FINAL OVERALL VALIDATION AND IMPACT REPORT

SmartH2O

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Executive Summary

This document is the deliverable D7.3 of WP7, titled **Final overall validation and impact report.**
According to the DoW, “This deliverable reviews and extends the outcomes of D7.2 providing the final results of the validation study. It analyses the different KPIs over the whole validation period and it makes a critical assessment of the impact achieved by the SmartH2O platform, identifying strengths and weaknesses, threats and opportunities, in the view of its exploitation in future applications”.

The core of this deliverable is, therefore, contributing an overall assessment of the outcomes achieved in the SmartH2O project, as well as the impacts of the SmartH2O platform in both the Spanish and the Swiss case studies. This assessment is performed based on the KPIs defined in D7.1 *Validation methodology* and updates the first outcomes reported in D7.2 *Validation report*.

The content of the deliverable is organised as follows:

- Section 1 introduces the rationale of the deliverable, which updates deliverables D7.2.
- Section 2 updates the description of the SmartH2O Consumer Portal, with details on the features added for its social awareness extensions. These latter allow SmartH2O users to interact with their social neighborhood and share the achievements they obtain as part of the gamification experiment.
- Section 3 summarizes the validation methodology, in order to describe how the content of D7.1 and D7.2 was specifically implemented in the two case studies of the project, in order to evaluate KPIs and overall SmartH2O impact.
- Sections 4 and 5 constitute the detailed core of the deliverable, as they present the final results for the Spanish and Swiss case study, respectively. First, the data analytic and modelling tools presented in D3.4 for single-user behavioural modelling and agent-based modelling are validated and adopted to numerically assess behavioural change (i.e., water consumption changes) as influenced by SmartH2O. Second, results from the SmartH2O awareness program are presented to assess water consumers’ engagement in SmartH2O. This includes the analysis of questionnaire responses, water consumption awareness, technology acceptance, and user activity on the SmartH2O platform. Ultimately, the impact of SmartH2O portal usage on water consumption is assessed.
- Finally, section 6 presents the overall assessment of SmartH2O. The impact of SmartH2O is evaluated in terms of (i) overall KPIs achievement, showing how well the objectives of the project have been reached, (ii) SWOT analysis, to understand strengths, weaknesses, threats, and opportunities, and (iii) exploitation opportunities in future applications, to envision how the SmartH2O is going to follow up next.

The conclusion that can be drawn from this deliverable is that the SmartH2O platform has been demonstrated to successfully and effectively impact the consumption of the engaged users. The difference in consumption between the intervention group and the control group in the Swiss case study is nearly 10% and 20% in the Spanish case study. Also awareness on consumption has sensibly increased as a consequence of the use of SmartH2O and correlations have been found between all the main functionalities and the reduction in water consumption. The platform, that is the SmartH2O software suite, that includes the web portal, the mobile app and the game, has been positively evaluated by the users, as demonstrated by the outcomes of the questionnaires.

1. Introduction

Recalling the introduction of D7.2 (*Validation report*) that precedes this D7.3 (*Final overall validation and impact report*) with preliminary validations, the main purpose of the SmartH2O project is to deliver solutions that can induce a quantifiable change in water consumption behaviour and an increase in the awareness about water.

The content of this deliverable updates D7.2 and extensively evaluates the outcomes from the real-world implementation of the SmartH2O project, according to the above general objective. The methodology introduced in D7.1 (*Validation methodology*) is adopted to present quantitative results on the validation of SmartH2O methods and overall assess the impact of SmartH2O. Consistently, the overall evaluation assessed 9 Key Performance Indicators (KPIs - see D7.1 for details on their definition), to quantitatively assess the impact of SmartH2O on both water consumers' behavior and water utilities' business. Starting from the final validation and KPI assessment, in this deliverable we ultimately provide an overall assessment of the SmartH2O project, identifying strengths, weaknesses, threats and opportunities, envisioning ways to follow up.

The SmartH2O platform has been developed in two real-world settings: Switzerland (Tegna) and Spain (Valencia). In both cases, the primary goal was increasing residential water consumers' awareness on water consumption issues and influencing their behaviour towards more efficient water consumption habits. On this purpose, the SmartH2O Consumer Portal constitutes a two-ways communication tool between the water utility and its users, thus potentially filling the interaction and user engagement gap existing in the status quo, baseline period (i.e., the period before the implementation of SmartH2O).
Yet, the two case studies differentiate with respect to specific goals and user samples. Indeed, the Swiss pilot has been conceived as a test case, to iteratively develop the SmartH2O application, as well as the measurement infrastructure to sufficient maturity for the larger Spanish pilot. Moreover, given the earlier implementation and data availability, it has been exploited along the project for building and refining the SmartH2O incentive model, as well as the data analytics and modelling tool for user behavioural modelling. Conversely, the large-scale Spanish pilot was set up to assess the core impact of the portal in a methodologically robust way, drawing on a large user base, and enabling the project to assess its final performance. To this end, a thorough methodology to isolate a treatment group of water users (subject to SmartH2O input) and monitor their behaviour change and engagement level overtime and in comparison to a control group (i.e., users not subject to the SmartH2O "treatment") was adopted.

Validation and assessment of the results from the above case studies is organized in this document according to the following structure.

Section 2 updates the description of the SmartH2O Consumer Portal provided in previous deliverables, with details on the features added on the final version for completing its social awareness extensions. These latter allow SmartH2O users to interact with their social neighborhood and share the achievements they obtain as part of the gamification model.

Section 3 recalls the validation methodology, extensively introduced in D7.1 and D7.2, in order to describe validation details and differences for the two case studies of the project, and how that relates to KPIs evaluation and overall SmartH2O impact assessment.

Sections 4 and 5 present the final results for the Spanish and Swiss case study, respectively. First, the data analytic and modelling tools presented in D3.4 for single-user behavioural modelling and agent-based modelling are validated and adopted to numerically assess behavioural change (i.e., water consumption changes) as influenced by SmartH2O. Second, results from the SmartH2O awareness program are presented to assess water consumers' engagement in SmartH2O. The presented results include the analysis of questionnaire responses, water consumption awareness, technology acceptance, and user activity on the SmartH2O platform. Ultimately, the impact of SmartH2O portal usage on water consumption is assessed.

Finally, section 6 present the overall assessment of SmartH2O. The impact of SmartH2O is evaluated in terms of (i) overall KPIs achievement, to examine how well the objectives of the project have been reached (ii) SWOT analysis, to understand strengths, weaknesses, threats, and opportunities, and (iii) exploitation opportunities in future applications, to envision how the SmartH2O is going to follow up next.

2. Final social awareness app

The present section describes the last features added to the SmartH2O Consumer Portal, i.e.., the social awareness extensions. By this term, we mean a set of functions whereby a user of the SmartH2O Consumer Portal can interact with her social neighbourhood in order to communicate her achievements in the water saving gamification exercise.

2.1 Social Share

Figure 1 show how the main menu area of the Consumer Portal has been extend, to add the icon for invoking the social sharing features (the small rounded icon immediately to the left of the user's profile menu).

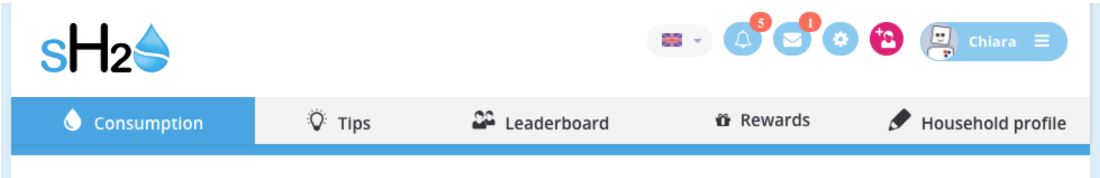


Figure 1 : Screenshot of the new version of the portal navigation bar including the invitation on Social Network.

Figure 2 shows the pop up window that appear by clicking on the "Invite a Friend" functionality of the social share menu. The window explains the purpose of the action and specifies the amount of points that it awards.

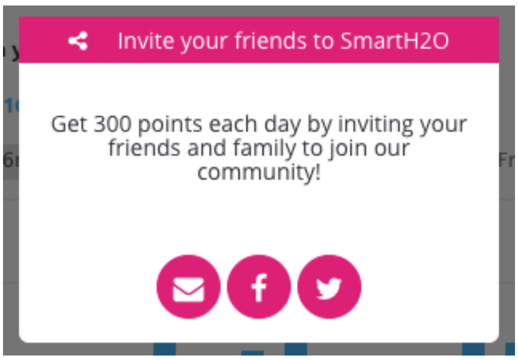


Figure 2: Popup on click on invitation button.

Figure 3 shows the dialog box that enables the user to send an invitation to a friend to join the community, using an email message. A preview of the message that will be sent is shown.

Figure 3: Send an invitation to a friend via an email message.

Figure 4 shows the dialog box that enables the user to send an invitation to a friend to join the community, using her Facebook Account. A preview of the message that will be sent by Facebook is displayed.

Figure 4: Send an invitation to a friend via a Facebook message.

Figure 5 shows the dialog box that enables the user to send an invitation to a friend to join the community, using a Twitter micro post. A preview of the message that will be sent is shown.

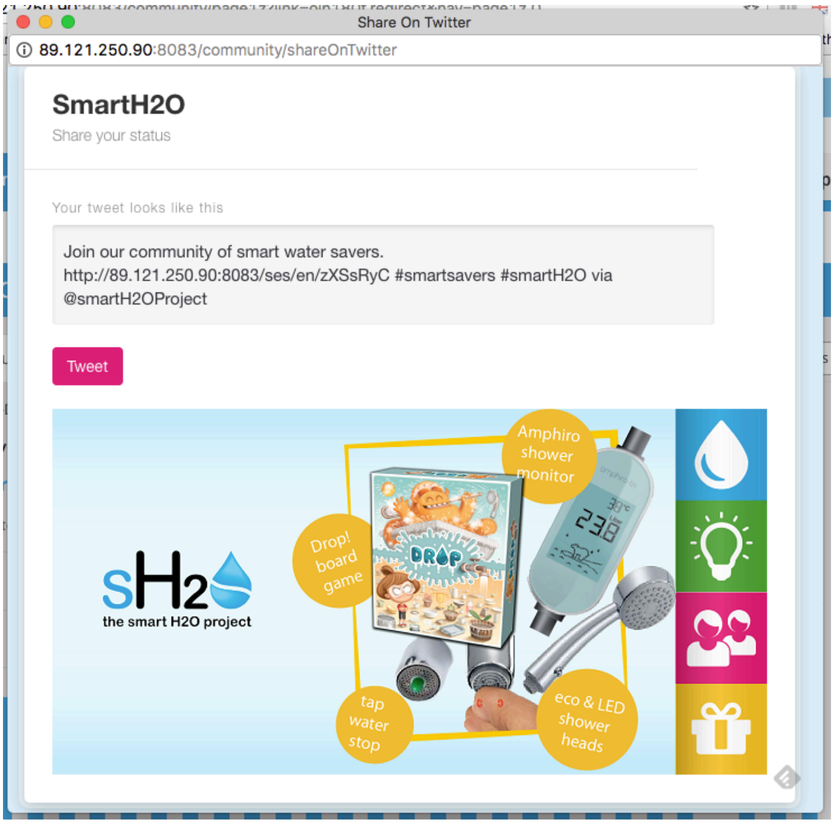


Figure 5: Send an invitation to a friend via a Twitter micropost.

Figure 6 shows the new command that enables the user to share a water saving tip, using an email, Facebook or Twitter message. A preview of the message that will be sent is shown, as in the preceding examples.

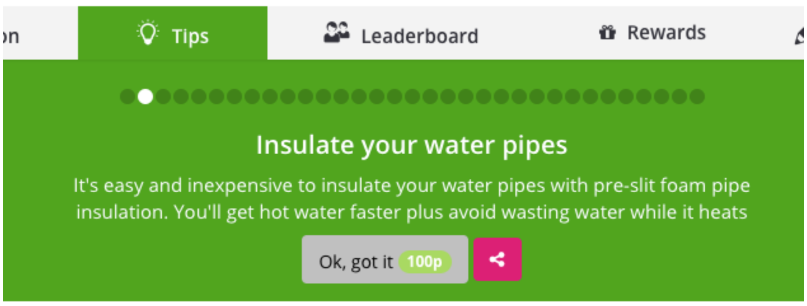


Figure 6: Tips page including sharing button.

Figure 7 and Figure 8 respectively show the new command that enables the user to share its status in the water saving community, using an email, Facebook or Twitter message, and the preview of the message that will be sent.

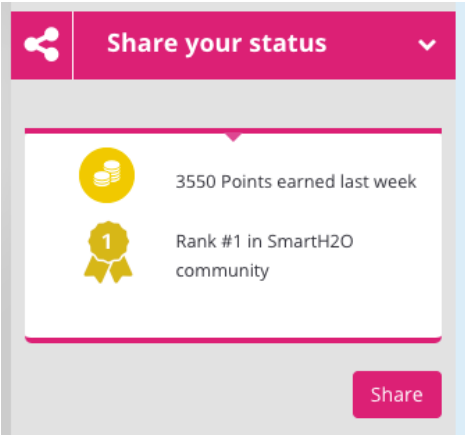


Figure 7: new achievement panel with sharing button.

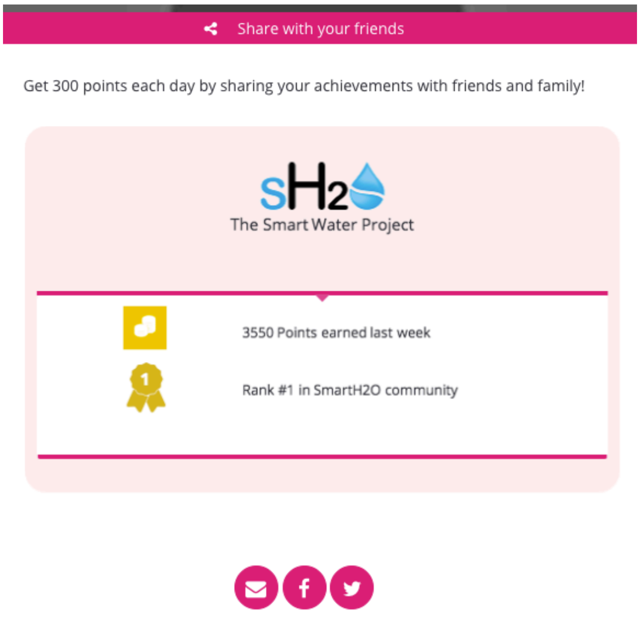


Figure 8: Popup for Sharing weekly achievements.

Figure 9Figure 6 and Figure 10 respectively show the new command that enables the user to share its status and goals in the water saving community, using an email, Facebook or Twitter message, and the preview of the message that will be sent.

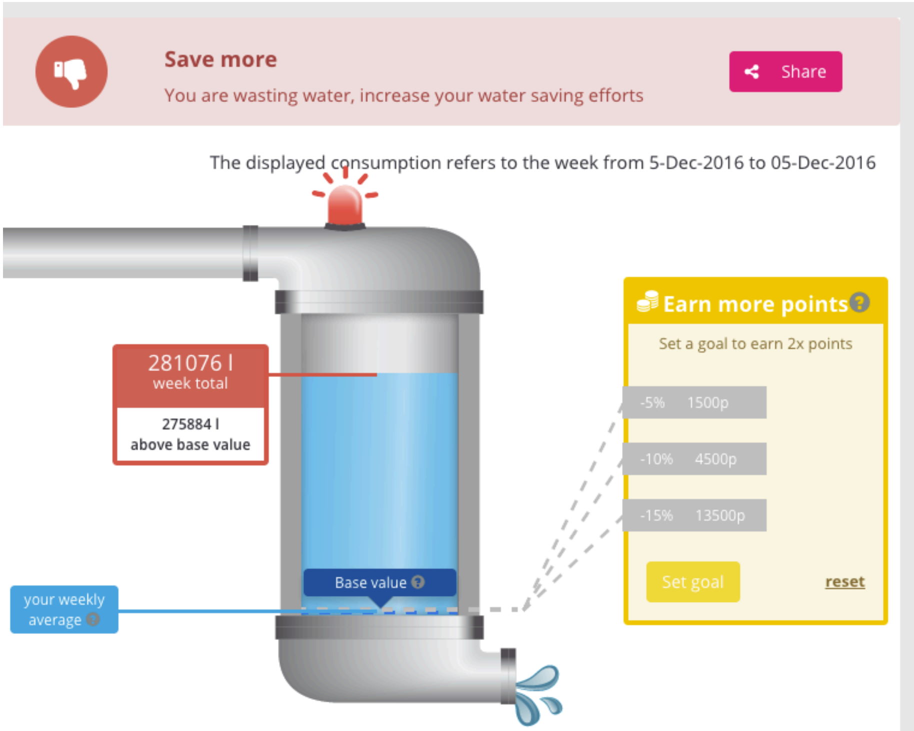


Figure 9: new version of the consumption overview including the goal/status sharing button.

Figure 10: Final post on Facebook.

Figure 11 shows a Twitter micro post from a user in the SmartH2O community in Valencia, advertising the water saving facilities provided by the Consumer Portal.

Figure 11: Final post on Twitter.

2.2 Neighborhood map

The last version of the Consumer Portal also included a new version of the peer comparison functionality, which allows the user to opt in by giving its ZIP code (Figure 12) and visualize its consumption together with that of the users in the same neighborhood in a map (Figure 13).

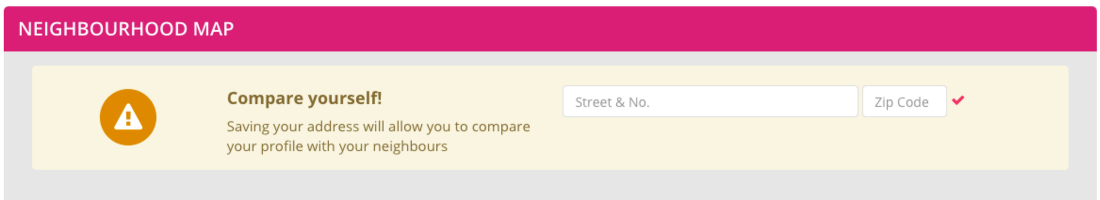


Figure 12: Invitation to partecipate to the Neighborhood Map.

The screenshot demonstrates that users need to explicitly provide their address before they appear on the map. This message also conveys how the provided address is used.

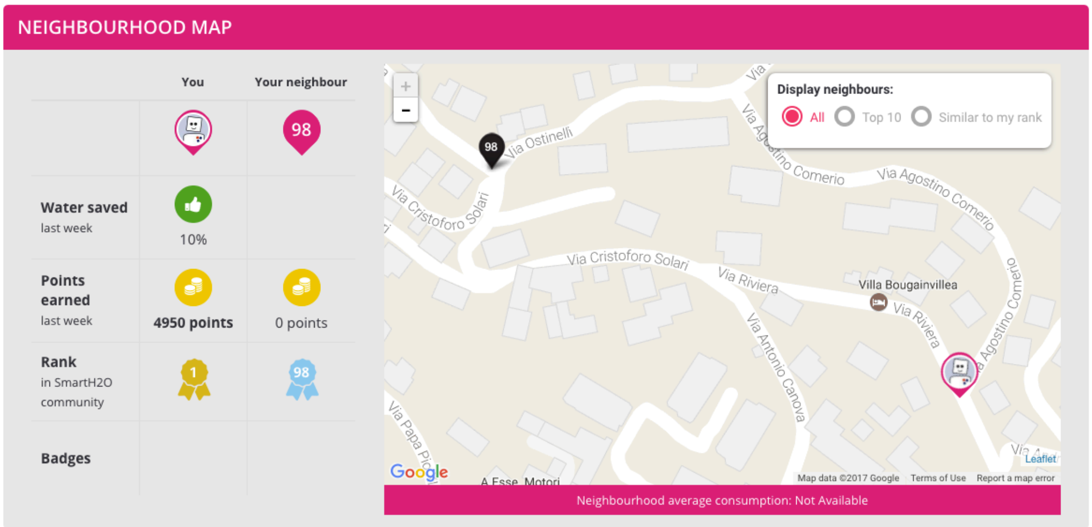


Figure 13. Neighborhood Map.

2.3 Weekly Reminders

Finally, the last version of the Consumer Portal also incorporates automatic messages sent by the platform to the users in order to engage them to be more active in the community.

Figure 14 and Figure 15 respectively show the messages that the systems sends to users that have been inactive and active in the past week.

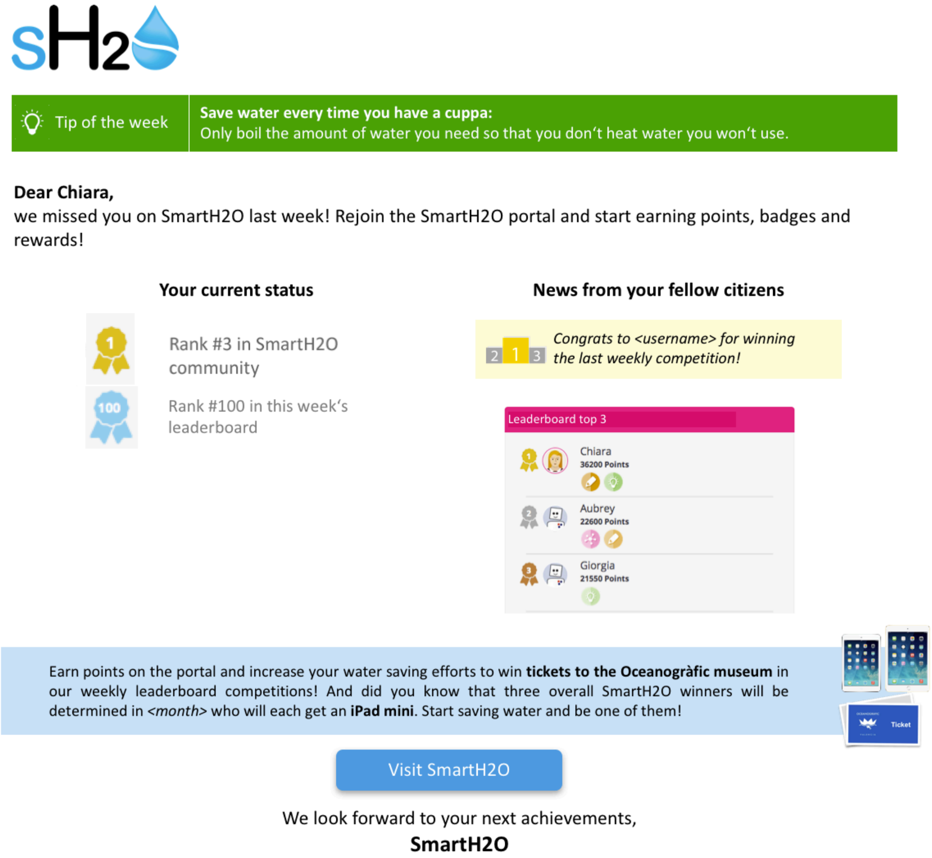


Figure 14: Comeback email sent weekly to user not active during the past week.

