
# D5.2 Consolidated WATERNOMICS Pilot Reports

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|---|---|
| Project Acronym: | **Waternomics** |
| Project Title: | **ICT for Water Resource Management** |
| Project Number: | **619660** |
| Instrument: | **Collaborative project** |
| Thematic Priority: | **FP7-ICT-2013.11** |

# D5.2

| | | |
|---|---|---|
| **Work Package:** | WP5 Pilot and Case Studies | |
| **Due Date:** | | M36 |
| **Submission Date:** | | M39 |
| **Start Date of Project:** | | 01/02/2014 |
| **Duration of Project:** | | 36 Months |
| **Organisation Responsible of Deliverable:** | | TUD |
| **Version:** | | 2.0 |
| **Status:** | | Ready |
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| | Schalk Jan van Andel | IHE |
| **Nature:** | ☒ R – Report ☐ P – Prototype<br>☐ D – Demonstrator ☐ O - Other | |
| **Dissemination level:** | ☒ PU - Public<br>☐ CO - Confidential, only for members of the consortium (including the Commission)<br>☐ RE - Restricted to a group specified by the consortium (including the Commission Services) | |
| Project co-funded by the European Commission within the Seventh Framework Program (2007-2013) | | |

# Revision History

| Version | Date | Modified by | Comments |
|---|---|---|---|
| 0.1 | 05/07/16 | Louise Hannon | Initial Version of Document |
| Draft 1.0 | 24/10/16 | Sandra de Vries | First Draft version |
| Draft 1.4 | 29/10/16 | Sandra de Vries | Draft of D5.2 |
| Draft 1.4 | 02/11/16 | Wassim Derguech | Review WD0.2 |
| Draft 1.5 | 04/11/16 | Sandra de Vries | Checked chapters 1,2,8 and 9 |
| Draft 1.5 | 08/11/16 | Sandra de Vries | Checked first review |
| Draft 1.6 | 14/11/16 | Schalk-Jan van Andel & Eoghan Clifford | Second review |
| Draft 1.7 | 23/11/16 | Sandra de Vries | Checked second review |
| Draft 1.8 | 24/11/16 | Sandra de Vries | Checked after proof reading |
| Draft 1.9 | 08/12/2016 | Wassim Derguech | Check and update |
| Draft 1.10 | 24/02/2016 | Sandra de Vries | Added version D5.2 |
| Draft 1.11 | 04/03/2017 | Wassim Derguech | Review and formatting |
| Draft 1.12 | 05/03/2017 | Edward Curry | Review |
| Draft 1.13 | 07/04/2017 | Wassim, Louise, Domencio | Updates following the review |
| Ready 2.0 | 11/04/2017 | Wassim Derguech | Final version preparation |

# 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 ICT tools [1]. The project develops and introduces 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 and other fault detection and diagnosis [2] [3] [4] [5].

This report consolidates the WATERNOMICS Pilot Reports (Corporate, User and Municipal) into one single report to disseminate documentation, data analysis, comparisons, and lessons learned from each of the pilot activities. The report outlines the specific measures that were undertaken at each of the pilot sites to examine the effect of ICT interventions on the awareness and behaviour of stakeholders in terms of water consumption. In addition, it reports analysis on the assessment and validation impacts of interventions made at each pilot.

The deliverable:

- Describes the data that is used to review established Water Efficiency Measures (WEMs).
- Reviews the pilot plan implementations in the different pilot sites.
- Reports on the outcome of achieving the pilot objectives.
- Compares the results of the different pilot sites with one another.

The four pilot sites have implemented all applicable WEMs and have observed, monitored and assessed the effects of these WEMs. All meters were placed, which was the first step to implement an effective Water Management System.

All pilots have activated the Waternomics Platform and have activated the participants in the pilots to use the platform, through which they could interact with the water usage data supplied from the meters. To strengthen the Platform, Apps have been created. All of the pilots except for Thermi have installed similar types of interactive digital displays that can be used by either travellers or students and staff with positive feedback received.

Open days and training events were held at all three pilot sites with positive feedback from the participants. These events were important to promote ideas and experiences exchange between the users and to increase their environmental responsibility. Participants were educated about water consumption and their role in conservation.

Evaluations of the effectiveness of the WEMS were performed at each pilot site. Some WEMs were found to be more effective in one pilot than in other pilots, due for example the different amounts of water initially used by the participants. Also, the effect of water awareness measures can differ greatly. Increasing water awareness of participants where the baseline was already high, proves to be difficult. In both the NUI Galway and Coláiste na Coiribe pilots it was found that the sample populations exhibit a moderately high level of water awareness. The platform could re-enforce this awareness but it has proven difficult show an increase in awareness over the established high-level baseline. Selecting the appropriate times and periods in applying WEMs turned out to be essential in all pilot sites. It found that exploiting existing communication channels of users is a key takeaway in strategies for increasing awareness. However, when there is a low economic incentive in engaging and learning more about water consumption, the existing communication channels will not be a sufficient drive. When system controlled water usage comprises the most significant proportion of water usage, behaviour changes by staff and students may be entirely masked. Finally, the water information provided by the platform played a key role to support water managers at each pilot site to detect and react to faults, for example monitoring in the Coláiste na Coiribe Pilot has led to the observation and reporting of three faults.

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# 1 Introduction

The goal of the WATERNOMICS Project is to explore how ICT can help households, businesses and municipalities to reduce their consumption and losses of water in the framework of a water management program [6]. A key component of the WATERNOMICS Project is the collection of water consumption and contextual information from different sources [7] to allow effective data analytics that will drive decision-making that optimises water consumption: e.g., planning, adjustments and predictions and to raise user awareness of water consumption.

This document, Deliverable 5.2 Pilot Report (D5.2), is the final report for Work Package 5 (WP5) - the WATERNOMICS implementation phase - and describes, by application of the WATERNOMICS Methodology the work (to-date) that has been performed at the project's four pilot sites (Table 1.1). In addition, details are presented of the current results, after implementations of planned measures, at each of pilot sites, reviewing whether or not both the project and pilot-specific objectives are satisfied. The report describes the implementation of WATERNOMICS in the demonstration pilots and can thus inform future research or commercial projects that aim to improve water efficiency and increase end-user awareness of water usage.

An overview of WATERNOMICS work packages and deliverables can be found at www.WATERNOMICS.eu. Deliverable 2.1 (D2.1), which described the WATERNOMICS methodology referred to in this report can be accessed through this site.

*Table 1-1: WATERNOMICS Pilot Sites*

| Environment | Site | User Description |
|---|---|---|
| **Corporate** | Linate Airport, Italy | Corporate Users & Customers |
| **Domestic** | Thermi, Greece | Domestic Users & Utility Providers |
| **Public/Mixed Use** | National University of Ireland Galway, Ireland | University Students, Staff & Management, Public |
| **Public/Mixed Use** | Coláiste na Coiribe, Galway, Ireland | School Students, Staff & Management, Public |

## 1.1 Work Package 5 Objectives

The high level objectives of WP5 are to:

- Pilot, demonstrate and validate the innovative WATERNOMICS Platform at the identified pilot sites representing commercial, domestic and municipal (mixed-use) water users;
- Analyse the efficacy of the deployed systems to enable increased awareness and reduced water consumption;
- Determine the feasibility and efficiency of the flexible tariff (pricing) mechanisms/incentives and their effect on demand prediction, demand management, and water consumption;
- Gain feedback from consumers and utilities on system performance to include;
    - personalised interaction with the system

- ease of data accessibility
- longitudinal user awareness/behavioural surveys at the demonstration sites
- the WATERNOMICS game

- Evaluate the WATERNOMICS Platform as an information platform for both water providers and water users.

## 1.2 The Role of Deliverable D5.2

The role of this deliverable is to consolidate the WATERNOMICS Pilot Reports (Corporate, User and Municipal) into one single report to disseminate documentation, data analysis, comparisons, and lessons learned from each of the pilot activities.

The report outlines the specific measures that were undertaken at each of the pilot sites to examine the effect of ICT interventions on the awareness and behaviour of stakeholders in terms of water consumption. In addition, this report outlines our findings on the effectiveness of the interventions.

## 1.3 Relationship with other Activities in the Project

This report follows on from previous deliverables including (i) Work Package 1 Deliverables, in particular D1.1 and D1.3 that describe the user requirements and Key Performance Indicators (KPIs) as determined from stakeholder's interaction (ii) Work Package 2 deliverables (D2.1 and 2.2) that detail the WATERNOMICS methodology and the measurement framework that informs the metering plan in each pilot. (iii) Work Package 3 deliverables (D3.1.1 and 3.2) detailing fundamentals of the developing WATERNOMICS software platform including data management plans, associated software, support services API's and components' libraries and (iv) Work Package 4 (D4.1, D4.2 and D4.3) detailing innovative metering techniques and the results of analysis and diagnostics trailed at the pilot sites. This report will directly follow on from Work Package 5 (D5.1) on the original Pilot Plan requirements. A schematic overview of the interrelationship of D5.2 within the Project Work Packages can be seen in Figure 1-1. Further details on these deliverables are available at www.WATERNOMICS.eu.

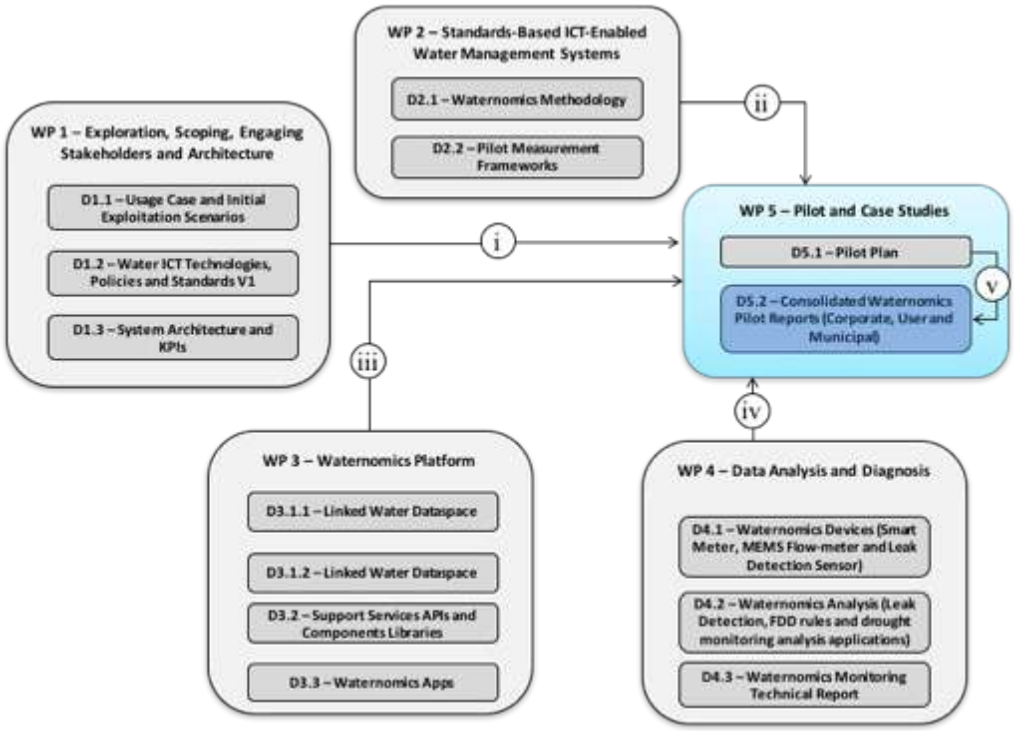



*Figure 1-1 Interrelationship of Project Work Packages*

## 1.4 Document outline

The report will start with Chapter 2 Data collation and reporting, which gives an overview of the available data, and collates the information that the data series provide.

Chapter 3 then reviews the pilot plan implementation for each pilot separately. This is followed by chapter 4, 5, 6, and 7, which report on the progress made for the pilot implementation of respectively Linate Airport, Thermi, NUIG and Coláiste na Coiribe. For each pilot the implemented WEM to achieve the site objectives are discussed.

In order to synthesize the pilot implementations, the pilot sites are compared with each other in Chapter 8. There, also concluding remarks are drawn, examining whether the Objectives of Work Package 5 are met and the role of deliverable 5.2 is fulfilled.

# 2 Data collation and reporting

In order to reach the objectives, Water Efficiency Measures (WEMs) were included which gave concrete measures on how the objectives could be achieved. One must designate the manner by which it can be determined whether the set of objectives and corresponding improvements in water use and consumption have been achieved, as well are what methods were used. Data from the baseline and details of the WEMs should not be lost over time. These have therefore been recorded. Documentation has to be recorded and stored in an accessible manner and designed to be understood by internal or external verifiers/users as required; data can often be required months or years after an event.

This chapter thus gives an overview of the available data, and collates the information that the data series provide.

## 2.1 Linate Airport

The effect of the different WEMs established for the pilot at Linate Airport, are a collection of the following types of data.

**Meter data**

- Starting in M26 an intermittent Data Collection from 5 installed USF meters continued on untill M36.
- In M32 collection and validation of tender meters started and went on without interruption.
- M36 all the tender meters were installed and the data trasmission was enabled.

**Surveys**

- Engagement of airport passengers to the project and to water consumption was tested in M30.
- Feedback from the users of the Linate dashboard for the Platform has been retreived in M32 to establish initial user trials.
- A collection of water awareness questionnaires was conducted among the SEA staff.

**Statistics**

- Use of the Platform by SEA staff and airport passengers.
- Use of Applications available for SEA staff.
- Amount of participants Open end-users seminar.
- Number of display interactions with thw two touch screen displays installed.
- Number of participants to the “water fair” workshop held in M35

## 2.2 Thermi

The pilot in Thermi reviews the set of WEMs on the basis of the following collection of data series.

**Meter data**

- In M20 metering with 6 sensors started.
- Between M24 and M27 measurements with sensors continued during installation and vallidation.
- Testing and validation of sensors in a household environment was performed at a U4 office in M28.
- Ongoing monitoring with sensors in households started in M29, giving water usage on the different household devices.

**Surveys**

- Participants filled in an initial questionnaire in the second year on infrastructure, in order to gather information about the existing water network infrastructure in houses in order to develop detailed metering plans for each of the households.
- Participants logged their consumption on a monthly basis based on the existing water utility metering infrastructure.

**Interviews and focus groups**

- Feedback from participating households has been collected about the first installation of sensors in households.
- Interviews with users on the launch of the Applications.
- Phone interviews with users conducted on M30-M31.

**Statistics**

- Campaign statistics on release of Applications and weekly newsletters.
- Login data per month to the Waternomics Platfrom.
- Web analytics data from Google analytics.
- Number of households participating to the pilot.
- Number of participants for the Open End-user Waternomics seminar.

**Observation data**

- Photos and notations were made in M21 of 10 households, in order to develop detailed metering plans for each case.

## 2.3 NUI Galway

Findings on the WEMs implemented in the NUI Galway pilot are reviewed on basis of the following data collections.

**Meter data**

- Validation and testing of 8 USF meters was performed in the period of M20 – M27.
- In M22 three extra in line meters were connected with already existing meters from the NUI Galway station, giving in total 11 connected water meters.

**Surveys**

- Preliminary survey, carried out on 70 first year students in M26. This will continue with surveys during the pilot to assess if change occurs.
- A feedback cycle with the users of the Waternomics Platform on the Engineering Building Public and Managers Dashboard started in M27.
- Feedback on the training and launch of the Platform was given in M31 by the Dashboard users.

**Statistics**

- Monitor the number of interactions with the Waternomics screen and Platform (amount of page views, sessions, and duration of sessions).
- Number of display interactions and interactive signages are being logged, using Google Analytics.
- Number of QR-code scans is being tracked.
- Number of new Apps that are developed.

## 2.4 Coláiste na Coiribe

The success of the WEMs in the Coláiste na Coiribe pilot is directly reviewed according to the following types of data sets.

**Meter data**

- 14 water meters have started measuring in M24, and have continued without interruption.

**Surveys**

- A users feedback cycle commenced in M28 on Public and Managers Dashboard Applications.
- Feedback from students and new projects based on Waternomics.

**Statistics**

- Logged interaction with the Managers Dashboard Application and the Public Dashboard, monitored using google analytics.
- Student interaction at the launch event.

# 3 Reviewing Pilot Plan Implementation

This chapter reviews each pilot's plan implementation separately. An overview of the identified Water Efficiency Measures (WEMs) at the start of the Waternomics Project by each pilot can be found in Appendix A. In Table A-0-1 the up to date implemented WEMs are listed, and it is showed how the realisation of the WEM is currently in practice. Appendix A furthermore sets out the preliminary results of the applied WEMs concerning the defined objectives in Table A-0-2, Table A-0-3, Table A-0-4, and Table A-0-5.

## 3.1 Reviewing Pilot Plan Implementation - Pilot 1 Linate airport

Linate Airport is an opportunity for the Waternomics project to interact with a large audience. On average over 26000 passengers and staff, use Linate Airport on a daily basis. Linate Airport is deeply embedded in the urban belt of Milan (Italy). SEA Corporate is the manager of the airport services. In the following are summarized some important notices about the Italian Pilot Site:

- 9.6 million passengers / year;
- 96,000 annual movements;
- deeply embedded in the urbanized southeastern belt of Milan
- an area of 350 hectares
- two runways: the first (2,442 m long) intended for commercial aviation and the second (601 m long) for general aviation
- 10 Km of drinking water network
- 60% of the pipes date back to the period between 1935 and the end of 1938

SEA is a company with public shareholders and the Metering Plan (Ref. D2.2_Phisycal Measurement Framework) developed for the Linate pilot required the development of a public tender. The process has taken more time than what we expected due some administrative problems (Ref: WP5 Pilot Status Report submitted in July 2016). Furthermore, the old age and condition of the water networks in some areas, during the meters' installation have created hydraulic problems (breaking pipes, water losses and interruption of water service).

In general, at the Linate Pilot, delays in the installation of meters and the collection of data have been encountered due principally to the following:

- Legal challenge to the public tender issued
- Operational problems encountered with USF (ultrasonic flow meters) meters installed
- Operational problems encountered with the tender meters during the installation phase due the old age of the water network

The problems encountered have been addressed and measures to mitigate these effects have been taken. In detail the delay registered in the tender procurement process to implement the complete physical measurement framework, has been overcome and the contractor has been selected (M25). So far (M36) the installation of the meters included in the public tender is ended (100% completed) while all the clamp-on meters provided by VTEC have been installed and are sending data discontinuously to the Waternomics Platform.

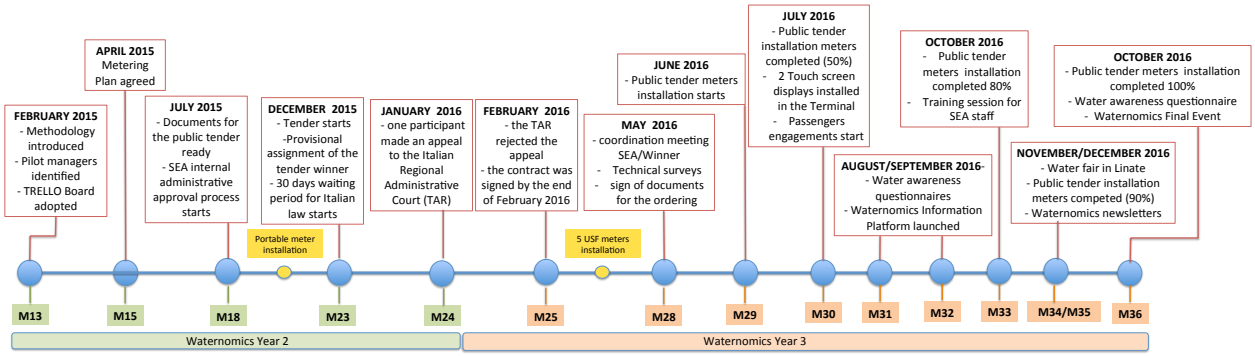



*Figure 3-1: Linate pilot timeline events*

Figure 3-1 shows the key events from M13 to present time (M36) and the timeline of activities at the Linate Pilot. Also, a detailed description is provided in the following:

- Ambitious Metring plan agreed in M15, about 50 meters installed.
- Tender issue solved in M25, Contractor appointed.
- Installation of 5 USF meters was completed in M26 (March 2016).
- Issues concerning the operation of some of the USF installed units became apparent in M26-M27 and on the recommendation of the metering partner VTEC, several on site visits in the Linate pilot were made in order to solve the problems concerning the BBB firmware and the data transmission system.
- Intermittent Data Collection from the installed USF meters continued during the period M26 – M36.
- A new data collection protocol was developed to gather data from the tender meters installed in Linate Pilot.
- The installation of the tender meters was at 80% completed (M33) in the Linate pilot. In order to avoid service disruption of the airport water service the installation works of some meters have been performed in the night time. However the installation registrs some delays due the fact that the water network is very old and carrying out the installation work is more difficult because of the leakages.
- Airport Passengers engagement activities commenced in M30.
- The collection of data from the connected tender meters has continued without interruption since M32.
- A launch / training event for the Waternomics platform among the SEA corporate staff took place in M32.
- Overall WEMs in place in the Linate Pilot since M32.
- Data available on the Waternomics Platform since M26 for USF meters and since M32 for the tender meters.
- Data collection and validation of the installed tender meters starts in M32.
- Initial user trials and feedback cycle of Linate dashboard for the Platform commenced in M32.
- SEA staff are now aware about their water consumption and measurements in the water network.
- Collaboration between Waternomics and ICEWater project completed, the Decision Support System has been included in the Waternomics Platform in order to investigate different pressure set point in the water network.
- M35 – Water fair held in Linate with both consortium partners and external stakeholders.
- Newsletters released to inform the SEA staff about the improvement of the Waternomic Application Platform.
- Second round of water awareness questionnaire performed in M36.

- Waternomics Final Event in M36.

### 3.1.1 Mitigation Measures

As proposed in the WP5 Pilot Status Report submitted in July 2016, the Pilot control period at the Linate Pilot has been extended from M33 to M36 to allow compensation for interruptions to the data collection system experienced, to overcome delays registered both for the legal issues of the public tender and for the USF / tender meters' installation.

### 3.1.2 Current Status and Revised WP5 Program

The installation of the planned meters at the Linate Pilot site is ended (100% completed) and data collection and processing started.

Analysis of historic (pre-Waternomics) baseline data 2008 – 2013 is complete and comprehensive analysis of new data recorded since September 2016 is presented.

Wide scale launch of water efficiency measures (WEMs) commenced M32. These are detailed Chapter 4 of this report. A launch and specific training session for SEA staff at the Linate Pilot site was held in M32. In M36 a "Water fair" has been held in Linate in order to promote Waternomics outcomes and the Application Platform installed in the Linate pilot.

## 3.2 Reviewing Pilot Plan Implementation - Pilot 2 Thermi

At the Thermi pilot, delays in the installation of metering and the collection of data have been encountered due principally to the following:

- Change of requirements in the hardware design by end-users
- Physical layout constraints particular to each household
- Problems encountered in sensors operation due to lower Internet speeds in households than in testing environment

These problems have been addressed and the pilot has already commenced with a revised plan to mitigate the effect of the delays.

Figure 3-2 shows the key events from the beginning of the WP5.

- At (M7) the Municipality of Thermi sent out a press release to local media about to gather interested participants households and a few months later (M10) a simple interface was created for participants to log their consumption on a monthly basis based on the existing water utility metering infrastructure.
- During the second year of Waternomics participants were asked to fill in an initial questionnaire aiming to gather information about the existing water network infrastructure in houses in order to develop detailed metering plans for each of them.
- In M20 the technical partner responsible for the development of sensors visited Thermi and installed 6 sensors in the first household. During this visit a meeting of the VTEC with participants in the pilot was organized in order to introduce end-users to the hardware and gather feedback from the first installation in a household. One of the main outcomes of this session was the request from end-users to decrease the number of boxes to be used in the installation by merging the hardware of the two receiver boxes under a single box instead of two. This request

created the first delay in the pilot.

- After the first installation, detailed metering plans were developed for all 10 household in October 2015 (M21) after visiting and documenting (photos and notations) in detail the requirements for each case.
- The sensors were delivered to Thermi during M24 and a first round of firmware updates took place immediately after the first household installation (M25) to eliminate some initial software problems identified.
- The installations in the rest of the households continued during M26 and M27.
- After having installed the sensors in most of the households (M27) many owners started complaining about the decrease in the Internet speed in their houses which was the second main reason for the delays encountered and which was tackled with a new round of firmware updates (M27) performed on site.
- During the installation period some data has been gathered which allowed us to introduce users to the applications platform. U4 also designed and released a set on initial dashboard applications for each household based on their needs and metering installation. End-users participated in the launch event of the applications platform and an initial round of feedback was gathered in this event.
- The latest firmware update created a need for some additional extensive testing and validation in a real household environment which would be difficult to perform on site. To answer this need, a set of sensors planned for installation in one house was moved and installed to U4 offices (M28). Infrastructure in U4 offices resembles the one in houses so testing and validation could be performed under a controlled environment which shared the similar attributes as the actual environment of households.
- The testing and validation conducted in U4 offices during M28 led to the final remote firmware update that was performed during M29. Since then operation of sensors in the houses has been monitored closely and no additional problems have been identified.
- For the rest of the pilot period an updated pilot plan was developed as seen on Figure 3-3.

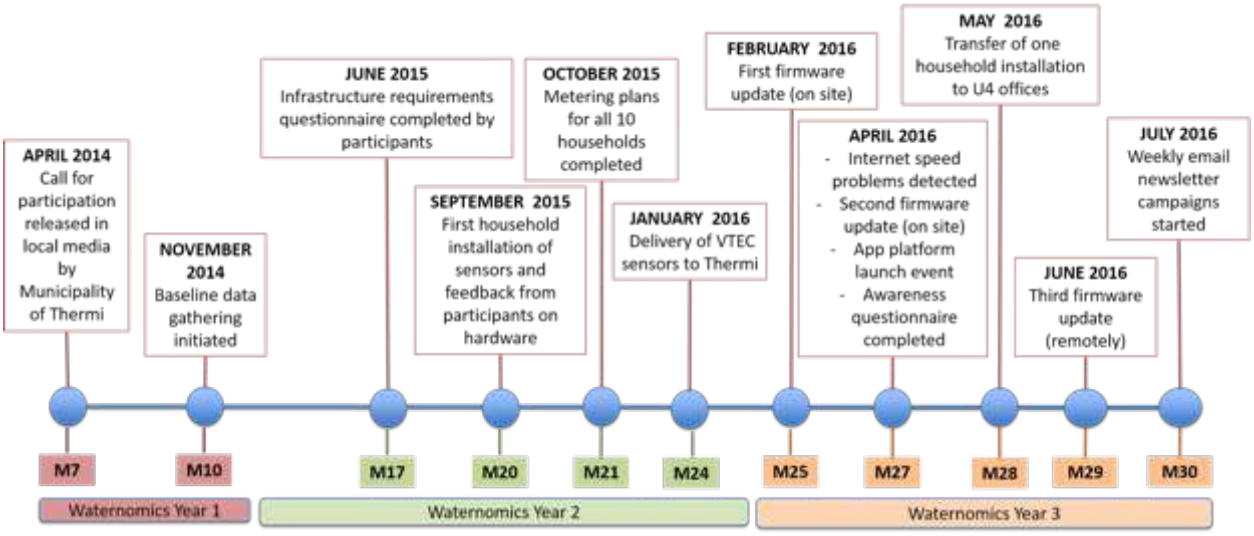



*Figure 3-2: Timeline for Thermi Pilot*

*Figure 3-3: Updated pilot plan Gantt chart*

### 3.2.1 Deviations to Original Program

The initial Pilot plan scheduled for the installation of sensors to happen between M22 and M24. The installation of the first household that happened 2 months ahead of schedule created the first delay since it changed the requirements on the hardware design from the end-users' side.

Further installations in households revealed additional problems not encountered in lab testing mainly due to reduced Internet speeds. Therefore, additional updates, testing and validation was introduced in the plan in order to accommodate the problems encountered.

Although the PLAN phase of the methodology (See Deliverable D 2.1) was completed by M21 the delays happened mostly during the DO phase and the installation of sensors. However, it is important to notice that both reasons that led to delays have to do heavily with end-users' requests and aim in increasing users' acceptance of the sensors in their households. Therefore, deviations to original plan such as a) the movement of the Start Pilot Control period from M24 to M29 and the end of to M36, b) the movement of all WEMs and c) the adjusting of interval periods between them, were necessary so that participants were kept in the project and accepted the sensor installations in their houses.

However, during the implementation of the pilot plan and more specifically during its interim evaluation on M31 based on users' feedback there was a strong request for an application to inform them through email of their consumption. This request led to increasing effort demanded to apply WEM5. Moreover, t was judged that the potential impact in the households from this app could be significantly bigger than WEM4. Therefore, it was decided to abandon WEM4 in favour of releasing this additional app.

### 3.2.2 Mitigation Measures

In order to mitigate the effect of the delays a plan to overcome them was developed. The launch of the initial Pilot apps and platform already took place with a 2 months' delay, although not all houses had complete data without breaks in their timeline. This allowed users to get familiar with the platform while also help in the validation and testing phase that concluded in M28.

The WEMs introduced in D5.1 remain the same with the addition of the extended validation and testing period that was speeded significantly with the installation of sensors in U4 offices. The second biggest change in the plan is that the release of Learning and Exploration apps (WEMs 3 and 5) will happen at the same time without an interval between them (*Figure 3-3*).

Moreover, a more aggressive user engagement strategy has been adopted early in the pilot implementation with the weekly email newsletters released to end-users in order to help in speeding up the engagement of users with the platform. The frequency of newsletters was later reduced as engagement increased.

### 3.2.3 Current Status and Revised WP5 Programme

Currently, most of the installed sensors are in working order (6 out of 8 households). The other two households were reluctant to turn on the sensors for their own individual reasons. The first one complained for decreased Internet speed when the sensor was online although the issue was resolved. The second one was absent from house during summer period and although attempts have been made to contact and investigate the reasons why the sensors were still offline there was no response.

For the other 6 households, the planned WEMs were applied with the only adaptation being the abandonment of WEM4 in favour of reinforcing WEM5 with an additional application release.

## 3.3 Reviewing Pilot Plan Implementation - Pilot 3 NUI Galway

At the NUI Galway Engineering Building, the pilot control period commenced as planned with all additional metering in place at M21.

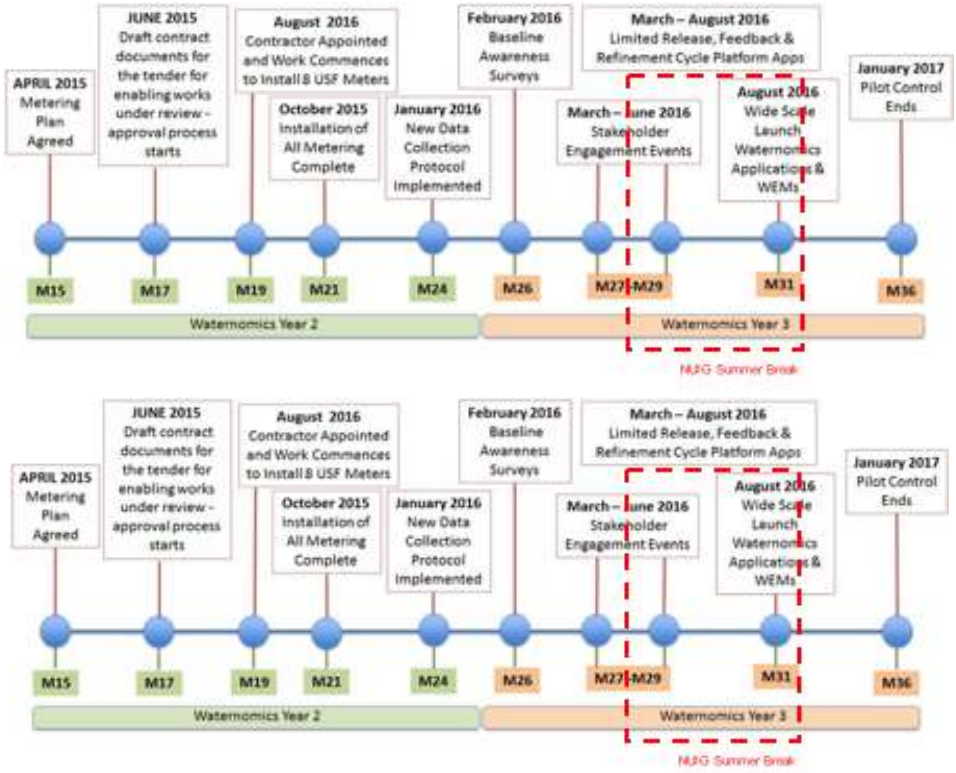



Figure 3-4 indicates the timeline of activities at the NUI Galway Pilot Site. These are described in Section 3.3.3.

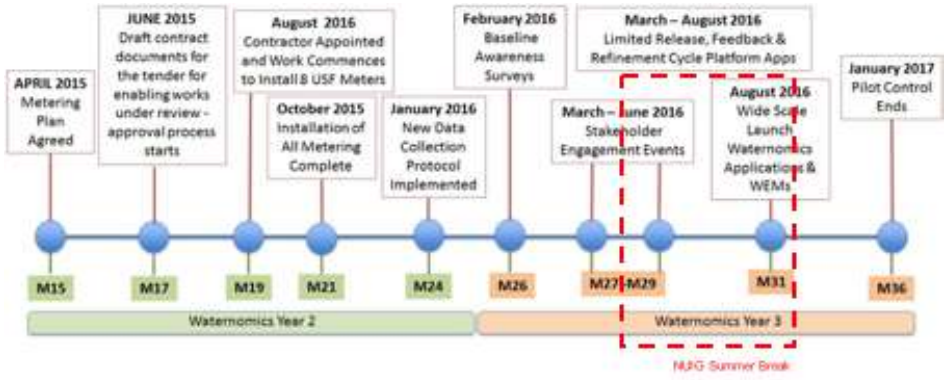



*Figure 3-4 Progress Timeline NUI Galway Pilot Site*

### 3.3.1 Deviations to Original Program

Wide-scale launch of the Waternomics NUI Galway Engineering Public Dashboard took place at the pilot in M31. The wide-scale launch was delayed to coincide with university academic calendar and facilitate initial user feedback results. The wide-scale launch of the manager's dashboard application at the pilot was delayed to coincide with the beginning of the new academic year to facilitate scheduling of staff training outside of holiday period.

### 3.3.2 Mitigation Measures

As proposed in the WP5 Pilot Status Report submitted in July 2016, the Pilot control period at the NUI Galway Pilot was extended to M36 to compensate for interruptions to the data collection system experienced in M22 and M23 and to extend the period of interventions at the Pilot during the academic terms.

### 3.3.3 Current Status and WP5 Programme Reviewed

- Installation of 8 USF meters and associated enabling work was completed at the NUI Galway Pilot in M20 (September 2015). Testing and validation of the meters commenced immediately and a representative of the metering partner VTEC attended the Pilot Site in M19 (August 2015) during the installation period.
- Issues concerning the operation of some of the installed USF units became apparent in M20 (September 2015) and on the recommendation of the metering partner VTEC, elements of hardware were replaced and revisions to installation were made. Intermittent data collection from the installed USF meters continued during the period M21 – M24.
- As a joint initiative with the Building Management at the NUI Galway Pilot and the Waternomics Team, a further 3 mechanical inline meters were installed during M21. The new mechanical meters were connected to the buildings existing Building Management System (BMS) system in M22.
- A new data collection protocol was developed in M24 to gather data from 11 BMS connected water meters pre-dating the Waternomics Project and the additional 3 mechanical meters. This protocol was developed to resolve stability issues with the existing building BMS database set-up. The collection of data from the BMS connected meters continued without interruption from M24 for the period of the pilot control.

- The collection of data from the installed USF meters was effected by some hardware, software and setup issues but data was gathered from 7 of the meters (although sometimes intermittently) from M21 for the period of pilot control. Extensive validation of the data collected from the installed USF metering.
- Analysis of historic baseline data 2011 – 2015 is complete and comprehensive analysis of new data recorded from January 2016 to July 2016 was completed in M32.
- Initial user trials and feedback cycle of Engineering Building Public Dashboard for the platform commenced in M27. Initial user trials and feedback cycle of Engineering Building Managers Dashboard for the Platform commenced in M27.
- Launch and training of the Waternomonics NUI Galway Engineering Managers Dashboard took place in M31. Wide-scale launch of the Waternomonics NUI Galway Engineering Public Dashboard took place in M31 following initial usability studies to coincide with university academic calendar. This launch facilitated inclusion of revisions to the dashboard following user feedback;
- Wide scale launch of water efficiency measures (WEMs) commenced M31. These are detailed in the pilot program (Figure 3-5) and described in Chapter 6 of this report.
- All planned WEMs at the NUI Galway Pilot have been implemented.

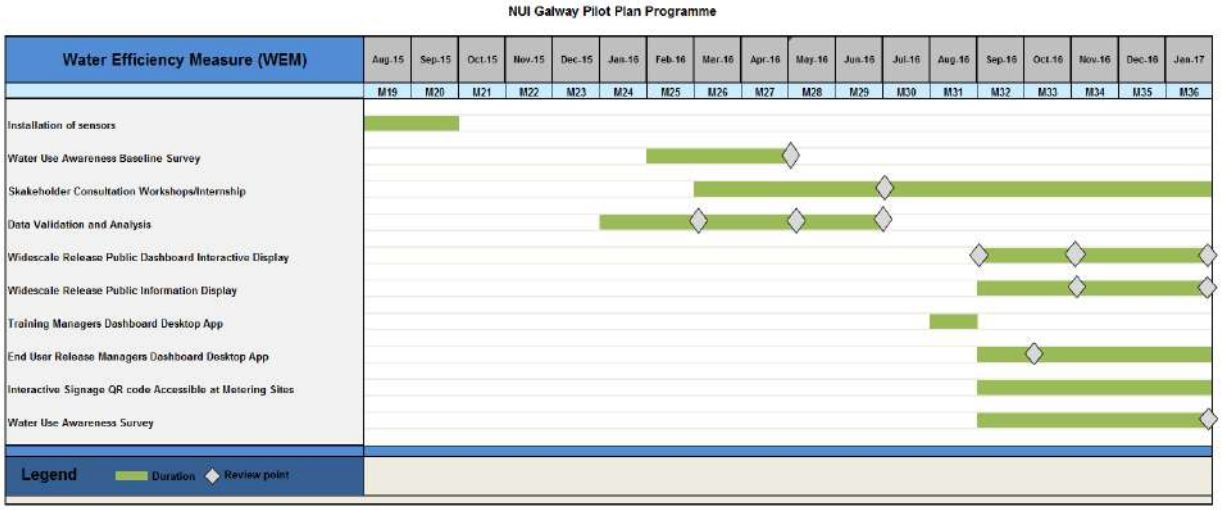



*Figure 3-5 NUIG Pilot site Gantt Chart*

## 3.4 Reviewing Pilot Plan Implementation - Pilot 4 Coláiste na Coiribe

At the Coláiste na Coiribe (CnaC) Pilot Site, the pilot control period commenced as planned in M20. Figure 3-6 indicates the timeline of activities at the CnaC Pilot Site which are described further in Section 3.4.3.

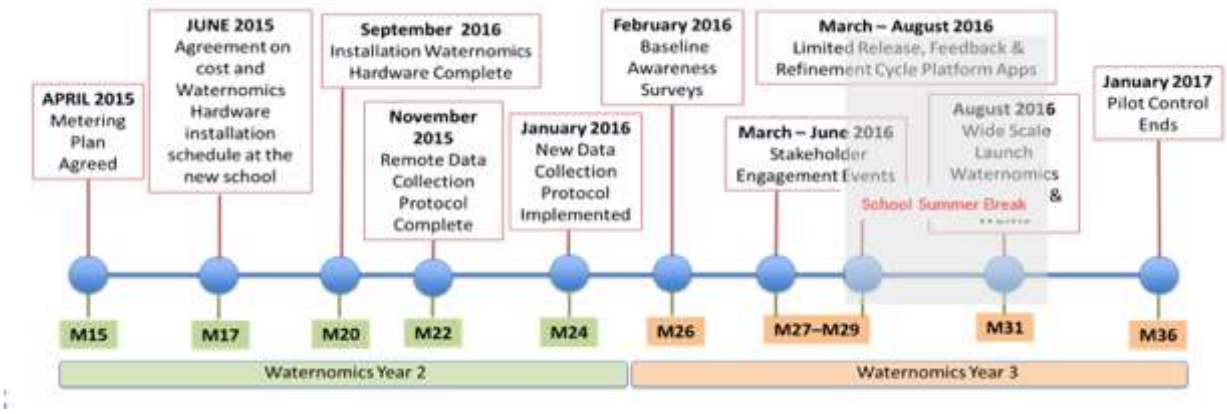



*Figure 3-6 Coláiste na Coiribe Galway Pilot Implementation Timeline*

### 3.4.1 Deviations to Original Program

Launch of the CnaC Public Dashboard was postponed to M32 to coincide with school Academic Calendar (secondary schools in Ireland are closed except for state examinations from the end of May until end of August) also to facilitate revisions to dashboard following initial user feedback.

The full launch of the manager's dashboard application at the pilot was also delayed to M31 to coincide with the beginning of the new school year to facilitate scheduling of staff training outside of holiday period.

### 3.4.1 Mitigation Measures

As proposed in the WP5 Pilot Status Report submitted July 2016, the Pilot control period at CnaC was extended to M36 to increase the period of interventions at the Pilot during the school terms.

### 3.4.2 Current Status and WP5 Programme Reviewed

- Agreement was reached with the school authorities on the installation of 7 additional water meters and an interactive site view screen at the new school premises during the school's construction (M15). Agreement on cost of the installation was reached with the main contractor and M&E sub-contractor undertaking the construction work at the new school premises in M17.
- A data collection protocol was developed in consultation with the school authorities, the M&E sub-contractor and the IT Department of NUI Galway in M18. Installation of all the planned water metering at the pilot site (14 meters) was completed in M20 and the school opened to students in M21. The agreed data collection protocol for metering data from the school was implemented in M22.
- The new data collection protocol developed for the NUI Galway Pilot to store and transfer data to Amazon Web Space (AWS) from NUI Galway meters was extended to the CnaC meters in M24. The collection of data from the CnaC meters continued without interruption from M24 for the duration of the pilot control period.
- Data validation and analysis commenced in M24 and stakeholder engagement activities commenced in M26.
- Initial user trials and feedback cycle of CnaC Public Dashboard and Managers Dashboard

Applications commenced in M28 with Watermomics Pilot site Managers.

- A Managers Dashboard Training session was held in M32 at the school and the dashboard was released for use to the school management.
- An early release for approval to the school authorities of the Public Dashboard took place in M32.
- Revisions to the CnaC Public Dashboard were completed in M33 and a wide scale launch event with students took place in the same month at the school. Figure 3-7 below indicates the timeline followed at the pilot site.
- All planned WEMs at the Coláiste Pilot have been implemented.

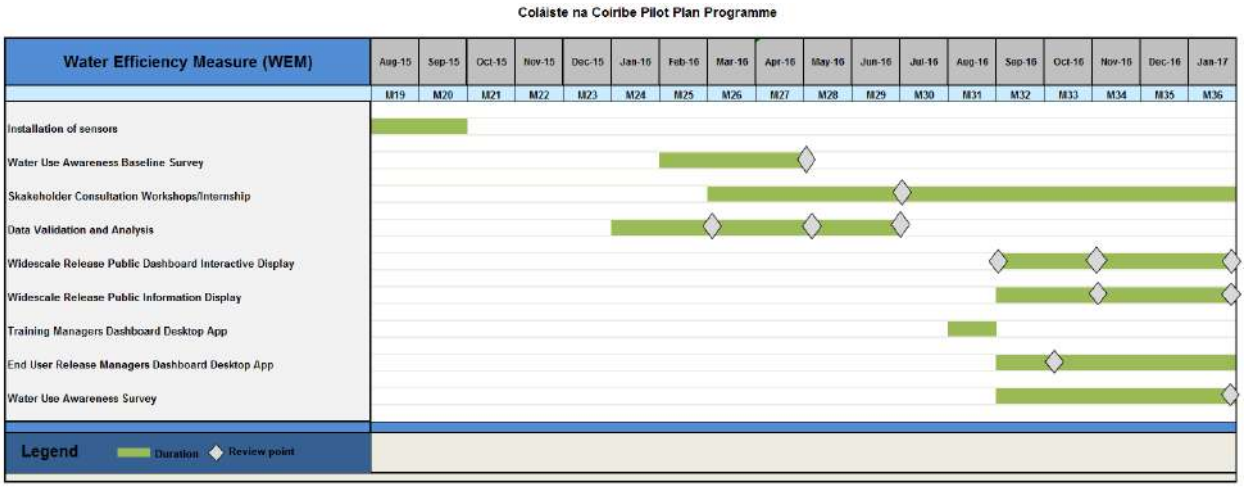



*Figure 3-7 Coláiste na Coiribe Pilot Programme*

# 4 The Pilot Report – Linate Airport

## 4.1 Meeting Pilot Site Objectives and KPIs

As discussed in deliverable D5.1, high-level sets of specific objectives have been identified for the Linate Pilot. These specific objectives can be organized in four specific areas, and they are derived from grouping the Specific User and Functional Requirements and KPIs identified in the D1.3 System Architecture report.

Figure 4-1 summarises the measures that were proposed to achieve each of the pilot specific objectives for implementing a Water Management Program at the Linate Pilot Site.

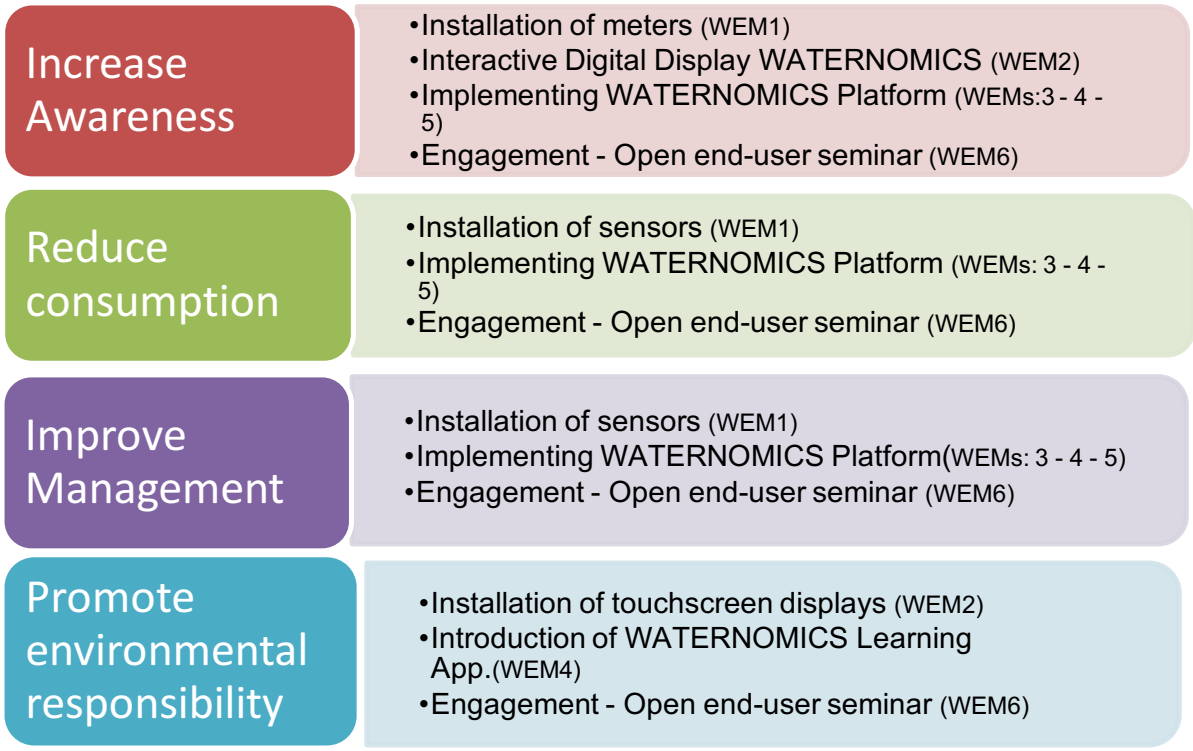



*Figure 4-1: Linate pilot specific objectives and associated WEMs*

This section will now discuss the WEMs that are implemented up to date, the future ones to be implemented from now on and the preliminary results from the application of WEMs so far.

