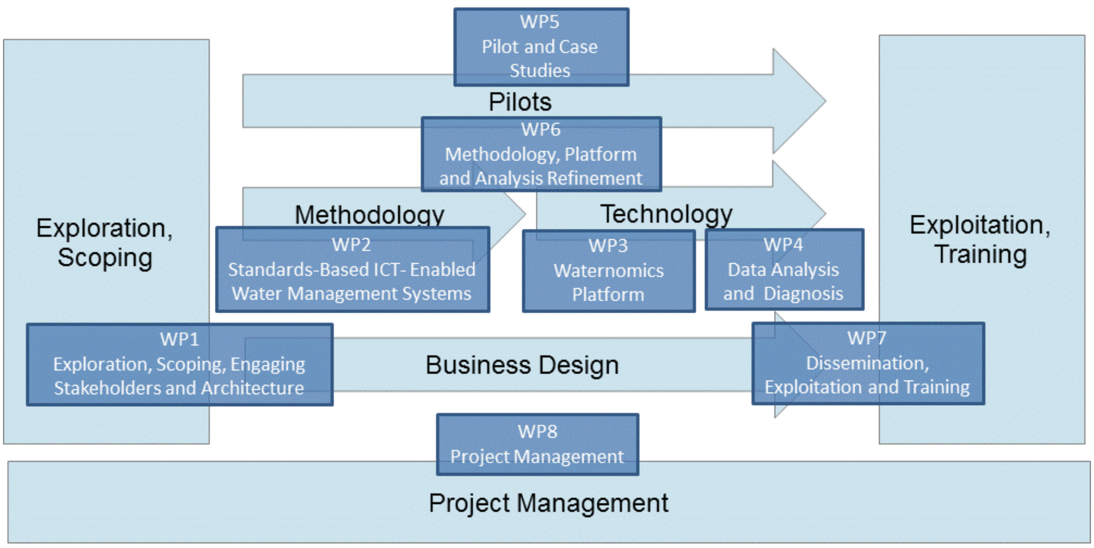


Figure 1 : WATERNOMICS WP structure.

Methodology development occurs for the first half of the project (18 months) and then is implemented and refined during pilot activities before being made available for exploitation and training. The links between WP2 and other activities in the project are outlined in Figure 2.

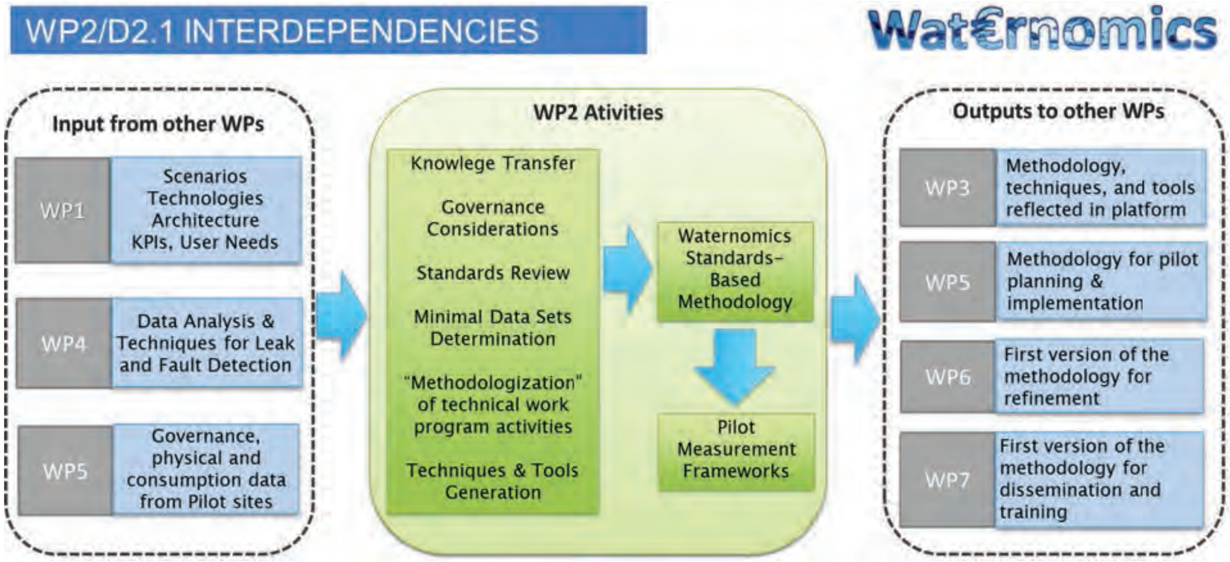


Figure 2: Relationships between D2.1 and other activities in Waternomics

Figure 2 shows the interdependencies and relationships between WPs as they relate to WP2 and Deliverable D2.1. From WP1, its stakeholder workshops and D1.1, D1.2 and D1.3, WP2 receives the project scenarios, information related to sensing technologies, the overall architecture, KPIs particular to delivering water efficiency for the targeted groups and user needs. From WP4, initial information related to leak detection, fault detection and data analysis are considered. From WP5, governance aspects, physical infrastructure data and consumption data have been collected and aggregated in parallel with methodology development.

This information set has been combined with WP2 activities which include knowledge transfer from other sectors (with focus on energy), governance aspects from governments, policy bodies and literature, a review of standards, research into the development of a method for minimal data sets determination, the "methodologization" of project technical activities and its consequent development of techniques and tools to make the methodology available to end users. One example is a technology selection approach that makes information available from WP1 (what types of sensors are available and for what purpose) and passes that information to WP3 in the Waternomics platform so that end users have a methodto begin to select technologies are optimal for their requirements.

This work leads to the project methodology reported in this document which creates a common standards-based methodology for the design and implementation of ICT enabled water management systems.It should be noted that such a methodology is sorely lacking in the water sector and thus this document is an important step in ensuring water efficiency measures can be implemented in a similar way that energy efficiency measures have been. It is used in WP2 to provide the physical measurement framework for the pilots (D2.2) and then becomes output for use by other WPsin Waternomics. In WP3(Waternomics Platform Design) parts of the methodology must be reflected in the ICT user environment that will be brought forward to the end users. In WP5 (Pilots), the methodology will be enacted in detail on the pilots and lessons learned from its first validation will be provided to WP6 (Refinement) where the final version of the methodology will be documented. For WP7, the methodology will serve as a publication opportunity (scientific dissemination) and also as a project outcome (communication activities).

1.4 Document Outline

The remainder of this document is organised as follows:

Section 2 describes the Waternomics methodology framework, the activities and methods to implement each phase, and how the methodology will be validated in the project. Section 2 is divided into four sub-sections:

Section 2.1 describes definitions, ideation &process
Section 2.2 describes the framework of the Waternomics methodology and its phases
Section 2.3describes the validation of the Waternomics methodology

Section3describes methods developed in the project which include ways to carry out the holistic methodology framework and ways to implement and an activity within a phase. Section 3 is divided into six sub-sections:

Section 3.1 describes the use of the Trello software environment as a platform to implement and manage the holistic methodology framework
Section 3.2 describes a stage-based approach to water auditing
Section 3.3 describes a method to specify minimal datasets
Section 3.4 describes a method to assist with strategy development and selection
Section 3.5 describes a water value map
Section 3.6 describes a technology selection tool

Section 4 presents information aggregated and analysed as part of methodology development and supports the WP intent to look outside of the project, outside of the water sector and outside of our own geographic boundaries for knowledge, information, standards, examples and best practices. Section 4 is organized into five sub-sections:

Section 4.1 presents a mapping of related EU research activities
Section 4.2 provides an analysis of energy and water related standards and programs
Section 4.3presents an analysis of governance aspects
Section 4.4 describes several international programs and case studies
Section 4.5 describes several European programs and case studies

Section5 provides conclusions related to methodology development, the review and analysis of external information, and future steps in the project related to methodology development and implementation.

1.5 About Waternomics

Waternomics is a three year EU-funded project that started in February 2014 that will develop and introduce ICT as an enabling technology to manage water as a resource, increase end-user conservation awareness and affect behavioural changes, and to avoid waste through leak detection. In saving water, energy will also be conserved (treatment and pumping) as will the CO_2 associated with energy production. The project is motivated by climate change, increased urbanization and world population, the ageing infrastructure problem, social responsibility and the fact that advances in ICT make such solutions possible and cost effective. Indeed, most persons would likely be surprised that the water crisis is the #1 global risk based on impact to society (as a measure of

devastation), and the #8 global risk based on likelihood (likelihood of occurring within 10 years) as announced by the World Economic Forum, January 2015[1].
Unique aspects of WATERNOMICS include personalized feedback about end-user water consumption, the development of a methodology for the design and implementation of systematic and standards-based water resource management systems, new sensor hardware developments to make water metering more economic and easier to install, and the introduction of forecasting and fault detection diagnosis to the analysis of water consumption data.

WATERNOMICS will be demonstrated in three high impact pilots that target three different end users/stakeholders:

- Domestic users in Greece implemented by a water utility
- Corporate operator in Italy provided by a major EU airport
- Public and Mixed-use based demonstrations in Ireland

Through these contributions, WATERNOMICS will pioneer a new dialogue between water stakeholders. It will enable the introduction of Demand Response principles and open business models through an innovative human centric approach that uses personalized water data, water availability based pricing, and gamification of water usage statistics. To maximize impact, the project highlights business development, exploitation planning, and outcome oriented dissemination.

[1]Available at http://reports.weforum.org/global-risks-2015/ accessed 29 June 2015.

2 The Waternomics Methodology

This section presents definitions, the Waternomics methodology framework, the activities that make up each phase of the methodology and the approach to methodology validation in the project.

2.1 Definitions, Ideation & Process

The development of a new methodology can be elusive. Teams working on methodology development may struggle to define an appropriate scope or lose focus as the process and way forward is beforehand unknown. The development of the Waternomics methodology benefitted from the knowledge and expertise of partner BMC (Business Model Change) who brought best practices and ideas from the business model generation community where ideation, roadmapping, and iterative process development are community strengths.

With this consortium expertise, the exercise to develop a methodology began with the documentation of answers to the following questions to ensure a common vision amongst the methodology development team: What is a methodology? What are its elements?How does one go about developing a methodology?

The Random House Dictionary defines a methodology as "a set or system of methods, principles, and rules for regulating a given discipline…." The Oxford Dictionary defines the term methodology as follows: "A system of methods used in a particular area of study or activity."
So, a methodology is a body of knowledge comprising the principles, guidelines, best practices, methods, and processes relating to a particular discipline such as wastewater treatment or water distribution network design.

Conclusion: A methodology is related to a particular discipline. For the Waternomics methodology this discipline is the improvement of the water efficiency of households, corporate users and municipalities

To further describe the goal and the scope of a methodology, a description of the methodology is needed. The description aids the user with deciding if a methodology is suitable for his or hers problem or task. Therefore the description is considered as an element of the methodology.

Conclusion: A methodology has a description. The description of the Waternomics methodology is: The Waternomics Methodology is a standards-based framework for the design and implementation of ICT-enabled water management programs to increase the water efficiency of end users at the domestic, corporate and municipal levels.

One element of a methodology are methods. Both definitions of methodology mention 'method' as being part of a methodology. But what is the difference between a method and methodology? Again

we look at two definitions of method. The Business Dictionary defines method as: “An established, habitual, logical, or prescribed practice or systematic process of achieving certain ends with accuracy and efficiency, usually in an ordered sequence of fixed steps.” The Oxford dictionary defines method as “A particular procedure for accomplishing or approaching something, especially a systematic or established one.”

Methods can be seen as the tools with which certain ends can be achieved whereas a methodology describes how such methods are deployed and interpreted. For example, methods for water treatment are ultraviolet disinfection or chlorination.

Conclusion: A methodology consists of methods which are prescribed practices or procedures for achieving specific ends. For example, the IPMVP measurement and verification protocol could be used in the Waternomics methodology as a method for assessing the benefit and impact of Water Efficiency Measures.

This leads to two other elements of a methodology, the rationale and the key concepts. First looking at the rationale, a methodology is not just a list of methods, it describes when and how to use these methods and how the results contribute to the purpose of the methodology. It describes why methods should be used, the rationale.

Conclusion: A methodology describes the rationale behind the use of methods. The Rationale for the use of the Waternomics Methodology is that the availability of a systematic and standards based approach supported by information, management and decision support tools that present meaningful and personalized information about usage, price, and availability of water to end users will increase water efficiency and facilitate efforts to manage water as a resource

The next key concepts are the major ideas behind the methodology. These key concepts give direction to the rationale and explain how a methodology differs with other methodologies in the same discipline.

Conclusion: A methodology is based on a limited number of key concepts. The key concepts of the Waternomics methodology are:

1. Waternomics methodology takes a holistic approach on water management
2. Waternomics methodology is a standards-based methodology
3. Providing timely and actionable water usage related information to water consumers and water managers reduces water consumption

In general the five elements mentioned above, namely; discipline, description, key concepts, rationale and methods, cover the components of a methodology. These five elements are captured in the accompanying Table 1:

Table 1: Five main elements of a Methodology

A methodology:		
Is targeted at	A discipline	Which defines the scope of the methodology
Has a	Definition	Which explains the goal of the methodology
Is based on	Key concepts	Which describe the basic ideas behind the methodology
Contains	Methods*	Which describe how specific ends can be achieved
Describes	The Rationale	Behind the use of the these methods

** An additional note on methods:*

The Waternomics methodology is made of five phases.
Those phases are broken into a series of activities and these activities can be considered a method to conduct each phase.
We also present different methods to conduct specific activities as there is more than one way to capture a baseline, conduct a water audit, determine strategy and so on.
We also present a method to implement the entire methodology in a management tool.
As such, methods appear at three different levels in this document, at the framework/holistic level, for the phases themselves, and within the activities.

2.2 The Waternomics Methodology Framework

The culmination of the methodology work is a 5 phase methodology (Assess, Plan, Do, Check, Act). The methodology draws strong inferences from and integrates the principles of ISO50001 (Energy Management Programs), ISO 50002 (Energy Audits/Diagnosis), IPMVP (International Performance Measurement & Verification Protocol) and ISO14046 (Water footprint) into a holistic framework. This is coupled with project activities toward the development of a water information system, directed at the challenge of water resource management. Several of the associated standards are recent (ISO50002 and ISO14046) and furthermore the focus of several is energy (ISO50001 and ISO50002).The application and adaptation of such standards in a holistic framework is innovative and new.It should be noted that the authors did not confine their research to just energy and water based standards but also looked across other disciplines. However, the energy-based standards were found to be most relevant and applicable to this sector.

The basic framework for the methodology is depicted in Figure 3. The Plan-Do-Check-Act (PDCA)cycle is well known (ISO50001) and deliberately chosen to provide decision makers a familiar framework when considering a water management program. In this way, the linkages to and transition from energy management to water management are intuitive and clean. It is also timely in that in several EU countries the use of ISO50001 is becoming mandatory for certain types of organizations in 2015.

Added to the PDCA cycle is an initial “Assess” phase. Because end users may be less aware of water efficiency, water scarcity and how/why it affects them, the Assess Phase in the Waternomics methodology is a deliberate attempt to engage and educate the end user. For this reason we number it “Phase 0” which intuitively implies something to be done before even getting started although it in effect is a start point itself. The activities that make up the Assess Phase can be used in a light / information gathering way but they are also robust enough to support complex and large organization water management program development. As such, the desired outcome of the Assess Phase is end user understanding and commitment. Once engaged, the end user enters into a continuous iterative cycle of improvement guided by the PDCA cycle.

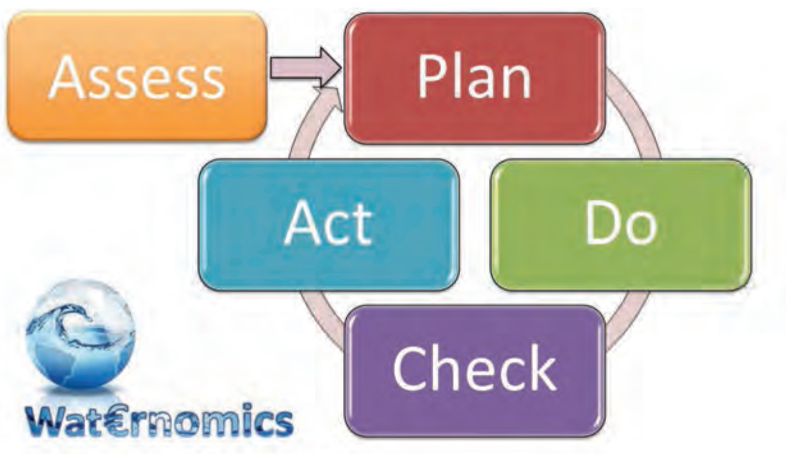


Figure 3: Basic framework for the Waternomics Methodology

In assembling relevant standards and in constructing the Waternomics methodology, it is noted that many standards have overlapping aspects and as such a direct overlay of each of the steps from the standards would produce redunancies. It is also true that terminology is not yet completely harmonized across the various standards and that some propose themselves as an umbrella to group other availablestandards. Regardless of any sticking points, we instead found it most useful to look

at what each standard was trying do to and then to assemble those intents in a logical way from initial consideration of the problem to its definitive conclusion and/or iterative loop. The result is a logical process (the five phases) where it was not constrained to have a one-to-one mapping between a standards and phases (e.g. each phase does not correspond to only one standard).

Figure 4 shows a more refined and full view of the Waternomics methodology. In specific, the activities, desired outcome, and related standards are shown for each phase.

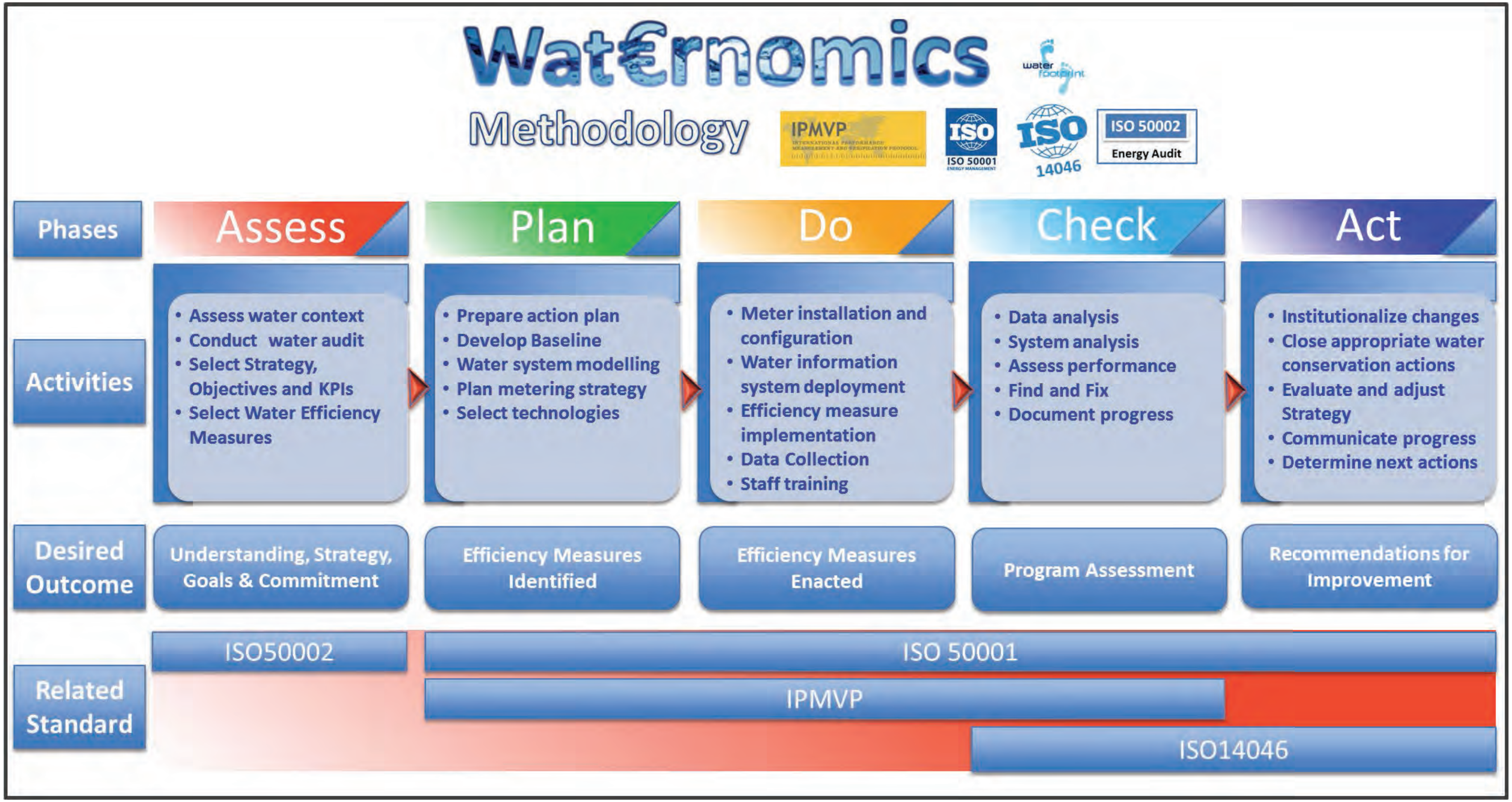
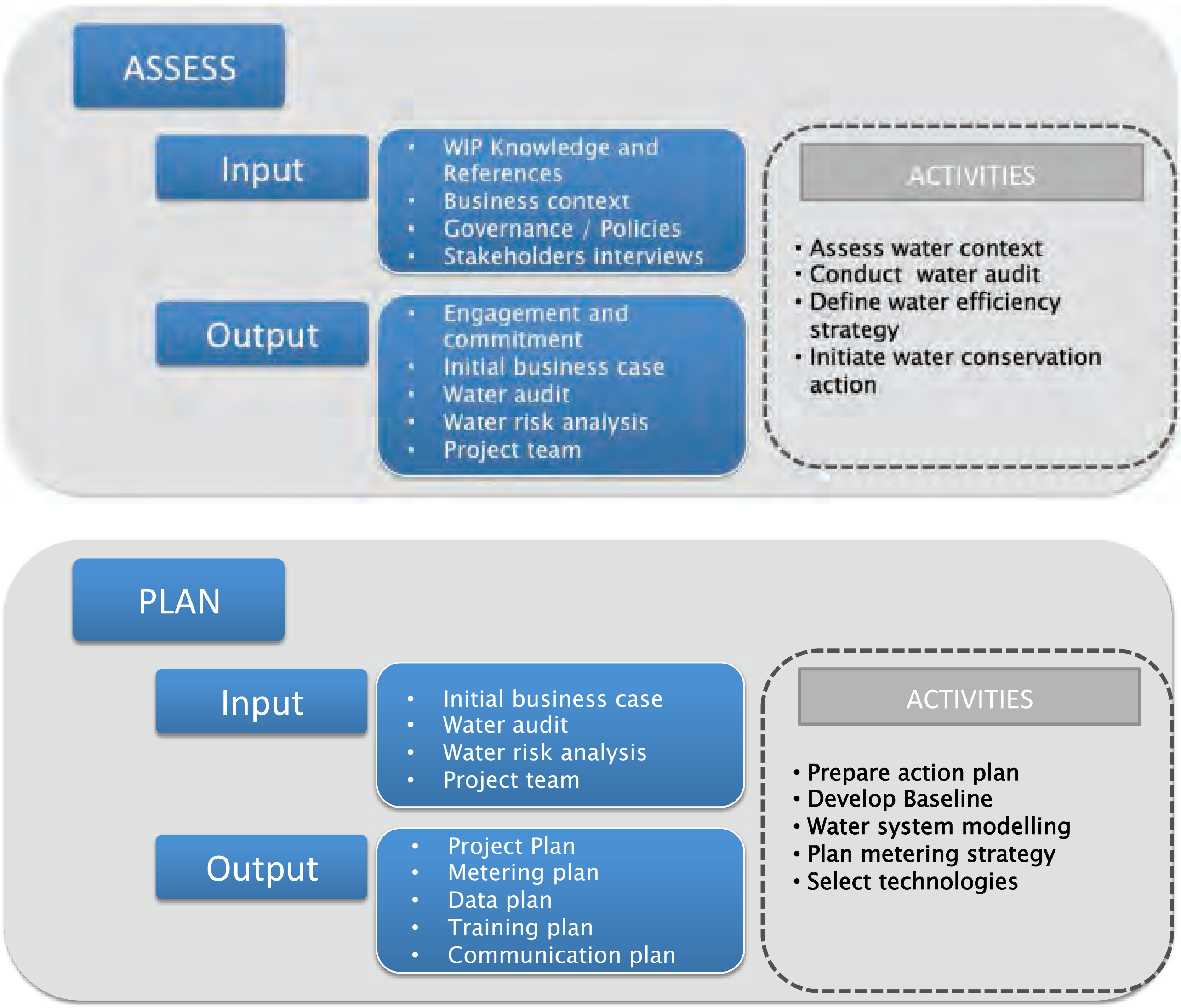


Figure 4: The Waternomics Methodology (full view) which includes activities, outcomes and its relation to the assembled standards

In considering the methodology, special attention is drawn to the “Activities.” These in fact become the core of the methodology and are the steps necessary to accomplish the phases. Within each activity, various methods are possible. For example, IPMVP offers four unique methods to calculate a baseline (an activity under the Plan phase). We propose three different levels (or types) of water audits (an activity within the Assess Phase). In using the methodology, it is up to the end user to determine what method and level of detail from the methodology is appropriate for them. For example, a domestic user may most appropriately employ only the higher level concepts (phases and select activities). Instead anenvironmental manager of a large and complex organization may utilise available phases, activities, methods and references with more rigor.

In the sub-sections that immediately follow (2.2.1-2.2.4), each phase is described. Its goals, outputs, and activities are described. In several cases references are provided and in others methods are embedded and detailed.

In a further detailing of Figure 4, Figure 5 provides an additional intuitive view of the methodology. These figures (or a more cosmetic version of them) will be made available in the Water Information System and in particular in Waternomics Platform.



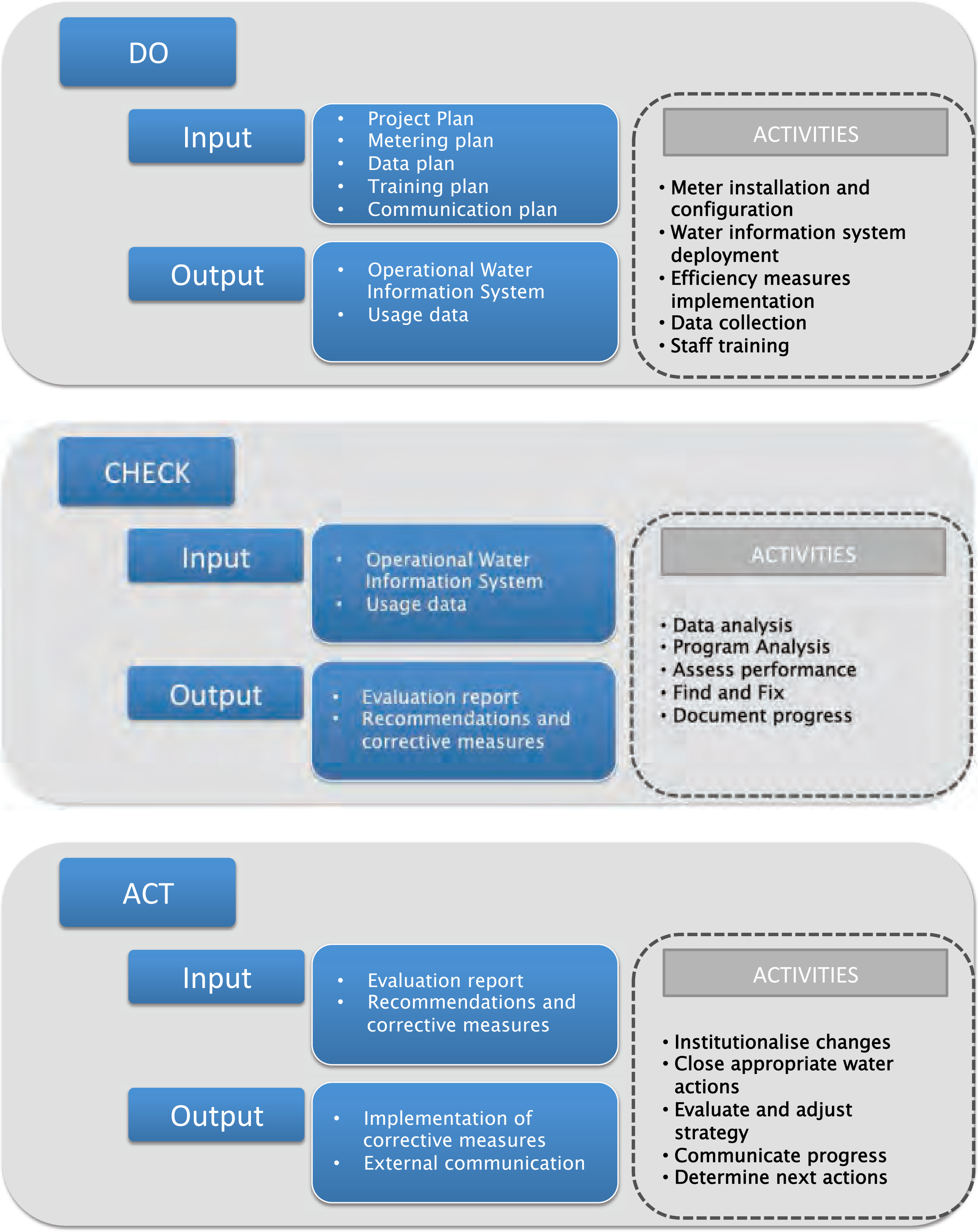


Figure 5: The guidelines to follow to implement Waternomics Methodology

2.2.1 Phase 0 - Assess

The goal of the "Assess"- phase is to determine whether or not an end user or decision maker should engage in the construct of a water management program, take water efficiency measures and/or implement a water information system. During this phase a decision making team will identify if a water management program can realistically be deployed and if so, what goals should be met and which strategy is the best to reach these goals.

The activities that make up this phase are:

1. Assess water context
2. Conduct water audit
3. Select strategy, objectives and KPIs
4. Select Water Efficiency Measures

In the following a detailed description of each activity is provided

Assess water context

Step 0 involves the organisation/user understanding the issues and taking the first step towards engaging with water efficiency. The key questions include: Does water efficiency affect me and do I care? If a person can be engaged with these two simple questions, then behavioural change and organizational change is possible. The "assess water context" activity is therefore established to facilitate exploration of these questions. This is done through the aid of a checklist in the form of questions and references to external sources that can be provided by the Water Information System.

External Considerations:

- How does where I live/operate relate to water scarcity and drought?
- What policies govern water in my area?
- Do I have various billing options?
- Do I have access to any incentive programs for investment or improvement?
- Are their indirect benefits (personal value, marketing or branding) that are important to me or my organization?
- Am I aware or interested in other water conservation programs for ideas or benchmarking?
- Am I aware or interested in research activities related to ICT-enabled water efficiency?

Internal Considerations:

- Do we know how much water we consume?
- Is someone responsible/held responsible for water management?
- How does billing/payments work? Do users have visibility on costs?
- Is there an existing water efficiency program in place? Is it working? Are there gaps?
- Do I, my staff, or my superiors have knowledge or concerns that should be considered?
- Is there awareness of existing water efficency measures among staff or other household members?
- How will water consumption be impacted by future growth strategies given a "do nothing" scenario (useful for corporates)?
- Are there well known problems in the water distribution network or with consumption patterns/behaviours?

This series of questions and answers may be self-guided, assisted by the water information system, or conducted through a series of interviews by a consultant or internal professionalstaff. Through

this, before starting any consideration about the opportunity to implement a water saving program in a household, a corporate or a municipality, it is possible to better understand the stakeholders' needs, what are their problems, what are their operational procedures and behaviours related to their water consumption. This process will help the decision makers, individuals or professionals understand the real problems and opportunities related to achieving improvements in water efficiency.

Conduct wateraudit

A water "audit" (or "diagnosis" or "review" depending on preference of terminology) is critical to understanding the real situation of a water network, water program, organization or household water use. In this particular case for water auditing, it is possible to conduct knowledge transfer from the energy sector where energy audits have reached a good level of maturity. Information related to the definition, steps, scope and benefits of a water audit are discussedin this section.

What is a water audit?

A water audit is used to account for all water input and all water output within a defined boundary space within a specified period of time and to a specified level of user or process precision. This can also be called a water balance. It is up to the decision maker and "auditor" to jointly define the level of precision associated with inputs and outputs and also to clearly define the boundary conditions. It can be particularly relevant for inputs as organizations may be responsible for sewage costs related to runoff that pass through their sewage system. It can be relevant for outputs because leakages or evaporation where open water surfaces are present can be significant. It is relevant for boundary conditions because a decision maker may be concerned with their entire organization or facility or a particular area of interest. It is relevant with respect to time for KPI calculations and internal reporting purposes, to align (or not) with billing cycles, and/or to have visibility on data in more precise intervals to understand exactly when water input or output is happening. It is relevant with respect to user or process precision because an organization may consist of many water consuming processes or a decision maker may want to segregate water consumption by the various types of consumption (showers vs toilets vs sinks in a washroom as a simple example).

Typical water inputs:

- Water provided from the water distribution system to the area of concern
- Water provided from organizational wells within the area of concern (if any)
- Water from reuse (if any)
- Rainfall (if applicable)
- Any other water ingress

Typical water outputs:

- Water discharged to the sewage system
- Water leakages
- Evaporation
- Any other water egress

Quantities for water inputs or outputs may be determined in various ways:

- Available water bills
- Water meters (for example those from the utility)
- Water sensors (for example those installed for a dedicated measurement)
- Estimates from device usage (e.g. a 5 litre toilet used 10 times per day)

- Balance calculations between metered and unmetered users or parts of the network which may also include leakage estimates
- Simulation environments

Audits may involve physical inspections and inventory of all water use points in the facility to develop flow rates for each point. For items such as toilets and faucets, the inventory should include the item, its location and its flow rate. If the facility has low-flow fixtures or if flow restrictors have been installed, this should be annotated. Where pumps are concerned, values about its capacity and energy demand should be documented. Pipe diameters, lengths and material composition (for friction coefficients) become important for simulation model development. If a Building Information Model (BIM) is available or made and/or if a simulation model already exists or is made these tools can significantly speed up the audit process and be a great tool to any auditor.

Recommendations

A final output of water auditing are recommendations. Especially for detailed water audits where the auditor is expert and significant time is invested, recommendations can provide valuable insights for the decision makers in selecting strategy, objectives and water efficiency measures. In the energy sector, recommendations are a mandatory part of the energy performance certificates.

What are the benefits of conducting a water audit?

Comprehensive audits provide decision makers and end users with a detailed profile of their water use and system, allowing for more effective management of resources and improved reliability. Thus water auditing serves as an important step towards improved water efficiency, energy efficiency, network optimization and their corresponding financial savings.

Waternomics has develeped its own Auditing Method that draw strongly from AFNOR BP X30-120 (Energy Diagnosis in Industry). This norm is a base reference for the international energy auditing standards used today. More detail about Waternomics Auditing Method is provided in Section 3.

Define Strategy, Objectives& KPIs

This activity is the development and documentation of the strategy, objectives and KPIs for the PDCA cycle or more globally for the water management program.

Criteria for evaluating strategic options are suitability, acceptability, feasibility and associated risk. Sharp changes in strategic direction require a culture change in an organization. For considerations where this may be the case or to inform the interested reader, a Waternomics method is dedicated to strategy selection in Section 3. An addition tool created as a Waternomics method to place context and auditing results into a visual tool to assist in the determination of strategy, objectives and KPIs is a Water Value Map. This tool and method is also provided in Section 3.

With respect to objectives, they should be specific, measurable, assignable, realistic and time-related (SMART)

- *Specific* – target a specific area for improvement.
- *Measurable* – quantifiable by units or linked directly to Key Performace Indicator
- *Assignable* – specify who will do it.
- *Realistic* – state what results can realistically be achieved, given available resources.
- *Time-related* – specify when the result(s) can be achieved.

Water efficiency objectives are specific to each organization or end user. In general, objectives can be defined in terms of quantity (e.g. monthly water usage consumption), quality (e.g. water network maintenance frequency)and compliancy (e.g. meeting specific standards).

Key Performance Indicators (KPIs) are the data, information, measurements or status that the decision maker or end user wants to follow and have reported. Examples could include water volume and costs per month. The estimated leakage in the network. The associated carbon savings resultant from water efficiency and its associated energy savings. The water footprint. KPIs may place requirements on the metering strategy, data collection, and data analysis requirements. KPIs may also place requirments on the customization of a platform and/or development of applications.

Strategy, objectives and KPI development can also benefit from an analysis of the business case, a stakeholder analysis, and risk analysis.

Develop the initial business case

The business case is a cost-benefit analysis related to recommended efficiency measures and/or developed objectives. In this analysis non-monetised benefits such as environmental and public image should be considered. The business case may also look to the broader business context which looks at the internal and external business environment to gain understanding about the context in which the water efficiency activity is executed to identify forces the business must react to such as new regulation, water scarcity or the cost of doing nothing. External factors can be separated in broad factors, applying for every organisation or household in a specific region, like the economic climate, political regime or available technology. Specific external factors only apply to a specific business or household, such as price forces, competition or local environmental changes. Also the internal context drives change within an organisation or household. For example, changing ambition levels in the area of sustainability can drive water efficiency improvement actions and result in new business objectives.

Some recommended methods and tools to develop a business caseanalysis are:

External analysis: PESTEL, SWOT, Trend Analysis
Internal context analysis: Structural Analysis, Business Model Canvas, SWOT

Stakeholder analysis

Stakeholder analysis is the process of identifying and categorising the persons, groups and organisations who have an interest in the water efficiency improvement activity, and the analysis of relationships between stakeholders. With the resulting information from the stakeholder analysis it is easier to gain or increase support for the water efficiency improvement activity. When performing a stakeholder analysis in the Assess-phase, one can detect and act to prevent potential misunderstandings about and/or opposition to the water efficiency improvement activity.

Stakeholder analysis can be seen asa three step process:

1. Identification of stakeholders
2. Categorisation of stakeholders
3. Analysis of stakeholder relationships

To identify stakeholders it is important to think beyond the obvious and see who will be affected, directly or indirectly, positively or negatively, by the action. To identify people and groups that are

directly affected by water efficiency related actions, a systematic approach often works well, delineating the physical water distribution network and its sphere of influence.

One segmentation of stakeholders, more aimed at commercial businesses, is according to the scheme below:

- External primary stakeholders (customers and suppliers)
- Secondary stakeholders (rivals, NGO's, press)
- Internal primary stakeholders (employees, shareholders)
- Regulatory stakeholders (governments, public agencies)

It is not practical, and usually not necessary, to engage all stakeholders with the same intensity. By prioritising stakeholders and by determining their interests, the most appropriate ways to engage them can be determined. Stakeholders are typically categorised based on power, influence and the extent to which they are affected by the activity. A commonly used method to cluster stakeholders is to use a 4- or 9-sector interest-influence tables, as shown in Figure 6.

High power	SATISFY	MANAGE
Low power	MONITOR	INFORM
	Low impact	High impact

High power			
Moderate power			
Little power			
	Little impact	Moderate impact	High impact

Figure 6: Stakeholders Matrix analysis

Each stakeholder is plotted in the interest-influence table. Based on its position in the matrix, for each stakeholder the most suitable engagement strategy can be determined. Other classifications of stakeholders can be based on function or role or degree of aggregation (individual-collective).
Finally, analysis of relationships between stakeholders, as individuals and groups, develops insights which can lead to criteria for improving relationships as well as negotiating preferred linkages. Criteria for appreciation of the relationship can include; frequency of contact, formal versus informal, awareness, timeliness, level of intimacy. Relationships can be categorised as strong, weak or non-existent or focus on the business or social roles.

Stakeholder	Customers	Employees	Suppliers	Manager
Customers				
Employees				
Suppliers				
Manager				

Figure 7: Relationship between stakeholders' individuals and groups

With the results of the analysis one should decide how to manage stakeholders. Action should be taken to win doubters and sustain and enthuse supporters. When a more participatory approach is used to for the activity, the stakeholder analysis can be used to engage stakeholders in an early stage. Methods and tools include:

Stakeholder identification: Brainstorming, Interview, Roleplaying, Expert Judgement
Stakeholders categorisation: Interest-Influence matrix, Venn diagram
Stakeholder relationship analysis: Actor linkage matrix, Social Network Analysis, Knowledge Mapping

Water risk analysis

The goal of awater risk analysis is to identify possible negative conditions, events or situations caused by external and internal water related events. With the results of the water risk analysis, the vulnerability of an organisation with respect to water can be determined and risk mitigating actions can be taken.

The most common categories of water related risks, as defined by WWF and other organisations, are:

- *Operational risk*. The Basel Committee defines operational risk as "the risk of loss resulting from inadequate or failed internal processes, people and systems, or from external events". In the context of water related risks, the definition is narrowed down to the risk of loss resulting from water availability, water quality, water related events or extreme water hazard risks like floods and droughts.
- *Reputational risk* is defined by the Board of Governors of the Federal Reserve System as "the potential that negative publicity regarding an institution's business practices, whether true or not, will cause a decline in the customer base, costly litigation, or revenue reductions". Changing expectations of customers, staff or society with respect to water, may lead to reputational damage. Extensive water usage or water pollution may result in customers stop buying, staff leaving or regulators starting inquiries.
- *Regulatory and legislative risk*. The CEO Water Mandate states that "Regulatory risk relates to the imposition of restrictions on water use by government and the capacity of government to manage water effectively and sustainability. This may include the pricing of water supply and waste discharge, licenses to operate, water rights, quality standards, infrastructure development, water allocation, etc."

The scope of the water risk analysis can be threefold: Supply chain, direct operations or product use.Water risk assessment tools are widely available. Most tools use one's geolocation information to determine risks of floods and droughts in a specific region.

Because of a lack of global datasets containing sub-basin level information, water withdrawal and disposal, freshwater availability and water quality, coverage of these tools is often limited and results vary across tools.Examples of Water Risk Analysis tools are provided in Table 2:

Table 2: Water Risk analysis tools

	External Link
WBCSD Global Water Tool	http://www.wbcsd.org/work-program/sector-projects/water/global-water-tool.aspx
GEMI Water Management Risk Assessment	http://waterplanner.gemi.org/module2.asp
Ceres Aqua Gauge	http://www.ceres.org/issues/water/corporate-water-stewardship/aqua-gauge
AQUEDUCT Water Risk Atlas	http://www.wri.org/our-work/project/aqueduct
AQUEDUCT Global Flood Analyser	http://floods.wri.org/#/
WWF Water Risk Filter	http://waterriskfilter.panda.org/
Water Risk Monetizer	http://www.waterriskmonetizer.com/
India Water Tool 2.0	http://www.indiawatertool.in/

Select Water Efficiency Measures

This activity is the development and documentation of the Water Efficiency Measures (WEMs) that will be implemented into the PDCA cycle and made part of the water management program.

WEMs can be for short-term or long-term demand reduction[1]. Short-term demand reduction may be applicable in response to specific water supply deficits such as a summer drought. Long-term demand reduction has the objective to reduce water demand into the future via systemic change. When planning for future water needs, long-term conservation can significantly reduce capital expenditures for new facilities. There are a multitude of WEMs available to communities, corporations and domestic users. Hence, the myriad of options must be narrowed down by evaluating the measures with regard to water savings, cost reliability and feasibility. Generally, WEMs can be categorized either as pricing, regulation, education, or hardware.

