WATERNOMICS

(ICT for Water Resource Management)

Methodology for Deployment of a Water Management System

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Abstract. WATERNOMICS is a three years EU funded research project and responded to the call FP7-ICT-2013-11. The partners variously specialize in ICT & Automation systems development, sensors development, business model development, water system design, open source based platform, energy and sustainable management, exploitation and dissemination activities. WATERNOMICS will provide actionable information on water consumption/availability to individual households, companies and cities in an intuitive & effective manner at relevant time-scales for decision-making. Key project objectives include: to introduce demand response and accountability principles in the water sector, to engage consumers in new interactive and personalized ways increasing their water efficiency and leads to changes in water behaviors; to provide decision makers with the actionable information they need to get started in the implementation of a water management program. WATERNOMICS will develop a standards based methodology to implement a Water Management System (WMS) as a personalized and customizable solution for stakeholders.

Keywords: ICT · water savings · water management system · water consumption · raising awareness

1 Introduction

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 [3]. 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.

Currently the limited information available from the water services ecosystem is not interoperable or not presented effectively to stakeholders. Waternomics overcomes this problem by implementing a new level of smart meter and sensor technology and a standard based methodology. These decision support services are enabled by smart water technology [5], which (i) enables the detailed and real-time measurement of water flows and usage, (ii) informs analysis of water consumption patterns and (iii) provides key recommendations on how to increase water efficiency in a holistic context that includes governance, standards and local area policies and environmental conditions.

Waternomics project aims to raise awareness on water consumption and conservation issues in a range of different contexts and users [1]. The project is going to explore and test applications and results in four different contexts (pilot sites). The first is placed in Italy in the large corporate environment of an airport (Linate Airport). The second and the third are to be conducted in Ireland at a primary school building and the Engineering building of NUI Galway. Finally the fourth pilot is to be conducted in a set of households in the municipality of Thermi (Greece) engaging domestic environment users.

In the first year of the project a standard based methodology for the implementation of Water Management System has been developed and is going to be validated and demonstrated in the three high impact pilots:

1. Domestic: Households in the municipality of Thermi, Greece.
2. Corporate: Operator from Linate Airport in Italy.
3. Municipal: University in Galway, Ireland.
4. Municipal: Public school in Galway, Ireland.

2 Objectives

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 [2]. 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. In doing this, it is important to develop a common standards-based framework with which to plan, implement and assess Water Efficiency Measures (WEMs).

To this end, a key outcome of the work consists of designing the first version of Waternomics methodology and 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 efficiency efforts 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.

3 Outline of the work

One of the main outcomes of The Waternomics Project is the Standards based Methodology adopted to guide the project phases.

Waternomics Methodology is a standards-based methodology developed "ad hoc" 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.

The desired outcome of the Waternomics methodology is 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.

4 Materials and methods

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.

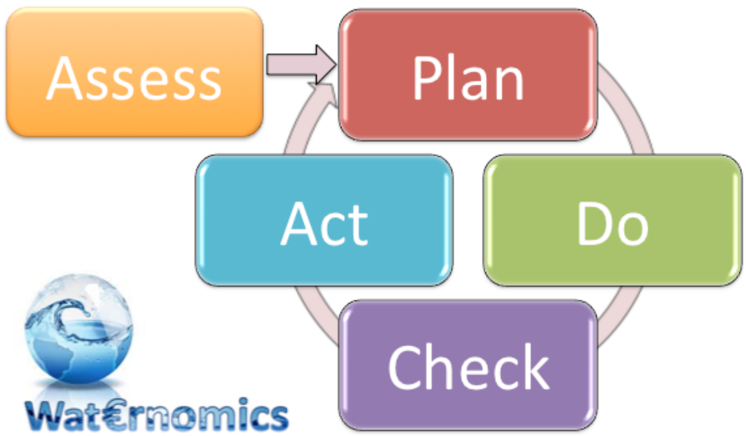

Fig. 1. Waternomics Methodology Overview

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 customized 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.

5 Results and discussion

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 partners like R2M Solution and BMC (Business Model Change) who brought best practices and ideas from energy sector and from the business model generation community where ideation, roadmapping, and iterative process development are community strengths.

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

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[1]	Which describe how specific ends can be achieved
Describes	The Rationale	Behind the use of the these methods

Waternomics leads to the project methodology 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. 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. 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.

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 available standards [4]. Regardless of any sticking points, we instead found it most useful to look at what each standard was trying to do 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 standard and phases (e.g. each phase does not correspond to only one standard). Figure 2 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.

[1] 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.