Anyhow Figure 4-2 is intended to give a visual overview of what is being discussed in the next sections and on the current status of the methodology implementation in the pilot site.


*Figure 4-2: Current status of deployment of the WEMs in Linate Pilot*

## 4.2 WEMs applied

### *WEM 1: Installation of sensors*

Water, energy and pressure sensors are now installed (Figure 4-3) in the pilot site according to the implemented physical measurement framework agreed in M15 (100% installation completed). The installation has been very difficult in some cases in which was necessary the water flow interruption in the overall Linate Airport water network, anyhow these problems have been overcome step by step and now water consumption data is available in the Waternomics Platform and the SEA staff is able to get information about their water consumption and this is the first step to enable changes in water consumption behaviours.

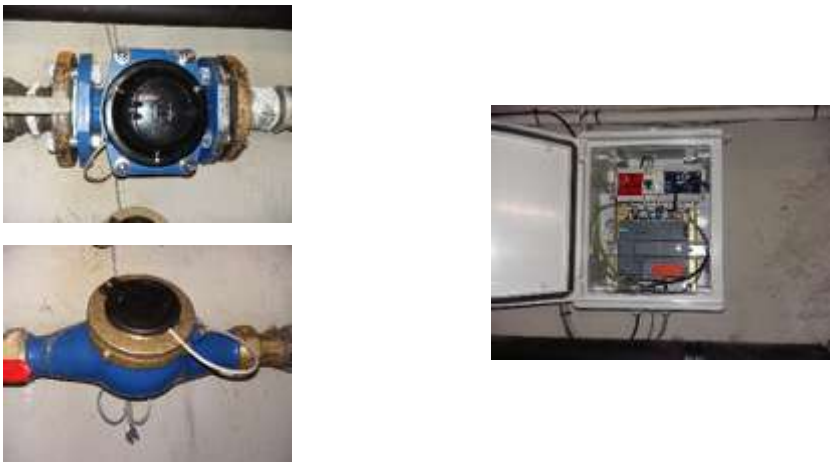


*Figure 4-3: Flow and energy meters installed in Linate Pilot*

Figure 4-3 shows some installation performed in the Linate Pilot that represents the Waternomics pilot site with 50 more meters installed inside. All these meters are necessary to have the real time monitoring

of a large water network of about 10 Km of pipes and to have an overall knowledge of the water consumption of some building inside the airport area.

### *WEM 2: Interactive digital displays*

In M30 two interactive digital displays have been installed in the Linate Airport Terminal building. The Linate airport is for the Waternomics project a unique opportunity to interact with the passengers and to engage them; we have tried to do this by installing two touch screen displays. They convey information about Waternomics project and its applications via videos / tips / games. R2M-U4-SEA have collaboratively worked together to design the content that appears on these interactive monitors. These touchscreens have been procured, configured, and content developed and installed in Linate Pilot (see Figure 4-4).

*Figure 4-4: Touch Screen displays installed in the Terminal building – Linate Airport – Milan - Italy*

They also are equipped with a user's counter and already from the first days of installation a positive user experience was observed (more than 50 users' interactions in 1 day). To interact with the passengers is one of the key aspects to understand the way through which the Waternomics project leads to a change in their water consumption behaviour. The passengers can interact with the Waternomics project by giving a feedback to some sections. Positive user experience was observed in six months of installation and this ensures that it will be an effective dissemination and communication tool at Linate. So far more than 2 thousand users have interacted with the screen to view the content and about 50 users have calculated their water footprint by giving a feedback.

### *WEMs 3-4-5: Launch of the Waternomics Application Platform*

The targets of the Waternomics Application Platform (WAP) are the managers and in general the Staff of SEA corporate and the WAP is the project's product that well summarize the goal of the WATERNOMICS project: "to provide personalised and actionable information about water consumption and water availability to end-users in an intuitive and effective manner at a time-scale relevant for decision-making". The WAP is the way through which the users can interact with the water usage data supplied from the meters and the access to this information will increase end-user awareness and improve the quality of the decisions from decision makers regarding water management and water government. As the WAP is customizable from the end-users, the commercial potential of this product is clear; the end-users can develop applications depending on their needs to visualize the data that they want in the time-scale they think to be opportune to know this information.

Linate Pilot Dashboard

On the basis of what afore mentioned a Dashboard has been developed for the Linate pilot. As the targeted users of the dashboard and in general of the water consumption data could be the managers/ the

operational staff of SEA corporate and due the fact that they could have different needs regarding the information they would like to get from the WAP, what has been developed are some specific applications stored in a market place and each end-user can choose the most appropriate for his needs rather than develop a new application by themselves.

The dashboard is an online platform whereby managers and SEA corporate staff, can access data from the buildings sensors as it is streamed to the database. The dashboard contains unique application development tools that can be intuitively developed by the end-users for their specific needs. Video tutorials on how to develop the apps are also available. There are 4 main sections within the Linate Dashboard and each one has its specific objective as in the following:

- **HOME**: the objective is to convey in the home page of the dashboard the most important information for the end-users. In the Linate case initial surveys have shown that this information is: the percentage of water leakage in the District Meter Area n. 6 (DMA6), the water consumption of the metered buildings within the airport area, the amount of water withdrawn from the three potable wells owned by SEA and the Fault notification in the water network.
- **MONITOR**: the section contains 8 applications installed and each one is targeted to give specific information to the end-users. Figure 4-6 shows the Monitor section. By using these applications the end-users can get information about the water consumption of each building (see Figure 4-5), the water balance in the DMA6 area and the percentage of water leakage, the water consumption in the Terminal building, the water withdrawn from the wells, the installation point and the measurement performed by each meter, some applications to check if the meters are working properly are also available.
- **LEARN**: The section is aimed to give to the end-users the possibility to learn from some video tutorials the following basic actions to start to use properly the Waternomics Applications Platform:
- How to create a your own application
- How to create a single point graph
- How to create a group of point graphs
- How to create a distribution graph
- How to create a comparision graph

  Figure 4-7 shows a screenshot of the Learn section for Linate pilot Dashboard.

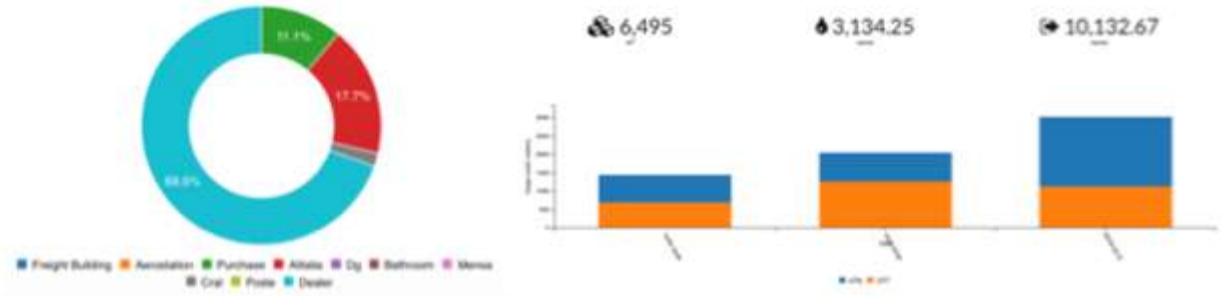



*Figure 4-5: Real time Water Consumption data gathered from the flow meters*

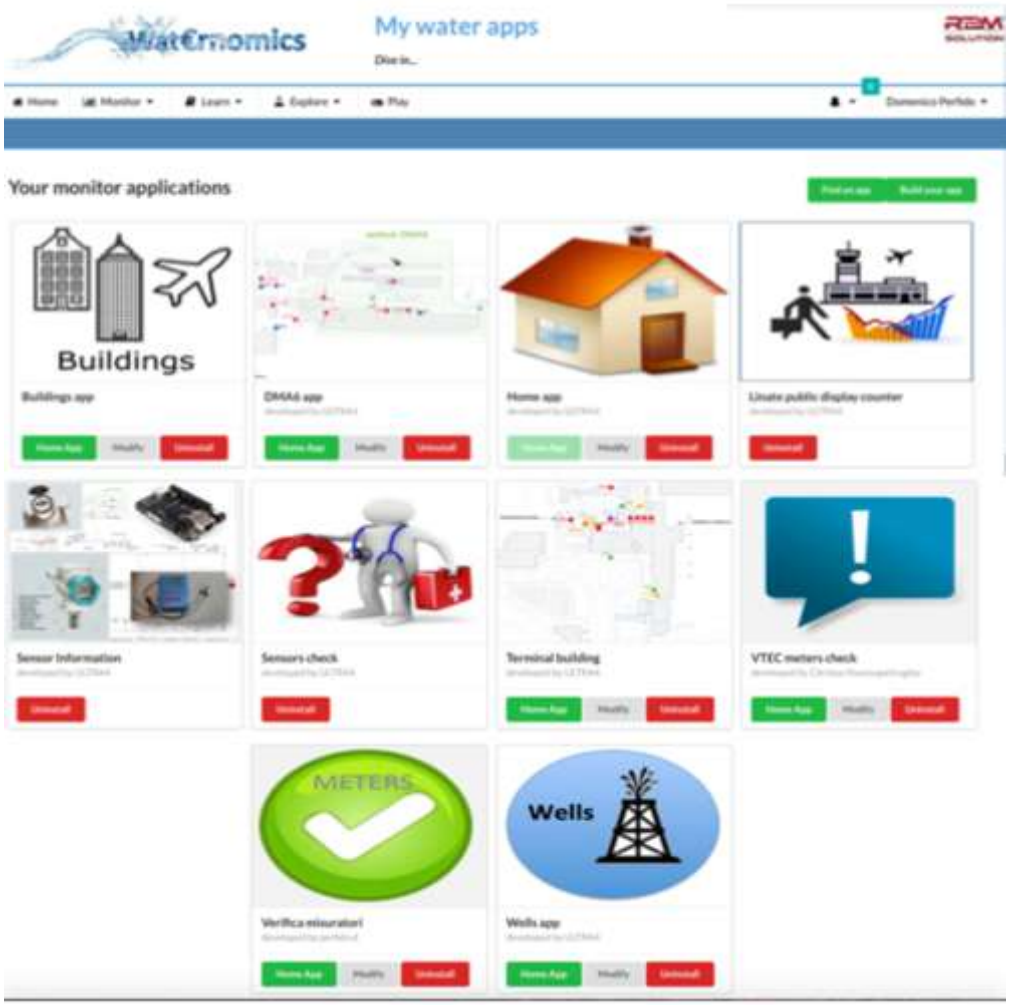



*Figure 4-6: Overview of the Monitor section of the Linate Waternomics Applications Platform*

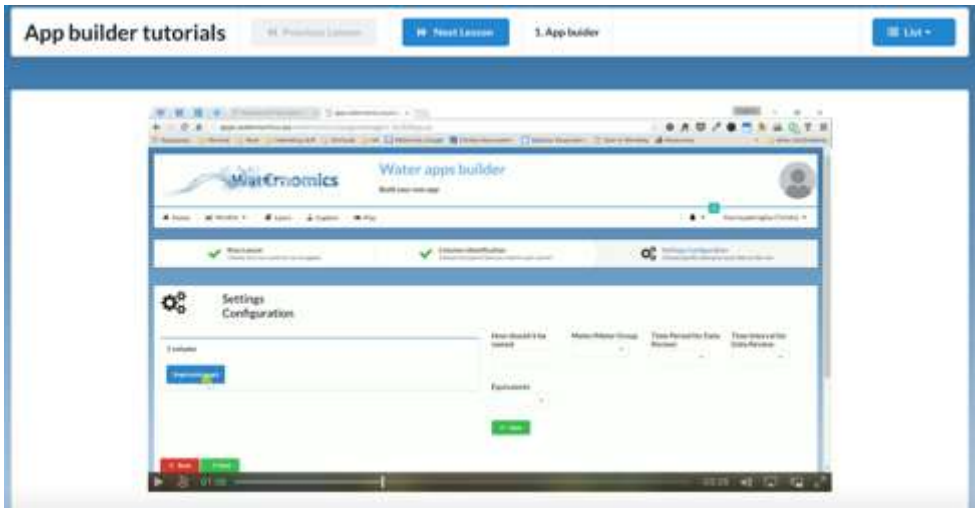



*Figure 4-7: Overview of the Learning application*

The introduction of end-users to learning applications has been conducted through a series of Skype meetings held on M31 and M32, and with a face to face meeting held in Linate on 28th September (M32) (see Figure 4-8). Also, on-line help for the end-users is provided by R2M and U4 in order to solve problems and to address some other needs both from managers and operational staff side.

*Figure 4-8: Waternomics Platform Training session at Linate Pilot*

- **EXPLORE**: The aim of section is to introduce some applications such as prediction services, comparison watches and applications that help users explore and benchmark specific scenarios or enforced measures. The section in itself contains two main applications, the Goal Setter application through which the managers or the operational staff can set a rule based fault detection and diagnsosis applyied to the water network. The Figure 4-9 shows an example of notification.


*Figure 4-9: Example of Notification provided by the Waternomics Platform*

The other application is the Decision Support System (DSS) application (see Figure 4-10). This last application is the result of the collaboration between Waternomics Project and IceWater project. In detail the Waternomics project provided the hydraulic model simulation in Epanet of the Linate Water network while the IceWater project provided the visualization software. The availability of a hydraulic simulation model of the water network has multiple advantages. Such a model can be used as a DSS component by itself, for testing various operational strategies in a pure simulation mode (testing different strategies in a 'what-if' manner). The users have the opportunity to run hydraulic simulation scenarios by changing the input in the Epanet software by using a user-friendly visualization mode. The application also supports a georeferenced map of the existing water network and obtains information data from every single pipe or meter installed within it.

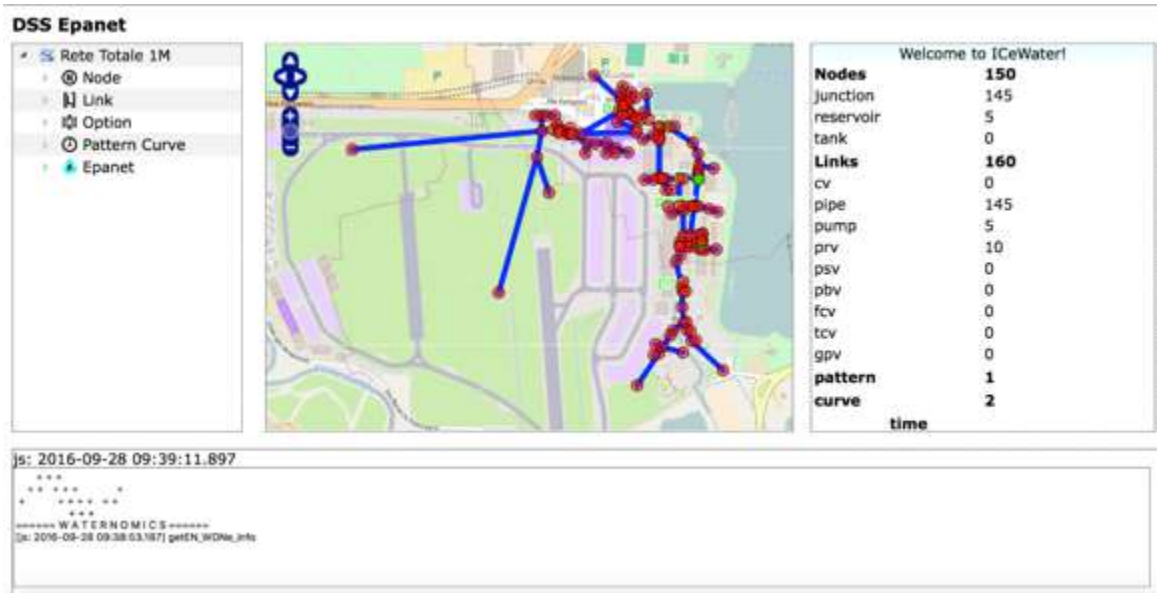



*Figure 4-10: DSS component developed in the Explore section of the Platform*

Similarly, to the Learn application this set of applications have been introduced via presentation to end-users during the face-to-face meeting held in Linate on 28th September (M32) and also on-line help for the end-users is provided by R2M and U4. For the DSS application also training material has been developed and presented in D6.2.

A lot of other applications are available for the Linate pilot Dashboard and here below is a list of applications currently available on the platform:

- Buidings Comparison: Provides the water consumption of the metered buildings within the airport area.
- Leaks Check: allows end-users to visualise night time flows for each building.
- Meter Comparison: compares the information gathered from various meters.
- Sensor Information: provides a map of the water distribution network and location of meters.
- Custom Notification Creator: allows users to customise their own notifications.
- Goal Setter: permits users to customise their own goals or determine when a fault has occurred.
- Dealers Consumption: provides the water consumption of some dealers within the Terminal building and comparition of water usage data.
- Water balance: provides the water balance for a District Metering Area (DMA6) in order to higlight the water leakages percentage.
- Model based FDD [2] [3]: the model based FDD developed is based on the development of a hydraulic model of the water network by using the EPANET software coupled with an anomaly detection algorithm (ADWICE) [8] that is able to get data both from the hydraulic model and the meters installed to find whether there is a leakage in the water network. The algorithm (ADWICE) will point out whether abnormal conditions are occurring in the Water Distribution System (WDS) [9] [10] arising an alert that will be shown in the Waternomics application platform.

### *WEM 6: Engagement – Open end-users' seminar*

In order to achieve the key objective of the Waternomics project: "Increase water awareness", it is important to engage the end-users, understand their needs and share the lessons learned from the pilot sites in implementing a Water Management System. With this objective on the 11th of October (M33) an open day seminar was conducted in Thermi (Greece) with representatives from all pilot sites introducing

their pilot activities and first experiences from using the platform to local external stakeholders (see Figure 4-11). The Open-day seminar was a success both for the about 20 participants really interested in the Waternomics project and its outcomes and for the researchers because it was a good opportunity to share knowledge from different pilot sites and lessons learned.

*Figure 4-11: Open-day end-users meeting in Greece*

Moreover, an open end-user seminar was held in M35 in the Linate Pilot. The open end-user seminar allowed the end-users of the WATERNOMICS project to share their experiences. For example, large businesses of the wider municipality area were invited to learn from the experiences in the Linate airport and also representatives from institutional bodies, water utilities and corporate staff members attended the event. At the event, SEA – R2M and Ultra4 presented the Waternomics project outcomes (See Figure 4-12).


*Figure 4-12 Workshop held in M35 in Linate pilot*

## 4.3 Effect of WEMs towards objectives

In the following sections a short description of each WEM introduced to achieve the Pilot Specific Objectives is provided and also the specific KPIs measurement will be pointed out.

### 4.3.1 Objective 1: Increase Awareness of Water Consumption

#### *WEM 1: Installation of sensors*

Water, energy and pressure sensors are now installed in the pilot site according to the implemented physical measurement framework agreed in M15 (100% installation completed). SEA staff is able to get information about their water consumption and this is the first step to enable changes in water consumption behaviours.

In order to understand the effect of the WEM 1 an example is introduced below. Before installing the water flow meters, SEA staff didn't know exactly the real time water consumption of each building inside the airport area. The installation of the flow meters and their connection with the Linate Waternomics Application Platform has given to them the opportunity to know this data, to implement comparisons and to think about potential problems in the water network. Figure 4-13 shows the water data consumption for the Freight building placed within the DMA6 area of the Linate Airport. It is clear that the meters registered a water consumption data during the night-time while the consumption increases during the working time (8:00 am to 18:00 pm).

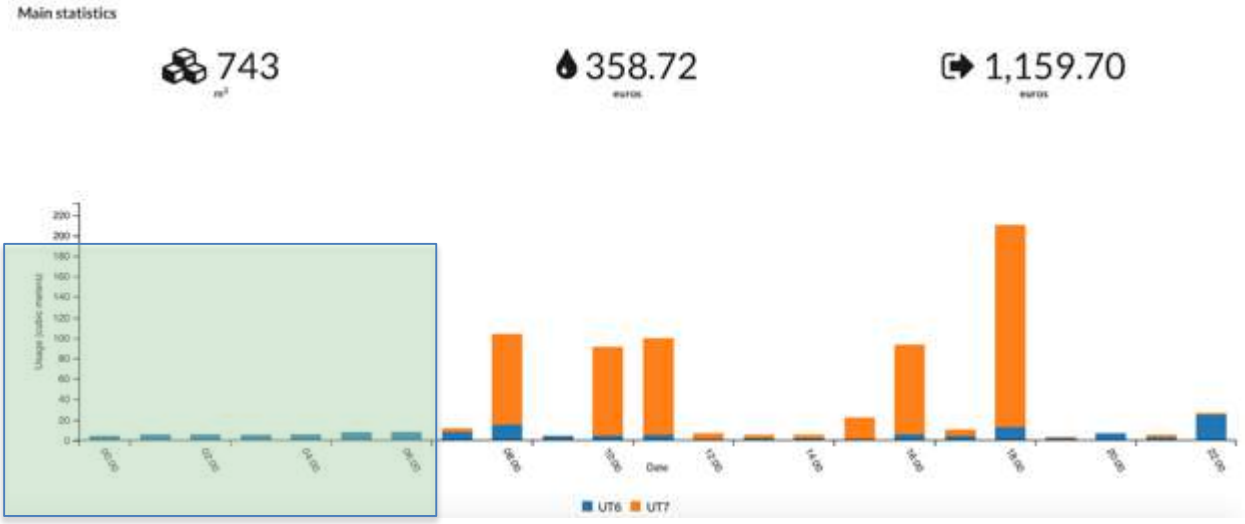



*Figure 4-13: Water consumption for the Freight building within the Airport area*

The situation is clearer if we take into account the day/night time comparison graph of Figure 4-14.

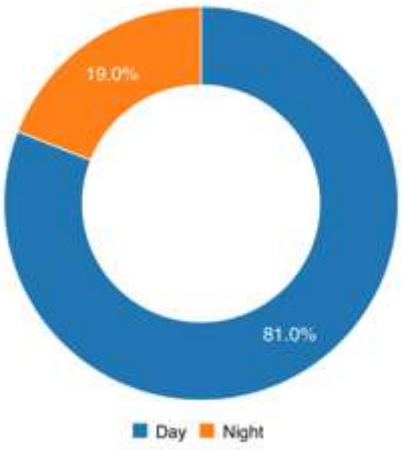



*Figure 4-14: Comparison graph – Day/night time water consumption for the Freight Building*

The night consumption could be normal in this case if the maintenance staff is going to use the showers during the night time, however this information allows managers to think of any problems to the water network and it invites them to investigate in more detail the specific case.

### *WEM 2: Interactive digital Displays*

To interact with the passengers is one of the key aspect to understand the way the Waternomics project leads to a change in their water consumption behaviour. The passengers can interact with the Waternomics project by giving a feedback to some sections. Positive user experience was observed in six months of installation and this ensures that it will be an effective dissemination and communication tool at Linate. So far more than 2 thousand people have interacted the screen to view the content and about 50 users have calculated their water footprint by giving a feedback (See Figure 4-15).

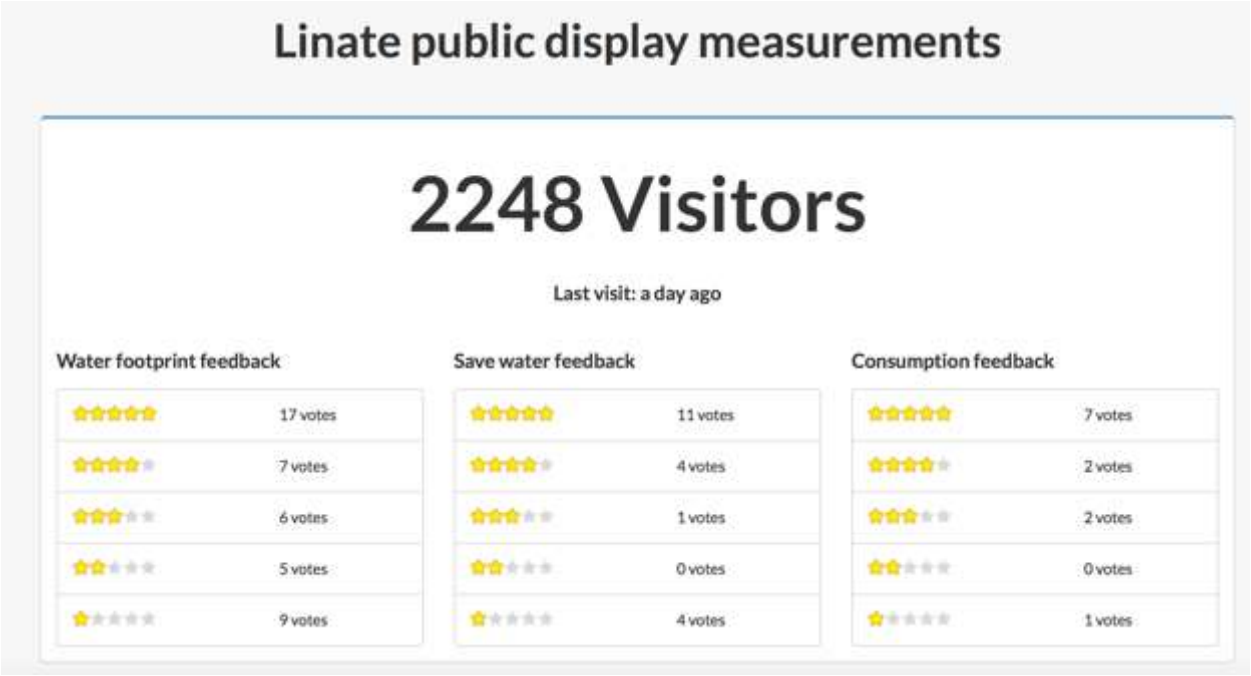



*Figure 4-15: Linate public displays measurements (15th January 2017)*

### *WEMs 3-4-5: Implementing Waternomics Application Platform*

A key indicator of the success of the Objective n. 1: "Increase awareness of water consumption" is realized by an increase in awareness of water consumption among staff at Linate pilot. This has been carried out by implementing the Water Applications Platform for the corporate staff (Managers, Technicians, and Employees) and by implementing questionnaire studies that will analyse water conservation awareness and self-reported behaviour among staff members. By measuring water conservation awareness and self-reported behaviour in advance of the introduction of water management interventions at the Pilot Site, a baseline can be established. In addition, this baseline can be further validated by conducting the same measurements among a peer group where water management interventions will not be introduced or among the same group before implementing the water management interventions. The questionnaire study has involved a group of 10 staff members and has been conducted in M30. By repeating the questionnaire study at intervals over Pilot Control Period, changes in awareness and self-reported behaviour should be perceptible. In M36 has been repeated the water awareness questionnaire.

The comparison between the two questionnaires in terms of problem awareness / outcome efficacy /

ascription of responsibility and personal norms show this results:

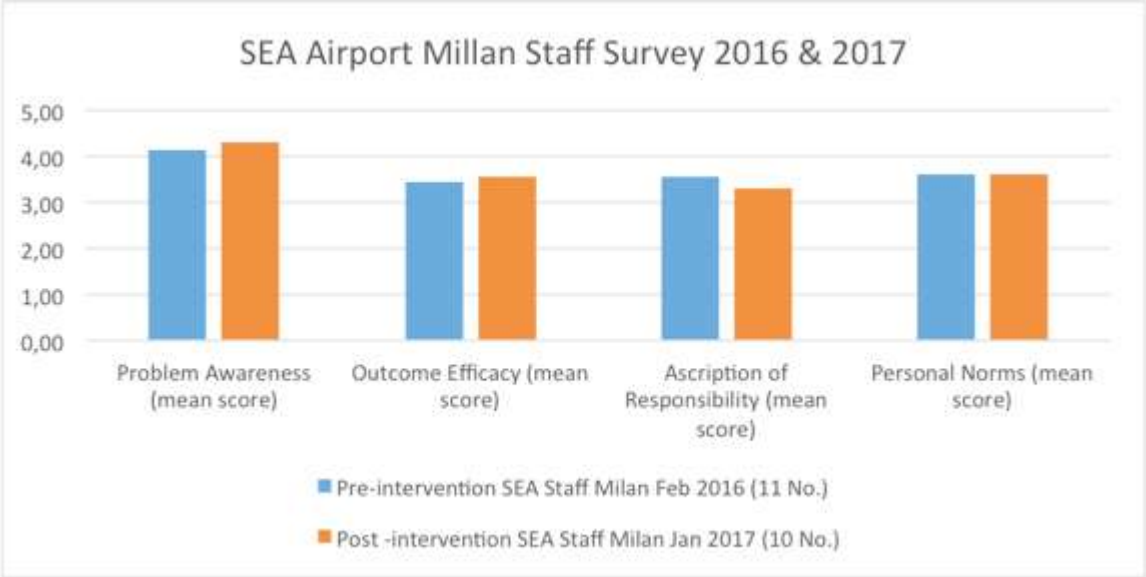



*Figure 4-15: Comparison between the results of the two water awareness questionnaires implemented in the Linate pilot in M30 and M36*

In terms of problem awareness Figure 4-15 shows a slight increase. Among the staff of SEA corporate increased the problem awareness about the water consumption and this affect their water related behaviour. We have calculated this average value and standard deviation:

| | **Pre intervention Questionnaire** | | **Post intervention Questionnaire** | |
|---|---|---|---|---|
| **Aspect** | **Mean** | **SD** | **Mean** | **SD** |
| **Problem Awareness (mean score)** | | | | |
| | 4.15 | 0.31 | 4.30 | 0.15 |

Furthermore, in terms of outcome efficacy we have registered slight positive results. The people effectively think, as for example, that they can reduce their water consumption by making changes to their existing habits. We have calculated this average value and standard deviation:

| | **Pre intervention Questionnaire** | | **Post intervention Questionnaire** | |
|---|---|---|---|---|
| **Aspect** | **Mean** | **SD** | **Mean** | **SD** |
| **Outcome efficacy (mean score)** | | | | |
| | 3.44 | 0.44 | 3.56 | 0.42 |

In term of ascription of responsibility, we registered a slight decrease. It's the only parameter that registers a negative trend. We have tried to give to us an explanation for this and we come with this conclusion: now the SEA staff start to think that they can have a key role in reducing the overall water consumption each in his own area but where there is no saving to a person's own finances, it is hard to

change people. Anyhow they also are able to promote water efficiency measures in different environments (as for example at their homes) now and may be in this case they could reach very positive results. We have calculated this average value and standard deviation:

| | Pre intervention Questionnaire | | Post intervention Questionnaire | |
|---|---|---|---|---|
| **Aspect** | **Mean** | **SD** | **Mean** | **SD** |
| **Ascription of responsibility (mean score)** | | | | |
| | 3.57 | 0.26 | 3.30 | 0.20 |

In term of personal habit also the WEMs have registered steady trend. We have calculated this average value and standard deviation:

| | Pre intervention Questionnaire | | Post intervention Questionnaire | |
|---|---|---|---|---|
| **Aspect** | **Mean** | **SD** | **Mean** | **SD** |
| **Personal norms (mean score)** | | | | |
| | 3.61 | 0.45 | 3.61 | 0.21 |

Another key indicator of the success of the objective n.1 is the web analytics that show the access to the Linate Waternomics Platform along the time. We expect that the access to the Waternomics Platform will increase during the time and so far, a positive user experience with the Waternomics Applications Platforms has been registered. Figure 4-16, Figure 4-17, Figure 4-18, Figure 4-19, Figure 4-19, Figure 4-20, and Figure 4-21 show some statistics related to the utilization of the Waternomics Platform among the SEA staff.


*Figure 4-16: Summary of web analytics statistics for Linate pilot (M32 – M36)*

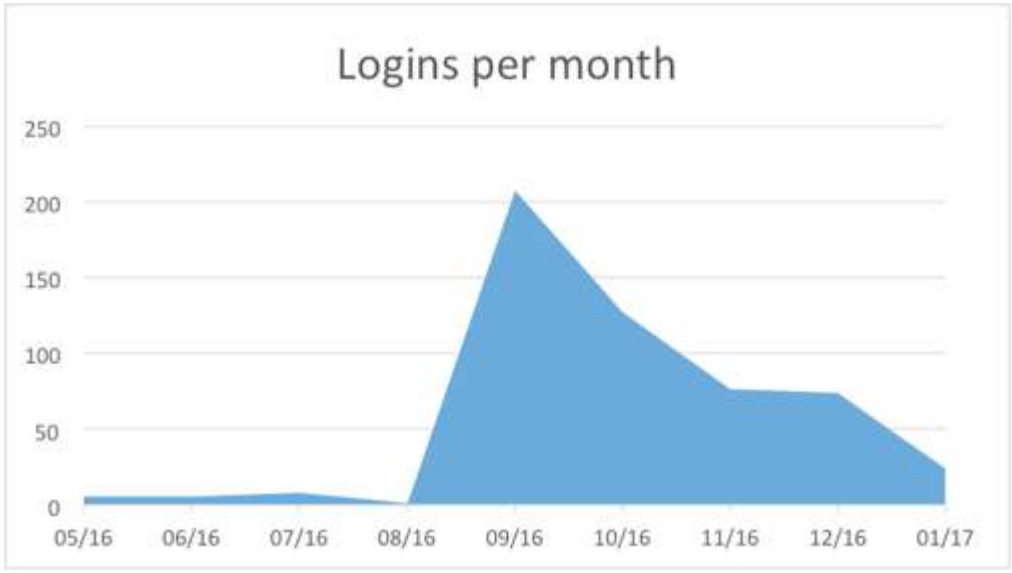



*Figure 4-17: Logins per month graph*

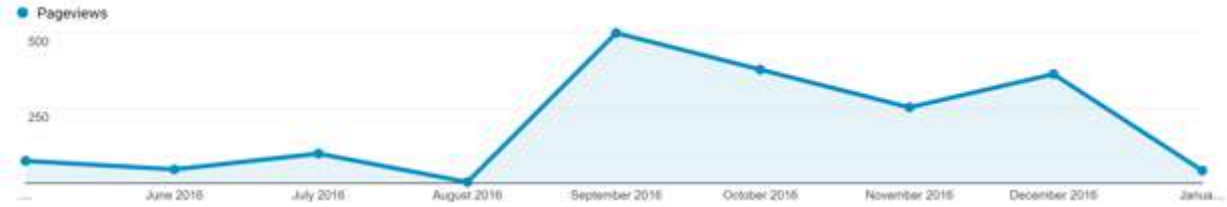



*Figure 4-18: Page views graph for Linate pilot (M30-M36)*

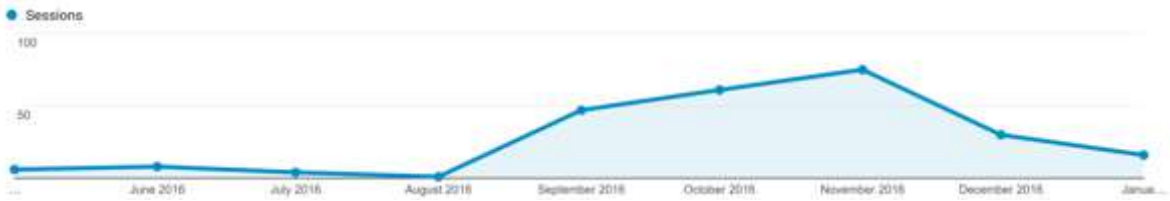



*Figure 4-19: Sessions graph for Linate pilot (M30-M36)*


*Figure 4-20: Average Session duration graph for Linate pilot (M30 – M36)*


*Figure 4-21: Users graph for Linate pilot (M30-M36)*

From the last graph, above is clear that the first period (M28 – M30) highlight the time used in the deployment of the Waternomics Platform while after the official introduction of the Waternomics

Applications Platform the number of users increased.

### *WEM 6: Engagement – Open end-users' seminar*

The Open-day seminar and the Linate Water Fair were a success both for the high numbers of Participants really interested in the Waternomics project and its outcomes and for the researchers because it was a good opportunity to share knowledge from different pilot sites and lessons learned (see Figure 4-22). Press release and Interview also were done.


*Figure 4-22: End-Users open day – Sharing the lessons learned*

In detail the two days' workshop named "Water Fair" in Linate Airport in M35 has been a unique opportunity for the Waternomics project to continue to interact with end-users and external stakeholders in order to improve its impact and increase the end-users' water awareness. The agenda was as in the following:

- Day n. 1: Round table on "water issues"

- Day n. 2: Stakeholders Workshop

The targeted audience was: SEA Managers, SEA staff, Municipalities and Water utilities.

During the water fair, Waternomics has played a key role and the consortium has had the possibility to introduce the Waternomics project, its messages, its targets and its outcomes. As for example a conference section was intended to make an overview of the Linate Waternomics Platform by showing some data gathered from the meters in real time.

## 4.3.2 Objective 2: Reduce water consumption

Also for this specific objective the start point is to measure and make the users aware of their real water consumption. For this reason, it's important to install the meters and to connect them to the Waternomics Platform. In the same way, also the possibility to point out leakages or faults in the water network will help in the achievement of this specific objective.

### *WEM 1: Installation of sensors*

The start point to consider in order to achieve a water consumption reduction is to measure it. For this reason, the installation of sensor represents one of the most important actions to put in place. Only by measuring the water consumption over the period control time we can assess if the objective has been achieved. In the Linate pilot, we have 50 meters and all are now installed. Thanks to these sensors we can check over the time the water consumption of some buildings and also of the Terminal. As for example Figure 4-23 shows the available data for the Terminal building and we can see that the dealer metered by the UTT3 flow meter is the dealer that has the highest water consumption. Figure 4-24 shows that UTT3 water consumption trend seems to be decreasing, anyhow the graph shows the data available from M32 to M35 and a longer period of observation is needed in order to get a conclusion.

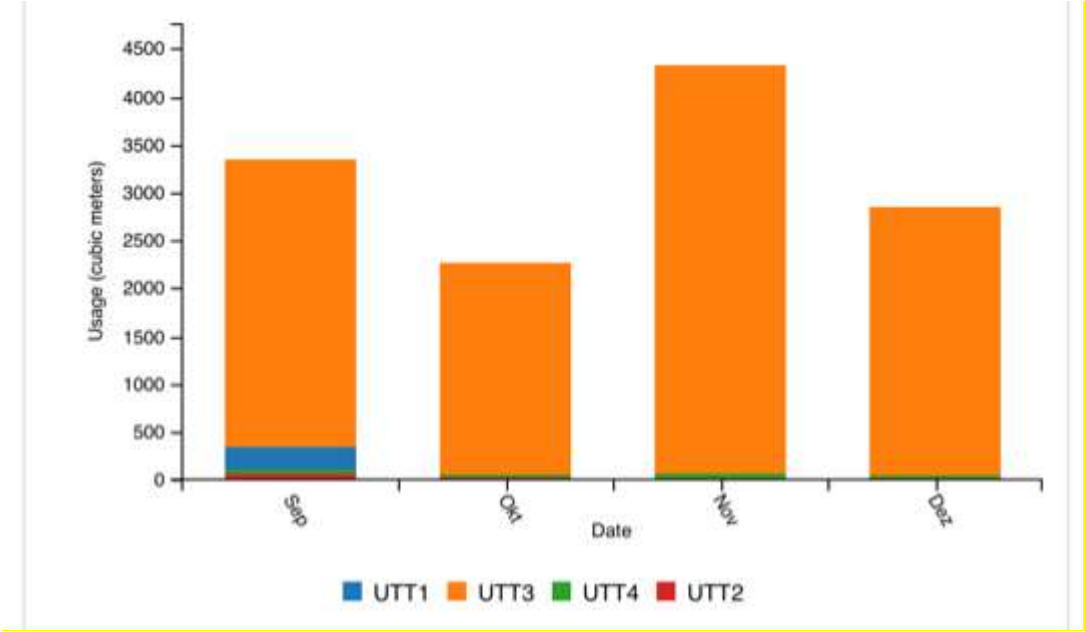



*Figure 4-23 First data available on water usage for the Terminal building, arranged per metering sensor*


*Figure 4-24 Water usage metered by the UTT3 flow meter over time*

However, from the data gathered from other buildings and showed in the Platform we cannot yet observe any significant reduction in water consumption. SEA staff members seem to now start understanding how

they use water and this combined with targeted specifics internal information awareness campaigns on water conservation and with future incentives (increase the competitiveness among the staff members in order to reduce water consumption by giving incentives to the most virtuous department) could lead to a reduction in their water consumption in the next periods.

In the same time the meters installed will allow us to calculate the water balance for the district metering area n. 6 (DMA6). The information will inform us about the percentage of leakages in the water network within the DMA6 and this will lead to renegotiate the agreement with the wastewater utility AMIACQUE with annual savings of approximately € 250k for the waste water treatment. About this last point the following image can help to understand the information that the manger can get from the WAP.

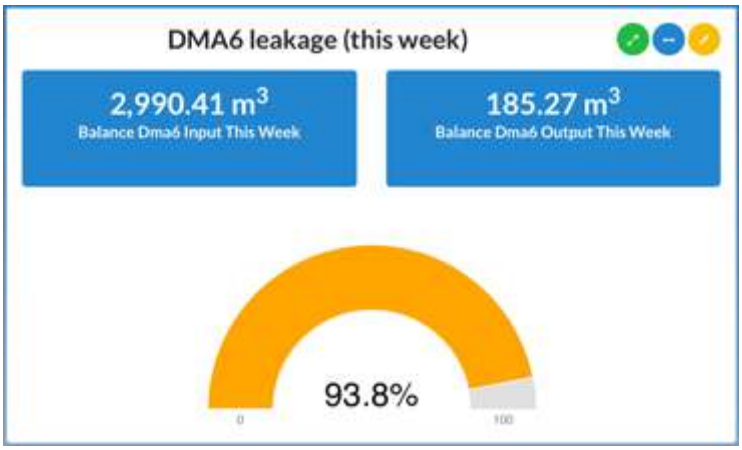



*Figure 4-25 DMA6 water balance*

The percentage of leakage of the DMA6 area is high because in this period (M36) the calibration of the S6 meter (open channel flow meter that gives the output flow data) is ongoing.

### *WEMs 3-4-5: Implementing Waternomics Application Platform*

By increasing awareness of water consumption users, we also expect to achieve a reduction in water consumption patterns and the best way to do this is the introduction of the Linate Waternomics Platform.

As explained before, the Linate Waternomics Platform has many sections within it (Home / Monitor / Explore / Learn). Each one contains in itself some applications developed *ad hoc* for the Linate pilot in order to increase the users' water consumption awareness.

Moreover, the introduction of applications as:

- comparison between night /day consumption,
- water balance in DMA6 area,
- and the leakage notification system connected with Epanet model of the water network and to the model based fault detection & diagnosis method developed for the Linate pilot,

can lead, in a long-term, to a reduction in the consumption of water through detection of leakages / faults in the water network and this represents a positive performance of the system.

The release of the Linate Waternomics Platform has had a little effect in the water related behaviour that users exhibited so far, but we strongly think that in a long-term period and coupling the WAP with incentives that promote the water consumption reduction, more positive results can be achieved.

A key role in engaging users to convey messages about "how to save water", as already explained, is the open day seminar held in M33 in Thermi – Greece and the Water fair held in M35 in Milan - Italy. We think that an "active" engagement through which convey the Waternomics information is more well accepted from the end-users and in general from the stakeholders if we can show them what have been done in the real case study. This was the aim of the open day seminar and we have received a very positive feedback measured by this numbers:

- 20 people (households and stakeholders) attending the meeting in Thermi
- a lot of questions arised when we have shown the pilot sites real case study
- 4 articles were posted on local electronic media
- 1 was posted in a local newspaper
- about 50 people (Water utilities rapresentatives, SEA staff members, external stakeholders) attending the Water Fair event in Linate

The events also have given the opportunity to the Waternomics pilots to exchange suggestions, ideas, to point out the problems encountered so far in implementing the Water Management System (WMS) in each pilot site and to highlight the solution found to resolve them. The ideas exchange is the basis to build an efficient WMS aimed to get the priority objective of "reducing water consumption".

The effect of the open end-users' seminar and also of the Linate Water Fair is well assessed through the afore mentioned water awareness questionnaires through which we have gathered responses on the effect that the presentations have on water awareness and how ICT can help them find out more about their water consumption.

#### 4.3.2.1 Future WEMs to be introduced towards the objective

No other WEMs are planned to be introduced in the near future anyhow, to promote the SEA staff water related behaviour change in a more effective way, could be opportune to investigate the introduction of economic incentives in order to obtain a water reduction.

### 4.3.3 Objective 3: Improve management

#### *WEM 1: Installation of sensors*

The WEM1 has been described in detail before, what we would like to stress here is the effect of this WEM upon the SEA corporate decision makers.

The physical measurement of the water consumption within Linate airport area make easier to understand what happens in the water network and when it's necessary to intervene when a problem is occurring.

In the previous section, also some examples have been introduced to demonstrate how the increased Linate water consumption knowledge has given the opportunity to the decision makers to think about some specific cases that need to be investigated, as for example, if the night water consumption of a certain building is a normal circumstance or if a leakage is in site and SEA is going to waste their water.

Already from the first data gathered form the meters installed in the Linate Water network we have received a positive feedback from SEA staff and it's a key indicator of the success of the WEM. Up to now almost two cases are under observation: The Freight building water consumption and the Poste building water consumption. In both cases the meters have registered a night consumption of water (see Figure 4-26 and Figure 4-27) that need to be much more investigated. In detail, the investigation performed results in the following:

- Freight building: the building is used also during the night time from the maintenance staff, then

the naight water consumption is not strange.

- Poste building: the building is not used during the night time. The night water consumption shows that there is a problem in the local water network. The cause could be the flushing of toilets malfunctioning. However the maintenance staff is going to investigate in more details.