Pricing

The price the consumer pays for water can have a significant effect on the amount of water used. Typical rate structures for water conservation are based on three types of pricing: flat rates, seasonal pricing and inclining block rates.

- Flat rate water pricing applies the same unit charge for water regardless of the quantity consumed.
- Seasonal pricing involves a higher rate during peak times/seasons. Seasonal demand periods can stress water infrastructure and increase the costs to produce peak demand capacity. These increased rates are designed influence customers to reduce water usage during such periods.
- Inclining block rates apply progressively higher rates to each increment of water used above some base amount. This method encourages customers to save water, and frugal customers will benefit from lowered rates.

The effectiveness of these types of price structures as water conservation measure depends on

[1] "Water Conservation Measures for long and short term water demand reduction" – Laurie E. Ashmore (2009)

demand price elasticity. Price elasticity is the ratio of the change in water use to the change in price. Values of price elasticity vary widely in the literature. Specific price elasticity must be determined for a service area by examining the effect of price increases on demand.

Monetary incentives may be used to enhance compliance with water use restrictions. Excess use charges can be implemented which impose stiff charges for water used above the rationed allotment Fines can be levied against customers that do not comply with bans.

Regulations

Regulations requiring water conservation can take many forms and include (1) requirements for new construction, (2) water use restriction, and (3) rationing. For example low water use fixtures could be required by a local law and result in individuals/organisations adapting newer fixtures that reduce water consumption.

Restriction of water use, such as odd-even outdoor watering restrictions, have become a commonly used water conservation measure during recent drought years. Restrictions can take many forms, depending upon the desired water reduction, and the water use pattern of the service area.

Water rationing is a severe, but very effective, water conservation measure. The reduction percentages required can be constant, stepped, or variable. In implementing water rationing, it is important that the program is perceived as equitable. Percentage reductions may be perceived as inequitable because identical houses could receive vastly different allocations. A fixed water allowance per capita may be perceived as more equitable.

Education

The end users, attitudes, and decisions with respect to water use dictate the demands placed on a water system. To be effective, a water conservation education program must consider the end users' view- point. An effective education program needs goals, a commitment of resources and a theme. The program must be honest and convincing when addressing the issue of why the users are being asked to conserve water. The most cost-effective means of communicating varies depending on the interested party and includedirect contact with users, mass media, in-school training, information booths, and participatory campaigns.

Hardware

This category includes both traditional (e.g. meters, sensors) and new (e.g. ICT measures) hardware measures that are used as tools in water system management and conservation. The measures can be organized into three general categories: Level 1, Level 2, and Level 3 (Figure 8). Within each level are four subcategories that are used to organize a variety of specific conservation measures:

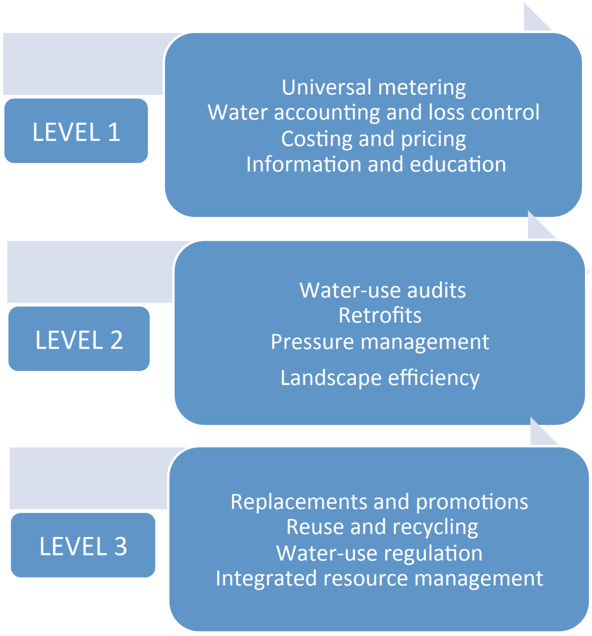


Figure 8; Level of detail in choosing WEMs related to the water measurement

This system of organizing the conservation measures recognizes that the measures considered can vary with the size and capability of the water system. Water stakeholders are strongly encouraged to explore a comprehensive range of efficiency measures. While the list in Figure 8 is relatively current and comprehensive, planners should not limit their analysis only to the measures mentioned here. Planners also should consider new technologies and approaches as they become available. The three levels represent the detail of the water efficiency measure selected to be implemented in a water facility.

International and European examples and case studies related to pricing, regulations, education and hardware are presented in Section 4 and as an appendix.

2.2.2 Phase 1 - Plan

The goal of the Plan Phase is to take all necessary actions to fully prepare water efficiency measures for implementation. The activities that make up this phase are:

1. Develop baseline
2. Conduct water system modelling (if applicable)
3. Plan metering strategy
4. Prepare action plan
5. Select technology

In this plan phase, the activities are highly interdependent and may occur in parallel or in a different order than presented herein.

Develop baseline

A baseline develops a comparison other for water efficiency measures so that the impact, improvement or return on investment can be calculated. Stated another way, the baseline is a snapshot of the current system that reflects a larger period of water consumption. To establish a

baseline, literature shows that a baseline period is necessary both to be aware of typical activity and an accurate representation of usage patterns as a whole. The length of this period must take into account the complexity, operational/usage cycles and weather of the organization, structure, or device in question. For example, water use for an industrial process may be independent of external factors and a short baseline of a few hours or days with spot measurements may be appropriate. In contrast, an organization such as a school that has seasonal effects due to both weather and staffing (school in or out of session) will require a longer baseline (often one year) and plans for adjustment.
The baseline physically exists and can be measured before changes are implemented. Sometimes past data are not available so there is the need to make consumption estimates based on historical data, such as hours of operations for the baseline, equipment manufacturer's published ratings, water bills or simulations.
Baseline documentation should include:

- Identification of the baseline period
- All baseline water consumption and demand data
- All independent variable data coinciding with the water data
- Equipment inventory: nameplate data, location, condition.
- Equipment operating practices (schedules and set points, actual pressures)
- Significant equipment problems or outages during the baseline period

A detailed baseline documentation typically requires well-documented surveys, inspections and/or short-term metering activities. Detailed baselines are appropriate (for example) when large 3rd party investors are involved and the performance change resultant from investments must be accurate.

Water system modelling

The development of a simulation model of the water network is a helpful instrument both for the decision makers and for technicians. For the decision makers it is important to investigate the possibilities to set the pressure of the network at lower level and for which area or district can be set the minimum suitable pressure such that all users in the network have the services needed and in a way that guarantees user satisfaction; and for the technicians it is a helpful instrument to evaluate the consequences of different set points in the water network (e.g. in the case of upgrading the network or of the expansion of the water network).
The New Zealand Water Association has published a detailed approach to the development and use of water distribution models which breaks the task down into a series of components or stages. The staged approach of managing the modelling of water distribution systems can be presented as shown in Figure 9. The process is common for almost any such type of project, regardless of the size of the system and it could be divided into eight characteristic stages, namely:

- Setting up a new modelling project or Re-establishing the existing,
- Data Collection, Model Build (or Model Update)
- Data Verification and Model testing
- Model Calibration and Validation
- Model Use
- Results Interpretation
- Reports and model documentation
- Change monitoring and model management

The following should be noted in the management of the modelling process:

a) The key decision which must be made at the very start of the process is whether or not to use the hydraulic network modelling software as the right tool for providing answers to problems faced in managing water distribution systems.

b) If a hydraulic network model is the right tool, running the water distribution modelling project is an ongoing activity, which needs regular model updating and checking if the existing model is still an adequate tool for providing answers to actual requirements.

c) The process of the management of the modelling process inherently has many loops and feedbacks from previous steps.

d) One of the key characteristics of the process is that these feedbacks make the modelling work an iterative process – not linear as it was traditionally presented.

e) The modelling process should be considered as a process closely linked to other organizational or corporate systems and not as an isolated activity. As such, the model requires strong linkages with transmission data system, water billing and other information management systems.

f) The process requires at various stages, agreements with involved parties, on reached verdicts about the quality of completed work at certain project stages and recommendations prior to commencement of the next stage. Supervision of the project should be continuously run from the beginning of the process.

g) Depending on the size of the distribution systems, models can vary from very simple - with only one water source and a small network, up to very complex systems with multiple sources and sophisticated operating regimes. Although the level of complexity in managing a modelling project varies with the size and complexity of a particular system the principles of the modelling process remain the same.

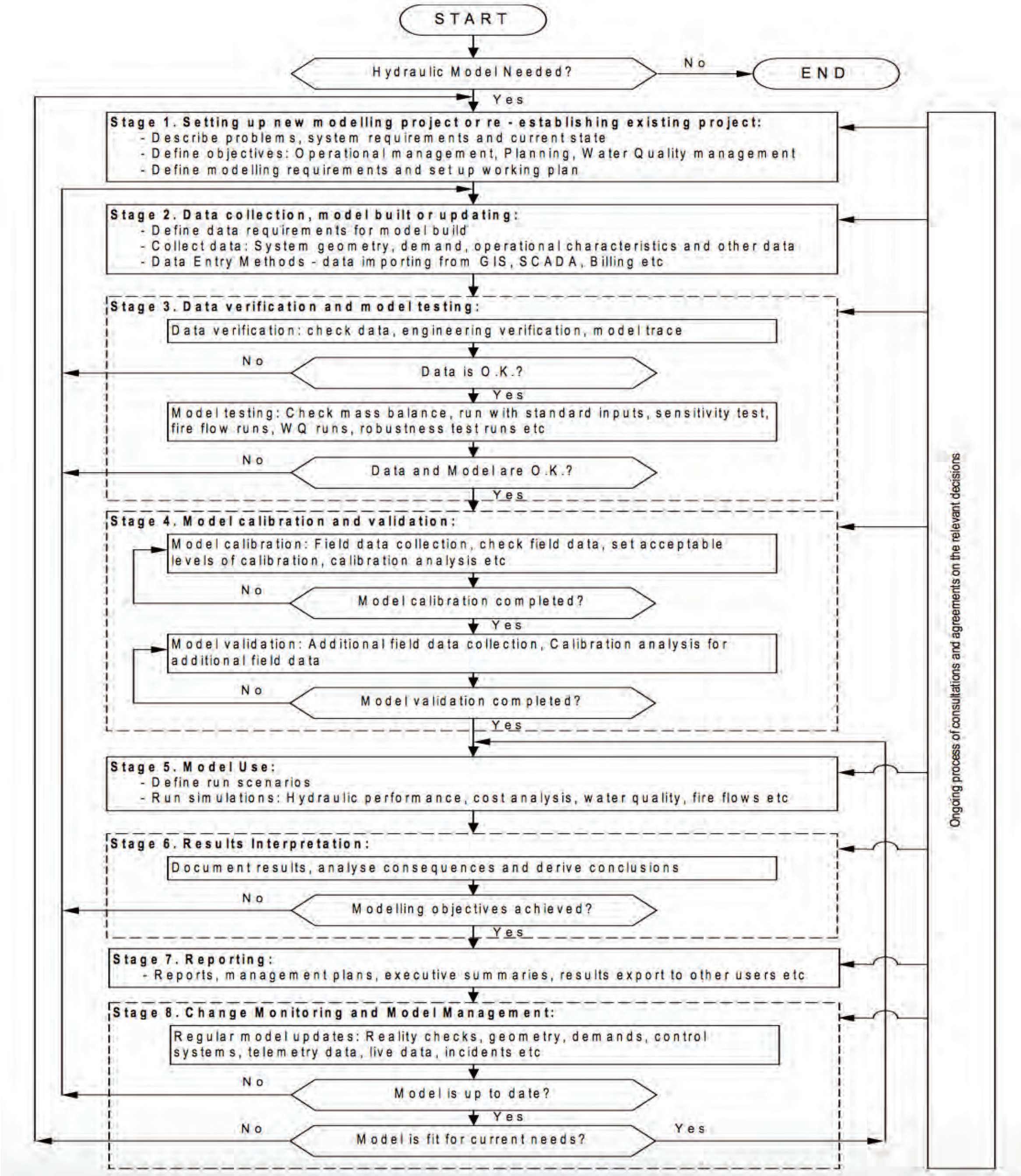


Figure 9. The staged approach of managing the modelling of water distribution systems[1]

Plan metering strategy

The importance of a metering strategy can be taken from relevant standards:

> *ISO 50001: A systematic review and analysis of water consumption forms the basis for an increase in water efficiency. The higher the consumption the more detailed the measurement should be and, consequently, the easier it is to ascertain the savings potential.*
> *IPMVP: Continuous metering provides greater certainty in reported savings and more data*

[1] The New Zeland Water Association – "National modelling guideline – Water distribution network modelling" https://www.waternz.org.nz/Folder?Action=View%20File&Folder_id=91&File=090420ws_draft_modelling_guidelines.pdf (accessed 30 June 2015)

about equipment operation. This information can be used to improve or optimize the operation of the equipment on a real-time basis, thereby improving the benefit of the water saving program. Results from several studies have shown five to fifteen percent annual resource (energy/water) savings can be achieved through careful use of continuous data logging (Claridge et al. 1994, 1996; Haberl et al. 1995).

A metering strategy can be developed to support various objectives. They include:

- Metering to capture the baseline or support system modelling
- Metering to support KPI determination, decision making and operational optimization
- Metering to conduct the verification of Water Efficiency Measures (e.g. given an awareness and training campaign, what was the result?)

With respect to metering, temporary or permanent solutions can be considered. With respect to metering, one meter may support all three objectives or three meters may be needed to cover them.

A data collection and management plan is inherently linked to the metering strategy. Further information related to data collection is provided in Phase 2 as a Data Collection Activity.

Because there is a cost/benefit tradeoff between more information/meters and increased costs, a metering strategy is governed by resource constraints. The metering strategy may also be governed by other constraints: operational, regulatory, feasibility, time. To assist in the specification of minimal data sets to determine the physical measurement framework, Waternomics has developed a method. This method is detailed in Section 3.

With respect to the verification of WEMs, a user may want to consider IPMVP, an international protocal dedicated to this purpose. Indeed it is called the International Performance Measurement & Verification Protocol. Within it, IPMVP outlines 13 steps to construct a Measurement & Verification Plan. Briefly, they are:

1. **WEM Intent:** Describe the WEM, its intended result, and the operational verification procedures that will be used to verify successful implementation of each WEM.
2. **Selected Strategy and Measurement Boundary:** Specify which Strategy will be used to determine savings. Identify the measurement boundary of the savings determination. The boundary may be as narrow as the flow of water through a pipe, or as broad as the total water use of one or more facilities.
3. **Baseline:** Period, Water and Conditions Document the facility's baseline conditions and Water data, within the measurement boundary. A water audit (discussed in the previous "Assess" phase) used for establishing the objectives of a savings program or terms of a Water performance contract usually provides most if not all of the baseline documentation needed in the Plan.
4. **Reporting Period:** Identify the reporting period.
5. **Basis for Adjustment:** Declare the set of conditions to which all water measurements will be adjusted. The conditions may be those of the reporting period or some other set of fixed conditions.
6. **Analysis Procedure:** Specify the exact data analysis procedures, algorithms and assumptions to be used in each savings report. For each mathematical model used, report all of its terms and the range of independent variables over which it is valid.
7. **Water KPIs:** Specify the water KPIs that will be used to value the savings (as before mentioned).
8. **Meter Specifications:** Specify the metering points, technologies, and period(s) if metering is not continuous. For non-utility meters, specify: meter characteristics, meter reading and witnessing protocol, meter commissioning procedure, routine calibration process, and method of dealing with lost data.
9. **Monitoring Responsibilities:** Assign responsibilities for reporting and recording the water data,

independent variables and static factors within the measurement boundary during the reporting period.
10. **Expected Accuracy:** Evaluate the expected accuracy associated with the measurement, data capture, sampling and data analysis.
11. **Budget:** Define the budget and the resources required for the savings determination, both initial setup costs and ongoing costs throughout the reporting period.
12. **Report Format:** Specify how results will be reported and documented.
13. **Quality Assurance:** Specify quality-assurance procedures that will be used for savings reports and any interim steps in preparing the reports.

The results of these 13 steps are provided in a report for approval and use between the involved parties.

Prepare action plan

ISO 50001 states that the **action plan** should include concrete measures (WEMs: Water Efficiency Measures) on how the objectives are to be achieved. For each objective and related work packages, responsibilities must be defined, a deadline established and resources for implementation provided. In addition, one must designate the manner by whichit can be determined whetherthe set objectives and corresponding improvements in water use and consumption have been achieved, as well are what methods were used. The preparation of an action plan is a recommended part of savings determination. Advance planning ensures that all data needed for savings determination will be available after implementation of the savings, within an acceptable budget. Data from the baseline and details of the WEMs may be lost over time. Therefore record them for future reference in case conditions change or WEMs fail. Documentation should be recorded and stored in an accessible mannerand designed to be understood by internal or external verifiers/users as required;data can often be required months or years after an event.

Select technology

The main objective of this step is to carry out a detailed analysis of which technology is most suitable for:

- Capturing the baseline if dedicated / unique measurements are required
- Implementing the action plan or measurement & verification plan (depending on approach selected)
- Implementing the water efficiency measure

Decision making criteria for technology selection may include:

- Price
- Performance, features and/or accuracy
- Warrantee
- Ease of installation
- Local availability
- Trust associated with brand or name

To assist in the specification of technologies, Waternomics has developed a method. This method is detailed in Section 3.

2.2.3 Phase 2 – Do (Implement)

This phase execute previous planning activities and begins the data collection for charting and analysis in the following "CHECK" and "ACT" steps. It consists of the following activities:

1. Meter installation and configuration
2. Efficiency measure implementation
3. Data collection
4. Water information system deployment
5. Staff training

In the following a detailed description of each activity is provided.

Metering installation

Planning processes typically underestimate the time, effort, number required and costs of metering installation. The activity properly consists of implementing the plan but in support of that, the following requirements (or challenges) should be anticipated which may in the end lead to a re-selection of technologies and/or measurement points:

- The requirement for qualified staff or the need to contract installation professionals
- The need to cut or adapt existing pipes or junctures
- The potential for service interruption and subsequent consumer dissatisfaction or commercial disruption
- Accessibility and/or the need to excavate to reach existing pipes or junctures
- Errors or breakages in disrupting existing infrastructure / discovery of problems
- Permissions and potential disruptions to operations
- Challenges associated with data transmission and connectivity
- The requirement to function check, calibrate and verify everything is working properly
- The requirement to fix everything not working properly

Efficiency measure implementation

This activity is the formal start of the water efficiency measures and implementation of the action plan. It delineates the baseline from the reporting period. It begins the process of data collection and data management. It may involve the installation of hardware (infrastructure upgrade), implementation of software (such as the Waternomics Information System), commencement of awareness campaigns or any combination of activities as driven by the selected WEMs in the assessment phase.

Data collection

The objective of this activity is to setup a data collection systems on the facility water network - including data collection scripts, databases, etc. with the aim of gathering and measuring information on variables of interest, in an established systematic fashion that enables one to answer stated research questions, test hypotheses, and evaluate outcomes.
The data that will be collected are the following:

- Water flow
- Water pressure

- Discharged water volume
- Hydromechanical equipment energy consumption
- Operational status and settings of water network infrastructure

It is crucial to ensure accurate and appropriate data collection in the implementation phase because from these data we will understand the real water resource savings obtained. Both the selection of appropriate data collection instruments (existing, modified, or newly developed) and clearly delineated instructions for their correct use reduce the likelihood of errors occurring.
Consequences from improperly collected data include:

- Inability to assess performance accurately
- Inability to validate results
- Compromising decisions

The primary rationale for preserving data integrity is to support the detection of errors in the data collection process, whether they are made intentionally (deliberate falsifications) or not (systematic or random errors). Most et al., (2003)[1], describe 'quality assurance' and 'quality control' as two approaches that can preserve data integrity and ensure the scientific validity of study results. Each approach is implemented at different points in the research timeline (Whitney et al., 1998):

- Quality assurance - activities that take place before data collection begins
- Quality control - activities that take place during and after data collection

Quality Assurance

Since quality assurance precedes data collection, its main focus is 'prevention' (i.e., forestalling problems with data collection). Prevention is the most cost-effective activity to ensure the integrity of data collection. These activities may be demonstrated in a number of ways:

- Identify the timing, methods, and person(s) responsible for collecting data
- Complete listing of items to be collected
- Accurate description of data collection instruments to be used and step-by-step instructions on administering tests
- Identify specific content and strategies for training or retraining staff members responsible for data collection
- Instructions for using, making adjustments to, and calibrating data collection equipment
- Identify a mechanism to document changes in procedures that may evolve over the course of the investigation.

An important component of quality assurance is developing a rigorous and detailed recruitment and training plan. Implicit in training is the need to effectively communicate the value of accurate data collection to trainees (Knatterud, et al, 1998). The training aspect is particularly important to address the potential problem of staff that may unintentionally deviate from the original protocol. This phenomenon, known as 'drift', should be corrected with additional training.

Quality Control

While quality control activities (detection/monitoring and action) occur during and after data collection, the details should be carefully documented in a procedures manual. A clearly defined communication structure is a necessary pre-condition for establishing monitoring systems. There

[1]Most, Craddick, Crawford, Redican, Rhodes, Rukenbrod, and Laws (2003). Dietary quality assurance processes of the DASH-Sodium controlled diet study. Journal of the American Dietetic Association, 103(10): 1339-1346

should not be any uncertainty about the flow of information between principal investigators and staff members following the detection of errors in data collection. A poorly developed communication structure encourages lax monitoring and limits opportunities for detecting errors. Detection or monitoring can take the form of direct staff observation during site visits, conference calls, or regular and frequent reviews of data reports to identify inconsistencies, extreme values or invalid codes.
Examples of data collection problems that require prompt action include:

- Errors in individual data items
- Systematic errors
- Violation of protocol
- Problems with individual staff or site performance
- Fraud or scientific misconduct

To verify data quality, one can perform a comparison between data measured in different periods or with literature. Two additional points to consider are: 1) cross-checks within the data collection process and 2) data quality being as much an observation-level issue as it is a complete data set issue. Thus, data quality should be addressed for each individual measurement, for each individual observation, and for the entire data set.

A comprehensive documentation of the collection process before, during and after the activity is essential to preserving data integrity.

Water information system deployment

Water information systems already exist in the market in various versions and with a wide variety of features[1] such as:WaterSmart[2], TaKaDu[3], etc. , most of them however focus on water utilities and businesses with heavy usage of water such as agriculture and each one is targeted to a particular end-users. In contrast, WATERNOMICS provides an environment customizable and available to a broader set of end users.

Due the different typology of end-users (domestic, corporate, municipal), the functionalities and system deployment needs will also be different. For example, at the household level the Waternomics platform could focus on only overall water consumption to enable simple cost monitoring while at the corporate level a greater level of detail will generally be required (volumes, costs, savings across users or processes, strategy assessment, leak and fault detection, etc).

In customizing the Waternomics Information System to unique end user needs, applications and personas are used. A persona is a way of communicating information from a group of users and it is depicted as a single user but represents a group or community. Personas have numerous benefits and the most frequently mentioned are:

- Increase communication about the target users with the design team and stakeholders
- Creating empathy, goals and motivation when it comes to water efficiency
- Engaging, familiarizing and motivating the end user to use the platform

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[1] C. Kouroupetroglou, J. Van Slooten, S. Smit and D. Perfido, “Waternomics: serving diverge user needs under a single water information platform”, for 36th IAHR world congress (IAHR 2015)
[2] http://www.watersmart.com/
[3] http://www.takadu.com

The personas help both in the design of user specific applications and in the deployment of the system itself.

For Waternomics, personas (emerging from stakeholder interviews) have been created to show general information, motivation, pain points, opportunities and key variables which can be rated from high to low. Personas specific to the project university building pilot are:

- Communication manager
- Environmental manager
- Operational manager
- Students

Figure 10 shows the student persona as an example.

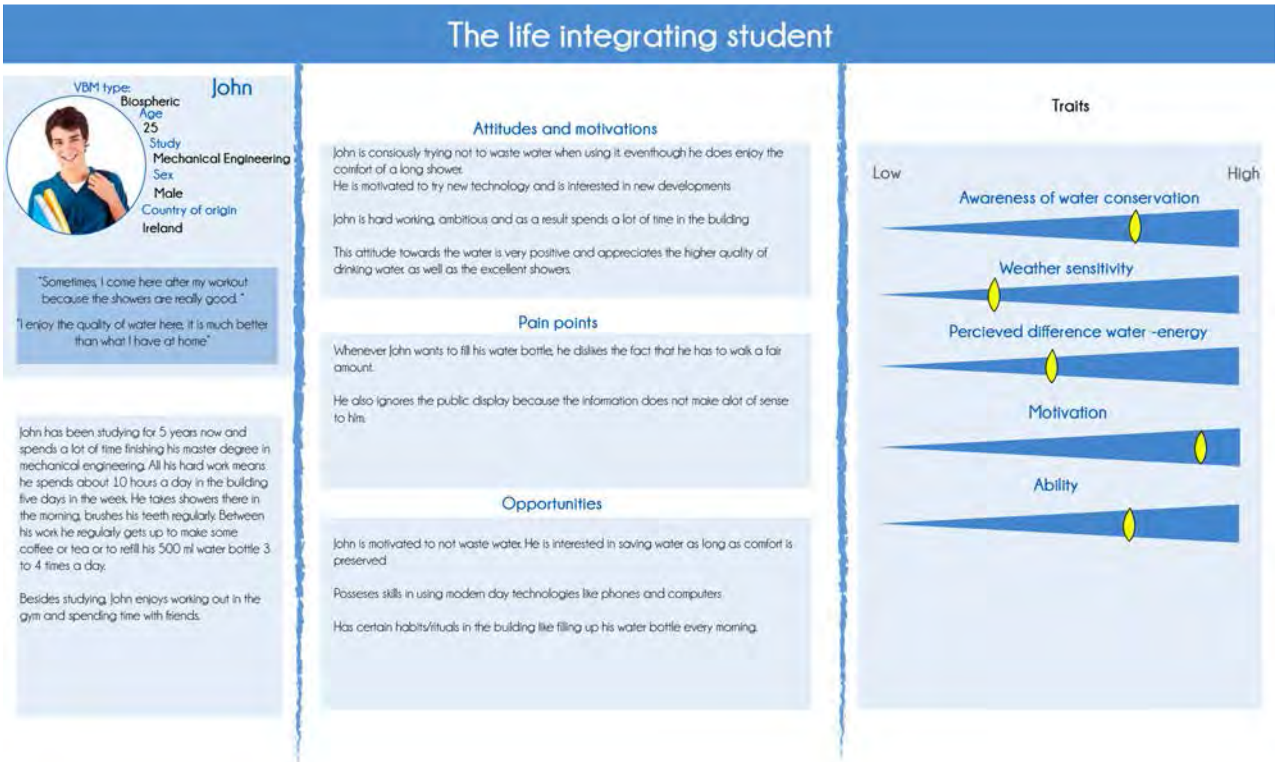


Figure 10: Design Personas – The student

Through these personas and customized applications, the Waternomics information system will help water users implement 'smarter' water management programs, conduct data analysis of consumption, leak detection and repair and most importantly facilitate communication among stakeholders to raise awareness of source exploitation.

Staff training

In addition to personas and training within the tool itself, staff training should be deliberately organized and scheduled with each type of stakeholder and end user so that WIS and overall water efficiency strategy can have maximum impact. This training should ensure that all relevant personnel receive training for the types of activities or responsibilities they must carry out. It should include the general concept of water management as well as skills training (usually on-the-job) to

allow personnel to carry out their tasks with an awareness of the impact their activities can have on the water performance. Examples are provided in Table 3.

Table 3: Examples of Types of Training and their Targets

Type of Training	Targets
WEMs awareness	- all employees
WEMs implementation training	- Middle Management - Management Representative - Water Management Team
Water Information System training	- System users

2.2.4 Phase 3 – Check

According to ISO 50001, an important aspect of management is the process of continuous improvement. In order to ensure this, regular checks are required to ensure all water objectives and targets set in the Assess and Plan phases have been achieved. Checks should also ensure that the Water Efficiency Measures (WEMs) are functioning optimally. If necessary, corrective measures can be undertaken.

By frequently and regularly comparing the expected and actual water consumption, it is possible to quickly detect inefficient use of water or problems in the network. Indeed, fault detection and diagnosis rules and algorithm are a part of Waternomics research objectives. In the IPMVP this phase is named "Operational Verification" and its aim is to check that the WEMs are installed and operating properly and have the potential to generate savings. Operational verification may involve inspections, functional performance testing, and/or data trending with analysis. IPMVP includes both operational verification and an accounting of savings based on site water measurements before and after implementation of a project, and adjustments.

The activities of the Check Phase are:

1. Data Analysis
2. Programanalysis
3. Assess performance
4. Find and fix
5. Document progress

These activities are detailed as follows:

Data Analysis

According to ISO 50001 it is possible to detect inefficient water consumption promptly if there is a frequent and regular comparison between the expected and actual water consumption. In any case, the areas of significant water use and the relevant factors for water consumption must be monitored. The typical time period depends on the type and size of the organization and individual

facilities. Measurements can be made as real-time measurements, or be carried out in monthly or even less frequentintervals.

Research activities in Waternomics include data analysis in the form of leak detection and fault detection and diagnosis. Leak detection is being conducted through sound measurements. Fault detection and diagnosis is being conducted through rule bases and analytical methods. Examples of faults that may be detected in such ways (in if so lead to water savings) include network operation at sub-optimal pressures, a stuck toilet or faucet, or a sudden leak which creates an abnormal data signature. A Waternomics objective is to make such features part of the Waternomics information system.

Program Analysis

The intent of the program analysis activity is to determine if all previous actions are complete and functional. It is a management tool and can be conducted in the form of a report (internal audit), status table, checklist or dashboard. In the Waternomics Information System, this activity is to be made into an operational dashboard that shows the status of KPIs and actions of interest in real time. Its aim is to further develop the functionality of the WEMs, water management program, objectives / targets and to help develop new measures for optimizing the Water management. As such, it is intended not only as a control measure but as an opportunity to further improve stakeholders awareness regarding water problems. In this regard, a program analysis may also contain a description of follow-up activities, monitoring and measurement of results, as well as a description of responsibilities.

Assess performance

The assess performance activity is the execution of the calculation methods and adjustments established in the measurement & verification plan from the Plan Phase plus the determination of performance related to any KPIs or objectives not part of these calculations. In the case where a water information system is used and the overall program is simple, this activity may be fully automated. In other cases, a combination of automated and manual calculations will be required.

Appropriate procedures should be in place to ensure the reliability of the data through the testing of equipment, calibration and sampling. Evaluation of actual versus expected water consumption as well as reviewing its measurement needs shall be carried out. The organization shall also investigate and respond to significant deviations in water performance. These can be easily addressed through periodic meetings of the Water Management Team or other working groups. Such checks are in line with ISO 50001 which states that organizations should establish a program to evaluate periodically on its WEMs implementation and check the effectiveness of the system in fulfilling their energy policy.

The frequency of the assessment activity must be clear and agreed as part of program design.

Find and Fix

A fundamental principle of the ISO 50001 standard is that organizations are capable of identifying and fixing the problems, as well as taking actions to eliminate the cause of the problem. According to the standard, corrective action refers to action to eliminate the cause of a detected nonconformity that in a water network can be associated with Faults detection and leaks detection. The ability to detect faults will bring added value to water management systems by increasing awareness of the role of system faults in (1) increasing costs and (2) causing meter problems at the consumer level and (3) contributing to higher water consumption rates. Examples of faults could include two similar pumps consuming different amounts of energy or providing different pressure outputs,

projected violation of consumption targets, using water during “peak hours”, unexpected pressures, unexpected consumptions, problems with water quality and so on. The reasons for faults can include equipment over or under dimensioning, equipment malfunction, pipe blockages, leaks, contaminants, behavioural errors, procedural errors, etc. Detecting faults at the earliest possible stage can lead to maintenance, repairs, savings well beyond those associated with only water savings as well as taking actions to eliminate the cause of the problems.

Document progress

This activity is the documentation and internal communication of of program status to the management and staff involved or impacted by the water efficiency program. Its role is to present outcomes, explain deviations and non-conformity and to identify possible improvement measures. It also facilitates users awareness about both the targets achieved and the deviations registered to avoid the problems and decide corrective actions. In establishing internal communication procedures, one must plan for horizontal and vertical communication links throughout the organization and by what means information is sent and at what frequency. The communication procedures should also cover the process of how to capture and/or incorporate suggestions by staff and/or contractors working for the organization. Methods for communication include, for example: meetings, teleconferences, briefings, e-mails, posters, memos, etc.

2.2.5 Phase 4 – Act

The Act Phase is a systematic leader level review of the program to determine if it is meeting its objectives, if all or some parts can be concluded, or if adjustments to existing objectives or new objectives are required. If it is the case that the objectives of the WEMs are not fulfilled, then one must put in place corrective actions.

The activities of this phase are:

1. Institutionalize changes
2. Close appropriate water efficiency measures
3. Evaluate and adjust strategy
4. Communicate progress
5. Determine next actions

In the following a detailed explanation of each stages of the “Act” phase is provided.

Institutionalize changes

For successful WEMs that have met their objectives, this activity may consist of two actions:

- To make policy changes that make actionable points of the WEM permanent
- To replicate WEMs that might have taken place on a trial scale or within a localized area of an organization to the organization at large

For WEMs that have not met their objectives, they are treated within the “Evaluate and Adjust Strategy” activity that follows.
This activity (Institutionalize Changes) is supported by decision making and both internal and external communication activities.

Close appropriate Water Efficiency Measures

Holistically, the methodology is an iterative process that makes water efficiency improvements. In doing so, actions must close so that results can be communicated, leader support can be maintained and new actions can be opened. This activity is the leader level decision that a WEM has met its objectives and can close – "mission complete." At the time of doing so, organizations will benefit from capturing and documenting the facts and results associated with the WEM so they can become part of an organization's knowledge repository and be used for internal and external communications.

Evaluate and adjust strategy

For WEMs that do not close, the "Act" phase implemented corrective actions and/or adjusts strategy to realign the WEMs to the expected targets. At a broader level, in this activity, leaders evaluate the program strategy at large established in the "Assess" phase when initiating the program.

- Did we meet our goals and objectives?
- Do we want to continue the program and its iterative PDCA loop?
- Do we need any adjustments to our targets, objectives and strategy?
- What new WEMs will the organization consider, if any?

The answers to these questions and decisions taken in this activity lead to the next iterative Plan Phase and the loop continues.

Communicate progress

Benefits of the implementation of a water management program include environmental stewardship, sustainable image and resource savings (water, energy, CO_2 from energy avoidance, and money). To fully realize these benefits, they must be communicated both internally and externally to targeted individuals and in some cases to the public at large. For external communication the organization should maintain a documented decision on whether it will communicate its water policy, WEMs and water performance. In communicating this information externally, the following aspects can be considered:

- Type and level of information to be communicated
- Targets of communication
- Mechanisms and responsible parties to handle and respond to enquiries
- Official response time
- Recording system and format of communication and the associated correspondence.

Determine next actions

This activity translates the decisions and adjustments from the "evaluate and adjust strategy" activity to actionable items. In the case of new WEMs, it can look back to the "Initiate Water Efficiency Actions" activity of the Assess Phase. In the case of adjustments to strategy, it can look back to the "Define Water Efficiency Strategy" activity of the Assess Phase. In this way, the program is ready to enter a new PDCA cycle where an organization is constantly reviewing and revising the system in a continuous improvement loop.

2.3 Validation Approach

The effectiveness and efficiency of the Waternomics methodology is assessed both qualitatively and quantitatively in the project in the following way.

- Development: Throughout its development, meetings and interviews with end users and targeted stakeholder profiles have been used to both aid development and to validate the usefulness of the concepts coming into place.
- Coding into the Water Information System: An additional level of scrutiny is provided when one has to transform from paper (this report) into an interactive software environment. This is forcing the methodology team to think additionally of "how" to bring the methodology concepts to end users in a term internally being called "methodologization."
- Use case and exploitation scenarios: D1.1 (Usage Case and Exploitation Scenarios) is a public deliverable that details a series of examples (use cases) that bring project core concepts to life for end users in an engaging way. These examples are being connected also to the methodology and two are provided immediately following these bullets*
- Pilots Implementation: Waternomics has four pilots across three targeted stakeholder groups (domestic, corporate, municipal). These real-world pilots provide a unique and excellent opportunity to assess the methodology and impact of project results.
- Methodology Revision: Lessons learned from all project activities (and especially the pilots) will be reflected back into the methodology for a second updated version at project conclusion.
- Scientific Validation: A peer-reviewed publication is planned to introduce the methodology to the scientific community and to receive independent expert feedback.
- PAB Validation: The project has a project advisory board (PAB) consisting of external experts and organizations that provide feedback on project results. The methodology will be shared with the PAB and their opinion solicited.
- Methodology Replication: The methodology will pass an initial validation if it is use is continued and expanded at the pilot activities. After the first cycle of the methodology (in the project), this would take the form of the decision makers at the pilots completing the act phase, adjusting strategy and selecting a new round of efficiency measures to be conducted after the project, thus continuing the PDCA cycle.

** Two use case examples that link project use cases to the project methodology*

Example 1: Using WATERNOMICS methodology in a household situation

Situation: Mary and John are married and have two children. They own a house with a garden in a small village in southern Europe and both are concerned with the environment.

Phase 0 - Assess: Mary and John are discussing on how they could decrease their environmental footprint. They compare their energy and water usage with households that have similar characteristics. Because they installed solar panels last year, their energy consumption is below average but their water usage is still a bit high. Looking at their night-time water usage it is not likely that they suffer from leakages so they decide to purchase a rainwater harvesting system. Their goal is to reduce their drinking water consumption with 15%.

Phase 1 - Plan: Mary is creating an overview of available rainwater harvesting solutions. They can opt for an underground storage with large capacity or they can decide to connect a barrel to the drains from the roof. Since they plan to use rainwater for the garden and the toilets, they decide to go for a 5000 litre underground silo. Mary requests some proposals from construction companies and selects one that has a fair price and good service.

Phase 2 – Do: The construction workers place the reservoir and connect the pipes and pumps to the drains and the toilet. A smart meter is placed at the entry and the exit of the rainwater reservoir so Mary and John can still track their total water usage.

Phase 3 - Check: In the months after the reservoir has been installed, Mary and John check their water usage. Despite the fact that is summer time, and it did not rain very much, their drinking water consumption is reduced with 12%. The expectation is that annually they will save up to 20% of drinking water.

Phase 4 - Act: With the rainwater harvesting system in place, the house of Mary and John improves the rating of their house's sustainability label from rating B to rating A. Mary is already thinking about how they can improve their environmental footprint even more.

Example 2: Using WATERNOMICS methodology in a corporate environment

Situation: ABC Company is an established furniture company, producing wooden furniture for over 50 years and selling their products worldwide. They have one production plant with offices for the commercial departments located near a medium sized city in the northern part of Europe.

Phase 0 – Assess: During a regular strategy meeting, the managing director and the environmental manager decided that it was time to review their sustainability strategy. They both noticed an increased interest of their customers about the ecological footprint of their products and up until now they hadn't reported about their use of energy, water or carbon footprint. The results from an assessment showed them that there where gaps in their information on water consumption. Although the more recently build offices where all equipped with fine grained meters for water, the water distribution network in the older part of the factory was never recorded properly. Without this information it would be very difficult to identify areas for improvement, so they decided to start an action to install baseline metering throughout all facilities. Their goal was to have metering in place for water usage on department and production process level and to make the first step in reaching ISO14046 compliancy.

Phase 1 – Plan: The project manager who was assigned to lead this project, started with mapping the locations which lacked proper metering or descriptions of the water distribution network. Based on the baseline information a plan was made that included a metering strategy, technical architecture and cost overview. Third parties where invited to make a proposal for the installation of the sensors and meters and the configuration of the information systems.

Phase 2 – Do: Third parties installed the meters and a technology provider installed the information system and management dashboard. During the whole process, staff from the factory was closely involved in the implementation process.

Phase 3 – Check: During the 3 month pilot phase, the complete system was tested and the collected water usage data was checked against historic data. Results of the pilot where communicated back to the factory workers and already after 2 months a decrease of water consumption was measurable.

Phase 4 – Act: After the pilot phase, the project has reached it goals and was considered successful. The new information about water usage and performance was included in the regular reporting structure of the company and new KPI's on water management where set. An ISO14046 (water footprint) assessment showed that the company had not fully met its objectives but had made significant progress. Based on the results of the assessment and the analysis of water consumption, recommendations for a follow up actions and new efficiency measures were made.

3 The Waternomics Methods

A methodology assembles methods (how to do something) in a systematic and rational approach or framework. This section details six methods uniquely developed by the Waternomics project as part of methodology development and its initial implementation in the early stages of pilot activities. The methods deal with how to best implement the methodology or how we can bring the knowledge attained in developing the methodology to the users of the Water Information System and in particular of the Waternomics Platform. Figure 11 shows a mapping of the six methods to the Waternomics methodology. One method (Visualization & Management) applies to the entire framework and the others support the implementation of individual activities.

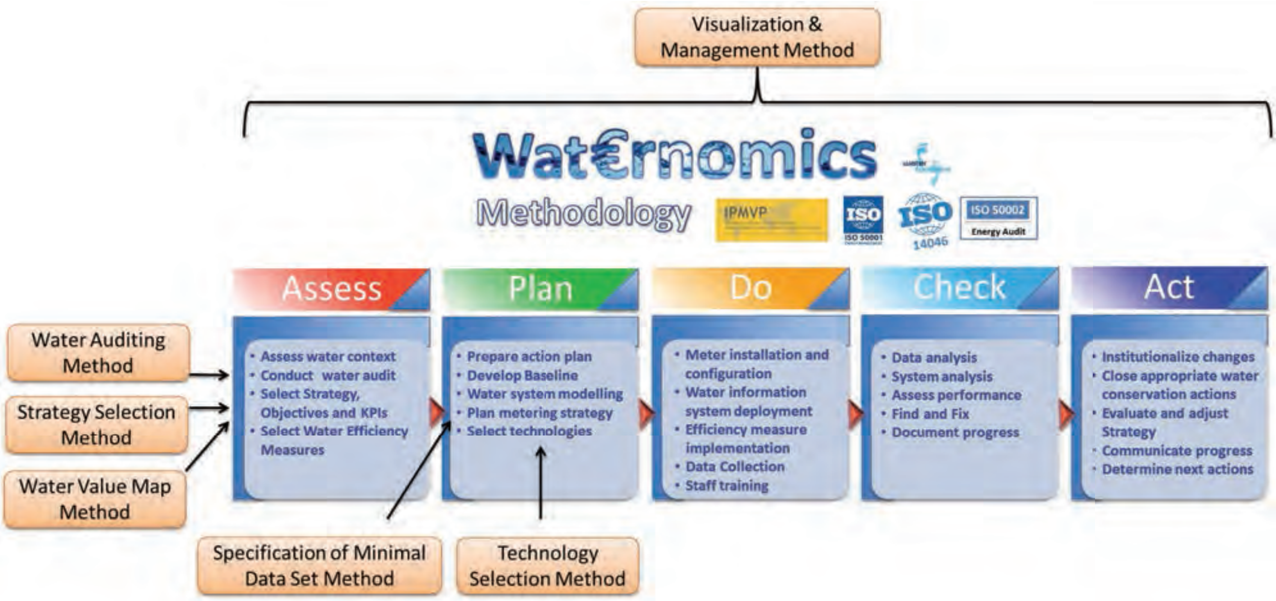


Figure 11: How Waternomics methods match the Methodology phases

The figure provides an indication of where project activities have focused to date. As the project matures and the pilots are implemented, it is likely that new methods will be developed and these will be reflected in the final version of the methodology (Deliverable D6.2).