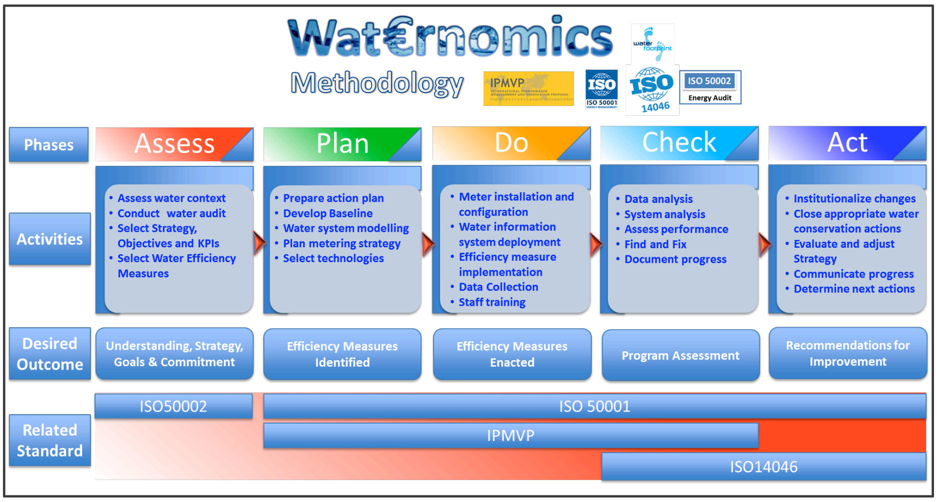

Fig. 2. The Waternomics Methodology (full view) which includes activities, outcomes and its relation to the assembled standards

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".

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 an environmental manager of a large and complex organization may utilize available phases, activities, methods and references with more rigor.

In a further detailing of Figure 2, Figure 3 - 4 – 5 – 6 – 7 provide an additional intuitive view of the method.