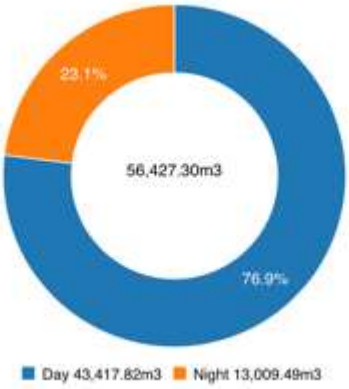



*Figure 4-26: Freight Building Day/Night water consumption distribution (M32-M36)*

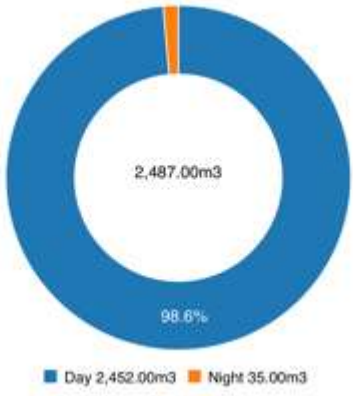
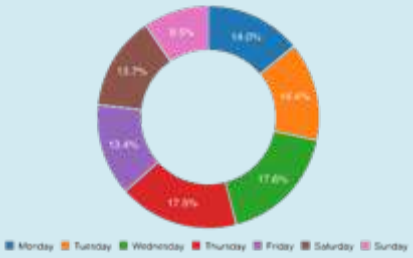


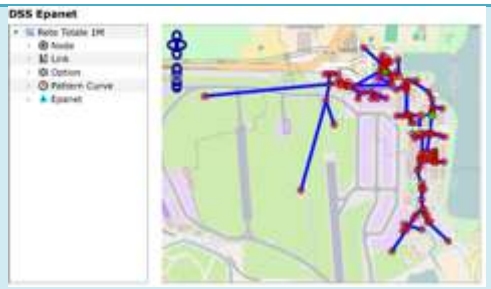
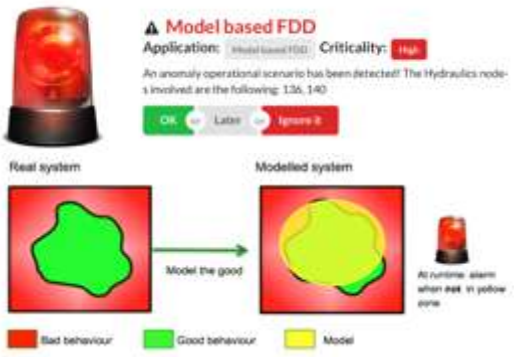
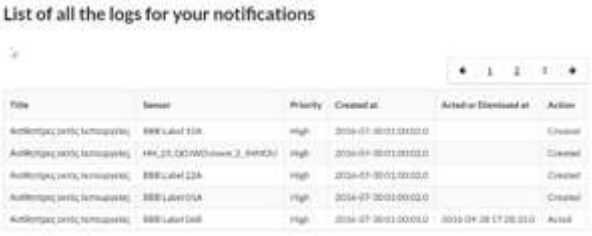

*Figure 4-27: Poste Building Day/Night water consumption distribution (M32-M36)*

### *WEMs 3-4-5: Implementing Waternomics Application Platform*

The introduction of the Linate Waternomics Platform and its related sections will enable a more effective water management for the Linate airport. The SEA managers and staff can get the information set out in Table 4-1 (for larger version of Table 4-1 see Table B-0-1 in Appendix B).

*Table 4-1 Information available on the Linate Waternomics Platform for the SEA managers and staff*

| | | |
|---|---|---|
| **1** | The real-time water consumption of each single building and make comparisons between them to point out which one is the building with the largest water consumption |  |
| **2** | the real-time water consumption of each single building and make comparisons between them to point out which one is the building with the largest water consumption |  |
| **3** | The consumption of each building for past periods and relative main statistics in which are provided information about:<br>• the total water used in cubic meters<br>• the total cost of the overal water used so far<br>• the total cost of the discharged water. For this information, it is assumed that all the |  |

| | | |
|---|---|---|
| | water used is discharged, but after the DMA6 water balance is ready we will make a correction of this information on the basis of the percentage of leakage found in the DMA6 area | |
| **4** | The effect of different Pressure set points in the Airport water network by implementing by their own hydraulic model simulation in real time by using the Epanet model and the Decision Support System (DSS) introduced in the Exploration section of the Linate Waternomics Platform |  |
| **5 *** | If in the Linate water network there is a fault or a leakage, identify it and isolate it by taking remedial actions. This could be implemented through the Model Based FDD method developed within the Waternomics project that is able to compare the real data gathered from the meters installed in the water network with the "optimal" data gathered from the Epanet Hydraulic model. If an anomaly is detected an alert is sent to the Managers and the Operation staff of SEA corporate. |  |
| **6** | The water balance for the DMA6 area. It is an indicator of the percentage of leakage in the overall water network. |  |
| **7** | The benchmarking of repairs/notifications acted by the maintenance staff so far. This information will give to the decision makers the opportunity to know what happened in the water network, if the problem has been solved and who has acted on it. |  |

All this information enables a more efficient water management system and they lead to informed choice on the global water network.

### *WEM 6: Engagement – Open end-users' seminar*

Sharing ideas is the start point to improve any kind of management process, for this reason the open end-users' seminar, held in M33 in Greece, plays an important role because it has given the opportunity to the Waternomics pilots to exchange suggestions, ideas, to point out the problems encountered so far in implementing the Water Management System (WMS) in each pilot site and to highlight the solution

found to resolve them. The ideas exchange is the basis to build an efficient WMS aimed to lead informed choice on the global water network and get the priority objective of "reduce water consumption".

#### 4.3.3.1 Future WEMs to be introduced towards the objective

No other WEMs are planned to be introduced in the near future.

### 4.3.4 Objective 4: Promote environmental responsibility

#### *WEM 2: Interactive digital Displays*

The engagement of the passenger will increase both the SEA corporate sustainability image and promote environmental responsibility. Education to passengers is delivered by providing them with information about water consumption in simple, informative and visually appealing ways through the two touch screen displays installed in the terminal building. The touch screen displays are conveying information by using some effective engagement techniques such as gamification, metaphors, quiz games and sustainable tips on water consumption. To measure the maximum impact, data is collected regarding the visits of users to such multimedia touch screen displays and the interactions they have with the pieces of information. So far more than 1 thousand people have interacted with the screen to view the content and about 30 users have calculated their water footprint by giving a feedback.

#### *WEM 4: Introduction of WATERNOMICS Learning Application*

To promote the environmental responsibility of SEA staff is necessary to make them be familiar with the Linate Waternomics Platform. In this way, they can learn to use the platform and customize it depending of their needs.

For this purpose, during M32 the learning applications set was introduced to the SEA staff. More specifically an app with video tutorials on the platform was released to them through Skype meetings and a training session that took place on the 28$^{th}$ of September. More Learning applications (e.g. the training manual for the Decision Support System) are also planned to be released in the next period.

#### *WEM 6: Engagement – Open end-users' seminar*

Events like the open end-users' seminar helps in engaging the people, involving them to think about how they can improve their water consumption related behaviour and promoting, in general, environmental responsibility among the end – users.

#### 4.3.4.1 Future WEMs to be introduced towards the objective

In M35 has been held a two day "Water Fair" in Linate airport in order to continue an "active" engagement of end-users and stakeholders and to increase their environmental responsibility.
Decision Support System has been released in order to complete the Learning section of the Linate Waternomics Platform.

## 4.4 WATERNOMICS Methodology 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. Check should also ensure that the Water Efficiency Measures (WEMs) are functioning optimally. If necessary, corrective measures should be undertaken.

### 4.4.1 Summary of the Pilot

Currently, the WEMs to achieve the Pilot Specific Objectives have been implemented at the Linate pilot and they continuously are under review in accordance with Phase 3 of the WATERNOMICS Methodology since M32 (September 2016).

### 4.4.2 Effectiveness of the WEMs

Despite the short time of application of the WEMs in the Linate pilot site we can already draw some conclusions.

**WEM 1: Installation of sensors**

It represents the principal WEM for implementing an effective Water Management System. The first results after the application of the WEM show that the monitoring phase can lead to informed choices on the global water network and highlight goals in advance.

**WEM 2: Installation of interactive digital displays**

It represents the best way to try to engage the end-users and try changing their water consumption related behaviour. Positive feedback has been measured in the Linate pilot in terms of users that have interacted the screen and in terms of users' feedback.

**WEM 3: Implementing Waternomics Platform**

It represents the best way to provide personalised and actionable information about water consumption to end-users in an intuitive and effective manner at a time-scale relevant for decision-making. The web analytics clearly show that the end-users are interested in this tool through which they can interact with the water usage data supplied from the meters. The access to this information will increase end-user awareness and improve the quality of the decisions regarding water management and governance. The Platform is customizable and this is a point of strength since it can adapt to the actual users' needs.

**WEM 4: Introduction of Waternomics Learning application**

It is necessary to make the users familiar with the Linate Waternomics Platform. In this way, they can learn to use the platform and customize it depending of their needs. The WEM has been improved with the addition of on-line guidelines and on-line helpdesk. The effectiveness of this WEM could be measured through the web analytics associate to the Waternomics Platform in terms of Users access, page views, sessions, average sessions duration. We expect these values increase becoming the Waternomics platform more familiar to the end-users.

**WEM 5: Introduction of Waternomics Exploration application**

It represents an important WEM for managers and Designers because through it they can easily explore the effect of different pressure set points in the Airport water network, can set the notification system to

arise alarms when an anomaly occurs in the water network. The effectiveness of this WEM could be measured through the web analytics associated to the Waternomics Platform in terms of Users access, page views, sessions, average sessions duration. We expect all these values increase during the next time when the Waternomics platform will be more familiar for the end-users.

**WEM 6: Open end-user Waternomics seminar**

In M33 has been held an open day seminar in Thermi – Greece with positive feedbacks from the participants. The WEM is important to promote ideas and experiences exchange between the users and to increase their environmental responsibility. In M35 has been held a "Water Fair" in the Linate Pilot.

Despite all the positive aspects aforementioned, it was nonetheless still possible to outline some early issues surrounding the effectiveness of the WEMS based on the water usage reduction. For this reason, we suggest to introduce among the SEA corporate incentives for those departments that register a reduction of their water consumption. In this way, the staff will be engaged in a competitive game that coupled with the relevant information provided by the WAP could lead a more effective water consumption reduction behaviour.

# 5 The Pilot Report – Thermi

## 5.1 Meeting Pilot Site Objectives and KPIs

In Deliverable D5.1 we presented the measures that were proposed to achieve each of the pilot specific objectives and KPI's at the Thermi Pilot Site (Figure 5-1). This section will now discuss the WEMs that are implemented up to date, the future ones to be implemented from now on and the preliminary results from the application of WEMs so far.

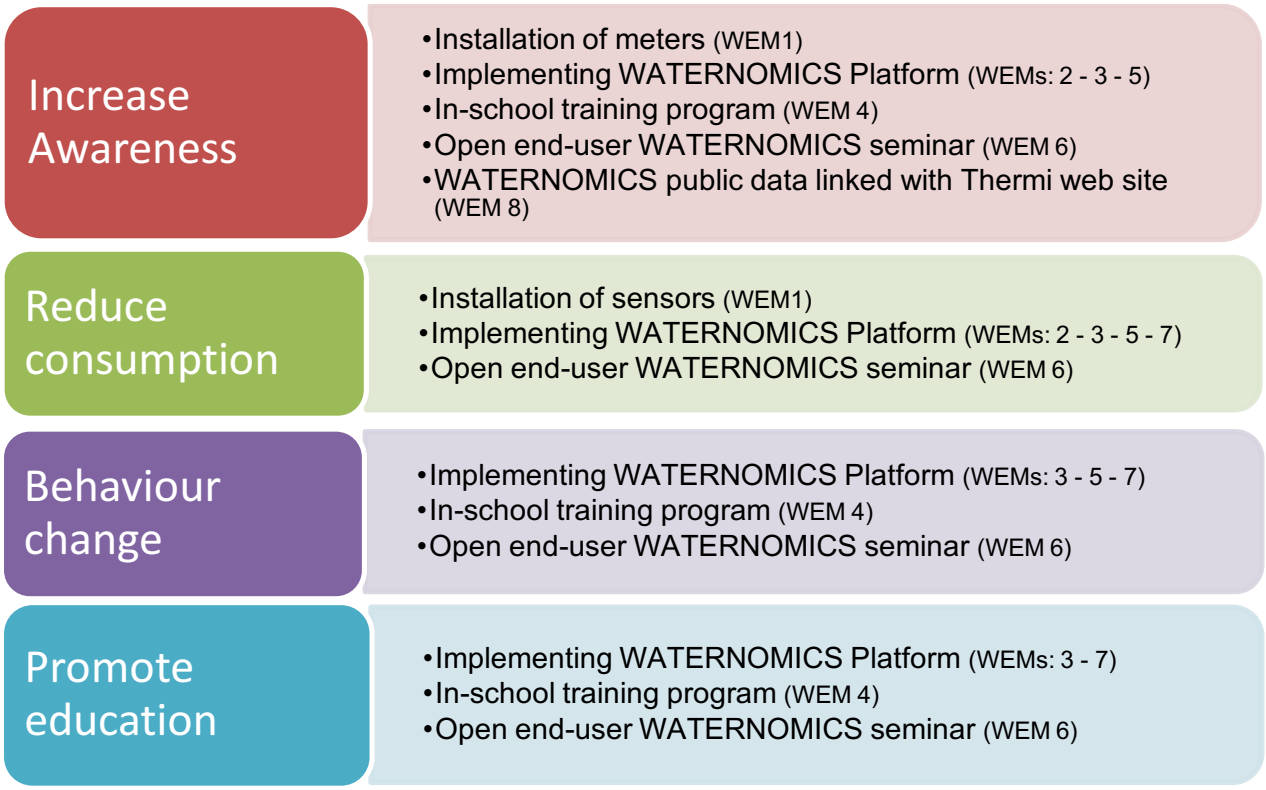



*Figure 5-1: Thermi pilot specific objectives and related WEMs*

## 5.2 WEMs applied

### 5.2.1 WEM 2: Introduction of WATERNOMICS Applications Platform and initial Monitoring applications

In M27 the Waternomics applications platform was introduced to users in Thermi on an event organised for the participants. 6 of the participant household owners attended the event and login credentials were distributed to them. The users were then introduced to the platform and to the way that they can develop their own applications based on their needs using the tools provided. In total, 42 monitoring applications have been developed for the 8 participant households each focusing on specific individual needs on their owners.

During the launch event for the applications platform, participants were also asked to complete a water awareness questionnaire to baseline their water awareness (Figure 5-2).

*Figure 5-2: Launch event of the applications platform in Thermi*

### 5.2.2 WEM 3: Introduction of WATERNOMICS Learning Applications

During M31 the learning applications set was introduced to the participants. More specifically an app with video tutorials on the platform was released to them through a newsletter campaign that took place on the 9th of August. More Learning applications (e.g. the news aggregator) are also planned to be released in the next weeks through similar newsletter campaigns.

### 5.2.3 WEM 5: Introduction of WATERNOMICS Exploration Applications

During M31 participant household owners were also introduced to the first exploration application and to a further update of it (Figure 5-3). The goal setter was the first application introduced to them through a newsletter campaign explaining its functionality.


*Figure 5-3: Exploration applications available in the platform for domestic users*

Following the release of the goal setter a consecutive newsletter after about two weeks introduced a new feature on the goal setter application allowing users to find predefined rules to make easier for them the set-up process. Moreover, the second newsletter was also introducing a new application in the exploration category allowing users to see how their consumption in specific outlets compares with average consumption on the other households metered (Figure 5-4).


*Figure 5-4: Screen shot for the comparisons applications*

### 5.2.4 WEM 6: Open End-user WATERNOMICS seminar

On the 11th of October, an open day seminar was conducted with representatives from all pilot sites introducing their pilot activities and first experiences from using the platform to local external stakeholders. Approximately 20 invitations were sent out to municipalities and water utilities in the greater area of Thessaloniki. In addition, 80 invitations were sent out to business associations, research institutes and large enterprises using significant amounts of water. Moreover, a press release was sent out to local media for potential domestic user that might be interested. About 20 people from domestic users to invited organisations representatives attended the open day and followed the presentations about the experiences gained so far on the 4 pilot sites of Waternomics.

### 5.2.5 WEM 7: Introduction of WATERNOMICS Gaming Applications and Gamification features

On M34 the Leaderboards application was released to users. Users were able to see a number of different leaderboards where they were getting points based on their consumption on different outlet points. The family with the lowest per person consumption for every week was getting 10 points and the next ones were getting 9, 8 and so on. This way participant households were able to compete and see how well they were doing in total compared to other households.

### 5.2.6 WEM 8: WATERNOMICS public data to be linked with the municipality website

A web app (see Figure 5-5) showing some general statistics of the pilot in Thermi was linked to the municipality of Thermi website in order to raise awareness.


*Figure 5-5: Waternomics Thermi pilot in numbers app*

## 5.3 Effect of WEMs towards objectives

### 5.3.1 Objective 1: Increase Awareness of Water Consumption

The first objective for the Thermi pilot site is to increase awareness of water consumption at households involving all members and effect behavioural change, in particular using ICT, towards the consumption of water.

#### 5.3.1.1 Effect of WEMs

**WEM 2: Introduction of WATERNOMICS Applications Platform and initial Monitoring applications**

M27 saw the launch of the applications platform and release of the first monitoring applications for end-users in Thermi. The web analytics and login statistics graphs (Figure 5-8, Figure 5-9, Figure 5-10) reveal that they were a little bit active on visiting the platform at the beginning. Then for a period starting from June and continuing up to August the activity on the platform was reduced. This period was for many of the participants a summer holiday period when they were absent from their houses for long periods of 1 to 2 weeks. This explains the fact of the low activity in the platform (Figure 5-6).

In order to raise engagement from users, in the middle of July, we started communicating to them small changes and new features of the platform through email newsletter campaigns. In the first email newsletter campaigns, during July and beginning of August, the response was also low but started to increase thereafter as it can be seen on Figure 5-8. This increase of interest was continued until November when the frequency of the newsletter campaigns was reduced. This resulted in a reduce in interest for the platform as well.

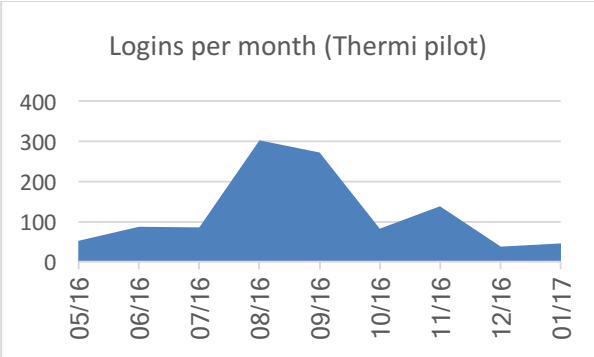



*Figure 5-6: Logins per month graph*


*Figure 5-7: Summary of web analytics statistics for Thermi pilot (M28-M36)*

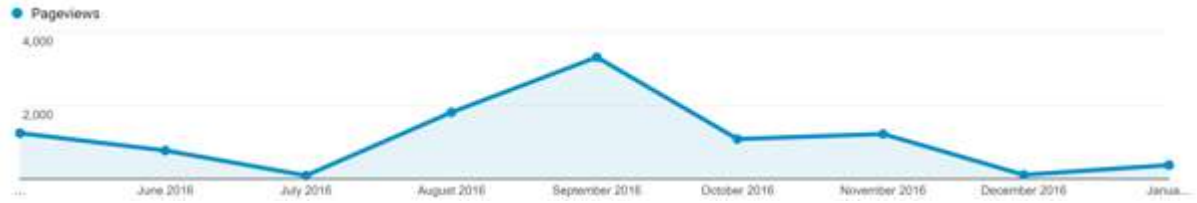



*Figure 5-8: Pageviews graph for Thermi pilot (M28-M36 per month)*

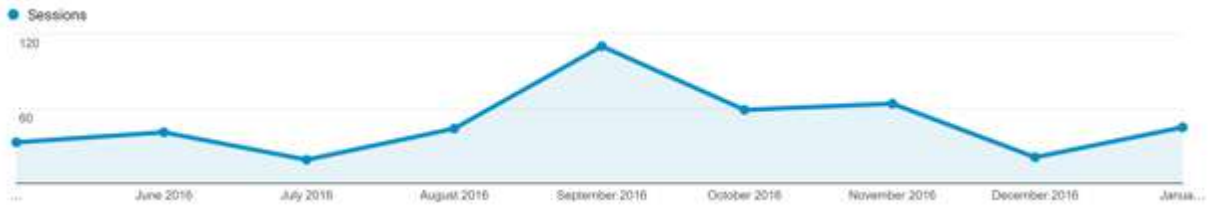



*Figure 5-9: Sessions graph for Thermi pilot (M28-M36 per month)*

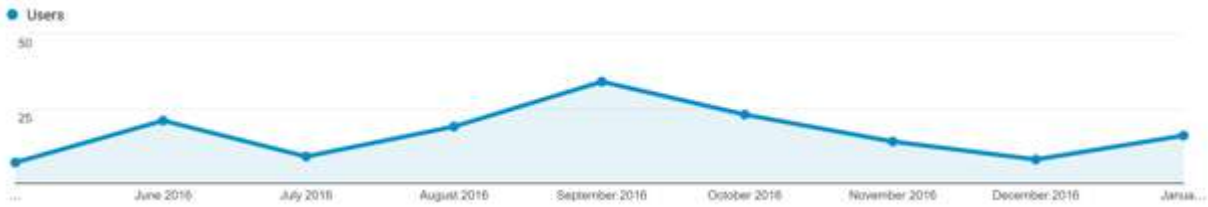



*Figure 5-10: Users graph for Thermi pilot (M28-M36 per month)*

During the last week of August and the first week of September a set of phone interviews was conducted with end-users to investigate the reasons for low engagement with the platform. In particular, 5 of the household owners were interviewed through phone and in most cases the responses to the reason for low engagement were similar. The two main reasons mentioned were:

- Summer holiday period and getting back to daily routines
- Daily routines did not include checking water consumption on a frequent basis therefore it was difficult for them to take it as a habit.

Most of the users recognised the benefits from using the platform but they did not have time to really engage with it and grasp the information given to them through applications.

Apart from web analytics awareness is also to be measured using the awareness questionnaire used in other pilots adapted for the Thermi pilot. 5 household owners answered the questionnaire in the launch event and during the next weeks the questionnaire will be answered again to measure the effect of the platform so far in terms of awareness. However, low numbers of people completing the questionnaire meant that we could not deduct and statistical significant results and therefore it was decided that the last

assessment will not use the questionnaire but focus more on qualitative methods such as focus group and interviews.

In M36 a focus group and 2 individual phone interviews were conducted and the comments were again in line with observations of the intermediate interviews. As far as the monitoring applications users reported that they indeed helped increase awareness but their engagement was not high because as all participants agreed water consumption is just a low priority in managing their household. However, the participants also mentioned that some of the other WEMs (in particular the exploration application of the digest emails) in combination with the monitoring apps helped in the direction of increasing their engagement and therefore their awareness

**WEM 3: Introduction of WATERNOMICS Learning Applications**

The analytics for the newsletter introducing the video tutorial application was used by 60% of end-users and in total there were 2 clicks to get to the platform site from then on (Figure 5-11). Although most of the end-users viewed the video tutorials app it was not often revisited mainly because of the fact that applications were already built for end-users and this way there was no significant need to revisit the videos demonstrating the process of building an application in the platform.

In M34 a newsletter introduced the social media and news aggregator app. Discussions in the final focus groups and interviews revealed that the idea of the application was interesting but in practice people could not devote much time to exploring the information provided by the app. Therefore, the application had potentials to increase their awareness but it did not help a lot in that direction due to low engagement in total with the platform.


*Figure 5-11: Campaign statistics for the newsletter on the video tutorials*

**WEM 5: Introduction of WATERNOMICS Exploration Applications**

Similar to the learning applications, the exploration applications and mainly the comparison application and the goal setter application were released through two consecutive email newsletter campaigns. Figure 5-12 and Figure 5-13 show that there were in total 5 household owners that red the emails. However, there was no actual follow up in getting to the platform and testing the application.


*Figure 5-12: Campaign statistics for release of goal setter*


*Figure 5-13: Campaign statistics for release of comparisons*

The release of the two applications in the exploration category was followed by the phone interviews presented earlier. As already discussed the difficulty in engaging with the platform was the lack of a clear trigger to get them to the platform. The newsletters were mostly noticed by the users and in many cases opened. In the end of each newsletter there was a clear call to action button trying to motivate user to engage in the platform. The frequency of emails and the fact that many users opened it but did not really read through it was hindering them from following the call to action.

To face the situation, we combined the following in designing a new application aiming to attract attention and raise awareness to end-users even without them getting in the platform.

- Emails from newsletter were mostly noticed and in many cases opened.
- Emails are in the daily routine of most of the users according to their answers on the interviews.

The new application allows the user to set up a set of metrics to get them in a short email digest at specific intervals. More specifically, users can setup to get daily, weekly and monthly digest emails. The application has been installed and set up for most of the users to send daily, weekly and monthly digest emails.

In the final focus group participants mentioned that this was one of the most welcomed applications in the platform and as mentioned before in combination with the monitoring apps that it was linking, helped a lot in raising awareness of their own consumption. They liked a lot especially the weekly and monthly digest emails that were providing comparisons with previous average consumption rates. The daily emails were found interesting in the beginning but most of the participants reported that they became overwhelming after some time and they would prefer to stop getting them.

**WEM 6: Open End-user WATERNOMICS seminar**

After there were 4 original articles were posted on local electronic media and 1 in a local newspaper. The electronic versions of the articles were also reposted by other news sites reaching to a total of about 20 reposts to date.

**WEM 4: In-school training program**

Due to effort requested for the additional application of the email digest application this WEM was decided to not be applied, as it would not have a direct effect on the participant households. Therefore, effort to develop the training material was transferred to developing the digest emails app and this decision proved to be quite effective.

**WEM 8: WATERNOMICS public data to be linked with the municipality website**

A web site with general statistics of the Thermi pilot has been developed and linked from the municipality of Thermi web site aiming to inform visitors about the measurements in Thermi households. However, this WEM did not have direct effect on participants' awareness that was assessed through focus group and interviews.

### 5.3.2 Objective 2: Enable behaviour changes in water consumption

By increasing awareness of water consumption and educating users we also expect to achieve an additional objective which is to enable and trigger behaviour changes in water consumption patterns.

#### 5.3.2.1 Effect of WEMs

**WEM 2: Introduction of WATERNOMICS Applications Platform and initial Monitoring applications**

As already explained most of the users are now starting to engage with the platform and therefore it is early to expect any change in behaviour yet. One of the main questions raised in the interviews from household owners was how much water is saved by following simple advices like using the dish washer instead of washing the dishes by hand. In the following diagrams, we can see the use of machines (dish washers and washing machines) (Figure 5-14) and the use of manually controlled outlets such as tabs (Figure 5-15). The patterns observed are similar to the ones identified in the general trend presented in the objective of raising awareness. Moreover, no significant change is also observed in the usage of dishwashers and kitchen tabs. A change of behaviour there would result in increased use of the dishwasher and a parallel decrease in the kitchen tabs (Figure 5-16, Figure 5-17).

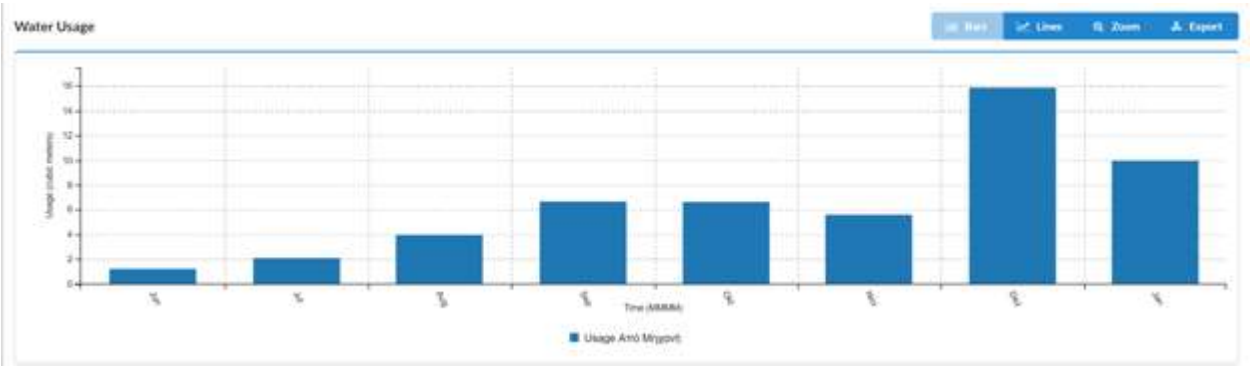



*Figure 5-14: Machines usage weekly measurements (M28-M36)*

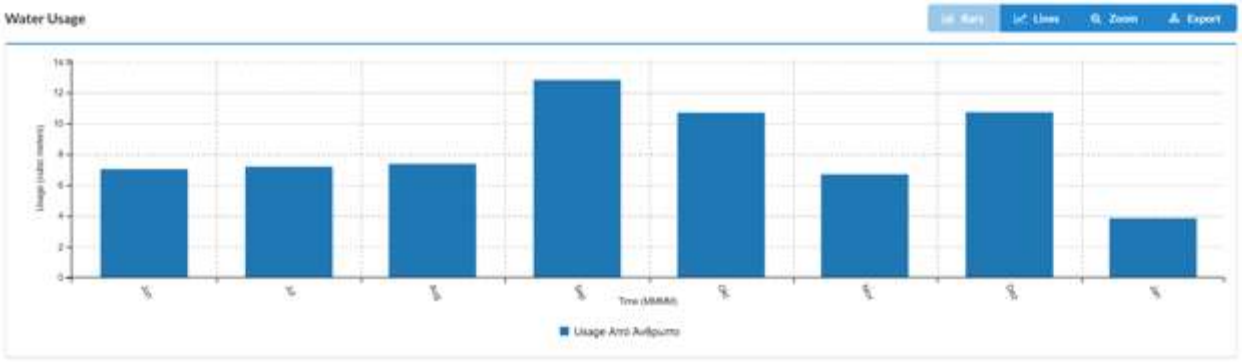



*Figure 5-15: Manual usage of water (tabs) weekly measurements (M28-M36)*

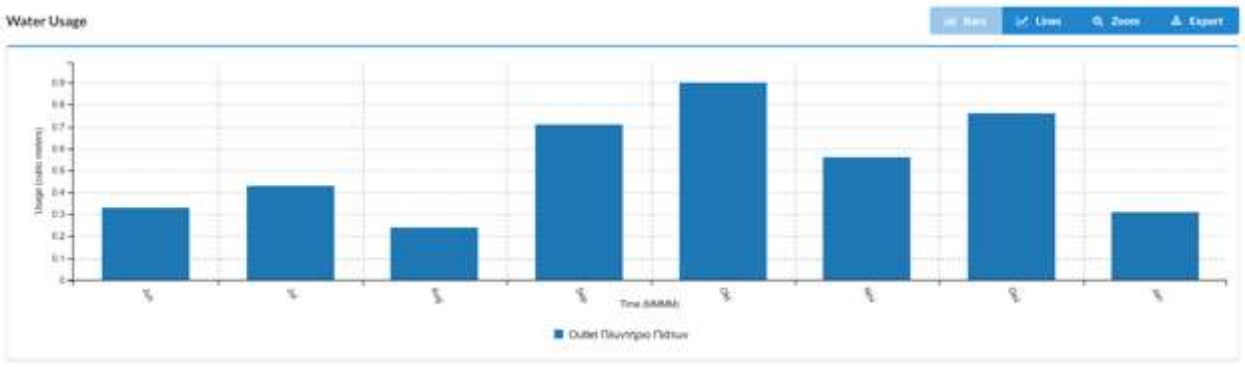



*Figure 5-16: Dish washer usage weekly measurements (M28-M36)*

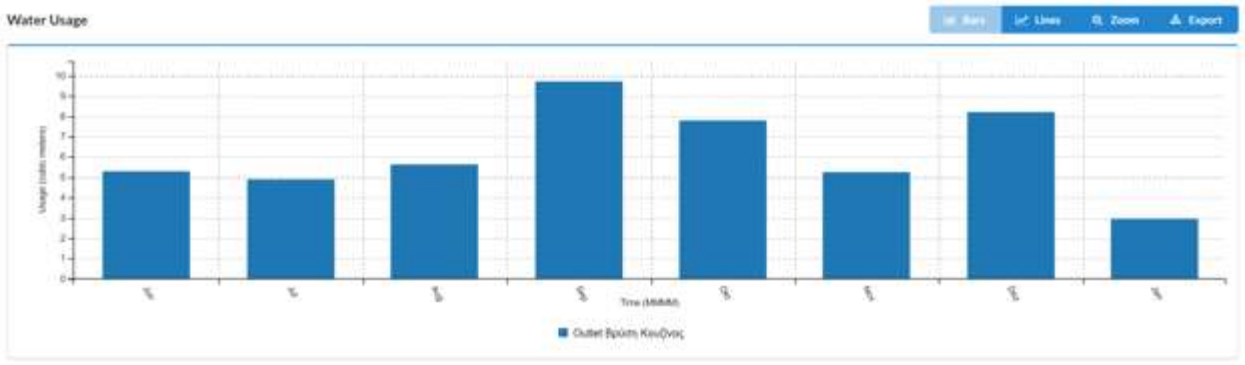



*Figure 5-17: Kitchen tab usage weekly measurements (M28-M36)*

Although measurements do not reveal a change in behaviour in the final focus group some participants mentioned that it might not be visible in measurements but they were more conscious of the water usage when washing the dishes by hand and therefore they were more hesitant to do so in some cases.

**WEM 5: Introduction of WATERNOMICS Exploration Applications**

Although, the general trend doesn't seem to show changes in the water usage behaviour some preliminary results from interviews currently conducted show that the comparison applications might be affecting some of the people and at least discuss about changing some of their habits. Figure 5-18 shows the two graphs comparing the household's consumption in the kitchen tab and the dishwasher. The recent realisation of the over consumption in the kitchen tab compared to other households seems to trigger a sudden decrease for the last week and in parallel the "under-usage" of the dishwasher seems to turn the opposite way for the last week. These are of course very early observations but they might signal the start of a behaviour change in the specific household.

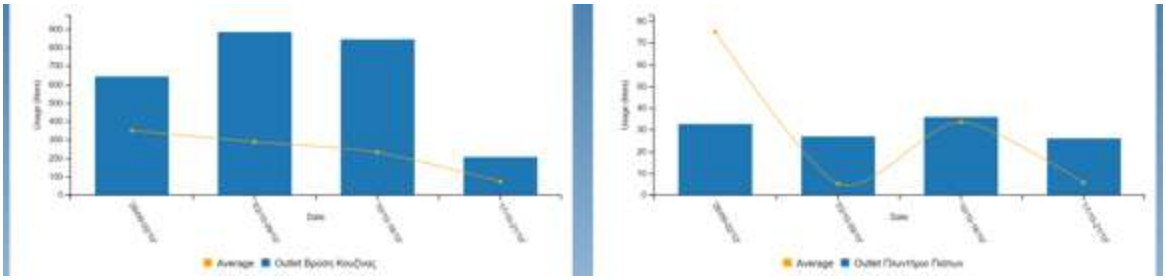


*Figure 5-18: Screenshot of the comparison app for a specific household.*

**WEM 3: Introduction of WATERNOMICS Learning Applications**

As already explained for the previous objective the news aggregator application which was expected to have an impact on changing behaviour did not have the expected results. The main issue was the same as for the previous objectives. Participants did not see a strong incentive behind devoting the time to learn more about their consumption and how to change their behaviour therefore reading related articles was not seen as an activity that would pay back significantly.

**WEM 7: Introduction of WATERNOMICS Gaming Applications and Gamification features**

The last months of the project saw the release of the leaderboards application. In the final focus group and interviews, the users found the idea of having a competition between them interesting as they also found the comparisons application in the exploration category. However, it still did not give them enough incentive to trigger a significant change in behaviour.

### 5.3.3 Objective 3: Reduce water consumption

The behaviour change presented in the previous section is in turn expected to lead to reduce of water consumption which is the third objective of the pilot.

#### 5.3.3.1 Effect of WEMs

**WEM 2: Introduction of WATERNOMICS Applications Platform and initial Monitoring applications**

The following graphs (Figure 5-19) demonstrates the monthly measurements from the start of May till M36. The low consumption in May can be attributed to many of the household sensors being disconnected. However, after middle of June most of the current online households were online. The decrease observed during July and August can be justified by summer holidays period. From early September and on, the usage seems to have stabilized to about 4-5 $m^3$ per week.

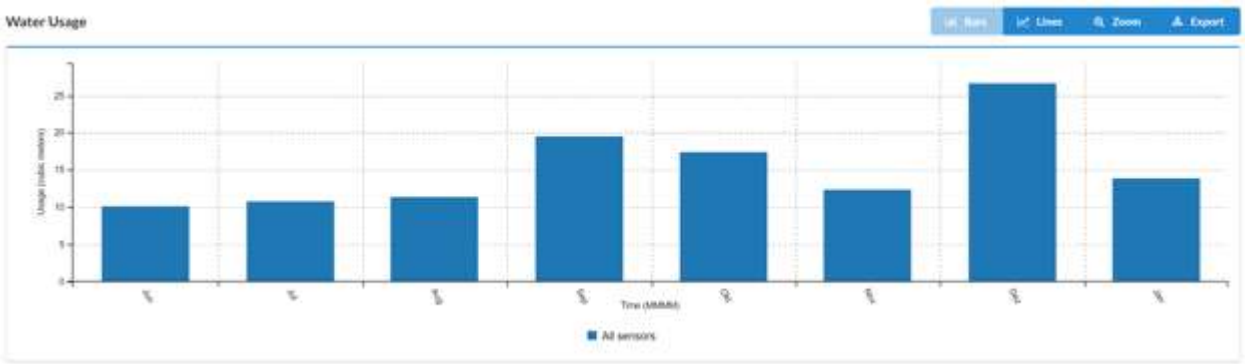



*Figure 5-19: All sensors monthly measurements (M28 –M36)*

The period from September to November seems to indicate a slight reduce of consumption pattern which is then disrupted by December. This can be explained by the Christmas holidays when families are spending more time in the house for December and the demand for ware in increasing. From then on the monthly consumption seems to drop again to levels similar to November. These measurements cannot be compared with consumption trends from previous years due to lack of granularity in the data from past years (quarterly measurements). Moreover, the most of the households were measuring only part of their consumption and not the whole amount and this again makes difficult comparing with previous years. However, we can observe that the periods that see the decrease of consumption are the same with the ones showing an increase in interests and visits to the platform as presented in the previous objective (Figure 5-20).

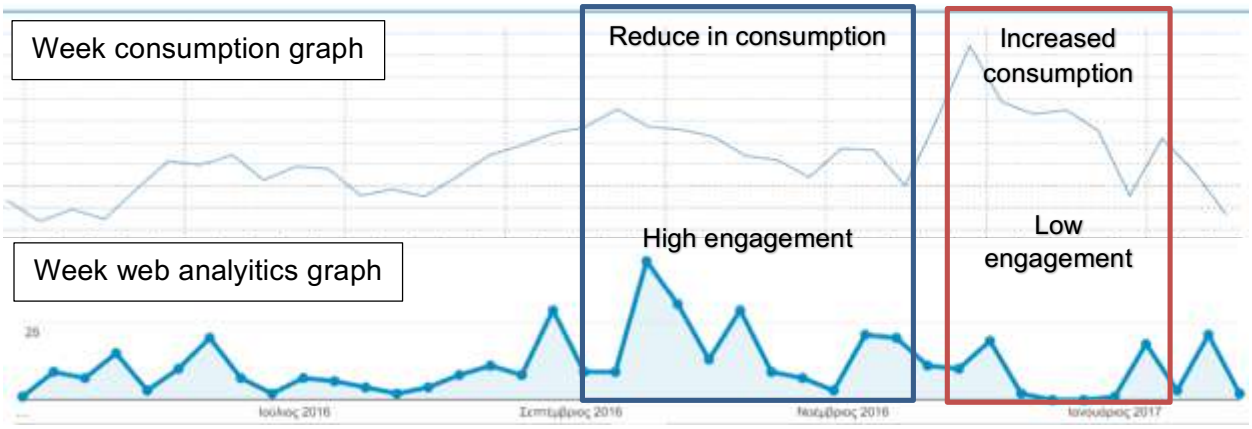



*Figure 5-20: The effect of engagement in consumption*

**WEM 3: Introduction of WATERNOMICS Learning Applications**

The release of the news aggregator app as explained in the focus group was not used much from participants and therefore we cannot observe any significant impact of it in the reduce of water consumption found from September to November.

**WEM 5: Introduction of WATERNOMICS Exploration Applications**

The comparisons application released expected to play a role in decreasing the water consumption. Interim interviews with household owners revealed that after checking the application for a couple of weeks they realized that they were overusing the kitchen tab and under using the dishwasher. This triggered an attempt to use the dishwasher more to save water.

However, the application that seemed to play a significant role and was mentioned a lot in the final focus group was the digest emails. Although, daily digest emails were found to be overwhelming after some time the weekly and monthly digest emails were commented to be quite helpful in tracking their own consumption. The digest emails application was released in mid-September and this coincides with the start of the period that reduce was observed (Figure 5-21).

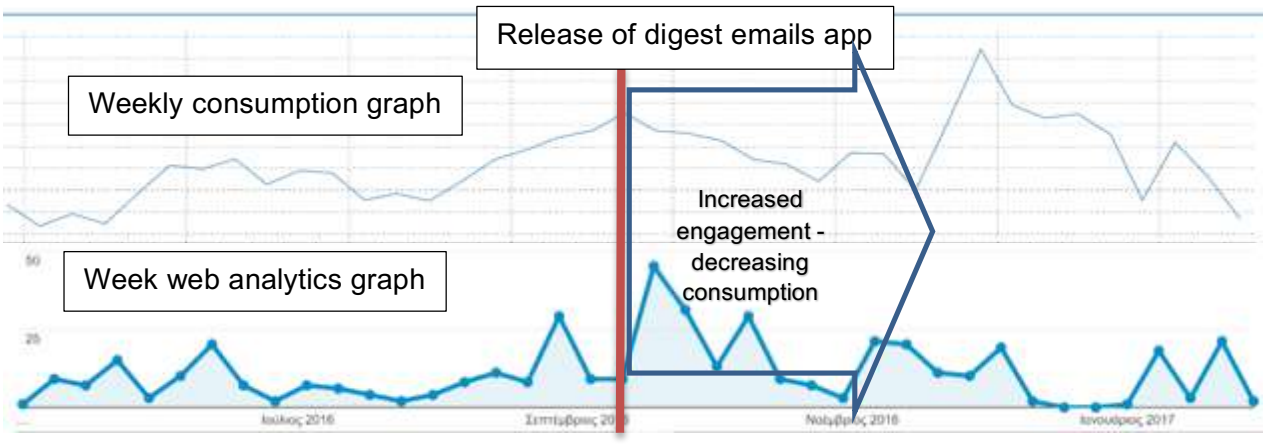



*Figure 5-21: Effect of release of digest emails app*

**WEM 7: Introduction of WATERNOMICS Gaming Applications and Gamification features**

The leader boards based on consumption were released close to the Christmas holiday period and was only used for about 2 months. Participants commented that although it was interesting it wasn't the main factor to lead to a reduction in water consumption. Applications such as the ones mentioned in the exploration category where commented to be much more effective than the leaderboards one.

### 5.3.4 Objective 4: Educate domestic consumers about water consumption and their role in conservation

To educate domestic consumers, the water information system will provide data to engage users by providing meaningful and actionable information and insights on their consumption.

#### 5.3.4.1 Effect of WEMs

**WEM 3: Introduction of WATERNOMICS Learning Applications**

In terms of educating users, some interesting observations were made by the use of metaphors in the monitoring applications. People found them interesting and can at least relate their water consumption to other equivalents while also finding out how water is used in cases of food production. However, participants in the focus group mentioned that it would be much more interesting if instead of a water footprint we could present a more holistic environmental footprint combining both energy and water consumption. This shows that the metaphors triggered a more holistic sustainability approach to users and created some more questions for discovering more knowledge.

The release of the news aggregator app was expected to help even more in educating users but as explained already was not used much and therefore no significant impact could be observed.

**WEM 5: Introduction of WATERNOMICS Exploration Applications**

As already discussed in the previous objective the final focus group and interim interviews results showed that the comparison applications have affecting some of people and at least discussed about changing some of their habits. Some of them commented in the final focus group that they would tried to adopt a new behaviour in their household but enforcing it to all other household members was the difficult part since it required changes in behaviours and habits that was difficult to be achieved. The comparison application helped people realise if they are consuming water according to normal water usage patterns.

The digest emails application cannot be accounted for educating users but rather keeping them aware of their consumption. However, the use of metaphors in the daily digest emails was the only point where this could happen.

**WEM 6: Open End-user WATERNOMICS seminar**

Feedback received in the end of the open day from attendees and the journalists shows that the content was interesting and people were interested to learn and find out more information on water consumption. The follow up email to assess the presentations through an online questionnaire was not successful as only 3 recipients of the request filled in the questionnaire.

**WEM 7: Introduction of WATERNOMICS Gaming Applications and Gamification features**

The leaderboards application released was not accompanied or tied well enough with providing follow up information and this is the main problems that it faced in educating users. A better and tighter connection to learning applications such as the news aggregator might have resulted in more engagement and better impact for this objective for both applications.

## 5.4 WATERNOMICS Methodology Phase 3 – Check

### 5.4.1 Summary of the Pilot

7 out of the 8 planned WEMs have been applied in the Thermi pilot with the in-school training program abandoned in favour of developing an additional exploration application for the participants. The interim assessment through interviews helped in making this decision and the final focus group confirmed that the impact from the additional exploration application was quite important. 6 out of the 8 households are consistently sending data and issues from the remaining 2 households are being addressed.

### 5.4.2 Effectiveness of the WEMs

Although there was a slow start on the on-boarding process of users in the platform and raising the effectiveness of the WEMs appropriate measures have been taken (weekly newsletter campaigns and email digest app) which paid off in increasing the effectiveness of the WEMs in total.

**Objective 1: Increase Awareness of Water Consumption**

- Data from web analytics and visits to the platform show an increasing interest especially during th emonths where the newsletters were distributes.
- The initial lack of interest was tackled by introducing a set of email newsletter campaigns during July and August that kept users in contact with the platform and the pilot. However, summer holiday periods and personal routines made difficult the attraction of significant attention until early September and on.
- The exploration applications increased interest from users' side and initial feedback shows their usefullness.
- Interim interviews on the lack of engagement led to the development of an additional exploration app (the digest emails app) that was not initially planned for development. Final focus group and interviews confirmed that this change in plans was effective since many users commented positive on it.
- The main factor that contributed to the success of the diggest email app was that it was providing users with infromation from the platform through communication channels they already use on their daily lives. Exploiting existing commnucation channels of users is a key takeaway in strategies for increasing awareness.