3.1 WATERNOMICS Methodology Visualization Method

In organizing Waternomics pilot activities, the group adopted TRELLO, an open source project management platform. This environment was trialled, adapted to the Waternomics methodology, and has proven an excellent resource. It provides an intuitive graphical visualization and scheduling tool used to sequence project activities and assign dates and resources to them. Instead of email, users can post information, status, comments, requests for information all on the same "board."

Figure 12 shows the "homepage" for the Waternomics Methodology "Trello Board" for the NUIG pilot activity. The screen is split up into five columns corresponding to the Waternomics methodology phases and activities within them. A sixth column captures associated research tasks and activities of interest to the working group. This (blank) template will be made available to users of the Water Information System. Embedded within it is a concise version of Section 2 (e.g. description of the methodology through its phases and activities). Clicking on a phase or activity, opens a description of that phase or activity, the status of the activity and previous discussions/documents related to that field.

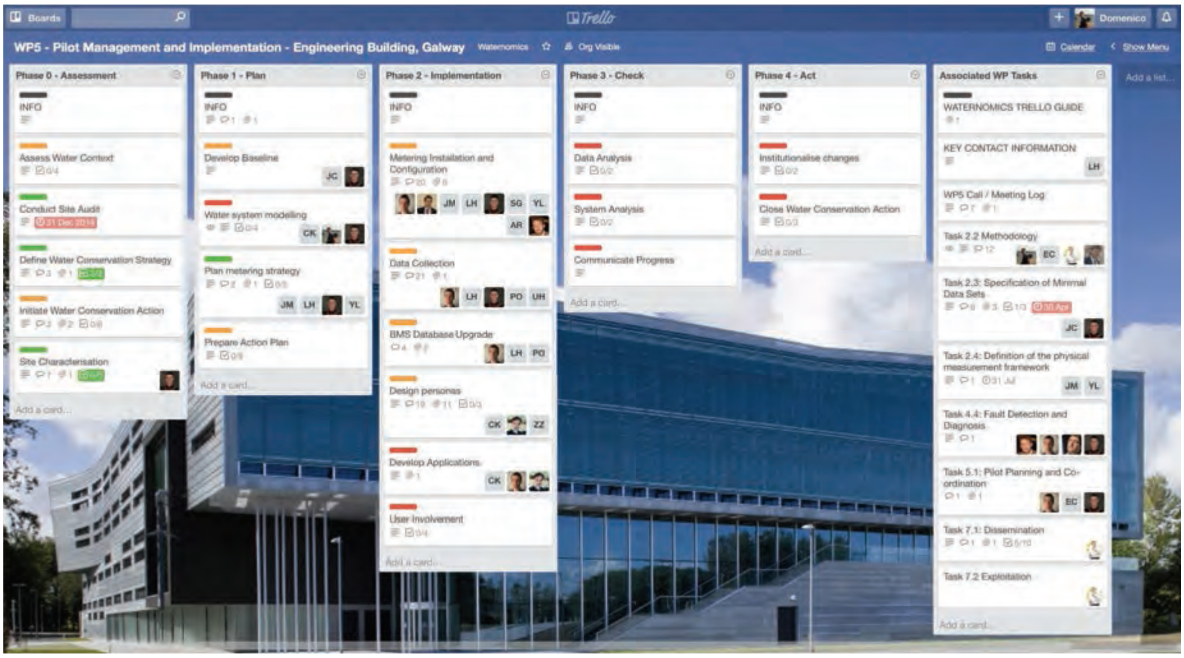


Figure 12: The main user interface of Trello Board

Through use of the Waternomics Methodology TRELLO Board, an organization can better ensure that a water management program is performed in a consistent way and have relevant information captured and communicated all in one place.

3.2 WATERNOMICS Auditing Method

Waternomics draws strongly from AFNOR BP X30-120 (Energy Diagnosis in Industry). The norm is further described in Section4 and was developed over time through an iterative national energy auditing initiative for French industrials. This norm has since been a base reference for the international energy auditing standards used today.

Features that make AFNOR BP X30-120 an excellent reference and starting point for a Waternomics method are that it provides guidelines for various audit intensities (simple vs. detailed). It provides guidance in sufficient detail to be useful, and it goes beyond data aggregation to specifically target diagnosis which entails the determination of the causes of problem as well as potential solutions. These features are appropriate since Waternomics targets stakeholders with spatial scales of greatly different magnitudes: household, municipality and corporate supply and water resource systems that integrate several uses of water. For example, for the household level a simple water audit may be most appropriate whereas for a large corporation, a detailed audit is likely the best choice. Varying levels of audit intensity may also be progressive in time as an organization or end user determines the need to increase the knowledge and precision associated with a previous audit and this could align with the Assess and Plan phases in Waternomics. The accompanying tables show the goals, actions and report characteristics of the three stages of audit and diagnosis work adapted from AFNOR BPX30-120 for use in Waternomics:

Stage 1: Preliminary Study

Goals	• To collect relevant information • To conduct a preliminary assessment of the water situation • To identify water savings potential
Actions	• Preparation with the stakeholders (communication of the information) • Information gathering of the site (visit, meetings, interview) • Analysis of data and drafting of the preliminary analysis report • Delivery of the preliminary analysis
Report characteristics	• First analysis of the water situation • The identification and justification of savings sources • A description of basic actions to be implemented • A description of the detailed analysis to be continued in stage 2 • The suggestion of a monitoring plan for water consumption and savings

Stage 2: Detailed Analysis & Measurement Campaigns

Goals	• To extend the analysis of the main savings identified in the first phase and chosen with the stakeholders • To establish the real water needs of the established process(es) • To include measurement campaigns • To consolidate the sites global water situation
Actions	• To work on the basis of the water needs issued resultant of the measurement campaign • To compare with ratios, performances • To describe water savings sources • To research malfunctions and their causes (management, maintenance, sizing of equipment, technological choices)

Stage 3: Searching for Improvements Solutions

Goals	• To specify the actions to make water savings • To identify and describe the solutions • To provide an estimate of the implementation cost and payback period
Organization/ Classification of Solutions	• Behavioural best practices related to raising awareness, training and increased knowledge of the facility based on monitoring of the operations • Operational best practices related to maintenance and operating optimization, replacement or installation of low cost measures • Measures requiring high cost investments such as modifications of the process, replacement of machines/equipment, ...etc
Final Reporting	• The file for each solution and for combined actions • The main comparison criteria between the solutions • A preferred plan for the implementation of actions, undertaking of feasibility studies • The main results: water situation, proposition of an water management system, etc.

Figure 13 conveys these principles in a more concise manner for use in Waternomics.

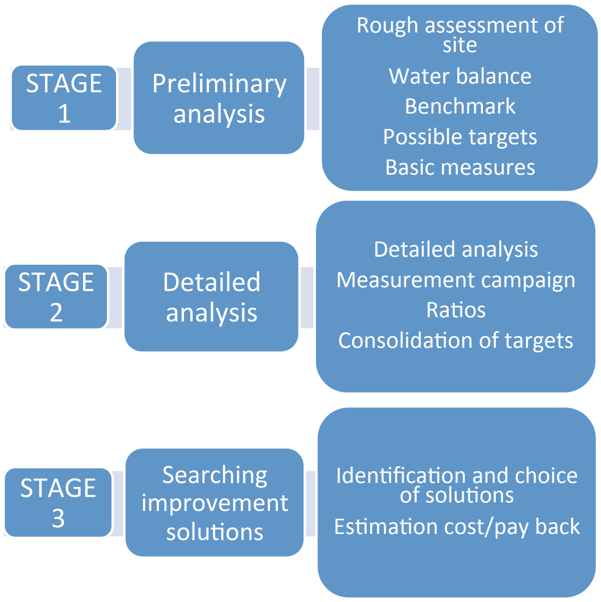


Figure 13: The three stages of Water audit / diagnosis in Waternomics[1]

3.3 WATERNOMICS Strategy Selection Tool

Different business environments and goals require different strategies for implementing a water management program and corresponding information system. Each strategy has its advantages and disadvantages and selecting the right strategy determines largely the efficiency and impact of the change process. This is comparable (or constitutes) a cultural change in the organization.

Table 4 shows an overview of various strategies for achieving cultural change in an organisation.

Table 4: Approaches for cultural change in organisations (Boonstra 2013)

Power strategy	Planned Strategy	Negotiating Strategy	Development Strategy	Learning Strategy	Transformational Strategy
- Forcing - Goal oriented - Position power - Input controllers - Linear process - Pressure - Telling and selling	- Pushing - Solution oriented - Expert power - Input experts - Linear process - Rational persuasion - Convincing	- Exchanging - Result oriented - Position power - Different coalitions - Iterative process - Negotiation - Compromising	- Developing - Problem oriented - Informal power - Input employees - Iterative process - Participation - Guiding and - coaching	- Learning - Transition oriented - Seductive power - Input learning teams - Cyclic process - Action learning - Facilitation	- Discovering - Future oriented - Visioning power - Collaboration - Cyclic process - Dialoguing - Mutual interaction

[1] Figure adapted from: adapted from AFNOR BPX30-120

For Waternomics we consider the six change strategies from Boonstra who are defined as follows (Boonstra 2013):
"Power Strategy: Based on the idea that people only will change under external pressure, leaders create a sense of urgency. Conflicts and resistance to change are unavoidable and have to be overcome through the use of power. Desired behaviour is rewarded and behaviour that is not appropriate to the new standards is punished.
Planned Strategy: Leaders try to predict future developments and anticipate them. The assumption is that people always choose the most logical solution. Experts and leaders analyse the problem and develop a solution and convince people that their solution is the right one.
Negotiating Strategy: Brings together parties with different interests who need each other to realise their wishes. The idea is that people focus mainly on their own interest but that they take others into consideration if there is a need to collaborate. Personal interest motivates people to change if that serves their own interests. This strategy is about making force fields visible, articulating one ' s own advantage and exchanging interests.
Development Strategy: In this participative change approach, the initiators listen to the people who are involved in the change and use their advice. The problem-solving capabilities of the people involved are appealed to in the change process. Changes are realized gradually and step by step, and people are involved in all phases of the change.
Learning Strategy: The idea behind the learning strategy is that people act on the basis of assumptions, emotions, feelings and almost unconscious patterns. Making people aware of these assumptions and patterns and making it possible to discuss the feelings create space for learning processes in which people change their behaviour. The underlying idea is that learning takes place in a cyclical process in which concrete experiences are followed by reflective observation of these experiences. These reflections are then analysed and incorporated in new concepts and frames of reality. It is about mental clearing of limiting beliefs and the creation of new images of reality.
Transformational Strategy: The idea behind this strategy is that reality is not objective but is anchored in the minds and hearts of people. These subjective images and definitions of reality change continuously through interaction and sense-making. If this view of reality is linked with a future ideal, energy is created and people get moving. Interacting, acting, reflecting and learning are inseparable during the change process. Meanings and basic assumptions become visible and joint alternative actions are initiated which lead to a process of discovering new futures and destinies."
Another classification (Table 5) of change strategies comes from Bennis, Benne and Chin 1969 who identified three basic change strategies.

Table 5: Classification of change strategies (Bennis, Benne and Chin)

Strategy	Description
Empirical-Rational (Rational)	People are rational and will follow their self-interest — once it is revealed to them. Change is based on the communication of information and the proffering of incentives.
Normative-Reeducative (Social)	People are social beings and will adhere to cultural norms and values. Change is based on redefining and reinterpreting existing norms and values, and developing commitments to new ones.
Power-Coercive (Compliant)	People are basically compliant and will generally do what they are told or can be made to do. Change is based on the exercise of authority and the imposition of sanctions.

To determine which strategy is most suitable for an organisation, three aspects of an organisation can be considered: Culture, Goals and Maturity.

Figure 14: Three aspects for consideration in strategy selection

Culture: The organisational or national culture defines how well an organisation or country can cope with change and new working methods.
Goals: The water and energy related business goals of an organisation or household. The goals reflect the ambition level. Examples of water related goals are compliancy with regulation, reduction of water consumption by 10% etc.
Maturity: The maturity of the organisation is looked at in terms of environmental policies, water information systems and education.

Corporate culture is considered as having the highest impact on the efficiency of a change process. Top-down strategies are less efficient in an environment where people are used to work in close collaboration (overleg). The other way around, using a transformational strategy in an environment where people are not used to give their opinion or share their ideas is also counter-productive. Therefore, the organisational culture determines if a more top-down strategy is more efficient or that a more collaborative strategy is to be used.
Second, the goals of the organisation show the ambition level of the organisation and determine the complexity and scope of the change. The more complex the change the more a strategy must be able to address uncertainty in the organisation. When low ambitious goals are set, a more straightforward approach can be selected.
Finally, the maturity of the existing water information system in the organisation has an impact on the strategy to be selected. When an organisation has no information system in place it is expected that it can achieve its goals with standard available techniques, measures and actions.

3.3.1 Culture

For selecting the right strategy for a given situation, information about the culture of the environment where the water information system has to be deployed, is necessary. For this, we use Hofstedes cultural dimensions.

Individualistic / Collectivistic	How personal needs and goals are prioritised vs. the needs and goals of the group/clan/organisation
Masculine / Feminine	Masculine societies have different rules for men and woman, less so in feminine cultures
Uncertainty Avoidance	How comfortable are people with changing the way they work or live (low UA) or prefer the known systems (high UA)

Power Distance	The degree people are comfortable with influencing upwards. Accept of inequality in distribution on power in society.
Time Perspective	Long-term perspective, planning for future, perseverance values vs. short time past and present oriented.
Indulgence / Restraint	Allowing gratification of basic drives related to enjoying life and having fun vs. regulating it through strict social norms.

Table 6 - Hofstede's Cultural Dimensions[1]

Hofstede's cultural dimensions are designed for comparing cultures between nations. The dimensions cannot be used to compare cultures between organisations because the correlation is too weak but we can use this framework to get an idea of the culture in an organisation or region.

3.3.2 Goals/Ambition

Hypothesis: if the goals are not that high, planned strategy is sufficient. If the goals are very ambitious, a more learning oriented strategy is required to deal with all of the uncertainties.
Factors to consider: Clearness of the goals, agreement about these goals, level of ambition of the goals.
Change can happen at different levels, from individual level to the level of an ecosystem. Understanding the levels of impact of the foreseen change is needed for the section of the appropriate strategy, measures and interventions. Different types and degrees of change levels exist.
Dongen describes three levels of change:

1. Improvement (first order): Changes within a known setting, improving what already is.
2. Transition (second order): Move from a known situation to another known situation.
3. Transformation (third order): Move from a known situation to a new, unknown situation.

Another classification for levels of change is looking at the scope of the impact of the change:

1. Individual
2. Team
3. Organisation
4. System or Environment

Other factors that have impact on the ambition level of the

- Complexity of the existing infrastructure
- Use or development of new non-proven technologies

3.3.3 Maturity

Hypothesis: Without a basic water management system an organisation can do with standard off the shelves solutions and a linear, planned strategy whereas organisations with a mature and sophisticated water management system have a need for a learning strategy.
The types of organization/maturity can be described as below in the table or as the typical growth, maturity and renewal, plus decline (even though in water utilities difficult since there is in some form or another always a market).

[1] Hofstede G. (1984), Cultural dimensions in management and planning, Asia Pacific journal of management

Table 7: Matrix for organization/maturity description

	Budget dependency	Shareholders /ownership	Biophysical reality	Regulation	Individuals /Staffing	Market/ Portfolio
Other interests are priority						
Low coverage						
Ok coverage						
100% coverage						

3.4 WATERNOMICS Water value map

A water value map can be a useful tool in the construct of a water management program, the selection of objectives, strategy and KPIs. It assists by providing by households and organizations to get an overview of water costs and benefits, to investigate measures for reducing water consumption and to identify knowledge gaps in water usage.

The starting point for developing any water conservation strategy should be a shared understanding of water usage and water related activities. Before starting one should ask itself three basic questions:

1. Why do I use water?
2. Where does my water come from?
3. Where does my water go to?

Based on the answers of these questions, one can determine which area to focus on when to start taking Water Efficiency Measures. The Water Value Map helps addressing these questions and helps with keeping an overview of all Water Efficiency Measures and their relations. By providing easy to understand symbols and terminology, people with different backgrounds and knowledge levels, can quickly start discussing water related issues and exchanging knowledge, without being hindered by lingual obstacles.

The Water Value Map consists of ten building blocks divided over three different functional areas, being Water Intake, Water Usage and Water Disposal as shown in Figure 15.

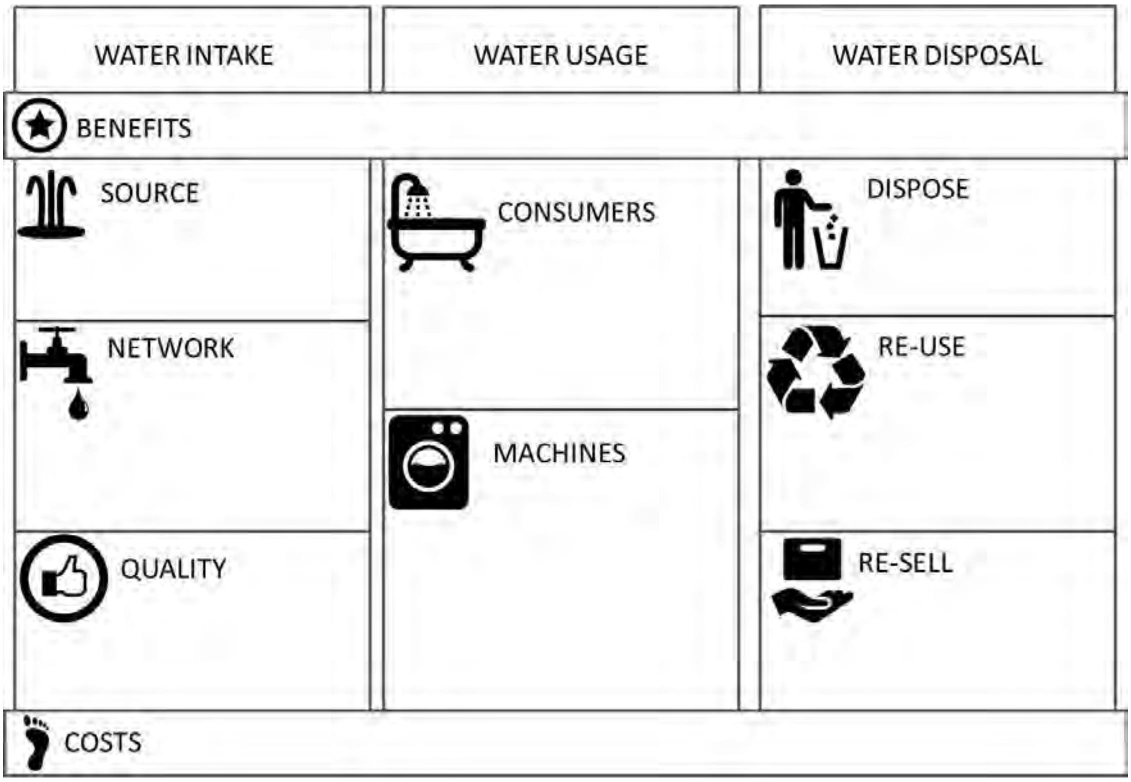


Figure 15- Water Value Map

The ten building blocks are:

Benefits	Direct and indirect benefits from water usage or trade
Source	The origin of the water used
Network	The infrastructure, pumps and pipes, needed to move the water from the source to its point of use.
Quality	The required and perceived quality of the incoming water
Consumers	All people that use water
Machines	All water using machines.
Costs	The cost structure for acquiring, using and disposing water

	**Dispose**	Wastewater that is being disposed and is of no value to anyone
	**Re-use**	Wastewater that can be used for other applications within the household or organisation
	**Re-sell**	Wastewater that is still of value for external parties

3.5 WATERNOMICS Specification of the minimal data set Method

Information has both a cost (sensor, installation, operation, maintenance) and benefit (ability to act on that information). As such, a method to find an optimal (or reasonable) balance between cost and benefit and its relation to monitoring of water networks is a vital part of the Waternomics Project and methodology. With this method, given usage and exploitation scenarios, physical space, functional purpose, systems, subsystems, and critical devices it seeks to determine the cost benefit ratios that drive minimal data sets that enable the characterization of explicit relationships between user operation, equipment performance and performance indicator. This element of work builds on the identification and assessment of KPIs that were presented as part of the Deliverable D1.3, System Architecture and KPIs, and in particular the top KPIs included in Appendix B of the report.

The approach for this work is a dedicated task in the work program (Task 2.3). Figure 16 presents a flow diagram for the approach.

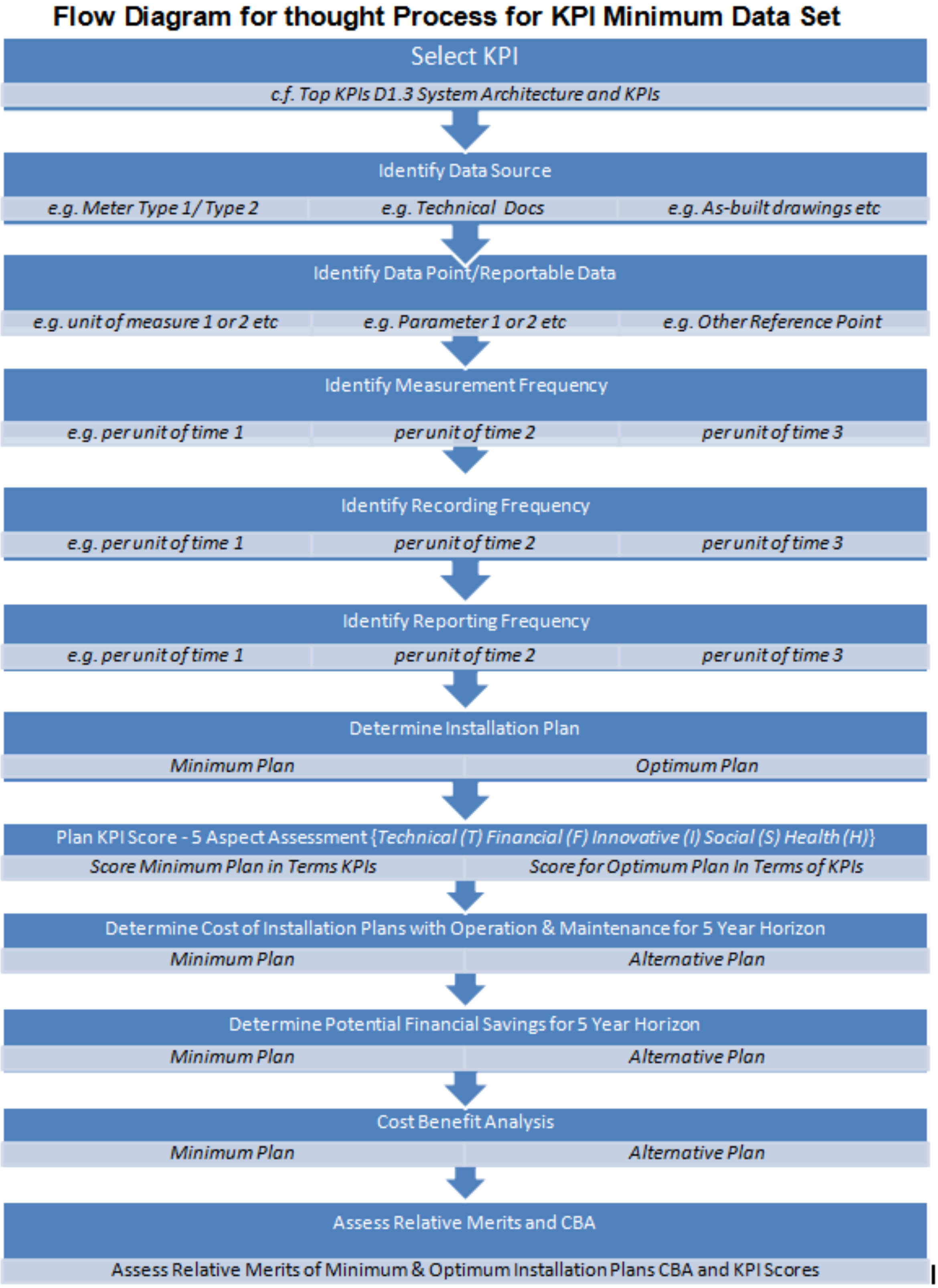


Figure 16: Flow diagram methodology used to set the pilots minimal data

The steps of the flow diagram have been implemented in an excel worksheet. In the following, figures are utilized to highlight certain aspects of the spreadsheet.

KPI Ref.	KPI	Key Stakeholder	KPI Description / Usage
	Enter KPI Name	Select from Dropdown	Enter Short Description of KPI
1	Retention Rate	Operational Management	The length of time a m^3 of water stays within the building's water system required to identifiy potential effects of water stagnation.

Figure 17: Identified top KPIs – Extract from spreadsheet

From the *Top KPIs* identified or each pilot site (Figure 17), consideration is given as to how these performance indicators can be measured, monitored and reported. It is acknowledged that there may be and often is a variety of possible means by which to assess any performance indicator.
The first step is to identify a number of potential *Data Sources* from where it is possible to retrieve measure data relating to a performance indicator. A data source may take many forms e.g. a live data feed, as-built drawings or a database. Data sources are sub-divided as either static or variable (Figure 18).

Data Source Options					
Select from Dropdown Up to 3 Options for Static and Variable Data Sources					
Static			Variable		
As-Built Drgs	Site Inspection	N/A	Fixed In-line Electromagnetic Water Meter	Fixed In-lineTurbine Meter	Externally Mounted Ultrasonic Water Meter

Figure 18: Data sources – Extract from spreadsheet

Having identified possible data sources, options in relation to *Data Points/ReportableData* are considered. A data point/reportable data may be any discrete unit of information that is required or may be used to monitor or report on the performance indicator e.g. a flow rate, flow volume, a unit of power consumption or a pipe size. *Data Points/ReportableData* are also sub-divided as either static or variable (Figure 19).

Data Points/Reportable Data					
Select from Dropdown Up to 3 Options for Static and Variable Data Points					
Static			Variable		
Pipework Details : (Internal Dia. (mm), External Dia. (mm) Pipe Length Between Measurement Device and End User (M), Pipe Material	Generic Water Consumption Rates	Unit Cost of Water	MWS Flowrate (m^3/ Unit of time)	CWS Flowrate (m3/ Unit of time)	Water Level (m)

Figure 19: Data points – Extract from spreadsheet

The next step is to consider the *Measurement Frequency* that is necessary to assess a system in terms of an identified performance indicator. The required measurement frequency may be driven by a stakeholder's requirements and may potentially be limited by a specification of a particular unit's specification. The measurement frequency may be per second, per minute, hourly, weekly etc. An optimum *measurement accuracy* that is required by the stakeholder may also be determined at this stage. Measurement accuraciesare generally in the range +/- 1% - +/- 5% (Figure 20)

Min Measuring Accuracy	Measurement Frequency
Select from Dropdown	Select from Dropdown
+/- 1%	One Per Minute

Figure 20: Data Points – Extract From Spreadsheet

Similarly, the necessary*Recording Frequency*can be identified. The required recording frequency is generally less than but may be a factor of the measurement frequency and may be driven by a stakeholder's requirements and may potentially be limited by a particular unit's specification or data storage limitations. The recording frequency may be per second, per minute, hourly, weekly etc.

The *Reporting Frequency* is the highest level factor to be determined in the measurement recording/reporting sequence. It may be equal or some factor of the recording frequency necessary to assess a system in terms of an identified performance indicator. The required Reporting Frequency will be driven by a stakeholder's requirements and similar be a determining factor in the choice of measurement apparatus. The measurement frequency may be per second, per minute, hourly, weekly etc (Figure 21).

Recording Frequency	Reporting Frequency
Select from Dropdown	Select from Dropdown
Hourly	Daily

Figure 21: Record and Reporting frequency – Extract From Spreadsheet

Having identified the requirements of a system in terms of measureable data for each performance indicator, alternative *Installation Plans* can then be developed to satisfy each performance indicator and match the requirements identified in the preceding steps. These installation plans are determined based on a realistic assessment of the requirements and a knowledge of the performance indicator and may comprise any combination of sensor type e.g. flow meter, energy meter, level sensor or other such similar device (Figure 22).

Minimum Installation Plan To Assess KPI							
List the Minimum Number of Meters/Sensors of Each Type required to Achieve the Relevant KPI i.e. Minimum Installation Plan							
Fixed In-line Electromagnetic Water Meter	Fixed In-lineTurbine Meter	Externally Mounted Ultrasonic Water Meter (VTEC)	Mini Water Meter (VTEC)	Water Level Sensor	Water Pressure Sensor	Energy Meter	Other
0	0	1	0	0	0	0	0

Figure 22: Example - Min. Plan to Assess Retention Rate NEB – Extract from spreadsheet

Once a minimum and an alternative installation plan (or perhaps a number of alternatives) have been identified, the next step is to carry out an assessment of each plan in terms of how reasonable or practical it is and how well it will satisfy the requirements of the identified performance indicator.

5-Aspect Assessment

The *Plan KPI Score - 5 Aspect Assessment* assigns a score of between 1 and 5 (1 = very low and 5 = very high) to each of the following 5 aspects of the plan designed to assess a given performance indicator; Technical, Financial, Innovative, Social and Health. Table 8describes the scoring aspects. This enables the stakeholder to estimate how beneficial a particular KPI will be thus whether it should be part of a metering plan.

Table 8: Plan KPI Score – 5 Aspect Assessment Scoring Defined

Scoring of Plans in terms of KPIs:	Each Installation Plan is scored in terms of how well they satisfy each Identified KPI. Scoring is under 5 different aspects. Scoring is out of 5; 1 - very low, and 5 scoring very high.
Technical (T):	How easily can the Installation plan be implemented?
Financial (F):	How expensive is the installation?
Social (S):	Will this Installation Plan create user awareness/social interaction and gamification?
Innovative (I):	Will this Installation Plan bring and/or produce a novel and innovative aspect of the WATERNOMICS project one that has not been yet developed worldwide.
Health (H):	How does this Installation Plan relate to the health of the user?

Tables 9 - 13 outline, for each scoring aspect, the metrics that are applied in the assessment of each plan that has been identified to satisfy the associated performance indicator.

Table 9: Technical Aspect - Assessment Metrics

Score	*Comment*
Technical (T)	
1	Very Difficult to Install with Substantial Enabling Works causing Disruption to 3rd Parties; Installation > 3 person-days
2	Somewhat Difficult to Install with Some Enabling Works and Some Disruption to 3rd Parties; Installation > 3 person-days
3	Some enabling works required with minor disruption to 3rd Parties; Installation = 1 person-day approx.
4	Minor enabling works required no 3rd Party disruption - Installation < 1 person-day
5	Minimal enabling works required no 3rd Party disruption - Installation < 0.5 person-day

Table 10: Financial Aspect - Assessment Metrics

Score	*Comment*
Financial (F)	
1	High Unit and Installation Cost > €20k per installation and ongoing maintenance/operational costs < €1k per annum. In addition, potential further indeterminate costs due to disruption to 3rd parties during installation
2	Moderately High Unit and Installation Cost €10k - €20k per installation and ongoing maintenance/operational costs < €1k per annum. In addition, potential indeterminate costs due to disruption to 3rd parties during installation
3	Moderately High Unit and Installation Cost €5k - €10k per installation with minimal ongoing maintenance/operational costs < €1k per annum. No potential

	additional costs.
4	Reasonable Unit and Installation Cost €2k - €5k per installation with minimal ongoing maintenance/operational costs < €1k per annum. No potential additional costs
5	Low Unit and Installation Cost < €2K per installation with minimal ongoing maintenance/operational costs < €0.25k per annum. No potential additional costs.

Table 11: Social Aspect - Assessment Metrics

Score	*Comment*
Social (S)	
1	This Installation Plan will not create user awareness/interaction and gamification
2	This Installation Plan is unlikely to create user awareness/interaction and gamification
3	This Installation Plan may create user awareness/interaction and gamification
4	This Installation Plan is likely to create user awareness/interaction and gamification
5	This Installation Plan will create user awareness/interaction and gamification

Table 12: Innovation Aspect - Assessment Metrics

Score	*Comment*
Innovation (I)	
1	This Installation Plan does not bring any novelty or innovation
2	This Installation Plan is unlikely to be considered novel or innovative to the WATERNOMICS project and similar are pre-existing worldwide
3	This Installation Plan may be considered novel or innovative to the WATERNOMICS project although similar are pre-existing worldwide
4	This Installation Plan is likely to be considered somewhat novel or innovative to the WATERNOMICS project although similar are pre-existing worldwide
5	This Installation Plan is highly innovative and not previously used

Table 13: Health Aspect - Assessment Metrics

Score	*Comment*
Health (H)	
1	This Installation Plan does not have any feature that relates to the health of the user.
2	This Installation Plan does not feature anything that is likely to be considered relevant to the health of the user
3	This Installation Plan may have features considered relevant to the health of the user
4	This Installation Plan has features likely to be considered relevant to the health of the user
5	This Installation Plan has features directly related to the health of the user

The 5-aspect scores are totalled and presented as a percentage total indicating how well each plan will satisfy the associated performance indicator. Using the above methodology, the suitability of various metering installation plans can be comparatively assessed.

Financial Assessment

Once defined, the cost associated with the supply and installation of each metering plan can be assessed. The following costs (Table 14), based on average prices from industry, are used as part of the assessment. Given the different requirements in terms of installation or enabling works that are required for different sensor types, reasonable uplift factors to account for installation costs are provided as part of the assessment.

Table 14: Water sensors costs used for assessment

Purchase Costs Ex VAT	Installation Uplift Factor	Purchase Costs Ex VAT
Fixed In-line Electromagnetic Water Meter	1,2	3.040
Fixed In-lineTurbine Meter	2,2	500
Externally Mounted Ultrasonic Water Meter (VTEC)	1,25	1.000
Mini Water Meter (VTEC)	2	130
Water Level Sensor	1,18	1.400
Water Pressure Sensor	1,45	560
Energy Meter	1	50

Overall Minimum and Alternative Installation Plan
At this point the overall minimum and alternative installation plans can be finalized. These may be, for the overall minimum plan, simply the sum of the all of the minimum installation plans developed for each KPI. However, this stage requires an assessment of each installation plan (minimum or alternative) associated with a performance indicator to establish if a meter/sensor identified for one task may also be used for another task. The object of this step is to identify if possible whether the overall minimum installation plan requirement is less than the sum of the individual minimum installation plans. The same process is applied in determining the overall alternative installation plan.

Cost – Benefit Assessment
Having determined the overall minimum and alternative installation plans, the financial assessment may be revised to determine a *Revised Total Cost for the Minimum Plan* and a *Revised Total Cost for the Alternative Plan.* These totals form the basis of the cost element of the *Cost – Benefit Analysis*.

Present Value of Installation Plan Costs with Operation and Maintenance
The *Present Value* of the *Minimum Installation Plan Costs with Operation and Maintenance* is calculated for 5-Year horizon assuming a 6% discount rate and average annual running and maintenance costs of 5% per annum of the original supply and installation cost.

Similarly the *Present Value* of the *Alternative Installation Plan Costs with Operation and Maintenance* is calculated for 5-Year horizon assuming a 6% discount rate and average annual running and maintenance costs of 5% per annum of the original supply and installation cost.

Present Value of Installation Plan Benefits with Operation and Maintenance
The *Present Value* of the *Financial Benefit of* each *Installation Plan* is calculated using a 5-Year horizon and assuming a 6% discount rate. The value of financial benefit is the per annum sum of savings in the cost of water and the savings in local system energy costs to supply the water. The running cost of the water supply is estimated at 1% of the overall cost of water consumed. The baseline for the cost of water is taken from recent annual water costs at the pilot sites. This is translated to a per person annual cost and allows different scenarios regarding financial benefits to be investigated based on various percentage reduction in usage per person.

3.6 WATERNOMICS Technology selection tool

In water sector there are many types of metering technologies from which to choose and making the wrong decision can result in additional problems instead of fixing those the technology was designed to solve. Moreover, new technologies are rapidly becoming available, making it more difficult to determine which one is more appropriate to be used in a specific case.
To solve this problem that afflict also the Waternomics end-users in the following are given some important tips to take care in choosing the right water metering technology.

Tips for Choosing the Best Tech Solutions

1. A rich user experience

Mangers / householder should have the option to be aware of their water consumption at any time. The best way to achieve this isto implement water information system associated with an online platform that offers an intuitive user interface across a range of devices based on consistency and simplicity.

2. Evolving capabilities

Since technologies evolve continuously the platform dedicated to the technology selection should be an instrument that can evolve at the same rate. As changes are needed additional informations, should be easily and seamlessly integrated.

3. Accessibility

One of the major benefits of an online system platform is that users can access it from anywhere at any time. Not only does this make it easier for stakeholders and end-users to do what they want, when they want, but it also allows them to have at their disposal the right information.

4. Customer involvment

External links are useful in the platform. Stakeholders and end-users should fully research the necessary informationto improve their knowledge and ensure the platform meets their needs.

Making the appropriate choice also requires careful attention to other matters that surround the technical choice. The Water Project Toolkit (EC, 2011:49) states “the choice (of technology) should be governed by considerations of its efficiency, appropriateness, cost and suitability for local conditions”. Some steps and generic themes that must be considered in Water supply technology choice analysis are presented in Figure 23 and it is clear that what is required is not a common solution to a problem, but a methodology for the analysis of problems.

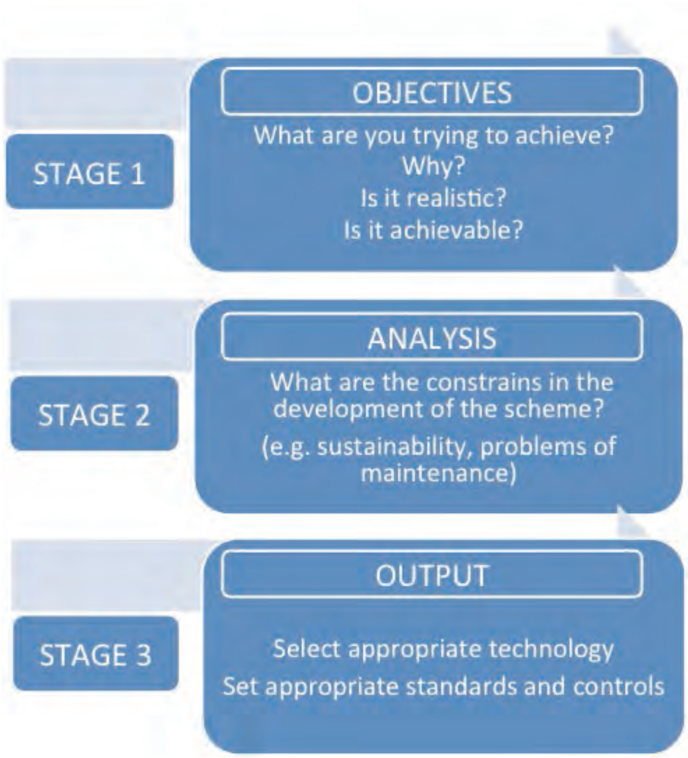


Figure 23: Steps in choosing the water supply technology

Stage 1: Objectives

The purpose of the analysis must be established. What are you trying to achieve, and why? Is it achievable, is it a realistic goal, is it the main problem? There may be a need to prioritize the problems. This stage is often underestimated or taken for granted. For example, in the case of water supply, the priority in developing water network metering often should be a low-cost, low-maintenance system.

Stage 2: Analysis

The constraints on the proposed development have to be identified and looking at the particularities of the individual case can only do this. Often, physical constraints such as water resources and land availability will be taken into account, but other fundamental factors that contribute to the success or failure of a scheme are not adequately addressed.

For analysis purposes we can group the issues to be addressed into the ‘**SHTEFIE**’ criteria, developed at WEDC by Richard Franceys, Margaret Ince and others as a tool to help with analysis of development programmes.

S — SOCIAL
H — HEALTH
T — TECHNOLOGICAL
E — ECONOMIC
F — FINANCIAL
I — INSTITUTIONAL
E — ENVIRONMENTAL

From these groupings, a checklist of factors to consider may be drawn up. As for example Table 15, extract from the document"49. Chosing an appropriate technology[1]" – Jeremy Parr and Rod Shaw WEDC Loughborough University Leicestershire (UK),shows an example of the sorts of issues that could be used for *selecting water-treatment options*. Think of it as a thought-provoker to ensure that all the relevant factors are taken into account; the SHTEFIE criteria can be useful in this context.

Table 15: The SHTEFIE criteria (example developed for selecting water treatment options)

S	**SOCIAL FACTORS**
	• Housing facilities; type, distribution • Public desires and preferences; aesthetic considerations, pressure groups • Welfare and equity considerations • Willingness to pay; ability to pay • Water tariffs; methods and ability to pay • Population distribution (age, location, growth rates) • Migration, urbanization • Cultural aspects, including attitude towards water recycling • Educational levels; structure of workforce; training • Influence ability to operate and maintain
H	**HEALTH FACTORS**
	• Health statistics, morbidity and mortality rates • Significant faecal-oral (and other) diseases • Health services available
T	**TECHNOLOGICAL FACTORS**
	• Water demand and use • Availability of spare parts and materials • Availability of local knowledge and expertise • Present water supply and sanitation facilities; proposed future investments • Raw water characteristics: source, quantity, quality, availability and reliability • Water standards • Power requirements
E	**ECONOMICAL FACTORS**
	• Structure of economy • Major employment sectors • Size of economy, future prospects, balance of payments, trade relations, isolation of economy and vulnerability, distribution of incomes
F	**FINANCIAL FACTORS**

[1] www.lboro.ac.uk/well/resources/technical-briefs/49-choosing-an-appropriate-technology.pdf (accessed March 2015)

	• Financial available: method of founding • Ability and willingness to pay
I	**INSTITUTIONAL FACTORS**
	• Existing roles and responsibilities for organization and management • Relationship between organizations • Legislation, policing and regulations
E	**ENVIRONMENTAL FACTORS**
	• Climate, rainfall, hydrology • Soil conditions, groundwater characteristics • Water resource availability • Impact of any plant: visual impact, health considerations • Sustainability

Stage 3: Output

After all relevant issues have been addressed, the output can be evaluated. Options and targets/standards must be considered together in order to select the appropriate technologies. In addition, price, operational costs and maintenance are factors.
The price of technologies can range from low to very high. The choice of which to procure must depend on consumer demand, geographical conditions and financial ability to buy and sustain the technology.