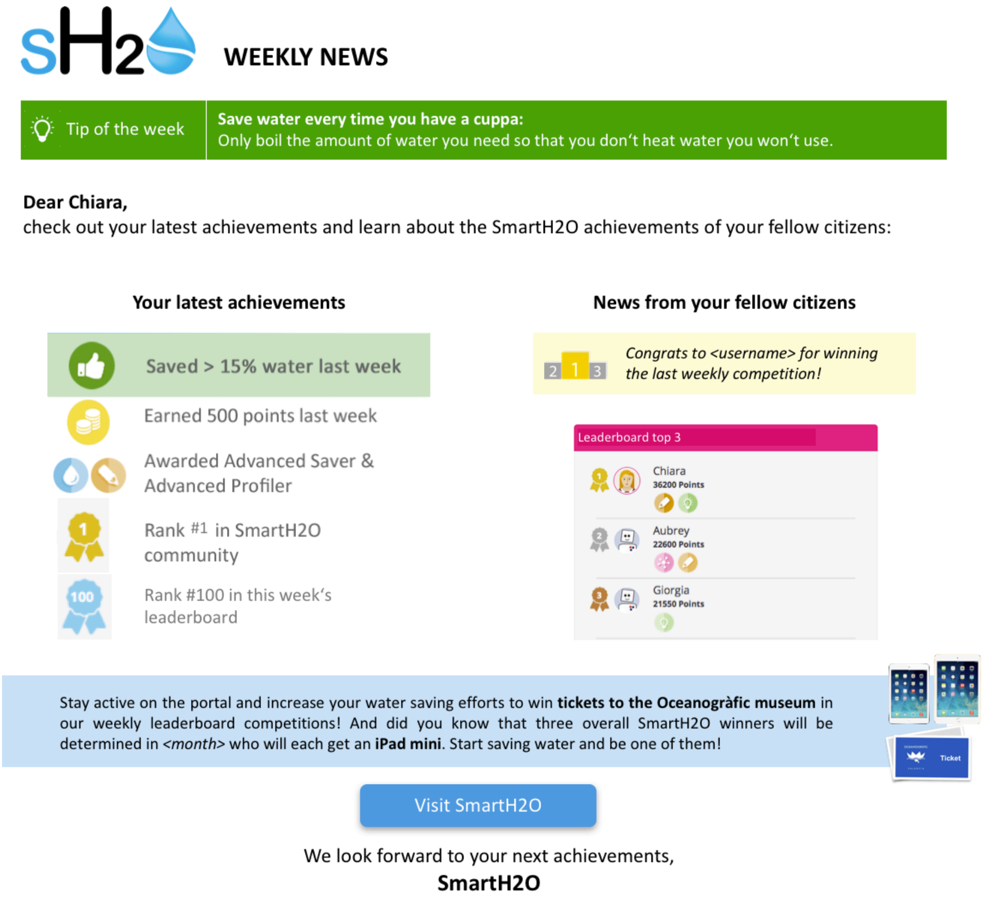
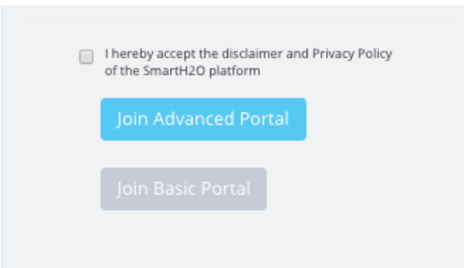


Figure 15: Weekly summary email sent to users active in the past week.

2.4 Privacy policies

2.4.1 Terms and conditions

At the time of sign-up, users must explicitly accept the terms and conditions.



The terms and conditions cover data storage, anonymized data processing, access of SmartH2O services to the data, use of the anonymized data for scientific purposes, and a statement that the data will not be shared with third parties.

The Terms & Conditions for the Swiss pilot are displayed in Figure 16, while the Terms & Conditions for the Spanish pilot are displayed in Figure 17.

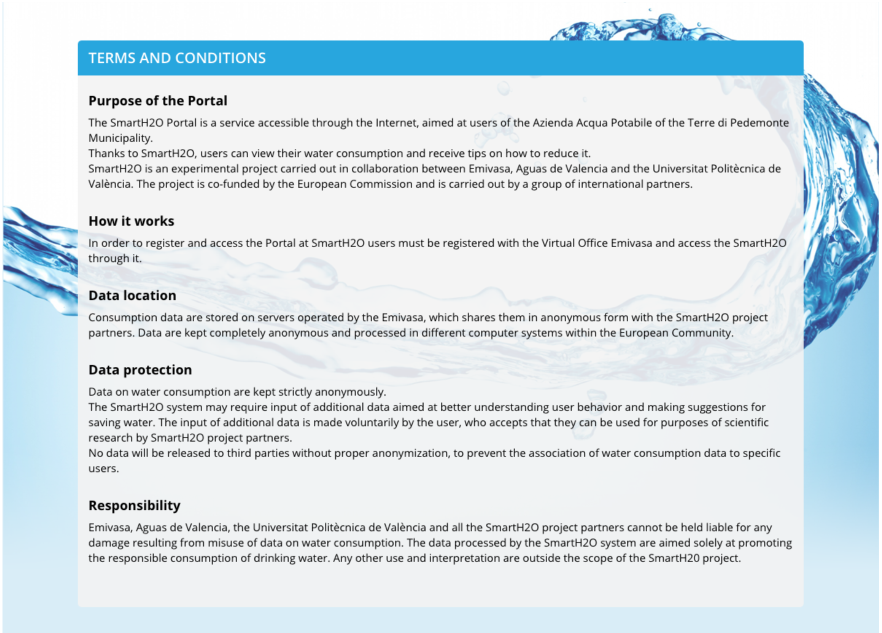


Figure 16. Terms and Conditions (Swiss pilot).

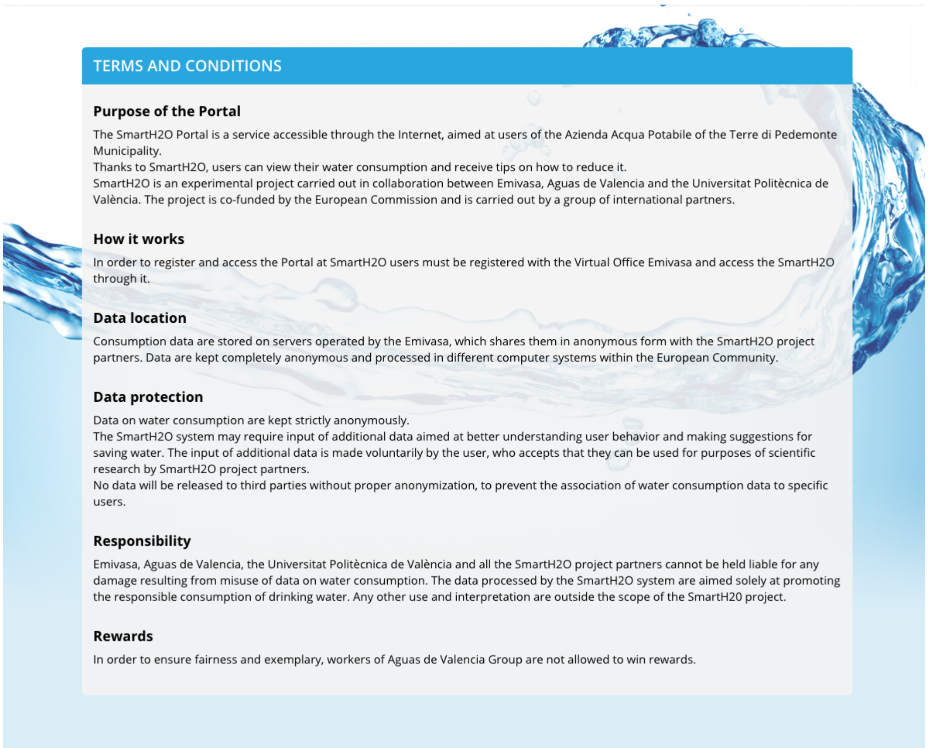


Figure 17. Terms and Conditions (Spanish pilot).

2.4.2 Pseudonymization of water consumption data

Data collected by the SmartH2O project potentially contains identifiers (which can be used to identify an individual) and quasi-identifiers (which in combination with other quasi-identifiers can be used to identify an individual). A secure process is therefore needed to maintain the anonymity of the users. The following steps describe the data workflow, that was set up to prevent users of the data to trace back the identity of the individual households:

1. Consumption and Features are read in structured datasets
2. The Meters IDs are remapped to new numerical values (pseudo-IDs), in order to suppress the original IDs
3. The Identifier and quasi-identifier are removed from the water consumption data. That is, attributes that can be traced back to individual households (such as the number of children) are removed from the dataset.
4. The anonymized dataset and the remapped IDs table are saved as CSV file type

A complete account of the data treatment has been published on Github: https://github.com/corradovaleri/smarth2o-anonymizer/blob/master/smarth2o-anonymizer.ipynb.

2.4.3 Neighborhood map

Exposing the user's address to other users by displaying the household's position on a map is a potential threat to the user's privacy. To mitigate the risk, an opt-in process has been put in place. That is, the user has to explicitly consent to making his address visible on the neighbourhood map, as shown in Figure 12 in Section 2.2. Furthermore, users can change whether they want to appear on the map at all times on the settings page (see Figure 18).

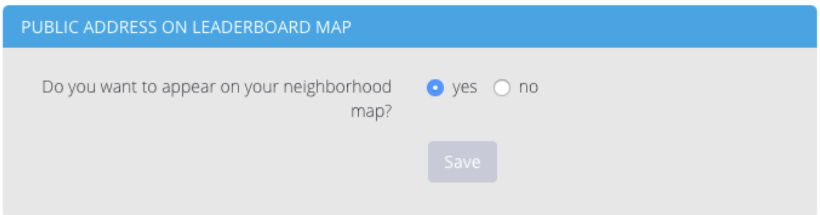


Figure 18. Opt-in/-out for appearing on the neighbourhood map.

3. Validation approach

This section describes the implementation of the validation methodology that has been described in *D7.1 Validation methodology* and elaborated and adjusted in *D7.2 Validation report*, after the introduction of the Spanish case study and the removal of the UK case study. The final KPI assessment reported in this deliverable has been done in line with the final approach described in D7.2.

The SmartH2O applications have been deployed and evaluated in two settings, one in Terre di Pedemonte, Switzerland, and one in Valencia, Spain. Whereas the Swiss pilot was set up to iteratively develop and test the application as well as the measurement infrastructure, the large-scale Spanish pilot was set up to assess the impact of the portal in a methodologically robust way, drawing on a large user base, and enabling the project to assess its KPI's. This section outlines the implementation of the methodology for the final evaluation.

3.1 Objectives of the final evaluation

The following objectives were defined for the final evaluation:

- *To assess the main KPI's in the project.*
  KPI's were defined in the DoW, and further elaborated in *D7.1 Validation Methodology*. This objective can be subdivided into:
  1. Large-scale assessment of the impact of SmartH2O portal and app on household water consumption behaviour.
  2. Large-scale assessment of the overall impact of using the SmartH2O portal on water consumption awareness.
- *To assess the SmartH2O incentive model by investigating the impact of using specific features in the SmartH2O on achieved water consumption reductions.*

Whereas the main focus of the final evaluation is on the large-scale Spanish pilot, the Swiss pilot results are also assessed, updating the findings and analyses reported in *D4.4 Final social game and implicit user information techniques* and *D7.2 Validation report*.

3.2 Validation method

This section summarizes the experimental set-up, the data collection, and the treatment of the data with respect to the users' privacy.

Experimental set-up and data collection

In each case study, data was collected for a SmartH2O treatment and a control group, differentiating a baseline, observation and post-trial period. The observation period for the water consumption data in the Spanish case study lasted from 1/06/2016 to 17/02/2017 and in the Swiss case study from 1/02/2016 to 17/02/2017.

After the observation period, questionnaires were distributed to collect user feedback on the portal as well as to assess awareness with respect to water consumption, while log analyses covering the time frame from the launch of the portal until the end of the observation period were conducted to assess usage of specific features and their impact on water consumption.

The control group in the Spanish case study was recruited by means of phone surveys. For these households, both consumption data (baseline and observation period), awareness data (baseline and post-trial) and socio-demographics (baseline) were collected.

For the control group in the Swiss case study, only consumption data was collected during the baseline and observation period. There, the control group was comprised of households in the same town who didn't sign up to the SmartH2O portal. As the focus of the pilot was on the testing of the application and the water measurements, no awareness measurements were taken, given this focus and the small size of the water consumption control group from which awareness questionnaire respondents would need to be recruited.

The methodology is summarized in Table 1.

Table 1. Summary of the SmartH2O validation methodology.

Case study	SmartH2O treatment			Control group		
	Baseline	*Observation*	*Post-trial*	*Baseline*	*Observation*	*Post-trial*
Swiss	Water consumption Awareness Socio-demographics	Activity log analysis Water consumption	Awareness Technology acceptance	Water consumption	Water consumption	N/A
Spanish	Water consumption Awareness Socio-demographics	Activity log analysis Water consumption	Awareness Technology acceptance	Water consumption Awareness Socio-demographics	Water consumption	Awareness

Water consumption analysis. Water consumption is evaluated over a baseline period, and then compared against the observation period. In the Spanish case study, the baseline period covered 1/06/2015 - 30/04/2016,and the observation period covered 1/06/2016 - 17/02/2017.

In the Swiss case study, the baseline period was 1/06/2015 - 31/01/2016 and the observation period covered 1/02/2016 - 17/02/2017. For the observation period, average daily water consumption is compared between control group and the SmartH2O group and between the baseline and the observation period. Methodological details will be provided in the next sections.

Water consumption awareness and sociodemographics. At sign-up, users fill out a questionnaire that is comprised of baseline water consumption awareness and selected socio-demographic questions (see Appendix A)

In September 2016, for both the Swiss case study and the Spanish case study an interim assessment of water consumption awareness was conducted (see *D4.4 Final social game and implicit user information techniques*). At the end of the observation period, users were asked again to respond to a 10-minute questionnaire. Post-trial data collection started on February 27th 2017, and lasted until March 16th 2017.

Drawing on the Theory of Planned behaviour [Ajzen, 1991], and its applications in the water domain (e.g. [Corral-Verdugo, 2003]; [Fielding et al. 2012]), the questionnaires measured beliefs, attitudes, subjective norm, perceived behavioural control, and behavioural intention with respect to water consumption. As such, these constructs operationalize awareness, in addition to single-item questions about estimated consumption levels, and environmental sensitivity.

Technology acceptance. Technology acceptance was assessed at two levels: at the level of the application as a whole, and at the level of individual features. Questions were introduced in the same questionnaire as used for the interim water consumption awareness assessment in September 2016, as well as the final evaluation reported in this deliverable.

Technology acceptance items addressed constructs of the UTAUT framework [Venkatesh, 2003], [Venkatesh et al. 2012]: performance expectancy (e.g. perceived usefulness), effort expectancy (e.g. ease-of-use), attitude towards technology (e.g. fun of use). The items on individual features allowed for the assessment of the success criteria introduced in *D2.2 Final requirements*. The complete set of questionnaire items can be found in Appendix A.

User log analysis. Every user-system interaction has been logged. The log analysis investigated the usage of individual features as well as the development of usage over time. Furthermore, the relationship between how often SmartH2O features are used on the one hand and awareness levels and water consumption reductions on the other hand were investigated, using correlational analyses. These analyses were done in order to assess the effectiveness of the incentive model that has been described in D4.3. As such analyses require a large number of users, only the Spanish case study could be used for this purpose.

Below we briefly summarize the implementation of the validation methodology that was addressed extensively in D7.2.

Privacy and data treatment

No sensitive personal data are collected through the questionnaires. Rather, they ask for opinions and attitudes with regard to water consumption behaviour and the SmartH2O system. Only generic personal questions were asked that taken together did not allow for the identification of an individual (e.g. gender, and educational level).

The treatment of the data was explained at the start of the questionnaire, as shown in Figure 19 (example from the questionnaire used in the Spanish pilot).

No hay respuestas correctas e incorrectas a las preguntas, sino que es su opinión lo que nos interesa.

Por favor, sepa que todos los datos que facilite serán tratados confidencialmente. Dado que este cuestionario es parte de un proyecto académico de innovación, la información extraída sólo será utilizada con fines académicos y no-comerciales. La empresa gestora del abastecimiento (Emivasa) únicamente recibirá información anónima de datos agregados.

Note that there is no right or wrong answer to the questions we will ask you. It is your personal opinion that counts!

Please note that all data you provide will be treated confidentially. As this questionnaire is part of an academic research project, the data will only be used for academic, non-commercial purposes. Your utility (Emivasa) will only receive the aggregated, anonymized results.

Figure 19. Data treatment explanation for questionnaire data.

Additionally, it was explained to the users that their SmartH2O user IDs were only used to link their questionnaire responses to the water consumption data. This was done through the a mapping of the user ID to the pseudonymized smart meter ID (as explained in 2.4.2).

3.3 Spanish case study

The Spanish case study is a large-scale deployment of the SmartH2O application as an extension of the 'Virtual Office' EMIVASA customers can already use. As such, it is a production-ready extension of EMIVASA's services to their customers. Therefore, the development process involved development-testing iterations (see D6.6 SW Quality Assessment Report).

The Spanish trial has been set up and promoted as two competitions, one for 2016 and one for 2017. At the end of each competition, the overall leaderboard top-3 users could win iPads (iPad Air 2 for first place and iPad mini 2 for second and third place). Additionally, every week a weekly winner was announced. The user that placed first on the weekly leaderboard (on Sunday at 23:59) received a ticket for the Oceaonogràfic Museum in Valencia (two tickets in the second competition round because the competition period was shorter).

In Valencia, an experimental design was used, with measurement moment (baseline, post-trial) as within-subjects factor, and platform usage (SmartH2O users vs. control group) as between-subjects condition. For SmartH2O users, response to the sign-up questionnaire was stimulated with awarding the first points. Control group users who responded to the survey could win 2 tickets to the Oceanogràfic museum in Valencia.

At the final evaluation, to incentivize users to fill out the questionnaire, a raffle was organized where respondents could win an iPad Mini 2. Additionally, each user received a €15 Amazon voucher. This incentive strategy was both necessary and successful. The vouchers were necessary not only to stimulate the response rate, but also to prevent a self-selection bias from distorting the results, as without the extrinsic motivation of a voucher typically only users who have a clear interest in SmartH2O would have responded to the questionnaire.

The questionnaire addressed water consumption awareness levels at the end of the trial, as well as the users' final impressions of the portal, both at the level of the application as a whole and at the level of individual features, covering the success criteria defined in D2.2. The focus of this questionnaire was on the impact of features on how often users think about water and on their motivation to save water.

3.4 Swiss case study

The small-scale Swiss case study was set up to test the platform deployment, measurement infrastructure and the SmartH2O incentive model.

For the assessment of the water consumption data, SmartH2O users were compared against a control group, consisting of households from the same town who did not sign up for SmartH2O.

Users could save points for selected water saving gadgets (see D4.3). User perceptions of the portal and water consumption awareness were evaluated at the following moments:

- At sign-up: water consumption awareness (continuous)
- Evaluation of the basic portal (October 2015, before the release of the advanced portal, see D7.2)
- Evaluation of the advanced portal (September 2016, see D4.4)
- Post-trial evaluation (February/early March 2017).

Following a similar incentive approach as in the Spanish case study, Swiss users responding to the post-trial questionnaire each received a 20CHF supermarket gift card and could enter a raffle to win one of three Amphiro b1 shower meters.

Similar to the Spanish case study, log data were also analysed. However, as a result of the small user base no correlational analyses were conducted to relate SmartH2O usage to awareness and water consumption behaviour.

4. Final results of the Spanish case study

The large-scale pilot in Spain was set up to systematically evaluate the KPI's with respect to water consumption, and awareness, as well as to assess the relationship between portal use and consumption. In this section we report the main findings.

4.1 Water consumption results

In this section, we validate the single-user behavioural modelling and agent-based modelling techniques we developed and exhaustively detailed in deliverable D3.4. The purpose of this validation on the two case studies of SmartH2O is two-fold. First, we aim at updating the validation of our models on data directly monitored for water consumers during the SmartH2O project. Second, our ultimate goal is exploiting the output of our models to assess whether any behavioural change occurred, in terms of water consumption, among those consumers who engaged with the SmartH2O platform (i.e., SmartH2O users), in comparison to those who did not (i.e., control group).

4.1.1 Baseline water consumption profiles

As a first step of our validation, we applied the hierarchical clustering procedure presented in deliverable D3.4 (see also Figure 20 below) for constructing single-user behavioural models of those customers of EMIVASA who subscribed to the SmartH2O web portal, in the Spanish case study. We considered data in the baseline period between 1/06/2015 and 30/04/2016 for model calibration and validation. In particular, we used 2/3 of this dataset (i.e., data between 1/06/2015 and 31/12/2015) for model calibration, and the remaining 1/3 for model validation (i.e., data between 1/01/2016 and 30/04/2016). The baseline period is chosen prior to the adoption of the SmartH2O web portal by EMIVASA's user, so that water consumers are not influenced by any demand management or behaviour change intervention and their consumption in a non-intervention period can be evaluated.

The dataset we considered includes 1-hour or daily resolution data for 206 users after data cleaning. This is quite a big reduction in terms of sample size, as we managed to consider only 206 users out of 525 users who registered to the SmartH2O portal. However, EMIVASA's meters and transmission infrastructure are not homogeneous, in terms of technology and sampling frequency. This hampers data quality and caused data from many users to be excluded from analysis after pre-processing, because of the following reasons: 72 users were found to have always zero consumption (i.e., probably due to meter errors), 5 had readings for less than 1 week time, 17 did not have data for either the baseline or the observation period, 174 did not have data either during the calibration or the validation period, and finally 51 did not have at least 2 weeks of data (and at least readings for each day of the week) during the calibration period.

Our thorough pre-processing procedure ensures that only cleaned and complete water use time series are considered for rigorous model building, calibration, and validation. Moreover, this data quality check constitutes itself a contribution to inform EMIVASA's about potentialities for data analytics on the considered sample of users: at the status quo, data with gaps and prolonged missing reading periods do have anyway a sufficient reliability for low-resolution applications (e.g., billing) but cannot be always considered reliable for high-resolution applications, i.e., monitoring users behavior and changes along time or anomaly identification (e.g., leak detection).

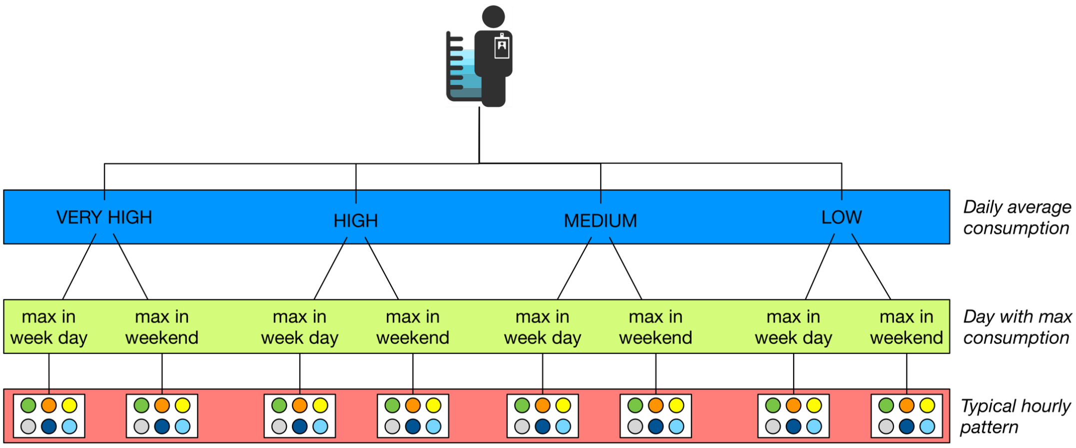


Figure 20. Hierarchical clustering procedure for the identification of consumption profiles.

According to the procedure adopted in D3.4 over a large sample of 20,000 users, also in this case we extracted 4 clusters computed on the average daily consumption of the considered EMIVASA users over the baseline period. Then, we partitioned each cluster in two subclasses depending on the day-label, i.e., weekend or weekday, depending on when water users usually consume the most. The resulting profiles, illustrated in Figure 21, show a good separation of the clusters and a good distribution of the users among the profiles, with the medium and low profiles containing more users than the high and very high ones.