**Objective 2: Enable behaviour changes in water consumption**

- There was no significant behaviour change observed but the exploration app of comparisons with other households showed a potential enabler of behaviour changes based on focus groups and interviews with household owners.
- One of the difficulties faces in many cases was that changing behaviour in the household evnironment requires changing behavior in all users and if not all are interacting with the infroamtion this becomes more difficult.
- The news aggregator app was not as helpful as expected mainly due to the fact of low economic incentives in engaging and learning more about water consumption.

**Objective 3: Reduce water consumption and energy**

- Reduction of water consumption was observed pver a period of 3 months but to verify the stability of this reduction a longer period of observations might help.

- Comparison with previous years measurements was difficult doe to lack of comparable data.
- One of the main factors in achieving a significant water cosnumption reduction is the low economic incentive for households. Water is relatively cheap and does not affect significantly household budget so the incective for reducing water consumption was also low.
- A combination of water with energy consumption towards a holistic sustainability tracking platform was metioned by participants as a potential factor that would increase their interest and incentives in total including water.

**Objective 4: Educate domestic consumers about water consumption and their role in conservation**

- Results from the impact of the Open day event showed an interest in the local community

The news aggregator and leaderboards applications could have been linked better together to drive increased engagement and provide more incentives for being educated on water conservation.

# 6 The Pilot Report – NUI Galway

The measures implemented to meet the Pilot Site Objectives are described in the following along with a review of the Pilot Site Objectives as defined in D5.1.

## 6.1 Meeting Pilot Site Objectives and KPIs

The Pilot Site Objectives to be achieved by implementing a Water Management Program at the NUI Galway Pilot Site are fully described in Project Deliverable D5.1 – Pilot Plan and are highlighted in Figure 6-1 below. The objectives reflect both the user requirements and KPIs described in earlier Project Deliverable D1.3 System Architecture and KPIs as well as the overall project aims.

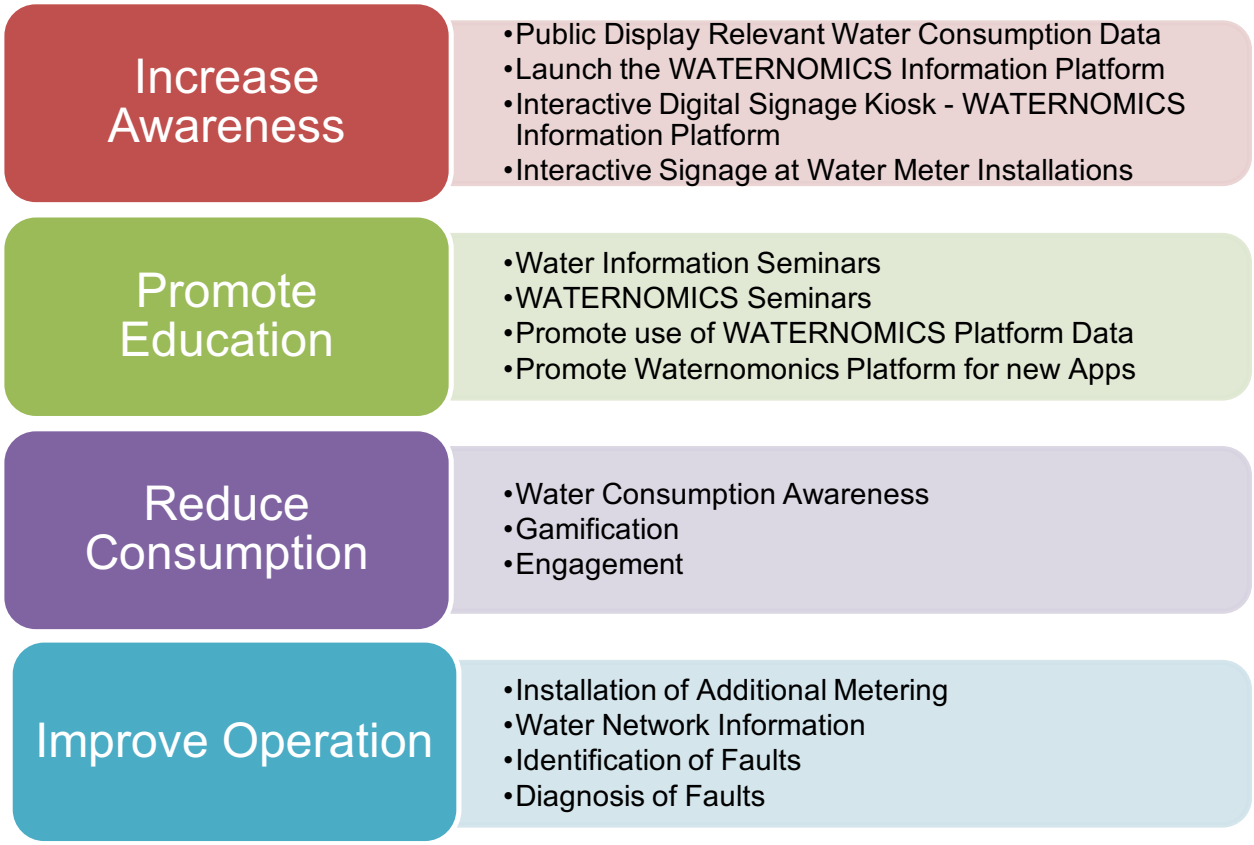



*Figure 6-1 Pilot Specific Objectives and Associated WEMs - NUI Galway Engineering Building*

### 6.1.1 Objective 1: Increase Awareness

The measures as listed in Figure 6-1 above implemented at the NUI Galway Pilot Site to increase awareness of water usage are discussed in the following sections. As described in D5.1 Pilot Plan, a key indicator of the success of the implementation Water Management Program and in particular the associated water information system would be realized by an increase in awareness of water usage and conservation at the NUI Galway Engineering Building. The success of this objective is measured by analysis of pre and post intervention questionnaire survey. Following the Norm-Activation-Model [11], a Water Awareness Questionnaire Survey was developed by the Waternomics team in collaboration with a researcher specialising in the area of phycology and in particular Technology Adoption. The

questionnaire survey is included in Appendix C of this report. The survey examines the issue of water conservation awareness by users by assessing their response to questions designed to gauge the following: problem awareness, ascription of responsibility, outcome efficacy, intention to participate, personal norms and existing behaviour. Survey participants were asked to indicate on a scale of 1-5 the level to which they agreed or disagreed with a statement; a score of 1 indicates completely disagree and a score of 5 indicates completely agree. The results of these surveys are included in Section 6.2.

### *WEM 1: Public Display Relevant to Water Consumption*

**Description:** A Water Awareness slide show developed by the NUI Galway Waternomics Team is on display on a wall mounted 42 inch screen in the foyer of the Engineering Building as shown in Figure 6-2 and Figure 6-3, and can be found in Appendix C. The slide show opens with a problem statement and describes the energy intensive process of water treatment. Hints and tips regarding reducing water consumption relevant to the Engineering Building and its occupants are also described. The visuals are based on a US based water conservation campaign 'Water Use It Wisely' http://wateruseitwisely.com/. The problem statement was developed by the Waternomics Project Team following initial feedback and gathered as part of usability testing for the early versions of the Waternomics Public Dashboard. Slides are also available as part of the training material on the project website [waternomics.eu].

*Figure 6-2 Information Screen - Water Awareness Slide Show*


*Figure 6-3 Information Screen - Water Awareness Slide Show*

**Status:** The public display Water Awareness slide show was launched in early M31 (August 2016) in advance of the wide scale launch of the Public Dashboard (discussed later). The slide show will remain in place until the end of M36 and appear intermittently to ensure maximum impact.

**Resources:** Staffing assignments are provided in the Project DOW to complete Demonstration Activities.

**Review:** The effect of this measure is reviewed by an analysis of pre- and post-intervention questionnaire surveys designed to measure Water Awareness and an analysis of Water Consumption patterns over the control period.

### *WEM 2: Launch of WATERNOMICS Applications Platform*

**Description:** A key element of the WATERNOMICS Project was to develop a WATERNOMICS applications platform facilitating user interaction with water usage data analytics from by meter/sensors recordings from the pilot. The software platform was launched in M25 and the two pilot specific applications listed below that are hosted by the platform were fully released to the pilots in M31 and remain in operation for the full pilot control period and at the time of writing;

- The NUI Galway Engineering Building Managers Dashboard
- The NUI Galway Engineering Building Public Dashboard

**The NUI GALWAY Engineering Building Managers Dashboard**

The managers' dashboard is a web-based application that allows building managers and administrations to monitor, analyse and assess information relating to the water infrastructure in the NUI Galway Engineering Building. The main application that is the Managers Dashboard allows the users to view and interrogate data from the Waternomics dataspace [7] [12] [13] [14] detailed in D3.1.1 and D3.1.2. It hosts a number of bespoke pre-installed apps in the following main categories:

- Learn
- Monitor
- Explore

The following monitor and explore apps were designed in part by the Waternomics Team for the NUI Galway Engineering Building Management Team following through an initial consultation session to determine user requirements for the system. Other apps were developed in consultation with the NUI Galway Waternomics Team that reflects their knowledge of the key system aspects:

- Biggest User Comparison App: Provides a breakdown (dissagregation) of the overall water usage in the building.
- Leaks Check: Allows end-users to visualise night time flows.
- Meter Comparison App: Compares the information gathered from various meters.
- Rainwater Harvesting System App: Provides the status of the rain water harvesting system by comparing water supplied from the underground rainwater storage tank to the water supplied from the mains together with available weather data.
- Sensor Information: Provides a map of the water distribution network and location of meters.
- Goal Setter App: Allows users to customise their own goals or determine when a fault has occurred.
- Monitor App: Displays recent water usage as recorded by selected sensors.
- Retention Time Observer App: Creates an email notification to the building management team when the system determines that there is a low level of usage at certain outlets.

The dashboard allows managers to create their own apps and to edit, install or remove existing apps. Step by step guidance on how to create and use the managers' dashboard apps is included on the managers' dashboard in the form of video tutorials accessible through the learn tab on the dashboard home screen. Examples of the building managers apps are displayed in Figure 6-4, Figure 6-5, and Figure 6-6.

**The NUI Galway Engineering Building Public Dashboard**

The public dashboard is a web-based application to allow the public or general occupants (e.g. staff and students) of the Pilot Site access to water usage information from the Waternomics Platform. The NUI Galway Engineering Building Public Dashboard is designed to be displayed on a dedicated interactive device in a publically accessible area.

**Status**: The Waternomics Platform was launched in M25 with the specific dashboard applications being released to users in M31 (August 2016) at the NUI Galway Pilot. In addition to the Waternomics Team at NUI Galway, user access to the NUI Galway Managers Dashboard was given to four members of the NUI Galway Building Management Team.

**Review:** The success of this measure is directly related to interactions with the dashboards and these are monitored using Google analytics. Figure 6-7 below indicates the user activity on the Manager's Dashboard applications in Galway since launch in M31. The Google analytics represent activity on Managers dashboards from both the NUIG and the CnaC Pilots the Public Dashboard is discussed below as part of WEM 3.

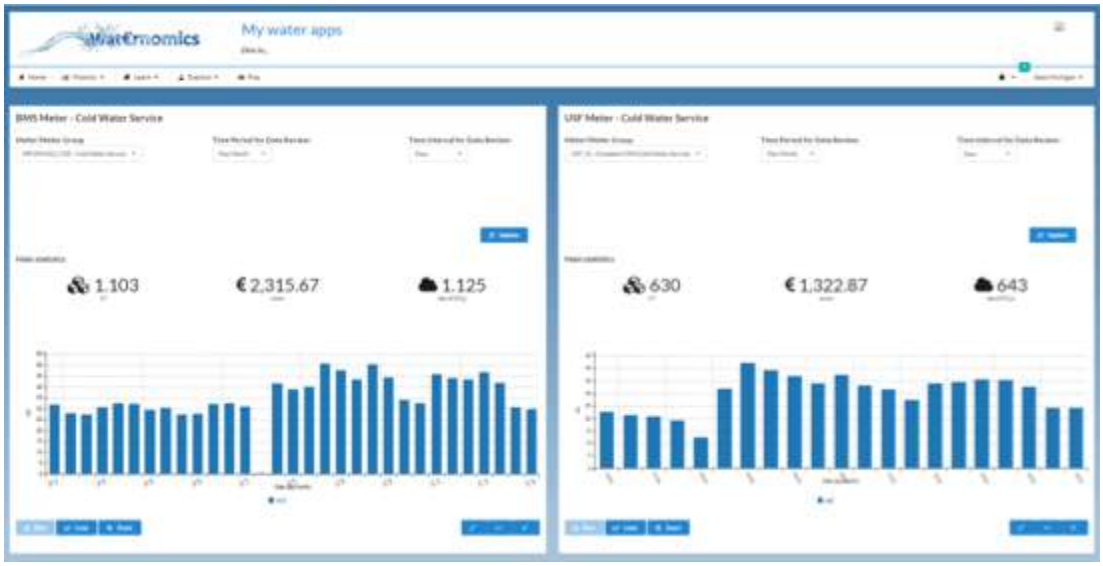



*Figure 6-4 NUI Galway Engineering Building Managers Dashboard – Monitor App*

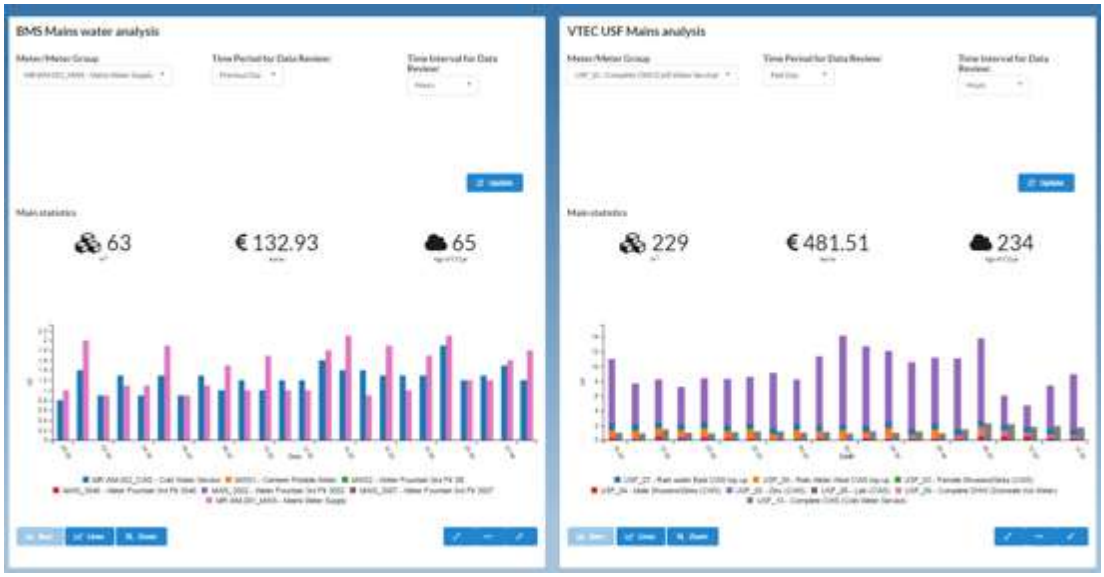



*Figure 6-5 NUI Galway Engineering Building Managers Dashboard – Meter Comparison App*


*Figure 6-6 NUI Galway Engineering Building Managers Dashboard Explore & Monitor Apps*

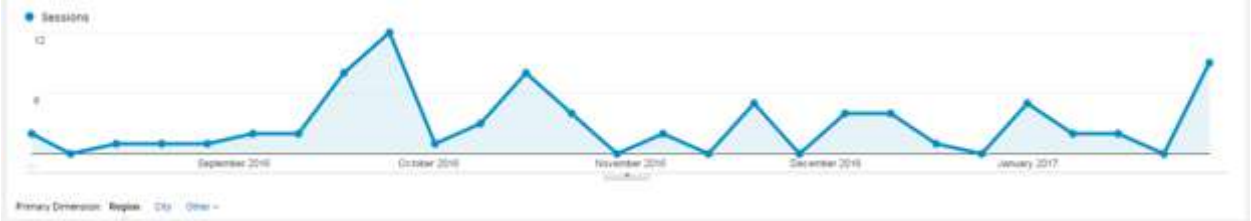


*Figure 6-7 NUI Galway Managers Dashboard Interactions August 2016 (M31) – January 2017 (M36)*

The analytics indicate increased activity during the month of September (M32) after the dashboard launch with 40 logins recorded in the period M32-M33, inclusive.

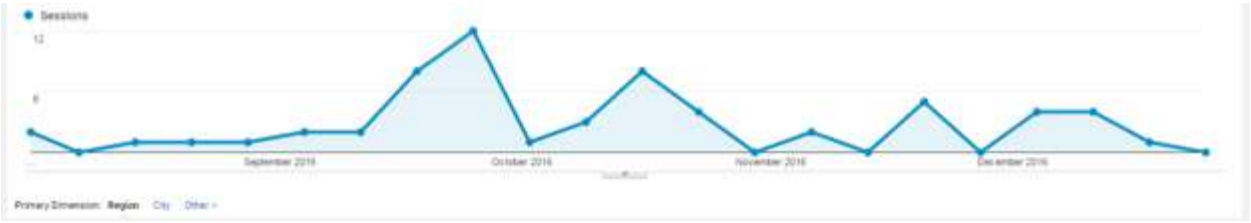


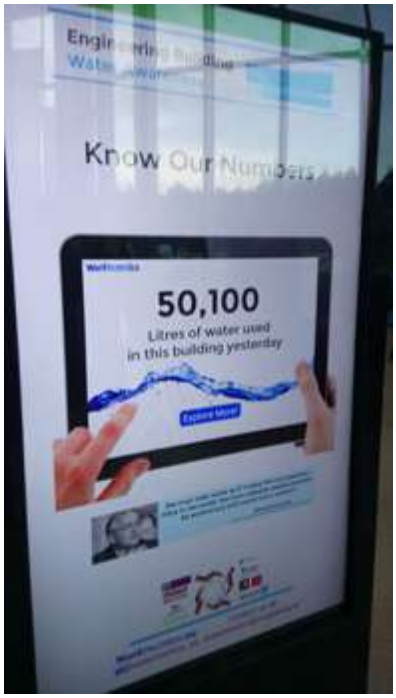
*Figure 6-8 NUI Galway Managers Dashboard Interactions August 2016 (M32) – December 2016 (M35)*

Efforts to increase the login rate at the Managers Dashboard continued at the pilot site for the control period and include the release of newsletters to dashboard account holders which contained elements to simplify the login process.

### *WEM 3: Interactive Digital Signage Kiosk - WATERNOMICS Information Platform*

**Description:** An Interactive Digital Kiosk display located at the Engineering Building Foyer displays the NUI Galway Engineering Building Public Dashboard Application as described above. The public dashboard (displayed in Figure 6-9) provides building occupants and visitors with information regarding the building's previous day's water usage together with a live feed of water usage from the building's ultrasonic flow (USF) meters.

The public dashboard display comprises two screens. Screen 1 is designed to be a 'Passive Screen' that displays a single numerical value of the buildings total water usage in addition to quotes from famous people on the subject of water awareness, conservation and environmental responsibility (Figure 6-10). The passive screen is designed to invite passers-by to 'Explore More'.




(a)


(b)

*Figure 6-9 Public Dashboard Passive Screen (a) & Active Screen (b)*


*Figure 6-10 Public Dashboard Passive Screen (Main Usage Number and Famous Person Quote)*

The active screen presents a schematic describing the problem to be addressed as well as highlights of the water usage in the building. A real-time feed of data from USF meters which gather water usage data every second is also presented. The active screen displays information on the Waternomics Project and ICT4Water, videos, and links to relevant social media updates via selected Twitter feeds as well as details on how to contact the Waternomics team.

**Status**: The Interactive Digital Signage Kiosk and access to Public Dashboard was launched in M31 (August 2016). The passive screen display has undergone two revisions since launch with the aim of encouraging new interactions.

**Review:** The first revision of the passive screen and its subsequent revision are indicated in

Figure *6-11*. User feedback at the Pilot Site indicated that although occupants were aware of the usage number on the screen and interested by the volume and its changes, the interactive nature of the screen was not obvious to the majority of staff and students casually surveyed.

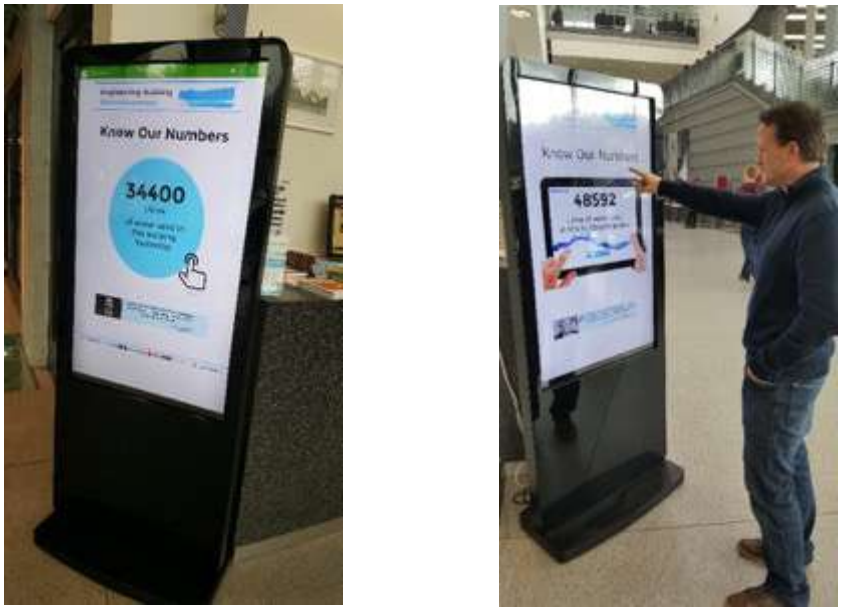



*Figure 6-11 Passive Screen Revisions since M31 Launch*

The level of interactions with the digital display is logged using Google analytics and reviewed for the pilot control period. The success of this WEM is related to interactions with the dashboard. Figure 6-12 and *Figure 6-13* below indicate the increase in user activity on the interactive screen since at the time of its launch in M31.

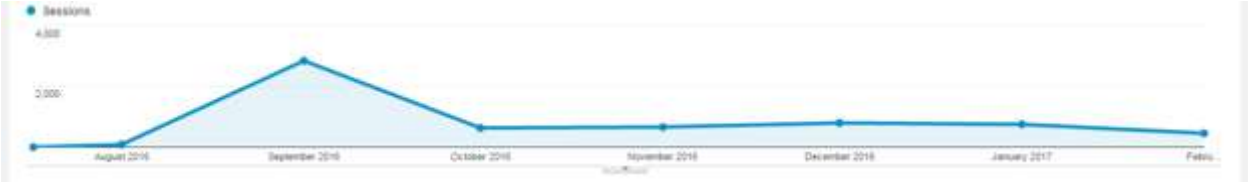



*Figure 6-12 NUI Galway Public Dashboard Interactions August 2016 (M31) – January 2017 (M36)*

The analytics indicate a peak in the number of interactions in the period coinciding with the start of the academic term in early M32. A of total of 5,783 interactions were logged at the screen in the period from (M31) to the end of the control period in M36 Following the start of term, there was a fall-off in activity from the beginning of M33 to the end of the control period with an average of 712 (SD = 77) interactions per month recorded during the period (see *Figure 6-13*).

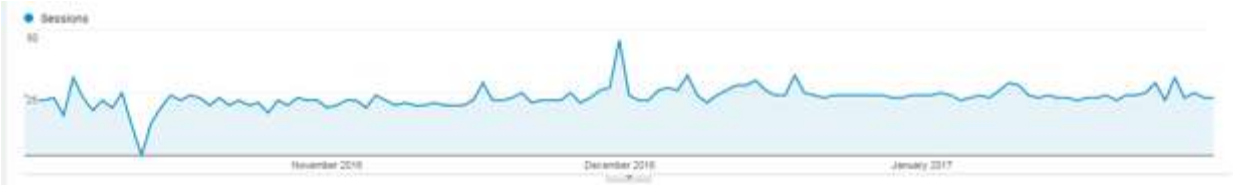



*Figure 6-13 NUI* Galway *Public Dashboard Interactions October 2016 (M33) – January 2016 (M36)*

### *WEM 4: Interactive Signage at Water Meter Installations*

**Description:** A number of the USF meters installed as part of the Waternomics Project are located in high profile publicly accessible areas of the Engineering Building. For security, the meters are enclosed in locked wall mounted units along with the associated BBBs. However, the easily visible location of these meters provides a good opportunity to engage users with the project and the installations. In three locations in the NUI Galway Pilot Site, the meter enclosures are fitted with QR codes linking to a USF meter data application giving quasi real-time information on the meter recordings. A signage poster

(Figure 6-14) describing the Waternomics Project and its aims and also featuring the QR code linking (Figure 6-15) to the relevant application is also in place adjacent to the USF meter enclosures at the selected locations. The USF flow meters featuring the interactive signage poster are located as follows:

- the male shower room water supply USF_04
- the female shower room water supply USF_03
  the domestic hot water supply USF_09

**Status**: The Interactive Device Signage and Associated QR code application was launched at three 3 locations in the pilot site in M32 (September 2016). An interaction monitoring application was implemented mid-M34.


*Figure 6-14 Interactive Signage Poster at USF meter installations*

**Review:** Interaction with this measure was monitored using Google Analytics, from the time of launch a total of 105 QR code events were recorded to M34. There has been a distinct fall-off in interaction since mid M34, with the following total activations of the USF QR Code visits recorded for the building since November 15: USF_03 =6, USF_04=3, USF_09=1

*Figure 6-15 Interactive Signage Application in use*

### 6.1.2 Objective 2: Promote Education

Many of the initiatives described in 6.1.1 above will contribute to realising this objective, however the specific measures as listed in Figure 6-1 are discussed in the following.

***WEM 5 & 6: Waternomics Seminars and Water Information Seminars***

**Description:** To-date a number of specific lectures and workshop activities have been held to introduce Waternomics to staff, students and visitors to the NUI Galway Pilot Site. The main events are briefly described below.

M27 (April 2016) – Water Awareness Workshop for Transition Week.

A group of 25 local students 15-17 year olds attended a Water Awareness Workshop to introduce the water treatment process and the energy costs associated with supplying clean water to our homes and schools. The importance of water conservation and the motivation and aims of the Waternomics Project were also addressed.

*Figure 6-16 Waternomics Showcase M28*

M28 (May 2016) - Waternomics showcased to visiting professors and students from US Universities.

A group of approximately 50 students and academics visiting from Construction Management at Purdue University and Auburn University attended a Waternomics showcase (Figure 6-16) introducing the project and examining some of its innovations.

In M31 (August 2016) a Building Managers Dashboard Training Workshop was held with the Engineering Building Manager and a representative of the NUI Galway Building's Office. Following a brief introduction and project recap, attendees were introduced to the functionality of the building manager's application (Figure 6-17) and in particular some of the bespoke apps created for the pilot site such as, the Biggest User App, Rainwater Harvesting App, Meter Comparison App and Water Retention Observer App. The feedback in general was very positive.

M32 (September 2016) A short Waternomics Talk introducing 250 1$^{st}$ year Engineering Students to the Project took place (Figure 6-19). In particular, the students were introduced to the aim of the project and encouraged to engage and interact with the innovations such as the interactive kiosk and QR codes etc. The lecture was followed by a targeted Student Waternomics Newsletter circulated in M33.

M33 (October 2016) a specific Retention Time Observer Application training session took place with the Building Manager at the Engineering Building Pilot. The aim of this session was to address detail of the requirements for alerts and the details included in same.

M36 (January 2017) a series of presentations and discussion platform was held at the NUIG Engineering as part of the Waternomics final event. The all-day event was attended by approximately 30 staff, students, stakeholders and guests.

### *WEM 7 & 8: Promote use of WATERNOMICS Platform Data and Platform for new Apps*

**Description:** A number of measures are currently in place to promote and encourage staff and students to interact with and use the information that is gathered by the Waternomics Platform. It is intended that data gathered for the Waternomics Project will be used in the future as the basis for further research and development work.

The Waternomics Platform is designed to host innovative water information based applications developed by any 3rd party. The applications must be non-commercial and free of charge and have a water related focus. Efforts to promote the facility are underway.

The M33 1st Year Engineering Email Newsletter (see Figure 6-18) invites submission from students for ideas for the creation of new apps and proposes short-term internships to develop these.

In addition, at Project Partner Unesco-IHE, it is intended to incorporate the NUI Galway Managers Dashboard into a lecture series on water network management including giving access to existing apps on the dashboard and the app creator tutorials.

The WATERNOMICS Project has a number of dissemination channels such as twitter @WATERNOMICS_eu and website http://WATERNOMICS.eu/ where the platform facility is actively promoted.

**Status:** A student focused e-bulletin was circulated to first-year Engineering students in M33. 3 Managers Newsletters were circulated to Managers in months M31, M32 and M35.

**Review:** No new applications were developed during the project control period however proposals are being developed to extend the public dashboard applications to total energy consumption as part of the campus Sustainability Initiative (see 6.2.2 below).

*Figure 6-17 Waternomics Managers Dashboard Training M31*

*Figure 6-19 Waternomics Lecture 1st Year Eng M32*


*Figure 6-18 First Year Engineering Newsletter*

### 6.1.3 Objective 3: Reduce Consumption

Monitoring of the water consumption at the NUI Galway Pilot Site is on-going since the commencement of the Pilot Control Period. The analysis of this information and early conclusions is fully described in Section 6.2 below and represents the baseline usage by which changes in consumption will be assessed.

### *WEM 10: Water Consumption Awareness*

**Description:** Section 6.1.1 describes the measures implemented at the Pilot Site to Increase Awareness. These measures are also aimed at changing water use behaviour and reducing consumption.

In brief, the measures as described are:

- Public Display Relevant Water Consumption Data
- Launch the WATERNOMICS Information Platform
- Interactive Digital Signage Kiosk - WATERNOMICS Information Platform
- Interactive Signage at Water Meter Installations

**Status:** The status of these measures is described in Section 6.1.1.

**Review:** The review of these measures is described in Section 6.1.1.

### *WEM 11: Gamification*

**Description:** Given the age of the majority of students at the NUI Galway Pilot Site is 18-24 years, an element of gamification in some of the engagement activities is appropriate. The overall visual design of the Public Dashboard Application and the interactive nature of the kiosk displaying the application is an example of how gamification has been employed. The active screen display adopts simple effective graphics red or green depending on whether an average water use baseline has been exceeded or not.

In addition, two competitions are currently running to increase engagement with the Public Dashboard Application. Details of the competitions are included in the Student Newsletter shown above and described in the following.

### *Famous Person Quote*

Acknowledging the popularity of the celebrity, the NUI Galway Public Dashboard Passive display includes a number of quotations from famous people that change throughout the day. The NUI Galway Waternomics Team has invited submissions for additional 'famous-persons' quotes to be included on the passive screen of the NUI Galway Pilot Site dashboard (see Figure 6-20).

**Deadline**: The competition was launched in M33 in the Student Waternomics newsletter and ran for the remainder of the Pilot Control period.

**Review:** Submissions were not received from students during the pilot control period, however in March 2017 the famous person quote section of the display was updated to include biographical details of Alice Perry, the first female engineering graduate Europe who graduated from Civil Engineering at NUIG in 1906 and in who's honour the Engineering Building at NUI Galway was officially named March 2017.

### *Public Dashboard App Ideas*

The NUI Galway Waternomics Team has invited submissions for ideas for apps to be included on the Waternomics Public Dashboard (See Figure 6-21).

**Deadline**: The competition was launched in M33 in the Student Waternomics newsletter and ran for the remainder of the Pilot Control period.

**Review:** Submissions were not received from students during the pilot control period, the proposal to include total building energy consumption and building energy consumption associated with building water usage are under consideration.

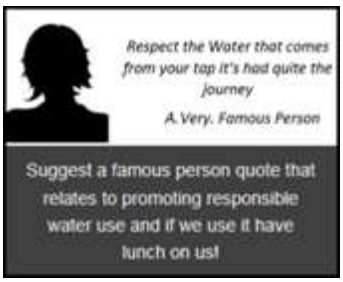



*Figure 6-20 Famous Person Quote Competition c.f. M33 Waternomics Student Newsletter*


*Figure 6-21 App Development Competition c.f. M33 Waternomics Student Newsletter*

### *WEM 12: Engagement*

The measures described in Section 6.1.1, 6.1.2 and 6.1.3 represent engagement activities undertaken by the NUI Galway Waternomics Team to encourage pilot site occupants to participate with the innovations and interactive with the installations.

**Description:** In particular, the measures listed below are designed to engage users in the project:

- Public Display Relevant Water Consumption Data
- Launch the WATERNOMICS Information Platform Applications (Public and Managers Dashboards)
- Interactive Digital Signage Kiosk - WATERNOMICS Information Platform
- Interactive Signage at Water Meter Installations
- Water Information Seminars
- Waternomics Seminars
- Promote use of WATERNOMICS Platform Data
- Promote Waternomics Platform for New Apps
- Gamification
- Newsletters (Student and Building Managers)

**Deadline**: The engagement measures are all underway and described in detail above.

**Review:** The review of individual measures is described in the preceding sections.

## 6.1.4 Objective 4: Improve Operation

The measures as listed in Figure 6-1 above implemented at the NUI Galway Pilot Site to increase awareness of water usage are discussed in the following.

### *WEM 13: Installation of Additional Metering*

**Description:** As proposed in the Measurement Frameworks Report D2.2, 8 USF meters were installed at NUI Galway Engineering Building in August 2015 (M19). An additional 3 in-line displacement water metres were installed at the pilot site in October 2015 (M21). Prior to project commencement, eleven in-line displacement meters were in place at the pilot. To-date and despite some initial operational issues and concerns regarding the integrity of the data from the USF meters, 6 of the USF meters together with the existing metering at NUI Galway and the 3 additional in line displacement meters installed have provided a significant amount of new information about the buildings water usage through a combination of high-

resolution and medium-resolution monitoring (ultrasound and in-line metering). This combination offers a unique advantage in analysing flows in mixed-use buildings where there are variations in water usage events (volumes used and event times). The sensor data acquisition frequency of 1 Hz is capable of resolving very detailed flow signature information from large flow events such as rainwater tank refills and laboratory usage down to a signal tap flow event. Under certain conditions, it was possible to identify some of the main end usage events in the mains line to the building which, when coupled with an activity recognition software, offers an automated activity numeration system for building managers to monitor their usage more intuitively. A number of journal articles on the findings of this research are currently being progressed one of which has been submitted for review to the Journal of Water Resources Research titled: "Flow signature analysis *of* water consumption in non-residential building water networks using *high*- and medium-resolution smart meter data: Two case studies*"*.".

**Status**: All new metering was installed at the NUI Galway Pilot by M19 and Data collection has continued since M24.

**Review:** Post-intervention analysis of data from metering is presented in Section 6.2.1.

### *WEM 14: Water Network Information*

**Description:** Water network information regarding pipe sizing and connections was reviewed by the NUI Galway Waternomics Team during the planning stage. This information was simplified and an updated schematic prepared for inclusion in the Building Managers Dashboard. Data from January to June 2016 recorded by the installed metering at the Pilot Site was assessed to establish a detailed usage baseline and patterns / flow signature work at the pilot during an in-term period. The data was downloaded directly from the BMS and USF collection systems for a total of 14 displacement water meters and 7 USF meters (8 USF meters were installed at the site in however, no data is received from one of these meters and there have been operational issues from another one).

The data recorded and analysed regarding the network operation is presented in detail in Section 6.2 of this report.

**Status**: In addition to the preparation of water network information in the form of schematics which have been included in the Managers Dashboard, baseline water data has been established for the pilot based on analysis of January 2016 – June 2016 data. Daily, weekly and monthly data is available on the public and managers' dashboard applications.

**Review:** Post-intervention analysis of Water Network Information will continue on a monthly basis for the remainder of the pilot control period. The work carried out to-date is presented in Section 6.2.1.

### *WEM 15 & 16: Identification and Diagnosis of Faults*

**Description:** Baseline flow values established during the pre-intervention period for the primary meters (mains, cold water and rainwater supply etc.) were utilised during the period of pilot control as a method for fault detection, whereby a substantial increase in usage would be a likely indicator of a fault [4]. This type of fault identification is automated by the following apps available on the NUI Galway Building Managers Dashboard;

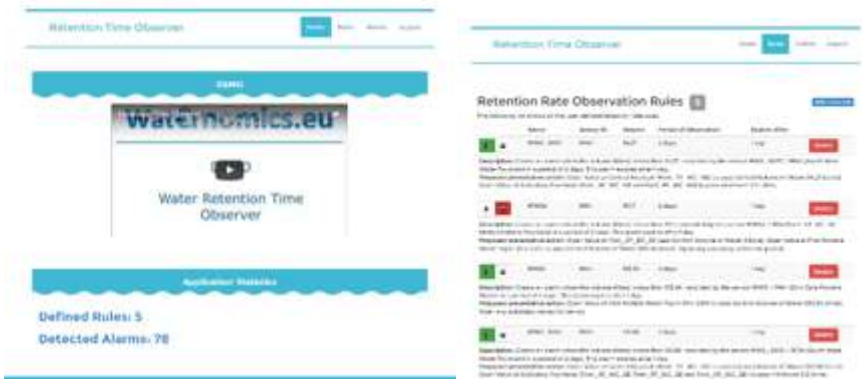



*Figure 6-22 Retention Time Observer NUI Galway Building Managers Dashboard*

1. Managers Dashboard Goal Setter (ref. 6.1.1 above)
   This app generates notifications when water usage falls outside expected volumes.

2. The Water Retention Time Observer Application

This app (Figure 6-22) generates email notifications when the residence times of potable water in a system are exceeded. These times are defined by rules developed for the building water system and reflected in the developed application. The Rule Based FDD and results app is fully described in Project Deliverables D3.3, D4.2 and D4.3. The email notification received by the Building Manager includes advice on resolving issues.

**Status**: The FDD applications were launched as part of the Managers Dashboard Application in M31.

**Review:** The Managers Dashboard Application logs the active, expired and resolved alerts. Since the launch of the retention application, a total of 216 alarms have been raised.

## 6.2 WATERNOMICS Methodology Phase 3 – Check

### *6.2.1* Effectiveness of the WEMs - Objective 1: Increased Awareness

Pre-intervention Water Awareness Surveys as described in 6.1.1 were completed by 70 1st year engineering students (class of 2015/2016) based at the NUI Galway Engineering Building. A control group of 37 1st year IT students based in an area on the NUIG campus remote from the Engineering Building also completed the survey in early 2016.

The questionnaire surveys were repeated in M36 with the 1st year Engineering class of 2016/2017 who had been exposed to the Waternomics measures at the NUIG Pilot since the beginning of their course. A control group of first year (class of 2016/2017) IT students were also surveyed as part of the post-intervention study. The results of the pre- and post-intervention studies are presented below.

The main age range of the IT Student control group and Engineering Students who took part in the questionnaire survey was 17-20, with over 70% of pre and post intervention survey respondents in this range. The respondents completed the surveys by hand and the results were transferred to spreadsheet for analysis. Respondents gave each attribute a score on a scale of 1-5 with 1 being the lowest results and 5 the highest.

Table 6-1 and Table 6-2 below indicate the average results of the pre-intervention and post-intervention surveys for each of the following aspects: Problem Awareness, Outcome Efficacy, Ascription of Responsibility and Personal Norms. Three questions numbered 2, 5 and 6 were used to measure Problem

Awareness. Five questions 7, 8, 11, 13 and 15 were used to measure Outcome Efficacy. Four questions numbered 9, 10, 12 and 14 were used to measure Ascription of Responsibility and three questions numbered 1, 3 and 4 were designed to measure personal norms.

*Table 6-1 Pre-Intervention Water Awareness Questionnaire Results*

| | **1st year Engineering Students** | | **1st year IT Students (control)** | |
|---|---|---|---|---|
| **Aspect /Survey Question** | **Mean** | **SD** | **Mean** | **SD** |
| **Problem Awareness (mean score)** | | | | |
| 2 | 3.47 | 1.07 | 3.41 | 1.09 |
| 5 | 3.84 | 1.15 | 3.86 | 1.03 |
| 6 | 3.89 | 0.91 | 3.73 | 0.96 |
| | **3.73** | **0.23** | **3.67** | **0.24** |
| **Outcome Efficacy (mean score)** | | | | |
| 7 | 4.13 | 1.01 | 3.51 | 1.19 |
| 8 | 3.76 | 1.84 | 3.73 | 1.81 |
| 11 | 3.76 | 0.95 | 3.81 | 0.91 |
| 13 | 3.71 | 0.92 | 3.73 | 1.10 |
| 15 | 3.27 | 1.35 | 3.22 | 1.00 |
| | **3.73** | **0.30** | **3.60** | **0.24** |
| **Ascription of Responsibility (mean score)** | | | | |
| 9 | 3.60 | 1.06 | 3.41 | 1.01 |
| 10 | 3.17 | 1.09 | 3.19 | 1.01 |
| 12 | 2.84 | 0.99 | 2.59 | 1.22 |
| 14 | 3.14 | 1.12 | 2.92 | 1.24 |
| | **3.19** | **0.31** | **3.03** | **0.35** |
| **Personal Norms (mean score)** | | | | |
| 1 | 3.71 | 0.97 | 3.65 | 1.18 |
| 3 | 3.84 | 0.86 | 3.54 | 1.12 |
| 4 | 3.10 | 1.08 | 2.81 | 1.24 |
| | **3.55** | **0.40** | **3.33** | **0.46** |
| **Mean/SD** | **3.55** | **0.25** | **3.41** | **0.29** |

*Table 6-2 Post-Intervention Water Awareness Questionnaire Results*

| | **1st year Engineering Students** | **1st year IT Students (control)** |
|---|---|---|

| Aspect /Survey Question | Mean | SD | Mean | SD |
|---|---|---|---|---|
| **Problem Awareness (mean score)** | | | | |
| 2 | 3.39 | 1.11 | 3.29 | 1.23 |
| 5 | 3.90 | 0.87 | 3.55 | 1.25 |
| 6 | 3.88 | 1.05 | 3.89 | 1.09 |
| | **3.73** | **0.29** | **3.58** | **0.30** |
| Outcome Efficacy (mean score) | | | | |
| 7 | 3.64 | 1.27 | 4.13 | 1.00 |
| 8 | 3.73 | 1.88 | 3.84 | 1.17 |
| 11 | 3.93 | 1.01 | 4.24 | 0.82 |
| 13 | 3.89 | 0.97 | 3.87 | 0.88 |
| 15 | 2.84 | 1.27 | 3.66 | 1.05 |
| | **3.61** | **0.44** | **3.95** | **0.23** |
| Ascription of Responsibility (mean score) | | | | |
| 9 | 3.64 | 1.05 | 3.37 | 1.28 |
| 10 | 3.23 | 1.10 | 3.29 | 1.29 |
| 12 | 2.90 | 1.14 | 2.78 | 1.34 |
| 14 | 3.23 | 1.09 | 2.92 | 1.30 |
| | **3.25** | **0.30** | **3.09** | **0.28** |
| Personal Norms (mean score) | | | | |
| 1 | 3.61 | 1.07 | 3.58 | 1.08 |
| 3 | 3.60 | 0.89 | 3.87 | 1.14 |
| 4 | 3.04 | 1.17 | 2.82 | 1.35 |
| | **3.42** | **0.32** | **3.42** | **0.54** |
| **Mean/SD** | **3.50** | **0.21** | **3.51** | **0.36** |

The Figures below indicate the difference the awareness aspects measured for the pre-intervention groups as per the tabulated results. The results are similar for the two groups with determined to be statistically not-significant using t-test of unequal variance. The results indicate that both groups' score relatively high in all of the aspects assessed with no means falling below 62% of a maximum score.

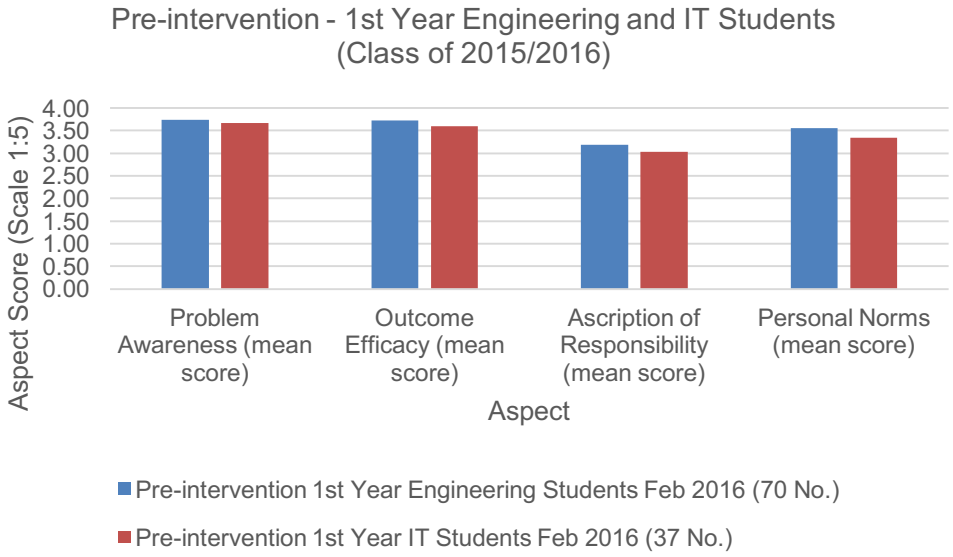



*Figure 6-23 1st Year Engineering Student & IT Control Pre-intervention Awareness Study*

The results of the post – intervention awareness surveys are shown graphically in Figure 6-24 and Figure 6-26. The results indicate the changes recorded from pre to post intervention in the factors assessed. Where changes are recorded, the results are determined to be statistically not-significant using t-tests of unequal variance.

Figure 6-26 shows the results of the pre and post intervention surveys determined from the NUIG control group. The changes recorded are found to be not statistically significant.

In addition to the aspects described above that were assessed as part of the Water Awareness Survey, respondents were asked to indicate their views on practicing and promoting water conservation in three specific questions in Part 4 of the survey (Ref Appendix 4). The respondents indicated how likely they would be to practice water saving/conserving measures by adopting new practices and engage in promotion of same to others. Responses were indicated by selecting one of the following; Definitely Not, Probably Not, Possibly, Probably or Definitively Yes. The pre and post intervention results of the 1st year NUIG Engineering Students are given in Figure 6-27 and indicate marginal improvements in the positive responses from pre to post intervention surveys in the likelihood to adopt water conserving measures.