In most cases Operation and maintenance costs vary considerably from technology to technology. For example, O&M costs are usually relatively low in rural schemes, while in urban areas they can be much higher where shared facilities are constructed. “Activities and repairs are part of O&M and the frequency with which they need to be carried out depends largely on elements such as the quality of materials, the quality of workmanship during the construction phase, and the level of corrective and preventive maintenance carried out by the actors concerned” (François Brikké and Maarten Bredero “Linking the technology choice with operation and maintenance in the context of community water supply and sanitation” - WHO 2003[1]).

To help stakeholders and end users in doing technology decisions, a Waternomics technology selection tool will be developed and made available in the WIS.The tool will support non expert people to make a better decision on which water technology to choose in their case. It will provide both a simple overview of technologies and also decision-support aids for technology selection. For each technology, the tool will contains short multidisciplinary information (**SHTEFIE**) on suitability and sustainability. In developing the tool, reference will be made to the following figures[2] that show how could be organized the main page of the Waternomics Technology Selection Tool and what kind of information the users can obtain from it in accordance with (**SHTEFIE**) methodology.

[1] http://www.who.int/water_sanitation_health/hygiene/om/wsh9241562153.pdf (accessed March 2015)
[2] http://www.watercompass.info (accessed March 2015)

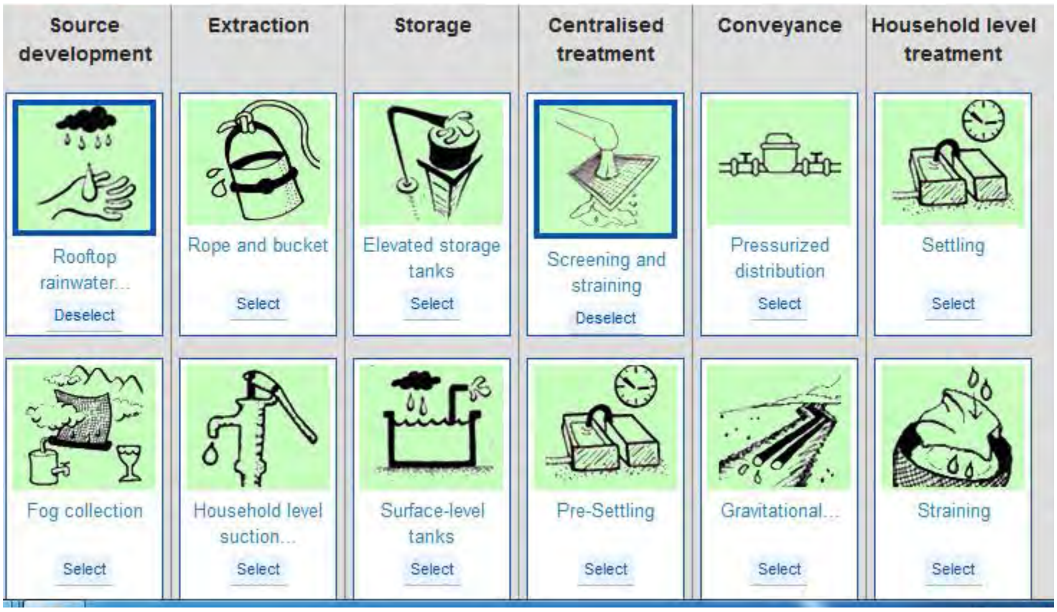
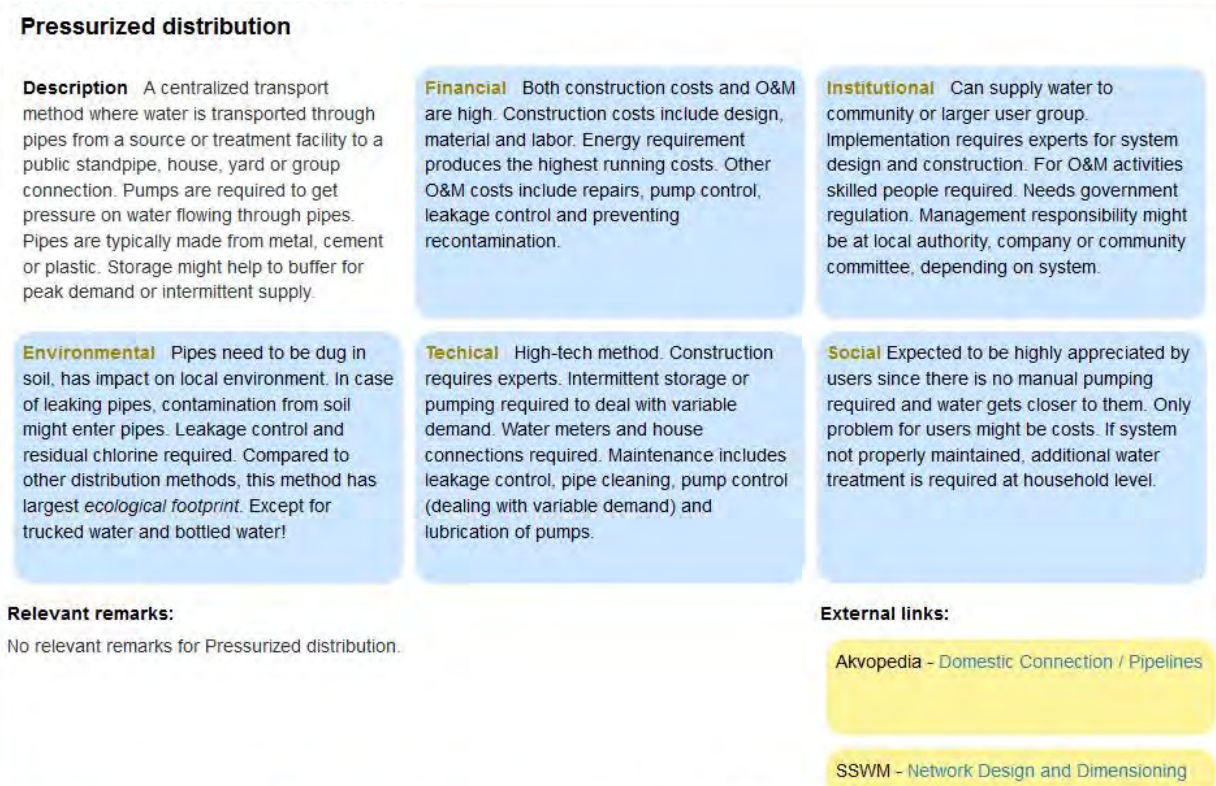


Figure 24: Technologies divided in functional areas - a way to organize the Waternomics Technology Selection Tool (Source: Watercompass[1])



Pressurized distribution

Description A centralized transport method where water is transported through pipes from a source or treatment facility to a public standpipe, house, yard or group connection. Pumps are required to get pressure on water flowing through pipes. Pipes are typically made from metal, cement or plastic. Storage might help to buffer for peak demand or intermittent supply.

Financial Both construction costs and O&M are high. Construction costs include design, material and labor. Energy requirement produces the highest running costs. Other O&M costs include repairs, pump control, leakage control and preventing recontamination.

Institutional Can supply water to community or larger user group. Implementation requires experts for system design and construction. For O&M activities skilled people required. Needs government regulation. Management responsibility might be at local authority, company or community committee, depending on system.

Environmental Pipes need to be dug in soil, has impact on local environment. In case of leaking pipes, contamination from soil might enter pipes. Leakage control and residual chlorine required. Compared to other distribution methods, this method has largest *ecological footprint*. Except for trucked water and bottled water!

Techical High-tech method. Construction requires experts. Intermittent storage or pumping required to deal with variable demand. Water meters and house connections required. Maintenance includes leakage control, pipe cleaning, pump control (dealing with variable demand) and lubrication of pumps.

Social Expected to be highly appreciated by users since there is no manual pumping required and water gets closer to them. Only problem for users might be costs. If system not properly maintained, additional water treatment is required at household level.

Relevant remarks:

No relevant remarks for Pressurized distribution.

External links:

Akvopedia - Domestic Connection / Pipelines

SSWM - Network Design and Dimensioning

Figure 25: Start point references for the development of a customized Waternomics Technology Selection Tool (source: Watercompass[2])

[1] http://www.watercompass.info (accessed March 2015)
[2] http://www.watercompass.info (accessed March 2015)

4 Standards, Governance and Best Practices used to construct the Waternomics Methodology

Section4 documents the principle topic areas considered in the construct of the Waternomics Methodology. They are:

- A review of water related ICT European projects
- A review of research projects in the field for benchmarking, knowledge transfer and clustering opportunities
- A review of standards with focus on those related to energy and water management
- The investigation of governance and its implication on methodology development
- The documentation and benchmarking of water labelling and certification schemes
- The investigation of selected water conservation programs in water scarce regions both internationally and in Europe

These areas have been investigated with the scopeand objectives of the Waternomics project in mind and how it intends to address the need for a water information, management and decision support tool that presents meaningful and personalized information about usage, price, and availability of water in an intuitive and interactive way to end users. The following sections aim to give to the readers a brief overview and references for these topic areas.

4.1 Water related ICT European Projects investigated

EU co-funded research projects[1] related to both ICT and water have been investigated from the past 7th Framework Programme (FP7) and the current Horizon 2020 program (H2020). Within FP7, one area of special attention was Information and Communication Technologies (ICT) with a total of €9.1 billion dedicated to its development with the objective to improve the competitiveness of the European Industry as well as to enable Europe to master and shape the future developments of these technologies. The new and current program (Horizon 2020) also has a considerate focus on excellent science, technology development, and EU competitiveness. Given the amounts of funds available and the direction EU establishes in the development of these technologies, such research projects are very important to consider. Table 16details the projects analysed by Waternomics from within these two research programs.

Table 16: Selected EU projects related to ICT and Water within the FP7 and H2020 programs

Project Name	Description	Example case	Savings Attained	Leak Detection and Repair	Implementing a Water Management Program	Communicating with Stakeholders	Upgrading Infrastructure	Conducting Data Analysys
IceWater	Develop the technical standards that ensure networks and technologies seamlessly interconnect, and strive to improve access to ICTs to underserved communities worldwide (Fantozzi et al., 2014)	Pilot site 1: centre-south of Milan Pilot site 2: Timisoara		X	X	X	X	X

[1] http://ict4water.eu/

IWIDGET	Advance knowledge and understanding about smart metering technologies (Kossieris et al., 2014; Loureiro, Alegre, Coelho, Martins, & Mamade, 2014)	Households and utility stakeholders (UK – Portugal – Greece)	Reduced demand for water and hence the energy required for its treatment	X	X	X	—	X
SMARTH20	Engage citizens by means of cooperative awareness tools, such as water consumption profiling and feedback, persuasive games for behaviour change, and computer-supported community work.(Harou et al., 2014)	Households: District of London (UK) and district of Locano (CH)	Maximize the water and energy saving	—	X	X	—	X
DIAD	Challenge of improving the management of water resources through real-time knowledge of water consumption, in order to improve societal awareness, induce sustainable changes in consumer behaviour, and explore new water demand management strategies	Residential households	User awareness and self-induced behavioural change for delivering sustainable changes in water consumption	—	X	X	—	X
EFFINET	Optimal operational control, real-time monitoring and demand forecasting. Flow and pressure control to minimize electricity costs also through model predictive control techniques (Patrinos, Sopasakis, Sarimveis, & Bemporad, 2014)	Residential households. Two real-life pilot demonstrations in Barcelona (Spain) and Limassol (Cyprus)	Techniques for the operational control of water networks, real-time monitoring to detect and locate leaks, software solution that serves as a decision-support tool	X	X	X	—	X
URBANWATER	The project provides an innovative modular ICT system and services for water utilities to smooth water consumption peak trough adaptive pricing and user empowerment solution	—	Decrease overall water consumption	X	X	—	—	X
ISS-EWATUS	Develop several innovative ICT methods aiming to exploit the untapped water-saving potential in EU. The overall goal will be achieved by developing an innovative, multi-factor system capable to optimise water management and reduce water usage.	Residential households, Municipality.	Focus on household and urban water-saving potentials	—	X	X	—	—
WatERP	Develop a web-basedPlatformsupported by real-time knowledge on water supply and demand, enabling the entire water distribution system to be viewed in an integrated and customized way.	Residential households, Municipality.	Develop a Decision Support System tool, to achieve water and energy cost savings.	—	X	X	—	X
SmartH20	Engage citizens by means of cooperative awareness tools, such as water consumption profiling and feedback, persuasive games for behavior change, and computer-supported community work.	Households: District of London (UK) and district of Locano (CH)	Maximise the water and energy saving	—	X	X	—	X

WISDOM	Water and energy savings through the integration of innovative ICT frameworks to optimize water distribution networks and to enable change in consumer behaviour through innovative demand management and adaptive pricing schemes (Zarli, Rezgui, Belziti, & Duce, 2014)	Domestic, corporate and city users. Two pilot projects – in Cardiff (UK) and La Spezia (Italy)	Collect real-time data about water consumption at domestic, corporate and city level. Improve the awareness of household and business water users, encouraging changes in their water usage behaviour	—	X	X	—	X

By examining these projects, it was possible to identify synergies with Waternomics, screen and utilize public deliverables to avoid redundant research, and to identify potential liaison opportunities. Consistent themes across these projects critical to water management success include:

- Implementing a Water Management Program
- Communicating with Stakeholders
- Conducting Data Analysis

Waternomics possesses these essential requirements.

In terms of implementing a Water Management Program, the standards-based Methodology work developed in Waternomics is unique with respect to the projects analyzed.

4.2 Standards, training circulars and certification program review

In choosing what standards, TCs, and certification program to review, the following rationale was utilized:

- Water management is in scope. Water quality is out of scope.
- Potable water distribution is in scope. Sewage treatment processes are out of scope.
- The energy sector is the sector to study most closely with respect to auditing, management programs, efficiency efforts, demand response principles and certification.

In general,while for energy sector a wide and growing range of sustainable certification programs, standards and labels exist; it is not the same thing for the water sector although the trend is in this direction.As such, one objective of the standards review has been to realize knowledge transfer from the energy sector to the water sector. Of note, the development of energy management and energy auditing related standards has been a process that has taken decades and is still ongoing. There is still work to do in harmonizing terminology and aligning standards at the international, national and local levels. It can be anticipated that the development of standards dedicated to water will also take time.

Table 17 shows the selected standards, protocols and certification programsconsidered by Waternomics in the construct of the Waternomics methodology.

Table 17: Standards, protocols, TCs and certification programs considered in the construct of the Waternomics methodology

Energy Related	Water sector
EN 16247	ISO 24510 - 11 - 12
UNI CEI/TR 11428	ISO 12242
ISO 50002	ISO14006
AFNOR BP X30-120	IPMVP*
EN 16231	IWA 6 GUIDELINES
EN 16212	ISO /TC 224
ISO 50001	
ISO 140001	
IPMVP*	

* IPMVP is dedicated to both energy and water.

In the sub-chapters that follow, information related to these standards is presented.

4.2.1 Selected standards from the energy sector

Table 18documents well known standards related to energy management and energy auditing. The number of the standard, its title, its core concept and additional remarks are provided. These standards relate most closely to the initial phases of the Waternomics methodology (Assess and Plan).

When considering these standards, we can say that there is no single adopted standard that organizations must use that provides comprehensive guidelines for industrial energy auditing. Instead there are choices of different frameworks and/or standards which exist at various levels (national, European, international beyond Europe) and organizations or persons may have a preference for one family of standards or another. Making standards more coherent and consistent is work that is in progress and there are efforts at the European and international levels to develop the next version or new comprehensive clear standards.

Table 18: Existing standards for Energy audit and Energy Management Program

Standard	Title	Remarks
EN 16247-1 (2012)	Energy Audit	• Basic Idea: Procedural steps to conduct an energy audit • In adopting this standard, several countries have released versions with more detailed information. • EN16247 is a large driver in the development and release of ISO 50002 which harmonize similar concepts to a larger body of adopting countries.

UNI CEI/TR 11428	Energy Efficiency	• Basic Idea: Procedural steps to conduct an energy audit • Based on Italian national program to support energy diagnosis
ISO 50002 (2011)	Energy Management Systems	• Basic Idea: It specifies the process requirements for carrying out an energy audit in relation to energy performance. It is applicable to all types of establishments and organizations, and all forms of energy and energy use.
AFNOR BP X30-120 (2006)	Energy diagnosis within industry	• Basic Idea: To customize energy auditing to industry and highlight diagnosis principles over auditing principles. • Based on French national program to support energy diagnosis in industry now with thousands of case studies. • Aspects of this standard have worked up into EN16247-1 and subsequently ISO50002 preparation.
EN 16231 (2012)	Energy Efficiency Benchmarking Methodology	• Basic Idea: to provide guidance on the criteria to be used in order to choose the appropriate level of detail for the data collection, processing and reviewing which suits the objective of the benchmarking
EN 16212 (2012)	Energy Efficiency and Savings Calculation, Top-down and Bottom-up Methods	• Basic Idea: to provide a general framework for energy savings calculations. • The standard has a high level of detail and provides examples and instruction.
ISO 50001 (2011)	Energy Management Systems	• Basic Idea: How to establish and execute and energy management program within an organization. • Recently replaced EN 16001 (organizations may still have programs based on EN 16001)
ISO 14001 (2011)	Energy Management Systems	• Basic Idea: It gives guidelines and best practices for Environmental Management Systems (EMS) • It is the dominant environmental management system in the world, and it follows a Plan-Do-Check-Act, or PDCA, Cycle
IPMVP (2012)	International Performance and Measurement Verification Protocol.	• Basic Idea: To provide a framework (typically between Energy Service Company - ESCO and client) to plan, measure or calculate, and verify the outcome of energy efficiency measures.

EN 16247

The EN 16247 Energy Audits standard was developed in response to the 2006 EU directive on energy end-use efficiency and energy services[1]. An energy audit is the first step in good energy management: identifying energy use and utilizing this information to reduce energy consumption and energy costs and meet increasing energy and environmental obligations. The standard applies to commercial, industrial, residential and public-sector organizations and complements the internationally recognized energy management system standard, ISO 50001:2011 which within its PLAN-DO-CHECK-ACT approach identifies the need for clear energy auditing. An energy audit is an important step for an organization, whatever its size or type, wanting to improve its energy efficiency, reduce energy consumption and bring related environmental benefits.
EN 16247 defines the attributes of a good quality energy audit. The energy audit process is presented as a simple chronological sequence; this does not preclude however repeated iterations of certain steps. This standard applies to commercial, industrial, residential and public-sector organizations, excluding individual private dwellings. The standard does not deal with the energy audit program/scheme properties (such as program administration, training of energy auditors, quality control issues, energy auditors' tools, etc.). The document develops mainly on two concepts: quality requirements (regarding who carries out the audit and the actual audit methodology) and key elements of the diagnostic process which span form the initial contact with the client, through the data collection and subsequent activities in the field and finally lead to the analysis of improvement opportunities and subsequent formulation of energy conservation measures. In conclusion and in a very general way, among the general requirements that must characterize a high quality audit according to the standard, it is useful to list:

- Adequate expertise of the editor of the audit, which should also ensure confidentiality (all information acquired during audit must considered private and confidential subject to agreement between the parties for their dissemination), objectivity (the interest the buyer is to be considered pre-eminent) and transparency (the client must be made aware about potential conflicts of interest of the editor of the audit).
- Completeness and correctness: an audit must be appropriate for the purpose, objectives agreed, and cover the whole energy/water system as agreed with the client.
- Reliability: Investigate the energy/water system diagnostic object, and acquisition of data relating to the consumption in the number and quality necessary for the development the diagnosis itself.
- Traceability: it must be possible to reconstruct the technical and logical path followed by the responsible of audit.
- Usefulness: the interventions proposed closure of the audit must also be evaluated in terms of costs / benefits in order to be really useful for the customer.
- Verifiability: at the end of the energy/water audit the client must be able to verify that the measures proposed and adopted actually lead to energy/water efficiency improvements in line with the budgeted ones.

UNI CEI/TR 11428

Many countries have issued a national level continuation/adaptation of EN16247. In Italy, it is called technical report UNI CEI/TR 11428:2011 “Gestione dell’energia – Diagnosi energetiche – Requisiti generali” which was published in 2011. Compared to the European standard (EN 16247) this report a more detailed and comprehensive step by step guide to carry out an energy audit using 13 steps which are depicted in the accompanying figure.

[1] http://www.fm-world.co.uk/news/fm-industry-news/bsi-publishes-guide-to-energy-auditing/ (accessed March 2015)

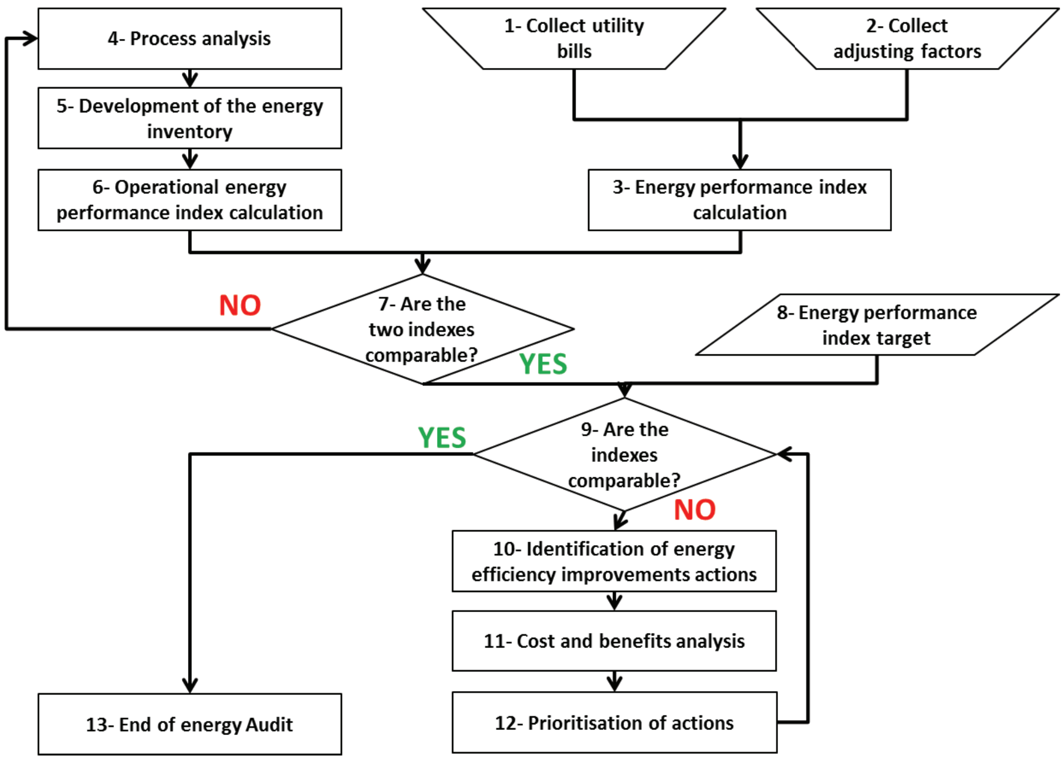


Figure 26: Steps to carry out an Energy audit – Source: UNI CEI/TR 11428:2011

These 13 steps could be a guideline suitable also for water sector and can be divided in 4 macro areas or stages:

1. Data Collection: energy (bills), identification adjusting factors, analysis of the process
2. Energy inventory development: identification and comparison of the energy performance indices (operational, effective and target)
3. Determination of efficiency improvement actions: cost-benefit analysis, the priorities of interventions.
4. Final Report.

where for each stage a technical report provides a detailed description of the actions related to it. Moreover, the Italian standard provides an Appendix A on "Identification, valuation and presentation of recommendations" which is of particular operational usefulness, both for the auditor and for the client. It provides an approach where the proposed improvements have to be identified on the basis of:

- "Hierarchical" order: rationalization of energy flows, waste energy recovery, identification technologies for energy saving, optimization of energy supply contracts (if applicable)
- Age, condition, mode of operation and management of energy consuming equipment
- Technology equipment installed compared with the best available technology (BAT)
- Operating conditions foreseen and planned.

ISO 50002

Figure 27[1] shows the main steps of ISO 50002 that reflect (more or less) the structure of EN 16247. This standard (ISO 50002) has been published in 2014. ISO 50002 is largely based on EN 16247

[1] Figure adopted from: http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/files/documents/events/iso_50002_and_the_iso_50001_family_of_standards_-_iso.pdf

but builds consensus over a wider sample of countries. The key players involved are from Europe, North America, South America, Africa, Asia Pacific. Compared to the EN 16247, some differences include amplification of the importance of communication, roles, responsibilities and authorities, addition of data measurements and break down analysis into smaller groups of work (similar to the Italian technical report). As reported by ISO[1], "*ISO 50002:2014 specifies the process requirements for carrying out an energy audit in relation to energy performance. It is applicable to all types of establishments and organizations, and all forms of energy and energy use. The standard specifies the principles of carrying out energy audits, requirements for the common processes during energy audits, and deliverables for energy audits. It does not address the requirements for selection and evaluation of the competence of bodies providing energy audit services, and it does not cover the auditing of an organization'senergy management system, as these are described in ISO 50003. The standard also provides informative guidance on its use.*"

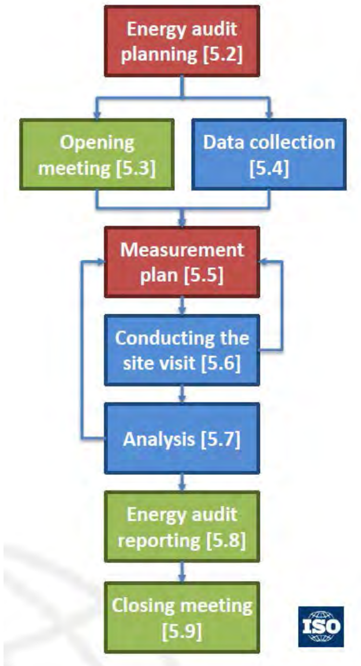


Figure 27: ISO 50002 Audit structure

The ISO 50002 is part of a common development of ISO standards that connect to the ISO 50001:2011 Energy management systems standard. This standard is a specification created by the International Organization for Standardization (ISO) for an energy management system. The standard specifies the requirements for establishing, implementing, maintaining and improving an energy management system, whose purpose is to enable an organization to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy security, energy use and consumption. The standard aims to help organizations continually reduce their energy use, and therefore their energy costs and their greenhouse gas emissions.

ANFOR BP X30 - 120

AFNOR BP X30-120 (Energy Diagnosis in Industry) was under the direction of the French government in 2004 and led by ADEME, a group of 30 experts worked to develop the first normative document on a reference frame concerning the good practices in the field of energy diagnoses which later became adopted as BP X30-120. This norm is significant because of its emphasis on the term diagnosis and for the fact that it has served as a key reference for the more general standards developed since that time. The difference between audit and diagnosis (at that time and by some people) was defined as:

Audit: A verification, an estimation, a judgment on a situation

Diagnosis: In addition to an audit, the optimization of the situation, and by the propositions of solutions

In committees and beyond, others may consider these terms synonymous. The BP X30-120 framework consists of three phases which have objectives as follows:

[1] http://www.iso.org/iso/catalogue_detail.htm?csnumber=60088

Phase 1: Preliminary Study

Goals

- To collect relevant information
- To conduct a preliminary assessment of the energy situation
- To identify energy savings potential

Actions

- Preparation with the industrialist (communication of the informations)
- Information gathering of the site (visit, meetings, interview)
- Analysis of data and drafting of the preliminary analysis report
- Delivery of the preliminary analysis

Report Characteristics

- First analysis of the energy situation
- The identification and justification of savings sources
- A description of basic actions to be implemented
- A description of the detailed analysis to be continued in Phase 2
- The suggestion of a monitoring plan for energy consumption and savings

Phase 2: Detailed Analysis & Measurement Campaigns

Goals

- To extend the analysis of the main savings identified in the first phase and chosen with the industrialist
- To establish the real energy needs of the established process(es)
- To include measurement campaigns
- To consolidate the sites global energy situation

Actions

- To work on the basis of the energy needs issued resultant of the measurement campaign
- To compare with ratios, performances
- To describe energy savings sources
- To research malfunctions and their causes (management, maintenance, sizing of equipment, technological choices)

Phase 3: Searching for Improvements Solutions

Goals

- To specify the actions to make energy savings
- To identify and describe the solutions
- To provide an estimate of the implementation cost and payback period

Organization/Classification of Solutions

1. Behavioral best practices related to raising awareness, training and increased knowledge of the facility based on monitoring of the operations
2. Operational best practices related to maintenance and operating optimization, replacement or installation of low cost measures
3. Measures requiring high cost investments such as modifications of the process, replacement of machines, …

Final Reporting

- The file for each solution and for combined actions
- The main comparison criteria between the solutions
- A preferred plan for the implementation of actions, undertaking of feasibility studies
- The main results: energy situation, proposition of an energy management system, …

These principles are captured in a slide (Figure 28) presented by Sylvie Riou at the 23 March 2010 Sustainable Energy Week.

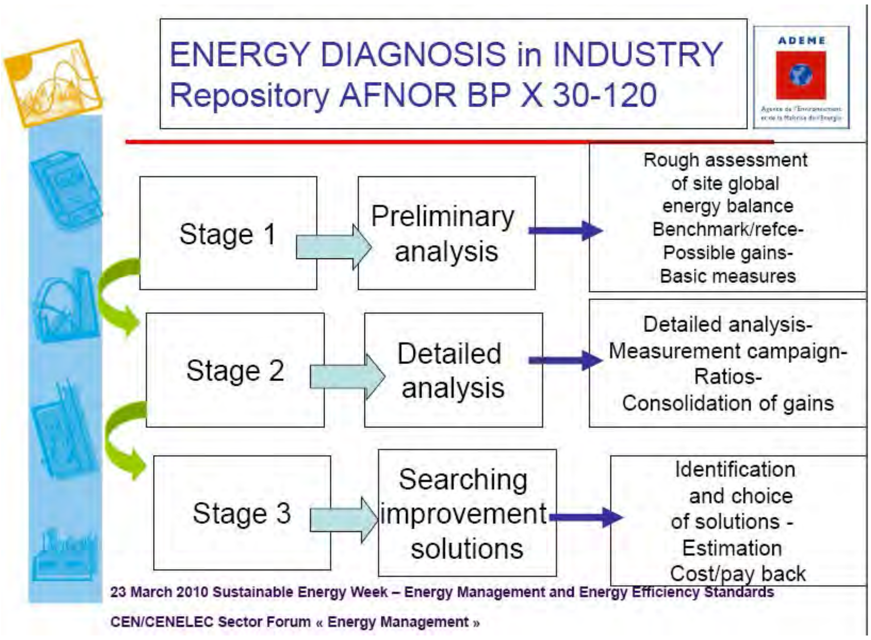


Figure 28: Energy diagnosis AFNOR BP X 30 - 120

In the Waternomics methodology, we have applied a similar approach and we can find the water audit and diagnosis in the Phase 0 of the methodology.

EN 16231

UNI CEI EN 16231: 2012 is the standard that defines the "Methodology of benchmarking energy efficiency." The standard defines requirements and gives recommendations on the methodology of benchmarking energy efficiency. The purpose of benchmarking is to identify key data and indicators of energy consumption. Indicators can beboth technical and behavioural, quantitative and qualitative, and should be aimed at the comparison of performance. Benchmarking can be either internal (relating to a specific organization) or external (between organizations). The standard aims to provide clear criteria for defining the boundaries of the object that is being analysed, for example with regard to facilities, activities, processes, products, services and organizations. It also provides guidance on the criteria to be used to choose the appropriate level of detail for the collection of information, for their processing and review in accordance with the objectives of the analysis. The benchmarking standard EN 16231 provides the first universal and uniform catalogue of requirements for the collection and analysis of operational energy data in terms of energy efficiency benchmarking. The requirements of the standard were structured in ten steps. Together they form the first action plan for the practical implementation. Completed benchmarking projects and studies from related topics are considered in more detail on the basis of this standard. At the end of each step, recommendations for action are provided.

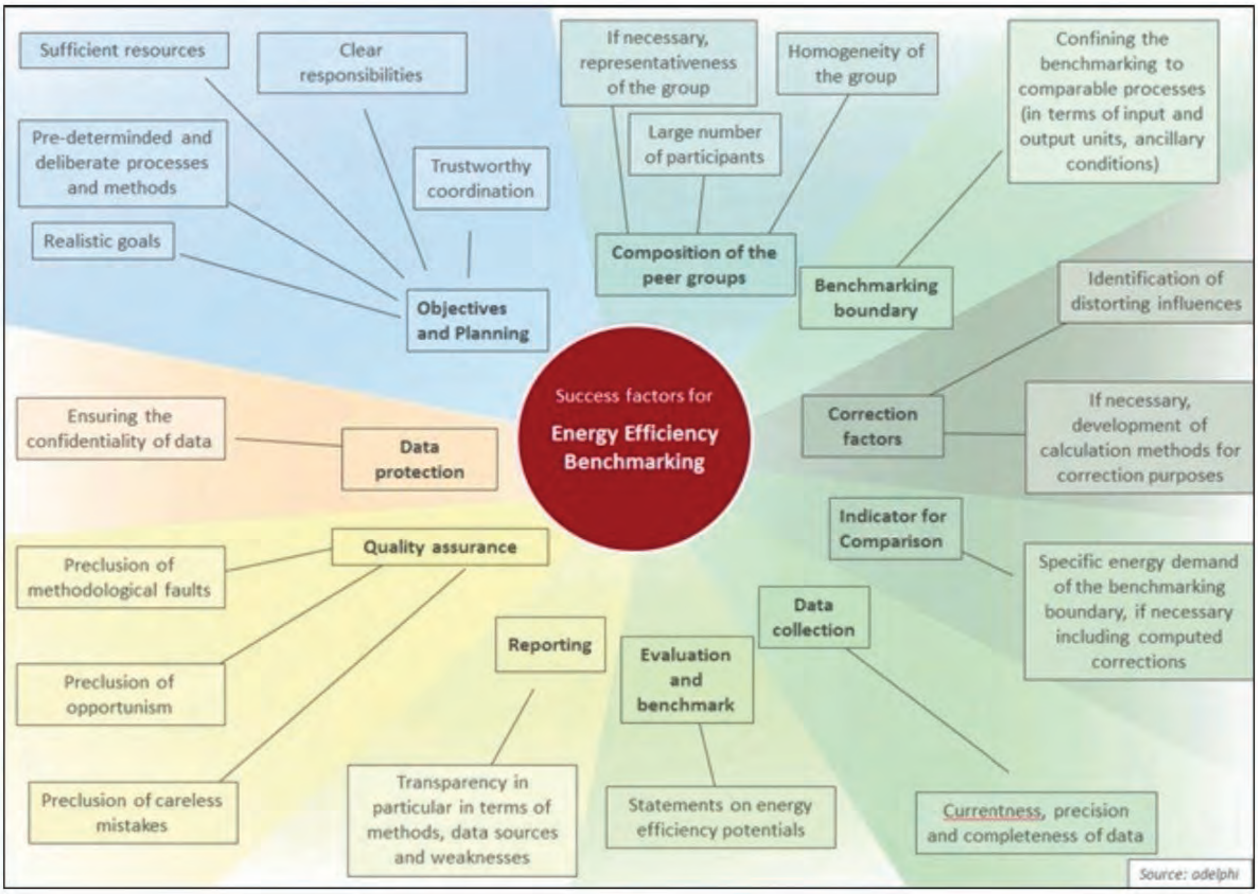


Figure 29:10 steps and related success factorsfor Energy Efficiency Benchmarking

There are several connecting factors between energy management and energy efficiency benchmarking. The principles of EN 16231 can be embedded in the energy management as an integral element. For that purpose, it is listed as an instrument in the energy management systems standard ISO 50001. Energy efficiency benchmarking can assist the planning of energy targets and the review of energy efficiency progress.

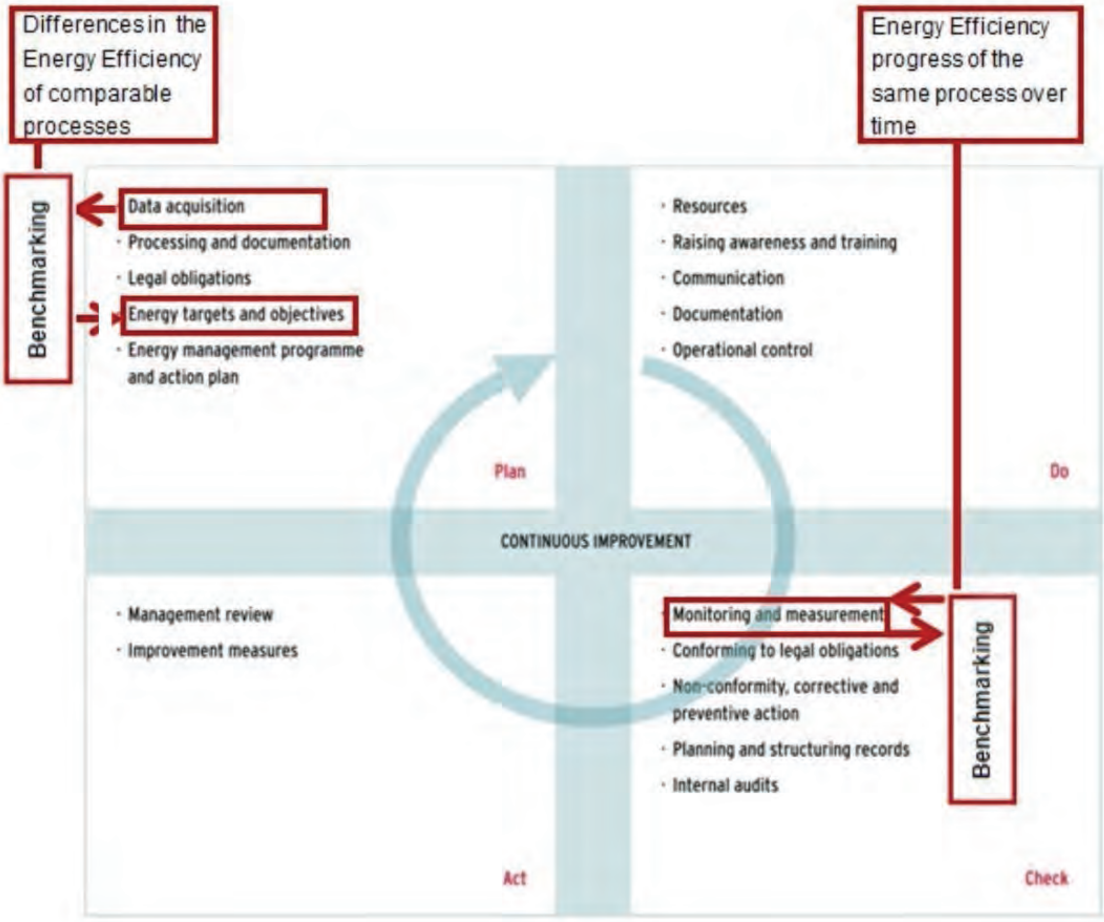


Figure 30: Benchmarking as an instrument in Energy Management Systems

EN 16212

EN 16212:2012 provides a general approach for energy efficiency and energy savings calculations with top-down and bottom-up methods[1]. The general approach is applicable for energy savings in buildings, cars, appliances, industrial processes, etc.
It covers energy consumption in all end-use sectors. The standard does not cover energy supply, e.g. in power stations, as it considers only final energy consumption.
It deals with savings on energy supplied to end-users. Some forms of renewable energy "behind-the-meter" (e.g. from solar water heating panels) reduce supplied energy and therefore can be part of the calculated energy savings. Users of the standard should be aware that this renewable energy behind the meter can also be claimed as energy generated.
BS EN 16212:2012 is meant to be used for ex-post evaluations of realized savings as well as ex-ante evaluations of expected savings.

ISO 50001

ISO 50001 (Energy Management Systems) is essentially most adopted resource management program worldwide[2]. This standard is related to improvement of energy performance, including

[1] Michael ten Donkelaar, Jan Magjar, Yannis Vouigiouklakis, Daniele Forni, Veronica Venturini – "Measurement and verification for energy services, IPMVP and other approaches" (2013)
[2] http://www.energy.gov/eere/amo/iso-50001-energy-management-standard (accessed March 2015)

energy efficiency, energy use and consumption. It specifies requirements applicable to energy use and consumption, including measurement, documentation and reporting, design and procurement practices for equipment, systems, processes and personnel that contribute to energy performance. It introduces a management system based on PDCA method (Plan – Do – Check – Act).

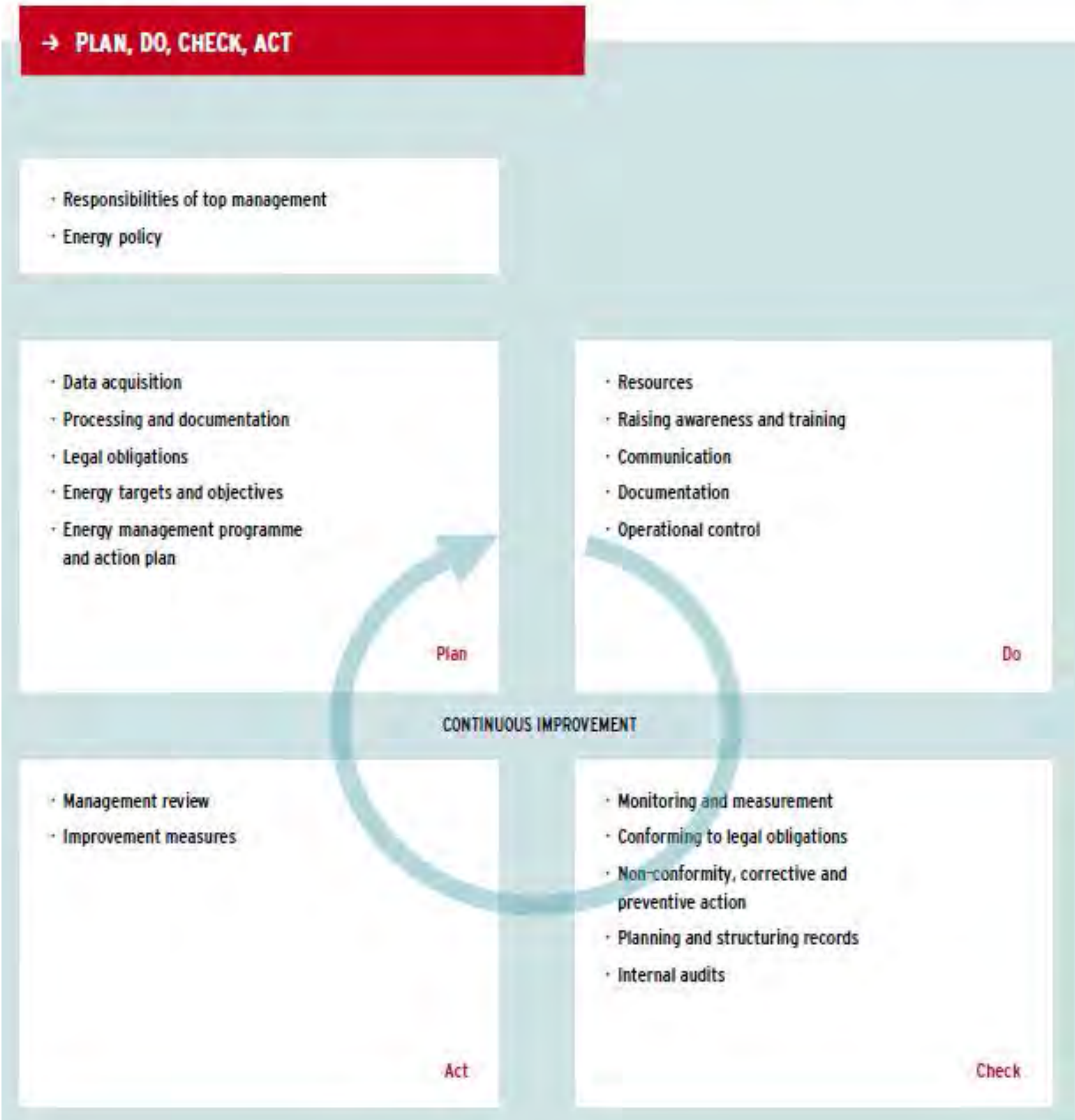


Figure 31: PDCA scheme[1]

It easy to see how this management method can be easily applied to other sectors and also to the water management sector, in this sense the method introduced by ISO 50001 is a base line to develop the Waternomics methodology. It is timely for this standard that in many EU countries it is being mandated by policy for large energy users (e.g. corporations) to have either an ISO50001 program in place or energy audit on file. By closely aligning the Waternomics methodology with ISO50001, Waternomics can benefit from the policy support related to ISO50001.