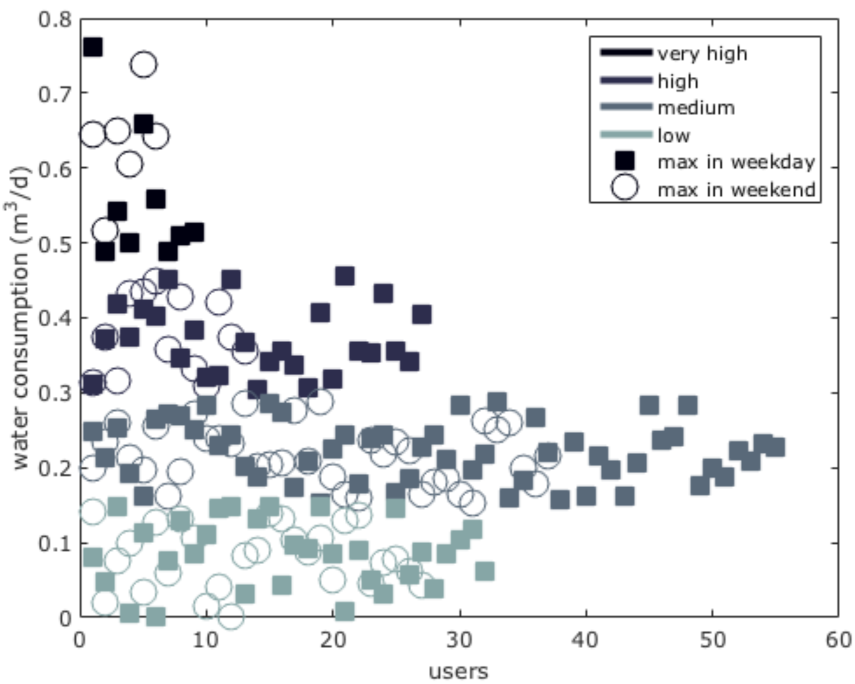


Figure 21. Daily consumption profiles of EMIVASA users.

Each profile is then modelled by estimating two probability density functions (assuming a normal distribution), the first for the daily consumption in weekdays and the second for the daily consumption in weekends. The statistics characterising the 8 probability distribution functions are reported in Table 2. As already found in D3.4, it is worth noting that the estimated standard deviations are, in most of the cases, larger in weekends than in weekdays due to more regular routines of the users during the week. In fact, during weekdays most users are likely to be at work during the central hours of the day and, consequently, their water consumption is concentrated in the morning and in the evening with consumption behaviours repeated almost equally every day at the same time.

Table 2: Statistics associated to the identified consumption profiles. All the values are expressed in m3/d.

Profile	M weekday	Std weekday	M weekend	Std weekend
Very high – max in weekday	0.5757	0.0847	0.5152	0.1140
Very high – max in weekend	0.6202	0.0722	0.6641	0.0751
High – max in weekday	0.3836	0.0470	0.3366	0.0557
High – max in weekend	0.3647	0.0480	0.4123	0.0671
Medium – max in weekday	0.2319	0.0421	0.1946	0.0394
Medium – max in weekend	0.2079	0.0399	0.2385	0.0439
Low – max in weekday	0.0930	0.0484	0.0679	0.0412
Low – max in weekend	0.0766	0.0386	0.0956	0.0534

From this statistical characterisation of the 8 consumption profiles, we finally model the single-user consumption behaviours by sampling the corresponding pdfs to generate a trajectory of daily water consumption for each user. Then, the generated trajectory is disaggregated from daily to hourly resolution by using the most typical load-shapes associated to each user. In total, we have identified 23 load-shapes, reported in Figure 22. Again, similarly to the findings of D3.4, most of the commonly adopted load shapes are characterized by a two-peak shape, with the late morning and evening peak. Moreover, high-frequency is obtained for the load shape characterizing days/houses with no or very low consumption all over day and night, ranked first in this case.

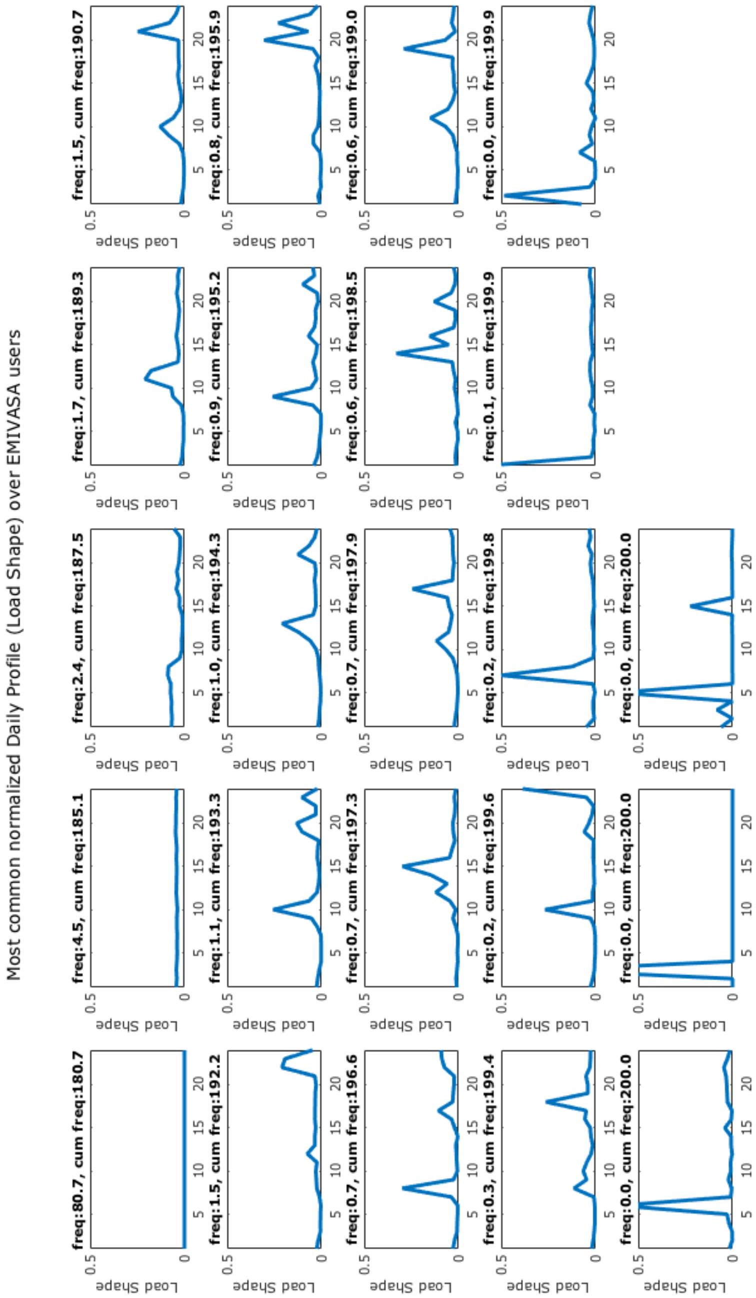


Figure 22. Set of load-shapes representing the typical hourly consumption patterns for EMIVASA users.

We evaluated the accuracy of the modelled single-user behaviours by comparing the simulated consumption against the observed one over the baseline validation period (1/01/2016 - 30/04/2016). Figure 23 shows that the distribution of the simulated daily consumption is close to the observed one, with a small overestimation of the very low consumers, and underestimation of very high consumers.

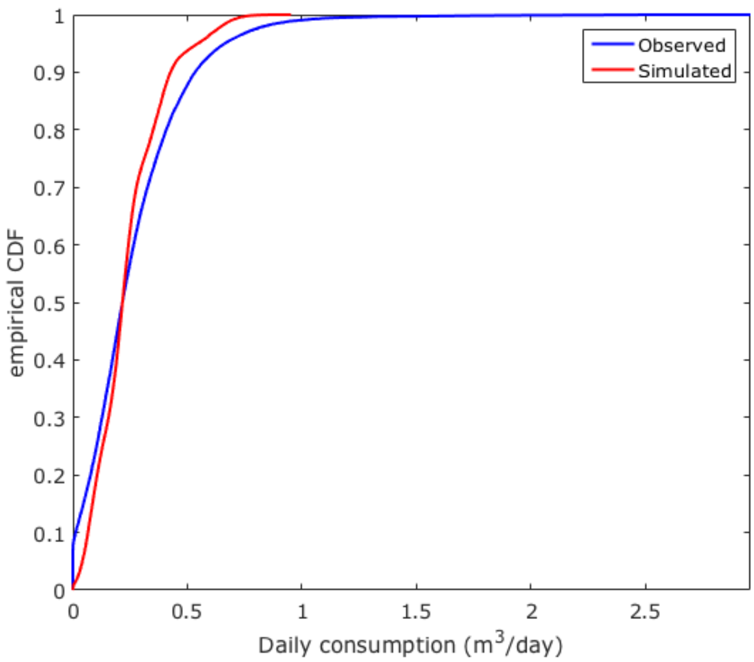


Figure 23. Empirical cumulative density function of daily consumption of EMIVASA users.

A more detailed comparison can be performed by comparing the empirical CDFs of simulated and observed consumption separated for weekdays and weekends, see Figure 24. Results show that our profiles successfully capture the differences in the users' behaviours: again, CDFs are well reproduced, apart from a small underestimation of high consumption levels, similarly to those presented in the paragraph above.

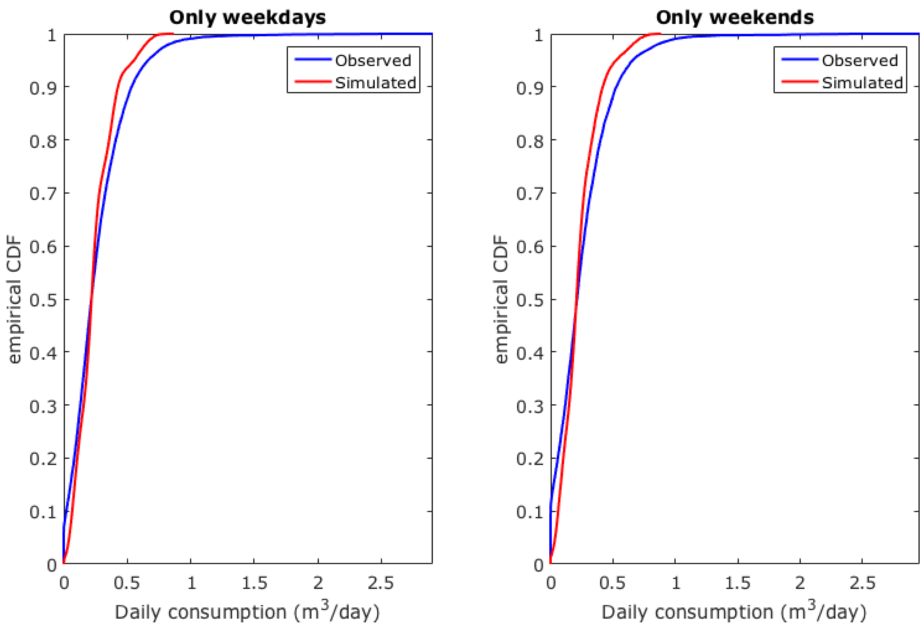


Figure 24. Empirical cumulative density function of daily consumption of EMIVASA users, estimated for weekdays (left panel) and weekends (right panel) separately.

Finally, we assessed the quality of our profiles in reproducing the hourly consumption patterns by comparing the empirical CDFs estimated on hourly consumption differentiated depending on different fractions of the days, specifically morning (i.e., from 5 to 9), middle day (i.e., from 10 to 16), evening (i.e., from 17 to 22), and night (i.e., from 23 to 4).[1] In this case, the accuracy is lower than that obtained in D3.4, because our model underestimates higher levels of consumption, regardless the time-of-day. This is likely due to the limited number of users considered for calibration, if we compare that number to the several thousand users included in D3.4 for model building and calibration, as well as differences in consumption between the calibration and the validation periods.

[1] Time intervals have been chosen consistently with those adopted in D3.4.

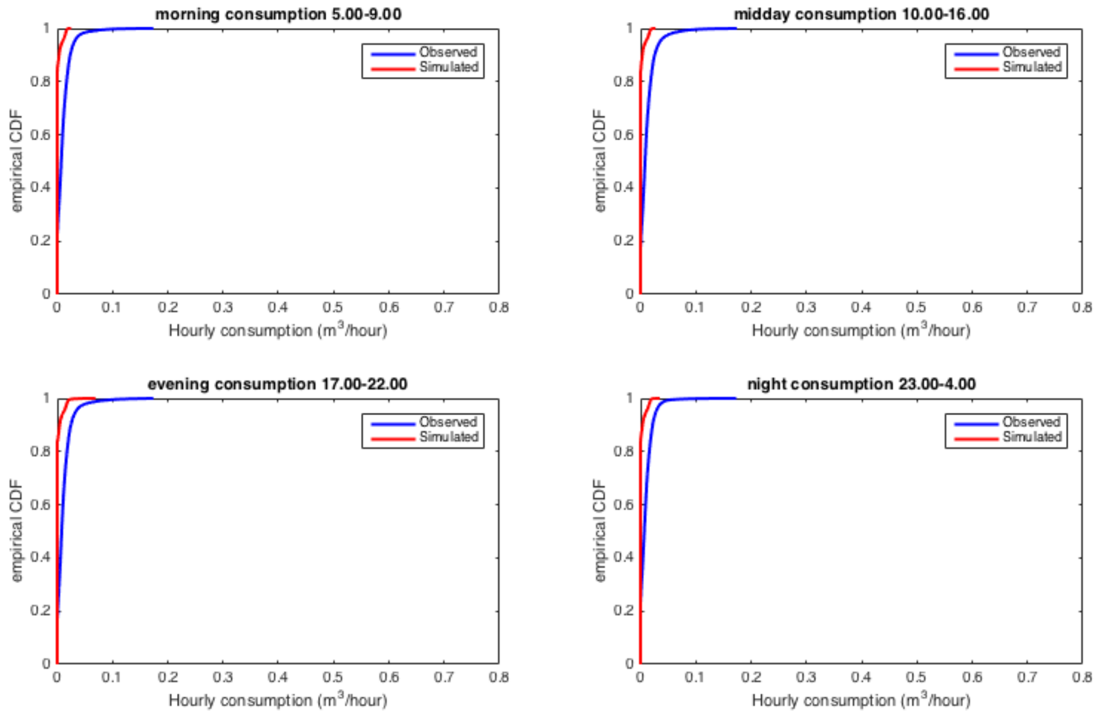


Figure 25. Empirical cumulative density function of hourly consumption of EMIVASA users, for different periods of the day.

4.1.2 Water consumption after SH2O portal signup

In order to assess whether EMIVASA users involved in the SmartH2O project modified their consumption as a result of adopting the SmartH2O web platform and app, we compared their distribution among clusters between the baseline period and the observation period, with this latter corresponding to the period following the introduction of the SmartH2O (1/06/2016 – 17/02/2017). For that purpose, we managed to increase the number of users considered in the comparison to 253 by including some with low data granularity that could not be considered for the hierarchical clustering. This latter indeed requires at least daily granularity to assess differences between weekdays and weekends. In addition, data were further cleaned by removing those users with unrealistic consumption change via Tukey's test for outlier removal [Tukey, 1977].

Apart from comparing water consumption changes in time, we also compared the distribution of consumption magnitudes between users adopting the SmartH2O platform and users from a control group, i.e., a group of 135 users (after data cleaning) who did not have access to the SmartH2O platform. These latter were not subject to behavioural change incentives, thus are suitable for benchmarking.

Results from the above comparisons are illustrated in Figure 26. The comparison is limited to the first level of hierarchical clustering, i.e., clusters of users are based on average daily consumption levels, because the granularity of users from the control group, often with lower sampling frequency than daily, could not allow for comparison based on consumption intensity during weekdays and weekends, or sub-daily consumption patterns.

These results show that, in general, the distribution of users among consumption clusters is comparable between SmartH2O users and control group users for the baseline period. In the observation period, instead, the distribution of SmartH2O users is slightly shifted towards the lowest consumption cluster, with a decreasing number of users in the highest consumption clusters (3,4), which suggest a decrease in the overall water consumption. Conversely, considering users in the control group, also their distribution shifts slightly towards lower clusters, but this shift is more directed towards cluster 2 (medium consumption level), rather than the cluster 1 (lowest consumption level).

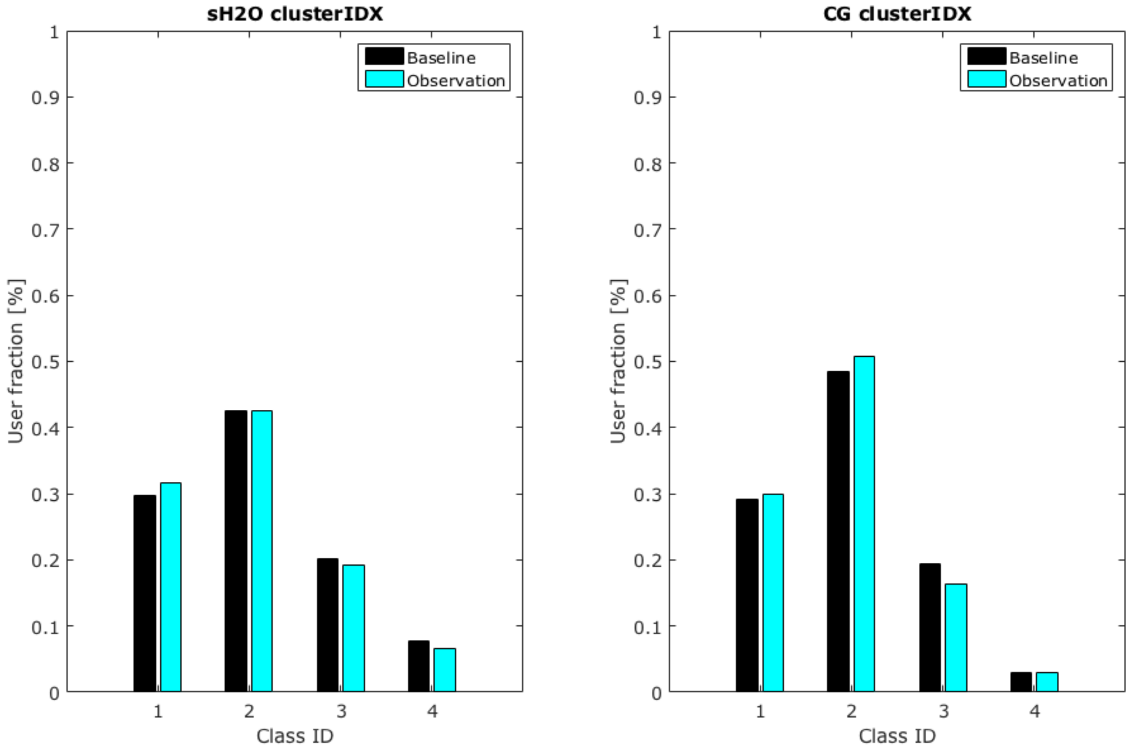


Figure 26. Distribution of users among clusters. SmartH2O users (sH2O) on the left, Control Group users (CG) on the right.

A more detailed overview of transitions among clusters for the SmartH2O users is reported in Table 3, where the percentage of users moving from one cluster in the baseline to another one in the observation period is reported. It is worth noticing that, in general, the tendency to remain in the original cluster is larger than that of changing cluster. Yet, percentages of users moving toward lower-consumption clusters are higher than those of users moving toward higher-consumption clusters. In particular, in terms of water saving we can observe a fairly high number of users (3.77% and 2.05%) moving from the baseline clusters 3 and 4 to the observation clusters 2 and 3, respectively.

Table 3. Matrix of transitions (%) of SmartH2O users among consumption clusters, between the baseline and the observation periods.

		OBSERVATION CLUSTER			
		1	2	3	4
BASELINE CLUSTER	1	27.40	5.82	1.03	0.34
	2	5.82	31.16	2.40	0.34
	3	0.34	3.77	13.01	1.37
	4	0.34	0.00	2.05	4.79

The effect of behavioural change, i.e., consumption change, are reported in Table 4 and Table 5. On average, SmartH2O users reduce their consumption in the observation period by 4.05% if compared to their consumption during the baseline. This implies an overall **reduction in volume of water used by over 5.6%**, and over 4.7% during the Summer peak-period. This is in line with other studies and, for instance, the results that WaterSmart Software obtained in California. As absolute values of water consumption, such percentages correspond to around 14.5 liters/day (this is approximately the volume of, for instance, two toilet flushes).

These results are very relevant for two reasons. First, the over 5% consumption reduction is in line with the literature and the KPIs of the SmartH2O project. Moreover, it becomes even more relevant considering that EMIVASA users, in general, have a very low consumption even in the baseline period (daily average equal to 258 liters/(user*day)). Second, if we compare this reduction to the increase in water consumption recorded by the users in the Control Group, the difference in percentage increases to over 10% along the full observation period as well as the Summer period.

A couple of additional comments can help better understand these results. First, the 17.66% increase in water consumption of the control group between baseline and observation period can appear very high, at a first glance. Indeed, we should keep into account that users in the control group showed, on average, a very low water consumption during the baseline period (192 liters/day against 258 liters/day for SmartH2O users). Therefore, the 17% increase computed with respect to this very low baseline consumption level corresponds to about 32 liters/day, which appears a more realistic value, also considering that most of this consumption increase occurred in Summer time (see Table 7, where an increase of about 25% is reported for that season. For the same period, SmartH2O users do not show significant behaviour change as % of individual consumption change: consumption increases in % by a value slightly larger than 0, but the cumulative effect is again a volume of water saved larger than 4%, as the percentage of reduction acts more powerfully for users belonging to higher classes of consumption). Summer 2016 (observation period) was indeed the driest since 1994 in Spain (both 2015 and 2016 among the 3 hottest). Second, keeping into account that the average consumption level for SmartH2O users was higher than the one in the control group during the baseline period, the 4.05% consumption reduction obtained for those users acquires even more value, as it is referred to a higher baseline value.

Table 4. Consumption change between baseline and observation period.

	Average per-capita % of consumption change from baseline	Total volumetric % of consumption change from baseline
sH2O users	-4.05	-5.66
Control Group	17.66	12.55

Table 5. Consumption change between baseline and observation during the summer (July - August) peak-period.

	Average per-capita % of consumption change from baseline	Total volumetric % of consumption change from baseline
sH2O users	0.47	-4.74
Control Group	24.94	3.36

4.1.3 Agent-based model simulation

In this section, we apply the agent-based model presented in D3.4 to the case study of

Valencia. First of all, we calibrate and validate the ABM with respect to the baseline water consumption data, defined accordingly to the previous sections (between 1/06/2015 and 30/04/2016). Thence, based on the previous step, we calibrate and validate the model with respect to the observed data after sH2O platform signup (between 1/06/2016 and 17/02/2017), and try to capture within the model the effect of the platform on water consumption.

***Modelling observed behaviour: the baseline period*.**

The single-user behavioural model described in Section 4.1.1 was run on the dataset collected by EMIVASA during the SmartH2O project over the baseline period (and thus prior to the adoption of the SmartH2O web portal by EMIVASA's user) between 1/06/2015 and 30/04/2016 for model calibration and validation. In this case too, we used 2/3 of the dataset (i.e., data between 1/06/2015 and 31/12/2015) for model calibration, and the remaining 1/3 for model validation (i.e., data between 1/01/2016 and 30/04/2016). The used dataset comprises water consumption readings 1-hour or daily resolution data for the same 206 users considered for the validation of single-user behavioural models.

During the initialisation process of the agent-based model, a household agent is generated for each of the 206 user. Based on the outputs generated by the single-user model, a consumption class C, a consumption profile class for the week-end P(1), and a consumption profile class for the week-days P(2) are associated to each household *H*. This triple (C, P(1), P(2)) constitutes the consumption profile of agent *H*.