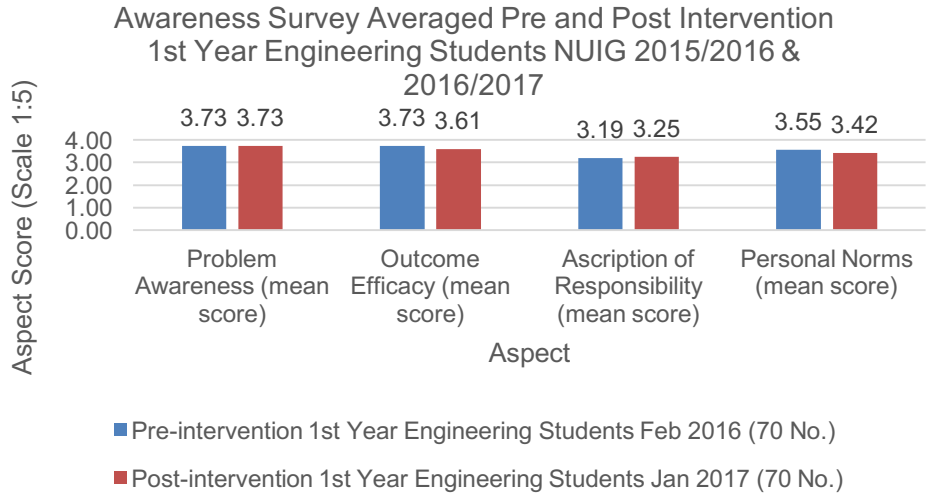



*Figure 6-24 1st Year Engineering Student Pre and Post Intervention Awareness Study*

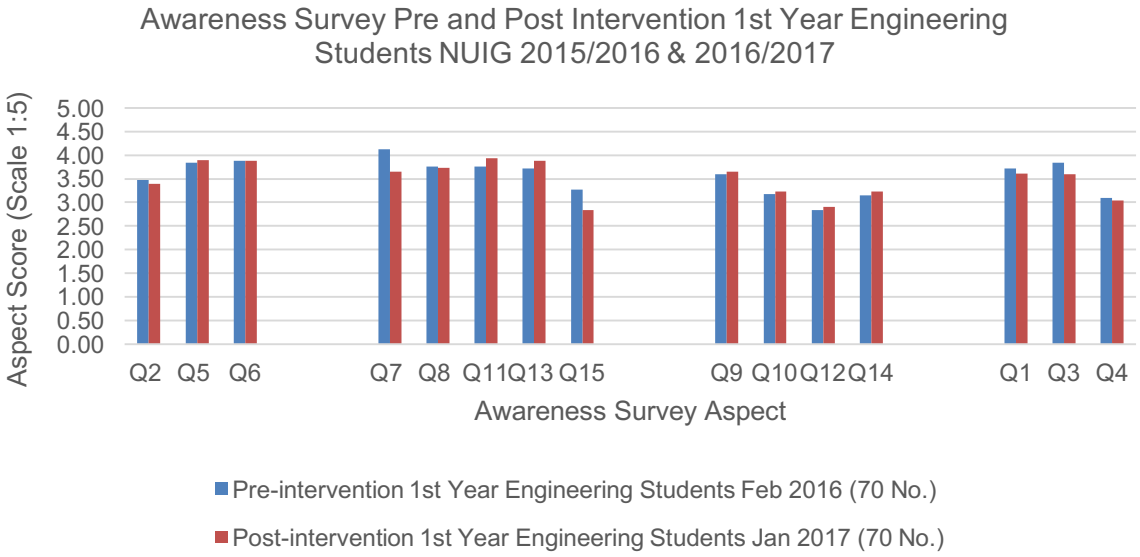



*Figure 6-25 1st Year Engineering Student Pre and Post Intervention Awareness Study (by Question)*

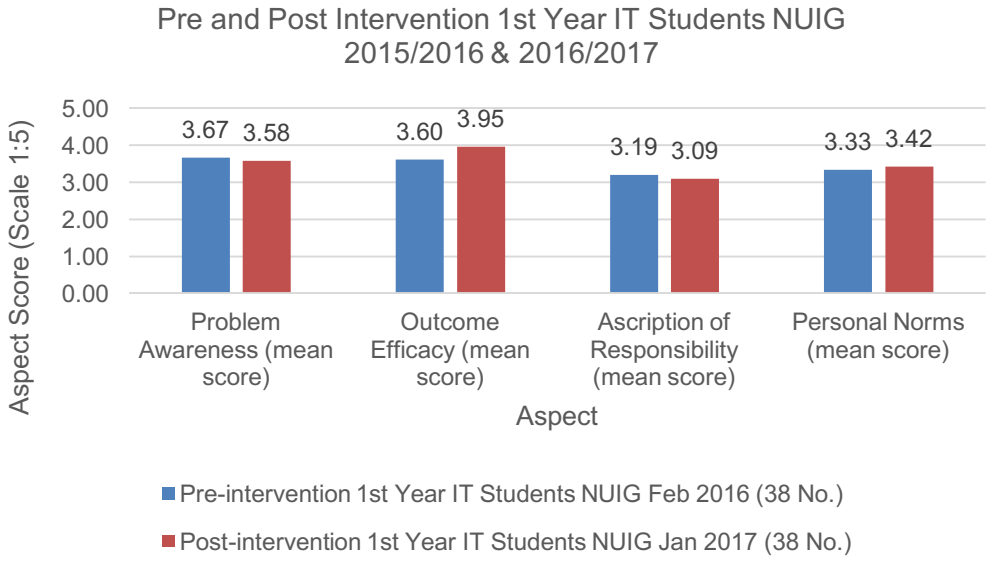



*Figure 6-26 1st Year IT Student (Control) Pre and Post Intervention Awareness Study*

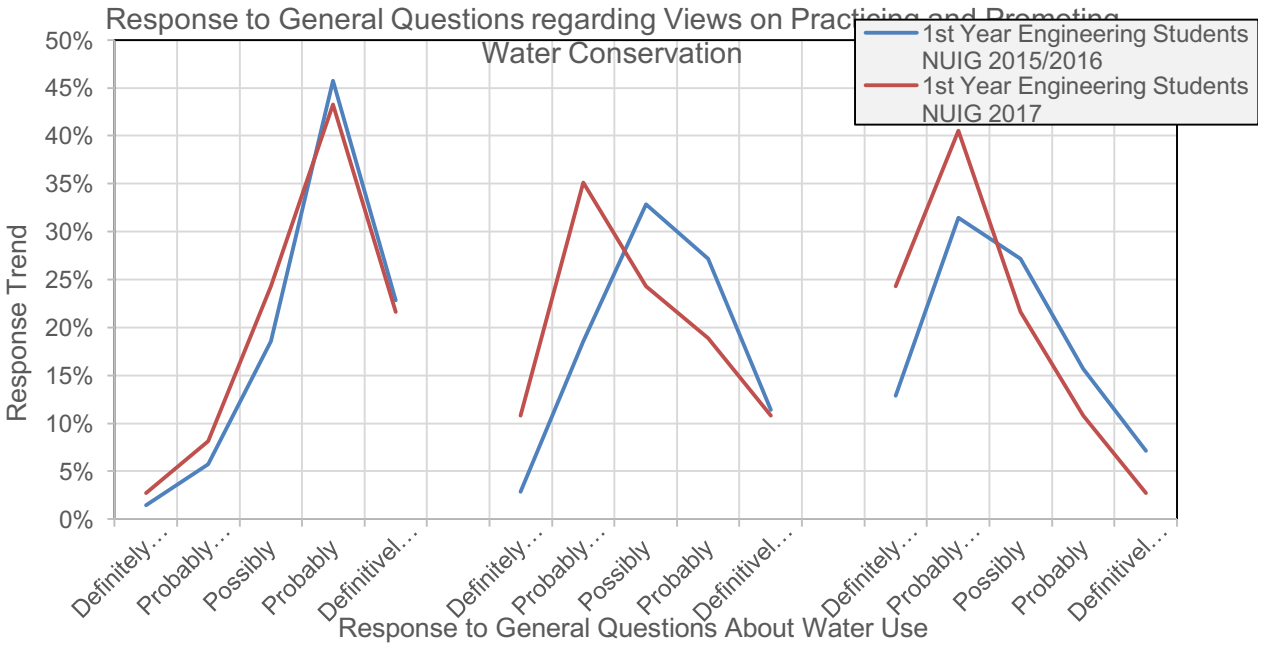



*Figure 6-27 Pre and Post Intervention Results of Part 4 Awareness Survey 1st Year Engineering Students NUIG*

### 6.2.2 Effectiveness of the WEMs - Objective 2: Promote Education

#### *Data Access Events*

- The interaction and login event activity to the main platform applications i.e. the NUI Galway Managers Dashboard and the NUI Galway Public Dashboard is outlined in Section 6.1.1. With activity recorded immediately post launch, this had reduced in the intervening period. As described and listed below measures are being introduced to encourage user engagement with the applications for the remainder of the control period. Managers Dashboard Monthly Newsletter;
- Staggered release of application Features;
- NUI Galway Student Newsletter;
- Quotation Competition;
- Short-term Internship for App Development.

As described in Section 6.1.1 above, the Google analytics results were reviewed for the period of the pilot control to assess the impact of the efforts and initiatives, however no significant positive increase in activity was identifiable immediately after the release of Managers Dashboards Newsletters on 22nd August 2016, 26th September 2016 and 15th December 2016 or following other initiatives to encourage use of the public dashboard. The usage Figures are presented in Section 6.1.1 above in WEM 2.

#### *New Projects*

To-date, the Waternomics project has been a key driver in the development of a number of new research projects at NUI Galway, listed following;

- Automating and refining (displacement) water meter data capture through optical character recognition – Undergraduate Final Year Project 2016 Dept. Electrical and Electronic Engineering, NUI Galway;
- Automating and refining (displacement) water meter data capture using simple ancillary electromagnetic pulse unit - Undergraduate Intern Project 2016 Dept. Electrical and Electronic Engineering, NUI Galway;
- Refining analogue meter data capture and validation from optical character recognition – Undergraduate Final Year Project 2017 Dept. Electrical and Electronic Engineering, NUI Galway;
- Examination of the Effects of various residence times of potable water in a pressurized building water network – Research Project, Department of Civil and Environmental Engineering, NUI Galway April 2017.

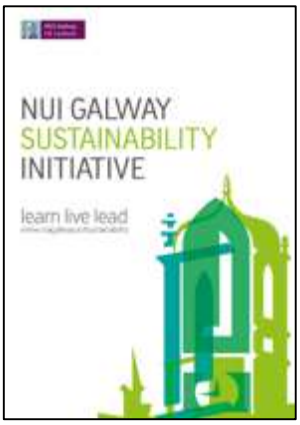



*Figure 6-28 NUI Galway Sustainability Initiative Brochure*

***Waternomics and NUIG Sustainability Initiative***

In addition, the Waternomics Project is well aligned with a new sustainability initiative launched at NUI Galway in June 2016 http://www.NUIGalway.ie/sustainability/. The Initiative is leading with a project to reduce the consumption of bottled water on campus by promoting the use of existing campus water fountains and discussions have been held by the Waternomics NUIG Team and a representative of the Initiative regarding the common message that '*the Water is Our Taps is Good Enough to Drink*.' The Waternomics water retention observer application is an effective resource to point to in the monitoring of water quality at the pilot site. In addition, the sensors installed by the Waternomics Project can provide the Sustainability Initiative with water usage metrics to assess the effectiveness of the campaign.

As part of the Sustainability Initiative (Figure 6-28), the NUI Galway Pilot Site is taking part in the Campus Battle of the Buildings which aims to make students, academics and staff more aware of the energy use of campus buildings and to encourage energy-efficient behaviour through collegial competition. The experience and innovations of the Waternomics Project serves as a perfect precursor to the Initiative and will likely be an excellent resource to inform its progress. In addition, the public dashboard display at the Engineering Building will in the future display energy use in addition to water use at the building.

***Waternomics and Galway City Council Green Leaf 2017***

Waternomics is collaborating with Galway City Council to help it transform to a Smart City [19]. The City Council was the 2017 European Green Leaf Recipient http://ec.europa.eu/environment/europeangreencapital/europeangreenleaf/, and Waternomics has been invited to participate in the relaunch of the City's Water Conservation Initiative 'Slow the Flow', which will likely take place in May 2017.

### 6.2.3 Effectiveness of the WEMs - Objective 3: Reduce Consumption

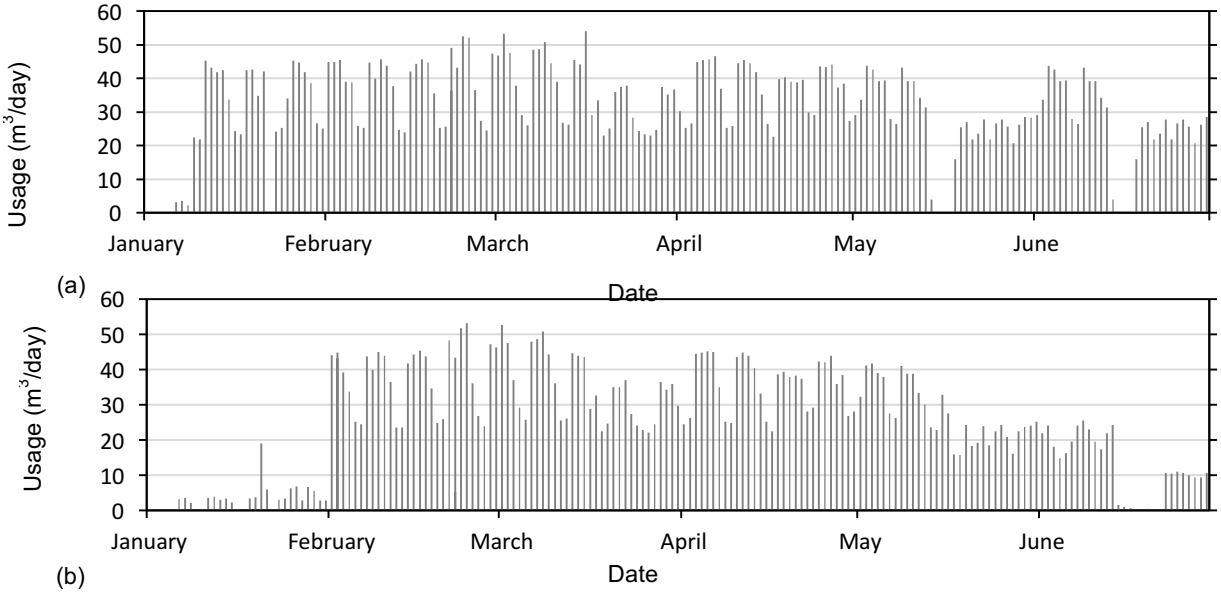
A detailed analysis of water usage patterns at the NUI Galway Engineering Building was undertaken for the period January 2016 – June 2016. This data allows the Waternomics Team to establish pre-intervention water usage patterns and baseline characteristics by which to later establish reductions in consumption and potential changes in water use behaviours as a result of WEMs.

The analysis was performed on medium-resolution meter data [15] obtained from the buildings 11 mechanical meters (at a 7.5 minute sampling rate) and on high-resolution data gathered from 7 ultrasonic flow meters (at a 1 second sampling rate). A total of 105.3 million data readings were gathered during this period. The variations in data resolution permitted an in depth evaluation of the water usage activity across a range of temporal domains i.e. from days to seconds.

A medium-resolution daily flow trace for the mains water supply and its primary uses in the NUI Galway Pilot Site is provided in Figure 6-29 (a - e) for the period of January 2016 to June 2016. From this it was possible to obtain an initial outline of the buildings main water usage characteristics together with the end-uses that contribute to the usage.

Within the mains water usage flow trace, it was found that there was a non-normal distribution of data suggesting that water usage was clustered. The water usage clusters were found to attribute to calendared water usage patterns. These include 'normal weekdays' (Monday-Thursday) (grey), 'Fridays' (red) and 'Weekends' (black) as outlined in Figure 6-30Figure 6-30 Cluster analysis applied to the mains water flow trace. Grey is normal usage, red is Friday usage and black is weekend usage.

Through statistical analysis of each cluster, the daily water usage baselines were established for each as outlined in Table 6-3 which will be used to benchmark any changes in consumption post-intervention. Figure 6-31 presents normality tests (quantile-quantile and histograms) for each of the clusters. As shown in each Q-Q plot, there is a linear relationship between the flowrate and the theoretical quantities depicting that the data is normally distributed about its average value. Similarly, with the exception of the Friday cluster, each histogram presents a typical Gaussian distribution about the average water usage. It was concluded that the small sample size for the Friday cluster resulted in a poor Gaussian representation of the data in the histogram.



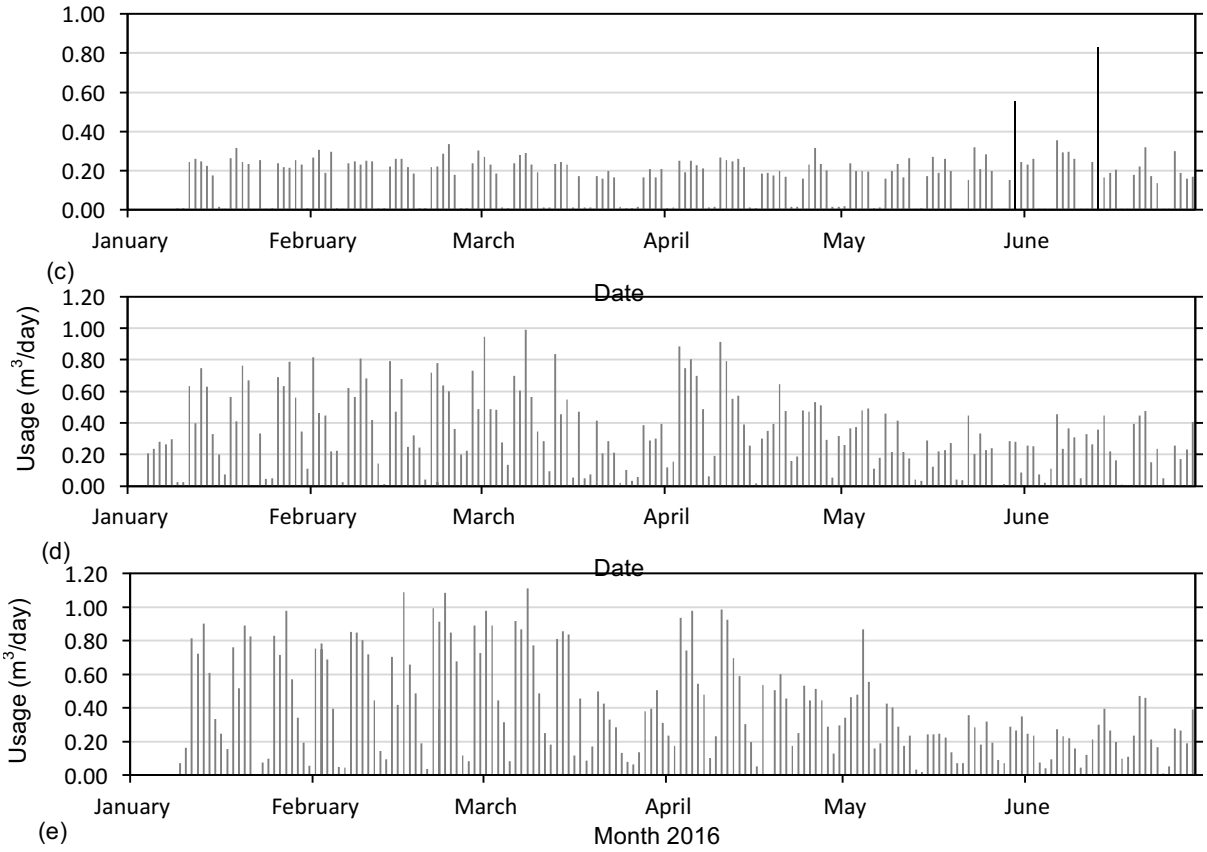



*Figure 6-29 Flow traces for individual meters at the NUI Galway during the monitoring: period (a) mains water supply, (b) cold water supply, (c) canteen, (d) female showers and (e) male showers.*

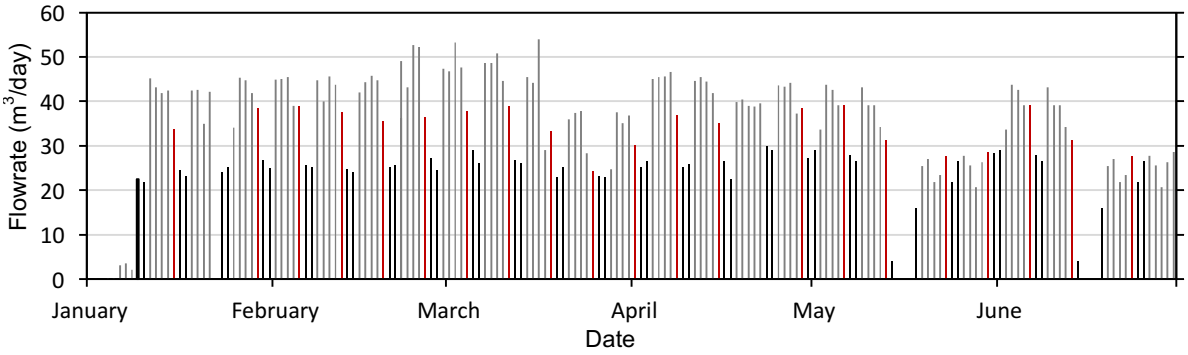



*Figure 6-30 Cluster analysis applied to the mains water flow trace. Grey is normal usage, red is Friday usage and black is weekend usage.*

*Table 6-3 Normal Usage Clusters Pre-intervention*

| Cluster No | Description | Water Usage ($m^3$/day) | Standard Deviation ($m^3$/day) |
|---|---|---|---|
| 1 | Monday - Thursday | 43.29 | 4.74 |
| 2 | Friday | 36.76 | 2.40 |
| 3 | Weekends | 25.50 | 1.99 |

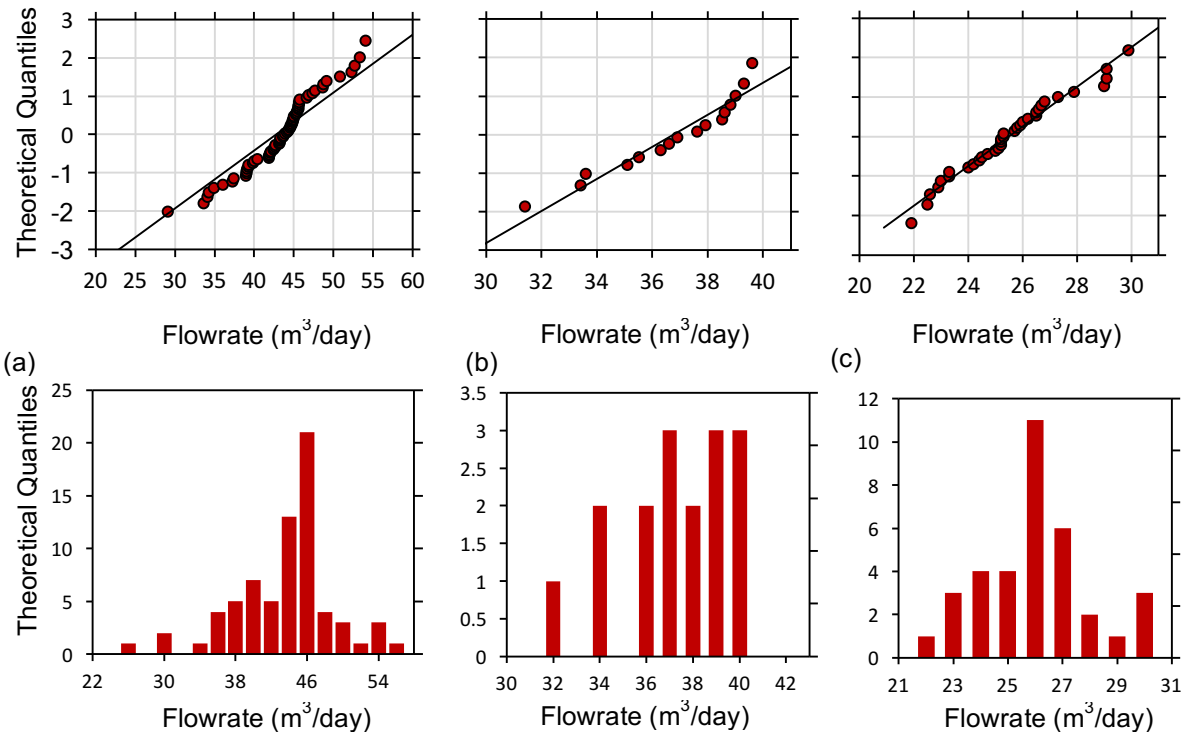



*Figure 6-31 Cluster analysis applied to the mains water flow trace for (a) normal weekdays, (b) Fridays and (c) weekends.*

The mains water usage was further disaggregated into diurnal (daily) usage patterns to identify diurnal flow signatures and peak water usage characteristics [16]. Examples of the time averaged diurnal flow signatures for the engineering building total water usage are presented in Figure 6-32, Figure 6-33, and Figure 6-34 for normal "week day", "Friday" and "weekend" clusters respectively.

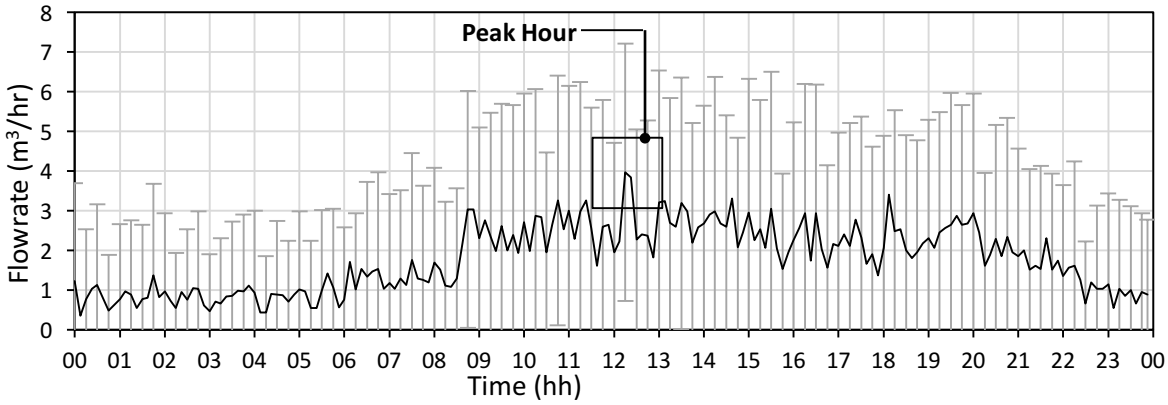



*Figure 6-32 Diurnal flow signature for a normal weekday.*

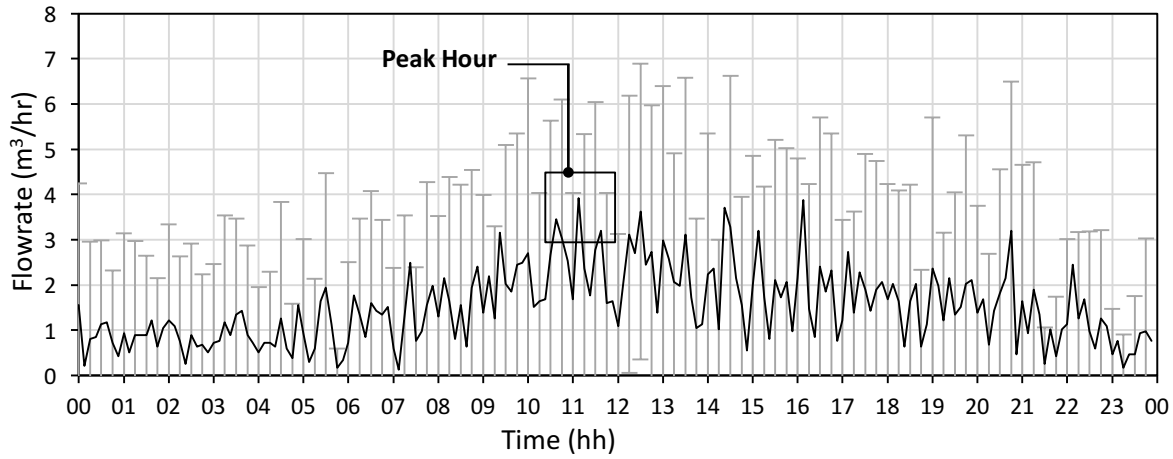



*Figure 6-33 Diurnal flow signature for a Friday.*

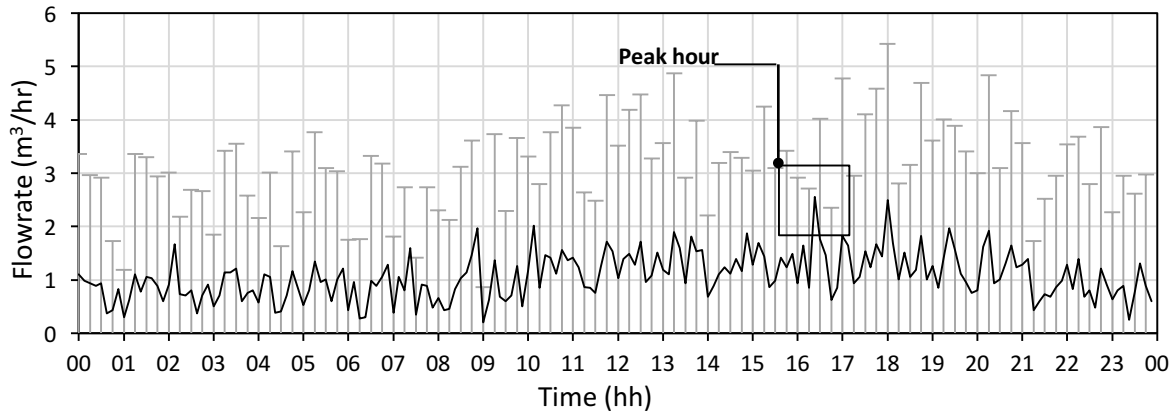



*Figure 6-34 Diurnal flow signature for a weekend.*

It is evident from Figure 6-32, Figure 6-33, and Figure 6-34 that significant water usage caused by urinal flushing throughout the building underpinned each diurnal flow trace. For example,

Figure *6-35* outlines a single day (29th March 2016) flow trace where mains water usage in the night hours (i.e. unoccupied hours) has been utilised by the cold water system in topping up the rain water header tanks for system scheduled flushing purposes. Further investigation revealed that the flushing flows would be on average 0.85 $m^3$/hr throughout the day (total of 20.4 $m^3$) and accounts for up to 80 % of all water usage at the building. The issue of excessive flushing was further exacerbated by a malfunction in the rainwater harvesting system at the pilot site which meant that harvested rainwater was not being used for toilet and urinal flushing but main water from the municipal supply.

The rainwater harvesting system at the NUIG pilot site operates by collecting rainwater from a 4,000 sqm roof catchment and transferring this to a 75 $m^3$ underground storage tank. This large storage tank supplies two 9 $m^3$ header tanks from which water is used to flush toilets and urinals. When there is insufficient supply in the underground storage tank water is instead fed from the mains supplied cold water storage system in the building to 'top-up' the shortfall in the rainwater header tanks.

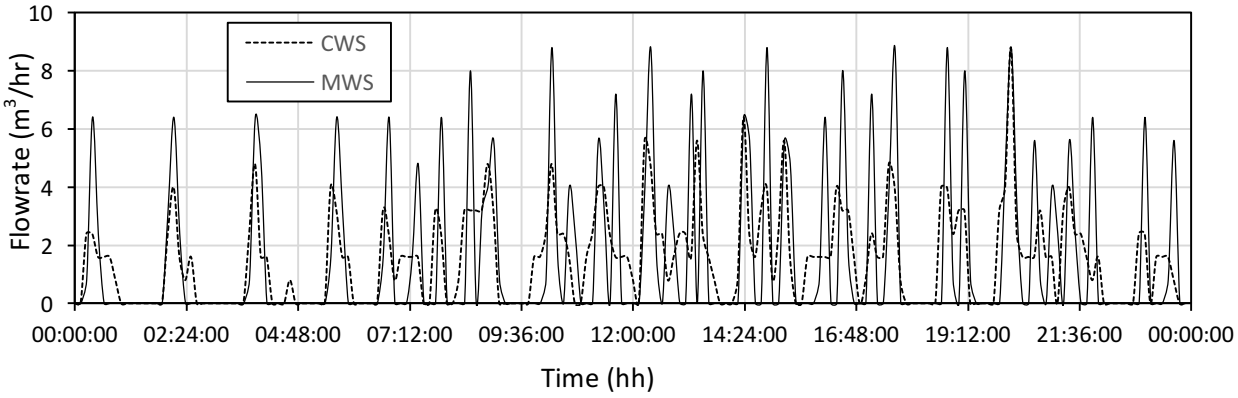



*Figure 6-35 Comparison of mains water usage to cold water usage in the engineering building.*

In addition to the principal water use in the NUIG Pilot site that of toilet and urinal flushing, water from the cold water supply is also used by the domestic hot water system, showers, hand washing taps and laboratory water usage. In order to determine the share of such uses, the high-resolution flow trace data (from ultrasonic meters) was used to numerate various water usage activities.

Figure *6-35* provides an example of a high resolution flow trace capturing a range of water usage events occurring simultaneously. From this it was possible to identify high resolution water usage signatures for detailed end-usage activity such as shower events.

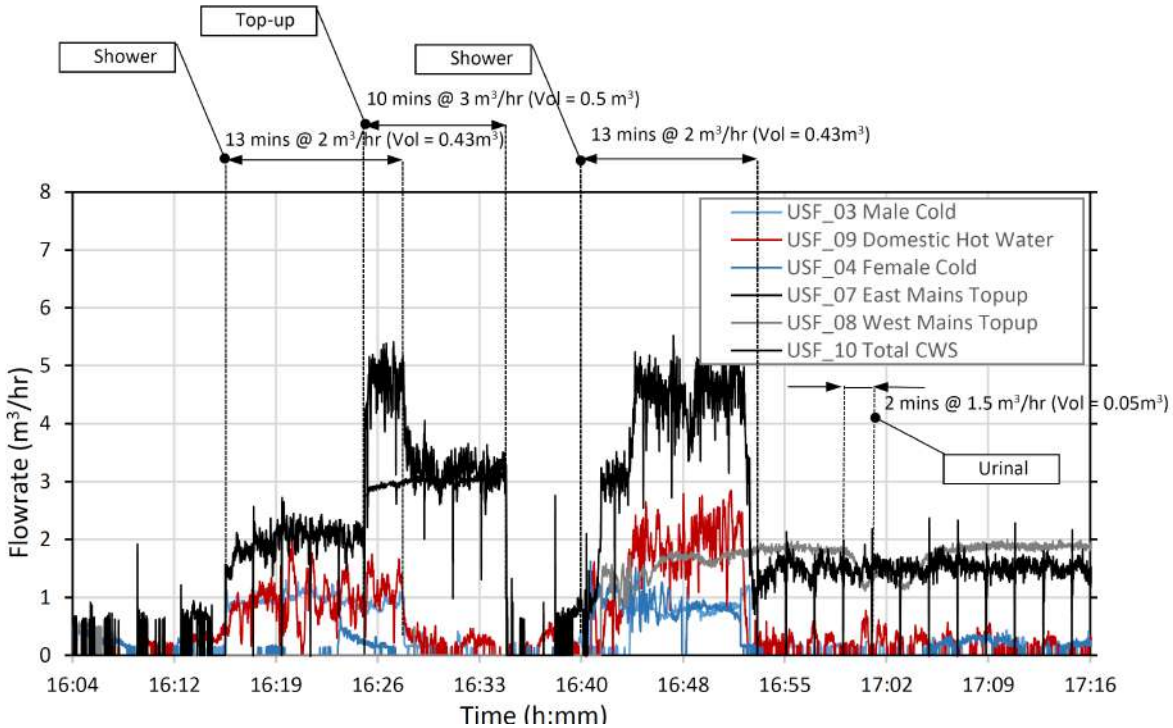



*Figure 6-36* Example of an aggregated and disaggregated high resolution flow trace over an approximate 1 hour period.

In November 2017, the rainwater harvesting system at the site was fixed following many months of malfunction. The Waternomics Team at NUIG notified the Buildings Office regarding the fault once it had first been identified and funds were allocated by the Office for repair and replacement works. Figure 6-36 below shows the record of daily volumes by month provided from the underground storage tank to the rainwater header tanks (the values are averaged per day for all days for each month). The volumes provided by the harvested rainwater are very low. An analysis of monthly rainfall as provided by the

meteorological service of Ireland (http://www.met.ie/climate/monthly-data.asp?Num=1875) from the Athenry weather station indicates that monthly rainfall figures for November and December 2016 are very low relative to other years (see *Table 6-4*) and that given the demand for water for flushing at the pilot site is at a minimum > 20m$^3$ per day, the 4,000 sqm rainwater harvesting catchment cannot supply the required demand. This rainfall information is also accessible from the Managers Dashboard Platform Application.

*Table 6-4 Monthly values for Athenry Weather Station, Galway (Total rainfall in millimetres)*

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 47.4 | 87.5 | | | | | | | | | | |
| 2016 | 145.2 | 129.8 | 79.4 | 49.2 | 56.7 | 98.5 | 85.1 | 96.3 | 138.0 | 58.4 | 59.1 | 78.5 |
| 2015 | 191.1 | 68.7 | 129.9 | 74.8 | 138.0 | 44.9 | 138.2 | 114.6 | 93.3 | 66.6 | 216.3 | 299.4 |
| 2014 | 182.5 | 177.7 | 103.1 | 47.6 | 103.1 | 38.6 | 92.4 | 104.9 | 10.4 | 140.9 | 139.0 | 124.1 |

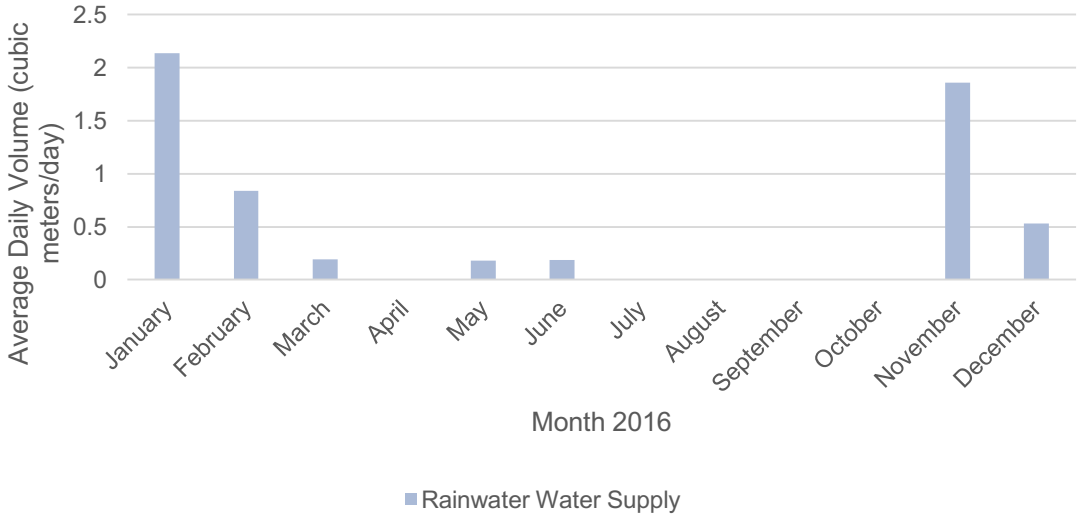



*Figure 6-37 Rainwater Water Supply from U/G Storage Tank to Header Tanks*

Figure 6-38 shows the relative supply of rainwater to the NUIG Pilot Site and that of mains water over the year 2016 (the values are averaged per day for all days for each month).

The post intervention and pre intervention mains water usage at the Engineering Building is given in the cluster analysis shown in Figure 6-39 below and the post intervention usage results are tabulated in Table 6-5 following. The results indicate an overall increase in average daily water usage at the Engineering Building of between 15 and 40% approximately. These comparative average mains water usage pre and post intervention results are shown graphically in Figure 6-40. The cause of the increase is attributed to a secondary fault within the rainwater harvesting system that had been fixed by manual override of an automatic valve.

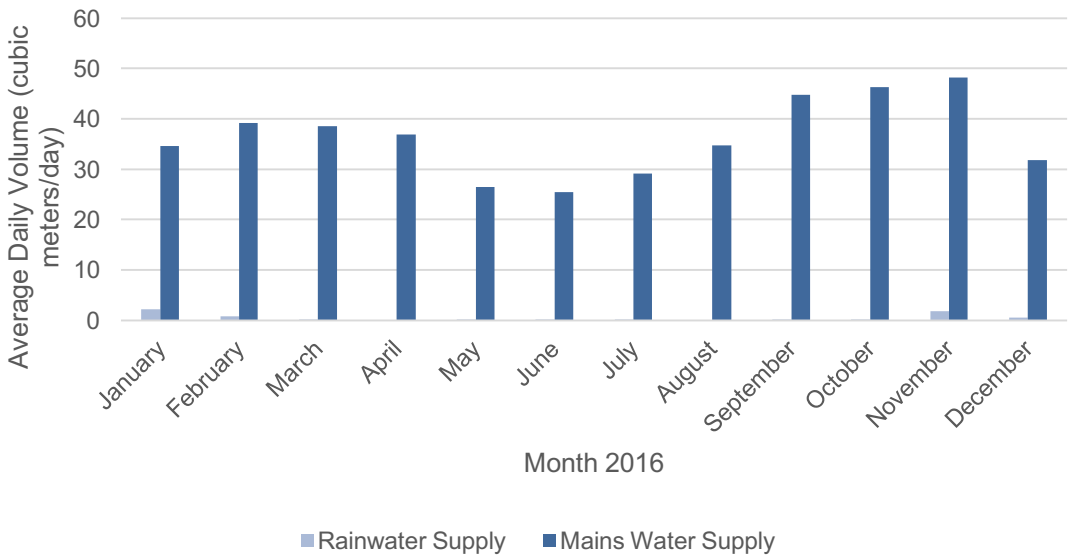



*Figure 6-38 Comparative Rainwater Water Supply from U/G Storage Tank to Header Tanks and total Mains Water Usage at Pilot*

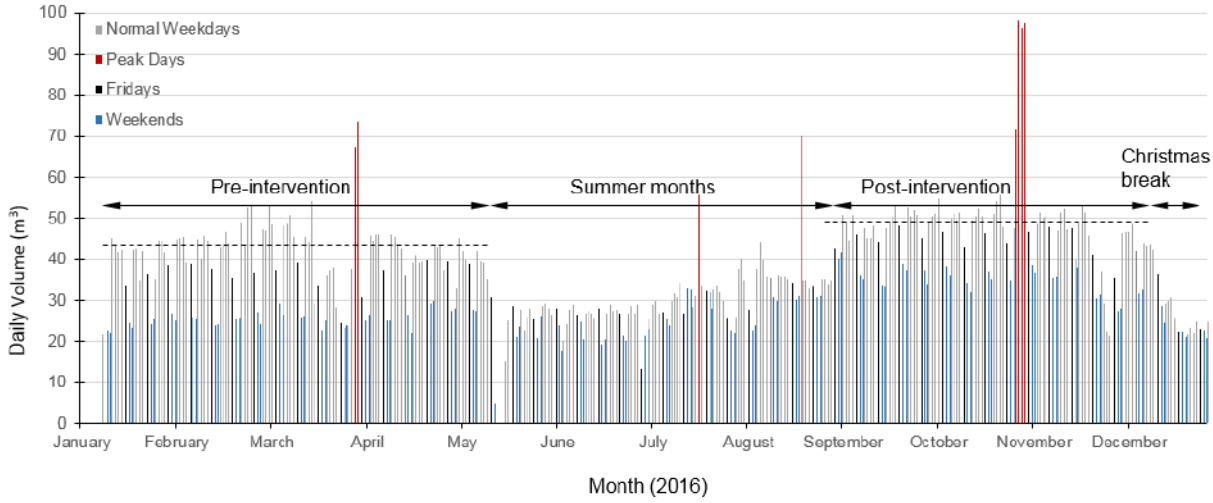



*Figure 6-39 Cluster analysis applied to the mains water flow trace*

*Table 6-5 Post-Intervention Daily Mains Water Usage*

| Cluster No | Description | Average Daily Mains Water Usage (July-December) ($m^3$/day) | Standard Deviation ($m^3$/day) |
|---|---|---|---|
| **1** | Mon - Thurs | 50.08 | 2.48 |
| **2** | Friday | 44.59 | 3.35 |
| **3** | Weekends | 36.48 | 3.55 |

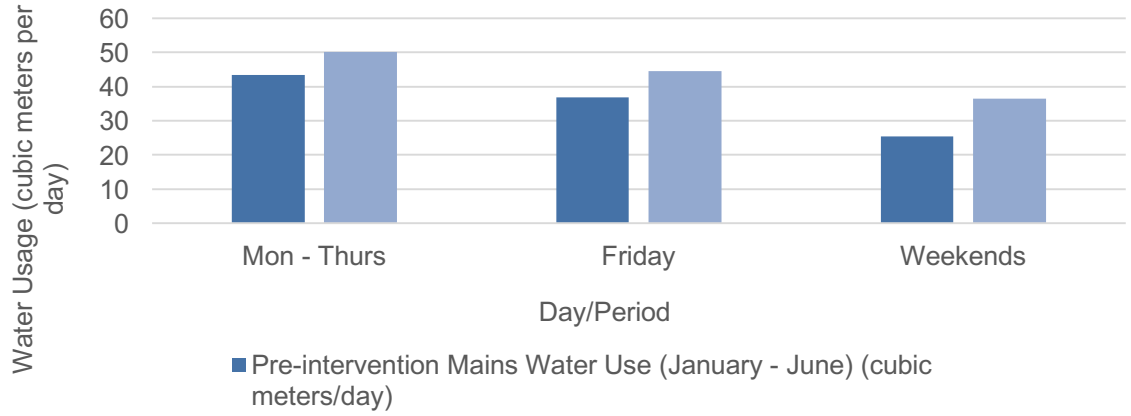



*Figure 6-40 Pre and Post Intervention Average Daily Mains Water Usage NUIG Pilot*

From a shower flow signature survey performed on the pre intervention (i.e. January-June 2016), it was found that approximately 18 shower events occur in the building each day utilising an average of 200 litres of water over an average duration of 6 minutes (see Figure 6-41). Therefore, showers can account for 10 % to 14 % of total cold water usage in the building corresponding to approximately 8-10 % of buildings total water usage which highlights good opportunities for user controlled water conservation.