[1] Figure adopted from: "Energy management system in practice" - Walter Kahlenborn, Sibylle Kabisch, Johanna Klein, Ina Richter, Silas Schürmann - Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) – June 2012

ISO 14001

ISO 14000 gives guidelines for a good Environmental Management System[1] (EMS), and more specialized standards dealing with specific aspects of environmental management.
The ISO 14000 standards reflect different aspects of environmental management. The following list outlines the broad coverage of each:

- Environmental management systems:
  - 14001-2004, 14002, 14004
- Environmental Auditing:
  - 14011
- Environmental Labelling:
  - 14020, 14021, 14022, 14023, 14024, 14025
- Life Cycle Assessment:
  - 14040, 14044

The ISO 14000 family includes most notably the ISO 14001 standard, which represents the core set of standards used by organizations for designing and implementing an effective (EMS). It can be used by any organization that wants to improve resource efficiency, reduce waste, and drive down costs. Cost savings is obtainedthrough the reduction of waste and more efficient use of natural resources (electricity, water, gas and fuels.) ISO14001 is the dominant environmental management system in the world, and it follows a Plan-Do-Check-Act[2], or PDCA, Cycle.

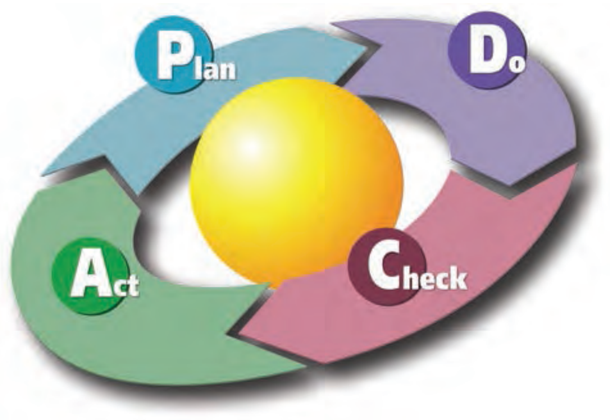


Figure 32: PDCA scheme[3]

The diagram shows the process of first developing an environmental policy, planning and then implementing it. The process also includes checking the system and acting on it. The model is continuous because an EMS is a process of continual improvement in which an organization is constantly reviewing and revising the system.

[1] **Environmental management system** (**EMS**) refers to the management of an organization's environmental programs in a comprehensive, systematic, planned and documented manner. It includes the organizational structure, planning and resources for developing, implementing and maintaining policy for environmental protection. http://en.wikipedia.org/wiki/Environmental_management_system

[2] **PDCA** (**plan–do–check–act**) is an iterative four-step management method used in business for the control and continuous improvement of processes and products. It is also known as the **Deming circle/cycle/wheel.** http://en.wikipedia.org/wiki/PDCA

[3] Figure adopted from: http://en.wikipedia.org/wiki/PDCA

IPMVP

The International Performance Measurement and Verification Protocol (IPMVP) defines standard terms and suggests best practise for quantifying the results of energy efficiency investments and increase investment in energy and water efficiency, demand management and renewable energy projects. The IPMVP was developed by a coalition of international organizations (led by the United States Department of Energy) starting in 1994-1995. The Protocol has become the national measurement and verification standard in the United States and many other countries, and has been translated into 10 languages. IPMVP is published in three volumes, most widely downloaded and translated is IPMVP *Volume 1*: *Concepts and Options for Determining Energy and Water Savings*.
A major driving force was the need for a common protocol to verify savings claimed by Energy Service Companies (ESCOs) implementing Energy Conservation Measures (ECM). The protocol is a framework to determine water and energy savings associated with ECMs. The purpose of the IPMVP® is to increase certainty, reliability, and level of savings; reduce transaction costs by providing an international, industry consensus approach and methodologies; reduce financing costs by providing a project with a Measurement and Verification Plan (M&V Plan) standardization.
M&V activities consist of some or all of the following:

- Meter installation calibration and maintenance,
- Data gathering and screening,
- Development of a computation method and acceptable estimates,
- Computations with measured data,
- Reporting, quality assurance, and third party verification of reports.

IPMVP provides four Options for determining savings (A, B, C and D). The choice among the Options involves many considerations. The selection of an IPMVP Option is the decision of the designer of the M&V programme for each project. These options are summarised below:

Option (A) Retrofit Isolation: Key Parameter Measurement

Savings are determined by field measurement of the key performance parameter(s) which define the energy use of the energy conservation measure's (ECM) affected system(s) and/or the success of the project. Parameters not selected for field measurement are estimated. Estimates can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required.

Option (B) Retrofit Isolation: All Parameter Measurement

Savings are determined by field measurement of all key performance parameters which define the energy use of the ECM-affected system.

Option (C) Whole Facility

Savings are determined by measuring energy use at the whole facility or sub-facility level. This approach is likely to require a regression analysis or similar to account for independent variables such as outdoor air temperature, for example.

Option (D) Calibrated Simulation

Savings are determined through simulation of the energy use of the whole facility, or of a sub-facility. Simulation routines are demonstrated to adequately model actual energy performance measured in the facility. This Option usually requires considerable skill in calibrated simulation.

Energy, water or demand savings cannot be directly measured, since savings represent the absence of energy/water use or demand. Instead, savings are determined by comparing measured use or demand before and after implementation of a program, making suitable adjustments for changes in conditions.

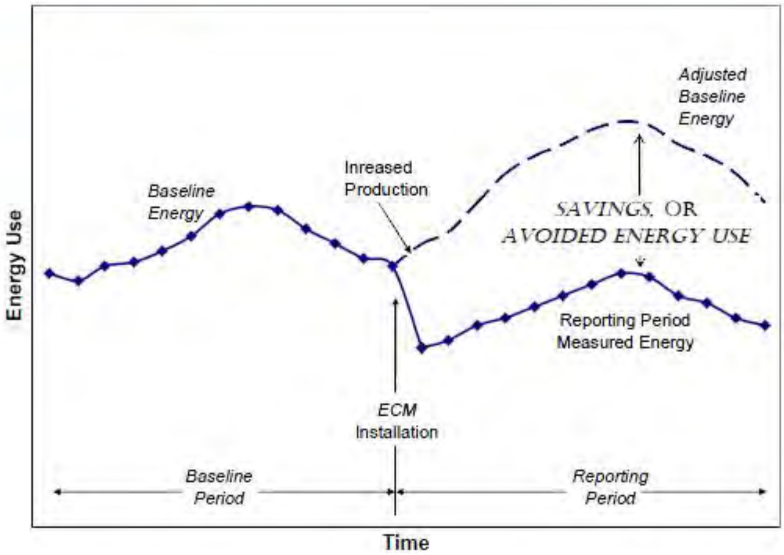


Figure 33: Example of savings determination process[1]

As an example of savings determination process, Figure 33: shows the energy-usage history of an industrial boiler before and after the addition of an energy conservation measure (ECM) to recover heat from its flue gases. At about the time of ECM installation, plant production also increased.
To properly document the impact of the ECM, its energy effect must be separated from the energy effect of the increased production. The "baseline energy" use pattern before ECM installation was studied to determine the relationship between energy use and production.
Following ECM installation, this baseline relationship was used to estimate how much energy the plant would have used each month if there had been no ECM (called the "adjusted-baseline energy"). The saving, or 'avoided energy use' is the difference between the adjusted-baseline energy and the energy that was actually metered during the reporting period.
Without the adjustment for the change in production, the difference between baseline energy and reporting period energy would have been much lower, under-reporting the effect of the heat recovery.
It is necessary to segregate the energy effects of a savings program from the effects of other simultaneous changes affecting the energy using systems. The comparison of before and after energy use or demand should be made on a consistent basis, using the following general Equation):

Savings = (*Baseline-Period Use* or Demand - *Reporting-Period Use* or Demand)± Adjustments

The "Adjustments" term in this general equation is used to re-state the use or demand of the baseline and reporting periods under a common set of conditions. This adjustments term distinguishes proper savings reports from a simple comparison of cost or usage before and after implementation of an energy conservation measure (ECM). Simple comparisons of utility costs without such adjustments report only cost changes and fail to report the true performance of a

[1] Figure adopted from: "International Performance Measurement and Verification Protocol" Prepared by Efficiency Valuation Organization (www.evo-world.org) - 2012

project. To properly report “savings,” adjustments must account for the differences in conditions between the baseline and reporting periods.
The processes of determining savings in energy are analogous to those for determining savings in water.
Indeed water-efficiency M&V is analogous to energy-efficiency M&V, so uses similar M&V techniques. Water-consuming equipment is often in the control of facility users (building occupants or production managers). Therefore it can be difficult to monitor user behaviour as needed to make adjustments to total-facility water use for the application of Option C methods. Retrofit Isolation methods are often more easily applied, using a sample of the retrofits to demonstrate the performance of an entire group of changes.

The Measurement and Verification Plan (M&V Plan) could be suitable with WATERNOMICS objectives and it can be surely applied to the pilots sites system development and to the methodology with the aim to assess the if the targets of Water Efficiency Measures have been achieved.

4.2.2 Principal Standards from water sector

In Table 19, the standards related to water are detailed which were referred to in Table 17by expanding their title and providing highlight remarks. The definitions for the standards are adapted from the ISO website http://www.iso.org/iso/home/standards.htm.

Table 19: Existing standards for Water sector

Standard	Title	Remarks
ISO 24510 (2007)	Activities relating to drinking water and wastewater services - Guidelines for the assessment and for the improvement of the service to users	• Basic idea: It specifies the elements of drinking water and wastewater services of relevance and interest to users. It also provides guidance on how to identify users' needs and expectations and how to assess whether they are being met. • The following are within the scope of ISO 24510:2007: • the definition of a language common to the different stakeholders; • the definition of key elements and characteristics of the service to users; • the objectives for the service with respect to users' needs and expectations; • guidelines for satisfying users' needs and expectations; • service to users assessment criteria; • introduction to performance indicators; • examples of performance indicators.
ISO 24511 (2007)	Activities relating to drinking water and wastewater services - Guidelines for the	• Basic idea: It provides guidelines for the management of wastewater utilities and for the assessment of wastewater services. It is applicable to publicly and privately owned and

	management of wastewater utilities and for the assessment of wastewater services	operated wastewater utilities, but does not favour any particular ownership or operational model. It addresses wastewater systems in their entirety and is applicable to systems at any level of development (e.g. pit latrines, on-site systems, networks, treatment facilities). • The following are within the scope of ISO 24511:2007: • the definition of a language common to different stakeholders; • objectives for the wastewater utility; • guidelines for the management of wastewater utilities; • service assessment criteria and related examples of performance indicators, all without setting any target values or thresholds.
ISO 24512 (2007)	Activities relating to drinking water and wastewater services -- Guidelines for the management of drinking water utilities and for the assessment of drinking water services	• Basic idea: It provides guidelines for the management of drinking water utilities and for the assessment of drinking water services. It is applicable to publicly and privately owned and operated water utilities. It does not favour any particular ownership or operating model. It addresses drinking water systems in their entirety and is applicable to systems at any level of development (e.g. on-site systems, distribution networks, treatment facilities). • The following are within the scope of ISO 24512:2007: • the definition of a language common to different stakeholders; • the definition of the components of drinking water supply systems; • guidelines for the management of drinking water utilities; • guidelines for objectives, service assessment criteria and related performance indicators, appropriate for the assessment of drinking water services.
ISO 12242 (2012)	Measurement of fluid flow in closed conduits -- Ultrasonic transit-time meters for liquid	• Basic idea: It specifies requirements and recommendations for ultrasonic liquid flowmeters, which utilize the transit time of ultrasonic signals to measure the flow of single-phase homogenous liquids in closed conduits. There are no limits on the minimum or maximum sizes of the meter. It specifies performance, calibration and output characteristics of ultrasonic meters (USMs) for liquid flow measurement and deals with installation conditions. It covers installation with and without a dedicated proving

		(calibration) system. It covers both in-line and clamp-on transducers (used in configurations in which the beam is non-refracted and in those in which it is refracted). Included are both meters incorporating meter bodies and meters with field-mounted transducers.
ISO 14046 (2014)	Environmental management -- Water footprint -- Principles, requirements and guidelines	• Basic idea: It specifies principles, requirements and guidelines related to water footprint assessment of products, processes and organizations based on life cycle assessment (LCA). It provides principles, requirements and guidelines for conducting and reporting a water footprint assessment as a stand-alone assessment, or as part of a more comprehensive environmental assessment. Only air and soil emissions that impact water quality are included in the assessment, and not all air and soil emissions are included. The result of a water footprint assessment is a single value or a profile of impact indicator results.
IPMVP (2012)	International Performance and Measurement Verification Protocol.	• Basic Idea: To provide a framework (typically between ESCO and client) to plan, measure or calculate, and verify the outcome of energy / water efficiency measures.
IWA 6 (2008)	ISO International Workshop Agreement (IWA)- Guidelines for the management of drinking water utilities under crisis conditions	• Basic Idea: It is intended to identify and chart the critical elements that are of great significance to drinking water security. Its purpose is to set in motion a continuous process for the establishment of guidelines on management systems for drinking water utilities under crisis conditions. • IWA 6:2008 provides the guidelines for a water utility, or anybody responsible for the management of parts of the water supply system, to be prepared and ready to manage a water crisis. It also provides a roadmap for possible relevant International Standards that could be useful and could be developed.
ISO/TC 224 (2008)	Service activities relating to drinking water supply systems and wastewater systems - Quality criteria of the service and performance indicators	• Basic Idea: Standardization of a framework for the definition and measurement of service activities relating to drinking water supply systems and wastewater systems. • The standardization includes the definition of a language common to the different stakeholders, the definition of the characteristics of the elements of the service according to the consumers expectations, a list of requirements to fulfill for the management

		of a drinking water supply system and a wastewater system, service quality criteria and a related system of performance indicators, without setting any target values or thresholds.

ISO 14046

It specifies principles, requirements and guidelines related to water footprint assessment of products, processes and organizations based on life cycle assessment (LCA). The water footprint is an indicator of freshwater use that looks not only at direct water use of a consumer or producer, but also at the indirect water use. The water footprint can be regarded as a comprehensive indicator of freshwater resources appropriation, next to the traditional and restricted measure of water withdrawal. The water footprint of a product is the volume of freshwater used to produce the product, measured over the full supply chain.
Until ISO 14046 publication, ISO 140001 was used to manage water use and supply[1]; anyhow while ISO 140001 is a generic standard ISO 14046 is a "*water management standard*".
The water footprint assessment according to this International Standard can be conducted and reported as a stand-alone assessment, where only impacts related to water are assessed, or as part of a life cycle assessment, where consideration is given to a comprehensive set of environmental impacts and not only impacts related to water (air and soil emissions are included in the assessment).
Water footprint assessment is an analytical tool, it can be instrumental in helping to understand how activities and products relate to water scarcity and pollution and related impacts and what can be done to make sure activities and products do not contribute to unsustainable use of freshwater. As a tool, a water footprint assessment provides insight, it does not tell people 'what to do'. Rather it helps people to understand what can be done.
A full water footprint assessment [2] consists of four distinct phases:

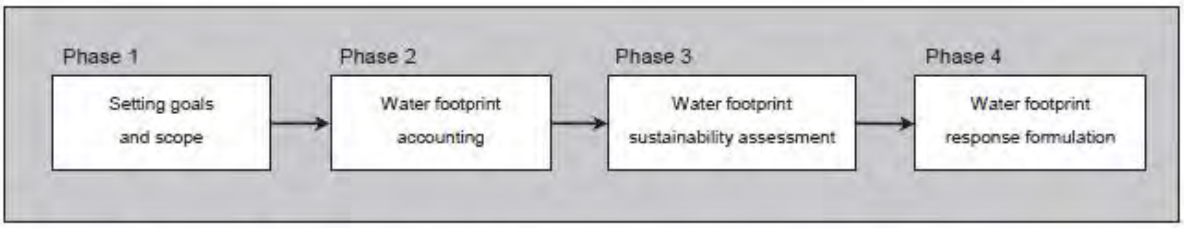


Figure 34: Water footprint assessment[3]

1. Setting goals and scope.
2. Water footprint accounting.
3. Water footprint sustainability assessment.
4. Water footprint response formulation.

A water footprint study can be undertaken for many different reasons. For example, a national government may be interested in knowing its dependency on foreign water resources or it may be interested to know the sustainability of water use in the areas where water-intensive import

[1] http://www.bsigroup.com/en-GB/ISO-14046-Water-footprint--Principles-requirements-and-guidelines/
[2] "The Water Footprint Assessment Manual" - http://www.waterfootprint.org/?page=files/WaterFootprintAssessmentManual
[3] Figure adopted from: "The water footprint assesment manual" – A. Y. Hoekstra, A. K. Chapagain, M. M. Aldaya, M. M. Mekonnen - 2011

products originate. The phase of water footprint accounting is the phase in which data are collected and accounts are developed. In the phase of sustainability assessment the water footprint is evaluated from an environmental perspective, as well as from a social and economic perspective. In the final phase, response options, strategies or policies are formulated.
Any way whereas reporting is within the scope of ISO 14046:2014, communication of water footprint results, for example in the form of labels or declarations, is outside the scope of ISO 14046:2014[1].
For this reason an EU project "Virtual Water" [2] has developed a label according to the water footprint ISO 14046:2014 to show to the water users haw much freshwater is used to produce a selected product, hoping for people to rethink their consumption pattern.

4.2.3 Labelling and certification

Labelling and certification is one possible outcome of Waternomics and can also be made part of water information system. It influences people and encourages changes in their water usage behaviour. As such, it is important for Waternomics to be aware of the landscape for water certification at management, process and policy levels. It is also the case that eco-labelling carries a positive sentiment worldwide and which is reflected in consumer demand which put pressure on industry to produce products that have such labels. As a consequence, many organizations commit to conducting and achieving such certifications and this becomes part of their marketing and branding strategy. In doing so, they save water, resources and money and this increases their competitiveness.In this sense, the objectives ofWaternomics are very relevant for water end-users, urban management and corporations.

Similarly to the standards,also the certifications and labels worldwide are numerous and various choices exist. With respect to the energy sector the most important certifications are these shown in the following table which are extracted as those relevant to water from a broader list of ecolabels (http://www.ecolabelindex.com/ecolabels/). Of note, the EU energy label contains water KPIs directly on the label itself:

Table 20: Energy certifications an labelling

Energy sector	
Certification	**Symbol**
EU Ecolabel	

[1] http://www.iso.org/iso/catalogue_detail?csnumber=43263

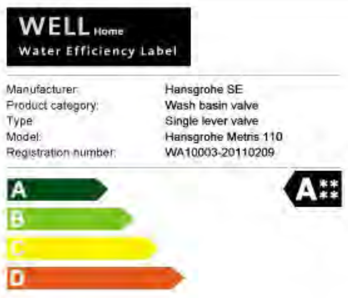
[2] http://virtualwater.eu/

USA Energy Star	
EU Energy Label	

Also in the water sector there are certifications and labels related to water efficient products and practices through which consumers can save natural resources, reduce water consumption, and save money. In order to realize these savings, consumers need to be able to identify products and services that use less water while performing as well as or better than conventional models. In this sense, it must be clear what the certification or label means, it must be easy to see and recognize and it should be trustable. With respect to independent labelling programs, several well known water-related certification and labels are shown in Table 21.

Table 21:Water certifications an labelling

Water sector		
Certification	**Symbol**	**Web link**
WaterSense		http://www.epa.gov/WaterSense/

WELL (Water Efficiency Label)		http://www.well-online.eu/en/default.aspx
Waterwise Marque		http://www.waterwise.org.uk/pages/the-waterwise-marque.html
WELS (Water Efficiency Labelling & Standards)		http://www.waterrating.gov.au/
Smart WaterMark		http://www.smartwatermark.org/home/default.asp
VirtualWater		http://virtualwater.eu/
WaterWally		http://en.wikipedia.org/wiki/Water_Wally

There is a wide range of product eco-labels and in recent years the demand for water label products has accelerated asmanufacturers have realizedthat theeco-label isan excellent tool formarketingand branding. In addition, consumer demand/choice is reflecting preference for sustainable products. Criteria for certification may vary depending on what is important to the company, consumer or policy (when present). Examples may include low emissions, energy efficiency, high percentage of recycled content, life-cycle features, carbon footprint, water footprint, etc. Some certifications only

look at one particular criterion (e.g. emissions or energy consumption or water consumption). These certifications are known as single-attribute certifications. Other certifications look at several product characteristics and are known as multiple-attribute certifications. Still others examine a product's raw materials, how it is manufactured, how it performs and what happens to it when its life is over. These are life cycle-based certifications. Some multiple-attribute and life cycle-based certifications also include performance standards (e.g. Water footprint – ISO 14046:2014).

WATERSENSE[1]

WaterSense, a partnership program by the U.S. Environmental Protection Agency, offers people a simple way to use less water with water-efficient products, new homes, and services.
The program seeks to help consumers make smart water choices that save money and maintain high environmental standards without compromising performance. Products and services that have earned the WaterSense label have been certified to be at least 20 percent more efficient without sacrificing performance.Upgrading to more efficient WaterSense labeled products can help to save billions of gallons of water in the country every year.

WELL[2]

WELL is a product classification system of the European sanitary valve industry, which

- Fulfils the increasing and understandable desire of consumers, both in Europe and worldwide, for information and guidance in making a conscious purchasing decision.
- Implements the industry's desire to promote responsible water usage by consumers.

The labelling system is very similar to the one that is already utilized in energy sector, indeed A 2-star classification is the maximum that can be achieved in each category, and a differentiation is made between valves for the domestic "Home" and the commercial "Public" areas, depending on their use. Valves for the public sector receive a score of up to 6 stars (efficiency classes A to F) and in the private sector a maximum of 4 stars (efficiency classes A to D).

WATERWISE[3]

Waterwise is an independent, not for profit organization and it has become the leading authority on water efficiency in the UK and Europe.
The Waterwise Checkmark provides consumers with an 'at a glance' indicator of a products water saving potential. The Checkmark signifies that the product is recognised as a water saver. A range of products have been awarded the Checkmark, ranging from; showers, domestic water recycling products, tap flow restrictors and toilet retrofit devices to name a few.

WELS[4]

WELS is Australia's water efficiency labelling scheme that requires certain products to be registered and labelled with their water efficiency in accordance with the standard set under the national Water Efficiency Labelling and Standards Act 2005.

[1] http://www.epa.gov/WaterSense/ (accessed November 2014)
[2] http://www.well-online.eu/en/default.aspx (accessed November 2014)
[3] http://www.waterwise.org.uk/pages/the-waterwise-marque.html (accessed November 2014)
[4] http://www.waterrating.gov.au/ (accessed November 2014)

Australia is the Earth's driest inhabited continent, itsuffers from serious problems of water scarcity, for this reason Australian Government inducesa changein people's behaviourwith regard towater use throughecolabelproducts.

Australians could save more than one billion dollars through reduced water and energy bills by simply choosing more efficient products.

The target is to achieve, using water efficient products, by 2021

- Reduce domestic water use by more than 100,000 megalitres each year;
- Save more than 800,000 megalitres (more water than Sydney Harbour); and
- Reduce total greenhouse gas output by 400,000 tonnes each year - equivalent to taking 90,000 cars off the road each year.

By choosing to use more water-efficient products in the home, Australians could both save water and reduce their water and energy bills. The concept is very simple: the more stars on the WELS label, the less water that product will use, and the more money and environment you will save.

SMART APPROVED WATERMARK[1]

The Smart Approved WaterMark was established by four associations, the Australian Water Association, Irrigation Australia, the Nursery and Garden Industry Australia and the Water Services Association of Australia.

- www.awa.asn.au
- www.irrigation.org.au
- www.ngia.com.au
- www.wsaa.asn.au

They are not-for-profit scheme and are overseen by a Steering Committee with representation from Commonwealth and State Governments, Water Utilities, the four governing associations, and the chair of the Technical Expert Panel. The Australian Government supports the scheme with a grant from the Water Smart Australia programme administered by the Department of the Environment, Water, Heritage and the Arts. Smart Approved WaterMark is Australia's water saving labelling program for products and services which are helping to reduce outdoor water use. Also in this case the concept is simple: look out for the Smart Approved WaterMark label when you're shopping to be sure that what you're buying really will save you water.

VIRTUAL WATER EU Project[2]

Virtual Water is a recently finished FP7 project which developed a label according to the water footprint ISO 14046:2014 to show to the water users how much freshwater is used to produce a selected product, hoping for people to rethink their consumption pattern. The virtual-water content of a product (a commodity, good or service) is the volume of freshwater used to produce the product, measured at the place where the product was actually produced (production-site definition). It refers to the sum of the water use in the various steps of the production chain. The virtual-water content of a product can also be defined as the volume of water that would have been required to produce the product at the place where the product is consumed (consumption-site

[1] http://www.smartwatermark.org/home/default.asp (accessed November 2014)
[2] http://virtualwater.eu/ (accessed November 2014)

definition). The adjective ‘virtual’ refers to the fact that most of the water used to produce a product is not contained in the product. The real-water content of products is generally negligible if compared to the virtual-water content.
Available via a poster or i-phone app, people are given information of how much water is necessary to produce a single product and grow more conscious about how much water our everyday food and beverages really consume. Although not as widely known (yet) as government level programs/labels, the work of Virtual Water is worth noting as it has become a reference and benchmarking source.

WATER WALLY[1]

As a densely populated island city-state with 5.4 million people living across roughly 710 km^2, Singapore has no natural water resources, making water management a huge challenge. In the ’60s and ’70s, Singapore was heavily reliant on imported water from Malaysia, however, in the last 50 years, by investing in water technology and adopting an integrated approach to water management, Singapore has developed a diversified and sustainable water-supply strategy utilising local catchment, imported water, reclaimed water (or NEWater) and desalinated water. To solve this problem as well asfocus onnew infrastructures,theSingaporeangovernmentalso tried tochange the attitudeof people towardsthe use of water, one example of this campaign is Water Wally.

Water Wally is the name of the official Singapore Public Utilities Board (PUB) mascot. Water Wally is blue in colour and shaped like a water droplet.Water Wally conveys messages about water conservation and usage to the public, hoping for people to rethink their water consumption pattern.

4.3 Governance investigated

For governance we understand those processes through which decisions are made within an organization, or a group of organizations that share one resource. The process of decision-making will define who is involved (stakeholders), how they are related to each other and for what they are responsible in the process (relationships). In other words, a governance model specifies the distribution of decision-making authority and influence. We see a governance element as part of Waternomics because understanding the processes of how decisions are made may explain the visible results of an organization. Pointing to different elements (and improving) governance processes can help/hamper water conservation in several ways (Cook et. al, 2008):

- Improve/facilitate access to information allows stakeholders make more effective decisions
- Participation by stakeholders and users increases buy-in to water conservation
- Engagement of national government in water management facilitates the implementation of efficiency standards, rather than municipalities alone

For Waternomics the decision-making processes for the implementation of water savings/efficiency programmes (ie. smart metering, leak detection) have been analysed. We do not aim at concluding which governance model works better than the other, rather than pointing out at different elements that have made the implementation of these programmes more effective.

In this section we will focus on an overview of regulations that have had or will have an impact on how water efficiency programmes have been developed. It is important to inventorise laws, regulations and policies that can foster the use and implementation of efficiency programmes, or, in

[1] http://en.wikipedia.org/wiki/Water_Wally (accessed November 2014)

the opposite way, may hamper de adoption of certain developments. For example, the development and implementation of Smart Water Management Technology is further fostered when clear laws and policies are in place governing it. Regulations can drive the development of environmental technology which in its turn foster developments in technologies related to water availability and quantity.

These regulations are developed in conjunction with and require the participation and adoption of them by entities at all levels of the governance process. Municipalities, governments and international governmental organizations are crucial to the overall process (EU, 2009: 14 - white paper). For example, Henriette Faergemann, leader of the 'scarcity and droughts' team at the European commission says: 'there are many possibilities to reduce leakages, but the management of water quantity needs to be much better integrated. In other words, policies and water management should not be understood exclusively in their individual use, or the management of individual organizations. Rather, water management and the implementation of water efficiency measures should be understood and researched in its entirety'[1].

Due to the regional variability and severity of climate impact, most adaptation measures will be taken at national, regional or local level. However, these measures can be supported and strengthened by an integrated and coordinated approach at EU level. (EU, 2009: 6 - white paper). Every location will have its own idiosyncrasies, its own specific user portfolio, as well as will have to manage specific locally available natural resources. All these elements will shape which technology is used, which prioritization it receives and how effective its implementation will be.

Every case, thus, will have to be understood locally, to see what regulations have been influential and how an overlap of institutions can foster developments, or hamper them. There are cases in which the not well defined position (be it because of geographical boundaries, or because of too much overlap) has hampered the progress and implementation of certain policies. Laffont (2005) reports on the case of the US in the 19th century where organizations using the resource from one geographical location, but actually formally belonging to another geographical jurisdiction are conflictive in pricing practices and environmental protection. Staub (2009), reports on the cases of Colombia and Peru, where conflicts between local and national regulation end up in lack of implementation of the legal framework at all levels. These conflicts still happen today in Europe. In Ireland conflicts have appeared between locals living along the river Shannon, and national interests of withdrawals of water from the river Shannon to feed the Dublin water systems[2].

'Regulatory bodies are characterized by different types of leadership and varying durations of term, with consequences on the stability of the process' (Staub, 2009: 20) - which who and how regulations are cascaded down could have an effect on their enforcement and on their impact/implementation.

The following overview aims to highlight the most relevant initiatives at EU level that have been potentially of influence in water efficiency practices and how they have promoted (or not) the development of ICT for the purpose of increased information and better control.

4.3.1 EU Water Framework Directive (WFD)

At European level the EU Water Framework Directive (WFD) was established in 2000 (Directive 2000/60/EC). For the first time at European level it was recognized that water management needed to move beyond water distribution and water treatment. EU water policy has successfully contributed, but also to date limited itself, to the protection of water resources. The main objective

[1] Euactiv --- ibid
[2] http://www.independent.ie/irish-news/dublin-to-get-water-from-river-shannon-by-2020-30265418.html

of the WFD is to achieve good status of all water bodies by 2015 (EU, 2012: 3). Several causes converge and are interlinked in their negative impact on the state of water bodies. From climate change to land use and economic activities (ie. energy production, industrial, municipal). These uses of water contribute to the source deterioration by increased/uncontrolled pollutant emissions or also water overuse or overexploitation. Even though the focus of the WFD and its interventions has been mainly geared to pollution and quality controls of water bodies (chemical status), deterioration of both quality and quantity of water bodies has a direct impact on utilities. The European Commission has identified a number of additional actions in terms of water efficiency that can potentially have an impact on water quality and contribute to achieve the Directive's objectives. These actions are cascaded down into the water management organization of each Member State and will eventually have an impact on water utilities, or other organizations that develop their own water resources (ie. big industries as the airports).

Some of these measures prompted from the WFD and that may have an impact on water utilities, as well as the outcomes of this project are (EU, 2012: 11-20):

- Water accounts at river basin and sub-catchment: These plans are still in development and are implemented at Member State level. The water accounts are targeted at providing a better insight for water managers on how much water flows in and out of a river basin, and in return, how much water can be expected to be available and allocated.
- Improved efficiency of water use: river basin authorities should develop water efficiency targets. Even though targets should be developed at national levels to reflect local realities the focus of this measure has shifted towards the development of new technology that can be adjusted and modelled according to the many different ways of managing water currently in use in Europe. The targets on efficiency have an increased emphasis on the impact of users on relevant conservation strategies.
- Improve leakage detection in distribution systems: Even though the European Commission believes that this can only be addressed on a case-by-case manner, as highlighted above, it has made the commitment in the framework of this Directive to work with the EU water industry to accelerate the development and spread of best practices and a strategic vision for the future of water infrastructure.
- Implementation of economic instruments and the push for full cost recovery principles within the management of water utilities (including as well polluter pays principle) have had an impact on how water utilities strive for efficiency measures

EU Directives provide a set of recommendations for national and policy development. The reason for that is the heterogeneous realities of the different Member States. In order to understand how EU policies have been adjusted to different levels of governance we will necessarily have to understand how these recommendations have translated into national and local regulations.

BLUEPRINT TO SAFEGUARD EUROPE'S WATER RESOUCES

Even though this document is not a regulation as such, its development has been of great influence. It is important to discuss The Blueprint since it set a before and after situation of the WFD by evaluating critical and influential EU water policies in a comprehensive documentation of the EU water policies until 2012. Additionally, it has set out key actions that need to be taken by water managers and policy makers to address the challenges faced in the field. This document also set out clearly the goals and development path for EU water policy:

'Blueprint to safeguard Europe's Water Resources' will review the water policy processes most important to resource efficiency: water scarcity and drought policy; the water-related part of

Europe's climate change vulnerability and adaptation policy; and, most important, the state of play in the implementation of the Water Framework Directive (EU, 2000).'(EEA, 2012 Towards efficient… page 9)

A main concern raised by this document was the lack of implementation of the numerous regulations developed by the EU. An emphasis is made in the development of new technology. Unfortunately, little of the products developed by European research in the field of water management has been applied (EUrActiv).

This document calls for:

- Greater implementation of (smart) technology: from development to implementation
- Develop partnerships at EU level: foster cross-sectorial approach (bring together path forward for the industry)

URBAN WASTE WATER AND DRINKING WATER DIRECTIVE

During the last two decades, the EU directives for drinking water and urban wastewater treatment have been key drivers of infrastructure development and compliance. The directives have had direct implications on utilities, as well as on industrial users. These developments have been focused mainly in the fields of water-quality criteria, and not necessarily in in water efficiency. The directives do not necessarily prescribe the use or adoption of new smart technology, other than encouraging it. Programmes of leakage detection and reduction are not specifically included in any policy. 'Currently leakage rates are not subject to regulation other than management decisions by utilities. These are often based on considerations such as consumer health and the economic return period for investments in infrastructure maintenance.' (EEA, 2012: 17 – towards efficiency). However, they offer great potential and are most suited to address efficiency problems. This Directive can have a two-fold effect on utility performance. They support the use of less (and of better quality) water which contributes to water conservation. At the same time, these policies and what they require from water utilities (and users) affects their financial performance as a smarter water management will result into a smarted financial management, derived from reduced investment requirements.

ENERGY POLICIES

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, also commonly known as the EU Energy Efficiency Directive, specifies that Member States should set an indicative national energy efficiency target, based on either primary or final energy consumption, primary or final energy savings, or energy intensity.

The EU climate and energy package is a set of binding legislation which aims to ensure that the EU meets its climate and energy targets for 2020. These '20-20-20' targets set three key objectives for 2020:

- a 20 % reduction in EU greenhouse gases (GHG) emissions from 1990 levels
- raising the share of EU energy consumption produced from renewable resources to 20 %
- a 20 % improvement in the EU's energy efficiency

In principle, the directive is an important driver for the national targets on energy efficiency, but it does not impose a specific regulation for the water utility sector.

4.3.2 Cascading to national, local, industry level

According to a survey developed in 2011 by the European Environmental Agency, very few countries (Austria and Germany and the Flanders region of Belgium) include a dedicated strategic policy document in their national regulations for resource efficiency. Instead, six broad 'economy-wide' types of strategies or action plans commonly include references to resource efficiency (EEA, 2011:9). The priority resources most commonly reported by countries were energy carriers (22 mentions) and waste (18 mentions), followed by minerals and raw materials (16) and water (14). Information provided by countries on targets and indicators for resource efficiency[1] shows a large variety of approaches to resource efficiency in national policies, remaining in its majority vague or fairly general. For example, some of the common strategic objectives referred to 'reducing use of water and protection water resources' (EAA, 2011: 9)

From the same report we distil that national policies geared towards resource efficiency or conservation are mostly motivated by changes in the environment and could roughly be grouped in those that relate directly to environmental degradation concerns (ie. Germany). The countries that provided information on the evolution of resource efficiency policy tended to identify the energy crisis of 1970s or the beginning of environmental policies around that time as a starting point for the development of their national policies. From the other hand, there were another group of countries that highlighted the economical factors (ie. increase costs of resources, or due to needs for economic reform) as another driver for change. The study highlights policy priorities were driven by an acute shortage of a critically important resource, which could be water, besides the environmental and economical implications of such a shortage.

Apart from the internal changes in the country, the study shows as well that EU policy initiatives are a strong driver for policy change or development at the national level. About half of the sample countries already included elements of resource efficiency in their national policies or strategies derived from the EU initiatives such as Europe 2020 (with its requirements for adopting national reform programmes and the Flagship Initiative for a Resource Efficient Europe) or EU Raw Materials Initiative[2]. When these policies or strategies, however, get translated to the national level a case by case study is necessary to determine how they have been adopted, who has promoted them and under which entity do they fall. There is a great variety of institutional arrangements and topics within the EU related to resource efficiency. Typically, these interests fall under several Ministries at national level (ie. energy, agriculture, economy and/or environment) and at the same time they are cascaded to a vast range of national organizations from river basin organizations, to environmental agencies and at the local level the municipalities. For example, the Energy Efficiency Directive does not establish obligatory prescriptions for the water sector. However, some associations or government organizations have taken the initiative to promote efficiency targets in terms of energy. The German Association for Water, Wastewater and Waste (DWA) has not specifically determined targets for energy efficiency at individual urban wastewater treatment plants (UWWTPs), but instead has proposed that energy checks and analyses are conducted. Resource efficiency targets may also be incorporated into policies by individual water utilities. For example, local authorities in the French towns of Orleans and Hyeres have requested that their water operators fulfil certain energy efficiency improvements, often with bonus/penalties clauses where such improvements are not met.

[1] The study did not spell out the definition of resource or resource efficiency. From the results, the analysis develops that there is no clear definition nor common understanding of the terminology. However, both terms were used as synonyms in the majority of cases as 'sustainable use' or 'minimizing the use' (EAA, 2011: 8)

[2] http://ec.europa.eu/enterprise/policies/raw-materials/index_en.htm

4.4 International and European benchmarking

For Waternomics we also have analysed the decision-making processes for the implementation of water savings/efficiency programs developed across the globe with particular emphasis on water stressed regions (Australia, California, Singapore) and with particular regard toseveral countries directly involved in the project (Italy, Greece and the Netherlands). The aim is to identify best practices and lessons learned. For the sake of brevity in the main report, these case studies are provided in Appendix A and summary tables are reported in this chapter.

4.4.1 International benchmarking

Table 22 provides a concise view of the programs, lessons learned and best practices related to the international countries analysed and how those aspects were considered or are relevant to Waternomics. The countries selected (Australia, Singapore and California, USA) are all water stressed regions and are leaders in the area of water efficiency programs.

Table 22: Lesson learned from international benchmarking

<table>
<tr><th>Country</th><th>Program, lesson or best practice</th><th>Consideration in Waternomics</th></tr>
<tr><td>Australia</td><td>• Issuance of water savings challenges
• Use of public engagement and public input to drive program success
• Use of gamification as a tool to educate users
• Tools and methods are necessary to easily manage users’ water consumption</td><td rowspan="3">• Water information systemas both a “serious” environment and an “educational environment”
• Development of a systematic and standards based approach to a Water management methodology
• Mehodology provides tools and methods for users to easily manage their water behaviour
• Inclusion of drought management
• Gamification as an important point to achieve users involvement and change in behaviour
• Metering is necessary to make informed choices and in turn increase the rate adoption of smart water technologies that reduce water consumption</td></tr>
<tr><td>Singapore</td><td>• Water Wally – national level mascot for water savings
• Impact of increasing water tariffs on consumption
• Public awareness as the starting point for all water saving programs
• Water is public domain, the government intervenes in water issues through administration and regulations in the public interest
• Water metering is mandatory
• High level water management is necessary</td></tr>
<tr><td>California, USA</td><td>• Use of educational programs, kits and game environments in broad public awareness campaigns
• Impact of drought
• Water rights, agriculture management, water rationing and water fines
• Monitoring infrastructure is necessary to demonstrate the success of a water saving programme and methods</td></tr>
</table>

4.4.2 European benchmarking

Table 23 provides a concise view of the programs, lessons learned and best practices related to the European countries analysed and how those aspects were considered or are relevant to Waternomics. The countries selected (Italy, Netherlands and Greece) are directly involved in the project and in which consortium partners have direct exploitation ambitions.

Table 23: Lesson learned from European benchmarking

<table>
<tr><th>Country</th><th>Program, lesson or best practice</th><th>Consideration in Waternomics</th></tr>
<tr><td>Italy</td><td>Fragmented water law sector
High level of leakages
Some projects are ongoing with the objective to reduce water consumption, they all leverage with users informations and water measures.
Tools and methods are necessary to easily manage users' water consumption (see Project: Fight against waste)</td><td rowspan="3">A systematic approach and a clear distribution of roles and responsibilities is necessary to have a succesflul Water management program.The Waternomics Methodology is designed to achieve this specific objective
The right technology selection is important to achieve water saving also when there is no scarcity of water. Waternomics will provide a Technology selection tool.
Water fault detection can provide significant benefit. Waternomics will develop new sensors and analysis techniques to achieve this target
A water management system is based on the measurement of water abstraction and of water consumption. The methodology has robust assess and planning phases to achieve this.
Public awareness and communication aspects as well as end-user engagement is key to changing behaviour and achieving efficiency targets. The methodology and WIS target these aspects.</td></tr>
<tr><td>Greece</td><td>Pricing based on volumetric consumption can help to change the usesrs water realated behaviour
It's important to meter both the water abstraction and the water comsumption</td></tr>
<tr><td>Netherlands</td><td>Netherlands provides an example of a country where water is not scarce, yet the technological developments are significant and leading in the sector
Netherlands has been characterized by a decentralized governance system. Water management is carried out all government levels in a very efficient way
Water companies in the Netherlands are semi-public bodies that operate under private law while their owners are provinces and municipalities
A working system requires a systematic approach and a clear distribution of roles and responsibilities</td></tr>
</table>

5 Conclusion

This report has outlined the Waternomics methodology, unique methods developed in the project to put it into use and the information aggregated and considered in its development. With respect to the methodology and developed content, the research and interaction with stakeholders in and outside of the project have shown a clear need for the development of tools, references and resources to assist in the construct and implementation of water management programs and the execution of water efficiency measures.