We recall here the procedure for calculating the consumption from Section 4.3 of D3.4. Recall that each consumption class is associated to a probability distribution estimated from the available data to characterise the water consumption levels within each class. This is done by providing a partition of the consumption spectrum of the class in 10 bins, each characterised by a minimum value, a maximum value and a probability. Hence :

- Firstly, agent *H* verifies the type of day for the current day, i.e., week-day (2) or weekend (1). Based on this information (let's call the type of day D) and on its consumption class C, it determines the 10 bins and the associated probability distribution. It thence chooses accordingly a bin, and uniformly samples a value within the bin range. This value (X), (possibly multiplied by a seasonality factor), constitutes its daily water consumption.
- Secondly, the agent *H* has to determine the hourly distribution of its consumption, i.e., for each hour h, the percentage of X that it will consume during hour h of the current day. To do so, it considers the pair (D, P(D)) and determines the list of possible load profiles and the corresponding probability distribution accordingly. It thence randomly extracts a profile according to such distribution. The chosen profile will provide for each hour of the day the amount of consumed water during that hour.

The calibration of the model has been obtained with the seasonality factors set at 0. This contrasts with the calibration of the ABM in D3.4 with non zero seasonality factors. Notice however that the considered calibration period for D3.4 was longer and very different (January 2014-January 2016), thus comprising two full years of data, i.e., 8 seasonal changes. Moreover, the number of users retained after the pre-processing was much higher (over 11,000 users against the current 206).

Table 6 summarises the obtained results based on 25 simulations. The aggregated average value over the whole period is reported in the first column (standard deviation in the second column). The aggregated average daily consumption obtained from the observed data is reported in the third column. As reported in the fourth column, the % mean square error between daily water consumption as estimated at the Valencian district level by the agent-based model, and the observed water consumption during the calibration period corresponds to 1.29%.

Table 6. Aggregated results for the calibration of the ABM over the baseline period for the Spanish case study (1/06/2015 - 31/12/2015).

	Mean [m^3/day]	*Standard deviation*	*Average user daily consumption in Valencia [m^3/day]*	*MSE of daily consumption [%]*
June 2015-December 2015	0.2378	0.0032	0.2346	1.29

The performance of the model has been evaluated by considering the validation period ranging from 1/1/2016 to 30/4/2016 against the observed SmartH2O data for the same period. The tested model can therefore be seen as an input-output model based on the implementation of the single user. For the whole period we have computed the average aggregate daily water consumption. Table 7 summarises the obtained results based on 25 simulations. The aggregated average value is reported in the first column (standard deviation in the second column). This is compared to the average daily consumption obtained from the observed data (third column).

Table 7. Forecasting consumption results of EMIVASA users on the baseline period (1/1/2016 - 30/4/2016).

	Mean [m^3/day]	*Standard deviation*	*Average user daily consumption in Valencia [m^3/day]*	*MSE of daily consumption [%]*
January 2016-April 2016	0.2379	0.0032	0.2840	1.51

From Table 7, we have that the consumption forecast provided by the model is close to the real water usage. This is confirmed by the fact that the mean square error between daily water consumption as estimated at the Valencian district level by the agent-based model, and the observed water consumption during the validation period is small and corresponds to 1.51%.

Modelling observed behaviour: the period after sH2O platform signup.

The model obtained in the previous subsection has then been used to study the period following the introduction of the SmartH2O platform (1/06/2016 – 17/02/2017). As for the baseline period, the ABM has been calibrated and validated against observed consumption data for the same period described in Section 4.1.2.

To capture the influence of the use of the platform, in the ABM we have activated the boolean parameter E and the value prob(E) described in Section 4.2.3 of the D3.4: the parameter E captures the predisposition that a user, once on the platform, will start reducing its daily consumption, whereas the parameter prob(E) captures the probability that an agent will have such a predisposition once on the platform.

Because of of the limited possibility of social interaction of the platform and the fact that we are in the intervention period, we assume that there are no diffusion sub-modules: hence all users are on the platform, and the attitude towards reduction is completely determined by the initial Boolean value of E assigned to the agent with probability prob(E) when the model is initialised. Moreover, based on the finding of Section 4.1.2, we refine the consumption reduction function as follows. Instead of applying a simple reduction factor as done in D3.4, we use the transition matrix depicted in Table 5. Hence, we add the following pre-processing step before agent *H* starts the procedure for calculating the consumption described in the previous subsection:

- Assume parameter E of agent *H* has value true, and let C be the consumption class of *H*. Then with probability given by the value in cell (C,K) in the transition matrix of Table 5 (K=1,..4), agent *H* will be in class K during this turn and will calculate its consumption accordingly.

In the D3.4, for the Swiss case study, the value of prof(E) was established based on the results of the survey conducted in WP5 on SES. Due to the absence of such survey for the Spanish case study, we first study the performance of the model calibrated according to 10 different value of the parameter prob(E) on a period ranging from 1/06/2016 to 18/11/2016 against the observed data for the same period. Table 8 summarises the obtained results based on 20 simulations for each considered scenario (in first column are listed the different values assigned to prob(E)). The average values are reported in the second column, standard deviation in the third column. In the last column we compare the obtained results to the average daily consumption coming from the EMIVASA database of Valencia of users considered in Section 4.1.2 by reporting the % mean square error between daily water consumption as estimated at the Valencian district level by the agent-based model, and the observed water consumption during the validation period. Notice that the mean of the average observed daily consumption was of 0.2346 [m^3/day].

Table 8. Results for the calibration of the ABM on the period after the sH2O platform signup for the Spanish case study (01/06/2016 – 18/11/2016).

prob(E) [%]	*Mean [m^3/day]*	*Standard deviation*	*MSE of daily consumption [%]*
0	0.2377	0.0031	1.15
10	0.2363	0.0037	1.15
20	0.2351	0.0042	1.15
30	0.2337	0.0042	1.15
40	0.2324	0.0047	1.15
50	0.2312	0.0050	1.19
60	0.2307	0.0053	1.19
70	0.2298	0.0057	1.19
80	0.2276	0.0058	1.24
90	0.2264	0.0060	1.24
100	0.2255	0.0064	1.24

From Table 8, we see that the variation interval of the % MES value among the ten different scenarios is very small. This is consistent with the values of the transition matrix, but also with the fact that, as shown in Figure 26, there is little variation of the distribution of users among clusters from the observation period to the intervention period in the case of SmartH2O users.

The performance of the model for all ten possible scenarios has then been tested against the observed data in Valencia during the period 19/11/2016-13/02/2016.

Table 9 summarises the obtained results based on 20 simulations for each scenario and compares them to the aggregate average daily consumption obtained from the data coming from the EMIVASA database of Valencia (fourth column). The mean of the observed average daily consumotion was of 0.2740 [m^3/day]. Table 9 shows that, considered the overall complexity of the case study, the consumption forecasts provided by the model are in all scenarios close to the real water usage.

Table 9. Forecasting consumption results of EMIVASA users on the period after the sH2O platform signup (19/11/2016 – 13/02/2017).

Prob(E) [%]	*Mean [m^3/day]*	*Standard deviation*	*MSE of daily consumption [%]*
0	0.2376	0.0032	1.09
10	0.2363	0.0035	1.13
20	0.2351	0.0041	1.17
30	0.2335	0.0044	1.20
40	0.2328	0.0049	1.24
50	0.2314	0.0050	1.28
60	0.2308	0.0052	1.28
70	0.2297	0.0056	1.31
80	0.2277	0.0058	1.39
90	0.2265	0.0060	1.42
100	0.2252	0.0064	1.50

From Table 9, we see that, analogously to the calibration, the variation interval of the MSE is small. Moreover, for all values of prob(E) the corresponding % MSE is always not greater than the 2%.

4.2 User base and questionnaire response

At the end of the trial, 508 users have signed up for the portal. In this sub section we characterize the users, and describe the response of these users to the final evaluation questionnaire.

Characteristics of the complete user base

Users were encouraged to provide information about their household through a gamified user profile page within the portal (see D4.3). Information was used for the agent-based modelling (see section 4.1), as well as to be able to characterize the user base. In Table 10, the main results are summarized.

Table 10. User profiling results: characteristics of the SmartH2O users.

Characteristic*	**Mean / % / *f***
Type of house	
% flat % Single-family % other	88.1 7.6 1.1
Household composition	
No. of adults % with 1-2 adults % with 3-4 adults > 4	 80.2 18.0 8.0
% with no children % with children	45.0
Children < 4 years old % with 1-2 children % with 3-4 children	16.5 1.1
Children between 5 and 9 years old % with 1-2 children % with 3-4 children	21.2 .4
Children > 9 years old % with 1-2 children % with 3-4 children	25.2 1.5%
House ownership % no % yes	 21.9 75.2

* Numbers do not add up to 100%, as not all users have completely filled out the profile.

As can be seen from Table 10, the user base primarily consists of users who live in a flat, consistent with the Valencian population at large (see D7.2). Additionally, the vast majority of the users live with one to two adults. Users with (45.0%) and without children are almost evenly spread.

User responses to questionnaire

Water consumption awareness and user perceptions of the SmartH2O portal and mobile applications were collected by means of questionnaires, as explained in Section 3. In * **Response** rates are calculated relative to the total user base (n=508).

we first provide statistics of the responses to the questionnaire, before addressing the results in the subsequent sections.

Table 11. Summary of response rates.

Condition	User base	Pre-trial		Post-trial	
		n	*Response rate (%)**	*n*	*Response rate (%)**
Control group	N/A	204		82	
SmartH2O	508	452	89.0	94	18.5
Of which:					
• Response to both baseline and final questionnaire				83	16.3
• SmartH2O app users	42			31	73.8
• Drop! The question users	23			13	56.5

* Response rates are calculated relative to the total user base (n=508).

Whereas in customer satisfaction studies online questionnaires typically yield response rates well below 10%, the response rate for the SmartH2O questionnaires has been substantially higher. The sign-up questionnaire resulted in a response rate of 89.0%. This can be attributed to the questionnaire being presented to the users as a logical final part of the sign-up process.

The high response rate of 18.3% to the final questionnaire can be attributed to the combination of different incentives extrinsic to the use of the portal (e.g. the iPad Mini raffle and the Amazon vouchers). These incentives not only stimulate the response rate but also reduce the selection bias in the results, which is typically the result of more active users participating in surveys, compared to users with limited or no activity. Note that the cross-section between the pre-trial and post-trial respondents is rather high (83/94), which suggest that SmartH2O has been successful in avoiding high drop-out rates – a common pitfall of longitudinal questionnaire-based research.

To estimate the comparability of the control group and the SmartH2O group with respect to baseline consumption, an independent samples t-test was run on the average baseline consumption for questionnaire respondents in the control group and the SmartH2O group. No significant differences between the groups were found (t(108)=-1.21; p=.23; n.s.), suggesting that the starting point at the beginning of the trial has been similar for both groups.

Furthermore, environmental attitudes were assessed, as this could affect the potential awareness increase that can be achieved through SmartH2O, assuming that stronger environmental attitudes are related to higher awareness levels. For users with strong environmental attitudes and engagement with environmental issues an increase in awareness is more difficult to achieve than for users who are less engaged with environmental issues. Environmental attitudes were assessed using a one-item Likert scale ranging from ‘Very unconcerned about the environment’ (1) to ‘Very concerned about the environment’ (5). Results are depicted in Table 12.

Table 12. Environmental attitudes.

Condition	Mean	S.d.

Control group	4.3	.61
Smart H2O group	4.4	.59
Total	*4.3*	*.60*

Results demonstrate strong environmental attitudes for both the control group and SmarH2O group, with small differences between users (judged from the low standard deviations). A univariate analysis of variance demonstrated that the difference between the two conditions was not significant ($F(1, 162)=2.05$; $p=.16$).

4.3 Water consumption awareness results

Water consumption awareness has been defined as a KPI, based on the assumption that awareness is a predictor of water saving behaviour. Awareness has been operationalized into determinants of water consumption, based on the Theory of Planned Behaviour (Ajzen, 1991). To assess the effects of using the SmartH2O portal and applications, beliefs, attitudes, social norm, and perceived behavioural control were measured both at sign-up, and after the use of the portal. At the start and the end of the trial, a control group answered the same questions. For the attitudes towards water consumption, and the behavioural intention, items were averaged as these constructs displayed satisfactory internal consistency (attitudes: $\alpha=.67$, intention: $r=.61$). For perceived behavioural control (1 item), beliefs (4 items) and the social norm (3 items), results are reported per item.

For each of the awareness measures, analyses of variance were run with a general linear model - repeated measures design, with time (baseline vs. post-trial) as the within-subjects factor, and condition (control group vs. SmartH2O group) as a between-subjects factor.

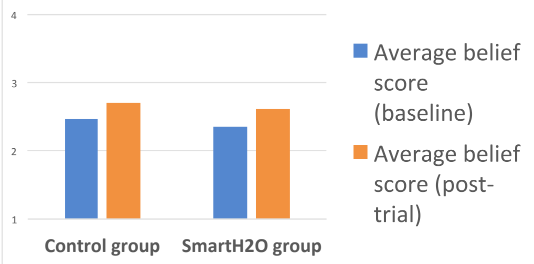
Results should be cautiously interpreted, as users in the SmartH2O group differ in activity level and sign-up date, which could affect the outcomes. Further inspection of the relationship between awareness and the usage of the platform is therefore required. In Section 4.5 we will correlate the use of platform features to the awareness constructs. Such correlational analyses provide insight into the contribution of individual elements from the incentive model to user awareness on water consumption. Furthermore, most likely as a result of the strong environmental attitude, attitudes towards water saving, behavioural control, and expectations of people to save water all received high average baseline scores of less than one point below the scale maximum, which potentially limits the potential contribution of SmartH2O to these measures.

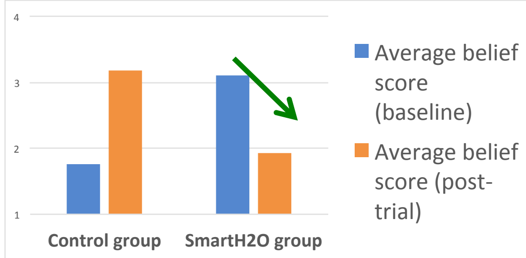
Before analysing the data for each of the constructs, outliers were removed, defined as those cases where the difference between the baseline and post-trial score exceeded the average plus or minus two times the standard deviation. Furthermore, for the SmartH2O group, users who have only registered and not logged in afterwards were excluded.

4.3.1 Beliefs about water consumption

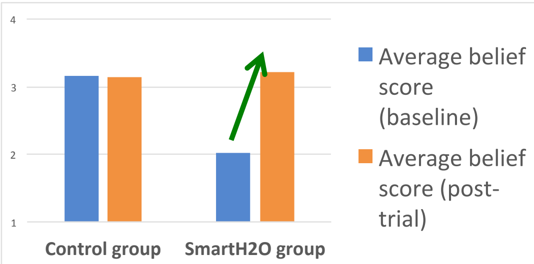
Beliefs about water consumption were measured with a four-point Likert scale ranging from completely disagree (1) to completely agree (4). The averages for the items are displayed in Figure 24.

TPB-beliefs: science surely will solve the problem of water scarcity.	TPB-beliefs: drinkable water is an unlimited resource.





TPB-beliefs: drinkable water will exhaust very soon if we do not save it.



TPB-beliefs: a way of preventing water exhaustion is using it when absolutely necessary.

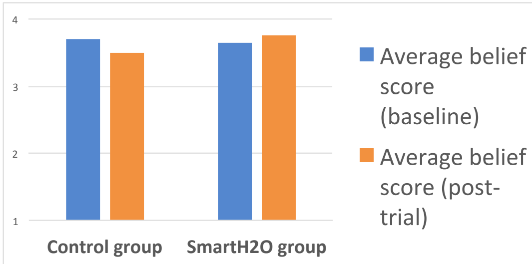


Figure 27. TPB - Average scores for beliefs about water consumption.

A GLM repeated measures analysis was performed to test the differences between conditions and between baseline and post-trial measurements that can be observed from the graphs. The results are shown in Table 9.

Belief	**F-score**	**p**
Science surely will solve the problem of water scarcity.		
• Time	3.61	.059
• Time * Condition	.96	.329
Drinkable water is an unlimited resource.		
• Time	1.05	.308
• Time * Condition	138.77	**.000**
Drinkable water will exhaust very soon if we do not save it.		
• Time	38.58	.000
• Time * Condition	41.91	**.000**
A way of preventing water exhaustion is using it when absolutely necessary.		
• Time	.18	.670
• Time * Condition	7.13	**.008**

Table 13. Statistical results for TPB - Beliefs.

The analyses demonstrate that after the trial, in comparison to the control group, beliefs about water and water saving have improved. The results show that SmartH2O users think less of water as an unlimited resource, think more often that saving water is necessary to prevent exhaustion, and that using water only when necessary is a good strategy to prevent exhaustion.

4.3.2 Attitudes towards water saving

The attitudes towards water saving were assessed using four semantic differentials, with the negative anchor (e.g. harmful) having the lowest value (1) and the positive anchor (e.g. valuable) having the highest value (5). The results are displayed in Figure 28.

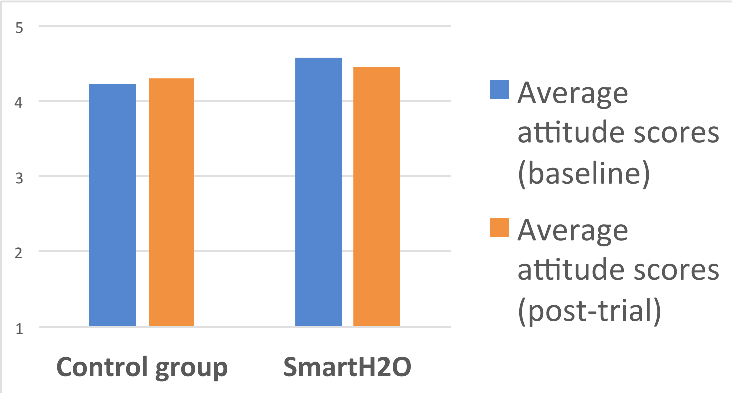


Figure 28. Average scores for the TPB - Attitudes scale.

The repeated measures analysis revealed that the results were not significant for neither the main effect of time (F(1, 143)=.132; p=.72), nor for the interaction between time and condition (F(1, 143)=2.95; p=.09). Further inspection of the data in relation to the usage of the platform is required to explain the absent interaction effect. More specifically, correlational analyses are required to assess the influence of duration of platform membership, and number of logins, as well as the usage of specific features on the difference between baseline and post-trial attitude measurements. Furthermore, as explained at the start of this section, a ceiling effect could have occurred, considering the high average scores at the baseline measurement.

4.3.3 Perceived behavioural control over water consumption behaviour

Perceived behavioural control is measured with a single five-point Likert scale (“I am confident that I could save water”), ranging from completely disagree (1) to completely agree (5). The average results are depicted in Figure 29.

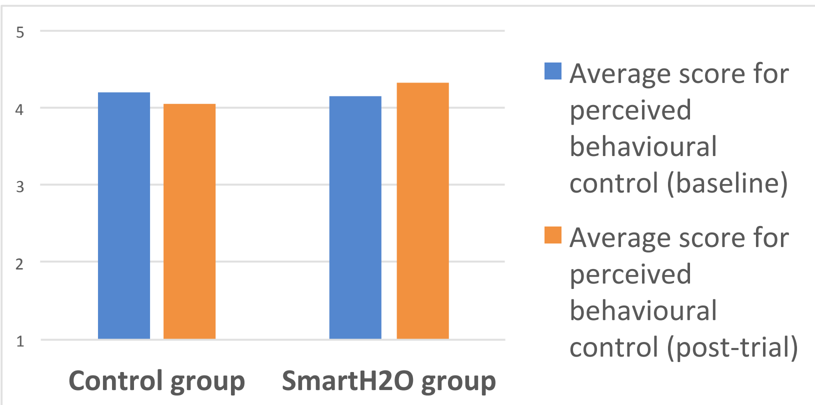


Figure 29. Average scores for TPB - Perceived behavioural control.

A GLM repeated measures analysis revealed that there was no main effect of time (F(1, 132)=.05; p=.82), but that the interaction between time and condition was significant (F(1, 132)=4.58; p=.034). From this result it can be concluded that SmartH2O users feel more confident about their ability to save water than users in the control group, and the change over time is different between both conditions. This result provides evidence for the effectiveness of the incentive model to stimulate behavioural control through water saving tips.

4.3.4 Subjective norm

The subjective (or social) norm was, in line with the TPB model (Ajzen, 1990), measured in order to assess the influence of the social environment on people's intention to save water. The incentive model leverages the potential of social comparison to change the subjective norm in favour of water saving behaviour. However, the related platform features were released on February 14th (social sharing, map-based comparison of achievements with neighbours). As the time span between the release of these features and the final evaluation questionnaire is relatively short, it cannot be expected that the subjective norm has significantly changed over that time. Nonetheless, the final questionnaire measured the subjective norm with three five-point Likert-scale items. The results are displayed in Figure 30.

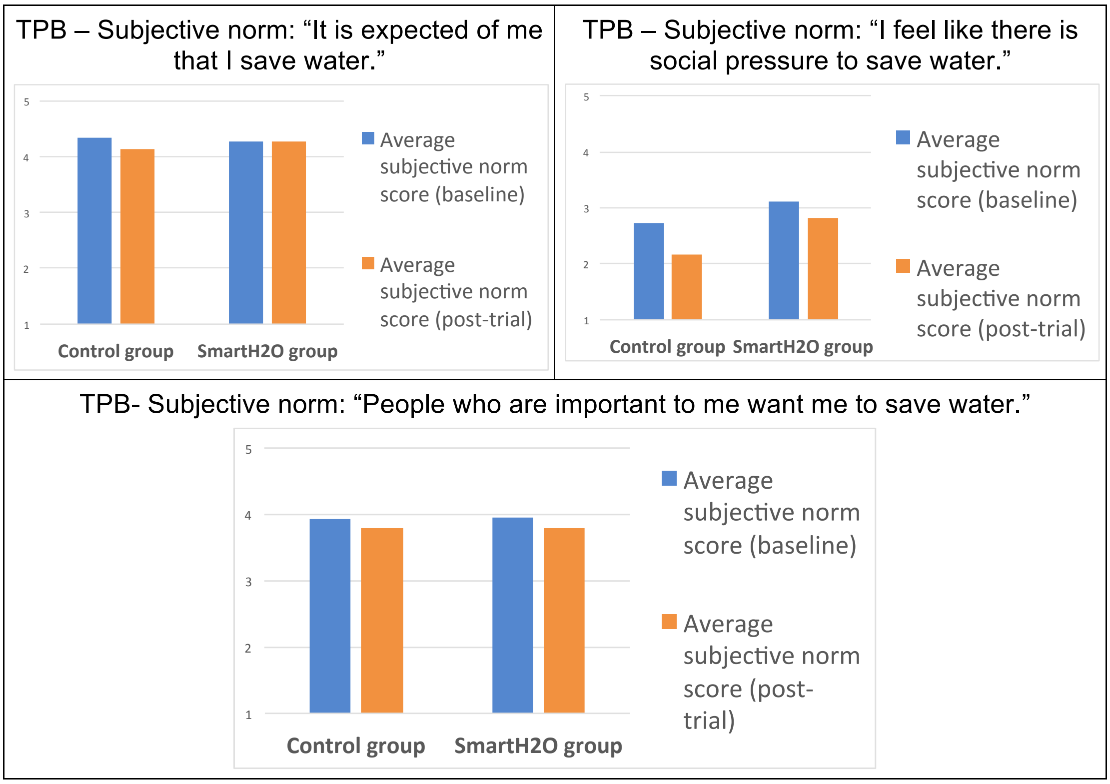


Figure 30. Average scores for the TPB-subjective norm scores.