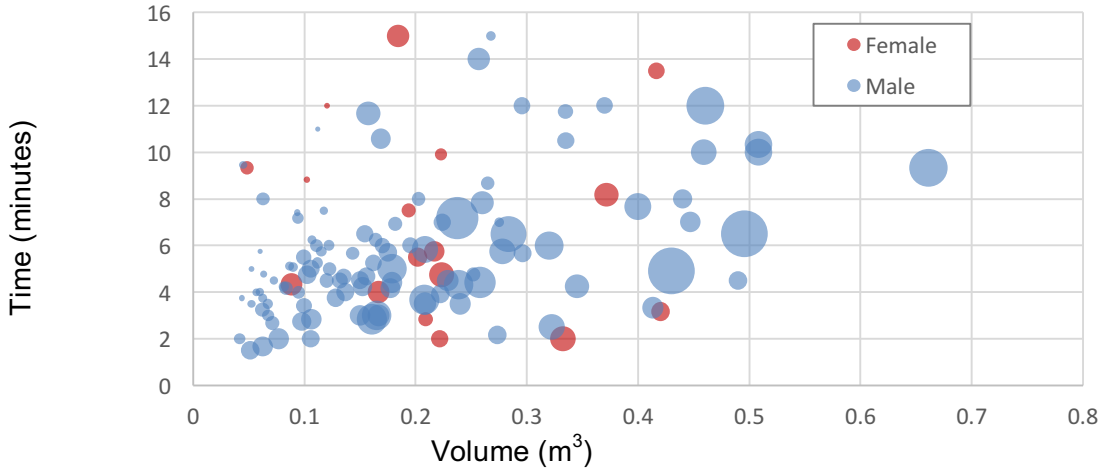



Figure 6-41 *Cluster diagram summarising the shower statistics in NUIG pilot determined from a sample size n=152 through shower flow signatures. The bubble size indicates the rate of water usage.*

In general, domestic hot water (DHW) usage at the NUIG pilot site is considered to be the best indicator of shower usage and activity. A pre and post intervention analysis of the available DHW meter data was carried out. The results are given in *Figure 6-42* and indicate that there is a reduction in DHW usage at the pilot site from the pre-intervention monitoring to the post-intervention period. In total, pre-intervention data was available for 5 weeks in term time in 2016 and this is compared with thirteen weeks of data recorded during the post-intervention period during September, October and November 2016.

The data displayed was recorded by USF meter USF_09 and as described in D4.2 and D4.3, a number of issues were highlighted regarding the data integrity provided by these metres. In particular, high levels of 'noise' were recorded causing readings to be higher, however, the general trends represented by the data from these meters were validated in testing also reported in D4.3.

Daily averaged DHW Usage pre and post intervention is also given in *Table 6-6* and *Table 6-7* indicating a reduction in DHW use by between 22% and 48%.

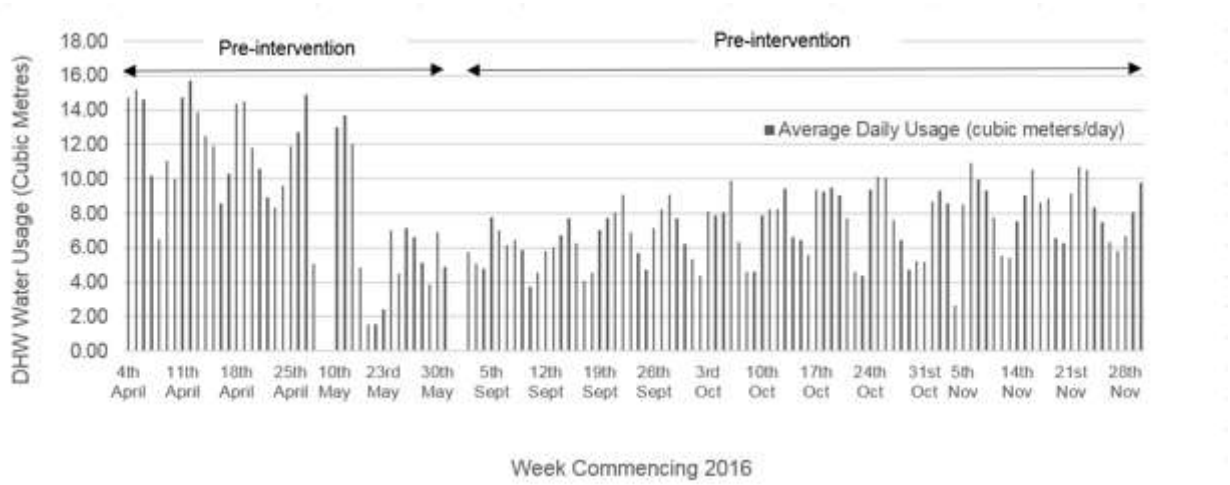



*Figure 6-42 Daily Domestic Hot Water Usage at the NUIG Pilot Site Pre and Post Intervention*

*Table 6-6 Pre -Intervention DHW Usage*

| Description | Average Daily DHW (April-May) ($m^3$/day) | Standard Deviation ($m^3$/day) |
|---|---|---|
| Mon - Thurs | 12.95 | 1.15 |
| Friday | 8.03 | 3.09 |
| Weekends | 9.63 | 0.80 |

*Table 6-7 Post -Intervention DHW Usage*

| Description | Average Daily Mains Water Usage (Sep-Nov) ($m^3$/day) | Standard Deviation ($m^3$/day) |
|---|---|---|
| Mon - Thurs | 8.10 | 0.98 |
| Friday | 6.23 | 0.97 |
| Weekends | 5.03 | 0.74 |

### 6.2.4 Effectiveness of the WEMs Objective 4: Improve Operation

Since the wide scale launch of the public dashboard and interactive kiosk, daily water usage data for the NUIG Engineering Building is displayed to all building users and visitors in a very prominent location. Variations to expected usage values immediately provoke commentary from occupants. Four weeks after the launch of the public dashboard, the usage value display increased from its expected daily value of 42$m^3$ (approx.) per day to over 50$m^3$ (approx.) per day. This immediately raised a concern and the Building Manager notified the Buildings Office who traced back to a valve in the RWH top-up system (this is described above in 6.2.3). The fault remains due to budgetary constraints; however, its timely identification and diagnosis is considered a success of the Waternomics Interventions.

The high volume water usage at the Engineering Building is of significant concern to the Waternomics Team and the Building Manager and details of both the significance of this and the likely economic impact have been notified to the Buildings Office. As a result of the water use monitoring and comparative analysis carried by the Waternomics Project, this issue is currently under investigation by the Buildings Office to find a suitable resolution.

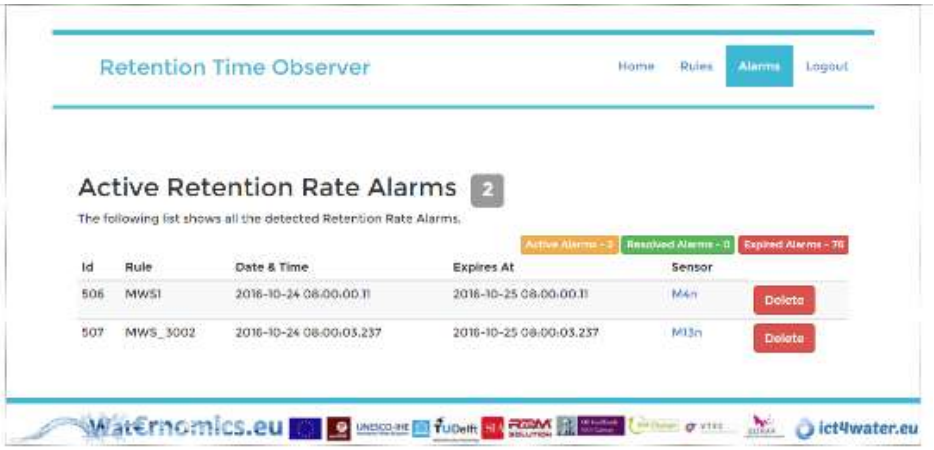



*Figure 6-43 Retention Time Observer App NUI Galway – Alarm History*

To-date (March 2017), a total of 216 alarms have been raised by the Water Retention Observer. These alarms include simple direction for resolutions and are generally actioned by the Building Manager. The level of alarms being raised is an issue and discussion regarding an automation of the recommended resolution is under consideration. The monitoring and timely identification of the Retention of potable water in the NUI Galway System is considered a success of the Waternomics Interventions.

### 6.2.5 Conclusions

The pre-intervention surveys indicate that the sample populations exhibit a moderately high level of water awareness with overall average pre-intervention scores of 3.55/5.0 recorded for those based in the Engineering Building and 3.41/5.0 recorded for those in the control group. Differences in pre and post intervention awareness surveys were found to be statistically not significant. Given the high level of pro-environmental/water awareness recorded in this socio demographic group, it is perhaps unsurprising that positive impacts of the implemented measures proved difficult to capture by the post intervention surveys…

The Waternomics Project has been successful in promoting education regarding water usage and the project aims. The achievements to date in terms of new project work are included in 6.2.2 with more fundamental educational activities undertaken listed in Section 6.1.2. Promotion of Education and Water Usage Monitoring continued throughout the Pilot Control Period and in addition to a number of new projects based on the work of Waternomics, post project initiatives as well as collaborations are on-going building on the work of Waternomics

The results of the pre-intervention and post-intervention analysis of water usage at the NUI Galway Pilot Site are detailed in Section 6.2.3. The impact of the measures introduced at the pilot on water consumption were assessed concluding that, due principally to system faults, no overall reduction in mains water usage was recorded but disappointingly an overall increase in water usage over the control period was noted. The significant impact of system controlled water usage i.e. automatic flushing of urinals and persistent faults relative to any user controlled usage is a significant finding of the project in terms of controlling water usage in public/mixed used buildings. The results of the pre and post intervention study of DHW usage, which is considered to be the best indicator of shower activity, records a significant trend towards reduced DHW use over the pilot control period (ref. Figure 6-42), however this is not reflected in the overall water usage of the building.

With timely and actionable information being provided to building managers regarding operational anomalies, unexpected occurrences and faults, the Waternomics Project has delivered a system that

provides improved operation of the building water network at the NUI Galway Pilot Site. Prioritising corrective action with Building Management when faults are notified remains an issue due to staffing and budgetary constraints. However, the water residence time observer has been a very successful system with email alerts of simple resolutions sent to the building manager to take preventative action to avoid issues with water quality due to extended potable water residence times.

Any sustained engagement of building managers in the manager's dashboard applications has been difficult to achieve, primarily due to workloads and the necessity to prioritise critical faults in the University Building stock. However, identification of the fault in the rainwater harvesting system by the Waternomics Project and its subsequent repair is considered a significant success of the project quantifiable by savings equivalent to the harvested rainwater used during the control period following the repair work. Over the pilot control period, the water volume, economic and carbon cost equivalent on this measure alone is as follows.

**Water Consumption Saving = 174m$^3$**

**Economic Cost Saving*= €365.11**

**Associated GHG Emission Saving** = 177 kg $CO_2$**

*Based on cost of water supply and treatment of €2.10 per cubic meter

http://www.galwaycity.ie/commercial-water-charges-information/

** Clarke, Alan, et al. "Quantifying the energy and carbon effects of water saving." Environment Agency, Rotterdam, UK (2009)

Following a final report on the significant findings of the Waternomics Project, an Electrical and Plumbing Contracting Company engaged by the Buildings Office are undertaking a review of the notified faults and excessive water use issues in March 2017. Remedial works are planned to take place in April 2017. It is expected that the water usage at NUIG Pilot will be reduced significantly by these measures.

With system, controlled water usage accounting for the most significant proportion of water usage, behaviour changes by staff and students may be entirely masked as evidenced by the DHW usage. It was determined from pre-intervention water usage analysis that 50-70 % of the total cold water usage in the building is due to faults connected with the urinal flushing and rainwater harvesting system. Once this system fault has been resolved, the building will immediately achieve significant water usage savings of over 50% (metered data indicates that weekend usage is over 70% of weekday usage when occupancy in the building is nominal and therefore water usage should be minimal). Comparatively, changes in user water behaviour and increased water awareness may introduce water usage efficiency and conservation but these will be far less dramatic e.g. the pre-intervention analysis has determined that showers account for up to 8 % of the buildings total water usage, but even a significant change in users' shower lengths will fail to make even a fraction of the impact that could result from system improvements.

Based on existing usage the annual water consumption in the NUIG Pilot site during the 36 week in term period is estimated at **11,443.32 m$^3$** and during the 16 week non-term period as **4,734.56 m$^3$.**

A conservative estimate of the potential 50% saving would result in the following per annum:

**Water Consumption Saving = 8,088.94 m$^3$**

**Economic Cost Saving = €16,986.77**

**Associated GHG Emission Saving = 8,250.72 kg $CO_2$**

# 7 The Pilot Report - Coláiste na Coiribe

The measures implemented to meet the Pilot Site Objectives are described following along with a review of the Pilot Site Objectives as defined in D5.1.

## 7.1 Meeting Pilot Site Objectives and KPIs

The Pilot Site Objectives to be achieved by implementing a Water Management Program at the Coláiste na Coiribe (CnaC) Pilot Site are fully described in Project Deliverable D5.1 – Pilot Plans. The objectives reflect both the user requirements and KPIs described in the earlier Project Deliverable D1.3 System Architecture and KPIs as well as the overall Project aims.

The Pilot Site Objectives are summarised in Figure 7-1 below along with a list of the WEMs proposed to achieve the objectives.

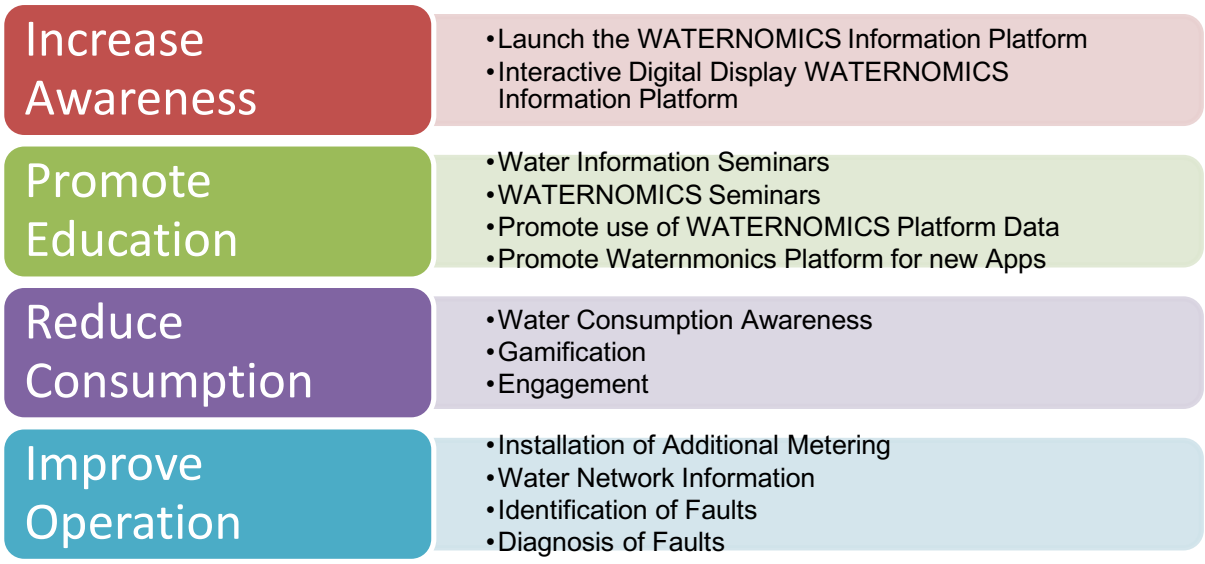



*Figure 7-1 Pilot Specific Objectives and Associated WEMs – Coláiste na Coiribe*

### 7.1.1 Objective 1: Increase Awareness

The measures as listed in Figure 7-1 above implemented at the CnaC Pilot Site to increase awareness of water usage are discussed in the following

#### *WEM 1: Launch the WATERNOMICS Platform*

**Description:** A key element of the WATERNOMICS Project was to develop a WATERNOMICS applications platform facilitating user interaction with water usage data analytics from by meter/sensors recordings from the Pilot. Following the launch of the platform in M25, the following two pilot specific applications listed below were released to the pilots in M31;

- The Coláiste na Coiribe Building Managers Dashboard
- The Coláiste na Coiribe Public Dashboard

**The Coláiste na Coiribe Building Managers Dashboard**

The managers' dashboard is a web-based application that allows building managers and administrations to monitor, analyse and assess information relating to the water infrastructure in the school. The main application that is the Managers Dashboard allows the users to view and interrogate data from the Waternomics dataspace. It hosts a number of bespoke pre-installed apps in the following main categories:

- Learn
- Monitor
- Explore

The following Monitor and Explore apps designed by the Waternomics Team for CnaC Building Management Team following, in part, initial consultation to determine user requirements for a system. Other Apps were developed in consultation with the NUI Galway Waternomics Team and reflect their knowledge of the key system aspects;

- **Biggest User Comparison:** Provides a breakdown of biggest water usage in the building.
- **Rainwater Harvesting System:** Provides the status of the rain water harvesting system by comparing water supplied from the underground rainwater storage tank to the water supplied from the mains.
- **Sensor Information:** Provides a map of the water distribution network and location of meters.
- **Custom Notification Creator:** Allows users to customise their own notifications.
- **Goal Setter:** Permits users to customise their own goals or determine when a fault has occurred.

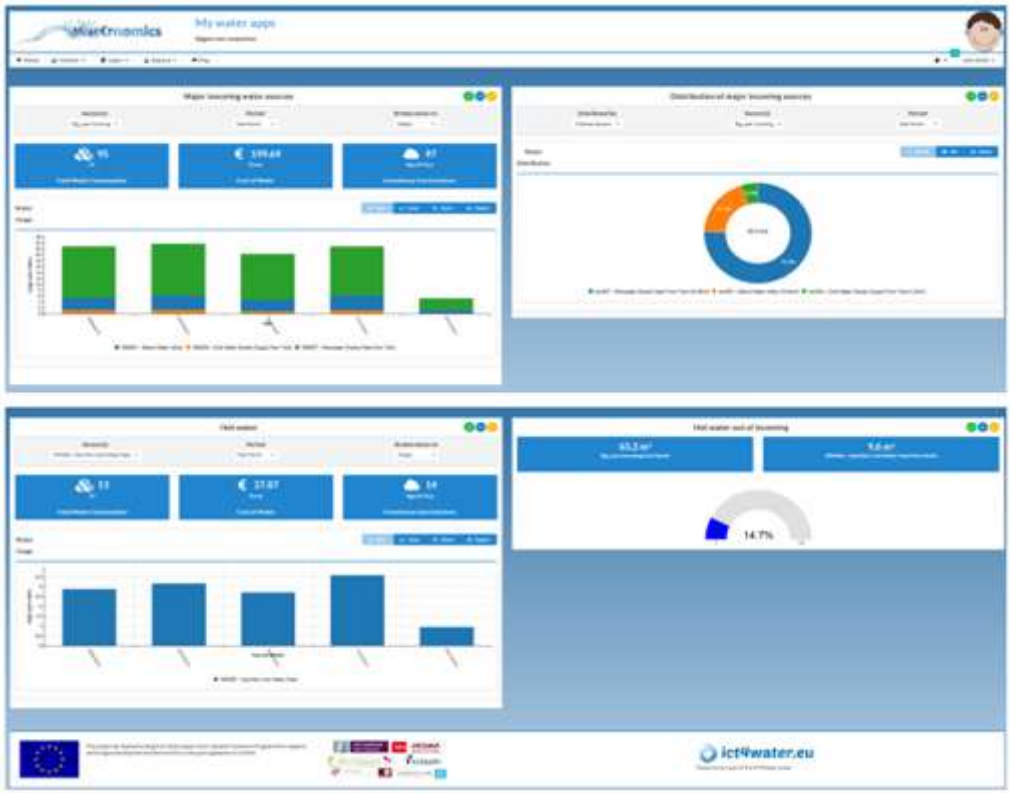


*Figure 7-2 Coláiste na Coiribe Managers Dashboard App – Biggest User Comparison*

The dashboard allows managers to create their own Apps and to edit, install or remove existing Apps. Step by step guidance on how to create and use the managers' dashboard Apps is included on the managers' dashboard in the form of Video Tutorials accessible through the learn Tab on the dashboard home screen. Examples from the Building Managers dashboard are given in Figure 7-2 and Figure 7-3 following.

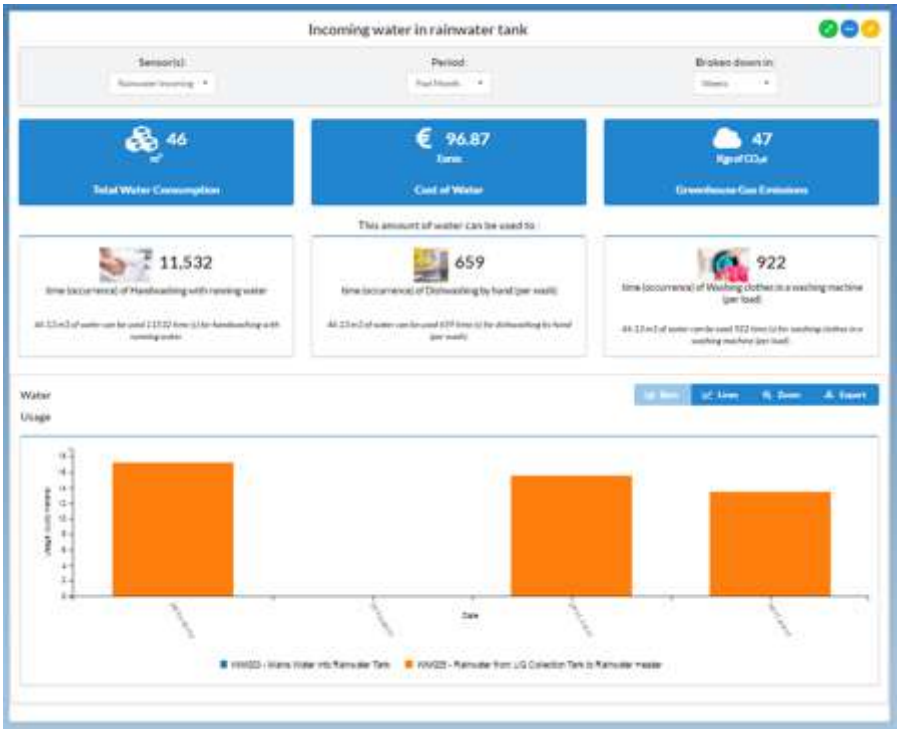



*Figure 7-3 Coláiste na Coiribe Managers Dashboard App – Rainwater Harvesting*

**The Coláiste na Coiribe Public Dashboard**

The Coláiste na Coiribe public dashboard is a web-based application to allow staff, students and visitors at the Pilot Site access to water usage information from the Waternomics Platform. The CnaC Public Dashboard application is designed to be displayed on an interactive device in a publically accessible area.

The Public Dashboard Application is accessible via a dedicated tablet device at the Pilot site. This is described in detail in WEM 2 below.

**Status**: The Waternomics Platform was launched in M25 with the specific managers' dashboard application being released to users in M31 (August 2016). In addition to the Waternomics Team, user access to the Coláiste na Coiribe Managers Dashboard was given to two members of the school staff and a demonstration account has also been setup to allow access to the application for students. A CnaC Managers Dashboard application training session took place at the pilot in M32.

**Review:** The success of the Managers Dashboard Application is directly related to logged interactions and these are monitored using Google analytics. The figures relating specifically to user activity at the CnaC Managers Dashboard are given below in Figure 7-4. The total number of logins recorded over the control period was 372. Given the low number of staff from the pilot site with access to the platform (i.e. 2) this represents substantial activity on the application.

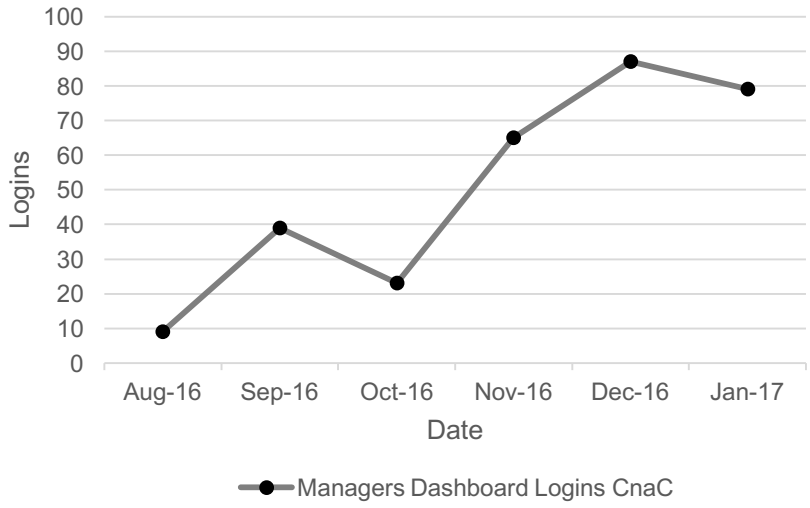



*Figure 7-4 Manager's Dashboard Logins Colaiste na Coiribe*

The Public Dashboard Interactions are discussed below as part of WEM 2.

### *WEM 2: Interactive Digital Display - WATERNOMICS Information Platform*

**Description:** An Interactive Digital Display located at the Pilot gives access to the Public Dashboard Application as described above. The public dashboard provides users with information regarding the buildings previous days' water usage. It provides end-users with quick access to the buildings water usage characteristics. The screen presents semi-disaggregated data on the buildings total water usage together with a video highlighting the importance of water conservation through the 'Water Cycle Process' as well as other features such as tips for water conservation. The public display also displays information on the project, videos, and links to social media (Twitter) and how to contact the WATERNOMICS team.
Figure 7-5 shows images of the CnaC public dashboard display.
**Status**: The Interactive Digital Display accessing the Public Dashboard was the subject of a wide-scale launch event to students in M33 at the school. Students were introduced to the public dashboard and a random sample (45 no.) were asked to give feedback in the form of questionnaires on their impression of the dashboard UI e.g.

Q1. What is your impression on the screen and its display?

Q2. Did you find the application easy to use?

Q3. Did you understand the information on the screen?

Q4. Did you like the presentations / visuals?

Q5. Will you use the application again?

The results of the questionnaire surveys were very positive, with all respondents indicating that they viewed the screen as either very or moderately interesting, 93% responding that the screen was either very easy or moderately easy to use, all respondents indicated that they understood the information on the screen. 60% of those surveyed responded that they liked the visuals on the dashboard and 27% indicated that they like some of them. 91% of students indicated that they would definitely (33%) or would be willing (58%) to engage with the platform again.

Since M24, a cylon site view screen installed at the pilot site has displayed current water usage information. The cylon site view screen is a 9 inch touch screen display that displays water usage data from the metering at the school, see Figure 7-6, Figure 7-7, and Figure 7-8, inclusive.


*Figure 7-5 Coláiste na Coiribe Public Dashboard Display*

*Figure 7-6 Cylon Site View Touchscreen Display at Coláiste na Coiribe Image 1 of 3*

*Figure 7-7 Cylon Site View Touchscreen Display at Coláiste na Coiribe Image 2 of 3*

*Figure 7-8 Cylon Site View Touchscreen Display at Coláiste na Coiribe Image 3 of 3*

**Review:** The success of this measure is directly related to interactions with the Waternomics Public Dashboard and these are monitored using Google Analytics and reviewed for the pilot control period. The success of this WEM is related to interactions with the dashboard. Figure 7-9 and *Figure 7-10* below indicate the increase in user activity on the interactive screen since at the time of its launch in M31.

The analytics indicate a peak in the number of interactions in the period coinciding with the start of the academic term. A of total of 313 interactions were logged at the screen in the period from (M31) to the

end of the control period in M36 Following the start of term, there was a fall-off in activity from the beginning of M33 to the end of the control period with an average of 45 (SD = 11) interactions per month recorded during the period (see *Figure 7-10*).

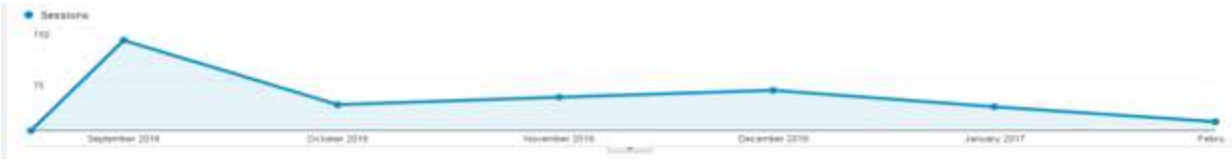


*Figure 7-9 CnaC Public Dashboard Interactions August 2016 (M31) – January 2017 (M36)*

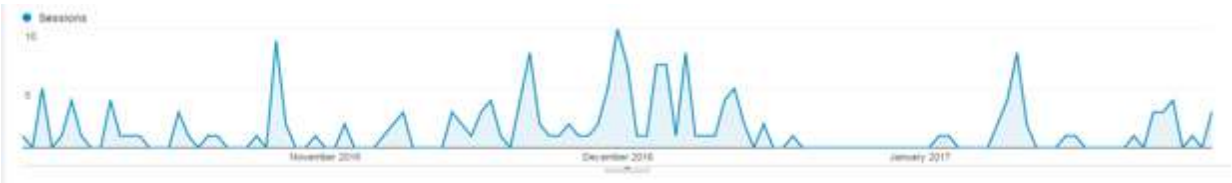


*Figure 7-10 CnaC* Galway *Public Dashboard Interactions October 2016 (M33) – January 2016 (M36)*

### 7.1.2 Objective 2: Promote Education

Many of the initiatives described in Section 7.1.1 contribute to realising this objective, however the specific measures as listed in Figure 7-1 are discussed in the following.

#### *WEM 3 & 4: WATERNOMICS Talks, Water Information Seminars and Workshops*

**Description:** A number of Workshops were carried out by the Waternomics Team with students from Coláiste na Coiribe. These events are listed below:

**M26 (March 2016):** 15 Students from Coláiste na Coiribe (aged 15-17) attended a Waternomics Event including a Water Awareness Workshop and App Development Session. This event was held at NUI Galway as part of Engineers Ireland https://www.engineersireland.ie/home.aspx Engineers Week. The Students were introduced to the concept of Water Conservation, the Waternomics Project and given hands on tutorial in app development. To reinforce the notion of effort and energy that is required, the Water Aware Workshop element involved getting the students to pump water using hand pumps from vessels representing source to end use and different stages of the treatment process; examining settlement, sedimentation and filtration.

**M26 (March 2016):** Over 100 Students from Coláiste na Coiribe (aged 12-17) attended a Waternomics Event held at the Pilot Site, see Figure 7-11 and Figure 7-12. Students were introduced to the projects key aims, the importance of water conservation and how this can be effected using ICT and smart metering and information on the metering at the pilot. Similar to that described above, the students were asked to take part in a workshop to demonstrate the effort and energy involved in the treatment and supply of mains water to homes, schools and businesses. The students also carried out a water audit on their school.

*Figure 7-11 Water Awareness Workshop at CnaC Pilot*

*Figure 7-12 App Workshop at the CnaC Pilot M27*

**M27 (April 2016):** Water Awareness Workshop for Transition Week. A number of 15-17 year old students from Coláiste na Coiribe took part in the Transition Week Water Awareness Workshops held at the school in M27. This is described in Section 6.1.2.

**M32 (September 2016):** Building Managers Dashboard Training and Public Dashboard Demonstration (see Figure 7-13). The Waternomics Team at NUI Galway together with a representative from Ultra4 gave a workshop on the use of the Building Managers Dashboard Application at the CnaC Pilot Site. The Public Dashboard Application was also demonstrated for final approval at the event.

*Figure 7-13 Managers Dashboard Training at the CnaC Pilot M32*

**M33 (October 2016):** The public dashboard launch event was held in the canteen area of the school and was attended by over 100 students. Following a recap of the project, students were invited to interact with the public dashboard and rewards were given to those who could relay a new fact etc. learned from their interaction.

**Status:** The Building Managers Dashboard Application training was held in M32 and a student based launch event for the Public Dashboard was held in M33.

**Review:** Despite positive feedback from both the managers and the public dashboard launch events held in the CnaC pilot in M32 and M33, respectively, there was no noticeable increase in interaction with the public and managers dashboards immediately following the launch events, see Figure 7-4, Figure 7-9 and Figure 7-10.

### *WEM 5 & 6: Promote use of WATERNOMICS Platform Data and Apps*

**Description:** The following initiatives have been introduced to promote the use of Waternomics Data and App Development.

The Coláiste na Coiribe Pilot Public Dashboard includes a message to invite students to use the data to carry out projects with the following text:

***Invitation Message Included on Public Dashboard (Irish Language) -*** *Má tá suim agat na sonraí seo a úsáid mar bunús do thionscnamh (don Comórtas Eolaí Óige mar shampla) labhair leis an Máistir Ó Marcacháin (seomra A305).*

***English Translation -*** *If you are interested in using this data as a basis for a new project (the Young Scientist Competition for example) contact Master Marcacháin (room A305).*

In M28, applications were invited for two student internships to work at NUI Galway as part of the Waternomics Team.

The interns were tasked with performing analysis of Waternomics Water Use data from the Coláiste na Coiribe Pilot Site. The Waternomics teams at NUI Galway hosted the two successful applicants (one from the pilot site school and one from another local post-primary school) winning interns for a week in M29 (from 5th to 10th of June 2016). The output was a research poster (Figure 7-14 ) presenting work undertaking in establishing baseline water usage at the school, the poster was translated to Irish to be displayed in the school pilot.

The student interns also took part in usability testing of the developing Public Dashboard (Figure 7-15). Discussions have been held with the schools to use the work undertaken as a basis for future science projects in particular a comparative study of water usage in a newly built school such as the Coláiste na Coirbe Pilot and a 1960s (approx.) construction where the second student intern was based.

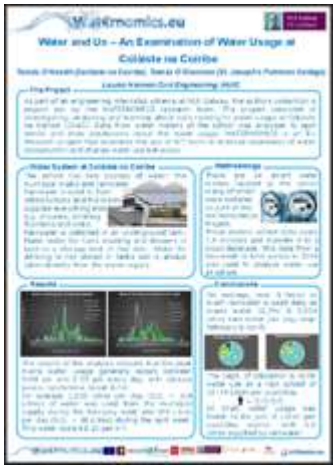


*Figure 7-14 Interns Research Poster*

*Figure 7-15 Student Interns Working with NUI Galway Waternomics Team*

**Status**: Promotion of use of the platform data and app development is underway and on-going at the pilot and a demo account to allow access for students to the Pilot Site Managers Dashboard has been created.

### 7.1.3 Objective 3: Reduce Consumption

**Review:** Although access to the water use data was allowed in class and discussed there, no new projects started at the school based on the Waternomics data. Objective 3: Reduce Consumption

Monitoring of the water consumption at Coláiste na Coiribe was maintained with little interruption for the extent of the Pilot Control Period. The analysis of this information and early conclusions is fully described in Section 7.2 along with the baseline usage and post intervention water usage.

#### *WEM 7: Water Consumption Awareness*

**Description:** Section 7.1.1 describes the measures implemented at the Pilot Site to Increase Awareness of Water Consumption. These measures are also aimed at changing water-use behaviour and reducing consumption.

In brief, the measures as described are

- Launch the WATERNOMICS Information Platform
- Interactive Digital Display – Waternomics Public Dashboard

In addition, an Irish language version of the Public Display Relevant to Water Consumption as described for the NUI Galway Pilot Site was developed for the Coláiste na Coiribe Pilot Site (see Figure 7-16 and Appendix D). The display is included on the school's 36 inch information screen at the entrance lobby.

**Status:** The display was released to the school in M33 but did not form part of an extended campaign at the pilot.

**Review:** The review of these measures is described in Section 7.1.1.


*Figure 7-16 Opening Slide of Water Awareness Display (Irish)*

#### *WEM 8: Gamification*

**Description:** The design of the public dashboard at the Coláiste na Coiribe Pilot site draws heavily on gamification in the design of its visuals. Given the age profile of the majority of students at CnaC Pilot Site is 12-18 years, an element of gamification in some of the engagement activities is appropriate. In addition to the overall visual design of the Public Dashboard, the interactive nature of the display device is an example of how gamification has been employed. The active screen of the public dashboard display adopts simple effective graphics red or green depending on whether an average water use baseline has been exceeded or not.

**Status**: Methods of gamifying water usage have been subject to a wide-scale release to the students in M33.

**Review:** The effectiveness of this WEM will be monitored by interaction events recorded by Google analytics. This is presented in Section 7.1.1 above and 7.2.1 following.

### *WEM 9: Engagement*

**Description:** The measures described in Section 7.1.1, 7.1.2 and 7.1.3 preceding represent engagement activities undertaken by the NUI Galway Waternomics Team to encourage Pilot site Occupants to participate with the innovations and interact with the installations.

**Description:** In particular, the measures listed below are designed to engage users in the project;

- Public Display Relevant Water Consumption Data
- Launch the WATERNOMICS Information Platform Applications (Public and Managers Dashboards)
- Interactive Digital Display – Public Dashboard
- Water Awareness Workshop Events
- Promote use of Waternomics Platform Data and Apps
- Gamification
- Internship Scheme

**Deadline**: The engagement measures are all underway and described in detail above.

**Review:** The review of individual measures is described in the preceding sections.

## 7.1.4 Objective 4: Improve Operation

The results of the key WEMs to **Improve Operation** at CnaC are discussed below.

### *WEM 10: Installation of Additional Metering*

**Description:** In line with the Measurement Frameworks Report D2.2, Installation of 14 mechanical water meters was completed in M20; 6 of these were as per the original building construction project and further 8 were added by Waternomics. The final meter data collection protocol has been stabilized and continues operation except for minor issues and temporary interruptions since early M24. The meter data at the site is recorded at 7.5 minute intervals and transferred to NUI Galway at the end of each day.

**Status**: The measurement of water consumption data in line with the proposed metering plan commenced in M20 and the final data collection protocol was implemented in M24. Baseline analysis of water

**Review:** Post-intervention analysis of data from metering will continued on a monthly basis for the pilot control period. The results of the review work are presented in Section 7.2. following.

### *WEM 11: Water Network Information*

**Description:** Construction issue plans of the water network regarding pipe sizing and connections were reviewed by the NUI Galway Waternomics Team during the planning stage. This review was the basis for the identified additional metering requirements for the project. A simplified and updated schematic of this information was prepared for inclusion in the Building Managers Dashboard (Figure 7-17). Data from January to June 2016 recorded by the installed metering at the Pilot Site was assessed to establish a detailed usage baseline and patterns / flow signature work at the pilot during an in-term period. The data was downloaded directly from the data collection system at the Pilot Site

The data recorded and analysed regarding the network operation is presented in detail in Section 7.2 of this report.

**Status**: Water network information in the form of schematics have been developed and included in the Managers Dashboard, baseline water data has been established for the pilot based on analysis of January 2016 – June 2016 data and additional usage data for the remaining control period is analysed and presented in Section 7.2.

**Review:** Pre intervention baseline analysis and post-intervention analysis of Water Network Information is presented in Section 7.2.1.

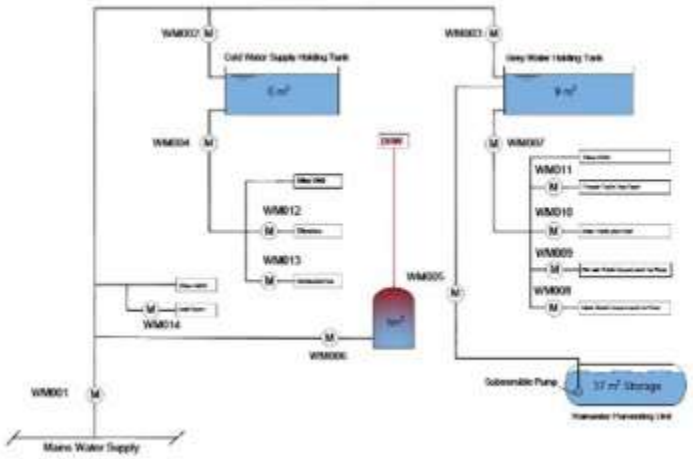



*Figure 7-17 CnaC Water Network Waternomics Schematic*

### *WEM 12 & 13: Identification and Diagnosis of Faults*

**Description:** The baseline flow values in the primary meters (mains, cold water and rainwater supply etc.) are currently being used as a method of fault detection, whereby a considerable and/or continuous increase in usage would be a likely indicator of a fault. Specific measures to aid fault detection and diagnosis in the pilot include the following:

- Unoccupied Hours Flow Monitoring – Managers Dashboard App
- Continuous flow identification – A definition for a continuous flow has been defined in a recent article under preparation compiled by the NUI Galway WATERNOMICS Team; Mulligan, S., E., Clifford and E Hannon, L..
- Equipment fault detection - a decision tree/algorithm based on a Dendogram of the water data transfer network to isolate the probable location of the fault.

**Status**: The goal setter application and un-occupied hours flow monitoring applications were launched as part of the Managers Dashboard Application in M32.

**Review:** The Managers Dashboard Application logs the expired and active alerts. The effect of this WEM is directly related to the Improve Operation Objective discussed below in Section 7.2.4. Since the buildings water monitoring service began in M24, two faults that were found to be significant leaks have been detected and diagnosed.

## 7.2 WATERNOMICS Methodology Phase 3 – Check

### *7.2.1* Effectiveness of the WEMs - Objective 1: Increased Awareness

Pre-intervention Water Awareness Surveys were completed by the following staff and students at the Pilot Site:

- 1st Year Class – 23 no. students (Age 11 -13);
- 2nd Year Classes - 80 no. students (Age 13-14);
- 5th and 6th Year Classes - 14 students (15 -18);
- 4th Year/Transition Year Class - 7 students (14-16) ;
- 7 no. teachers from the school.

The questionnaire surveys were repeated in M36 with similar classes who have been exposed to the Waternomics measures at the Pilot. The results of the pre and post intervention are discussed below.

Table 7.1 indicates the pre intervention analyses indicating that the youngest student age groups score lower than the older groups in all aspects of the water conservation awareness assessment. Similar to the findings from the initial pre-intervention surveys at NUI Galway, the overall results, particularly in the age range 14 and above have a high level of awareness of water conservation issues.

*Table 7-1 Pre-Intervention Survey Results CnaC Students*

| Aspect/Survey Question | 11-13 years old | 14-16 years old | 17-20 years old |
|---|---|---|---|
| **Problem Awareness (mean score)** | | | |
| **2** | 3.05 | 3.52 | 3.40 |
| **5** | 3.23 | 3.79 | 3.84 |
| **6** | 3.41 | 3.66 | 3.68 |
| **Mean** | **3.23** | **3.66** | **3.64** |
| **Outcome Efficacy (mean score)** | | | |
| **7** | 2.95 | 3.69 | 3.97 |
| **8** | 3.23 | 3.50 | 3.76 |
| **11** | 3.36 | 3.59 | 3.72 |
| **13** | 3.36 | 3.54 | 3.71 |
| **15** | 3.05 | 2.77 | 3.30 |
| | **3.19** | **3.42** | **3.69** |
| **Ascription of Responsibility (mean score)** | | | |
| **9** | 3.00 | 3.47 | 3.48 |
| **10** | 2.82 | 3.52 | 3.11 |
| **12** | 3.00 | 3.01 | 2.70 |
| **14** | 3.00 | 2.84 | 3.02 |
| **Mean** | **2.96** | **3.21** | **3.08** |
| **Personal Norms (mean score)** | | | |
| **1** | 3.52 | 3.47 | 3.68 |
| **3** | 3.23 | 3.52 | 3.73 |
| **4** | 2.68 | 3.01 | 2.99 |

| | | | |
|---|---|---|---|
| **Mean** | **3.14** | **3.33** | **3.47** |
| **Overall Mean** | **3.13** | **3.41** | **3.47** |

The post intervention surveys were undertaken with senior and junior cycle students in the 17-20 year (19 no.) and 14-16 year (16 no.) age ranges. Six teachers participated in the post intervention study.

*Table 7-2 Post-Intervention Survey Results CnaC Students*

| Aspect/Survey Question | 14-16 years old | 17-20 years old |
|---|---|---|
| **Problem Awareness (mean score)** | | |
| **2** | 3.88 | 3.16 |
| **5** | 3.38 | 3.79 |
| **6** | 3.81 | 3.47 |
| **Mean** | **3.69** | **3.47** |
| **Outcome Efficacy (mean score)** | | |
| **7** | 3.94 | 3.63 |
| **8** | 3.44 | 3.74 |
| **11** | 3.57 | 3.63 |
| **13** | 3.38 | 3.95 |
| **15** | 3 | 3.16 |
| | **3.42** | **3.69** |
| **Ascription of Responsibility (mean score)** | | |
| **9** | 3.13 | 3.53 |
| **10** | 3.36 | 3.16 |
| **12** | 2.71 | 2.74 |
| **14** | 3.29 | 2.79 |
| **Mean** | **3.12** | **3.14** |
| **Personal Norms (mean score)** | | |
| **1** | 3.81 | 3.74 |
| **3** | 3.81 | 3.84 |
| **4** | 3 | 3.21 |
| **Mean** | **3.54** | **3.60** |
| **Overall Mean** | **3.44** | **3.48** |

Pre-intervention and post intervention Awareness survey results are given in Figure 7-18 and Figure 7-19 below. The increase in awareness measured in the junior cycle students is statistically significant; increases in all measured aspects were identified and average % increases recorded as follows; Problem Awareness +14.24%, Outcome Efficacy +8.76%, Ascription of Responsibility +5.42% and Personal

Norms +12.74%. The changes in the Awareness aspects measured for the senior cycle students were not-significant using t-tests of unequal variance.

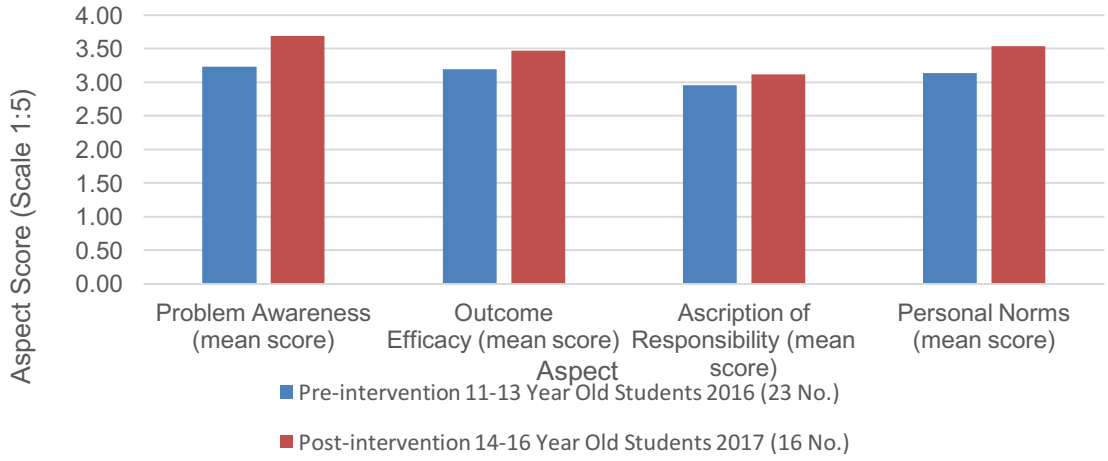



*Figure 7-18 Junior Cycle Students 2016 – 2017 Pre and Post intervention Awareness Results*

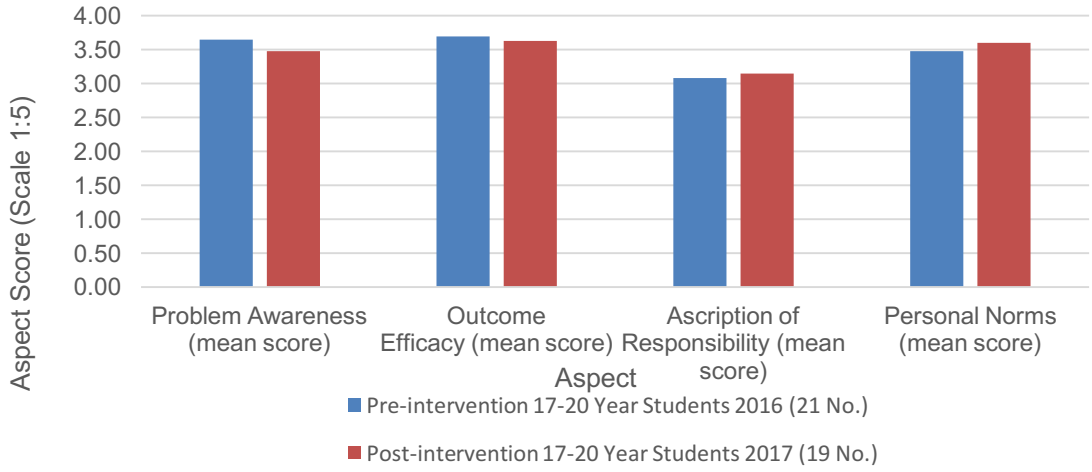



*Figure 7-19 Senior Cycle Students 2016 – 2017 Pre and Post intervention Awareness Results*

Interesting, the Awareness survey results for the 1st year NUIG students and the senior cycle CnaC students are comparable both for before and after studies where no changes of any significance are detected.