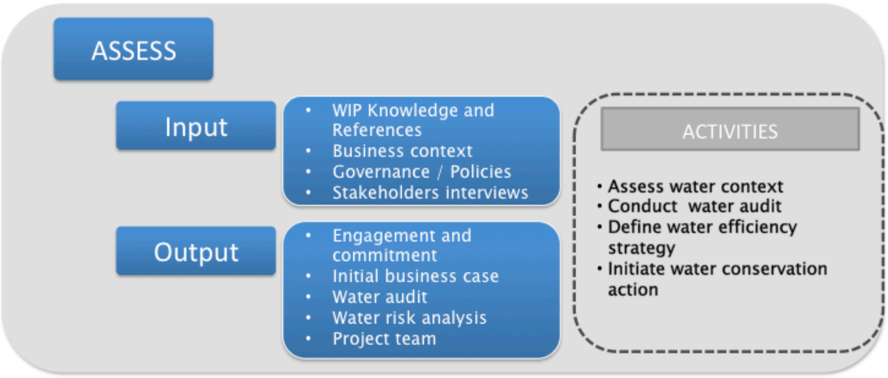

Fig. 3. The guidelines to follow to implement Waternomics Methodology – Phase 0

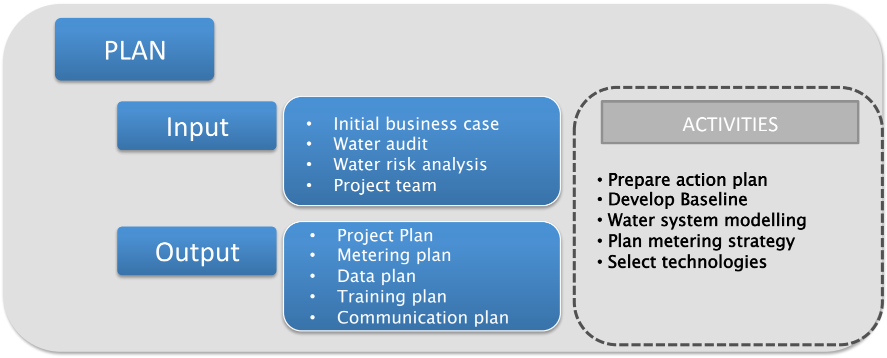

Fig. 4. The guidelines to follow to implement Waternomics Methodology – Phase 1

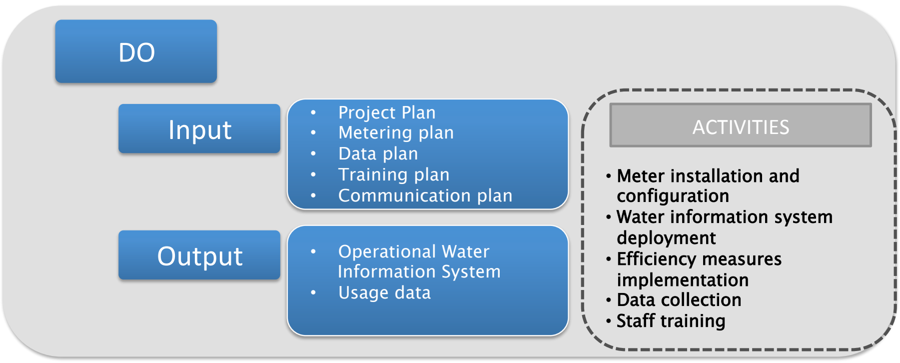

Fig. 5. The guidelines to follow to implement Waternomics Methodology – Phase 2

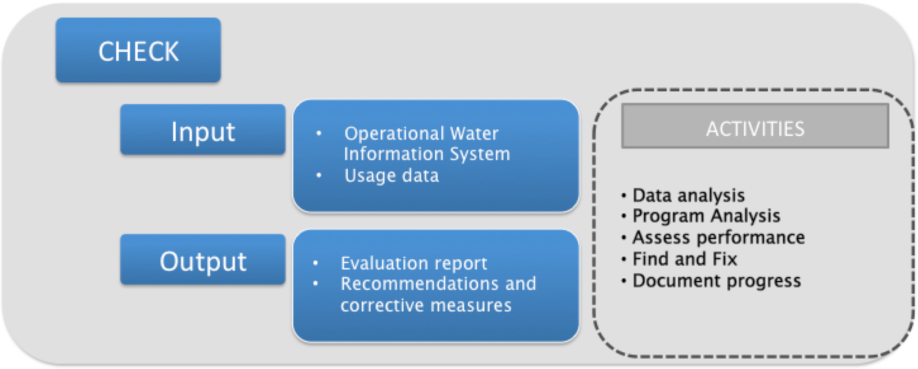

Fig. 6. The guidelines to follow to implement Waternomics Methodology – Phase 3

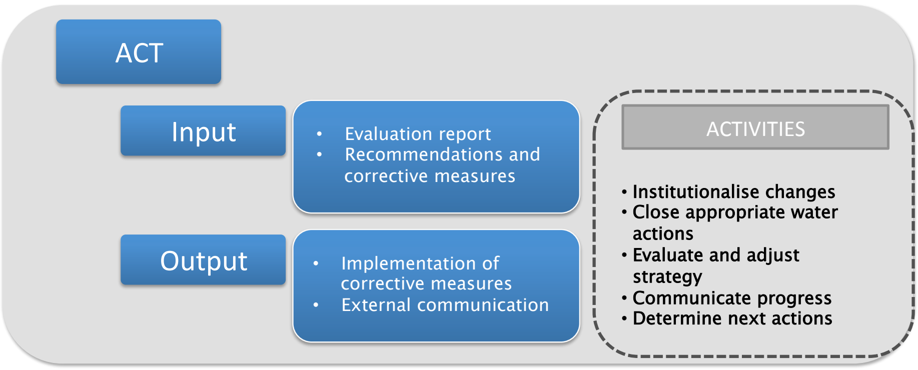

Fig. 7. The guidelines to follow to implement Waternomics Methodology – Phase 4

In the following each phase is described. Its goals and activities are described. More references are provided in "D2.1 – Waternomics Methodology" [7] available on line [8] as public report.

5.1 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

5.2 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.

5.3 Phase 2 – DO

This phase executes 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

5.4 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

5.5 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

6 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) [6] is a public Waternomics 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 paragraphs 6.1 and 6.2.
- 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 final 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 are provided in the following.

6.1 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.

6.2 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.

7 Concluding remarks

This paper presents and discusses one important result in terms of outputs of the WATERNOMICS project: the standard based methodology.

With respect to the Waternomics methodology and developed content, the research and interaction with stakeholders have shown a clear need for this project development. Waternomics is developing tools, references and resources to assist in the construct and implementation of water management programs and the execution of water efficiency measures. Waternomics standards-based methodology offers an innovative way of merging together the main standards of the water and energy sectors and providing the end users a step-to step guide to follow in implementing their water saving programs.

All the Waternomics Team strongly believes in the potential of this project and is investing heavily in the development of this new ICT technology. In the following months we will develop the Waternomics Information System and the applications to provide the water information to the end users and to make them easily apply the methodology.

At the end of the Waternomics project a final version of the presented methodology will be presented to the scientific community.

Acknowledgements.

They project is supported by the EC under grant agreement n. 619660. We would like to thank the Waternomics Partners and the demonstration sites for supporting in the project development.

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