The GLM - repeated measures analyses confirmed the expectation that across the three items little to no significant interaction effects were found between the time and condition ($F(1, 147)<2{,}06$; n.s.). However, for the social pressure item, a significant main effect of time was found ($F(1, 147)=18.23$; $p=.000$), with the post-trial measurements being significantly lower than the baseline averages.

Even though the social features have only been available for a relatively short time, the log analyses for the social features and user feedback from the final questionnaire can provide an initial indication of the effectiveness of these features in making use of social pressure to induce behavioural change.

4.3.5 Behavioural intention

Behavioural intention was measured using two five-point Likert scales from strongly disagree (1) to strongly agree (5). The values for both items were averaged. In Figure 31 the scale averages are displayed.

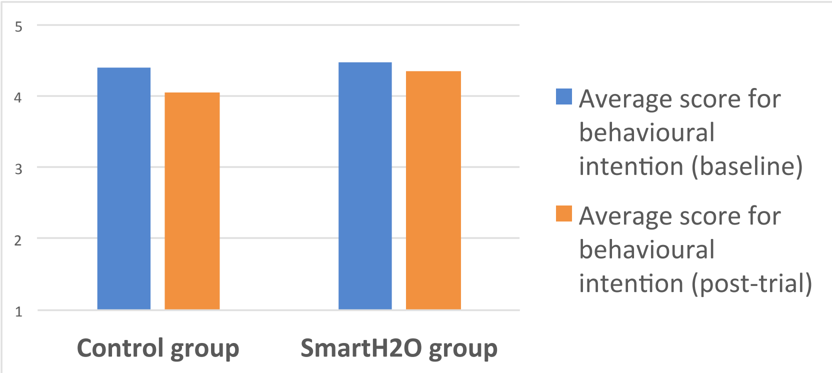


Figure 31. Average scores for TPB - Behavioural intention.

For both the control group and the SmartH2O group the behavioural intention is lower after the trial in comparison to before the trial, with the decline in intention seeming smaller in the SmartH2O group. The GLM repeated measures analysis however demonstrated that only the main effect of time was significant ($F(1, 141)=7.12$; $p=.009$). This was not the case for the interaction effect between time and condition ($F(1, 141)=1.74$; $p=.190$). The significant main effect of time suggests that influences outside the realm of the project have affected the behavioural intention to save water for both control group and SmartH2O users.

The absence of an interaction effect could be due to a ceiling effect. The SmartH2O users had a high behavioural intention at the baseline, with little variation between users ($M=4.5$; $s.d.=.53$). Further increase of the behavioural intention in such cases is difficult, given the well-known tendency of respondents to avoid the extremes of a scale (in this case 5, or 'strongly agree').

However, further analysis of the data is required to understand the relationship between usage of the SmartH2O applications and the baseline vs. post-trial difference in behavioural intention to save water. This will be addressed in Section 4.5.

4.4 Technology acceptance results

4.4.1 Technology acceptance at the application level

Technology acceptance at the application level was measured using the established UTAUT framework [Venkatesh et al., 2003]. In this final evaluation, performance expectancy and attitude toward using the technology were assessed to be able to account for temporal influences since the intermediate evaluation reported in D4.4. Social influence was measured as well and is reported in section 4.3.

Effort expectancy (usability) and Hedonic quality stimulation vs. pragmatic quality [Hassenzahl, 2004] have already been reported in detail in D4.4 and were omitted in the final questionnaire since no temporal effect is expected to occur.

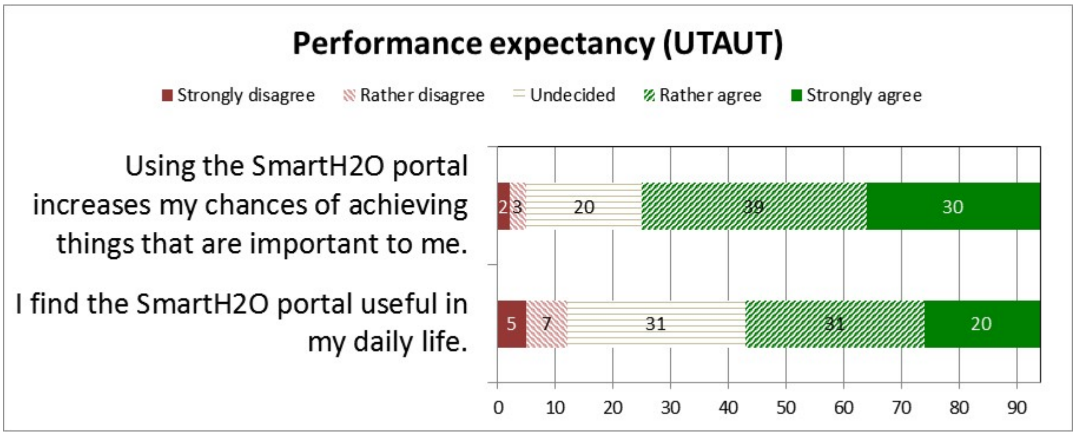


Figure 32. Spanish web portal (N=94): Performance expectancy (UTAUT).

Most users assess performance expectancy positively to very positively (Figure 32). 73% of users find that the Smarth2O portal increases chances of achieving things that were important to them. More than half find the SmartH2O portal useful in their daily life, while only 12% don't.

A third of users are undecided towards the usefulness of the portal in their daily life. This raises the question about the level of expectation from the side of the user. As water is considered a commodity that users take for granted, users are most likely not that much engaged that they will perceive the SmartH2O portal to potentially support achieving things important in daily life. Interestingly, still 51% of the users agree with this statement, which can be considered an indication of the effectiveness of the incentive model to intrinsically motivate a significant share of the users.

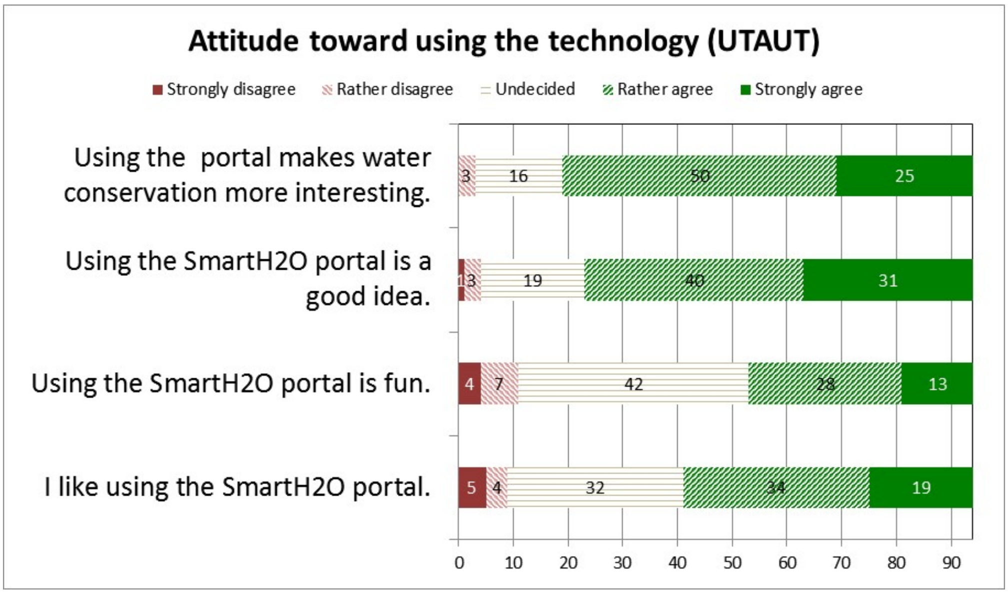


Figure 33. Spanish web portal (N=94): Attitude toward using the technology (UTAUT).

Users also express a positive attitude toward using the technology (Figure 33). Nearly 80% of users think that the portal makes water conservation more interesting and that using it is a good idea.

43% think it is fun to use, while just as many are undecided. More than half of the users like using the portal but again a fairly large percentage is undecided. This could indicate that while users do think that it is a good idea and interesting to use the portal, the utilitarian aspect of the topic of water saving prevails for those users, whereas for other users the hedonic qualities of the portal are equally well-received. This is in line with the results from D4.4, where a more in-depth comparison of hedonic vs. pragmatic quality of the portal was reported. There, the hedonic quality stimulation of the portal was assessed only slightly lower than pragmatic quality. On the other hand, more common water utility customer portals such as the virtual office in Valencia, in which customers are merely looking at their bills, only offer pragmatic qualities. The SmartH2O portal shows that even water utility portals can introduce hedonic qualities, which, in return, make water conservation more interesting.

It was also found that environmental sensitivity was related to the users liking the use of the portal ($r(95)=.24$; $p=.02$), while the correlation with the average attitude towards technology scale score approached significance ($r(96)=.20$; $p=.053$), which, in line with technology acceptance research [Venkatesh2003, 2012], suggests that users with stronger environmental attitudes are more inclined to like and subsequently use the portal.

To further explain the results on performance expectancy, and attitude towards technology the average scores on these subscales were correlated to the average usage of the different features in the portal. In the correlation between the average number of times a feature was used per month of platform membership on the one hand and performance expectancy and attitude towards technology on the other hand is displayed.

Platform usage indicator	**Corelation with**			
	Attitude towards technology		*Performance expectancy*	
	r*	p	r*	p
Average no. of logins per month	.21	.04	.22	.03
Average no. of consumption chart page views per month	.25	.02	.25	.01
Average no. of consumption pipe overview page views per month	.21	.04	.24	.02
Average no. of tips read per month				
Total no. of self-set goals				
Average no. of gamification sidebar views per month				
Average no. of leaderboard views per month				
Monthly average no. of reward page views	.28	.01	.30	.003

* Only significant correlations ($p<.05$) are shown.

Venkatesh et al. (2003) have shown that attitude towards technology and performance expectancy are predictors of technology use. If this suggested causal chain is valid, then the positive attitude and perceived usefulness contribute to the usage of the consumption feedback pages and the reward page, but not to the use of the tips, the goals, and the leaderboard. The analysis on feature level should give more in-depth explanations for these results.

4.4.2 Technology acceptance at the feature level

The following sections report on the technology acceptance at the feature level, focusing on the water consumption features, social sharing and e-mail summaries, which have only been introduced recently. The other gamification features have been assessed in the intermediate evaluation and results are reported in detail in D4.4.

Water consumption chart and overview

The water consumption chart is assessed very positively (Figure 34), in terms of the effect of the motivation to think about water conservation and to save water.

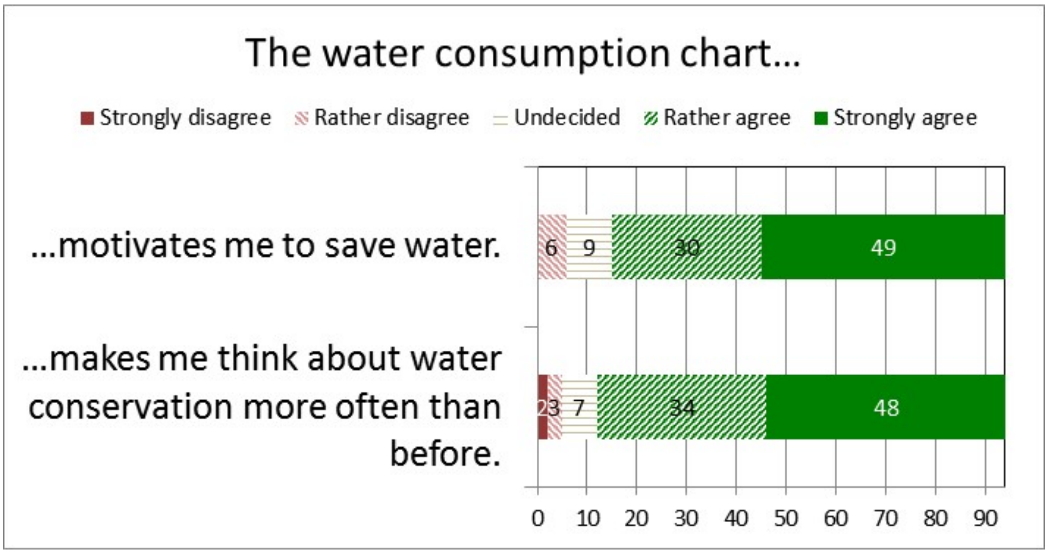


Figure 34. Spanish web portal (N=94): Water consumption chart feedback.

82% of users find that the consumption chart motivates them to save water and 84% even state that it makes them think about water conservation more often than before (Figure 34). This shows that providing users a visual representation of their consumption is certainly the first step towards making then aware and changing their behaviour. If this assumption is true, then the self-perceived motivational effect of the water consumption chart to save water and to think about water consumption was expected to be correlated with the beliefs about water consumption (see also Section 4.3). Results of this correlational analysis are displayed in Table 14.

Table 14. Correlation between the motivational effect of the consumption chart and beliefs about water consumption.

Effect of water consumption chart	**Correlation with beliefs**							
	Drinkable water will exhaust very soon if we do not save it.		Science surely will solve the problem of water scarcity.		Drinkable water is an unlimited resource.		A way of preventing water exhaustion is using it when absolutely necessary.	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*

makes me think about water conservation more often than before.	.33	.001	.216	.03			.42	.000
motivates me to save water.	.31	.002					.30	.002

Note. Only significant correlations are shown (p <. 05).

The results shown in Table 14 demonstrate moderately strong and generally significant correlations. The more users are receptive to the motivational affordances from the consumption chart, the more favourable the post-trial beliefs. This particularly applies to the conviction that water saving is necessary.

Subsequently, the results for the pipe overview were assessed. Results are shown in Figure 35.

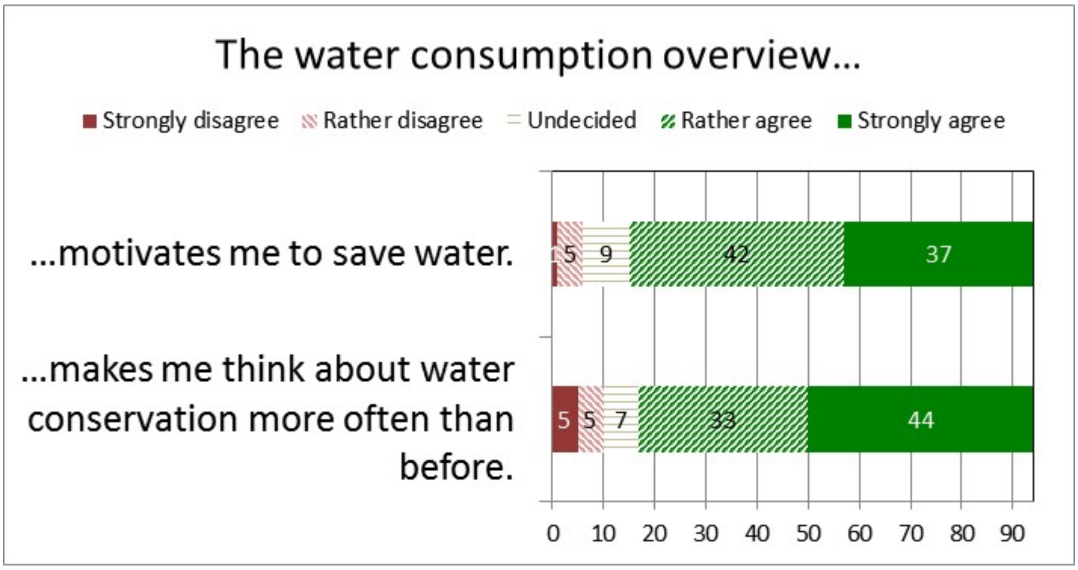


Figure 35. Spanish web portal (N=94): Water consumption overview feedback.

The water consumption overview is assessed very positively, showing that also visualizations that are less known and less data-oriented than the common consumption bar chart can stimulate motivation to save water and raise awareness.

When correlating the perceived motivational effect from the water consumption overview, a similar pattern was found as for the water consumption chart, with moderately strong correlations to beliefs about the need for water saving (see Table 15).

Table 15. Correlation between the motivational effect of the consumption overview and beliefs about water consumption.

Effect of water consumption overview	Correlation with beliefs			
	Drinkable water will exhaust very soon if we do not save it.	Science surely will solve the problem of water scarcity.	Drinkable water is an unlimited resource.	A way of preventing water exhaustion is using it when absolutely necessary.

	r	p	r	p	r	p	r	p
…makes me think about water conservation more often than before.	.27	.01					.37	.00
motivates me to save water.	.20	.05					.44	.00

Note. Only significant correlations are shown (p < .05).

Figure 36. Spanish web portal (N=94): Usefulness of water consumption alerts.

Users also find the water consumption alerts for high consumption useful to very useful (Figure 36). This shows that contextualizing water consumption is key, while merely showing e.g. a bar chart without meaningful reference points does not suffice. Instead, by comparing current consumption against a baseline to identify high consumption and be able to alert the users significantly adds to the value of a utility customer portal.

When users are positive about such alerts, it can be expected that this perception is correlated to the intention to save water. However, the correlation proved to be insignificant (p>.12).

Water consumption goals

Being able to set water consumption goals also motivates users to save water and makes them think about water conservation more often than before (Figure 37).

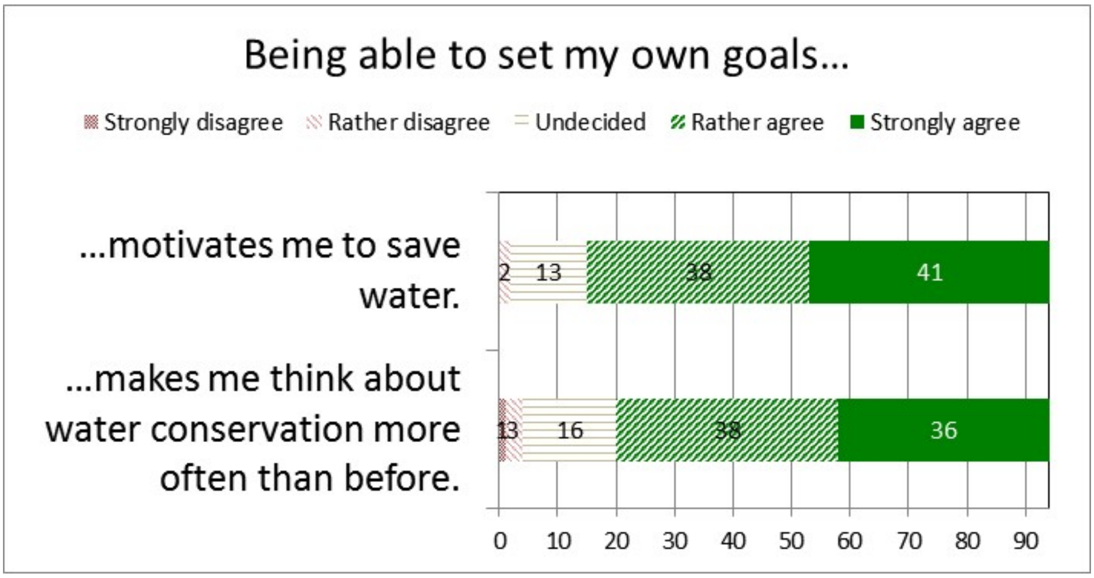


Figure 37. Spanish web portal (N=94): Water saving goals.

This also stresses the importance of introducing benchmarks and means of comparison that not only pre-defined by the system but also by the users themselves. And as Figure 38 shows, 80% of users also state that they are motivated to reach their water saving goal because they can compare their current consumption to their goal.

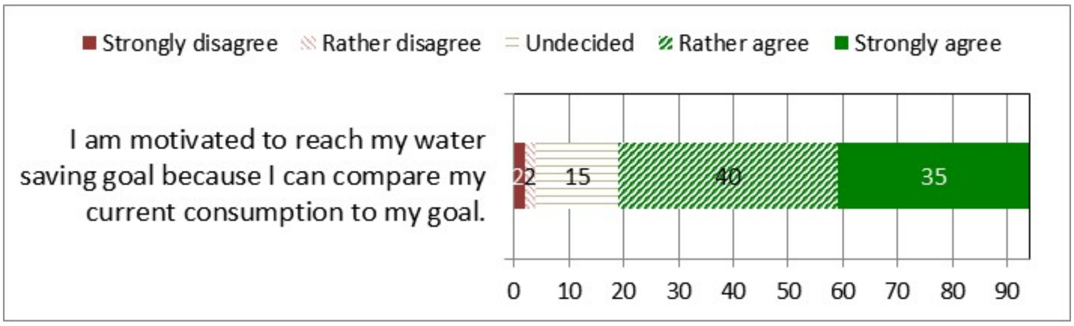


Figure 38. Spanish web portal (N=94): Motivation to reach water saving goal.

We expected that the user perception of the water consumption goals were directly related to the behavioural intention to save water. That is, the stronger the users feel motivated by such self-set goals, the stronger the higher the intention to save water. To test this assumption, we correlated the items about the motivational aspects of self-setting consumption goals to the behavioural intention for water saving. Results confirm the expected correlations for all items. High correlations were found (.45 ≥ $r(96)$ ≥ .65; p=.000), suggesting that motivating users to commit to a water saving target is more likely to lead to a positive intention to save water, and ultimately to change the behaviour (see also Section 0, which demonstrates that setting goals is correlated with a lower consumption).

Water consumption tips

Another important aspect to not only raise awareness but enable behaviour change are water consumption tips.

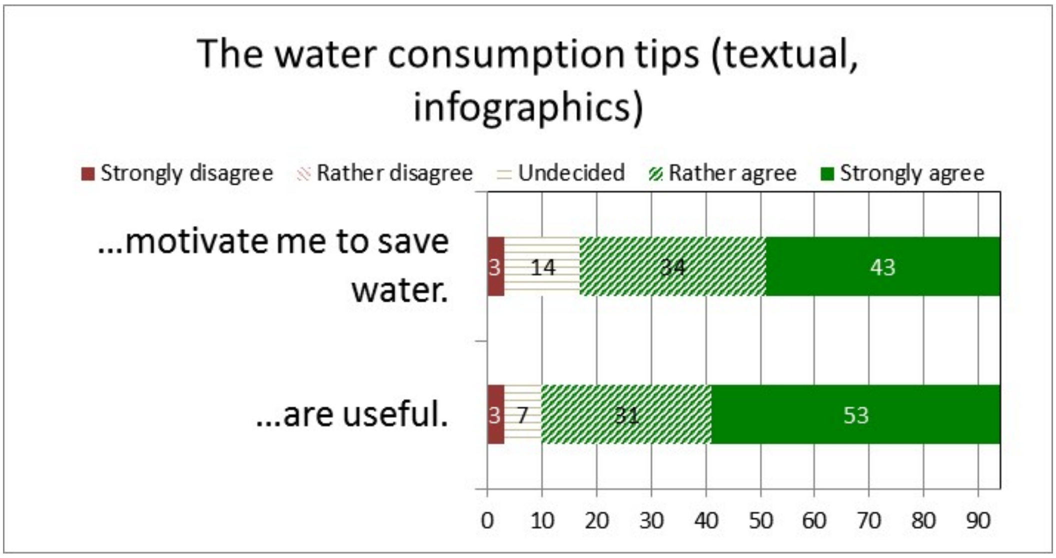


Figure 39. Spanish web portal (N=94): Water consumption tips.

Again, the vast majority of users finds the water consumption tips provided by the SmartH2O portal motivating to save water and useful in general (Figure 39). Furthermore, the perceived motivational effect of the tips and their perceived usefulness is strongly correlated to the perceived behavioural control measure form the TPB model (r(96)=.53; p=.000 and r(96)=.56; p=.000 respectively).