The methodology presented consists of five phases: Assess, Plan, Do, Check, Act. The Assess Phase is an entry mechanism into an iterative PDCA cycle of progressive improvement. Each of the five phases has approximately roughly five activities which are the steps and methods associated with each phase. The approach is general enough to applicable to the different targeted stakeholders (domestic, municipal, corporate) but also detailed enough to be useful and actionable. Deliberately and by design, the methodology is based on standards so that the approach overall has a higher likelihood of adoption, uptake and replication. The use of ICT is the second cornerstone of the methodology and overall the methodology is branded as a "Standards based approach for the implementation of an ICT-enabled water management program."

Each activity within the phases can be considered a method or way to do a task. In addition to the activities and embedded methods, four additional methods unique to the Waternomics project are presented. These are the use of a Trello Board for methodology communication and implementation, a method for minimal data set design, a method for developing organizational culture and strategy and a method for selecting water sensing technologies.

Research activities conducted in developing the methodology are organized in the following way: a review of like research activities, a review of the standards, TCs, certification programs and labelling programs most relevant to the Waternomics project, a review of governance aspects in general and then with focus to international and European best practices in water scarce nations. Conclusions from this review and how they are considered in the Waternomics methodology are provided for both the international and European case studies. Overarching themes include:

- Price increases have historically reduced consumption
- Policy and governance drives change
- Policy or decisions at the organizational or household level must be communicated across multiple platforms
- Resources and best practices are available – people need help finding them
- A systematic approach as that which is presented in this report is needed – and works

Now that the Waternomics methodology has been developed, it will be implemented in the project pilot activities which include domestic, municipal and corporate settings. Lessons learned from the pilot activities will be reflected back into the methodology for a final version published at project conclusion.

Through dissemination and communication activities, the Waternomics methodology can be one step and contribution in the development of standards dedicated to water management programs following the process that occurred in the energy sector.

6 Appendix A: International and European case studies

6.1 International case studies

6.1.1 Australia Water Governance and efficiency programme

Australia is one of the driest continents on the planet[1], making the country a necessary laboratory for innovative approaches to water management and governance. Australia is characterized by a sparsely populated, semi-arid interior that is dominated by agriculture and the relatively water-abundant coastal edges that are home to the country's urban areas. Nearly 40 percent of Australia's agriculture is in the Murray-Darling River Basin, which straddles four states, with the vast majority located in New South Wales (NSW). The basin covers part of four States, Queensland, New South Wale, Victoria and South Australia, and also encompasses the Australia Capital Territory. The relative areas are shown in the accompanying Figure 35. Like many other countries, Australia has dealt and is dealing with myriad challenges in water resources management, including high extraction and diversion levels; lack of awareness of water as a finite resource; the need to retain in stream water for aquatic ecosystem health; and current and impending climate change impacts[2], which are predicted to decrease water availability. Its response is a water law system based on administrative permits that are sufficiently flexible to deal with a range of water uses.

Figure 35: Australia's State boundaries and capitals

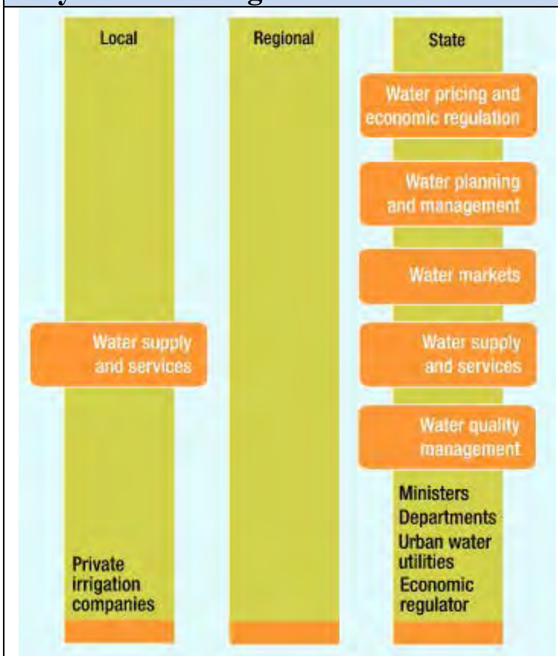
[1] "Murray-Darling River Basin Case Study Australia" – Braian Haisman (2013)

[2]http://www.csiro.au/science/climate-and-drought-in-eastern-Australia

Figure 36: Murray-Darling Basin showing Major Rivers[1]

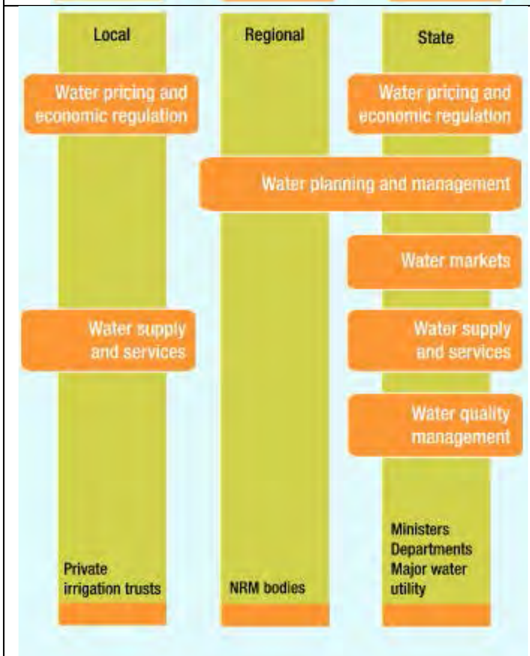
Understanding how water is managed in Australia and by whom is important to achieving National Water Initiative outcomes and long-term sustainable water management.

According to the Figure 36 above we can summarize in the following table the key water-management institutions (who is responsible) and legislative and administrative arrangements (how it is done) for each Australian state and territory[2]. A point to consider for Waternomics is that people need to know what the governance rules are where they live.

Key water-management institutions	Where	Short description
		In Western Australia, water management responsibilities rest with various state and local organizations

[1] Figure adopted from: "Murray-Darling River Basin Case Study Australia" – Braian Haisman (2013)

[2] http://archive.nwc.gov.au/home/water-governancearrangements-in-australia

		In the Northern Territory, water management responsibilities rest with various territory organizations.
		In South Australia, water management responsibilities rest with various state, regional and local organizations.

<table>
<tr>
<td>
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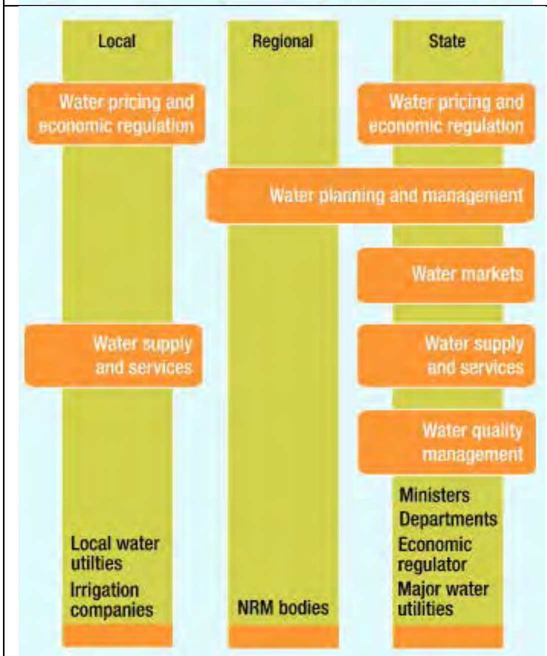
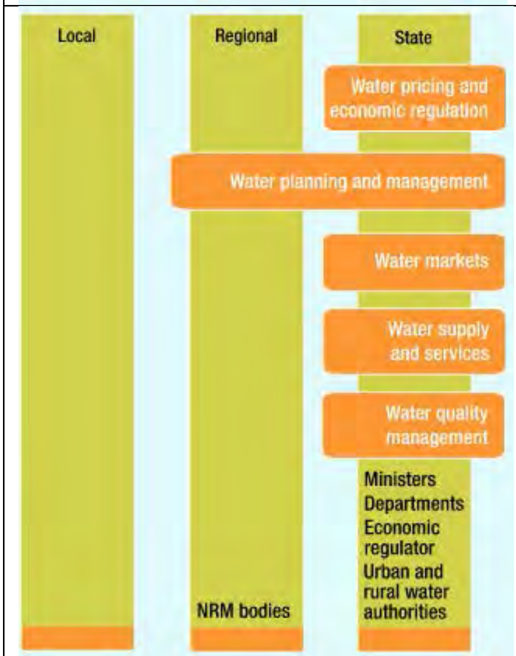
<td>
</td>
<td>In Queensland, water management responsibilities rest with various state organizations.</td>
</tr>
<tr>
<td>
</td>
<td>
</td>
<td>In New South Wales, water management responsibilities rest with various state, regional and local organizations.</td>
</tr>
</table>

		In the Australian Capital Territory, water management responsibilities rest with various territory organizations.
		Victoria, water management responsibilities rest with various state and regional organizations.

In Tasmania, water management responsibilities rest with various state, regional and local organizations.

Figure 37: Diagrams and accompanying text explain the key water-management institutions (who is responsible) and legislative and administrative arrangements (how it is done) for each Australian state and territory

Overview of the Water legal framework[1]*:*

Early water rights in the six colonies that would later form Australia were based in the same Roman and other ancient law concepts that the United Kingdom used, in which water was a common resource and there was a collective, public ownership of water. Under this system of "riparian" law[2], water use is tied to the land adjacent to the water body. While riparianism was suited for the relatively water-rich U.K., settlers in Australian quickly realized that riparian law was ill-suited for arid lands, where water was needed apart and at great distances from the land.

The first comprehensive piece of modern water legislation in Australia was the Water Act of 1912. This Act replaced common law riparian rights with statutory law to grant water use rights through an administrative process. This new system of water use rights required a license for water withdrawal, and the license was of limited duration and specified both use conditions and renewal procedures. The rights were granted on a first-come, first-served basis, and seniority or priority did not attach to these rights. Thus, all water use rights were viewed equally. Interestingly, the Act specifically excluded the payment of compensation for any changes in the volume of water allocations, based on the principle that water is a natural resource and owned collectively by the public.

During the years between 1912 and 2002, problems from over allocation of water resources arose with the introduction of irrigated cotton and large-scale farming operations. With this intense use of water, evidence of environmental harms began to appear, including irrigation-induced salinity in the waters of the Murray-Darling River Basin and declines of native fish and vegetation. Amidst the debate over the best uses of water, the discussion also turned to viewing water as a commodity, especially in the early 1980s, when Australia suffered a severe drought.

The most recent comprehensive water law reform was the Water Management Act of 2000[3]. This Act created separate rights for extraction or diversion of surface water or groundwater and for the right to use water at a particular place for a particular purpose. These are access license and water

[1] "Murray-Darling River Basin Case Study Australia" – Braian Haisman (2013)
[2] http://en.wikipedia.org/wiki/Riparian_water_rights
[3] http://www.statewater.com.au/Customer+Service/Compliance/GettingtoknowtheWMA2000

use approvals, respectively. The Act also prioritized water uses in times of shortage, from highest to lowest: domestic, environmental, commercial and urban uses, and irrigation.
The Act also adopts principles of adaptive management, an iterative learning process that constantly monitors, adjusts, and reevaluates management goals and targets. Under the Act, the government gives licenses and approvals for a ten-year period, which include all conditions and restrictions for that period. However, on renewal, the state has the option to amend the license or approval without having to pay compensation for altering water allocation for the benefit of the public. This aspect of the water use right retains the concept that water is subject to public ownership and should be managed for the public good.
The evolution of water law and water resources management in Australia has benefited from an early adoption of a use-based, administrative system that retains features of public ownership of water. Australian water law retains the marks of certainty found in prior appropriation and the communal aspect of riparianism. By viewing all rights equally without regard for priority or seniority, Australian water law has created more flexibility to meet environmental or other water use considerations. Most notably, the process of water law evolution in Australia has resulted in a wider realization, among the public, developers, irrigators, and politicians, that widely available, inexpensive water resources are finite and must be managed according to a diverse palette of interests.

National water related programs

The accompanying table shows several water related research programs. A short description and their main targets will be provided below:

Table 24: national water related programs

National			
Completed	Smart Approved WaterMark™ Scheme	National	$1,766,364
Completed	Magnitude of Surface Water and Groundwater Interaction	National	$1,350,000
Active	Australian Riverprize	National	$1,000,000
Completed	River Reach Water Trading System	National	$2,277,918

SMART APPROVED WATERMARK™ SCHEME[1]

The Smart Approved WaterMark™ is a simple identification label that is applied to water efficient outdoor products in order to assist consumers to make informed choices. Products and services are assessed by an expert panel and awarded the Smart Approved WaterMark™ if found to contribute to water savings and water efficiency.

The project has provided:

- a simple and identifiable label for products and services to allow them to differentiate themselves from competitors,
- recognition of those products and services that will contribute to a reduction in per capita water use and encourage further research and development,
- a simple and identifiable label for consumers so that they can make informed choices and in turn increase the rate of adoption of smart water technologies that reduce water consumption,

[1]http://www.environment.gov.au/node/24311

- increased water use efficiency in domestic and commercial settings, thereby advancing the National Water Initiative.

MAGNITUDE OF SURFACE WATER AND GROUNDWATER INTERACTION[1]

This project significantly advanced the understanding of surface water - groundwater interaction and associated impacts on water resources.

The reports produced by this project describe the findings from field assessments of surface water - groundwater interaction which took place in 10 selected catchments in 2008 - 2009. Five different methods for estimating groundwater discharge were trialed. All of these methods were considered suitable for providing regional scale estimates of discharge, but the methods had not previously been systematically compared and evaluated.

Through the development of methods implemented in the ten trial catchment studies and summary reports, a range of methods for the assessment of surface water - groundwater interaction have been demonstrated.

The project has:

- developed methods for quantifying the degree of connection between surface water and groundwater systems, both in a spatial and temporal context,
- improved the understanding of surface water and groundwater connectivity which can assist in improved decision making on water resource allocations,
- installed the necessary monitoring infrastructure and demonstrated the application of these methods in ten representative eastern Australian catchments,
- communicated the project outcomes to local, state and Australian Government decision makers enabling informed water resource management.

AUSTRALIAN RIVERPRIZE[2]

The Australian Riverprize was first awarded in 2001 and is now a partnership between the International River Foundation and the International River*symposium*. The Australian Riverprize is awarded annually for excellence in river management.

Applications for the prize are sought from individuals and organizations across Australia that are engaged in best practice river and catchment management.

This project show cases leadership and best practice river and wetland management across Australia. The winners must demonstrate excellence in program delivery, inclusiveness, public accountability and innovation.

The award of the Australian Riverprize recognizes outstanding achievement, promotes awareness of river management and facilitates networking between river management organizations.

RIVER REACH WATER TRADING SYSTEM[3]

The River Reach project explored and trialed the potential of innovative water market contracts (including options contracts) as an alternative to the permanent sale of water entitlements, used as a mechanism for providing water for the environment.

The project has:

- delivered water to the environment without the purchase of permanent entitlements,
- investigated the options for water trading between irrigated production and the environment,
- piloted a market mechanism and provided a model and framework that may enable the roll out of water exchanges to trade water,
- built awareness and the institutional capacity of the environmental water purchasers to engage in an options market.

[1]http://www.environment.gov.au/water/cities-towns/water-smart/magnitude-surface-water-groundwater-interaction
[2]http://www.environment.gov.au/water/cities-towns/water-smart/australian-riverprize
[3]http://www.environment.gov.au/node/24325

6.1.2 Singapore Water governance and efficiency programme

Singapore is a city state with an area of about 700 square kilometers and a population of 4,5 million, and has highly developed industrial, business, and financial services. As an essentially urbanized country, but one which lacks natural resources, Singapore is facing a serious shortage of water resources. Its current water demand is about 1.3 million cubic meters daily but domestic resources only meet about 50% of that (Baumgarten, 1998).
Water resource management becomes, therefore, a strategically important issue for national economic development and public and social life[1].

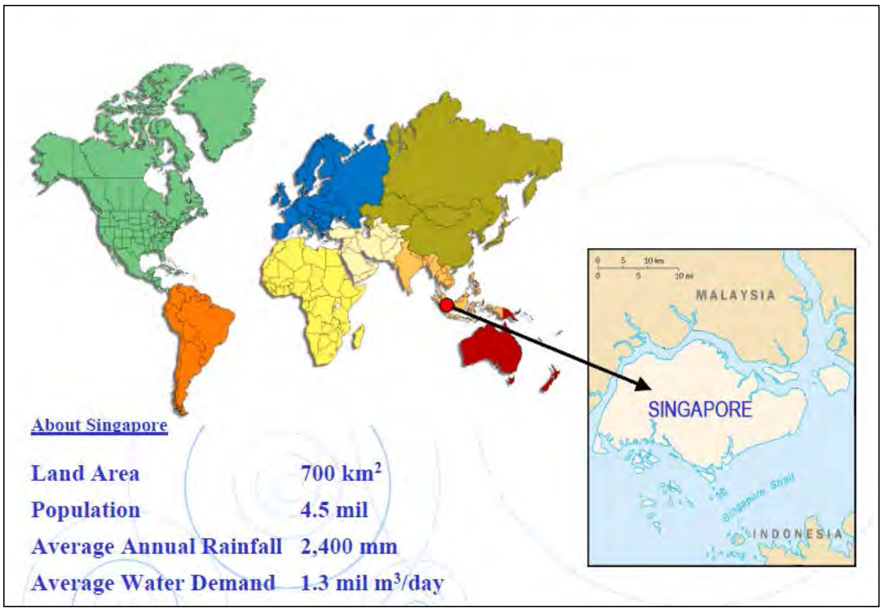


Figure 38: Some information about Singapore

From the 1980s to 1990s Singapore made tremendous efforts in establishing a legal and management system for the environment, including water; conducting pollution control, river cleaning and setting up industrial estates according to land planning; and building up a world class urban sanitation system including water and sewerage networks and treatment plants covering the whole island. With these institutional instruments and rigorous enforcement of regulations and legislation, Singapore has been referred to as a "Garden City Country".
From the later 1990s until the present the government has set "sustainable water supply" as the main target of water strategy, and for this a series of initiatives and actions have been taken, and the country has achieved remarkable progress in water resource management. Currently, its urban catchment area covers 50% of the island, and reused water represents about 12% of its water supply. To achieve this, several ambitious programs are being undertaken.

Competent Authorities and organizations for water supply, water and wastewater management

Institutional reform to allocate all water related administrations under one umbrella is a key component of Singapore's water resource management. In the past water supply and sewage treatment were managed separately by different institutions in Singapore. The Public Utilities Board (PUB) was responsible for water resources and supply, while the Ministry of Environment (MOE) was responsible for sewage treatment and the sewerage system.

[1] World Bank Analytical and Advisory Assistance (AAA) Program

To implement an integrated water resource management strategy, the Ministry of MOEWR (Ministry of the Environment and Water Resources), which replaced the previous MOE, was formed on 1 July 2002. The PUB became part of the MOEWR and was restructured. The new PUB's responsibilities have been extended and now include sewage treatment and reuse, flood control and sewer system in addition to water resources and supply. PUB is now the major institution responsible for comprehensive water related affairs in Singapore.
The new water institutions in Singapore provide favorable conditions for integrated water management and have largely wiped away administrative barriers which exist in many other countries.

Overview of the water legal framework and pricing

Singapore has a comprehensive environmental legislative system, important water resources – related regulations include:

- Public Utilities Act (2002) (Cap. 261). It stipulates the responsibilities of PUB;
- Public Utilities (Water Supply) Regulations;
- Public Utilities (Central Water Catchment and Catchment Area Parks) Regulations.

Public Utilities (Water Supply) Regulations stipulate that "*No supply of water, except with the consent of the Board, be given otherwise than through a meter*". The same regulations also stipulate that "*No person shall install, or cause or permit to be or to remain installed… any water fitting in any premises which is not fitted with such water saving devices as may be stipulated by the authorized officer*". These regulations make water metering and water saving devices mandatory in Singapore.
The Public Utilities (Central Water Catchment and Catchment Area Parks) Regulations stipulate that prior approval is needed to "*draw water from any reservoirs and streams*". These regulations indicate that water in Singapore is in the public domain. The government intervenes in water issues through administration and regulation in the public interest.

In the last period a huge public investment has been made in water and water-related infrastructure, including upgrading and rehabilitation as well as building new facilities and plants. Water collection and sewer systems now cover almost the whole island. Drinking water meets international standards. Six sewage treatment plants handle all the sewage collected from domestic and industrial sources.

Water Tariff System
Demand management is implemented with various economic instruments to reduce water consumption in Singapore. As shown in Table 25 an increasing block rate water tariff structure is used. An increase in fees up to $ 1.4 /m3 is collected when the amount of water used exceeds 40 m3/month. A Water Conservation Tax is levied by the Government to reinforce the water conservation message. Sanitary Appliance Fees and Waterborne Fees are statutory charges payable to the Public Utilities Board (PUB) under the Sanitary Appliances and Water Charges Regulations to offset the cost of treating used water and for the maintenance and extension of the public sewerage system. However, it appears that the costs of household sewage collection and disposal remain subsidized from general revenues.

Table 25: Singapore water rate tariff structure

Tariff Category	Consumption Block (m^3 per month)	Tariff (cents /m^3)	Water Conservation Tax (% of tariff)	Waterborne Fee (cents /m^3)	Sanitary Appliance Fee
Domestic	1 to 40	117	30	30	$3/- per chargeable fitting per month
	Above 40	140	45	30	
Non-domestic	All units	117	30	60	
Shipping	All units	192	30	-	-

The following Table 26 lists the prices of NEWater and Industrial Water (IW), which is non-potable reused water (grey water). To encourage water reuse, the Water Conservation Tax is not applied to NEWater[1] and Industrial Water (IW).

Table 26:prices of NEWater and Industrial Water (IW)

Tariff Category	Consumption Block (m^3 per month)	Tariff (cents/m^3)	WCT (% of tariff)	WBF (cents/m^3)
NEWater	All units	115	-	-
Industrial Water	All units	43	-	-

Several tax incentive schemes to encourage water recycling and water saving projects are administered by the Economic Development Board (EDB), the Trade Development Board (TDB) and the Ministry of Finance (MOF) under the Economic Expansion Incentives (Relief from Income Tax) Act and the Income Tax Act (RIET, 2004).

Tax exemption is granted on a portion of income based on a specified percentage (not exceeding 100 percent) of fixed capital expenditure incurred for certain projects or activities that reduce the consumption of potable water.

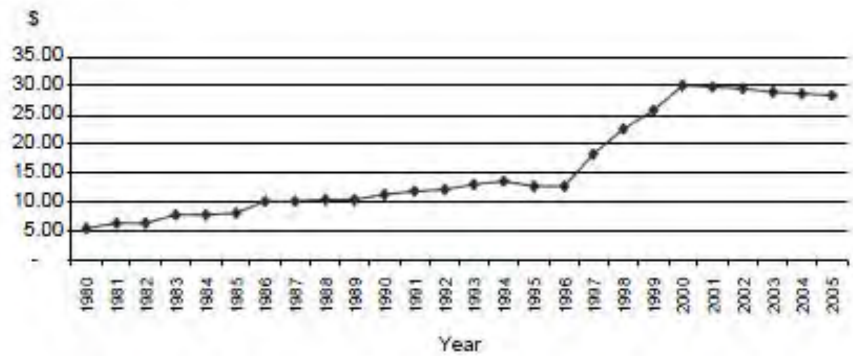


Figure 39: Taxes increase in the period 1990 – 2005 (Figure adopted from "New Water Program")

[1]*NEWater Program*. The PUB started to test the production of NEWater (treated wastewater) in 1998. Currently, there are three NEWater factories with a combined production capacity of 96,000 cu meters per day. At the end 2006, the biggest NEWater Factory in Singapore with production capacity of 116,000 cu meters per day will be completed. There will then be a capacity of about 200,000 cu meters per day of NEWater, corresponding to about 13% of the daily water supply. The treated wastewater becomes a new water resource, which closes the water loop. The NEWater application in Singapore is the largest in non-potable wastewater reuse in the world, and marks a milestone in the development of water reuse.

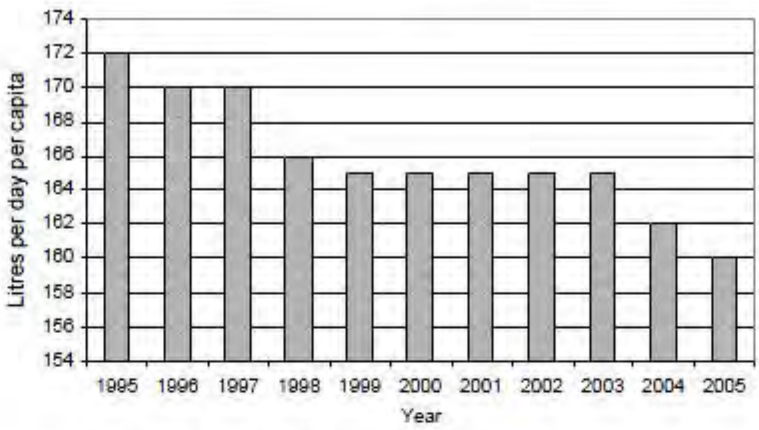


Figure 40: Household water consumption in the period 1995 – 2005 (Figure adopted from "New Water Program")

Average monthly household consumption steadily declined during the period 1995– 2004 (Figure 40). The consumption in 2004 was 11% less than in 1995. During the same period, the average monthly bill has more than doubled. Figure 40 shows the domestic water consumption per capita per day over the period 1995 – 2005. It shows a steady decline in per capita consumption because of the implementation of demand management practices, from 172 lpcd in 1995 to 160 lpcd in 2005.
These statistics indicate that the new tariffs had a notable impact on the behavior of the consumers, and have turned out to be an effective instrument for demand management[1].
This is a positive development since the annual water demands in Singapore increased steadily, from 403 million m3 in 1995 to 454 million m3 in 2000. The demand management policies introduced have resulted in the lowering of this demand, which declined to 440 million m3 in 2004.

National water related programs

Over the years, PUB has implemented various campaigns and programs to educate the public on the need to conserve water and to make it a daily, lifetime habit. The first nationwide campaign with the tagline "Water is Precious" was launched in 1971. Campaigns are ongoing since then. Other water conservation initiatives[2] that PUB has introduced in recent years include the following:

WATER-EFFICIENT HOMES[3]
Launched in 2003, the Water-Efficient Homes program was designed by PUB but run by organizations at the community level. This community-driven program encourages residents to conserve water by installing water-saving devices (such as thimbles in taps) and adopting good water-conservation practices in their homes. PUB provides Do-It-Yourself (DIY) water-saving kits free-of-charge to households. It also sets up mobile exhibitions to demonstrate to residents how to install water-saving devices. Its employees also visit households to install the devices.

[1] Water Resources Development, Vol. 22, No. 2, 227–240, June 2006 – "Water Management in Singapore" – C. TORTAJADA
[2] http://reliefweb.int/sites/reliefweb.int/files/resources/good-practices-urban-water-management.pdf
[3] http://www.pub.gov.sg/conserve/Households/Pages/WaterEfficientHomesProgram.aspx

10-LITER CHALLENGE[1]

This program was introduced in 2006 to encourage households to reduce their daily water consumption by 10 liters. The public was offered useful tips on how to save water.

WATER VOLUNTEER GROUPS[2]

Since 2006, PUB works with the People's Association, community development councils, schools, and grassroots organizations to form water volunteer groups. These volunteers encourage households to take the 10-liter challenge. They also teach residents ways to conserve water.

FRIENDS OF WATER PROGRAM AND WATERMARK AWARDS[3]

Implemented in 2006, the Friends of Water program aims to inculcate a greater sense of ownership among people to care for and cherish Singapore's water resources. PUB encourages individuals and organizations to join the program to contribute toward raising awareness about water and what it takes to sustain Singapore's water supply.

Watermark Awards, introduced in 2007, are given to Friends of Waters who make significant contributions in promoting water conservation, raising awareness about water issues, and keeping Singapore's waterways clean.

WATER EFFICIENCY FUND[4]

Launched in 2007, the Water Efficiency Fund encourages industries to try water-saving tactics (such as using NEWater or seawater as an alternative water source), and to promote water conservation in the community.

Under the scheme, corporations that have creative and innovative ideas on how to reduce water consumption could apply for financial support to carry out those initiatives, which include conducting feasibility studies, doing trials with new water-saving technology, or implementing community-wide water conservation campaigns.

10% CHALLENGE[5]

The 10% Challenge was introduced in 2008 to challenge nondomestic customers to improve their water efficiency and reduce their monthly water consumption by at least 10%.

PUB's practices in managing water demand (including increases in prices of potable water implemented in 1997–2000) and efforts in promoting water conservation have yielded positive results. Per capita domestic water consumption declined steadily from its highest historical level of 175 liters per day registered in 1994, to 156 liters per day in 2008 (Figure 41).

1 http://www.pub.gov.sg/conserve/Households/tenlitres/Pages/default.aspx (accessed November 2014)
2 http://www.pub.gov.sg/conserve/Households/Pages/WaterVolunteerGroup.aspx (accessed November 2014)
3 http://www.pub.gov.sg/fow/Programmes/Pages/WatermarkAward.aspx (accessed November 2014)
4 http://www.pub.gov.sg/wef/Pages/default.aspx (accessed November 2014)
5 http://www.pub.gov.sg/conserve/CommercialOperatorsAndOther/tenpercent/Pages/default.aspx (accessed November 2014)

Figure 41: Decline in Per Capita Domestic Water Consumption, 1994–2008 (Source: Data collected from PUB Singapore in 2009.)

Singapore has targeted to further reduce per capita domestic water consumption to 147 liters per day by 2020 and 140 liters per day by 2030 (Inter-Ministerial Committee on Sustainable Development 2009). To achieve these goals, the city state would further step up public education on water conservation, in line with its commitment to ensure that Singapore uses its energy, water and other resources efficiently.

Public awareness about environment, especially water matters, is developed in Singapore through three major avenues, namely specialized campaigns, the education system and the "Clean and Green Week." The first campaign, "Keep Singapore Clean," focuses on building public awareness about environment and water management. Often, a campaign will precede introduction of an environmental or public health law, which is then followed up with strict enforcement. Schools are important conveyors of environmental information. Since 1990, Singapore has held a Clean and Green Week with a different theme each year.
The Singaporean government also tried to change the attitude of people towards the use of water, one example of this campaign is Water Wally.

WATER WALLY[1] is the name of the official Singapore Public Utilities Board (PUB) mascot. Water Wally is blue in colour and shaped like a water droplet. Water Wally conveys messages about water conservation and usage to the public, hoping for people to rethink their water consumption pattern.

[1] http://en.wikipedia.org/wiki/Water_Wally (accessed November 2014)

Figure 42: Water Efficiency Measures – Water Wally Project[1]

Public Investments in water sector

One of the main concerns of the government has been how to provide clean water to the population, which currently consumes about 1.36 billion litres of water per day. Singapore is considered to be a water-scarce country not because of lack of rainfall (2400 mm/year), but because of the limited amount of land area where rainfall can be stored. Singapore imports its entitlement of water from the neighboring Johor state of Malaysia, under long-term agreements signed in 1961 and 1962 when Singapore was still a self-governing British colony. Under these agreements, Singapore can transfer water from Johor for a price of less than 1 cent per 1000 gallons until the years 2011 and 2061, respectively.
The water from Johor is imported through three large pipelines across the 2 km causeway that separates the two countries. In August 1965, Singapore became an independent country. The Constitution of Malaysia was amended on 9 August 1965. Under clause 14, this amendment stipulated that:

Art. 14: The Government of Singapore shall guarantee that the Public Utilities Board of Singapore shall on and after Singapore Day abide by the terms and conditions of the Water Agreements dated 1st September 1961, and 29th September 1962, entered into between the City Council of Singapore and the Government of the State of Johor.
The Government of Malaysia shall guarantee that the Government of the State of Johor will on and after the Singapore Day also abide by the terms and conditions of the said two Water Agreements.

The long-term security of water was an important consideration for Singapore when it became a newly independent nation. Accordingly, it made a special effort to register the Separation Agreement in the United Nations Charter Secretariat Office in June 1966.
The two countries have been negotiating the possible extension of the water agreement. The results thus far have not been encouraging since the two countries are still far apart in terms of their national requirements. Singapore would like to ensure its long-term water security by having a treaty that will provide it with the stipulated quantity of water well beyond the year 2061. In contrast, the main Malaysian demand has been for a much higher price of water, which has varied from 15 to 20 times the current price.
Because of this continuing stalemate, Singapore has developed a new plan for increasing water security and self-sufficiency during the post 2011-period, with increasingly more efficient water

[1]Figure adopted from: http://en.wikipedia.org/wiki/Water_Wally

management, including the formulation and implementation of new water-related policies, heavy investments in desalination and extensive reuse of wastewater, and catchment management and other similar actions.
Institutionally, Public Utilities Board (PUB) currently manages the entire water cycle of Singapore. Earlier, PUB was responsible for managing potable water, electricity and gas.
On 1 April 2001, the responsibilities for sewerage and drainage were transferred to PUB from the Ministry of the Environment. This transfer allowed PUB to develop and implement a holistic policy, which included protection and expansion of water sources, storm water management, desalination, demand management, community-driven programmes, catchment management, outsourcing to private sector specific activities which are not core to its mission, and public education and awareness programmes. The country is now fully sewered to collect all wastewater, and has constructed separate drainage and sewerage systems to facilitate wastewater reuse on an extensive scale.

In just five decades, Singapore has overcome water shortages despite its lack of natural water resources and pollution in its rivers.

Driven by a vision of what it takes to be sustainable in water, Singapore has been investing in research and technology. Today, the nation has built a robust, diversified and sustainable water supply from four different sources known as the Four National Taps (water from local catchment areas, imported water, reclaimed water known as NEWater and desalinated water). By integrating the system and maximizing the efficiency of each of the four taps, Singapore has ensured a stable, sustainable water supply that is weather resilient, capable of catering to the country's continued growth. One of these Taps is the high-grade reclaimed water known as NEWater, a success story made possible by state-of-the-art membrane technologies. Such new technologies are a potential goldmine. The Singapore government has identified water as a new growth sector and will invest about $330 million in water R&D in the next five years. Besides its strategic role, water is beautifying Singapore's landscape and improving Singaporeans' quality of life. By involving people as stakeholders of the country's water resources, we are moving closer to realizing the vision of Singapore as a City of Gardens and Water. As the national water agency, PUB is responsible for the collection, production, distribution and reclamation of water in Singapore.

Water Collection: Rainwater is collected through rivers, streams, canals and drains, and stored in 17 reservoirs. Various reservoirs are linked by pipelines so that excess water can be pumped from one reservoir to another, thus optimizing storage capacity.

Water production: Raw water is piped to the waterworks for treatment.

Distribution: After treatment, the water is stored in covered reservoirs before being distributed to customers.
Water reclamation: Water that has been used by customers is collected via an extensive sewerage system and treated at water reclamation plants. Used water is a resource too – treated used water is further purified using advanced membrane technology to produce high-grade reclaimed water, known as NEWater.

With an eye on the future, PUB has built the Deep Tunnel Sewerage System (DTSS) for long-term sustainability. An integral part of the water loop, the DTSS is a superhighway that channels used water to a centralized water reclamation plant for treatment. The treated used water will then be discharged into the sea or further purified into NEWater.
Singapore adopted an integrated and innovative approach to water management, which, together with careful planning and hard work over more than 40 years, enabled it to overcome water supply constraints and attain sustainable and cost-effective water management solutions. Today, its entire

population enjoys access to modern sanitation and high-quality piped water on a 24-hour basis daily.

Singapore's ability to manage its water supply, using it wisely to support its economic activities to become a city with a high standard of living, is impressive. Since 2003, Singapore succeeded in using innovation to enlarge its water supply. It turned wastewater into high-grade reclaimed water and produced the end product on a large scale to enhance self-sufficiency in water. Wastewater was renamed "used water" in Singapore, to reflect its value for reuse. The country's achievement in water reuse has made it stand out in the industry. Some countries that struggle with water scarcity and pollution have begun to look to Singapore's experience for solutions.

In recognition of its excellence in water management, the Public Utilities Board (PUB), was named the Water Agency of the Year 2006 at the international Global Water Awards organized by Global Water Intelligence (PUB Singapore 2006). In 2007, the coveted Stockholm Industry Water Award was conferred on PUB for being "an exemplary model of integrated water management in a framework of good policy and innovative engineering solutions" (PUB Singapore 2007b).

Singapore's experience in sustainable water management offers lessons that other cities could apply to solve their water woes.

At this time, Singapore represents the only country in which high level water management is applied and each kind of water sector is managed and related to the others through a closing water loop in which from rainwater collection to used water treatment, the entire water loop (Figure 43) is managed by PUB.

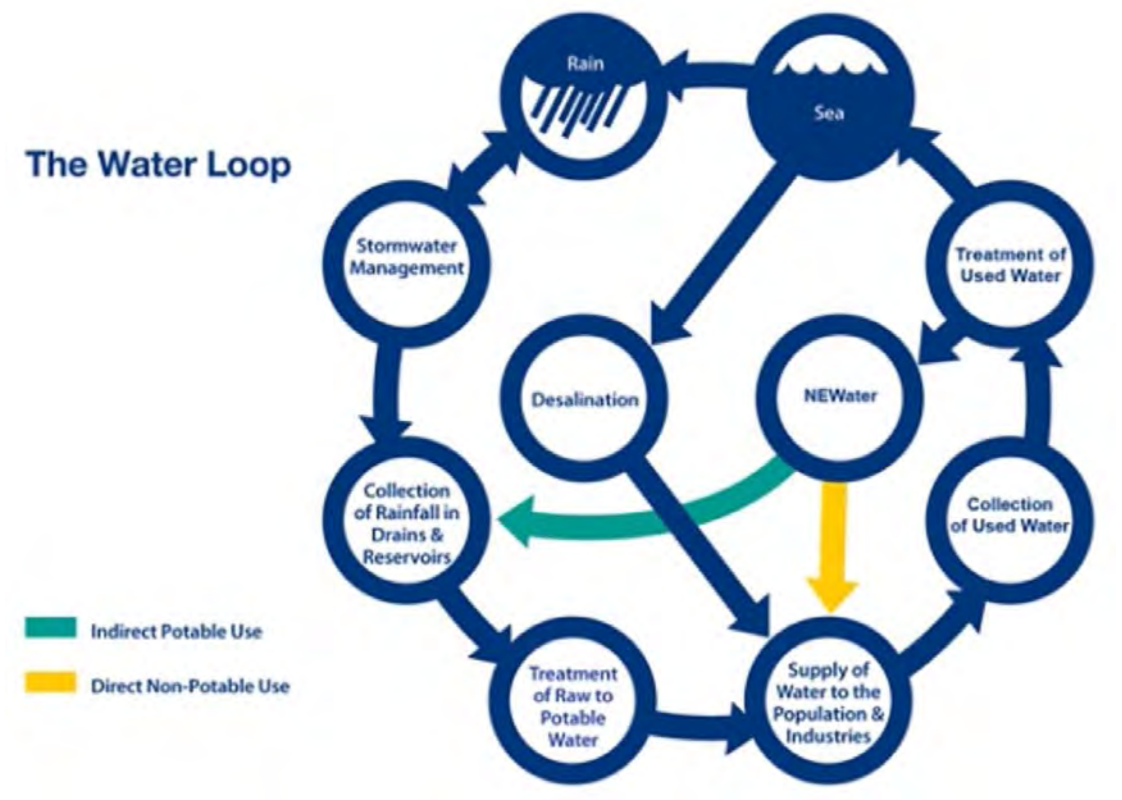


Figure 43: Singapore Water Loop[1]

[1] Figure adopted from: http://www.pub.gov.sg/about/Pages/default.aspx

6.1.3 California Water governance and efficiency programme

The State of California is located on the West Coast of the USA bordered by Oregon to the north, Nevada to the east, Arizona to the southeast, and the Mexican state of Baja California to the south. It is the third largest state by area, after Alaska and Texas, and it is the most populous state in the USA with a total of 38 million people[1] (i.e. one out of eight people who live in the USA lives in California).

Figure 44: Map of the State of California

The State of California shows different types of climate (from Mediterranean to Desert through an Alpine one) and is the most populated state in USA, the problem is water, and in particular the problem related to the water management, saving and so forth, is "well known". Indeed in much of California area, water must be managed with an eye toward drought, because California has run out of cheap sources of new water and needs to manage water carefully to satisfy the "new" water demand related to a growing population, economy and so forth... [2].
From Figure 45 below is possible to clearly understand that the water demand and water capacity is not well balanced in California. The north state is characterized by great availability of water while the southern state is characterized by an higher water demand against a consolidated lackof availability of water.
Many rivers and lakes meet the demand of water in the State of California as better summarized in the picture here below (Figure 45). The two most prominent rivers within California are the **Sacramento River** and the **San Joaquin River**, which drain the Central Valley and the west slope of the Sierra Nevada and flow to the Pacific Ocean through San Francisco Bay.
The vast majority of rivers are dammed as part of two massive water projects:

- **Central Valley Project (CVP):** providing water to the agricultural central valley. In addition to water storage and regulation, the system has a hydroelectric capacity of over

[1] Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2014" (CSV). U.S. Census Bureau. December 24, 2014. Retrieved December 24, 2014.
[2] ManagingCalifornia's Water. From Conflict to Reconciliation Executive Summary (2001). Ellen Hanak, Jay Lund, Ariel Dinar, Brian Gray, Richard Howitt, Jeffrey Mount, Peter Moyle and Barton "Buzz" Thompson. Public Policy Institute of California.http://www.ppic.org/main/publication.asp?i=944

2,000 megawatts, provides recreation, and promotes flood control with its twenty dams and reservoirs.

- **California State Water Project (CSWP):** diverting water from northern to southern California. About 70% of the water provided is used for urban areas and industry in Southern California and the San Francisco Bay Area, and 30% is used for irrigation in the Central Valley.

The drought problem

The other bodies of water, rivers, and so forth are regulated by the **California Coastal Commission.**

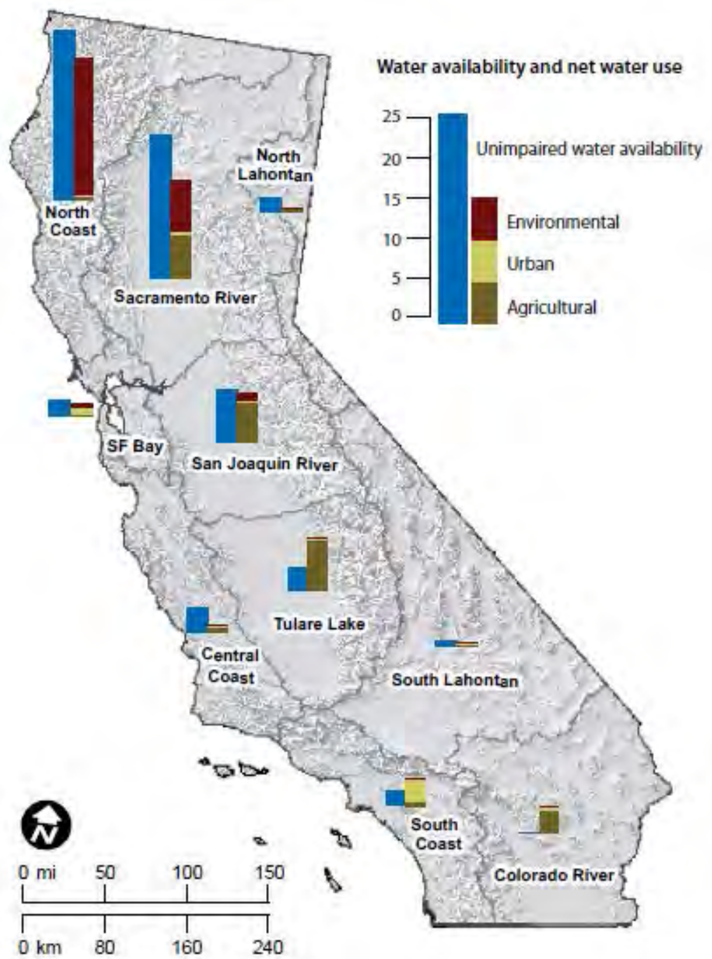


Figure 45: Net water use in the State of California[1]

[1] Figure adopted from: "Managing California's Water From Conflict to Reconciliation" – E. Hanak, J. Lund et al.