Pre-intervention and post-intervention survey results from the teacher's surveys are given below in Table 7-2 and Figure 7-20 below. The results indicate an increase in all aspects surveyed.

*Table 7-3 Pre and Post-intervention Survey results CnaC Teachers*

| Aspect/Survey Question | Pre-Intervention February 2016 | Post-Intervention February 2017 |
|---|---|---|
| **Problem Awareness (mean score)** | | |
| **2** | 3.29 | 4.17 |
| **5** | 3.29 | 4.33 |

| | | |
|---|---|---|
| **6** | 3.71 | 4.17 |
| **Mean** | **3.43** | **4.22** |
| **Outcome Efficacy (mean score)** | | |
| **7** | 3.29 | 4.67 |
| **8** | 3.57 | 4.17 |
| **11** | 3.86 | 4.17 |
| **13** | 3.86 | 4.00 |
| **15** | 3.57 | 4.20 |
| | **3.63** | **4.24** |
| **Ascription of Responsibility (mean score)** | | |
| **9** | 3.57 | 4.17 |
| **10** | 3.71 | 4.00 |
| **12** | 2.86 | 3.50 |
| **14** | 3.14 | 3.50 |
| **Mean** | **3.32** | **3.79** |
| **Personal Norms (mean score)** | | |
| 1 | 3.86 | 4.17 |
| 3 | 3.71 | 4.33 |
| 4 | 2.86 | 3.50 |
| **Mean** | **3.48** | **4.00** |
| **Overall Mean** | **3.47** | **4.06** |

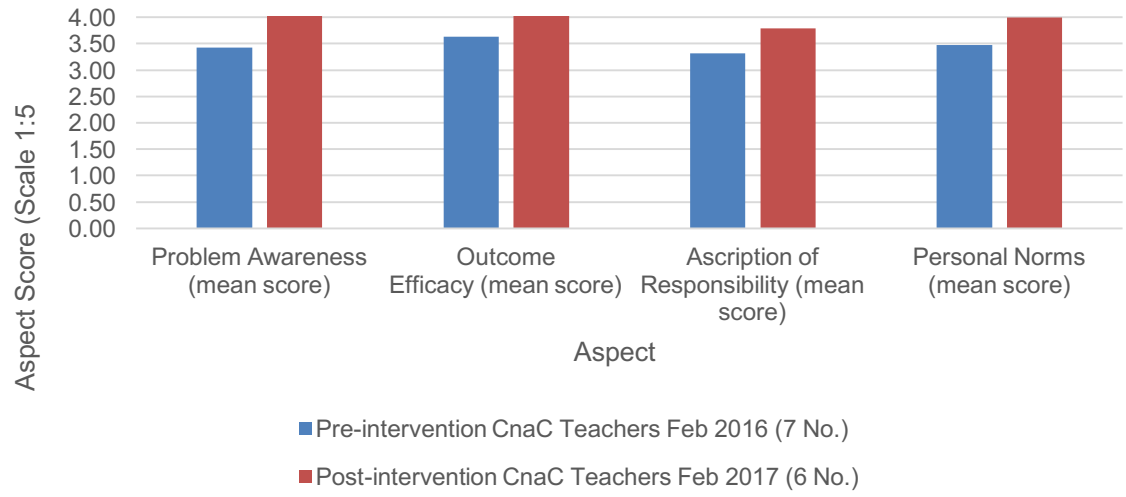



*Figure 7-20 CnaC Teachers Pre and Post intervention Awareness Survey Results*

### 7.2.2 Effectiveness of the WEMs - Objective 2: Promote Education

#### *Data Access Events*

The interaction and login event activity to the main platform applications i.e. CnaC Managers Dashboard and the Coláiste na Coiribe Public Dashboard were recorded by Google analytics and were assessed for the control period as described in 7.1.1 and 7.2.1 above. The measures listed below were introduced to encourage user engagement with the applications during the control period.

- Managers Dashboard Monthly Newsletter;
- Staggered release of application Features;
- Student access (demo-mode) to Managers Dashboard
- Promotion of projects for entry to National Science Competitions.

#### *New Projects*

The Waternomics project has facilitated the short-term Project at NUI Galway by two secondary school student interns described in Section 7.1.2. As described, discussions are underway in a comparative study for the schools where the interns are based, to examine the difference in water usage between a newly constructed school and an older construction, however this project has not been progressed at the schools to-date.

### 7.2.3 Effectiveness of the WEMs - Objective 3: Reduce Consumption

A detailed analysis of water usage patterns at Coláiste na Coiribe was made for the period January 2016 – June 2016. This data allowed the Waternomics team to establish pre-intervention water usage patterns and baselines at the pilot site by which to measure changes in water use behaviours resulting from Waternomics Innovations. The analysis was performed on medium-resolution data obtained from the buildings 14 mechanical meters (at a 7.5 minute sampling rate). A total of 419,328 data points were gathered for the building during this period.

A medium-resolution daily flow trace for the mains water supply and its primary uses at Coláiste na Coiribe is provided in Figure 7-21 for the period of January 2016 to June 2016. From this it was possible to obtain an initial outline of the buildings main water usage characteristics together with primary sources of end-use. For this period, it was found that the water usage patterns were relatively stable with the exception of two significant faults that occurred in the building and will be discussed in the following section (Objective 4 - Improving Operation).

To assess the water usage data for baselining purposes, a flow trace of the buildings total water usage was calculated by summing Total Water Usage = Rain Water Supply (WM007) + Cold Water Supply (WM004) + Calorifier Water Supply (WM006) + Potable Water Supply (WM001-WM002). Likely building faults were also excluded from the flow trace. The overall total building water usage flow trace is highlighted in Figure 7-22. Within total water usage flow trace, it was found that there was a non-normal distribution of data (Figure 7-23a) suggesting that the water usage was clustered, similar conclusions have been made in published work in this area [17]. The water usage clusters were found to attribute to calendared water usage patterns. Including ‘normal weekdays’ (Monday-Thursday) (grey) and ‘Fridays’ (black).

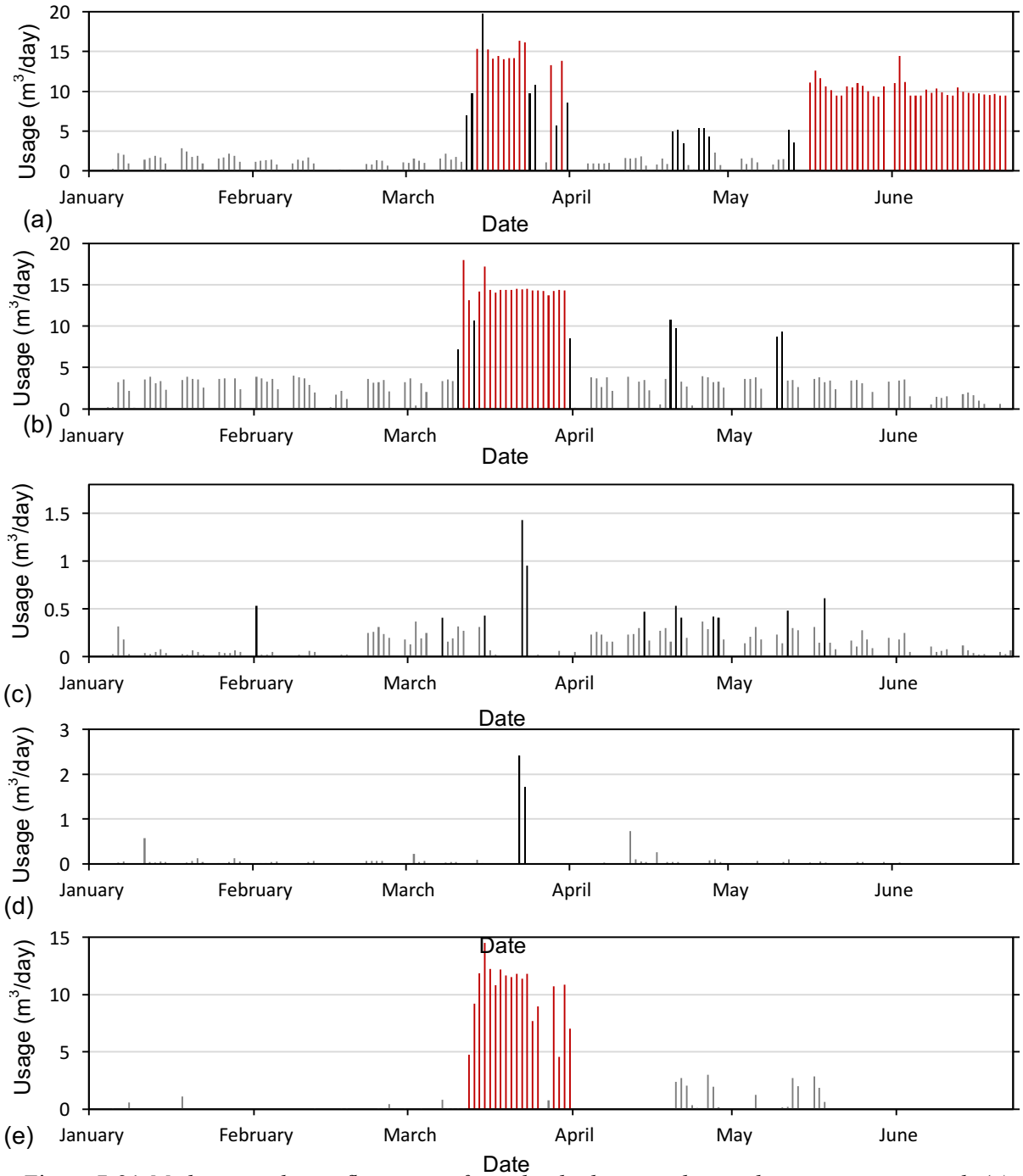



Figure 7-21 *Medium resolution flow traces for individual meters during the monitoring period: (a) mains water supply, (b) rain water supply, (c) cold water supply, (d) showers and (e) rainwater top-up.*

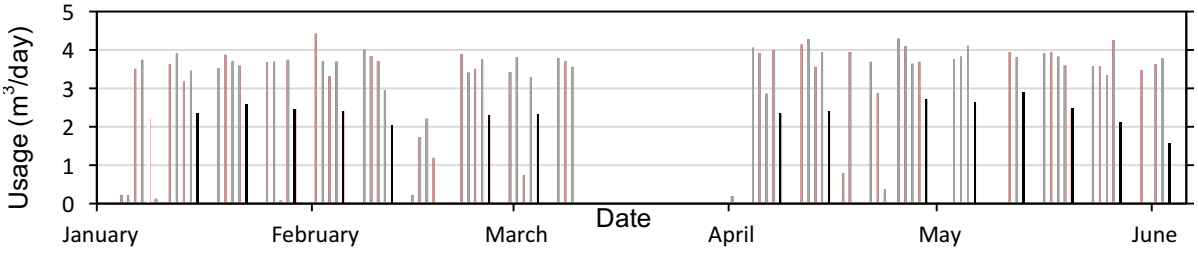



Figure 7-22 *Cluster analysis applied to the mains water flow trace. Grey is normal weekday usage and black is Friday usage.*

Through statistical analysis of each cluster, the daily water usage baselines were established for each cluster as outlined in Table 7-4 which will be used to benchmark any changes in consumption post-intervention. Figure 7-23 presents normality tests (quantile-quantile and histograms) for each of the clusters. Figure 7-23a shows a bimodal distribution of data for all weekdays indicating that the water usage was clustered during weekdays with a typical Gaussian distribution obtained when Friday was omitted from the data set (Figure 7-23b).

*Table 7-4 Water usage at CnaC (Jan 2016 –Jun 2016) Pre-intervention*

| Cluster No | Description | Total Water Usage ($m^3$/day) (Mains + Rainwater Supply) | Standard Deviation ($m^3$/day) |
|---|---|---|---|
| 1 | Monday – Thursday | 4.42 | 0.40 |
| 2 | Friday | 2.73 | 0.27 |

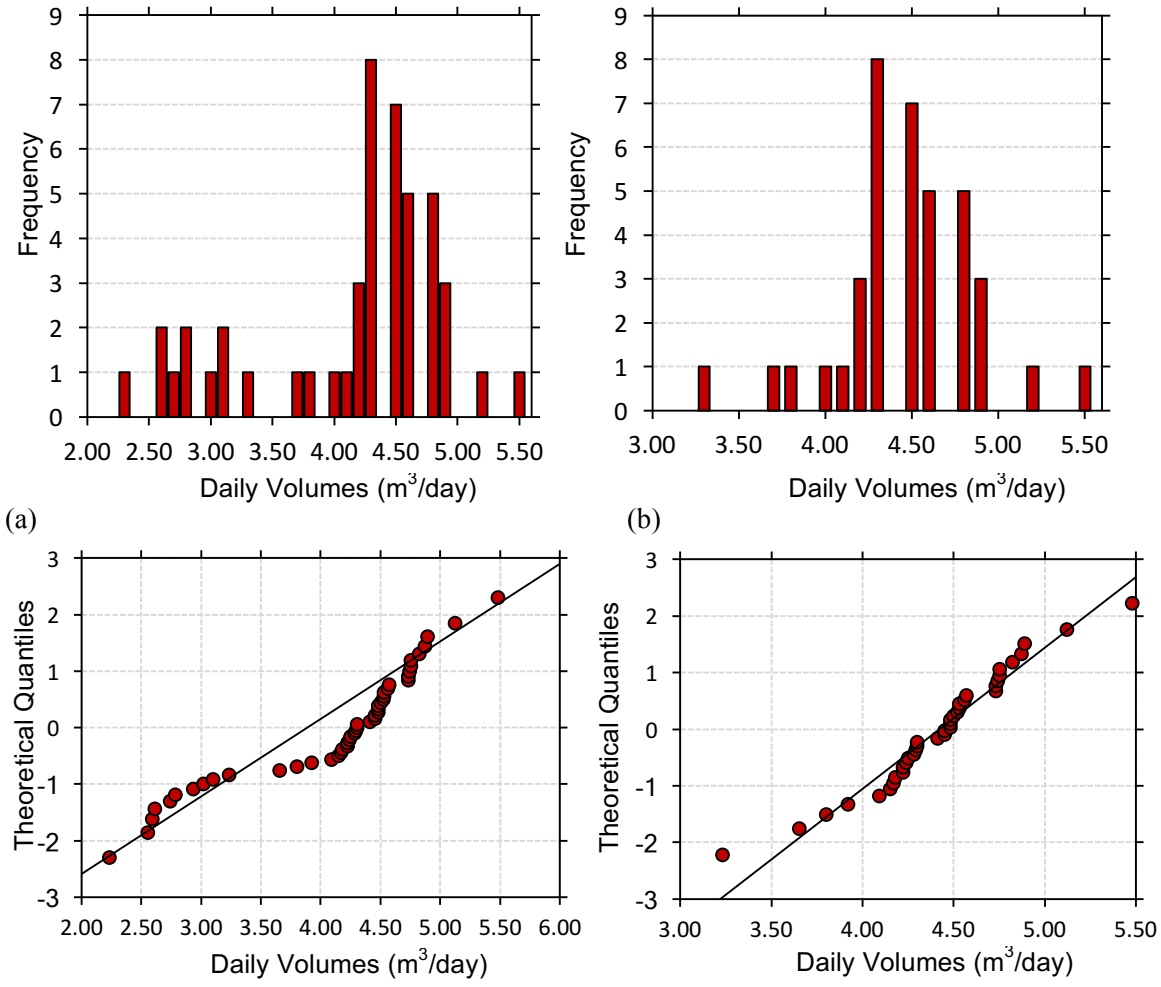



*Figure 7-23 Cluster statistics using quantile-quantile plots and histograms for (a) all days and (b) weekdays alone.*

The total water usage was time averaged over the monitoring period in order to identify diurnal flow signatures and peak water usage characteristics [16]. Examples of the time averaged diurnal flow signatures for the CnaC total water usage are presented in Figure 7-24a and Figure 7-25a

*Figure 7-25 Time averaged diurnal flow signature for the Friday cluster with (a) standard deviation and (b) end-usage disaggregation*

as for normal “week day” and “Friday” clusters with their standard deviations respectively. The total water usage diurnal signature disaggregated into its various end-uses is presented in Figure 7-24b and Figure 7-25b

*Figure 7-25 Time averaged diurnal flow signature for the Friday cluster with (a) standard deviation and (b) end-usage disaggregation*

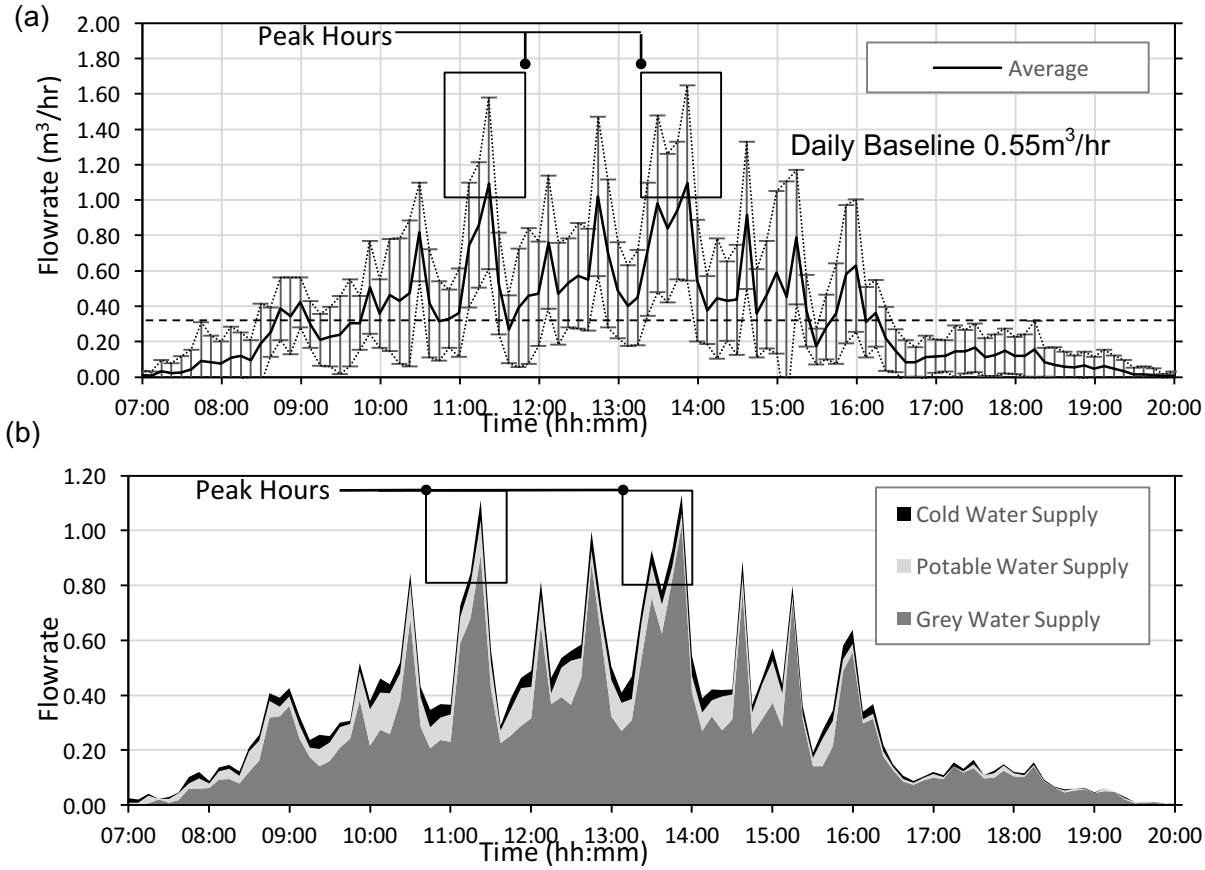



*Figure 7-24 Time averaged diurnal flow signature for the weekday cluster with (a) standard deviation and (b) end-usage disaggregation.*

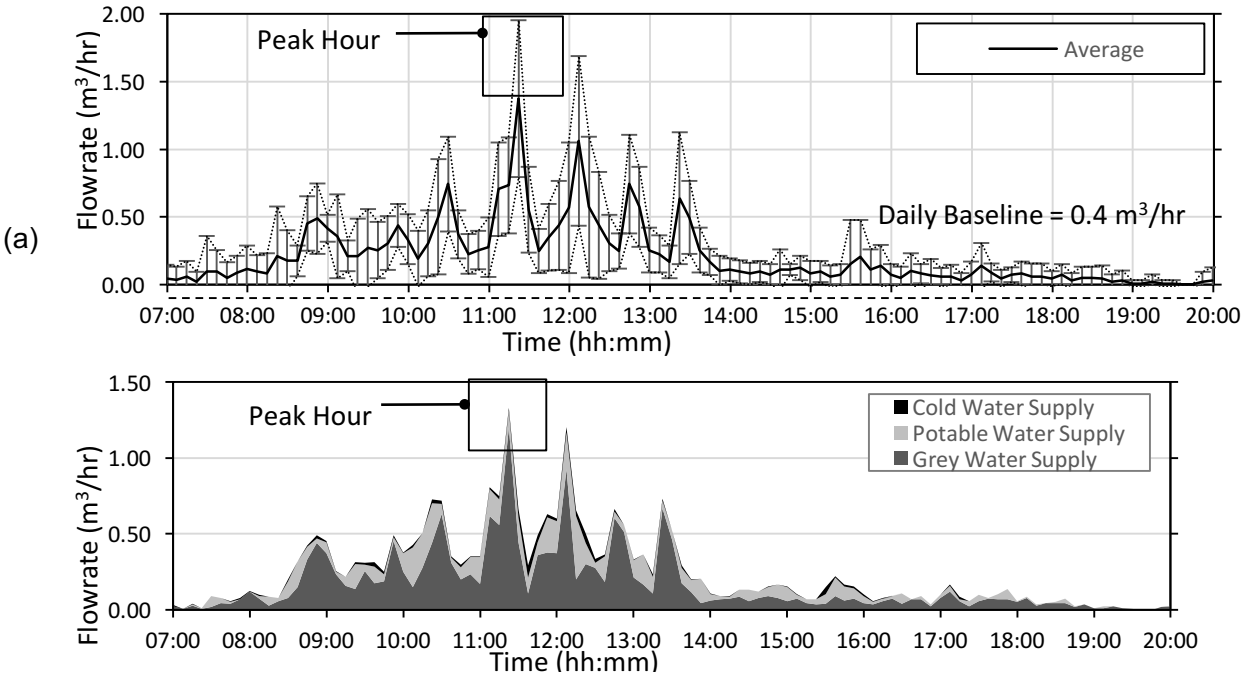



*Figure 7-25 Time averaged diurnal flow signature for the Friday cluster with (a) standard deviation and (b) end-usage disaggregation*

The diurnal flow signature explains why there is a significant difference in water usage between weekdays (Monday to Thursday) and Fridays where by the predominant flow activity appears to cease at 2.00pm on a Friday as opposed to 4.30pm on a typical weekday. The diurnal flow signature revealed periodic (recurring) activity spikes [18] reflecting intermittent activity between classes during a typical school day. Here, the peaking factor was found to be 2.5 and 3.5 for 'week day' and 'Friday' clusters respectively. The disaggregated water consumption in each cluster was used to detect the primary sources of the peak water demand and principle activity spikes as shown in Figure 7-24b and Figure 7-25b. Average rain water (grey water) usage in the building accounted for 70 % of total usage throughout all weekdays (including Friday). This can increase to 95 % during peak hours. Potable water supply and cold water supply were found to be 24% and 6% of total usage respectively. For the baselining period, zero or nominal water usage was recorded at the pilot site on non-working days/weekends.

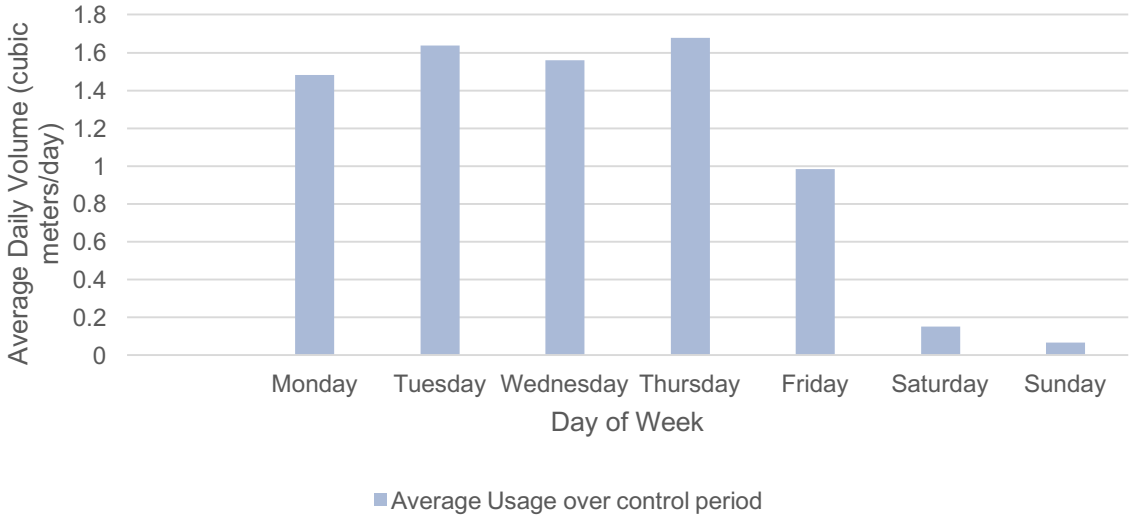



*Figure 7-26 Average Daily Mains Water Usage over Control period January 2016 – December 2016*

The post intervention average mains water and total usage by month is given in Table 7-5 below. The total water usage values given below are very similar to those in Table 7-4 in particular for the months M32, M33 and M34 indicating little change in overall water consumption over the initial months of the pilot control period.

The total water used at the CnaC pilot site during the baselining period (M24-M30) was found to equate, on average, to approximately 13 litres/student/day based on 350 pupils. In terms of the mains water, the total used is 4 litres/student/day during this period. For the post intervention period M32-M35, the total water used remained consistent with that of the baselining period, with a marginal increase in M36.

However, there is a distinct increase in the volume of mains water used at the pilot site from M35 (December 2016) to the end of the control period. The increase in mains water usage coincides with a period of lower than expected rainfall, relative to recent years, as described in Table 7-5.

*Table 7-5 Post-Intervention Water Usage Average Daily (September 2016 –January 2017)*

| Month | Description | Mains Water Usage ($m^3$/day) | Total Water Usage ($m^3$/day) |
|---|---|---|---|
| September | Monday – Thursday | 0.91 | 4.58 |
| | Friday | 0.55 | 2.97 |
| October | Monday – Thursday | 1.16 | 4.85 |
| | Friday | 0.41 | 2.7 |
| November | Monday – Thursday | 1.25 | 4.11 |
| | Friday | 0.79 | 2.79 |
| December | Monday – Thursday | 4.62 | 4.62 |
| | Friday | 3.83 | 3.83 |
| January | Monday – Thursday | 5.04 | 5.04 |
| | Friday | 3.10 | 3.10 |

Figure 7-27 shows graphically the usage of mains water at the pilot site. The increase in mains water usage is clearly shown in early December when following a period of low rainfall, mains water was used to fill a header tank of capacity 9$m^3$ that had run dry (this tank is one of two connected to rainwater harvesting system and the water from these is used to flush toilets and urinals). The school authorities were contacted regarding the increase in M35 and M36 and agreed to review operation of the rainwater harvesting system and relative rainfall.

Further investigation of the water network at the CnaC pilot site reveals that no flow has been recorded from the underground rainwater collection tanks to the header tanks for the period M34, M35 and M36 and that during much of this period, the tanks were filled with water originating from the municipal supply.

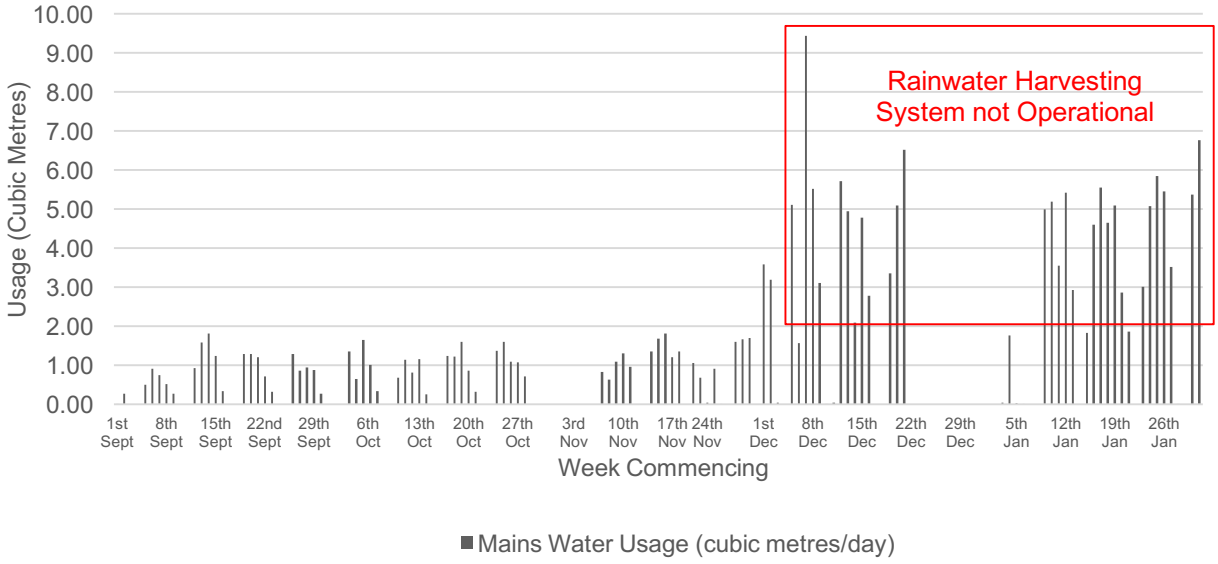



*Figure 7-27 Post-intervention Mains Water Usage*

Figure 7-28 shows the use of water from the CWS (which is fed from the MWS) to top-up the shortfall in available water for flushing of urinals and toilets due to in the rainwater harvesting header tanks. The usage clearly shows a fault in the system as rainfall was available over the pilot control period M34, M35 and M36 and this is given in

Figure *7-29* below.

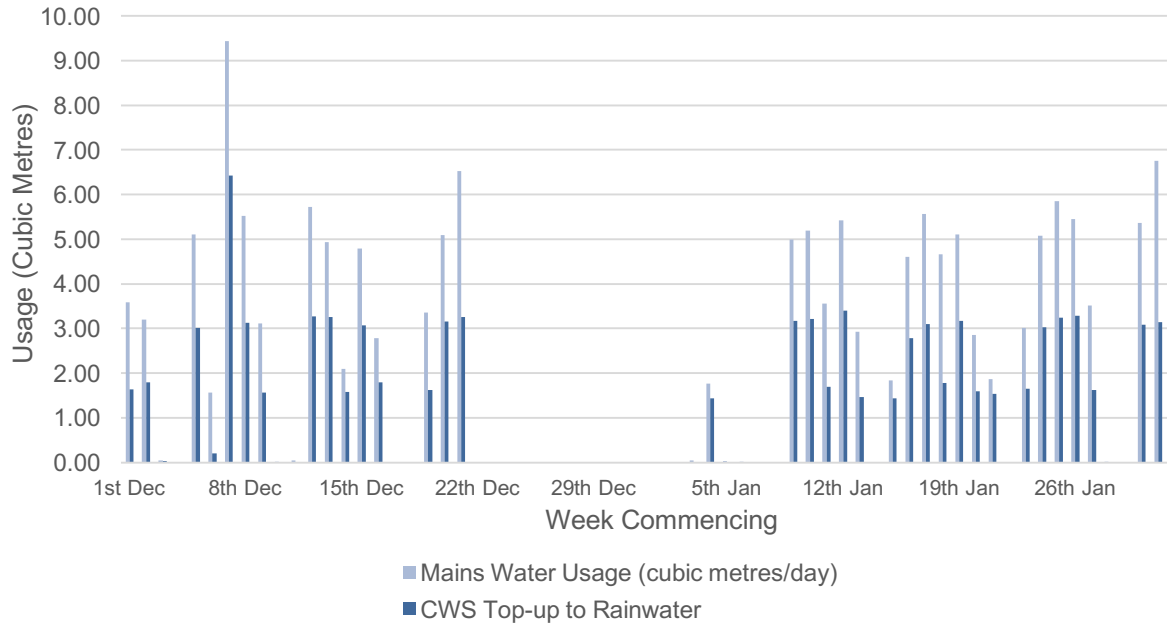



*Figure 7-28 Post-intervention Mains Water Usage and Top-up to Rainwater Harvesting System*

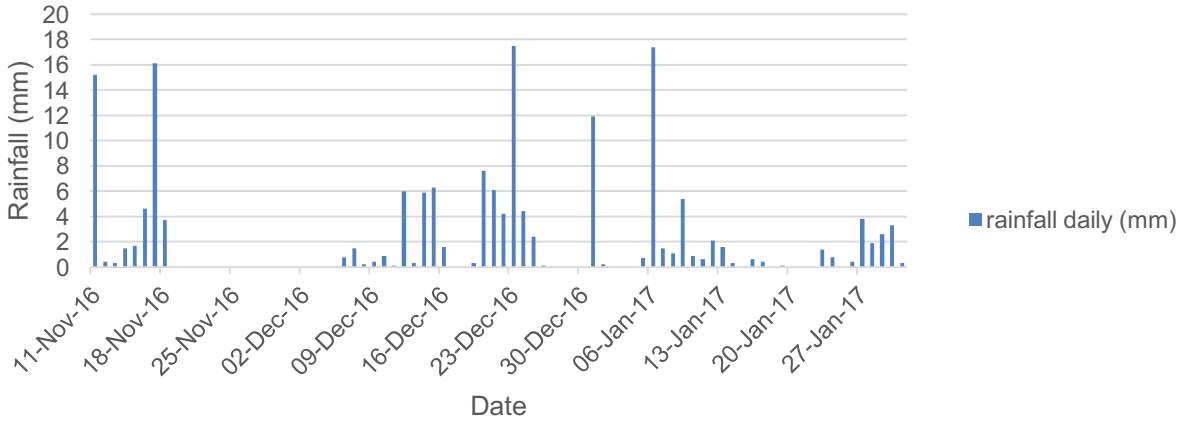



*Figure 7-29 Weekly Rainfall Galway M34 Nov, M35 Dec and M36 Jan (ref. [http://www.met.ie/climate-request/](http://www.met.ie/climate-request/))*

The Irish Department of Education and Skills Circular 0046/2008: Guide to water efficiency in schools recommends that a realistic guide for water use for new schools would be 12 – 14 litres per pupil per day, this is exclusive of shower and other usage connected with sports facilities, both the pre-intervention water end-use study and the post intervention analysis has shown that water usage at the pilot is within this range despite noted system anomalies.

### 7.2.4 Effectiveness of the WEMs - Objective 4: Improve Operation

Given that harvested rainwater generally accounts for 70-80% of all water used at the CnaC pilot and this water is used exclusively for toilet/urinal flushing, this case study effectively demonstrates the merits of using a rain water harvesting system. During the baselining period M24-M30 and the post intervention period M35 to M36, the rainwater harvesting system was fully operational and adequately met demand.

The CnaC pilot was continuously monitored during the pilot control period to improve operation and identify and diagnose faults should they occur in the building. During the pilot control period, three significant faults were observed and reported. The fault associated with the rainwater harvesting system is described above in Section 7.2.3, this was the 3rd fault chronologically that was identified.

Previous faults (Fault 1 and Fault 2) as highlighted Figure 7-30 were detected from a continuous flow signature recognisable by an exceptional constant flow in the building. These flow signature types are strongly indicative of a leak in the water infrastructure. Using the building water network dendogram together with the desegregated water meter information it was possible to isolate a region where the leak was occurring. Both faults were reported to the pilot site building management who resolved the problems on both occasions.

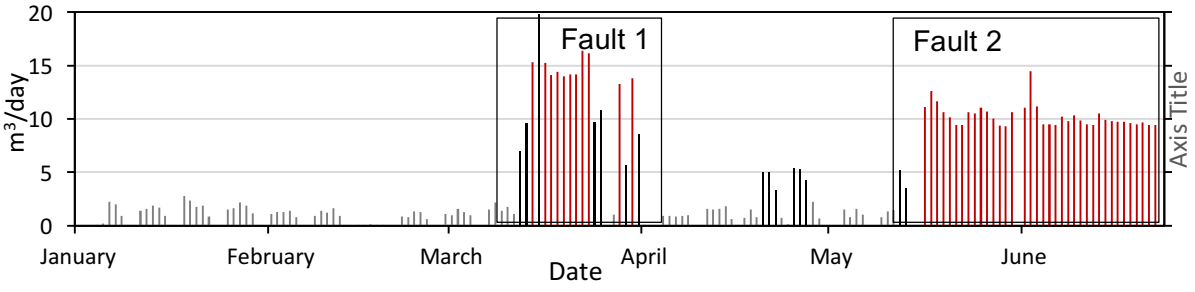



*Figure 7-30 Mains water usage highlighting two faults*

***Fault 1*** (see Figure 7-31) occurred on the 10th of March 2016. It was found that a faulty toilet cistern link was causing a continuous flow of water at approximately 0.6 $m^3$/hr. This resulted in a constant top-up of the grey water tank which occurred during a dry weather period meaning that mains water has been wasted through the leak. Upon reporting the fault was repaired on the 31st of March.

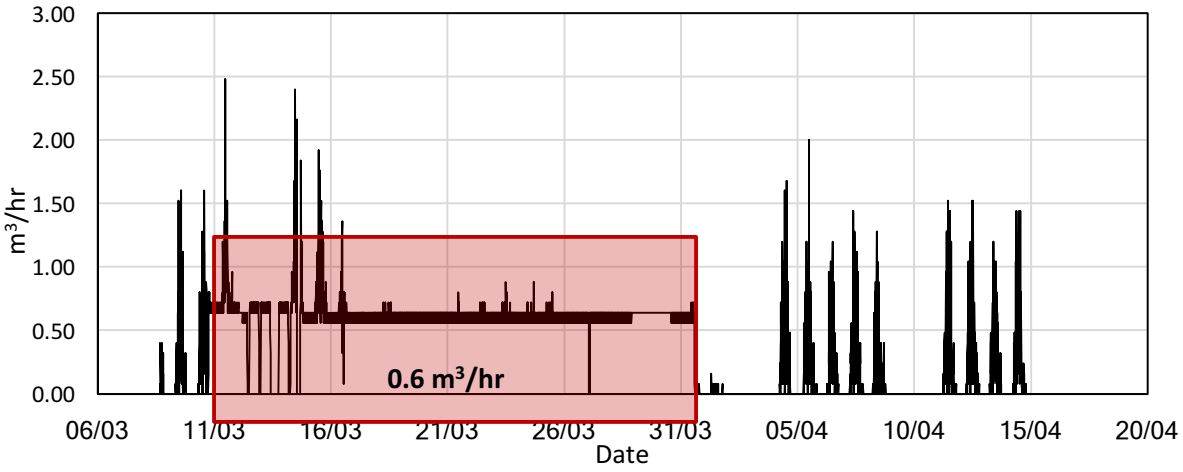



*Figure 7-31 Fault 1 (March 2016) resulting from a cistern leak*

***Fault 2*** (Figure 7-32) initiated on the 16th of May 2016 and was identified on the mains water supply on the 25th of May 2016. The fault was recognised on the WM001 meter which monitors all mains water flowing to the building. The continuous flow of 400 litres/hour (6.7 litres/minute) resulted in total daily usage of approximately 11.5 $m^3$ (almost 8 times that normally consumed by the building at 1.5 $m^3$). The location of the leak could not be isolated as the continuous flow was only apparent on the mains meter. The leak was reported to school with a suggestion to check the overall system plumbing from the mains line to the roof area. During the check, it was found that a temporary connection from the mains was taken to service the site offices during construction which was not closed properly when construction work was completed.

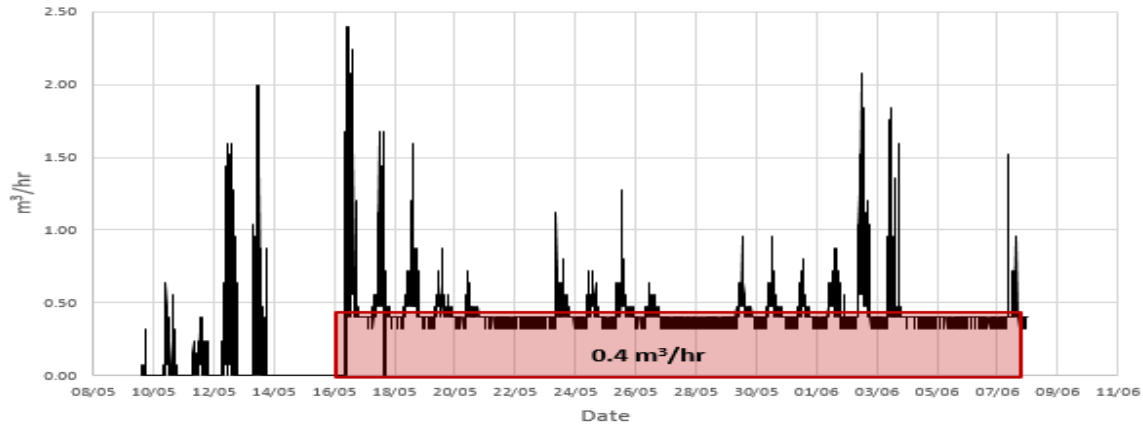



*Figure 7-32 Fault 2 (May 2016) resulting from a temporary connection from the mains left open*

### 7.2.5 Conclusions

Based on the data presented over, a number of conclusions can be made. The pre-intervention surveys carried out with students at Coláiste na Coiribe indicate that the sample populations exhibit a moderately high level of water awareness with overall average scores of pre-intervention score of 3.3/5.0 recorded for

those taking part in the surveys. When analysed by age range, a marginally lower score is determined from the younger age group of students at the pilot site (overall – 3.13/5.0 for students age 11-13). The results of post intervention surveys carried out with similar groups at the end of the control period revealed some increases in awareness among the junior cycle students ages 11-16 (9% increase) and the teachers who took part in the surveys (17% increase). No change in awareness was recorded from pre to post intervention among sample students from the senior cycle of the school i.e. 17-20 ages range. Interestingly, the results of the pre and post intervention awareness survey results were very similar (see Figure 7-33) for both the senior cycle students in the CnaC pilot and those from the 1st year Engineering students at NUIG, indicating perhaps that 1) these are a similar demographic and 2) confirming that increases in awareness are difficult to achieve in this group in particular given the high awareness baseline.

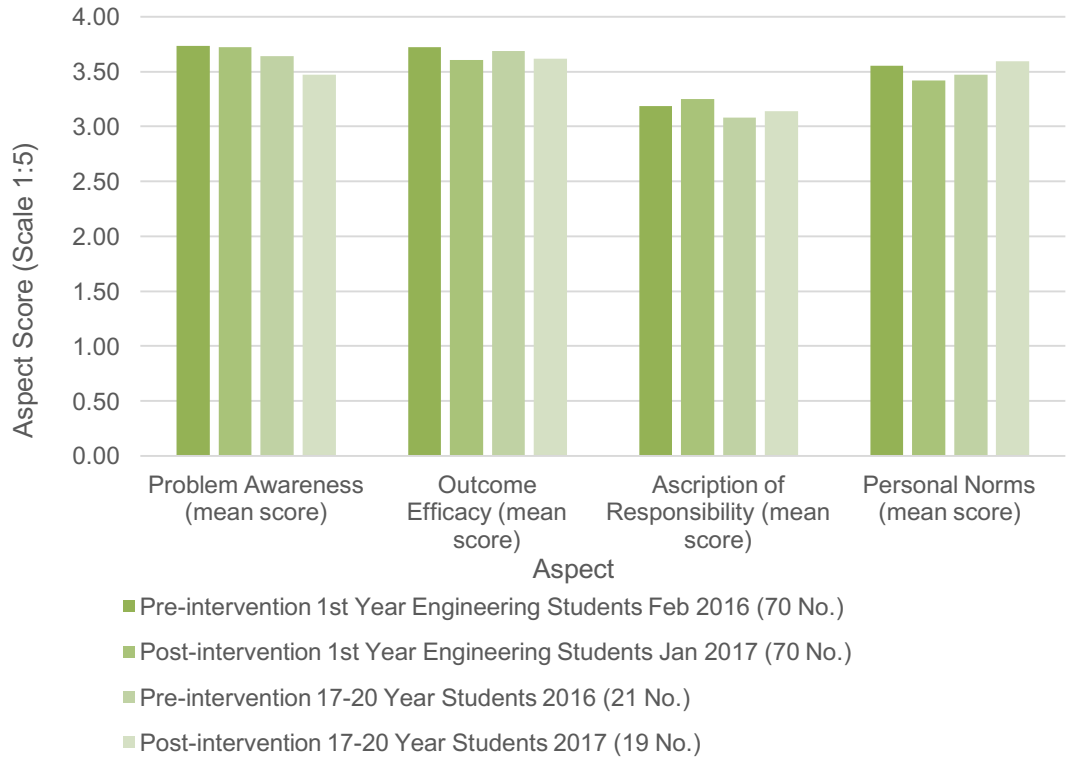



*Figure 7-33 Comparative Water Awareness Survey Results CnaC Senior Students and NUIG 1st Year Engineering Students*

The Waternomics Project has undertaken a number of initiatives aimed at promoting education regarding water usage and implementing the project goals, in this regard the achievements are described in Section 7.2.2 and 7.1.2 and include five workshop/training events held between M26 and M33. The development of new projects within the school based on the findings of the Waternomics project and the project data was a significant aim of the project and discussions are underway in this regard following the work of intern students from post-primary who undertook a short-term project with the Waternomics Team in M29.