In conclusion, these results show that the addition of water consumption tips to the consumption feedback is well-received by the users. The found correlations demonstrate the potential of the tips to influence the confidence of the users in their ability to save water, which is a predictor of water saving itself.

Social features

One of the recently released social features is the new neighbourhood map that allows users to compare their achievements against their neighbours' achievements. In the evaluation, despite being available only for a short period of time, it is also perceived very positively (Figure 40).

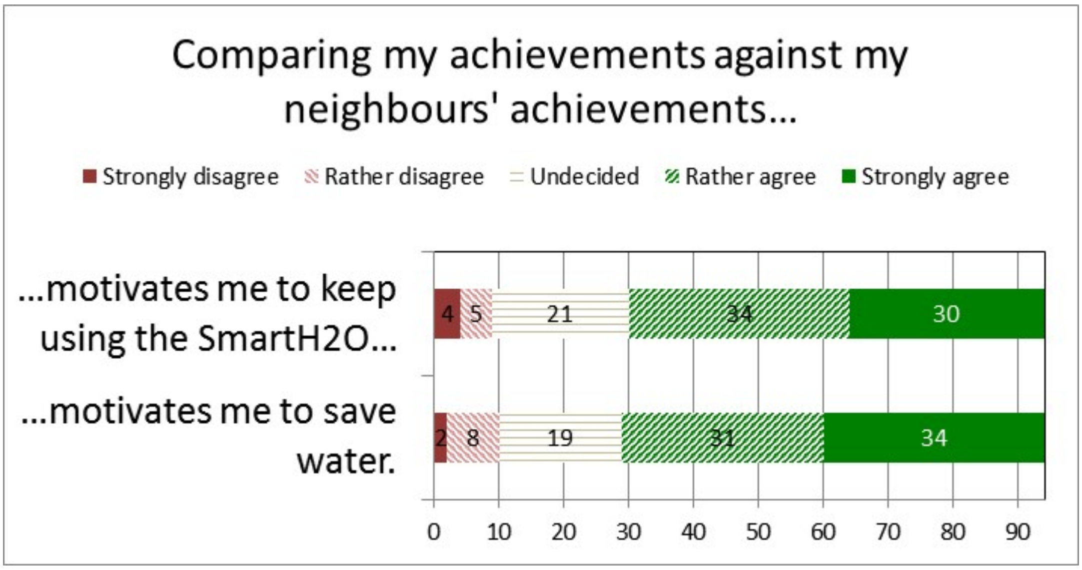


Figure 40. Spanish web portal (N=94): Neighbourhood map to compare achievements.

Nearly 70% of users find comparing their achievements against their neighbours' achievements on the neighbourhood map motivating to save water as well as motivating to keep using the SmartH2O portal. This demonstrates that a combined competitive and normative feature such as the SmartH2O neighbourhood map is a valuable addition to stimulate awareness and behaviour change.

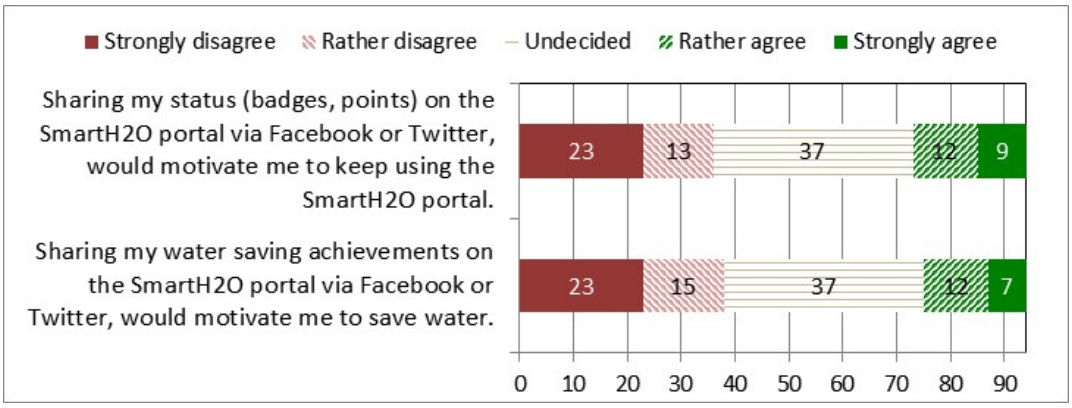


Figure 41. Spanish web portal (N=94): Social sharing of achievements.

The effect of sharing achievements and status via external social networks (Facebook and Twitter) or E-Mail is perceived in a more mixed manner (Figure 41). About 40% of users are either undecided or don't find that sharing their status on social networks motivated them to save water or use the SmartH2O portal. The indecisiveness of many users could be due to the fact that the features were released only recently and users have not yet been able to reflect and assess the effect of these features or haven't even tried them out yet. On the other hand, the aspect that is often found motivating in this context was not mentioned directly in this evaluation, which could have influenced responses: In fact, one of the most motivating aspects of social sharing features such as the ones provided in SmartH2O are often that friends and family can in return comment on the status and provide valuable feedback and motivational messages.

The social dimension is an important part of the incentive model, as argued in D4.3 and D4.4.

For that reason, awareness on water consumption was also measured in terms of the perceived expectations in the user's social environment to save water (in terms of the TPB model: the subjective norm, [Ajzen, 1991]). The social sharing features in the SmartH2O portal increase the social visibility of the water saving behaviour, enabling social approval and the display of one's achievements to important people.

It was expected that the more people are susceptible to such social expectations with respect to water saving, the stronger the perceived motivational effect of the social sharing features. To investigate whether this assumption behind the incentive model is valid, we computed correlations between the items on the perceived motivational affordances of the social sharing features and the subjective norm items from the TPB questionnaire. The computed correlations are shown in Table 16.

Table 16. Correlations between subjective norm and sensitivity to motivational affordances of social sharing features.

Motivational effect of social sharing	**Correlations with subjective norm items**					
	It is expected of me that I save water.		I feel like there is social pressure to save water.		People who are important to me want me to save water.	
	r	p	r	P	r	P
Social media						
Motivation to save water	.27	.008	.26	.009	.38	.000
Motivation to keep using the portal	.20	.049	n.s.		.31	.002

In line with the expectations, moderate to strong correlations were found between the perceived subjective norm and the motivational affordances in the social sharing features to keep using the portal and to save water. This result provides support for the social elements in the incentive model.

As the final step in the analysis, correlations were computed between the perceived motivational effect of sharing one's status on the intention to keep using the portal and the effect on water saving behaviour itself. For both the motivation to keep using the portal and to save water, the correlations were significant ($r(44)=-.31$, $p<.037$ and $r(44)=-.30$, $p=.048$ respectively). This result suggests that those users who are actually saving water would feel even more motivated to do so when they can share the results on social media.

E-Mail summaries

Finally, the perceived effectiveness of the e-mail summaries that were introduced in November 2016 was assessed as well (Figure 42).

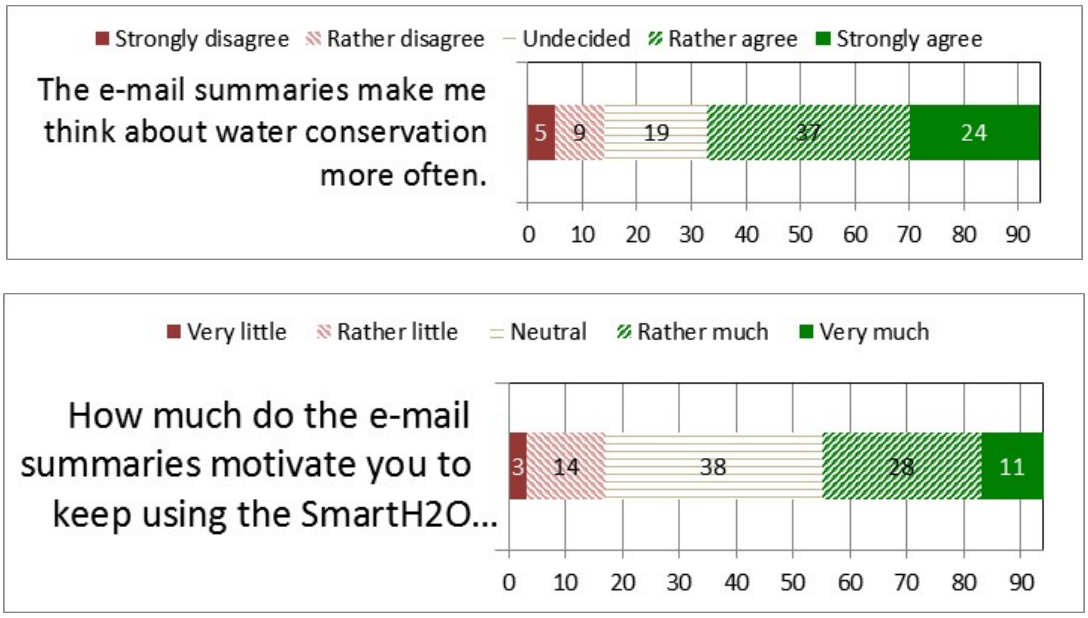


Figure 42. Spanish web portal (N=94): E-mail summaries.

Most users do agree to strongly agree that the e-mail summaries make them think about water conservation more often. However only 40% of users state that they also motivate them to keep using the portal, while 40% are undecided. Again, this indecisiveness is likely due to the short availability of the feature and users have not yet been able to reflect on the effect the emails might have on their portal use. Weekly reminders and digests are one of the keys to stimulate participation in similar online settings and if users already notice an effect of the emails on their awareness, it is likely that portal usage is also affected positively in the long-term.

Perason correlations between the user perceptions of the e-mail summaries and the behavioural intention to save water were strong and significant. The correlation between the perceived motivational effect of the summaries on the use of the portal was $r(96)=.68$ ($p=.000$). The correlation between the perceived effect on thinking about water consumption and the behavioural intention to save water was $r(96)=.43$ ($p=.000$).

Even though the social sharing features have only been available for six weeks at the time of writing, the positive perceptions of the users and the correlations between these perceptions and the awareness measures suggest that these social features are capable of inducing behavioural change when available for a longer period of time.

4.4.3 Technology acceptance and hedonic quality of SmartH2O Mobile

In addition to the web portal, the perception of the SmartH2O mobile app has also been assessed for those users indicating that they used the mobile app (N=31). Overall technology acceptance was measured using the standardized UTAUT framework [Venkatesh et al., 2003], which covered the aspects effort expectancy (usability aspects), performance expectancy and attitude towards the technology. In addition, hedonic quality stimulation and pragmatic quality were also measured using the Attrakdif framework [Hassenzahl, 2004] in the same way this was measured for the web portal in the intermediate evaluation that is reported in D4.4.

The results for effort expectancy of the SmartH2O mobile app are reported in Figure 43.

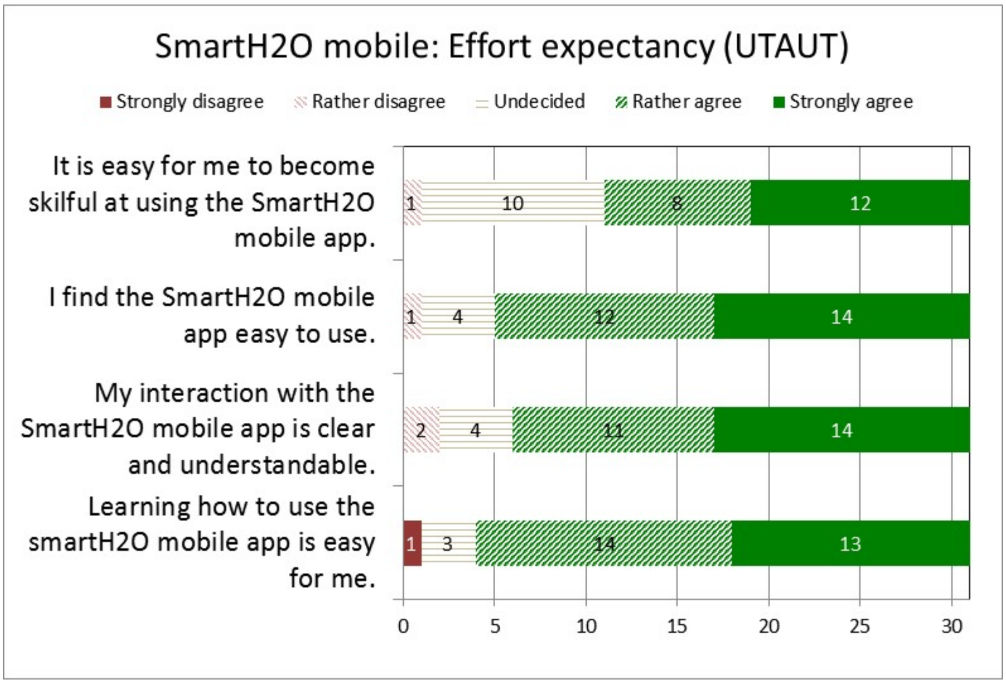


Figure 43. Spanish SmartH2O mobile (N=31) : Effort expectancy (UTAUT).

The mobile users assess effort expectancy, i.e. the overall usability of the app, very positively. Solely the statement “It is easy for me to become skilful at using the SmartH2O mobile app” also yielded a third of undecided responses, while the related item “Learning how to use the app is easy for me” was assessed very positively across almost all users. This could be due to the fine difference of the wording, where “becoming skilful” could have been associated to the purpose of the app – saving water – rather than the use of the app per se. As saving water is a more complex task, it is likely that the item has yielded more undecided responses. Overall though, these are very positive results that suggest that SmartH2O succeeded in providing the rather complex elements of the SmartH2O web portal in such a way that is manageable also on small screens.

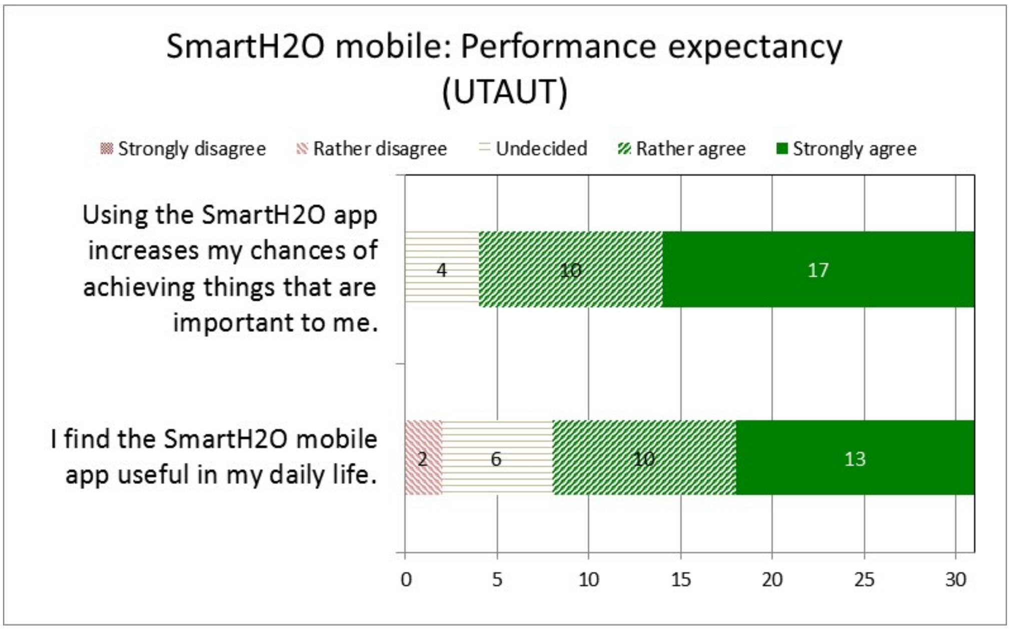


Figure 44. Spanish SmartH2O mobile (N=31): Performance expectancy (UTAUT).

Nearly all users think that the SmartH2O app increases their chances of achieving things that are important to them. There is some more indecisiveness towards the app's usefulness in their daily life. Since the app has not been designed as a daily companion but rather a tool that should trigger awareness and water saving on a weekly basis and in the long-term, this could have made people uncertain about what to respond here and results otherwise are very positive in terms of performance expectancy.

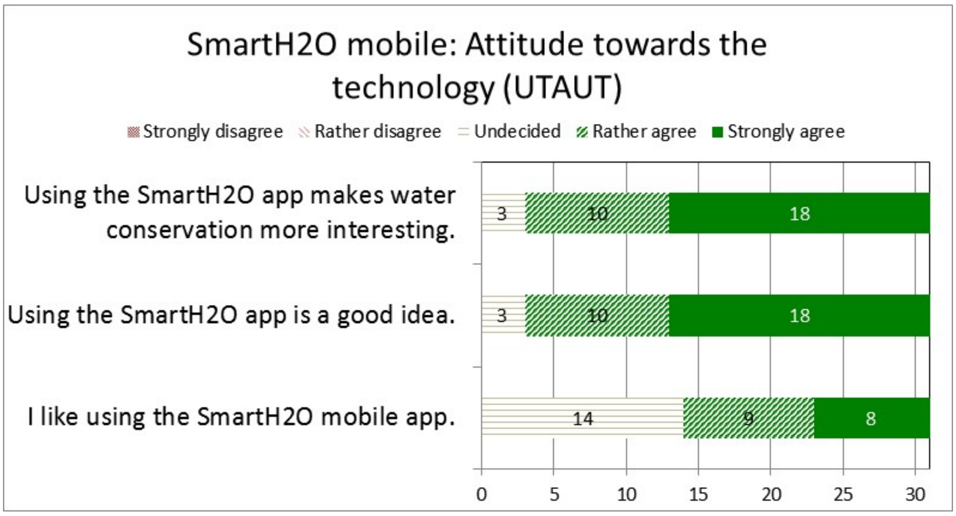


Figure 45. Spanish SmartH2O mobile (N=31): Attitude towards technology (UTAUT).

Mobile users also express a very positive attitude towards the technology in terms of it making water conservation more interesting and being a good idea to use (Figure 45). At the same time, nearly half are undecided whether they like using it. This is similar to attitudes expressed towards the web portal and in much the same way, users most likely compared the SmartH2O mobile app to more game-like mobile apps rather than related utility and other service portals that are only providing basic features and the water bill. These however are the key point of reference for the SmartH2O app. By already winning over more than half the users in terms of an enjoyable user experience, SmartH2O is clearly successful in providing a meaningful, enjoyable application for such a pragmatic and serious topic as water saving

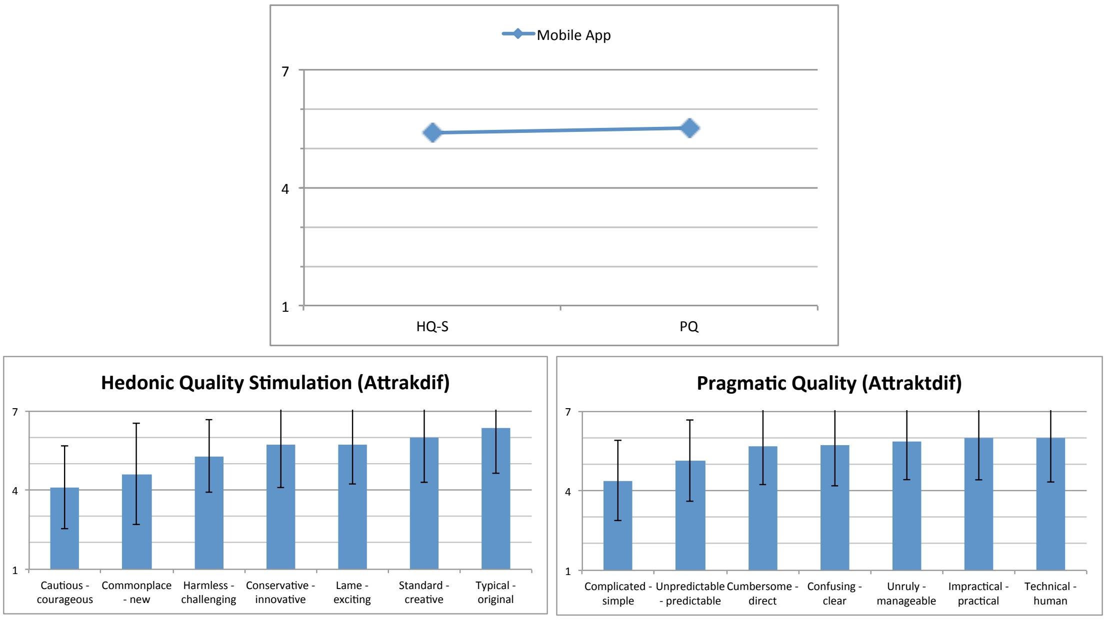


Figure 46. Spanish SmartH2O mobile (N=31): HQ-S vs. PQ (Attrakdif).

Hedonic quality stimulation yields a very positive overall score of 5.39 (s.d.=1.5), equally high as the pragmatic quality, which is rated 5.53 (s.d.=1.3) (Figure 46). This underlines that both the app's user experience and usability are perceived positively, and the goal to combine the pragmatic issue of water saving and hedonic gamification elements was successful in the mobile app as well.

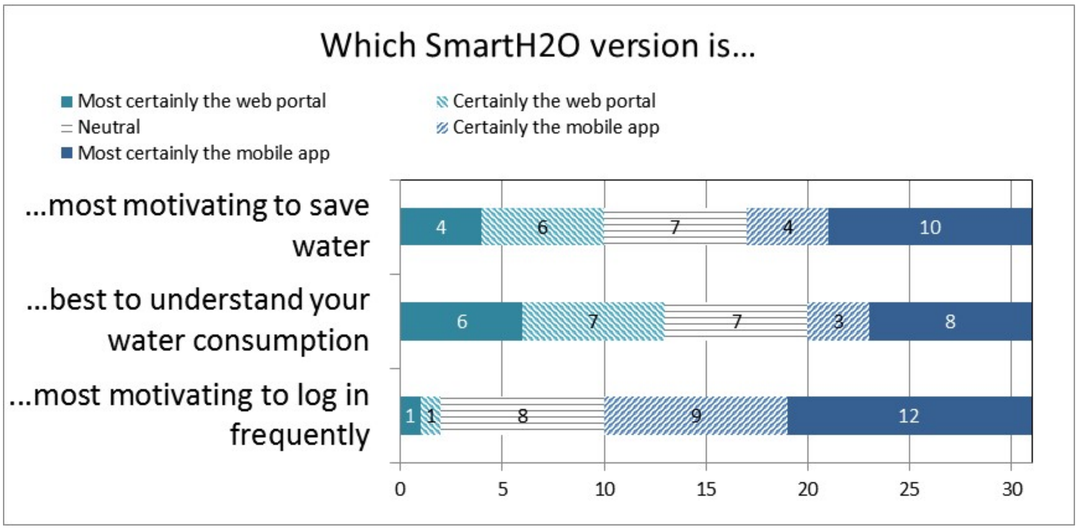


Figure 47. Comparison of SmartH2O Web portal vs. mobile app in Spanish case study.

A direct comparison of the web portal and the mobile app shows that users find the mobile app a bit more motivating to save water than the web app (Figure 47). Responses below indicate that e.g. the notifications with reminders to keep using the app and the tip of the week could play a key role here. In contrast, the web app is perceived slightly better to understand ones water consumption. Reasons for this could be the small screen of the mobile phone, which can't show the full range of data in the bar chart, or the fact that only a simplified version of the overview visualization could be displayed to ensure readability. Also, quite a few users expressed a neutral opinion, meaning that they would consider the two apps equally suitable.

More detailed questions were asked about the mobile notifications, the feature most relevant in the mobile context. Because while they also exist in the web portal, only the mobile phone is able to prompt them instantly even if not actively using the app.