Figure 46: Map of the State of California's rivers and lakes[1]

Nevertheless the California State is in the midst of a historic drought.

[1] Figure adopted from: "Managing California's Water From Conflict to Reconciliation" – E. Hanak, J. Lund et al.

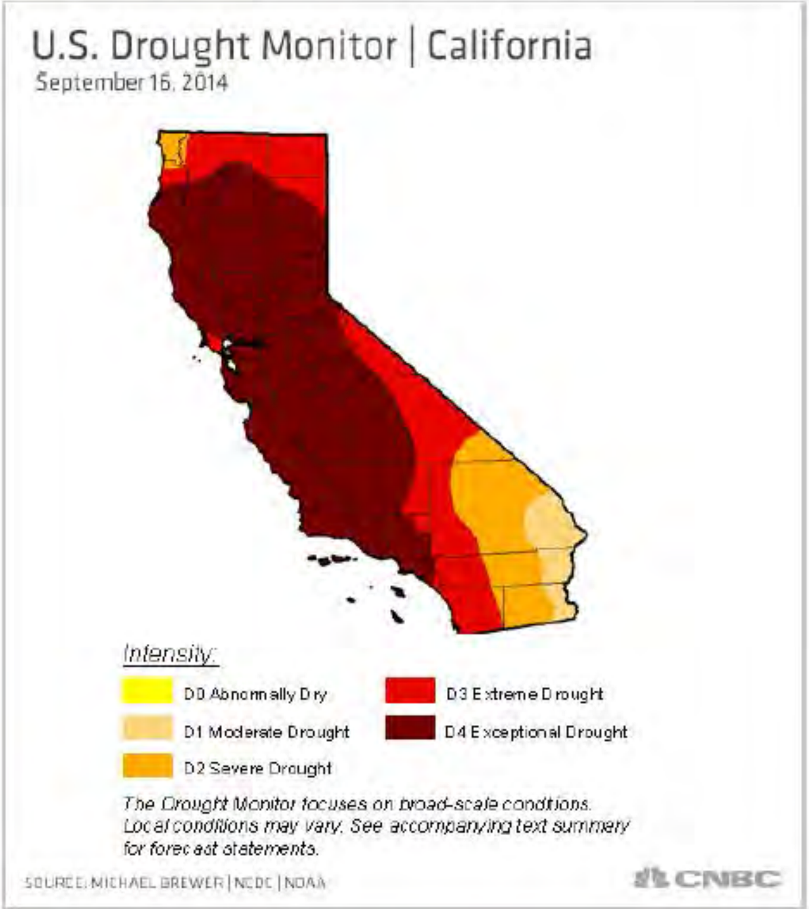


Figure 47: California's draught monitor[1]

The drought crisis has encouraged a parallel water market[2]. Private water sales are becoming more common in states that have been hit by drought. In California, the sellers include those who hold claims on water that date back a century, private firms who are extracting groundwater and landowners who stored water when it was plentiful in underground caverns known as water banks.

Unlike the previous drought in 2009, the state has been hands-off, letting the market set the price even though severe shortages prompted a statewide drought emergency declaration last year. Consequence of this market is that the water price has grown and more wells have been drilling, to sell off groundwater. Competition for water in California is heightened by the state's geography: The north has the water resources but the biggest water consumers are to the south, including most of the country's produce crops - see Figure 47 above – (some 80 percent of water used in California is for agriculture).

Starting at a fourth year of severe drought—and increasingly dependent on groundwater sources that are in danger of drying up—there was enough agreement among California's politicians to get a law on the books.

[1] Figure adopted from: http://www.cadrought.com/drought-monitor/ (accessed November 2014)
[2] http://news.yahoo.com/dry-california-water-fetching-record-182119533.html

Water legal framework to avoid draught problem

In general the laws will potentially worsen water shortages for farmers in future droughts by restricting their ability to use groundwater[1] to nurture their crops, this decision was taken because the groundwater supplies are under stress. The regulation plan is designed to stop the over-pumping of groundwater and to bring those supplies up to sustainable levels.
Water rights have long been considered property rights in California, leaving landowners with full discretion about how much groundwater they pumped from the land. Due to this, some water basins have suffered from overdraft, with more water being pumped out than could be replaced through natural processes. The closest the state has previously come to regulating groundwater is to encourage local agencies to adopt their own groundwater plans.
The law "Sustainable Groundwater Management Act". is broken up into three parts. One part instructs local water agencies to create sustainability plans for groundwater. Another measure establishes when the state government can intervene if the agencies don't do their jobs in making the plans. However, the third part postpones the state's intervention in certain areas where groundwater extraction depletes connected surface waters. This section was designed to help ease some of the concerns raised by farmers who have become more dependent on groundwater for crops and livestock, as surface water sources have dried up. Up to now the trio of bills represent an important step towards putting California on a path towards sustainable groundwater management.

In response to the on-going drought, the State Water Resources Control Board (Board) approved emergency regulations[2] on July 15, 2014, to increase water conservation by water utilities and their customers. A list of the Board's prohibited water uses, plus additional unauthorized water uses, are included in our Rule 14.1[3], "Water Conservation and Rationing Plan." Rule 14.1 was filed with the California Public Utilities Commission on April 1, 2014, and made effective May 1, 2014.

Examples of prohibited uses of water include:

- Use of water that results in runoff to gutters or streets
- Washing of vehicles without use of a shut-off nozzle
- Washing hard-surfaced areas (for example, driveways and sidewalks)
- Filling decorative lakes or ponds
- Decorative fountains that do not use a recirculation system
- Filling of swimming pools

National water related programs to raise water use reduction

The DWR[4] program is focused on educating customers about the importance of water conservation and providing them with tools to easily manage their water use. The conservation efforts support both short- and long-term water supply planning.

For this reason a massive awareness campaign was developed with videos, message, papers, radio spot and games customers have been doing a good job and, as of 2013, have reduced their overall water use by 15% compared to water use in 2007. The local government encourage users to continue using water efficiently and take advantage of available conservation programs to address

[1]http://www.cnbc.com/id/102012765
[2]https://www.calwater.com/conservation/state-water-resources-control-board-approves-emergency-water-use-regulations/
[3] https://www.calwater.com/docs/rates/rules/rule_14.1.pdf
[4] DWR: Department of Water resource

the current drought, help reach state-mandated reduction requirements, and ensure the water supply is reliable for generations to come.

Figure 48: A digital traffic sign informs travelers southbound on Interstate Highway 5 to conserve water, asthey pass through Del Mar, Calif.[1]

Web-water[2] game have been developed to aware users about their primary role in the water conservation program to fight against the drought situation. It is a good instrument that involve the users and gives suggestions about water saving. One example is given by H2Ouse program that deal with home water saving.

[1] Figure adopted from: http://uk.reuters.com/article/2015/04/03/uk-california-drought-fracking-exclusive-idUKKBN0MU01O20150403 (accessed December 2014)
[2] https://www.calwater.com/town/

Figure 49: H2Ouse program proposed by DWR to the Californian residential water users to show them how to save water[1]

The local government also offers to the single-family residential customers conservation kits featuring a range of water-saving plumbing retrofit fixtures. These kits are available at no charge to help make conserving water that much easier.

Each kit includes:

- Two high-efficiency showerheads (use 2 gallons per minute [gpm])
- One hose nozzle
- Two bathroom faucet aerators (use 1.0 gpm)
- Toilet leak tablets
- One kitchen faucet aerator (uses 1.5 gpm)

The California water department also give instructions about what kind of plants that are adapted to long, dry summers and short, rainy winters. These include plants that are native to California, as well as those that originated in southern Europe, South America, and other “Mediterranean” climates. These plants don’t need much water in the summer and have thrived in water-scarce conditions for thousands of years.

The plants suggested are appropriate for California’s climate and use less water than what an user may already have in his garden.

These initiatives are now reflected in local water saving programs:

[1] Figure adapted from: http://www.h2ouse.org (accessed November 2014)

Smart from the start[1]	Smart from the Start is a water conservation program that provides user friendly tools and landscape templates to assist new homeowners and developers design and install beautiful, water smart landscapes. The concepts and tools provided, however, may also be useful to people who are considering converting their existing water thirsty landscapes to less thirsty ones. The program provides templates sample designs with appropriate plantings, irrigation and site elements to envision how water conservation can be accomplished with good design.

Smart rebates[2]	Smart Rebates is a statewide program administered by the California Urban Water Conservation Council that offers a wide-ranging list of measures for conservation product and appliance rebates in areas that have never before operated programs. Residential and commercial customers of participating water utilities may qualify for Smart Rebates.

Main "water institution" in California

The main water-management institution in California (who is responsible) is the ***California Institute for Water Resources*** (WRC)[3]: an interdisciplinary research institute dedicated to developing and coordinating a system-wide approach to water conservation, for the purpose of developing ecologically-sound and economically efficient water management policies and programs in California.
The California's Water Governance (WG)[4] is layered and fragmented into different systems including public and private organizations from the Federal to the local level. Ground water and surface water resources are separately managed although their dynamic interaction. At **Federal level,** Federal government provides the general framework for state oversight and regulation of water sources. Within Federal level 37 different Federal agencies[5] have (some) jurisdiction in this field (among others US Army Corps of Engineers). About the Water Supply Management Structure (WSMS) at the State Level, three major state agencies have jurisdiction in California:

- the Natural Resources Agency
- the Environmental Protection Agency
- and the Health and Human Services Agency.

California Water Conservation Policy

As above observed water scarcity is an ongoing reality in California especially in Southern California with its arid climate and cyclical droughts. Southern California relies on upstate water imports provided by the Metropolitan Water District of Southern California (MWD) for a significant portion of its water supply. Thus, the key to the transportation of water from the mountains in Northern California to the south is the Sacramento-San Joaquin River Delta

[1] http://www.h2ouse.org/tour/landscaping/Smart-From-The-Start-Intro-06-02-09.pdf
[2] http://www.cuwcc.org/Resources/Conservation-at-Home-and-Work/Smart-Rebates-Program
[3] http://ciwr.ucanr.edu/
[4] http://sustainablecities.usc.edu/research/publications.html - chapter 2
[5] Fiero, P., Jr. (2007). Agencies and Organizations. In: Fiero, P., Jr. and Nyer, E.K. eds., 3rd edn. *The Water Encyclopedia, Hydrologic Data and Internet Resources*. Boca Raton, FL: CRC Press.

(vulnerable to aging levees, subsidence, saltwater intrusion and so forth). Hence a proper water conservation (or better management of water) was necessary.

One of the most influential federal regulations for water conservation policy, however, emerged from the *1992 Federal Energy Policy Act*. Very briefly, this policy act required higher water efficiency standards for faucets, showerheads and toilets.

The Act mandated that as of January 1994, only water efficient faucets, showerheads and toilets be sold in the country. This change, for example, reduced the water use of toilets from the typical 3.5 to 7 gallons per flush to ultra-low flow toilets (ULFTs) with 1.6 gallons per flush. Building on these federal requirements, the State of California has developed an ambitious water conservation program.

To fulfill these requirements, the State initiated in the early 1990s a voluntary urban water conservation program managed by the California Urban Water Conservation Council (CUWCC), which promoted the implementation of ***Best Management Practices (BMPs)*** to achieve more efficient water use[1], that was incorporated into the 2009 Comprehensive Water Package, passed by the California legislature in November of 2009.

This strategy planned a target of reducing urban water use by 20% by 2020 (***20x2020***), based on the next main principle: "…*diverse regional water supply portfolios that will increase water supply reliability and reduce dependence on the Delta*…". Thus, California placed the 20x2020 goal into statute with the enactment of SBX7 7 (Steinberg), as part of an historic package of water reforms.

The 20x2020 Plan will be implemented through three phases, as summarized inFigure 50.

Plan Phase	Year	Activities
I. *20x2020 Plan* Completion and Start-up Actions	2009 – 2010	• Finalize *20x2020 Plan* • Establish a lead agency and coordination framework • Convene a stakeholder advisory group • Develop detailed implementation task descriptions for recommended actions • Provide technical assistance in conservation legislation discussions • Evaluate an interim data collection and management mechanism • Collect, manage and validate data • Implement conservation actions • Conduct legislative, regulatory and administrative actions • Provide oversight
II. *20x2020 Plan* Implementation, Monitoring, Evaluation, Adjustments	2011 – 2020	• Establish interim and long-term data collection and management • Implement conservation actions • Monitor implementation progress • Assess and design additional measures such as a conservation offset and a conservation credits trading program as needed • Conduct an Interim Target Assessment and Performance Evaluation in 2015
III. Conclusion	2020	• Conduct a Final Target Assessment and Performance Evaluation • Publish Results and Lessons Learned

Figure 50: 20x2020 Plan Phases[2]

The process of developing the 20x2020 Plan is characterized by 5 steps here summarized and can be taken as a starting point for a new policy/strategy for the water saving:

[1] http://sustainablecities.usc.edu/research/publications.html - chapter 1

[2] Figure adopted from: "20x20x20 Water conservation Plan" – California Department of Water Resources – February 2010

1) data analysis
2) baseline definition
3) preliminary targets development
4) conservation potential identification
5) implementation planning

The above working principles are better summarized in the next flowchart (Figure 51).

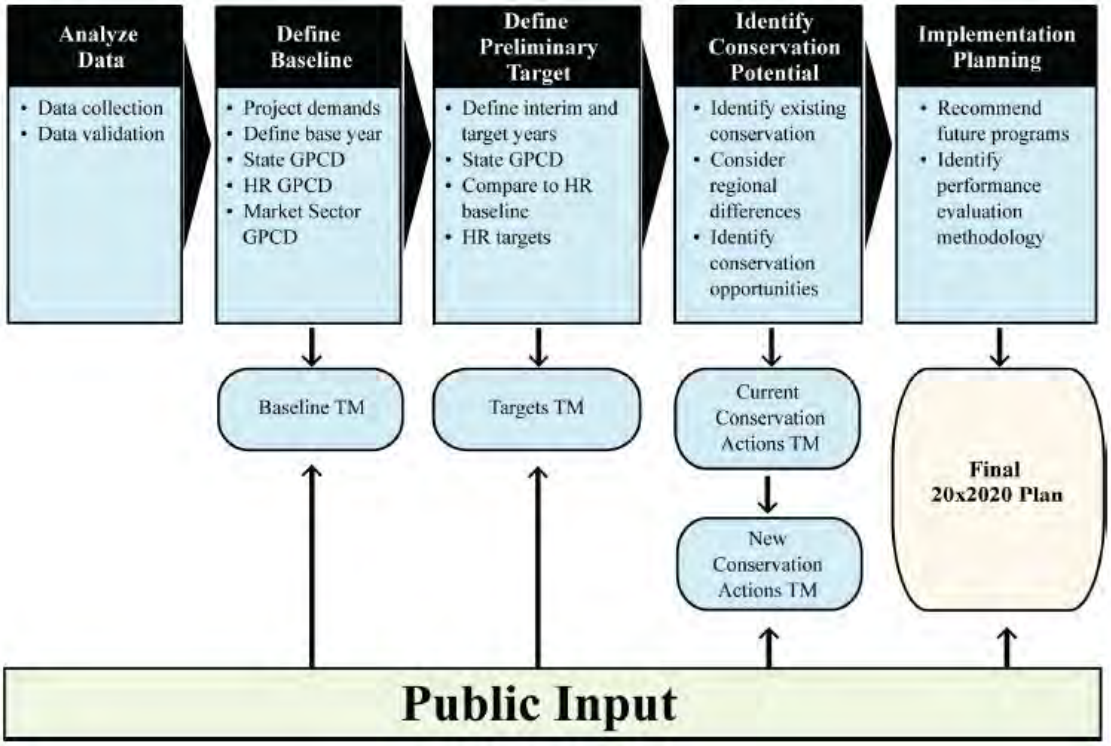


Figure 51: 20x2020 Plan flowchart[1]

In order to set conservation targets, the ***20x2020*** plan established baselines for hydrologic areas in the state (Figure 52). In Figure 53 some basic information about the South Coast Hydrologic Region size[2], sources of supply, population growth, the extent to which the supply meets an urban or agricultural demand, and so forth are summarized. This can be relevant to Waternomics if we think to provide end users with data and benchmarking related to the place where they live.

[1] Figure adopted from: "20x20x20 Water conservation Plan" – California Department of Water Resources – February 2010
[2] 20x2020 Water Conservation Plan – February 2010.

Figure 52: California's Hydrologic regions[1]

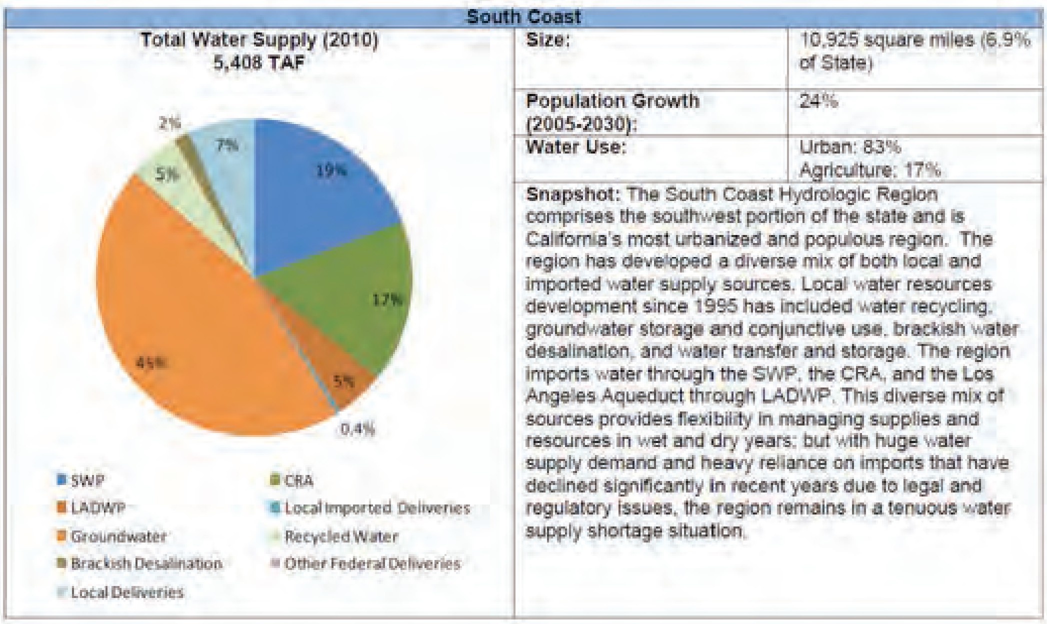


Figure 53: California's South Coast water supply summary[1]

[1] Figure adopted from: GEI Consultants/Navigant Consultants (2010) Vol. 1, p.36.

In its 20x2020 Plan, the State identifies the BMPs that water agencies can pursue to reduce water consumption to meet State targets (Figure 54); among others: retrofits of inefficient indoor residential fixtures, such as toilets, washers, and showers; increased efficiency in the commercial, industrial, and institutional accounts; and conversion of unmetered connections to metered connections. The BMPs include strategies to change behavior such as water survey programs, audits, school education programs, and retail conservation pricing.

BMP	Description
BMP 1	Water survey programs for residential customers
BMP 2	Residential plumbing retrofit
BMP 3	System water audits, leak detection and repair
BMP 4	Metering with commodity rates for all new connections and retrofit of existing unmetered connections
BMP 5	Large landscape conservation programs and incentives
BMP 6	High efficiency clothes-washing machine financial incentive program
BMP 7	Public information programs
BMP 8	School education programs
BMP 9	Conservation programs for commercial, industrial, institutional (CII) accounts
BMP 10	Wholesale agency assistance programs
BMP 11	Retail conservation pricing
BMP 12	Conservation coordinator
BMP 13	Water waste prohibition
BMP 14	Residential ultra-low-flush toilet (ULFT) replacement programs

Figure 54: Best Management Practices (BMPs) list[2]

In order to achieve a savings target, it is essential to first define a baseline. For the case under study, i.e. 20x2020 Plan, the methodology used to develop the baseline was based on the data and resources available at that time as summarized in Figure 55.

[1] Figure adopted from: GEI Consultants/Navigant Consultants (2010) Vol. 1, p.36.
[2] Figure adopted from: "20x20x20 Water conservation Plan" – California Department of Water Resources – February 2010

Data Source	Strength	Limitation
DWR – Public Water Systems Survey (PWSS)	• Detailed water production, water delivery, population, and connections data. • Categorized by market sectors (e.g., residential, commercial, industrial, etc.). • Compiled into a central database. • Conducted annually.	• Collected voluntarily, which impacts data completeness and accuracy. • Recent data (2005-present) have not yet been compiled and validated, and are not available for use for this Plan.
DWR – Land and Water Use Program (LWUP)	• An extension from PWSS database, with data validated and modified at a sub-county level and validated using professional judgment. • Every area has a water use value.	• Only three (3) years of data are available (1998, 2000, and 2001).
California Urban Water Conservation Council (CUWCC)	• Detailed water use data by demand sector/customer type • Includes estimates of water saved through conservation Best Management Practices	• Only entered by Signatories of Memorandum of Understanding (approximately 225 of largest urban water suppliers in 2008) • Values expressed in 2006 dollars.
CPUC	• Recent urban water use data readily available. • Mandatory so data set should be complete.	• Limited data points • Only residential data available. • Data for connections and water use only. • Data was reported on annual basis, which limits the analysis for residential indoor/outdoor water use.
DPH	• More complete database since the Safe Drinking Water Act requires water suppliers to report water use data annually.	• Not available electronically. • Has not been compiled into a central database. Stored as hard copies in each DPH office across the state.
Urban Water Management Plans (UWMPs) prepared by Water Suppliers	• Could provide more detail on water use because plans are prepared by individual water suppliers. • Water suppliers serving more than 3,000 connections or more than 3,000 AFY are required by law to develop and submit UWMPs. • Mandatory but compliance is not 100 percent.	• Developed only once every five years. • Not compiled into a central database and therefore not available electronically. • No data from small water suppliers that serve fewer than 3,000 connections or 3,000 AFY.

Figure 55: Dataset Strengths and Limitations - 20x2020 Plan[1]

As an example the Los Angeles metropolitan region falls within the South Coast Hydrologic Region labeled as "Region 4". For this region the estimated weighted average per capita per day during the period 1995-2005 was 180 gallons. The 20x2020 target for this hydrologic region is then 149 gpcd[3]. According to the legislation and the Plan, water agencies can set their own baselines to determine their specific 20% conservation target (see "20x2020 Water Conservation Plan – February 2010" document for more details[2]).

The following conclusions can be stressed by the California's experience:

- water conservation defined as a reduction in water loss, waste or use, is one of the key ways to provide water protect and improve the ecosystem
- water is a very limited resource and it must be used wisely, innovatively, responsibly, and more efficiently

[1] Figure adopted from: "20x20x20 Water conservation Plan" – California Department of Water Resources – February 2010

[2] http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/

- expand conservation programs, and develop "more aggressive" strategies with the final aim ofto achieve the goal of water conservation a great cooperation between public and privates agency should be required
- a proper strategy/plan to change behavior about water conservation should be adopted at all educational levels (e.g. audits, school education programs, etc.)
- share the achieved experience/knowledge with the national and international community to mitigate the global crisis of water deficiencies

6.2 European case studies

6.2.1 Italy water governance and efficiency programme

Italy has a largely temperate climate. "With 61 million inhabitants[1], it is the 5th most populous country in Europe". Italy is a very highly developed country and "has the third largest economy in the Euro zone and the eighth-largest in the world"[2].
Thanks to its climate, morphological, geographical and geological Italy is one of the richest countries in the world of water, as it theoretically has about 155 billion m3 of water. Approximately 97% of fresh water in Italy is in groundwater and it is estimated an average availability per capita of about 2700 m3.
In Italy, however, occur difficulties in relation to water availability and these are substantially related to the uneven distribution of both spatial and temporal rainfall in the area. Considerable differences in climate are due to the difference in latitude between the North and South Italy and this implies inequalities in height average rainfall between North and South resulting differences in water availability.
Italy is characterized by an uneven distribution of precipitation and it is estimated that the largest proportion of these precipitation, just over 40%, you should concentrate in the northern regions, 22% in the central regions, 24% in the regions South and only 12% on the major islands, namely Sicily and Sardinia.
Italy appears to be the largest consumer of water in Europe[3]: in fact, compared to an EU average of 604 m3 per capita per year, Italy has an estimated value of around 980 m3 per capita per year.
In Italy, the water sector is characterized by a very complex and problematical situation. Ther is a very complex legal fragmentation and sometimes conflicting regulations.
Italy withdraws the greatest quantity of water per person in Europe. In fact, the water consumption per day is on the average 280 liters per person[4]. Laws and Decrees fix the quantity for water that has to be guaranteed to users for domestic consumption and from 150 litres/person/day[5] (1996) the actual minumum amount required to ensure modern social and sanitary standard[6] became between 200 and 280 litres/person/day[7].

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[1] http://demo.istat.it/bilmens2015gen/index.html (accessed March 2015)
[2] https://en.wikipedia.org/wiki/Italy (accessed March 2015)
[3] http://www.casaeclima.com/ar_5681__ITALIA-Ultime-notizie-acqua--istat-Istat-in-Italia-consumi-pro-capite-di-acqua-superiori-alla-media-Ue.html (accessed March 2015)
[4] See Legambiente, L'emergenza idrica in Italia, Il libro bianco di Legambiente 22 (Rome, 3 May 2007).
[5] See Decreto del Presidente del Consiglio dei Ministri, 4 March 1996, 'Disposizioni in materia di risorse idriche', Gazzetta Ufficiale della Repubblica Italiana, 14 March 1996, n. 62.
[6] Autorità di Vigilanza sulle Risorse Idriche e i Rifiuti, Relazione Annuale al Parlamento sullo Stato dei Servizi Idrici, Anno 2005 at 119 (Rome, July 2006)
[7] Autorità di Vigilanza sulle Risorse Idriche e i Rifiuti, Relazione Annuale al Parlamento sullo Stato dei Servizi Idrici, Anno 2005 at 44 (Rome, July 2006)

To further aggravate the situation is compounded by the high age of the water supply systems characterized by numerous water leaks.
In Italy, the Committee for the Control and Use of Water Resources (COVIRI)[1] has estimated that around 40 per cent of the water in the aqueducts is lost because of an archaic and outdated infrastructure system. In 2003, in the Southern regions, water lost reached the peak of more than 50 per cent of water produced[2] (font: H2ZERO – Legambinte, 2003). As a result, several municipalities constantly have difficulties in guaranteeing regular water supply and often suffer interruptions in water services. From all that stated above we can conclude that Italy has enormous technical deficiencies in water infrastructure, suffering from lack of investment in modernising and maintaining it and from conflicting regulations. The water crisis can only be overcome by adopting policies specifically oriented towards saving water and renovating infrastructure[3].

Competent authorities and organizzations for water supply

The reform introduced by Law Galli (Law n. 36 /1994) created specific relevant areas for the operation of water services (drinking water, wastewater treatments, sewers, etc.) called Optimal Territorial Areas (OTAs). These OTAs were created following the river basins' geographical limits by using a territorial aggregation method. Regional authorities had jurisdiction over these areas. The reform led to the centralization of water management in comprehensive organs denominated Basin Authorities (vertical aggregation). However It is unthinkable not connect the development of major organizations related to the water sector to the national legal framework, for this reason, in the following paragraph will be provided an overview of the water legal framework and of the major water organizations.

Overview of legal framework

In a report[4] outlining the Italian legal framework, Authors point out that 'the substantial content of the human right to water is represented by everyone's entitlement to sufficient, safe, acceptable, physically accessible and affordable water for personal consumption and domestic uses'. However the recognition of the right to water depends firstly on its inclusion into the national legislative body, as a duty of the State to provide citizens with sufficient drinking water.
At present, Italian law does not recognize the right to water as an individual entitlement in any form, neither in its Constitution nor in any other legal instrument. However the national laws recognize that the water must be preserved aginst waste and pollution[5] given its importance for the satisfaction of vital human needs.
This means that water in Italy is still conceived as a commodity for the satisfaction of needs, rather than as an individual human right.

ITALIAN LEGISLATION BEFORE 1994

The Italian water sector is largely fragmented and it is difficult to find a single outline of the legislation in force. However we can distinguish two different periods: before and after 1994 when

[1] COVIRI - Comitato di Vigilanza sulle Risorse Idriche now AEEG – autorità per l'energia elettrica il gas ed il sistema idrico
[2] Legambiente, H2ZERO - L'acqua negata in Italia e nel mondo
[3] According to the Decree n. 99/1997, water losses can be reduced by adopting two specific methods: installing modern capacity counters and monitoring pressure. See Decreto Ministeriale, 8 January 1997, n. 99, 'Regolamento sui criteri e sul metodo in base ai quali valutare le perdite degli acquedotti e delle fognature', Gazzetta Ufficiale della Repubblica Italiana, 18 April 1997 n. 90
[4] Committee on Economic Social and Cultural Rights, General Comment No. 15 (2002) The Right to Water (arts. 11 and 12 of the International Covenant on Economic Social and Cultural Rights)
[5] Corte Costituzionale, Judgment, 10-19 July 1996, n. 259, in Gazzetta Ufficiale della Repubblica Italiana, 31 July

the approval of the Law n.36 (also known as Law Galli) reorganized water service in Italy[1]. Before the Law n. 36, municipalities were directly in charge of both water production and distribution. As a result, both the operation and distribution networks were highly fragmented. In a report presented at "Water Week 2004" by the Prof. Triulzi (University of Rome – La Sapienza) the author points out that the water sector was characterized by poor efficiency, lack of managerial good-practices and inadequate financial self-sufficiency because deficits were corrected through the general public budget. It also suffered a huge decline in investment, especially in the wastewater collection and treatment segments[2].

Before the reform of 1994, Italian laws dealing with water were mainly focused on combating water pollution and establishing fair quantity and quality standards for drinking water supply[3].

ITALIAN LEGISLATION AFTER 1994

In 1994, the Italian Parliament approved a water sector reform through the enactment of the Law Galli. This reform stressed two main aspects. Firstly, it consecrated the recognition of water as 'a public good and as a resource which must be protected and utilized according to criteria of solidarity'[4]. Secondly, the main goals of this reform were to reduce the fragmentation of the organizational framework by introducing the privatization of the water supply. This new centralized approach was achieved through the concession of the entire Integrated Water Service Management (IWSM) to a semi pubblic company. The reform also introduced created specific relevant areas for the operation of water services (drinking water, wastewater treatments, sewers, etc.) called Optimal Territorial Areas (OTAs) and the Italian Regional authorities have jurisdiction over these areas. The reform led to the centralization of water management in comprehensive organs denominated Basin Authorities (vertical aggregation).

The idea that led lawmakers in the drafting of the law n. 36 is that a private management of water utilities can bring more efficiency to water services operation, and that it could put a stop to the waste of water that the public management was causing. This is the main European trend (Figure 56[5]). For this reason the law differentiates between water network owner (public administration) and water network administrator (specialized companies).

The Italian water reform of 1994 (Law Galli) distinguishes different levels of responsibility in water services provision and the paper presentend at "Water Week 2004" by the Prof. Triulzi (University of Rome – La Sapienza) explain in a very imple way the Italian water regulatory structure (Figure 57[6]).

At the national level: the COVIRI is in charge of delivering a comprehensive supervision following governmental instructions.

[1] Law 5 May 1994, n. 36 'Disposizioni in materia di risorse idriche', Gazzetta Ufficiale della Repubblica Italiana, 19 January 1994, n. 14 [hereafter Law Galli].

[2] U. Triulzi, The Reform of the Italian Water Sector (Paper presented at the Water Week 2004 - Session 3 entitled 'How to Engage with Public and Private Sectors in Urban WSS', organized by the World Bank, Washington D.C., 24 February 2004), available at http://siteresources.worldbank.org/EXTWSS/Resources/337301-1147283808455/2532553-1149773713946/Triulzi_ReformofItalianWaterSector.pdf

[3] Law 18 May 1989, n. 183, Norme per il riassetto organizzativo e la difesa del suolo, Gazzetta Ufficiale della Repubblica Italiana, 25 May 1989 n. 120, supplemento ordinario

[4] Article 1, Law Galli

[5] U. Triulzi, The Reform of the Italian Water Sector (Paper presented at the Water Week 2004 - Session 3 entitled 'How to Engage with Public and Private Sectors in Urban WSS', organized by the World Bank, Washington D.C., 24 February 2004), available at http://siteresources.worldbank.org/EXTWSS/Resources/337301-1147283808455/2532553-1149773713946/Triulzi_ReformofItalianWaterSector.pdf

[6] U. Triulzi, The Reform of the Italian Water Sector (Paper presented at the Water Week 2004 - Session 3 entitled 'How to Engage with Public and Private Sectors in Urban WSS', organized by the World Bank, Washington D.C., 24 February 2004), available at http://siteresources.worldbank.org/EXTWSS/Resources/337301-1147283808455/2532553-1149773713946/Triulzi_ReformofItalianWaterSector.pdf

At the regional level: Regional and Basin Authorities are responsible for environmental regulation and the infrastructure planning for the basin areas under their jurisdiction.
Finally, at the municipal level: municipalities keep ownership of infrastructure and appoint OTAs Authorities, which set up contracts and are in charge of economic regulation, performance monitoring and control the fulfillment of obligations.

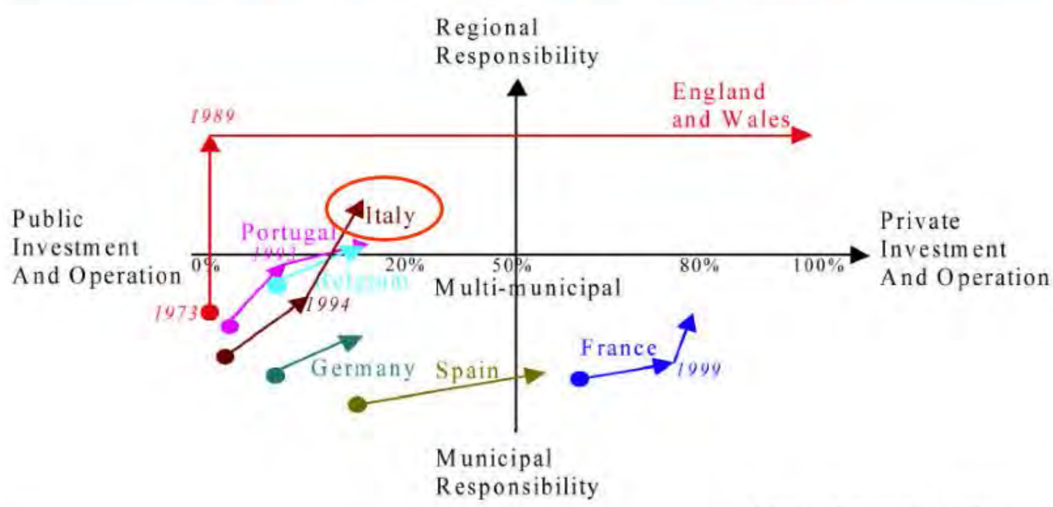

Figure 56: Water trend in Europe[1]

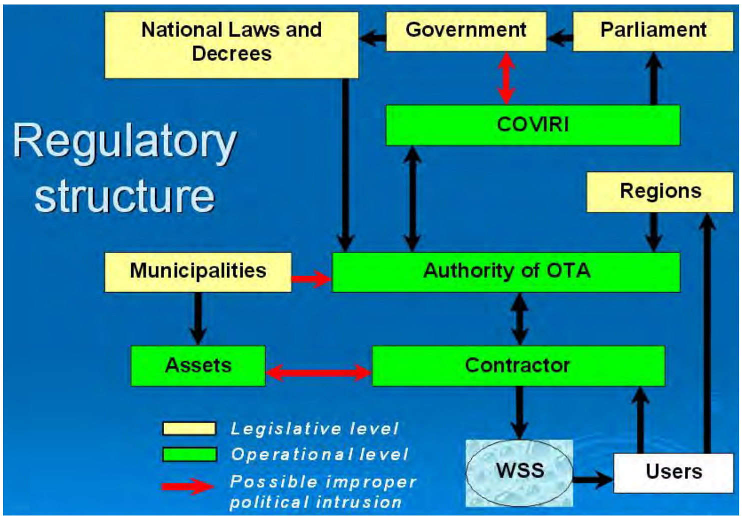

Figure 57: Italian regulatory structure[2]

The Law Galli confirmed that public sector maintaine ownership of infrastructure, but the operation services is transferred to the private sector.
However the reform is important to achieve two objectives:

- to solve coordination problems arising from the multiplicity of actors involved
- to eliminate the deficiencies of infrastructure

Overall, after the reform, some other problems araised, for example:

- inefficiency in the control of the Authority over private companies
- lack of public participation in water services

[1] Figure adopted from: U. Triulzi - 2004, see previous note.
[2] Figure adopted from: U. Triulzi - 2004, see previous note.

In 2006, the Environmental Code (D.Lgs 152/2006) repalaced the Law Galli, however the main legal framework for water services in Italy is still based on substantial provisions of that law[1]. In fact the Environmental Code has legally abolished the Law Galli, but, in the same time it has received within its own text the main principles and structure of the Law Galli.

National water related programs

In this section will be analyzed three case studies carried out in Italy about the "water-saving" topic. The first one regards the case of Domestic users; the second one the analysis of Municipality users (four example will be analyzed) and finally the third one is related to an example of Corporate users.

Domestic users

The first case study regards the so call "Domestic use" carried out in "Emilia Romagna" region.

The strategy carried out to achieve the final goal about the possibility to create a foreground level of awareness about the water waste, was an intensive regional campaign of communication called **"Water, life-saving"**.

Figure 58: Communication campaign in "Emilia Romagna" region[2]

It was initially launched in 2004 with the intention to spread information about the household water consumption and create awareness about "water-saving". It was the pilot project of a more extensive campaign that involved, during its lifetime, many public and private companies and citizens.

To achieve the goal of water-saving, **brochures** were distributed; **spots** at local TV and radio were realized; **advertisements** in the press were distributed and finally a "kit" for the domestic water-saving (water flow regulators and flow reducers) was distributed to the citizens. From this approach different events at regional level about this topic were created, among the others:

- the "*Settimane regionali per il risparmio idrico*" project that involved many public and private companies, and citizens,
- the "*Non c'è acqua da Perdere*" project;
- the "*I giovani non fanno acqua*" project.

The result of this strategy showed as with simple "home care" and minimal economic investment and structural water pipes refurbishment, one can get water-saving about 12-18%.

Municipality users

About the Municipality case study the first example here presented regards the *Municipality of Bagnacavallo*, a city with about 16k inhabitants located in "Emilia Romagna" region.

[1] Decreto Legislativo, 3 April 2006, n. 152, Norme in materia ambientale, Gazzetta Ufficiale della Repubblica Italiana, 14 April 2006, n. 88, supplemento ordinario n. 96.

[2] Figure adopted from: http://ambiente.regione.emilia-romagna.it/acque/informazioni/acqua (accessed November 2014)

Figure 59: Communication campaign in "Emilia Romagna" region[1]

The goal of this project was to verify if was possible to really save water simply using simple technical devices and taking daily cares (i.e. awareness about water-saving). This is first example at municipality level in Italy faced to household water-saving. To reach this purpose in this city were installed ad hoc "flow reducers" accompanied by an intensive communication strategy showing "how" it is possible to save water simply following trivial actions (e.g. use the water used to wash fruit and/or vegetables for watering the flowers). This project produced a water-saving of about 10%, that corresponds at regional level (i.e. Emilia Romagna region level) to about 20 million cubic meters.

The second example in this particular case study it is represented by the *Municipality of Ferrara*, a city located in "Emilia Romagna" region. This municipality, in association with the company "*HERA Spa*" started the project "Water losses Search" by:

- installing flow and pressure meters devices;
- realizing a districtualization of the municipality's water net in order to control and monitoring the amount of water really introduced into the net. The districtualization was realized subdividing the municipality into homogeneous areas to be controlled.

This approach produced a water loss saving of about 5% during the biennium 2006-2008. This resulted in a reduction of the quantity of water injected into the network of about one million cubic meters during the 2008.

The third example regards the *Municipality of Riolo Terme* (a city located in Emilia Romagna region not far from the town of Ravenna) where an important experimental campaign about the localization of the water losses in the net is still in progress.

Figure 60: Riolo Terme Municipality - Communication campaign[2]

The "workbench" regards the analysis/study of a water network of about 14 Km. In this net "hydrophones (noise sensors)" were installed on the fire hydrants staying along the above net. The

[1] Figure adopted from: http://risparmioidrico.racine.ra.it/progetto.htm (accessed November 2014)
[2] Figure adopted from: http://www.virtuousitaly.it/?enti_pubblici_luogo=riolo-terme (accessed November 2014)

system, called *Lorno* and designed by *Hera Spa*, consists of 13 sensors that control the whole water system thanks to the remote transmission of data and the presence of some alarms, with which one can monitor in real-time the whole situation. Thanks to these devices is possible to detect continuously the occurrence of any leakage simply analyzing the response of the wave “running” along the water net (e.g. if during the analysis the hydrophone will detect an anomaly, a warning signal will be sent to the control station from which will be possible implement all the necessary actions to ensure timely repairs and avoid water waste). This innovative system allowed water saves of about 50% compared to the quantity of water in input in the network.

The forth project analyzed regards the possibility to define a methodology for the detection of hidden losses in the water network and a system to manage them through the use of tools such as: geophone, correlator, noise analyzers; thermal imaging camera and georadar. This project was held in the *Municipality of Cascina* (a city in Toscana region not far from Pisa town). Thanks to this method more than 230 hidden losses have been identified that correspond, in this case, of a water savage of about 180 l/s. The benefit in terms of recovery of resource has been estimated between 10% and 20% of that introduced into the network.

Corporate users

About the Corporate case study the example here presented regards the project proposed by the *C.A.P. group*. The project called "Fight against waste" deal with the possibility to define a control plan about the use of water by public buildings belonging to the municipality, aimed at reducing waste water and reduce water bills. The project is organized into three phases:

- **Step 1: creation of the end users database**;
- **Step 2: identification of anomalous situations**. Simply comparing the information with the historical database consumption it is possible to identify situations that are beyond the average, or otherwise abnormal compared to the type of use;
- **Step 3: on site survey**. In this way it is possible to verify directly on site possible anomalies.

The project is still in progress, for more information please visit the web site: http://www.capholding.it/.