The results of the pre-intervention analysis of water consumption at the Coláiste na Coiribe Pilot Site are detailed in Section 7.2.3. The results indicate that the school is very efficient in terms of its water usage with on average 4.42m$^3$ of water used per day with generally 70-90%% of this provided by rainwater which dramatically reduces the requirement for treated water from the municipal mains. Given this baseline efficiency, there is little scope to reduce further building user (i.e. student/teacher) led

consumption. However, significant reductions in water consumption and associated economic and carbon costs have been achieved in the early identification and resolution of faults that would otherwise go undetected until a quarterly water bill is perhaps scrutinized or potentially indefinitely. A review of commercial water billing activity in Galway City, indicated that commercial premises are billed quarterly for usage periods from the 1st January each year and are generally issued 6 weeks after the end of the quarter.

The fault described in Section 7.2.4 above as Fault 1, first became apparent from metered data recorded on March 10th 2016, the fault was notified to the school management shortly after this and rectified on March 31st 2016. During the period from when Fault 1 became apparent to its resolution a total of 172.8 cubic metres of water had been used unnecessarily. However, if the fault had not been detected by the Waternomics monitoring, the period from when the fault occurred to it being notified to the school management would in the best case have been at the date of the receipt of the quarterly water bill, i.e. 16th May 2016. Allowing the 21 day period for resolution as was the case in March 2016 with the actual events, the expected date for resolution of the fault would have been 9th June, 2016 by which time 1,324.8 cubic meters of water would have been used unnecessarily. The reduction in water consumption attributed to the detection and resolution of Fault 1 is 1,152 cubic meters (i.e. 1,324.8 – 172.8 cubic meters).

**Fault 1**

**Water Consumption Saving = 1,152 $m^3$**

**Economic Cost Saving*= € 2,419.20**

**Associated GHG Emission Saving** = 1,175.04 kg $CO_2$**

The fault described in Section 7.2.4 above as Fault 2, first became apparent from metered data recorded on March 16th 2016, the fault was notified to the school management shortly after this and rectified on June 8th 2016. During the period from when Fault 2 became apparent to its resolution a total of 230.4 cubic metres of water had been used unnecessarily. However, if the fault had not been detected by the Waternomics monitoring, the period from when the fault occurred to it being notified to the school management would in the best case have been at the date of the receipt of the quarterly water bill, i.e. 19th August 2016, however, the school is closed during August for Summer holidays, this date is likely to have been 1st September. Allowing the 23 day period for resolution as was the case in May 2016 with the actual events, the expected date for resolution of the fault would have been 23rd September, 2016 by which time 1,257.6 cubic meters of water would have been used unnecessarily. The reduction in water consumption attributed to the detection and resolution of Fault 2 is 1,027.2 cubic meters (i.e. 1,257.6 – 230.4 cubic meters).

**Fault 2**

**Water Consumption Saving = 1,027.2 $m^3$**

**Economic Cost Saving*= € 2,157.12**

**Associated GHG Emission Saving** = 1,047.7 kg $CO_2$**

The potential annual savings associated with the current fault at the pilot site, described in Section 7.2.3) is estimated below. The estimate is based on the following assumptions: rainwater being generally 80% of the total baseline water usage of 4.42 cubic meters per day (Mon-Fri) and 2.73 cubic meters per day (Fri) and a school being open 167 days per year.

**Fault 3**

**Water Consumption Saving = 545.9 $m^3$ per annum**

**Economic Cost Saving*= € 1,146.38 per annum**

**Associated GHG Emission Saving** = 556.82 kg $CO_2$ per annum**

*Based on cost of water supply and treatment of €2.10 per cubic meter http://www.galwaycity.ie/commercial-water-charges-information/

** Clarke, Alan, et al. "Quantifying the energy and carbon effects of water saving." Environment Agency, Rotterdam, UK (2009)

# 8 Comparisons and Conclusions

This section reviews the Pilot reports and presents a comparative assessment of the results.

## 8.1 Comparison of the pilot sites

All pilots have set objectives that are similar to each other. All pilot sites have set Reduce Consumption and Increase Awareness as an objective. Furthermore, three out of four have Improve Operation or Management, which are similar to each other. Although most pilots have different target audiences and the situations are not all comparable, some of the results and observations in the pilots show similarities. A couple of WEMs turn out to be more effective than others, often due to the situation at the pilot itself. Also, lessons for implementation have been learned, which are comparable for the different pilot sites.

1. Measures at one pilot site influence water consumption on a higher scale then others because of the amount initially used by the participants. For example, rainwater harvesting at a school can have a much bigger effect on consumption compared to a household switching to using a dishwasher. The overall change of volume of water used in a larger building i.e. commercial or mixed use public compared to that in domestic households with 2, 3, 4 people is thus more effective.
2. The influence that end-users have on water consumption in a public building, compared to management and mangement staff is markedly different. With system controlled water usage accounting for the most significant proportion of water usage events in a public or commercial buildings, the effect of water usage behaviour changes by end-users such as staff and students alone may not be effective in changing the overall water consumption. However, in the domestic environment, the end-user is also generally the person responsible for system management and behavioural changes made are likely to be reflected very quickly in overall water consumption.
3. When system controlled water usage accounts for the most significant proportion of water usage, behaviour changes by staff and students may be entirely masked. Comparatively, changes in user water behaviour and increased water awareness may introduce water usage efficiency and conservation but these will be far less dramatic.
4. The relative effectiveness of water use behaviour change in different pilot types also means that even significant changes by end-users may be entirely masked or at least difficult to establish in public commercial buildings due to the small or almost impossible way to measure changes.
5. In the case that measurements actually show that there is a high initial baseline of Water Awareness, it suddenly becomes hard to find whether the WEM is effective, since the effect is almost not there or proves difficult to capture. This was the case at pilots NUI Galway and CnaC, where the pre-intervention surveys indicate that the sample populations exhibit a moderately high level of water awareness. With overall average scores of pre-intervention score of 3.8/5.0 recorded for those based in the Engineering Building of NUI Galway, and 3.3/5.0 recorded for post-primary students taking part in the surveys at CnaC. When analysed by age range, a marginally lower score is determined from the younger age group of students in the CnaC Pilot site. The overall average score of 3.3/5 recorded for post-primary students is 13% lower than those surveyed based in the NUI Galway Pilot. Positive impacts of the implemented measures may prove difficult to capture by the post intervention surveys due to this high baseline.
6. In two of the pilot sites, the surveys on water awareness showed no increase for a specific group of students; the senior cycle students in the CnaC pilot and those from the 1st year Engineering students at NUIG, indicating perhaps that 1) these are a similar demographic and 2) confirming

that increases in awareness are difficult to achieve in this group in particular given the high awareness baseline.

7. Some WEMs were found to have a different effect than expected. For example, the effect of increasing the awareness of water consumption in the domestic environment was that household participants discovered that by consuming food that uses less water in its production they could reduce their overall water consumption.
8. Timing in applying WEMs is essential. Both NUIG and CnaC pilots found that for an effective implementation of WEMs schedules needed to be timed according to calendars of the institutes. For example, the summer holiday's period has lower occupancy when water use patterns are different to normal usage, and students are not present to participate into the project.
9. Household participation and usage was similarly effected, but to a lesser extent, due to summer holiday periods.
10. Intervening into daily routines at homes for participants of the Thermi pilot seems to be more difficult than the other pilot sites. Personal and daily routines do not include checking water consumption on a frequent basis. Habits are not easily changed, especially in a home setting, and taking up new habits when you are not obliged (work or school often is) is difficult, especially because there are many other obligations and hobbies that require a person's time.
11. Exploiting existing communication channels of users is a key takeaway in strategies for increasing awareness.
12. Applications and other inputs have no great impact on changing water consumption when there is low economic incentive in engaging and learning more about water consumption. A combination of water with energy consumption towards a holistic sustainability-tracking platform was metioned by participants as a potential factor that would increase their interest and incentive for reducing water consumption.
13. Changing the behaviour in the household environment requires changing behavior in all users of that household, and if not all are interacting with the information this becomes more difficult.

## 8.2 Concluding remarks

With the proposed WEMs in place at each pilot site, a number of conclusions can be drawn.

### 8.2.1 Pilot Linate Airport

At the pilot site of Linate Airport, all WEMS are in place. The sensors have been installed, which is the first step to implement an effective Water Management System. Using the information collected by the sensors, monitoring can lead to informed choices on the global water network and highlight goals in advance. After the installation of the interactive digital displays, positive feedback by users has been received. There has also been a substantial use of the screens as measurements show (about 2250 users' interactions).

From the initial web analytics of the Waternomics Platform it is clearly shown that the end-users are interested in this tool through which they can interact with the water usage data supplied from the meters. The Platform is customizable and this is a point of strength since it can adapt to the actual users' needs. Apps were created in order to make the users familiar with the Platform. In this way, they can learn to use the platform and customize it depending of their needs. The introduction of an Exploration App gave managers and designers the possibility to set the notification system to arise alarms when an anomaly occurs in the water network. After adding on-line guidelines and on-line helpdesk, the effectiveness of the

WEM was measured through the web analytics associated to the Waternomics Platform. Increase of these values is still expected to occur.

An open day seminar was held in Thermi - Greece with positive feedbacks from the participants. The seminar was important to promote ideas and experiences exchange between the users and to increase their environmental responsibility. This was followed up by a "Water Fair", held in the Linate Pilot in M35.

However, some early issues surrounding the effectiveness of the WEMS based on the water usage reduction have been outlined. For this reason, we suggest to introduce among the SEA corporate incentives for those departments that register, a reduction of their water consumption. In this way, the staff will be engaged in a competitive game that, coupled with the relevant information provided by the WAP, could lead to a more effective water consumption reduction behaviour.

### 8.2.2 Pilot Thermi

Out of the 8 planned WEMs, 7 have been applied in the Thermi pilot. The in-school training program has been skipped, in favour of developing an additional exploration application for the participants. This was decided after an interim assessment on the impact of the implemented WEMS. During the Open Day Seminar, participants were educated about water consumption and their role in conservation. The final focus group confirmed that the impact from the additional exploration application has been quite important.

An increase in awareness of water consumption can be seen due to an increasing interest for the Platform, which has been ensured also with the help of email newsletter campaigns and the exploration applications. Exploration applications also increased interest from users' side, which was also shown in the positive comments from many users. The main factor that contributed to the success of the digital email app was that it was providing users with information from the platform through communication channels they already use on their daily lives.

Behavioural changes in water consumption were enabled with the exploration app of comparisons with other households. It showed potential based on preliminary results from interviews with some household owners. Unfortunately, no significant behavioural change was observed. A news aggregator app was also developed, but was not as helpful as expected. In many cases, it showed that, changing the behaviour in the household environment requires changing behaviour in all users of that household, and if all users are not interacting with the information this becomes more difficult.

Reduction of water consumption observations showed that for households, the economic incentive is too low. Water is relatively cheap and does not affect the household budget significantly, so the incentive for reducing water consumption is also low.

### 8.2.3 Pilot NUI Galway

With timely and actionable information being provided to Building Managers regarding the operational anomalies, unexpected occurrences and predicted faults, the Waternomics Project has delivered a system that provides improved operation to the building water network at the NUI Galway Pilot Site. Prioritising corrective action with Building Management when faults are notified remains an issue due to staffing and budgetary constraints. However, the water residence time observer has been a very successful system with email alerts of simple resolutions sent to the building manager to take preventative action to avoid issues with water quality due to extended potable water residence times.

Any sustained engagement of building managers in the manager's dashboard applications has been difficult to achieve, primarily due to workloads and the necessity to prioritise critical faults in the University Building stock. However, identification of the fault in the rainwater harvesting system by the Waternomics Project and its subsequent repair is considered a significant success of the project quantifiable by savings equivalent to the harvested rainwater used during the control period following the repair work.

The impact of the measures introduced at the pilot on water consumption could not be shown, due to system faults. No overall reduction in mains water usage was recorded but disappointingly an overall increase in water usage over the control period was noted due to the fault. The significant impact of system controlled water usage i.e. automatic flushing of urinals and persistent faults relative to any user controlled usage is a significant finding of the project in terms of controlling water usage in public/mixed used buildings. The overall effect on water consumption of even significant water use behaviour change in end-users is limited due to the Operation/ System controlled water usage is more significant than User controlled usage.

In terms of user awareness, the pre intervention surveys indicate that the sample populations exhibit a moderately high level of water awareness. Post intervention awareness surveys were found to be statistically insignificant. Since pre intervention surveys already indicated a high level of awareness, small differences that might or might not have occurred would have been difficult to capture.

The Waternomics Project has been successful in promoting education regarding water usage as evidenced by new projects at the site. Post project initiatives as well as collaborations are on-going, building on the work of Waternomics.

### 8.2.4 Pilot Coláise na Coiribe

The newly constructed Coláiste na Coiribe pilot is continuously being monitored to improve operation by detecting and diagnosing faults as they occur in the building. During the monitoring period, two faults were observed and reported. With the identification, diagnosis and resolution of two significant faults already achieved, the Objective 4 at the CnaC has been satisfied. The early detection of the faults has prevented expected extra losses of 2,179 cubic meters of water, which inherently makes an economic cost saving of around 4,576 euros and an associated GHG emission saving of approximately 2,223 kg $CO_2$. In the last period of the Waternomics project, another fault was detected between the underground rainwater collection tanks to the header tanks. This occurred in M34, M35 and M36. Instead of collecting rainwater, the tanks were filled with water originating from the municipal supply. Water consumption saving by detecting this fault was estimated around 546 cubic meters per year, also creating an economic and associated GHG emission saving.

The pre-intervention surveys indicate that the sample populations exhibit a moderately high level of water awareness. The results of post intervention surveys carried out with similar groups at the end of the control period revealed an increase in awareness of 9% among the junior cycle students and 17% increase among the teachers. However, no change in awareness was recorded among sample students from the senior cycle of the school.

The Waternomics Project has been successful in promoting education regarding water usage and the Project Aims. The development of new projects within the school based on the findings of the Waternomics project and the project data was a significant aim of the project and discussions are underway. The results of the pre-intervention analysis of water consumption indicate that the school is very efficient in terms of its water usage with on average 4.42$m^3$ of water used per day with generally 70-

90% of this provided by rainwater which dramatically reduces the requirement for treated water from the municipal mains.

## 8.3 Pilot Status

The final status at the pilot sites is reported in Chapter 3 and is summarised in Table 8-1 below. The pilot control period was extended to M36 to mitigate the effect of delays experienced at some of the pilot sites. All applicable phases have now been completed at the pilot sites.

**Legend**

| |
|---|
| Complete |
| In Progress |
| Not Applicable |
| Not Started |

* Water Information System as Described in D3.3
**Water Efficiency Measure as Described in D5.1
***Waternomics Methodology Phases Described in D2.1

*Table 8-1 Pilots' final status with respect to the methodology provided in D2.1*

| Pilot Site | Methodology Phase | Phase Action Status | | | | |
|---|---|---|---|---|---|---|
| **Pilot 1 Linate** | **Phase 0 Assessment** | Water Context | Conduct Water Audit | Strategy / Objectives / KPIs | Select WEMs** | |
| | **Phase 1 Plan** | Action Plan | Develop Baseline | Water System Modelling | Plan Metering Strategy | Develop FDD |
| | **Phase 2 Implementation** | Meter Install & Configuration | WIS* Deployment | WIS Design Personas | Implement WEMs | Data Collection |
| **Pilot 2 Thermi** | **Phase 0 Assessment** | Water Context | Conduct Water Audit | Strategy / Objectives / KPIs | Select WEMs** | |
| | **Phase 1 Plan** | Action Plan | Develop Baseline | Water System Modelling | Plan Metering Strategy | Develop FDD |
| | **Phase 2 Implementation** | Meter Install & Configuration | WIS* Deployment | WIS Design Personas | Implement WEMs | Data Collection |
| **Pilot 3 NUIG** | **Phase 0 Assessment** | Water Context | Conduct Water Audit | Strategy / Objectives / KPIs | Select WEMs** | |
| | **Phase 1 Plan** | Action Plan | Develop Baseline | Water System Modelling | Plan Metering Strategy | Develop FDD |
| | **Phase 2 Implementation** | Meter Install & Configuration | WIS* Deployment | WIS Design Personas | Implement WEMs | Data Collection |
| **Pilot 4 CnaC** | **Phase 0 Assessment** | Water Context | Conduct Water Audit | Strategy / Objectives / KPIs | Select WEMs** | |
| | **Phase 1 Plan** | Action Plan | Develop Baseline | Water System Modelling | Plan Metering Strategy | Develop FDD |
| | **Phase 2 Implementation** | Meter Install & Configuration | WIS* Deployment | WIS Design Personas | Implement WEMs** | Data Collection |

# Appendix A

Each pilot has identified several Water Efficiency Measures (WEMs) at the start of the Waternomics Project. Table A-0-1 discusses the WEMs that are implemented up to date and how the realisation of the WEM is currently in practice.

*Table A-0-1 Implemented WEMs and its current status*

| | Applied WEMs | Current status |
|---|---|---|
| **Linate Airport** | WEM 1: Installation of sensors | 100% installation completed |
| | WEM 2: Installation of touch screen displays | 2 digital touchscreens have been installed and used |
| | WEM 3, 4, 5: Launch of the Waternomics Application Platform (WAP) | Developed a Linate pilot dashboard with:<br>• Home section<br>• Monitor section<br>• Learn section<br>• Explore section |
| | WEM 6: Engagement | Open end-users' seminar has been conducted, a "water fair" in Linate Pilot held in M35 |
| **Thermi** | WEM 2: Introduction of Waternomics Applications Platform and initial Monitoring applications | 42 monitoring applications developed for the 8 participating households<br>A baseline water awareness questionnaire was completed by households |
| | WEM 3: Introduction of Waternomics Learning Applications | Learning applications were introduced to households through a newsletter |
| | WEM 5: Introduction of Waternomics Exploration Applications | Introduction of:<br>• Goal setter App + new feature to find predefined rules<br>• Compare of consumptions App |
| | WEM 6: Open End-user Waternomics Seminar | 20 people attended open day<br>4 original news articles published by the local media |
| **NUI Galway** | WEM 1: Public Display Relevant to Water Consumption | Display screen shows series of visuals to improve conservation through consumption habits. |
| | WEM 2: Waternomics Applications Platform | Consists now of:<br>• Managers Dashboard<br>• Public Display |
| | WEM 3: Interactive Digital Signage Kiosk | General information platform has been developed and launched |

| | | |
|---|---|---|
| | WEM 4: Interactive Signage at Water Meter Installations | Ultrasonic water meters have been installed.<br>Signage erected at each meter with QR-code with details of the project and important issues on water awareness. |
| | WEM 6&7: Waternomics Talks, Water Information Seminars and Workshops | • Seminars held for students and staff<br>• Workshop held to introduce building managers to the dashboard |
| | WEM 8: Promote use of Waternomics Platform data | By display screens, information signage, posters, leaflets, newsletters, and other dissemination channels. |
| | WEM 9: Promote Waternomics Platform for new Apps | • Course directors were contacted to promote this possibility<br>• Students are being invited to propose new apps in the newsletters |
| | WEM 10: Water Consumption Awareness | Aforementioned WEMS |
| | WEM 11: Gamification | Displaying water usage data as a function of the baseline value. |
| | WEM 12: Engagement | Two physical interventions that require user engagement are trialled:<br>• QR-codes<br>• Eco-feedback through water |
| | WEM 13: Installation of additional metering | Installed are:<br>• 8 ultrasonic meters<br>• 3 small in-line metres |
| | WEM 14: Water Network Information | Monitoring of meters in the building:<br>• 317376 data points obtained<br>• 105 million readings recorded<br>Characteristics that reflect building water usage and capacity to supply the water were determined. |
| | WEM 15: Identification of Faults | Use of baseline flow values and flow signatures<br>Identification of long drinking water residence time in pipes |
| | WEM 16: Diagnosis of Faults | A 5 step process of diagnostics is defined. |
| **Coláiste na Coiribe** | WEM 1: Launch the Waternomics Information Platform | Consists now of:<br>• Managers Dashboard<br>• Public Display |
| | WEM 2: Interactive Digital | General information platform developed that |

| | | |
|---|---|---|
| | Display Waternomics Information Platform | provides end-users with quick access to building usage characteristics. |
| | WEM 3&4: Water Information and Waternomics Seminars | Various Water Information Seminars and Workshops were held for students and staff. |
| | WEM 5: Promote use of Waternomics Platform Data | Data gathered by students will be used to develop and support research ideas.<br>Measures in place are display screens, information signage, posters, leaflets and bi-monthly newsletters for managers.<br>A competition was held for two student internships, hosted by Waternomics teams for a week. The students performed an assignment on the water usage data at the pilot. The output was a research poster. |
| | WEM 6: Promote Waternomics Platform for new Apps | Hosting of innovative water information based applications developed by any third party is now open for use. |
| | WEM 7: Water Consumption Awareness | Will be provided using the previous mentioned WEMs. These are fed with historic data from the building sensors to give access to water usage metrics.<br>Effect of Managers Dashboard, Public Dashboard, Water Awareness Information Screens, Workshops, Launch Event, and Intern Scheme. |
| | WEM 8: Gamification | Displaying water usage data as a function of the baseline value, displaying red or green depending on whether the baseline has been exceeded or not. |
| | WEM 9: Engagement | Public Dashboard, Managers Dashboard, Workshops, Students Interns, Launch Event |
| | WEM 10: Installation of Additional Metering | 14 water meters have been installed (8 added by the Waternomics project) |
| | WEM 11: Water Network Information | Schematic of Existing System.<br>Meters were monitored from M24 – M29 to gather information. Characteristics that reflect buildings water usage and capacity to supply water were determined: flow baseline in each metered pipeline, disaggregation of each meter to its typical end-uses, peak flows and peaking factors, water flow clusters such as normal days, diurnal flow signatures. |

| | | |
|---|---|---|
| | | Approximately 419328 data points were obtained. |
| | WEM 12: Identification of Faults | As per actioned WEMs above.<br>App in place on Managers Dashboard to allow Identification of abnormal Occurrences. |
| | WEM 13: Diagnosis of Faults | As per actioned WEMs above. |

High-level sets of specific objectives have been identified for each pilot. These objectives have been set out and the preliminary results of the applied WEMs concerning these objectives are shown in Table A-0-2, Table A-0-3, Table A-0-4, and Table A-0-5.

*Table A-0-2 Review of objectives at Pilot Linate Airport*

| Objectives | Results |
|---|---|
| **Increase Awareness** | • Awareness about night time water use.<br>• High use of interactive digital displays.<br>• Water consumption baseline has been established.<br>• Number of users of Waternomics Application Platform increased<br>• Participants of seminar interested in project and outcomes. |
| **Reduce Consumption** | Expected reduction of water consumption due to:<br>• understanding of staff on water they use and information awareness campaigns on water conservation<br>• release of Linate Waternomics Application Platform (WAP) |
| **Improve Management** | Installed sensors increase understanding of the network and show the necessity of intervening; when and where.<br>With the Waternomics Application Platform SEA managers can get:<br>• real time water consumption to make comparisons<br>• statistics on water consumption over time<br>• use a Decision Support System<br>• detect anomalies<br>• create water balances<br>• benchmarking of repairs/notifications to know what has happened |
| **Promote Environmental Responsibility** | • 50 users of digital displays have calculated their water footprint.<br>• SEA staff is getting familiar with WAP for use, to become more environmentally responsible. |

*Table A-0-3 Review of objectives at Pilot Thermi*

| Objectives | Results |
|---|---|
| **Increase Awareness** | • Start of activities on platform by household participants and increase after summer |

| | |
|---|---|
| | • Video tutorial app has been used |
| **Enable behavioural changes in water consumption** | Apps might be affecting some of the households, who discuss about changing some of their habits. |
| **Reduce Water consumption and energy** | People seem to start understanding how they use water. Reductions are expected in the next periods. |
| **Educate domestic consumers about water consumption and their role in conservation** | • Use of methophors in the monitoring Apps is found interesting.<br>• Comparison Apps show and affect of possible changes in habits.<br>• People were interested into the information on water consumption during the seminar. |

*Table A-0-4 Review of objectives at Pilot NUI Galway*

| Objectives | Results |
|---|---|
| **Increase Awareness** | • Analysis of pre intervention Water Awareness surveys showed that 70 first year Engineering students based at the NUI Galway Engineering Building have a good level of water conservation awareness , these results were similar for a control group first year IT student not based in the Engineering Building.<br>• Total of 8613 page views and 2527 sessions in the Public Dashboard Application since launch of the platform. Number of page views increased significantly upon launch of public display.<br>• A total of 105 QR-code logins have been recorded since launch of the interactive signage and QR code app at USF meters. |
| **Promote Education** | • After the workshop, a noticible increase followed in the number of logins on the Building Managers Dashboard.<br>• Projects for undergraduates are planned/have commenced based on work carried out as part of Waternomics.<br>• A number of presentations and workshops have been given.<br>• Short-term internship scheme advertised. |
| **Reduce Consumption** | • Analysis of water usage data Jan 2016-June 2016 carried out & summary of the water network data analysis compiled for submission to building management. |
| **Improve Operation** | • An overflow fault in rainwater top-up facility was detected by data analysis.<br>• Recommendations made to building management to repair the rain water harvesting system sensor.<br>• A rule-based FDD system to identify exceedances in recommended residence time of potable water in the system was transferred to a bespoke water retention observer software application – the system has been successful in notifying residence time occurences and recommending remedial actions. |

*Table A-0-5 Review of objectives at Pilot Coláiste na Coiribe*

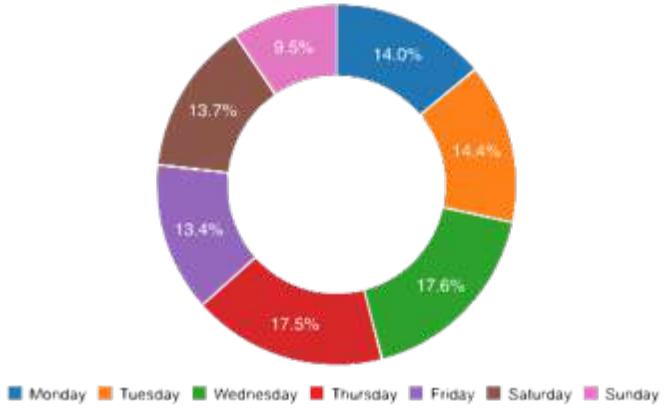
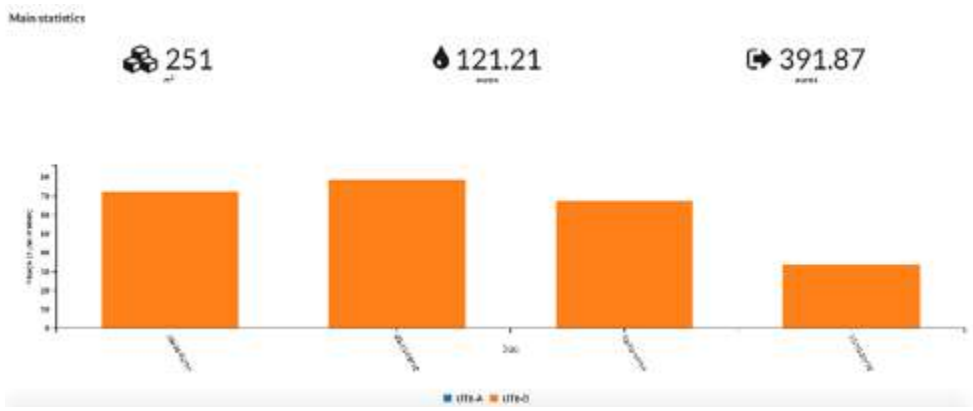
| Objectives | Results |
|---|---|
| **Increase Awareness** | Analysis of pre-intervention Water Awareness surveys showed that the sample populations exhibit a moderately high level of water awareness with overall |

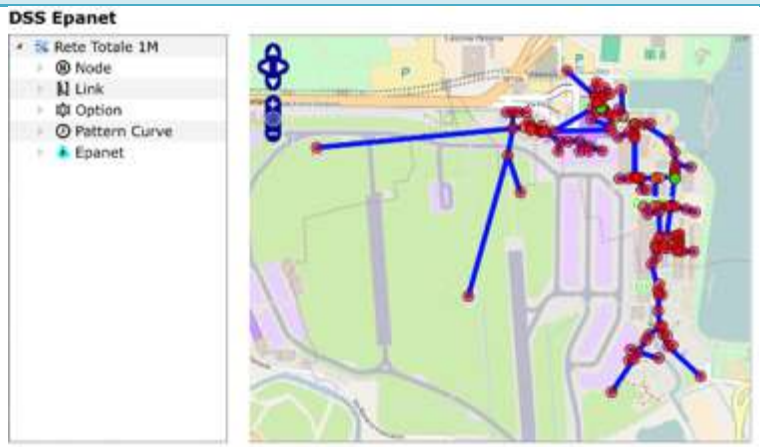
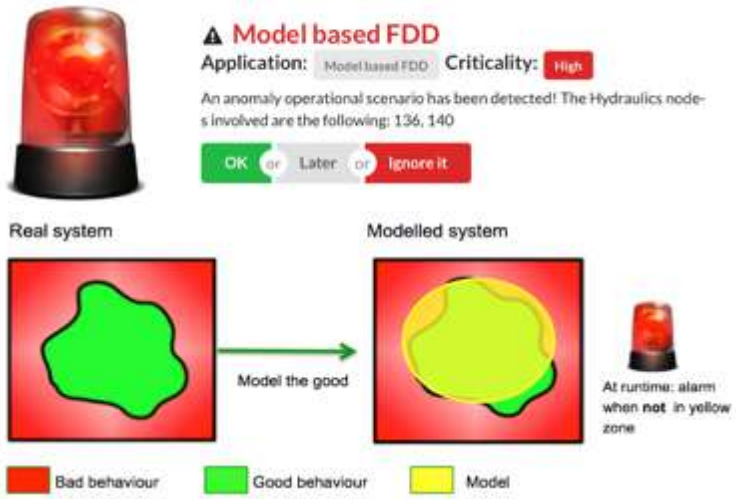
| | |
|---|---|
| | average pre-intervention score of 3.3/5.0 recorded for post-primary students taking part in the surveys. In particular, those in the age range 14 and above showed a relatively high level of awareness of water conservation issues in the pre intervention survey results. |
| **Promote Education** | • Students access (demo-mode) to Managers Dashboard<br>• Promotion of projects for entry to National Science Competitions<br>• Short-term Waternomics internship for 2 students completed in June 2016<br>• A number of Water Awareness Workshops have been held for students from the pilot |
| **Reduce Consumption** | An analysis of water consumption at the Pilot from Jan 2016 to June 2016 has been carried out. |
| **Improve Operation** | Two faults which were found to be significant leaks have been detected and diagnosed. An extra fault in the rainwater collection system has been detected. |

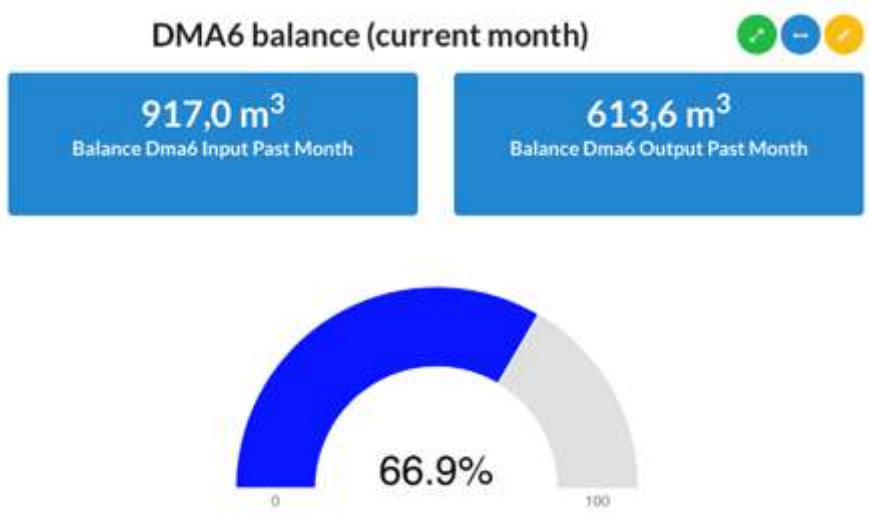
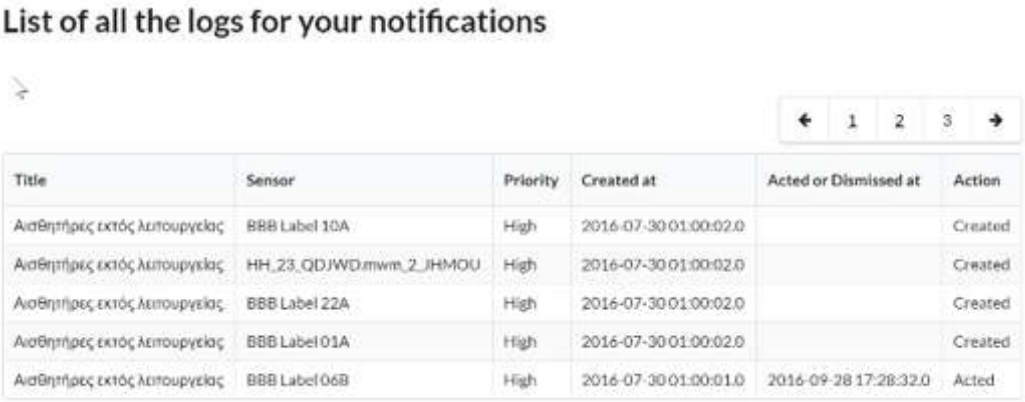
# Appendix B

In the following Table B-0-1 it is possible to consult the Linate pilot Table 4-1 with higher definition images.

*Table B-0-1 Linate pilot Table 4-1 with higher definition images*

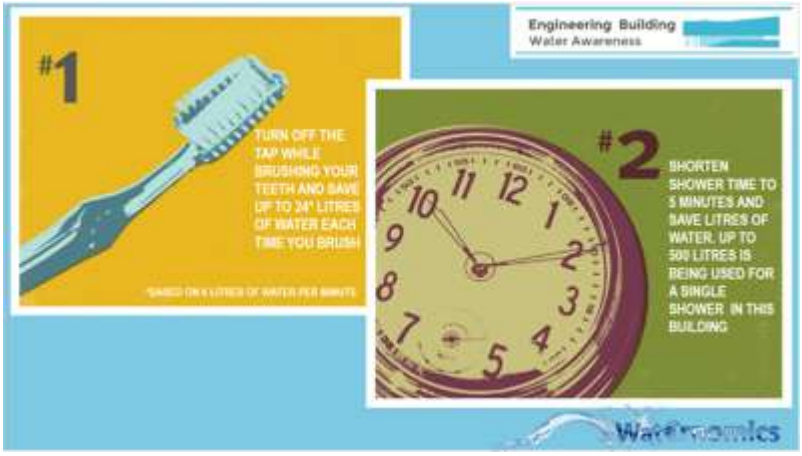
| | |
|---|---|
| **1** |  |
| | The real time water consumption of each single building and make comparisons between them to point out which one is the building with the largest water consumption |
| **2** |  |
| | the real time water consumption of each single building and make comparisons between them to point out which one is the building with the largest water consumption |
| **3** |  |
| | The consumption of each building for past periods and relative main statistics in which are provided |

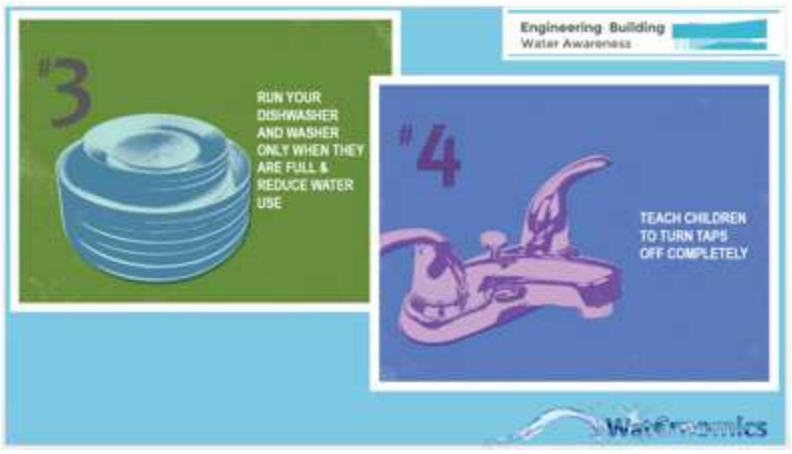
| | |
|---|---|
| | information about:<br>• the total water used in cubic meters<br>• the total cost of the overal water used so far<br>the total cost of the discharged water. For this information, it is assumed that all the water used is discharged, but after the DMA6 water balance is ready we will make a correction of this information on the basis of the percentage of leakage found in the DMA6 area |
| **4** |  |
| | The effect of different Pressure set points in the Airport water network by implementing by their own hydraulic model simulation in real time by using the Epanet model and the Decision Support System (DSS) introduced in the Exploration section of the Linate Waternomics Platform |
| **5*** |  |
| | If in the Linate water network there is a fault or a leakage, identify it and isolate it by taking remedial actions. This could be implemented through the Model Based FDD method developed within the Waternomics project that is able to compare the real data gathered from the meters installed in the water network with the "optimal" data gathered from the Epanet Hydraulic model. If an anomaly is detected an alert is sent to the Managers and the Operation staff of SEA corporate. |

| | |
|---|---|
| 6* |  |
| | The water balance for the DMA6 area. It is an indicator of the percentage of leakage in the overall water network. |
| 7 |  |
| | The benchmarking of repairs/notifications acted by the maintenance staff so far. This information will give to the decision makers the opportunity to know what happened in the water network, if the problem has been solved and who has acted on it. |

# Appendix C

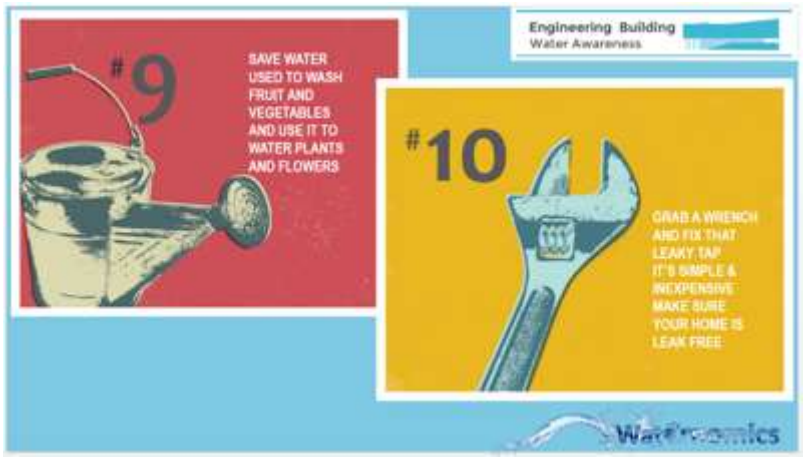
**NUI Galway Pilot Site - Water Awareness Slide Show**


Engineering Building
Water Awareness
#5
WASHING DARK CLOTHES IN COLD WATER SAVES WATER AND ENERGY AND HELPS YOUR CLOTHES RETAIN THEIR COLOUR
#6
KEEP A JUG OF WATER IN THE FRIDGE INSTEAD OF RUNNING THE TAP FOR COLD WATER
WatErnomics


Engineering Building
Water Awareness
#7
TURN OFF THE WATER WHILE WASHING YOUR HAIR AND SAVE UP TO 25 LITRES PER MINUTE
#8
WHEN WASHING DISHES BY HAND, DON'T LET THE WATER RUN FILL THE BASIN
WatErnomics


Engineering Building
Water Awareness
#9
SAVE WATER USED TO WASH FRUIT AND VEGETABLES AND USE IT TO WATER PLANTS AND FLOWERS
#10
GRAB A WRENCH AND FIX THAT LEAKY TAP IT'S SIMPLE & INEXPENSIVE MAKE SURE YOUR HOME IS LEAK FREE
WatErnomics

## NUI Galway Pilot Site - Water Awareness Questionnaire

| Ref No. | |
|---|---|

# WATER AWARENESS SURVEY

As part of the EU Research Project Waternomics http://waternomics.eu that examines the use of ICT to influence change in people's behaviour towards water consumption, NUIG is conducting a study on people's current behaviour and attitude towards water usage. We kindly invite you to participate in this study.

If you agree to take part in this study, you will be asked to complete a questionnaire, which will take approximately 10 minutes to complete. There are no "right" or "wrong" answers: we are interested in your opinion. All the information you provide will be strictly anonymous. No data collected allows you to be identified from the data set.

Your participation in this study is completely voluntary, if you have questions about this project you may contact the researcher, Louise Hannon at 091-492-733 or via email at louise.hannon@nuigalway.ie.

Thank you very much for your participation,

Louise Hannon
Senior Research Associate
Civil Engineering, College of Engineering & Informatics
NUI Galway

### Part 1 – General information about you

*To best assess the information that we collect, we would like to know about you. Please read each question or statement and tick the box that indicates your response*

1. Are you male or female?

| Male | Female |
|---|---|
| | |

2. What is your age range?

| 17 - 20 | 21 - 24 | 25 - 28 | 29 - 32 | 33 - 36 | 37 - 44 | 45+ |
|---|---|---|---|---|---|---|
| | | | | | | |

3. What is the highest education that you finished?

| No formal education | Primary Certificate | Junior /Inter /Group Cert (Lower secondary) | Leaving Certificate (Upper secondary) | Certificate/ Diploma | Degree or equivalent | Post Graduate Masters /PhD | Don't want to say |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

4. What best describes your role within university?

| Undergraduate Student | Post-graduate Student | Academic Staff | Research Staff | Technical Staff | Administrative Staff |
|---|---|---|---|---|---|
| | | | | | |



| Ref No. | |
|---|---|

5. What best describes your main residence?

| I am a homeowner | I rent my home | I live with my Parents | I am in a house/apartment share | Other |
|---|---|---|---|---|
| | | | | |

## Part 2 – General Questions about Your Current Water Use

***In this part of the survey we are interested in your current involvement in water conservation activities. Please read each question and indicate how often you do this by ticking the box that represents your current behaviour best.***

1. Do you turn the tap off during tooth brushing?

| Always | Often | Sometimes | Rarely | Never | N/A |
|---|---|---|---|---|---|
| | | | | | |

2. Do you Keep Showering Time to a minimum?

| Always | Often | Sometimes | Rarely | Never | N/A |
|---|---|---|---|---|---|
| | | | | | |

3. Do you wash your car with water bucket instead of a hose?

| Always | Often | Sometimes | Rarely | Never | N/A |
|---|---|---|---|---|---|
| | | | | | |

4. Do you fill the kettle only to the volume of water you need?

| Always | Often | Sometimes | Rarely | Never | N/A |
|---|---|---|---|---|---|
| | | | | | |

5. Do you choose water saving technologies where possible?

| Always | Often | Sometimes | Rarely | Never | N/A |
|---|---|---|---|---|---|
| | | | | | |

## Part 3 – Your Opinion on the Use and Conservation of Water

***In this part of the survey we are interested in your opinion and feelings regarding the use of water and its conservation. Please read each statement and consider whether you agree or disagree with it. Indicate by ticking a box the strength of your response from completely disagreeing at point 1 to completely agreeing at point 5.***

1. I feel a strong personal obligation to conserve water

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |



| Ref No. | |
|---|---|

2. I worry about the negative impact of increasing water consumption on the environment

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

3. I am willing to put extra effort into reducing my water consumption

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

4. I'd feel guilty of I did not implement water conservation measures in my day to day activities

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

5. The way in which we currently use water is a problem for society

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

6. I believe that the lack of water conservation has a significant negative environmental impact

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

7. It is pointless to change my habits; it will not have an effect on the overall consumption of water

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

8. I think that promoting water efficiency measures at work /school /college would result in a reduction in my water consumption

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

9. I feel responsible to take measures to reduce my water consumption

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

10. I feel a responsibility to promote water efficiency measures at home

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |



| Ref No. | |
|---|---|

11. I think that I can reduce my water consumption by making changes to my existing habits

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

12. I feel a responsibility to promote water efficiency measures at work /school /college

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

13. I think that promoting water efficiency measures at work /school /college would result in a reduction in overall water consumption

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

14. I believe that I have some responsibility for reducing the consumption of water in my area

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

15. I believe that promoting water efficiency measures will have little effect on people's water consumption habits

| Completely Disagree | 1 | 2 | 3 | 4 | 5 | Completely Agree |
|---|---|---|---|---|---|---|
| | | | | | | |

## Part 4 – Your Views on Practicing and Promoting Water Conservation

***In this part of the survey we are interested in recording your views on participating in water conservation activities. Please read each statement and consider whether you agree or disagree with it. Indicate by ticking a box the strength of your response from completely disagreeing at point 1 to completely agreeing at point 5.***

1. Would you be willing to adopt changes in your routine (e.g. turning off tap while brushing teeth, limiting shower length) to reduce the consumption of water?

| Definitely Not | Probably Not | Possibly | Probably | Definitively Yes |
|---|---|---|---|---|
| | | | | |

2. Would you be willing to encourage others to change their routines (e.g. turning off tap while brushing teeth, limiting shower length etc.) to reduce the consumption of water?

| Definitely Not | Probably Not | Possibly | Probably | Definitively Yes |
|---|---|---|---|---|
| | | | | |

3. Would you be willing to take part in a demonstration at work or at school to promote greater water efficiency?

| Definitely Not | Probably Not | Possibly | Probably | Definitively Yes |
|---|---|---|---|---|
| | | | | |



# Appendix D

**Coláiste na Coiribe Pilot Site - Water Awareness Slide Show**




Coláiste na Coiribe
Feasacht Uisce
#5
NÍOR EADAÍ DORCHA IN UISCE FUAR CHUN UISCE AGUS FUINNEAMH A SPÁRÁIL AGUS COINNEOIDH NA HÉADAÍ A NDÉATH CHOMH MAITH
#6
COINNIGH CRÚSCA UISCE SA CHUISNEOIR SEACHAS UISCE FUAR A FHÁIL ÓN SCONNA
www.waternomics.eu
WatErnomics


Coláiste na Coiribe
Feasacht Uisce
#7
NÁ FÁG AN T-UISCE AG RITH AGUS TÚ AG NÍ DO CHUID GRUAIGE AGUS SPÁRÁLFAIDH TÚ SUAS LE 25 LÍTEAR UISCE
#8
AGUS SOITHÍ Á NÍ AGAT LE LÁIMH, NÁ FÁG AN T-UISCE AG RITH LÍON AN BAISIN
www.waternomics.eu
WatErnomics


Coláiste na Coiribe
Feasacht Uisce
#9
ÚSÁID AN T-UISCE ÍNA NÍONN TÚ GLASRAÍ AGUS TORTHAÍ CHUN UISCE A CHUR AR PHLANDAÍ AGUS AR BHLÁTHANNA
#10
FAIGH RINSE AGUS DEISIGH AON SCONNA ATÁ AG RITH NÍL SÉ DEACAIR NÁ COSTASACH BÍ CINNTE NACH BHFUIL AON SCEITHEADH UISCE SA TEACH
www.waternomics.eu
WatErnomics

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