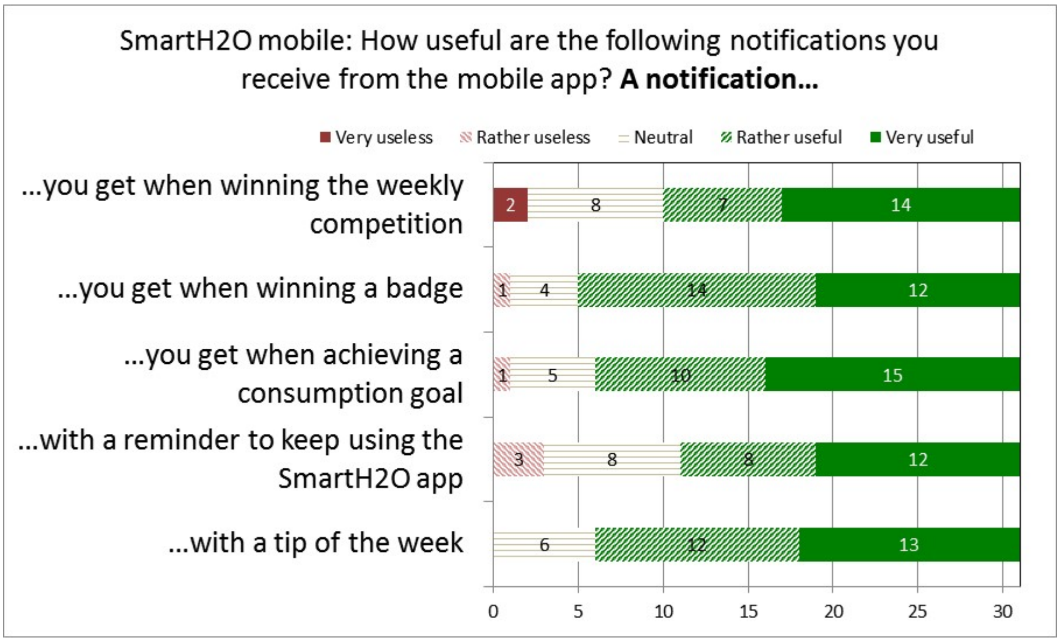


Figure 48. Spanish SmartH2O mobile (N=31): usefulness of notifications.

Overall, users state that the notifications are useful, especially those notifying them when they win a badge, achieve a consumption goal or provide a water saving tip of the week (Figure 48). Notifications on winning the weekly competition and reminders to keep using the app are perceived as a bit less useful or neutral by some users. An explanation for the reminders could be that they don't provide additional information other than "come back, SmartH2O misses you", which may thus be less useful to users than actually informing about an achievement or a practical tip. And since most users don't win the weekly competitions frequently, they may not find a notification about this relevant enough for them to be useful. In addition, the system informs users once a week who won the last competition and if it doesn't apply to the users themselves, they may be more jealous or annoyed by it instead.

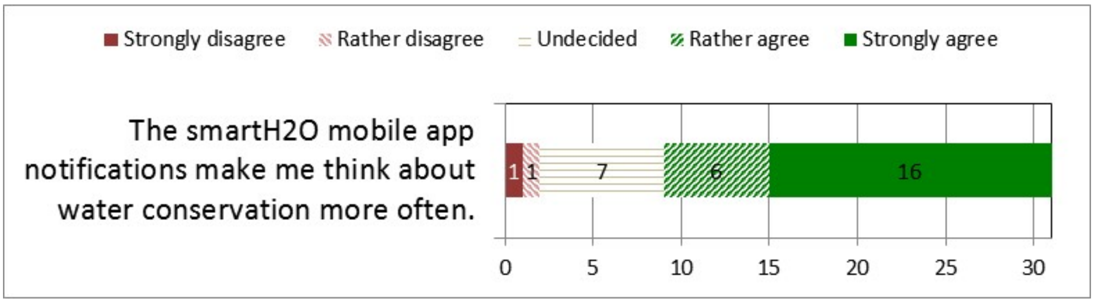


Figure 49. Spanish SmartH2O mobile (N=31): Notifications as triggers to think about water conservation more often.

71% of the users find that the notifications make them think about water conservation more often (Figure 49), and most even strongly agree with this statement. This is a very positive result for the notifications feature, confirming that notifications are a very suitable means to raise awareness about water conservation.

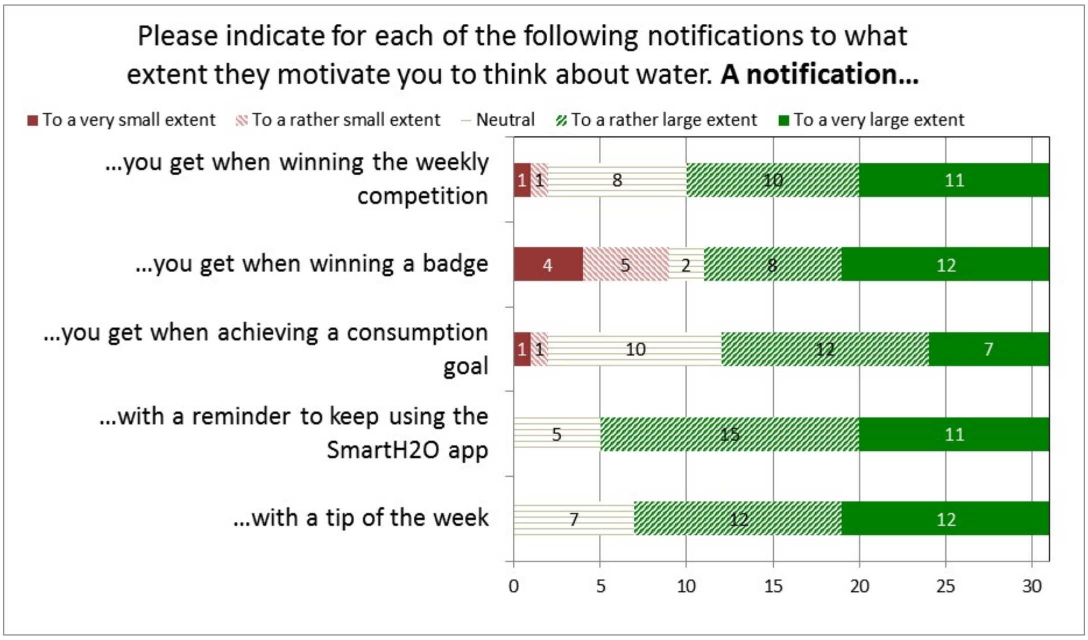


Figure 50. Spanish SmartH2O mobile (N=31): Motivational effect of notifications to think about water.

When looking at the effect of individual notifications in terms of motivating users to think about water, some notification types stand out more than others (Figure 50). Especially the reminder to keep using SmartH2O and the tip of the week are perceived motivating to a large extent. While the latter is directly linking to water conservation through practical tips on how to save water, the responses also show that people automatically link the SmartH2O app to water and reminding them to use the app already acts as a reminder to think about water. The gamification features on the other hand (winning the competition, winning a badge, achieving a goal) motivate users to a slightly lesser extent to think about water. There, people who are less motivated most likely focus more on the game-like aspects like competition and reputation rather than the underlying topic or content.

Finally, for those users who did not use the mobile app yet, we asked for the reasons why they did not do so. Results are shown in Figure 51. It should be noted that users could indicate multiple reasons.

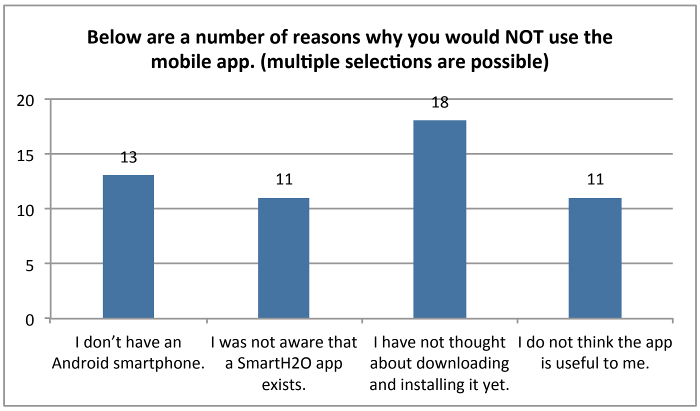


Figure 51. Reasons for not using the mobile app.

Figure 51 shows that most users (18) just hadn't thought about downloading it yet and only 11 were not aware of the app's existence. Other reasons were not provided (free text field was available). A count of the unique users who were either not aware of the app's existence or have not thought about downloading it, showed that 28 additional users could potentially download the app in the future, while those 23 who didn't find it useful or don't have an Android phone are less likely to do so. This results is promising in the light of the future adoption of the SmartH2O app and its potential to increase the level of activity (see also section 4.4.6 for an analysis of the activity in the mobile app compared to the web portal).

4.4.4 Technology acceptance of Drop! Games platform

To assess technology acceptance of the Drop! The Question application and board game, we apply the Unified Theory of Acceptance and Use of Technology (UTAUT) [Venkatesh et al., 2003]. In this evaluation, the following indicators that were derived from the UTAUT framework were used [Venkatesh et al., 2003]:

- Effort expectancy: the ease of use of the system;
- Attitude towards using technology: an individual's overall affective reaction to using the application.
- Social Influence: the social impact on the individuals towards using the application.

In addition, questions about the following aspects were also included for specific interactions:

- Perception of challenge level of Drop! questions
- Perception of joy of gameplay
- Perception of difficulty to perform specific Drop! actions

Each indicator was evaluated with a subset of standardized questionnaire items using a 5-point Likert scale. 12 Drop! The Question users who also use the SmartH2O portal responded to the questionnaire (response rate = 50%), 4 of which had also played the board game with the application.

Most respondents assessed the ease of use positively to very positively (Figure 52). Only 2 users were undecided about the ease to become skillful at playing the game. All the respondents consider the game easy to play, understandable, and easy to learn. This indicates that the game design and implementation was successful as it does not present problems to the users to understand the rules and start to play.

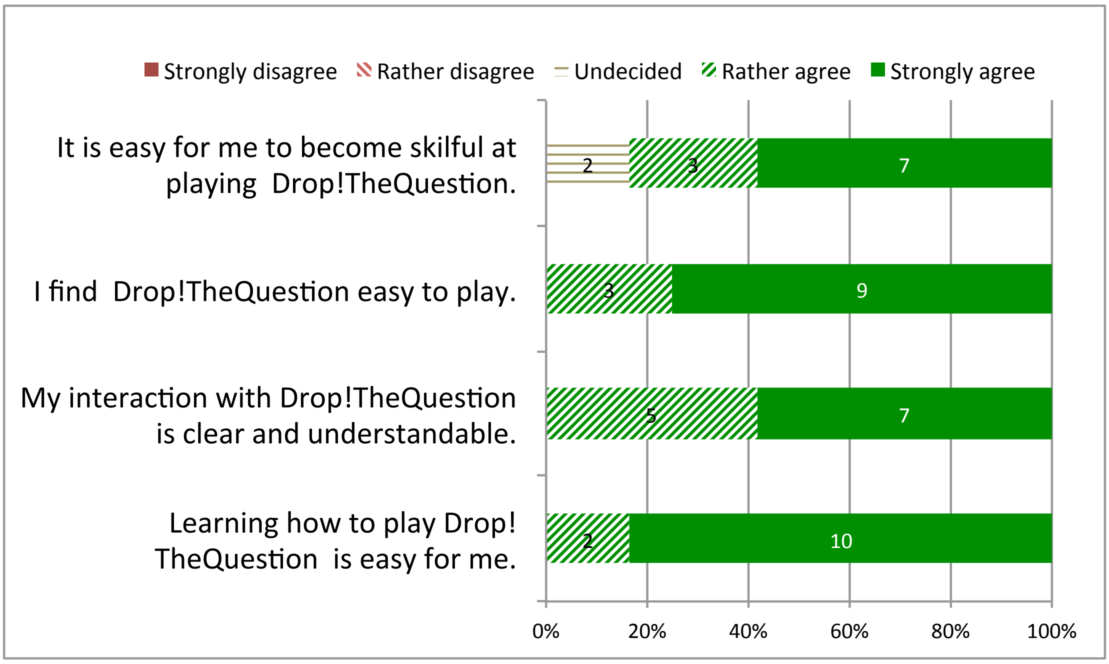


Figure 52. Spanish Drop! The Question (N=12): Effort expectancy (UTAUT).

On attitude towards using the technology, most respondents also expressed a positive attitude towards using the application (Figure 53), while the rest remained neutral and only 1 disagreed with having fun with the game, this again show that the design of the game mechanics where successful as user perceived the game as fun and interesting.

What is especially positive is that most respondents think that the application makes water conservation more interesting and all of them consider playing with the app a good idea in general, this is an indication that the game accomplished the objectives of creating user engagement and raising awareness of water conservation.

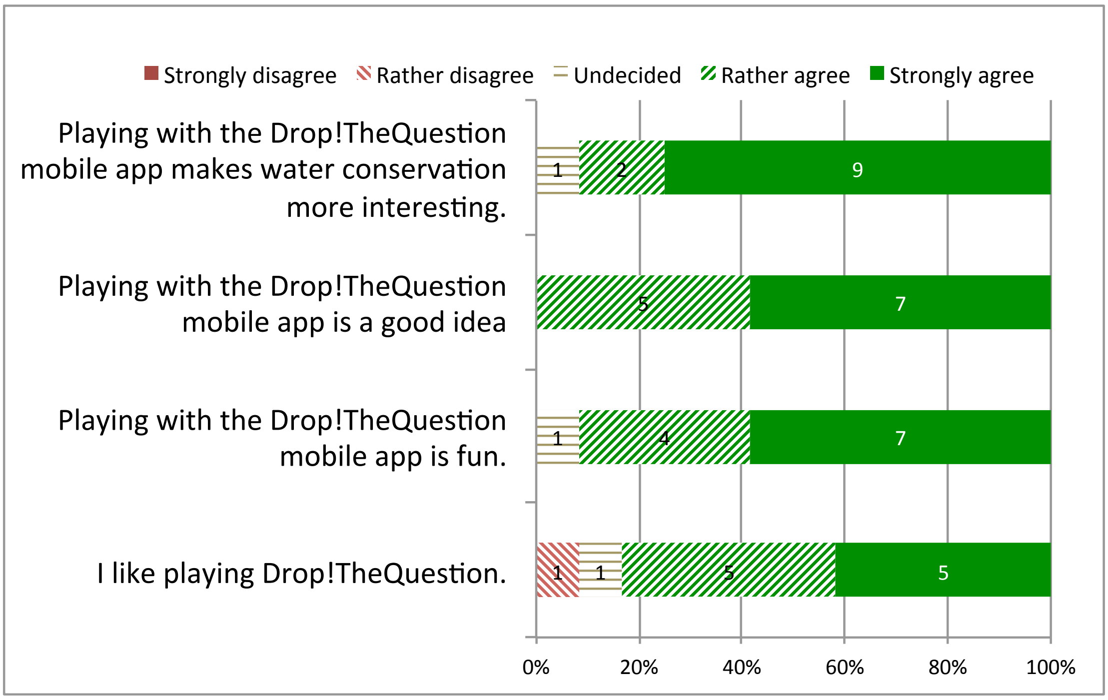


Figure 53. Spanish Drop! The Question (N=12): Attitude towards using the technology (UTAUT).

In the evaluation of perceived Social influence to play the game, responses are polarized (Figure 55). While 3 of the respondents are undecided about the influence to play the game, the rest is evenly distributed either on the positive or negative sides, 5 agreed that people that they consider important and that people that influence them think they should play the game, the other 4 disagreed. This contrasts with the previous result where all users consider playing the app a good idea (Figure 53).

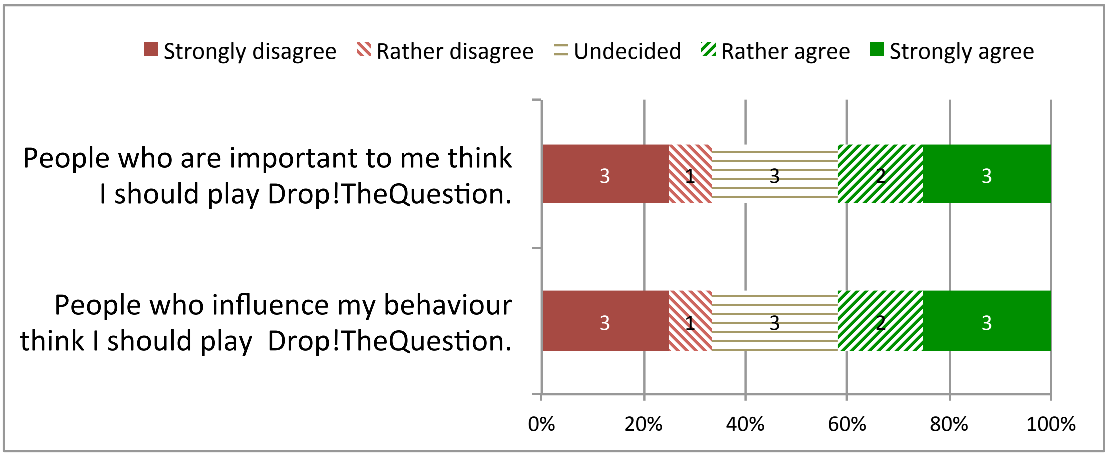


Figure 54. Spanish Drop! The Question (N=12): Social influence.

In terms of the challenge level of the questions, the evaluation shows that most of the users found the questions from intermediate to very difficult to answer (Figure 55). This was already indicated through the comments of users in the Google Play store, where users complained about the questions becoming very hard after a short period. This was due to the fact that there was only a limited number of questions available, and most of the question were from a moderate to high level of difficulty. In conclusion, easier questions should be collected and introduced with future updates of the app. Another approach could be that based on e.g. the age of the users, an additional pre-selection of questions could be done to exclude very difficult questions altogether e.g. for younger children.

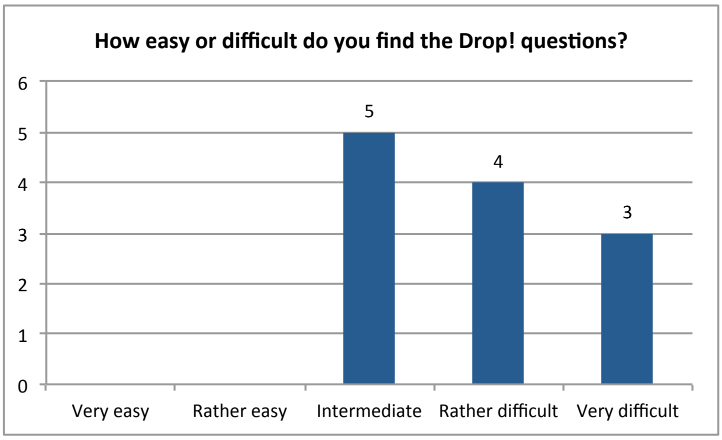


Figure 55. Spanish Drop! The Question (N=12): Challenge level of Drop! questions.

In addition, the questions a) “It is fun to earn points on the SmartH2O portal with the Drop! mobile app” and b) “It is easy to connect my Drop! player profile to my SmartH2O portal account” were asked. Due to a technical routing error in the online survey, only four users could respond to these questions. Still, results indicate a positive tendency for all four users (a-4 strongly agree; b-3 strongly agree and 1 rather agree), further more from the application data it can be observed that only 2 users didn’t use application connect to the SmartH2O portal, while the other 10 used it actively to get points, getting on average 18000 points only from playing the game, which is equivalent to answer correctly 180 questions.

Moreover feedbacks collected during SmartH2O workshops in schools demonstrates that DropTheQuestion is perceived as “fun” and “interesting”. Below a feedback sent by teachers after the workshop in Albavilla secondary school.

The project had a remarkable impact on the class as it aroused their interest in the topic. In addition, the issue itself perfectly fits the school curriculum relating to science and technology, citizenship and English, which currently focuses on the environment sustainability and consequently on water saving measures. *Indeed, the board game was exciting, interesting and fun.* *In conclusion, the teacher staff is impressed by the students' participation and positive feedback.*

Out of the four users that played the board game together with the mobile app, all four players find it rather to very easy to scan the monster cards, and three of four players find it fun to play the board game with the mobile application (Figure 56). This is encouraging for hybrid games such as Drop!, but a future goal could be to distribute more Drop! board games to Drop! The Question mobile users, e.g. with a voucher to pick up their free copy of the game after downloading the app, or offering a discount on the board game in a commercial setting.

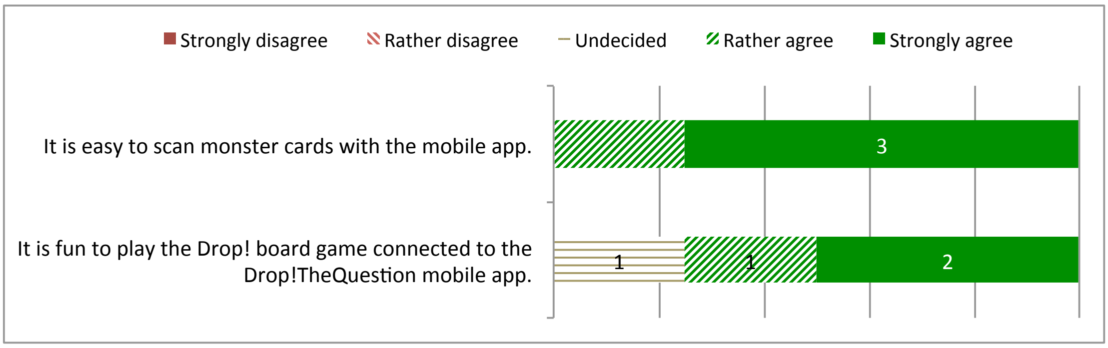


Figure 56. Spanish Drop! (N=4): Playing Drop! The Question app with board game.

User activity logs were analysed with the purpose of assessing the relative usage of each of the features in the SmartH2O platform and to relate this use to the observed water consumption and water consumption awareness levels. The results extend the findings reported in D4.4 [title] to cover a larger timeframe and a larger number of users. The logs cover the timespan between the launch of the portal (April 19th until February 13th 2017), involving in total 508 users.

We first summarize the usage of the portal, in terms of how often the constituent features are used. Subsequently, we relate the usage to the indicators included in the KPI's: water consumption, and water consumption awareness. Finally, we zoom in on the usage of the mobile apps: the SmartH2O app and the Drop! The question app.

4.4.5 Overview of activity

In total 508 users have signed up to the SmartH2O app. In Figure 57 a histogram is displayed that contained the frequency of new sign-ups per month.

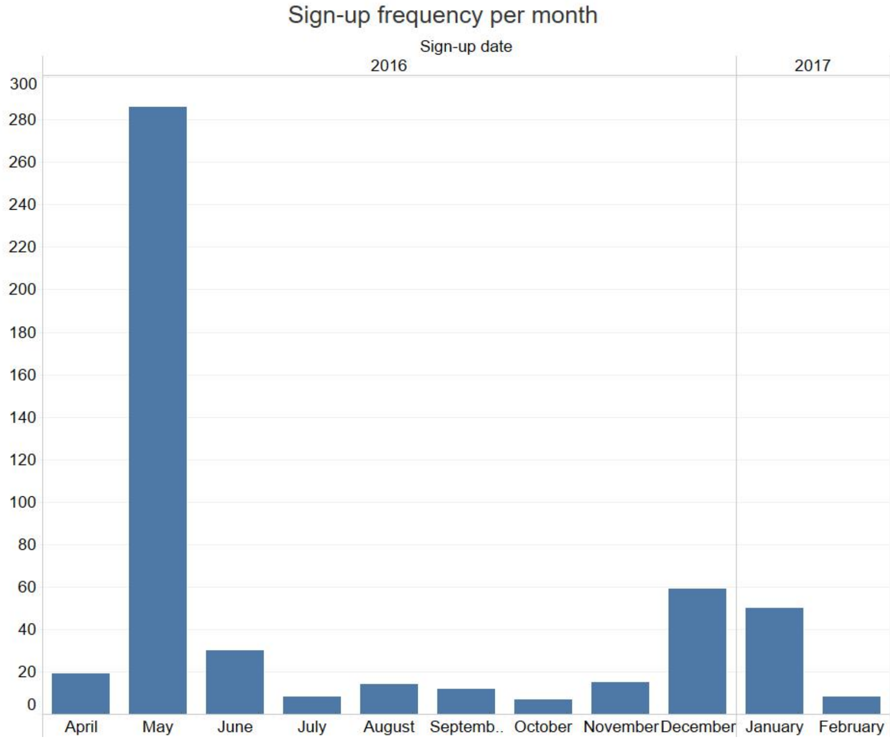


Figure 57. Sign-up frequency per month.