Figure 61: C.A.P. Group - Communication campaign[1]

[1] Figure adopted from: http://www.capholding.it/ (accessed November 2014)

6.2.2 Greece[1] water governance and efficiency programme

Greece occupies a total area of 131.957 km2 and has been divided into 14 Water Districts with quite similar hydrological and hydro-geological conditions. In general Greece has adequate surface and groundwater resources. However, there are various reasons which reduce significantly the actual available water for use. Some of these reasons are:

- Unequal distribution of few water resources in the area. Western Greece receives greater amounts of rainfall that the East side.
- Uneven distribution of water resources during the year. The highest concentration of rainfall occurs during the winter months.
- Unequal distribution of water demand in the area in relation to the unequal distribution of water resources. The water use/demand is concentrated to the East and South of the country.
- Demand of water (for all uses) concentrated during the same period of time. The biggest consumer of water is agriculture (84%) and it concentrates its consumption during the dry season. During the same season, particularly during the months of July and August water consumption is doubled because of tourism.
- Dependence of northern Greece from transboundary rivers (about 13 billion m3/year)
- The big coast expansion (tourism and urbanization) increased the intensive exploitation of coastal aquifers leading to salinisation.

It is concluded, that on top of these (semi) natural conditions (besides agricultural and tourism exploitation) the availability of water resources in Greece is exacerbated by:

- Significant increase of consumption
- Reducing water inflow from neighboring countries
- Pollution
- Externs events such as droughts (due to climate change).

Overview of Regional and National Water legal framework

In the below table a list of regulations selected from a broader collection of water management and protection related regulations, to reflect regulations directly affecting water utilities in Greece.

Table 27: Regulations affecting water utilities in Greece

JMD 39626/2009	Determination of measures for the protection of groundwaters from pollution and degradation in complianace with the provision of EU Directives 2006/118/EC
JMD 43504/2005	Categories of water usage Permits and implementation of water exploitation works
JMD Y2/2600/2001	Quality of drinking water in compliance with Directive 98/83/EC of the European Union of 3 November 1998. Later on modified by M.D. 38295/2007
P.D. 256/1989	Water Permits
JMD 16/5813/1989	Implementation Permits for exploitation of water resources by private legal entities, not included in the public sector and individuals
N. 1069/1980	Incentives for the Founding of Water Supply and Sewerage Enterprises
Law 3199/2003	Aligns Directive 2000/60/EC referring to Administrative organization of

[1] Extracted from 'Water Management Analysis in 'water district 10'of Region of Central Macedonia, Greece. . 1G-MED08-515 WaterinCore. Anatoliki. December, 2009.

	the water sector

Competent Authorities and organizations for water supply, water and wastewater management: Law 3199/2003 aligned with the Directive 2000/60/EC of the European Parliant to restructure the administrative organization of the water sector and in relation to all organizations: National Water Committee, National Water Council as well as national and regional water Directorates.

Table 28: Competent authorities and organizations for water supply in Greece

National Water Committee	Formulation of the government's policy and also for submission of Annual Report to the European Parliament with an update on the environmental status of the aquatic bodies and the implementation of legislation
National Water Body	Convened once a year and represetnated by scientific institutions, members of political parties and representatives of the Ministry of Environment, Energy and Climate Change
Regional Water Directorate	Evaluates management plans and puts into place measures programs - also issues water extraction permits
Regional Water Council	Consultative response to every water protection and management topic
Municipal Enterprises for Water Supply and Sewerage	Responsible for hte control, pricing and management of water supply, sewerage and waste water treatment

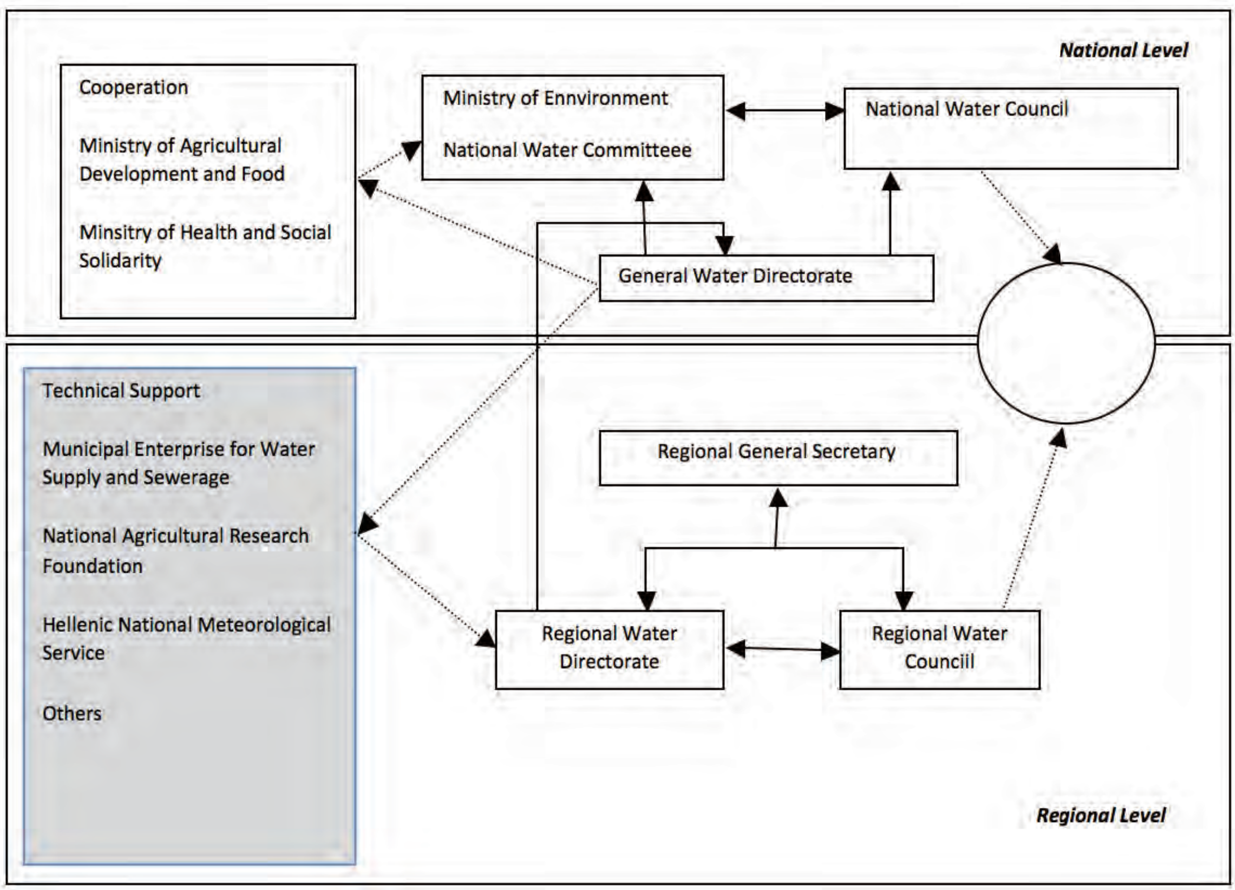

Figure 62: Interaction between National and Regional Regulation levels

Thermi Municipal Water

The Municipality Water Supply has been in a processes of adaptation as part of the consolidation of municipalities Thermi (provisions of law. 3852/2010 "New Architecture of Government Administration and Decentralization - Programme Kallikratis") as amended and currently in force, set up the single Municipal Water Supply and Sewerage Municipality of Thermi - D.E.Y.A. Thermi - after merger of Municipal Enterprises for Water Supply and Sewerage Thermi, Mikra and Vasilika. The DEYA Thermi governed as to the management, organization, execution, operation and maintenance of power projects from the provisions of law. 1069-1080.
DEYA Thermi municipal enterprise is the sole responsible organization for water supply, sanitation and irrigation, i.e. the management of water resources. In its nature of a public sector (recently modified in 2011) strives for a compulsory transparent system of organization. Along with the general policy of water and natural resources, it is the aim of the municipal company to in this times of strong economic-social crisis (and the necessary support to vulnerable social groups) to provide cheap and quality services to its citizens, while covering operational costs such as maintenance and staffing. It is the aim of the company to remain a sustainable local business resisting plans of shouting down municipal structures, while reducing the social role of local authorities.
With the creation of the new municipality of Thermi (1/1/2011) with the number 101/2011 decision of the City Council Thermi has in principle the integration of existing DEYA Thermi and Mikra (GG 1101 / vol.B / 02-06 -2011). By the numbers 596 / 16-11-2011 Decision of the City Council completed the delivery receipt of the property of former water authority and the Royal City 27/12/2011 repealed and the Association of Greater Water Supply Area Mikra and after this development received all movable and immovable property of the legal person in the upper D.E.Y.A.TH (GG 2985 / vol.B / 27.12.2011)[1].
Evolution of management in DEYA Thermi
AS far as municipal pricing policies are concerned, there is lack of homogeneity in tariffs and pricing methods. A change initiated by the European Framework Directive is ongoing in order to adjust the tariff to cost recovery.
The cost recovery of domestic water supply had significantly decreased in 2004 in the municipalities of Thermi and Vasilika[2]:

Table 29: Cost recover rates for domestic use Thermi and Vasilika

	2001	2002	2003	2004
Thermi	104%	101%	93%	77%
Vasilika	105%	101%	74%	56%

Since then, and the merge, DEYA Thermi has developed a new pricing policy. The pricing policy applied by the D.E.Y.A.TH. is deals with economic, technical and administrative services and it aims at moving towards cost recovery. The pricing policy recommending the services is further processed and decided by the Governing Council of D.E.Y.A.TH. The final decision on pricing is decided upong the Municipal Council of the Municipality of Thermi. By the Decision No. 426/2011 of the City Council decided to apply a uniform pricing policy across the new Municipality of Thermi (uniform scale volumetric water consumption in all local communities Municipality implementing similar invoice and implementation of the quarterly consumption

[1] Public Consultation for the management of drinking water and pricing of water supply in the municipality of Thermi. DEYA Thermi. July 2013.
[2] 'Water Management Analysis in 'water district 10'of Region of Central Macedonia, Greece. . 1G-MED08-515 WaterinCore. Anatoliki. December, 2009

measurement). On this basis it was decided the pricing policy in all settlements based volumetric tariff and to address the effects of drinking water wastage motivated by financial reward consumers who demonstrate their environmental sensitivity, and through the economy in water consumption. The current tariff for drinking water consumption today is:

Table 30:The current tariff for drinking water

Consumption (m3)	Price (EUR/m3)
0-35	0.30
35-70	0.40
70-105	0.60
105-140	1.00
More than 140	1-60

Investment plans

Due to the merge of utilities, DEYA Thermi was forced to accelerate the investment plan in order to bring up to speed the infrastructure of the municipalities of Mikra and Vasilika that were significantly lagging behind.
The main investments at this moment are in: drainage infrastructure and exploration of new sources. In addition to that, the DEYA Thermi has initiated a program of Operation and Maintenance of existing infrastructure to reduce its current Non-Revenue Water rate of 40%. A very significant program has been initiated in 2011 to record abstraction and consumption. The utility investment in the installation of flow meters and currently all hosueholds are metered (a total of 25.000 - excluding buildings for public use such as schools or municipality owned buildings , but a new initiative is being developed to fully meter all consumption - private and public).[1]
The budget for DEYA Thermi can be described as follows (approximations):

- 1 million EUR invested in maintenance: including routinary controls and purchase of small infrastructure or replacements (fully financed by water tariff)
- 3.2 million EUR from European Union in the form of grants: 300.000 dedicated to water supply network improvements and aprox. 3 million for drainage
- They do not receive any support from municipal taxes.

6.2.3 Netherland water governance and efficiency programme

The Netherlands had to deal with water since the very beginning of its existence. Excavations in 1990 along the coast proved that water management was already part of dutch people's lives even before the Common Era began (Rijkswaterstaat, 2011). Progressively, the Netherlands became pioneering at land reclamation, and as a direct consequence they had to become experts in land protection due to increased land subsidence (due to excessive drainage operations). The result of these exercises created the Water Boards already in the Middle Ages. The cooperation of landowners to protect and maintain the construction of dikes created one of the first water management bodies, and certainly the oldest democratic form of government in the Netherlands.

Water supply in the Netherlands is of good quality and available, at a reasonable price, to the entire population. Even though water is abundant, the Netherlands has one of the lowest water

[1] Interview DEYA Thermi management (13 October 2014)

consumption rates in developed countries with about 130 liters per person per day (VEWIN, 2012) and water leakages in the distribution systems between 5 and 6% (VEWIN).

As opposed to the other cases documented, the Netherlands provides an example of a country where water is not scarce, yet the technological developments are significant and leading in the sector. Technology adoption is very often geared for resource efficiency, that in its turn is motivated by lack or a decrease in the resource available. With the case of the Netherlands we show that in an opposite scenario, where water is abundant, resource efficiency programs, resource protection, and therefore technology adoption is still on top of the agenda of developments.

Overview of Regional and National Water legal framework

Water management in the Netherlands has been regarded as a public responsibility relying on public authorities developing policies and managing generally the water affairs. This is due significantly to the specific challenge that the country faces in maintaining water levels at the required levels to maintain the economy and life developed in the extensive territory of reclaimed land. For the execution of water related works, the Dutch water sector heavily relies on private sector companies for the dredging, pumping stations, wastewater treatment plants or building of dykes. Besides that, Dutch water companies even though operated publicly remain under private Dutch law. The Netherlands has typically from its beginning of water management initiatives (when they were not even called like that) been characterized by a decentralized governance system. Roles and responsibilities were last updated in the last revision of the Water Act (in 2009). Water management in the Netherlands is carried out all government levels (OECD, 2011).

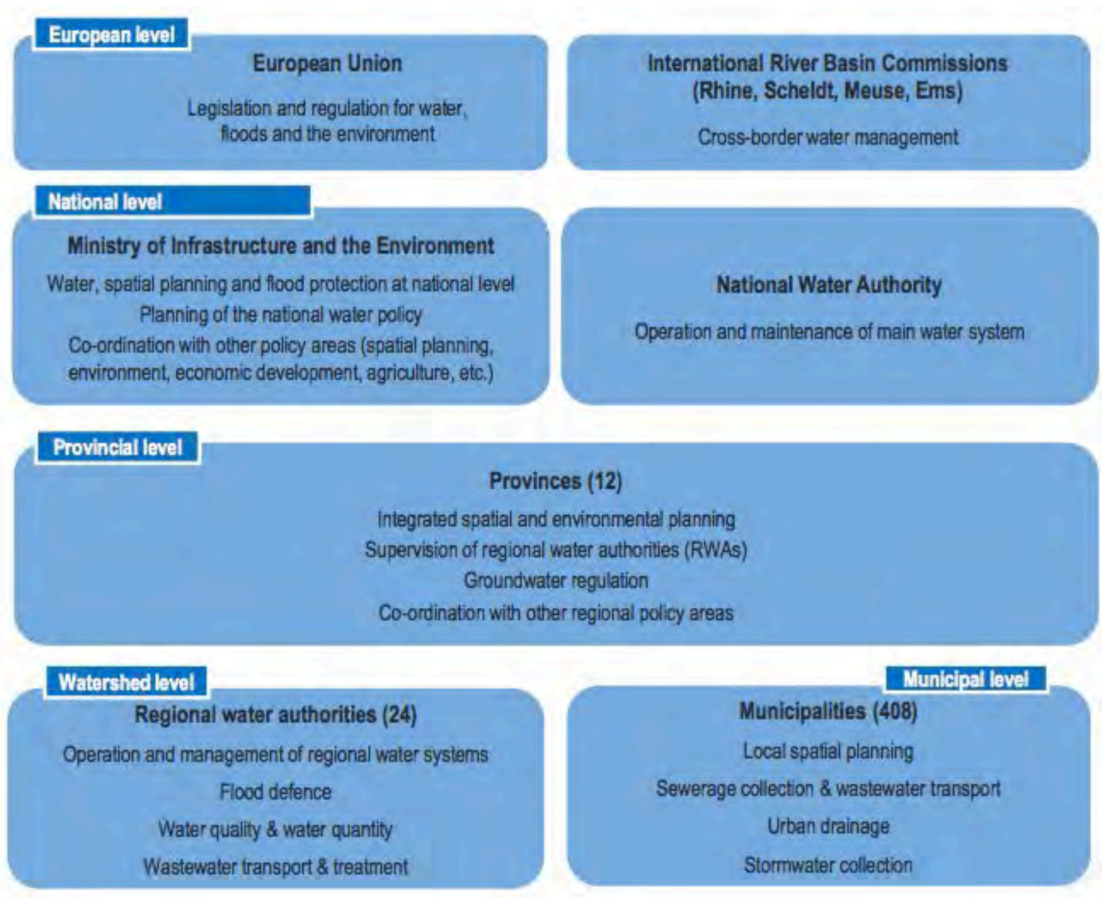

Figure 63: Institutional layers of water management in the Netherlands (OECD, 2014)

The intricate and mutually dependent governance system of the Netherlands (note that figure 63 does not show all organizations - i.e. drinking water companies) requires a systematic approach and a clear distribution of roles and responsibilities, in particular in the following fields (OECD, 2014):

- Responsibility of drinking water supply is closely linked to the quality of water resources (rather than to quantity)
- In a densely populated country like the Netherlands issues of water are intimately linked to issues of land use, which convey significant problems in water management because limits to water use may narrow land uses and hamper economic development
- The agricultural use of water in the Netherlands is significant as to consider it in relation to distribution of water supply for human consumption, and even land use impact and on flood management and water quality.

Characteristics and Responsibilities in the Dutch Drinking Water Sector

Until now, however, we have not covered anything about the specifics of the drinking water sector in the Netherlands. The Drinking Water Act sets up the organization of the drinking water supply in the Netherlands and relies on government bodies to ensure public water supply. The central government plays still a central role but responsibility for the operation of the drinking water supply systems is entrusted to (ten) drinking water companies. Water companies in the Netherlands are semi-public bodies (**Figure 64**) that operate under private law while their owners are provinces and municipalities. In 2004, parliament banned private sector involvement in water supply, however, in practice, drinking water companies contract our many services to the private sector directly (i.e. repairs or engineering design).

Two characteristics of the water supply sector deserve to be highlighted as distinguishing features of the Dutch water sector. Firstly, the production and supply of drinking water has been segregated from the treatment of wastewater. Water supply companies do not engage themselves in the collection and treatment of wastewater. The task of wastewater conveyance, treatment and discharge is left to the Waterboards. Secondly, water supply companies are currently not subject to an external economic regulator. Despite plans from the Ministry of Economic Affairs to introduce economic regulation the water supply companies, united in the Netherlands Waterworks Association (VEWIN), have been able to postpone such regulation. Instead the companies rely on a system of economic self-regulationi. The quality of drinking water produced, however, is regulated. A Public Health Inspectorate ensures that drinking water meets hygiene standards that are set by national and European Law.

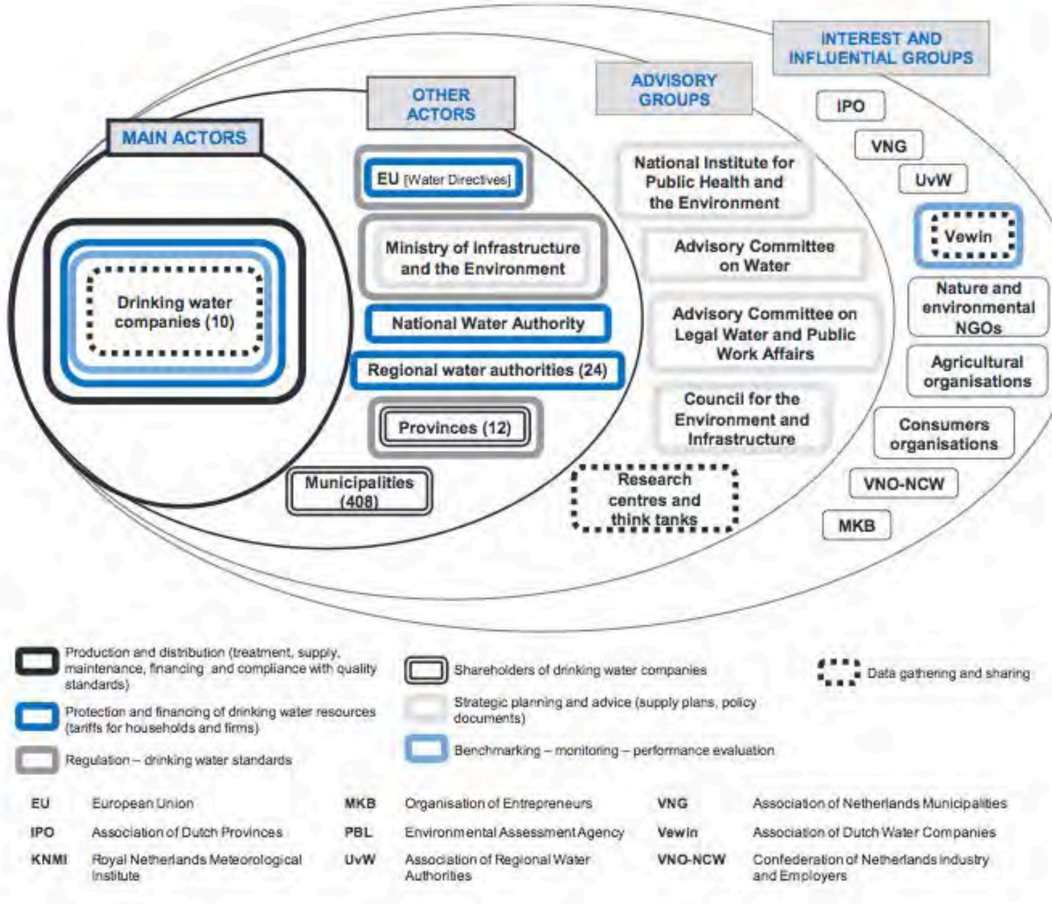

Figure 64:Water Companies organization in Netherlands

The government-owned public limited company (PLC) enjoys considerable prominence in many parts of the world where it can alternatively be known as a ‘public company’, ‘government-owned company’, ‘state-owned enterprise’ or a ‘state-owned company’. The essence of the government-owned PLC is that the company is established and operates under company law whilst the shares of the company are in hands of national, regional or local government authorities. Generally, there is no legal or organizational difference between a publicly owned and a privately owned PLC apart from the government ownership of shares. In some countries, however, special laws may exist that regulate government shareholdings in PLC[1].

In the past decades the government-owned PLC has become increasingly popular in various branches of infrastructure services provision. The government-owned PLC has been promoted as a means of stimulating more efficient management of infrastructure by introducing corporate structures similar to commercial, market-oriented enterprises. One of the main reasons for introducing such a structure is that it allows burdensome civil service regulations, which may impede the performance of public utilities[2], to be by-passed. Also, the government-owned PLC has been used as a transitional stage in the move towards full divestment. Examples of Dutch PLCs that were at one time government-owned but have since been privatized include KLM Royal Dutch Airlines, DSM chemical company, the

[1]In New Zealand for example it is a ‘constitutional convention that government requires explicit statutory authority before acquiring a shareholding in any company […]. Accordingly, there are no cases of companies used as instruments of state action where the only statutory framework is the Companies Act’ (McKinlay 1998).

[2]In Indonesia, for example, one of the reasons that introduction of the PLC structure is being considered is the desire to mitigate the burdensome labour regulations that are stipulated in the civil service code.

NMB/Postbank which would later merge into the ING Group, the Postal and Telecommunications Service (PTT) and the Dutch Railways (NS) (Van de Ven 1994).
Since the early beginning of water supply in the Netherlands in the 1850s the sector has evolved continuously. This evolution is illustrated by the various modes of organization that have been dominant since the first water supply company started operating in 1853. Broadly three distinct periods can be identified (Blokland 1999).

1. 1853-1920. In this era the water supply sector was dominated by privately owned water supply companies (full divestiture). Towards the end of this era the municipal public utilities were steadily increasing in number.
2. 1921-1974. During this period the municipal public utilities formed the predominant mode of organization in the Dutch water sector. The private utilities were declining further in number and the public water PLC was emerging.
3. 1975-present. During this phase the public water PLC has become the most prominent mode of organization whilst the other existing forms were reduced further in number. At current only two privately owned water supply utilities and one municipally owned public utility operate in the Netherlands.

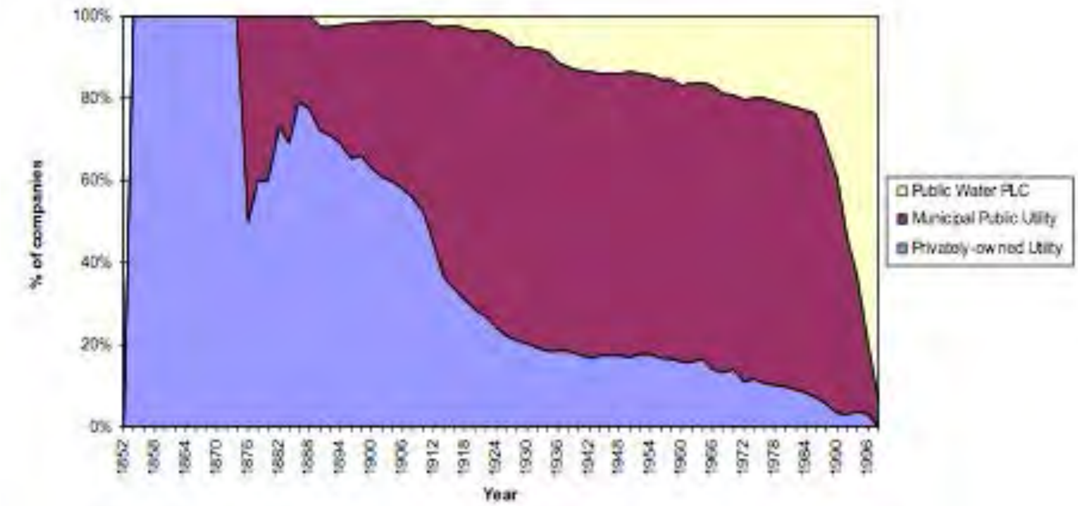

Figure 65 Source: Blokland (1999)

For the drinking water sector, however, the Dutch Government recently decided against privatization of water supply companies. The decision to 'secure government ownership of water supply companies' is based on the belief that the emergence of private monopolies in the water supply sector would be 'undesirable' in the context of the Government's duty to ensure safe drinking water and to protect public health (Ministry of Housing, Spatial Planning and Environment 2000).
In the water sector, government-owned PLCs or public water PLCs, as they are also known, are quite common in Western Europe, where they can be found in Germany, the Netherlands, Belgium, as well as in the Scandinavian countries. They are also found in the United States under the name of municipal stock corporations, but are less prominent in low and middle-income countries. In the landscape of modes of organization in the water supply and sanitation sector, government ownership and the legal framework under which it operates distinguish the Public Water PLC from other modes of organization. Figure 65 provides an overview of the main differences between the public water PLC and other generally accepted modes of organization in the water supply and sanitation sector.

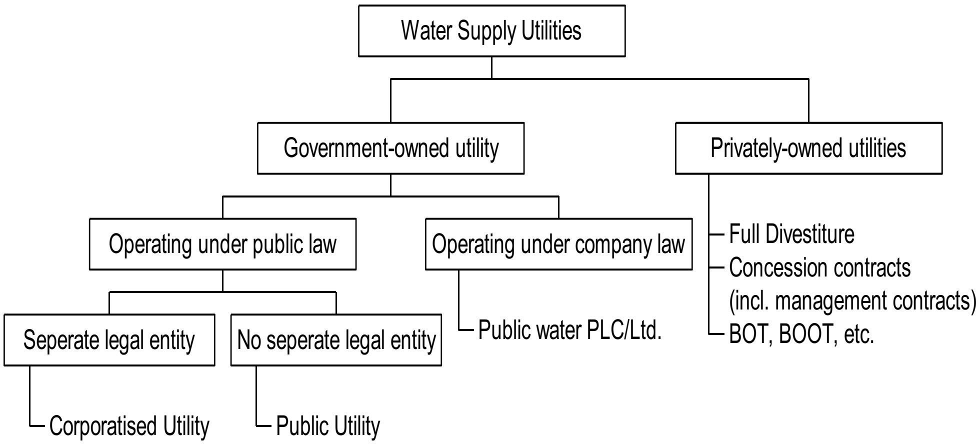

Figure 66: Distinguishing Features of the Public Water PLC

Regulation in the Netherlands

Water Act (2009)

The Act of 29 January 2009 contains provisions for the management and use of water systems. This Act highlights the integrated management of water based on 'water system approach' which mains that efforts were main to identify and properly distinguish the relationships between all elements within a water system: quality, quantity, surface and groundwater, and land and water use. The Act is a framework legislation that is translated and implemented through secondary legislations such as the Water Decree or Water Regulation (Rijkswaterstaat, 2011).
These are some of the factors collected in this Act that are relevant for our study:

- Priority of rights: in case of water shortage the Water Act enables the water authority responsible to take one function precedence over the other.
- Project plans: a water authority can construct a civil-engineering structure or modify it by means of a project plan. In the project plan interrelationships are collected such in the event that these construction has a major impact on flood defenses.
- Water permit: the Water Act introduced an integrated water permit, replacing previously six permits. These permits include a wide range of activities (ie. extraction from groundwater or discharge of polluted water). A 'one stop shop' approach and ICT facilities will support efficient working procedures for the processing of permits.
- Organization of water management: Provinces and municipalities do not act as water management authorities, even though they do develop certain related tasks (i.e. sewage tax collection). Provinces remain the competent authority for three categories of groundwater extraction: public drinking water extraction, underground storage of energy and industrial extraction of more than 150.000 m3/year. Municipalities, regional water authorities and provinces supervise and oversee each other's activities
- Financial provision: it provides the basis for the pollution charge and groundwater charge as well as ring-fences the collection of water related taxes/levies for the use exclusively of water related tasks. Nothing is mentioned in the act about drinking water pricing.

Drinking Water Law (2011)

In July 2011 the Drinking water Policy together with the Drinking Water Law were approved. These regulations were developed to replace the existing Water Distribution Law and Water Distribution Policy.

Some of the technical regulations implemented with this law were:

- regulate the use of materials and chemicals for warm water distribution
- Connection to small users (applicable only after April 2012)
- Prevention of legionella infection in water distribution networks
- General drinking water regulations

The Governance Structure of the Public Water PLC

The legal framework of the public water PLC consists of three complementary parts. The first part concerns legislation that regulates the drinking water sector in general and legislation that regulates government-ownership of shares in PLCs. In the Netherlands, the cabinet decision to prohibit privatization of the water sector is an example of such legislation. The second part of the legal framework concerns company law, which defines, in broad terms, the main characteristics of a PLC as well as the main rights and obligations of the various actors in a PLC. In the Netherlands, company law concerning PLCs is mainly to be found in articles 64 to 174a of the second book of Civil Law or 'BurgerlijkWetboek'(BW:2). The third part of the legal framework concerns the articles of association that have to be adopted at the time the PLC is established. These articles of association specify in greater detail the obligations and rights of the various actors.
National and supranational legislation with respect to the drinking water sector will generally have precedence over company law, which in turn has precedence over the articles of association of a PLC. In this chapter the focus will mainly be on the company law and on the articles of association.
Dutch law identifies and attributes responsibilities to four main actors in PLCs. These four actors are the managing director or management board, the board of directors, the shareholders and the worker's council. The first three actors are present in each PLC. The worker's council is usually only required in companies, which have at least 100 staff members. Below these different actors are elaborated upon in greater detail[1].

<u>Managing Director</u>
The managing director is responsible for the day-to-day management of the company. The managing director is also the company's legal representative unless stated otherwise by law. Decisions and actions taken by the management must be directed at realising company goals. To ensure this company law dictates that the managing director is personally responsible for any debt that cannot be covered by company assets, in case the PLC goes bankrupt and it is plausible that the bankruptcy is the result of mismanagement on the part of the managing director. Moreover, if the managing director has presented misleading figures about the (financial) state of the company, he/she is personally liable for debts resulting from the misrepresentation of figures.

By law, the managing director is also responsible for presenting the annual accounts to the shareholders meeting and the worker's council within five months of the closing of the financial year. These accounts provide information about the company's financial performance over the previous year, solvability, assets and liquidity. The annual account has to be approved and signed by the board of directors and by a reputable, independent accountant prior to being sent to the shareholders meeting.
Within the PLC structure the managing director has a bridging function. The managing director cushions the impact of the board of directors on the work of the company's staff and interprets particular demands from the board of directors to the staff. At the same time the managing director represents the interests of the staff before the board (Thynne 1998). In addition, the managing director of a government-owned PLC must be able to display considerable political sensitivity. The government-ownership of the company as well as the fact that the company provides the essential service of drinking water supply inevitably exposes the managing director directly or indirectly to

[1]Based on articles 64 -174a of the 'BurgerlijkWetboek' unless mentioned otherwise.

the wider political environment. The managing director must be able to function effectively in that environment (Thynne 1998).

Board of Directors

The board of directors is responsible for supervision of the management of the company and of the general functioning of the company. Article 139 specifically stipulates that in performing their tasks the board of directors is to be guided by company interests. Similar to the case of the managing director, company law dictates that the board members can also be held personally responsible for any mismanagement of the company.

The board has free and unlimited access to all company facilities and information and can advise the management of the company on any issue it considers relevant. Among the more important tasks of the board are the appointment, dismissal and suspension of the managing director, and approval of the annual plan. Dismissal of the managing director requires prior consultations with the shareholders meeting. As mentioned earlier, the board of directors also has to approve the annual accounts prepared by the managing director.

Members of the board of directors can be suspended by other board members. A request for dismissal of a board member on grounds of neglecting his/her responsibilities can be submitted to a Court of Law by other board members, a representative of the shareholders meeting or the works council. The Court of Law in question ultimately decides if the request for dismissal is valid.

Similar to the managing director, the board of directors also fulfils a bridging function. The board of directors has to look outwards to the shareholders of the company and inwards to the management and staff of the company (Thynne 1998).

Shareholders Meeting

The shareholders meeting, which is to be held at least once a year, is granted “all powers, within limits set by Law and articles of association, that are not bestowed upon the management or others” (art. 107 BW:2). Although article 107 seems to attribute considerable powers to the shareholders, in most large PLCs, the shareholders have little direct control over the management of the company because considerable powers are bestowed upon other actors by the articles of association. Generally, the powers of the shareholders are limited to approval or rejection of the annual accounts, proposals to amend the articles of association, and ultimately, proposals to dissolve the company. Although the shareholders theoretically have the opportunity to adjust the balance of powers and tilt it in its favour by amending the articles of association, the shareholders generally refrain from doing so.

The shareholders meeting, which is convened by the board of directors or the managing director, is entitled to receive all desired information from the management and board of directors unless disclosure of particular information poses a severe threat to company interests. All shareholders have the right to vote during the shareholders meeting. The number of votes that a shareholder has is dependent on the number of shares that the shareholder owns.

Workers Council

The rights and obligations of the workers council are stipulated in the 'Law on Worker's Councils'[1]. Every company with over 100 employees must establish a worker’s council. All Dutch water companies employ more than 100 employees and as such have a workers council. The functioning of the council is mostly arranged in the statutes that every council must draft. These statutes relate to all matters that have been delegated to the council by the 'Law on Workers Councils'. The council and the managing director are to meet at least six times a year during which any issues

[1]Wet op de Ondernemingsraden

considered relevant can be discussed. The council has the right to request all information that could be considered relevant in performing its tasks. The council has the right to inspect the accounts, annual budget, multi-year forecast, and other key strategic and legal information. In addition to the right to such information, the council has a range of advisory powers on issues such as changes in organisational structure, termination and expansion of business activities, company siting and major investment and lending activities, and tendering consultancy assignments. Moreover, the council has the right of approval on regulations pertaining to matters such as pension plans, work hours, holidays, recruitment policies, training and handling of complaints.
The advisory powers of the council are only sparingly used. However, when used the advice tends to be accepted by the managing director. On average the managing director adopts three out of four initiatives (Blokland and Schwartz 1999).

The Articles of Association

The articles of association are drawn up before a public notary and need to be approved by the government for compliance with private company law and public law. These articles may stipulate company objectives, maximum capital outlays or loans that the managing director can decide upon independently, the composition of the board, the ownership and transferability of the shares, the number of annual shareholder meetings, the financial result which is to be obtained and how to utilise this. The articles also specify in greater detail the powers held by the board of directors, the managing director, and the shareholders. The restrictions and limits set in the articles of association are self-imposed by the shareholders meeting. The articles of association actually define in detailed terms the operating structure of the PLC. Below, the way in which the articles of association define the operational structure of the PLC is illustrated by looking at the articles of two water supply companies.

Distinguishing Characteristics of Dutch Water PLCs

Publicly owned water PLCs in the Netherlands have certain characteristics that are not shared by other PLCs. These salient features result directly or indirectly from the fact that the water supply companies are owned by government agencies and from the nature of the drinking water sector in the Netherlands. These characteristics can be divided into managerial characteristics and financial characteristics. The management characteristics relate to mayors in the Netherlands being appointed instead of elected, the composition of the board of directors, the fact that the shareholders have limited their powers and the fact that the issue of water supply lacks political appeal in the Netherlands. The financial characteristics are the low levels of equity, a history of full cost recovery and limited profit sharing.

The Appointed Mayor

In the Netherlands the mayor of a municipality is appointed by the national government. The relevance of the appointed mayor for provision of water supply lies in the fact that the members on the board of directors of public water PLCs tend to be mayors from shareholding municipalities. The only ways in which mayors can be removed from office are by a ‘vote of no-confidence’ from the city council (which rarely occurs) or if the mayor tenders his or her resignation. As such, mayors tend to remain in office for a long period of time. The long-time horizon that the mayors can adopt and their (relative) independence from municipal politics insulate the board of directors of many Dutch water supply companies from political opportunism[1].

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[1]In discussing the constraints to improving water services in Latin America Spiller and Savedoff have indicated that the main reason for the poor performance of water utilities is the problem of governmental opportunism. Governments with

Composition of the Board of Directors

A key question in the government-owned PLC is what role the board of directors should play. The role played by the board may be one of representing the government shareholders or it may be one of providing commercial expertise to the PLC. The membership of the board and how these members are appointed or elected will depend on how the shareholders define the role of the board. Historically, the Dutch water PLCs have placed emphasis on the role of representation of the government shareholders. Mayors from the shareholding municipalities and provinces generally populate the board of directors. As such, most board members are politicians with an administrative background. The problem with a board of directors that emphasizes representation of (government) shareholders is that the board members are often not well versed in the technical, financial, and commercial aspects of the drinking water industry. In fact, when one takes into account the likely expertise of the managing director, there appears to be a serious imbalance between the knowledge of the board members and that of the managing directors when it comes to running a water supply company. The result of such a knowledge-imbalance is that the board members are unlikely to have the necessary skills to properly supervise the actions of the managing director. The dangers of inadequate supervision speak for themselves.

In recent years, this problem has been recognized and the role of the board as a source of commercial expertise is increasingly gaining importance. In other words, the board of directors is becoming increasingly professionalized. However, such a development is not without obstacles. Replacing a director with an expert-director requires a municipality to give up their seat on the board. Giving up a seat on the board means giving up influence. Needless to say, this is a very sensitive issue. Despite its sensitivities the process of professionalization is slowly taking place. For example, the board of Limburg's WML decided to take additional expertise on board. The board invited a surface water expert into its midst. One geographical region has voluntarily given up one of its seats on the board to enable the water supply expert to join the board. In the long run, WML appears to strive for a 50-50 distribution: half private-sector representatives, half government officials.

A second characteristic that follows from the fact that the board members are overwhelmingly government representatives is that most board members have to return the fee they receive for sitting on the board. According to Dutch law, government employees who are also board members of a PLC have to return the fee they receive for being a board member. This means that the mayors who sit on the board of directors do not gain financially from their board membership.

A third issue that derives from the composition of the board of directors is the potential conflict of interests between the responsibilities as board member and those of mayor. Although formally, a board member must set aside other commitments (for example to the constituents of his/her municipality) it remains to be seen if such separation of responsibilities can always be achieved.

A fourth issue relevant to the composition of the board of directors in the Netherlands is the agreements (often specified in the articles of association) between the shareholders concerning the regional distribution of seats on the board of directors. Often the board members will come from different regional areas of the service area, thus ensuring that all regions are represented on the board.

Limited Powers of Shareholders

As mentioned earlier all powers not bestowed on the managing director and board of directors belong to the shareholders. Characteristic for Dutch water supply PLCs, however, is that the shareholders

short time-horizons are likely to avoid unpopular decisions that may yield benefits only in the longer term (Spiller and Savedoff 1999).

have substantially limited their powers in the articles of association. By way of these articles, the shareholders are largely limited to accepting or rejecting the annual accounts and to rejecting or accepting amendments to the company statutes.

Lack of Political Appeal
With almost universal service coverage and high customer approval rates[1] the issue of water provision is largely lacking in political appeal in the Netherlands. Although the water supply sector did receive some media attention due to a government decision to prohibit privatisation of the water supply sector and the Second World Water Forum in The Hague, the issue of water supply does not seem to be high on the agenda of the consumers.
As long as drinking water quality is beyond reproach and prices are acceptable, the drinking water industry offers politicians little incentive to intervene for the sake of personal (political) gain.

Limited Profit-sharing
A fifth characteristic of the water supply PLCs is that a large number of these PLCs have limited the dividend payments to the shareholders. The limits are stipulated in the articles of association. Although some PLCs, like WBE, do not impose restrictions, most water PLCs either limit dividend payments, such as WML that restricts payments to 7%, or even entirely forbid dividend payments, such as the Dune Water Company South Holland (DZH). All the profit earned above 7% in the case of WML and any profit in the case of DZH goes to the reserves of the water supply company to pay for future investments or production costs. Clearly, the limits to profit sharing illustrate that the first priority of the shareholders is not the return on their investment but the continued supply of drinking water.

Low Equity
Another characteristic concerns the low amount of equity that the shareholders bring into the company. In the case of WML for example, the 57 shareholders hold a total of 500 shares. Each share is worth approximately US$5,263[2]. The total amount of the shares thus amounts to just over US$2.6 million. Considering the capital-intensive nature of the drinking water industry, this is a very low amount. The shareholders are only liable for the capital they have put into company shares. Low equity levels thus, also imply low (financial) liability levels for the shareholders. The low level of liability of the shareholders in conjunction with the fact that the shareholders are municipalities and provinces, mean that the shareholders are not as adamant about performance efficiency as private investors would be. The shareholders have relatively little to lose and, with some drinking water companies restricting the dividend payments, there is little incentive for shareholders to press the management of the PLC for greater efficiency.

Cost Recovery
As mentioned earlier, the origins of the water supply sector in the Netherlands sector lie in the private sector. This has meant that since the early beginning the Dutch water supply companies have operated on the principle of full cost recovery. Still today, no public funds are used for public water supply. Only for special innovative, pilot projects, such as deep-infiltration experiments can companies request government subsidies. This has meant that the consumers are accustomed to paying the full cost of water.

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[1]A benchmarking study undertaken in 1999 showed that the services provided by Dutch water supply companies are rated well. On average a 7.7 (on a scale of 1 to 10) rating was given. This compared well with service provision by Dutch supermarkets (7.0) and Dutch public transportation companies (5.9) (VEWIN 1999).
[2]Figure dates from 1997 and may have altered slightly due to exchange rate fluctuations.

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