Results clearly display the effect of the promotion campaigns that were conducted to recruit users. The initial campaign that co-occurred with the launch of the platform yielded 305 sign-ups at the end of April and in May. The promotion campaign in December and January resulted in in sum 109 new sign-ups. In between the campaigns 94 new users have signed up to the portal. To reduce the dependency on promotion campaigns for the recruitment of new users, new features have been launched at February 14th with which current users can get points for inviting new users. Even though at the time of writing only one month of usage could be analyses, the initial results are promising (see section 4.4.7).

First step in the analysis of the activity level is comparing the average number of logins per month against the number of times users get in contact with their utility before the launch of the portal. Before the launch, customers could make use of the Virtual Office. Additionally, users received water saving bills every two months. For the Virtual Office, only 3% of the users log in every month. The activity level during the SmartH2O is summarized in Table 17.

Table 17. Login frequency during the SmartH2O trial in comparison to the pre-trial situation.

Login frequency	**% of the user base**
Pre-trial:	
% of customers logging in to the Virutal office monthly	3%
During the SmartH2O trial:	
% of customers logging in once every two months	47%
% of customers logging in once every month	32%
% of customers logging in every week	11%

Results demonstrate a substantial increase of contact points between the utility and the customer in comparison to the pre-SmartH2O situation, resulting in an increased exposure to incentives to start saving water. The results show that 11% can be considered lead users, user who make use of SmartH2O every week (or more). 32% of the users log in every month, while 47% log in every two months. Note that while not very intensive for 47% of the user base, the nature of the contact is rather different, as logging in means exposure to behavioural change incentives beyond what a water bill can induce.

To get an overview of the relative usage of each of the features, for each feature the monthly average frequency was computed per month of platform membership. This frequency was computed by dividing for each user the total frequency by the number of days between sign-up and the end of the trial, multiplied by the average no. of days in a month (30.42).

As the consumption chart is the first page users see after logging in, a decision rule was formulated to distinguish consumption chart inspections from login actions. The time spent was used as a basis. When a user spent between 5 and 60 seconds on the consumption chart page, this was counted as a consumption chart view. This approach could not be applied to sessions where a user logs in and immediately logs out. For these actions, the time spent on the page was not available. The average monthly frequency was computed separately, referred to as login only sessions.

In we summarize the average monthly frequencies for the main pages in the portal.

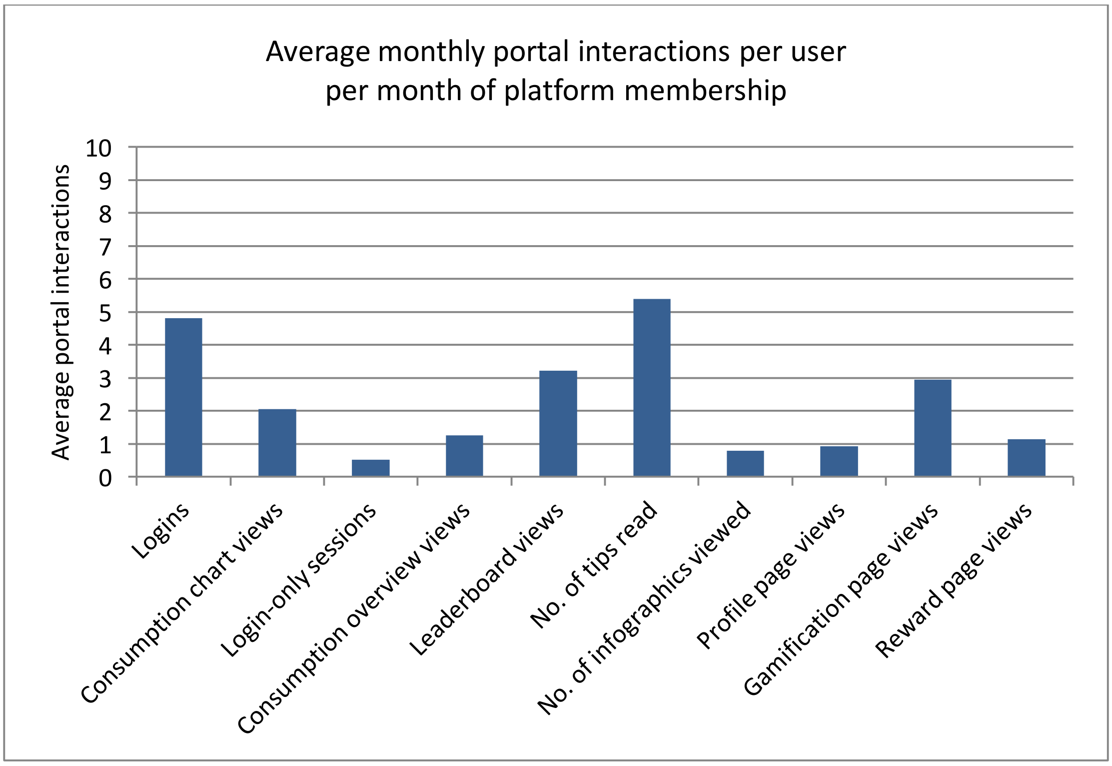


Figure 58. Usage of portal features in the Spanish case study.

As can be seen from Figure 58, users in the Spanish case study log in to the portal on average close to 5 times a month (M=4.80), with a high variability between users (s.d.=22.24). In comparison to the other features, the water saving tips were inspected most often, followed by the leader board and gamification sidebar. This suggests that incentive model elements aimed at saving water and aimed at stimulating users with extrinsic gamified incentives have yielded a substantial number of users. The high standard deviations across the different features suggest that there is a large variability between the users. For example, the gamification overview page was used on average 2.9 times a month with a s.d. of 18.6.

On average users visit the consumption overview and consumption chart one to two times a month. Such exposure to water consumption feedback contributes to an improved consumption awareness and early detection of leaks or other sources of increased consumption.

Water consumption tips

In the number of tips and infographics are displayed, as indications of the concrete advice users have been exposed to save water.

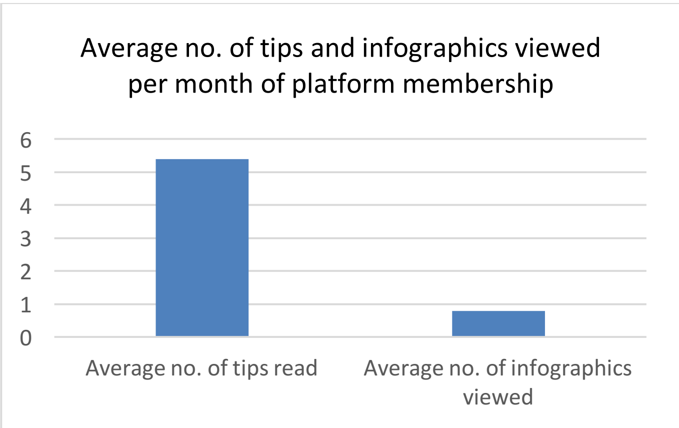


Figure 59. Water saving tips and infographics viewed.

Results suggest that users have on average read more than 5 tips per month of platform membership. This result is rather promising when taking into account that before the trial users have just received a water bill. Whereas transforming tips into action and ultimately into new water efficient habits is a long process, this monthly exposure can be considered a first step towards accomplishing this goal.

As the number of infographics was rather limited at 4 infographics, it was not surprising that the average number of infographics viewed was substantially lower.

Setting water consumption goals

SmartH2O users received points for achieving water consumption reductions. When users have set a goal themselves, they received more points to stimulate users to do so and to create commitment to the goal. We analysed the number of self-set weekly and monthly goals, as well as the number of goals that was achieved. The results are depicted in .

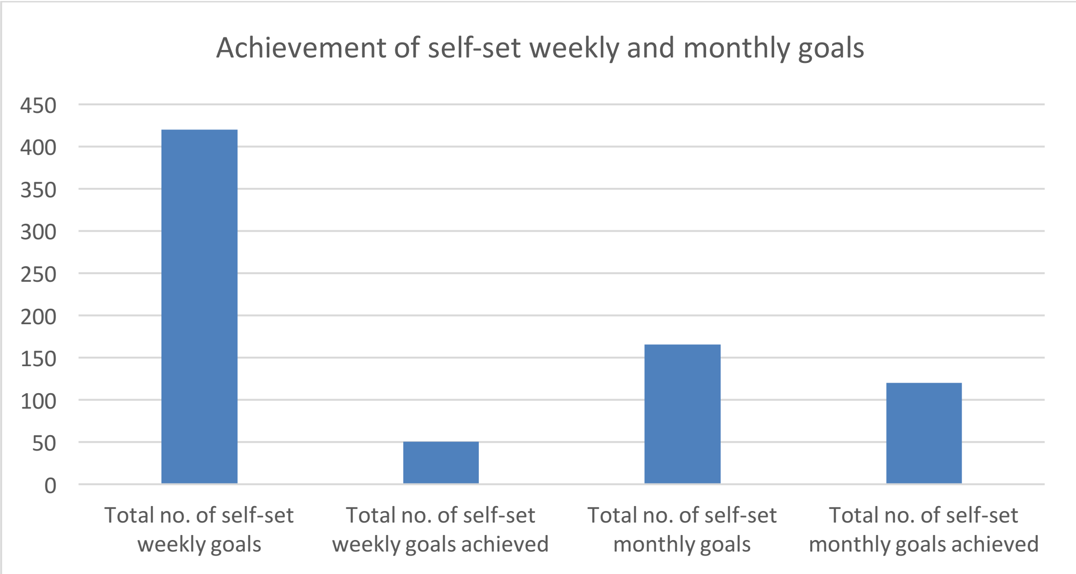


Figure 60. Achievement of self-set weekly and monthly goals.

As can be seen from Figure 60, substantially more weekly goals are set in comparison to monthly goals. However, the results also show that monthly goals are achieved more frequently (72%) than weekly goals (12%). 49 users have set on average 3.4 monthly goals (166 in total), while 30 users have set on average 14 weekly goals (420 in total).

The results suggest that the weekly goals encourage a smaller set of the users to make short-term commitments, whereas the monthly goals incentivize a somewhat larger group to make a commitment with a timeline of a month. As users require a change in behaviour in order to achieve the goal, achieving the weekly goals is more challenging than monthly goals, since changing (environmental) habits is a complex process (e.g. [Dahlstrand & Biel, 1997]).

Engagement with the gamification features

The SmartH2O portal has been set up to appeal to hedonic user motivations in an otherwise utilitarian application. The actual use of the hedonic features provides evidence whether these motivational affordances have worked for the users. The results are depicted in Figure 61.

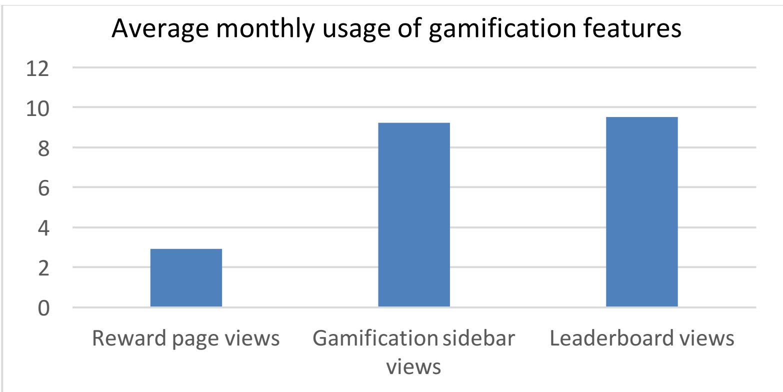
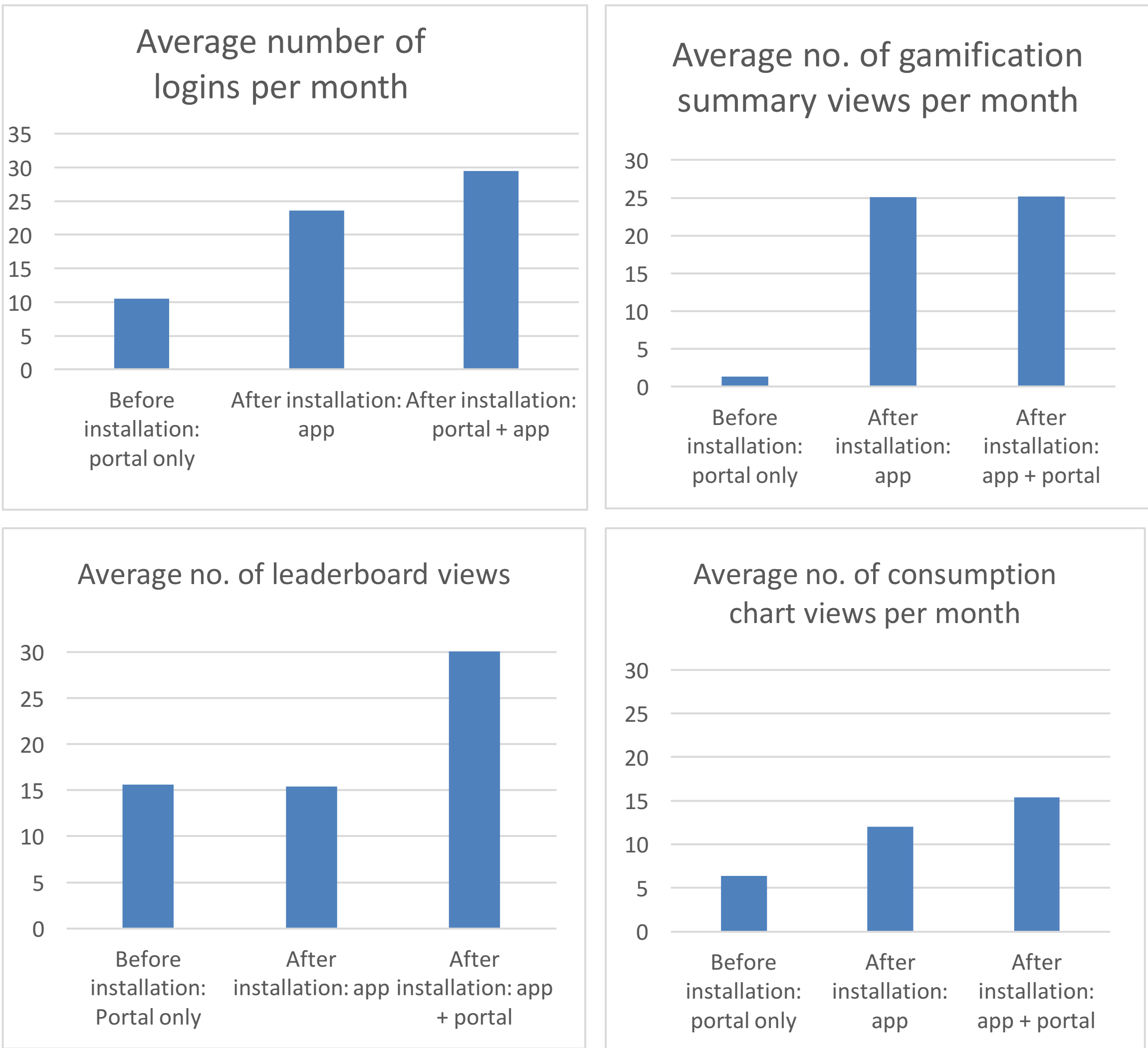


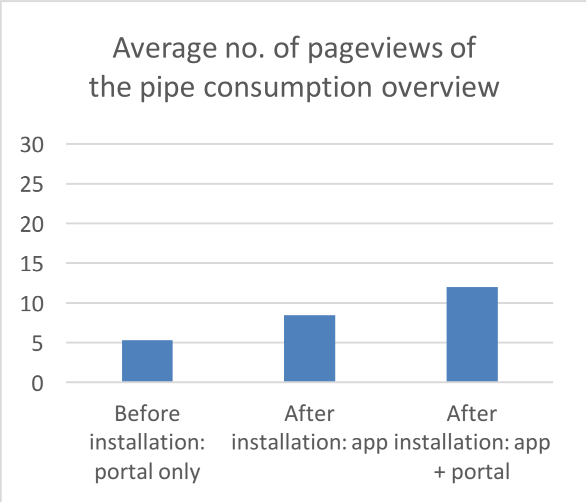
Figure 61. Usage of gamification features.

Results demonstrate that users inspect the gamification sidebar with the points and badges they have collected and the next actions they can do to collection points on average close to three times a month (M=2.96; s.d.=18.57). The leaderboard is used to a comparable extent (M=3.23; s.d.=17.87), while the reward page attracts substantially less attention (M=1.14; s.d.=3.76). The high standard deviation demonstrates the large variability among the users, suggesting that the appeal of these features varies among users.

4.4.6 *User activity in mobile apps*

On November 30th 2016 the SmartH2O app was launched in Valencia. Since then, 42 users have installed the app. From these users, 16 users have signed to SmartH2O through the mobile app. The remaining 36 users have installed the app later. The app has been launched to increase the level of activity of the users. To assess whether this has been the case, we compare the activity of the users before and after they have installed the application. We only include users that have used the portal for at least one month before installing the app, as shorter timeframes make predictions about usage of the portal before the installing the app unpredictable. Before analysing the results, outliers were removed based on the Tukey's fences method. For the remaining 17 users, we analysed the monthly average frequency with which each of the features was used, before and after installing the app. The results are displayed in Figure 62.





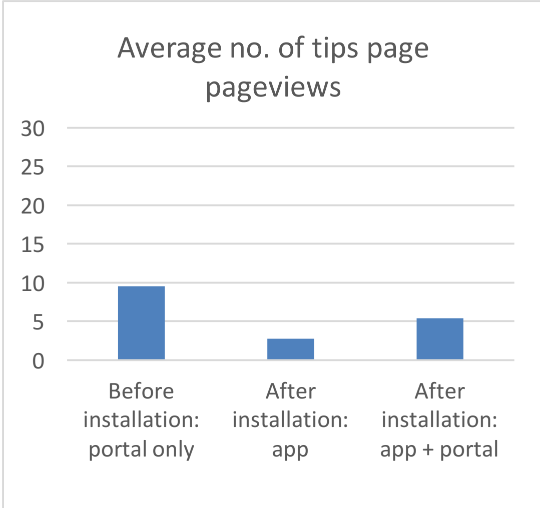


Figure 62. Differences in SmartH2O use before and after installing the app.

The graphs demonstrate that overall activity has increased substantially after installing the SmartH2O app. Paired samples t-tests were conducted to test whether the observed difference between are statistically significant. The difference between the average number of logins per month before installation the app and after the installation of the app was significant. This applies to both the use of only the app (t(16)=-2.33; p=.03), and the combined use of portal and app after the installation date (t(16)=-2.54; p=.02). The same applies to the inspection of the gamification overview page (app and portal combined: t(16)=-2.82; p=.01) app only: t(16)=-2.82; p=.01).

The difference between the use of the consumption chart before and after the installation was also significant. This applies to the difference between the use of the chart on the portal before installation versus the use of the chart in the app after installation (t(16)=-2.13; p=.049) and the combined use of the consumption chart in the app and the portal after installation taken together (t(16)=-2.24; p=.04).

In contrast to the consumption chart, there were no significant differences between the use of the consumption overview on the portal before installation of the app, and the use of the overview in the app (t(16)=-1.29; p=.22) or for the combined use in the app and the portal (t(16)=-1.68; p=.11). As the design of the consumption overview could not be translated one-on-one to the app due to screen resolution limitations, the full pipe metaphor and associated consumption information elements is not conveyed to the user. Such limitations could have caused the smaller increase of usage in comparison to the other features. Nevertheless, the graphs in Figure 62 demonstrate a tendency towards increased usage. A longer time span of usage and a larger number of app users will determine whether this observed tendency will become statistically significant.

Finally, users seem to have viewed the tips page less frequently after installation of the app than before the installation. However, a paired samples t-test showed that the difference in pageviews before installation and both the number of pageviews in the mobile app (t(16)=-1.21; p=.91), and the total number of pageviews after installation in both the app and on the portal was insignificant (t(16)=-.70; p=.50). One possible explanation for this observed but non-significant tendency might be that users primarily make use of the app to check the game status and their consumption, while the web portal is more suitable for tasks that require more attention, such as learning about water saving.

Overall, this activity analysis demonstrates that the mobile app is used more frequently than the web portal. This applies to the overall activity, the consumption information as well as the gamification status page, whereas tendencies towards the same direction have been found for the leaderboard and the consumption overview. These results indicate that the use of a mobile app can stimulate both hedonic use of the gamified features and utilitarian use of the water consumption-related features.

Notifications

Six different types of notifications were sent to the mobile app users in order to increase their level of activity. With a limited user base of 42 users results on the response to notifications should be interpreted with caution. Nevertheless, for each notification type the total number of sent notifications that were sent and the number of notifications users tapped on was counted. Results are displayed in**Table 11. Summary of response rates.** Table 18.

Table 18. Response to notifications in the mobile app.

Type of notification	Total no. of notifications sent	Notifications clicked	Click rate
Weekly leaderboard winner	279	15	5.4%
Tip of the week	279	11	3.9%
Receiving a badge	53	5	9.4%
Achieving a goal	102	3	2.9%
Come back-message for inactive users	132	0	-

The response rates demonstrate that users more often respond to notifications about the gamification features (weekly winner, and receiving a badge) than to notifications about water saving (tip of the week, achieving a goal).

The low response rate can be explained from the abundance of notifications from other apps. [Pielot et al., 2014] have demonstrated that users involved in their study receive on average 63.5 notifications per day. With such competition, social pressure is a key factor in deciding whether to respond to a notification. As a result, users prioritize on notifications of apps for personal communication over messages from other applications. This could also explain why the response is lower in the case of the SmartH2O app.

Furthermore, users had the opportunity to switch off the notifications. Given the abundance of notifications users regularly receive, some users may have switched off the SmartH2O notifications. As these preferences are stored locally, unfortunately we do not have any data on the number of users who have done so.

In the future, experiments with different designs and phrasings of the notifications are necessary to increase the response rate to the notifications.

4.4.7 Social sharing results

On February 14th, 2017, the extended SmartH2O social features were launched, accompanied by an e-mail announcement to all users. This includes the neighbourhood map as well as the option to share achievements and invite users via Facebook, Twitter or e-mail. The use of the social features was monitored over the period of one month (14/02/2017-14/03/2017). For the analysis, only users who signed up before the release of the new social features were considered.

From the analysed user base of 506 users, only six users opted out of the neighbourhood map and 23 already confirmed their address to appear on the map regarding the popularity of the map. For a period of one month, this is very promising and suggests the overall acceptance of this tool, but more time is needed to make more significant observations.

During the first month, the social sharing features were used by 12 users. Overall, the 12 users who used the features sent 184 invites to invite new users onto the portal, and performed 218 sharing actions, i.e. the sharing of water saving tips, water saving achievements, and the gamification status.

In addition, the average use of the sharing features was analysed per user (Figure 63).

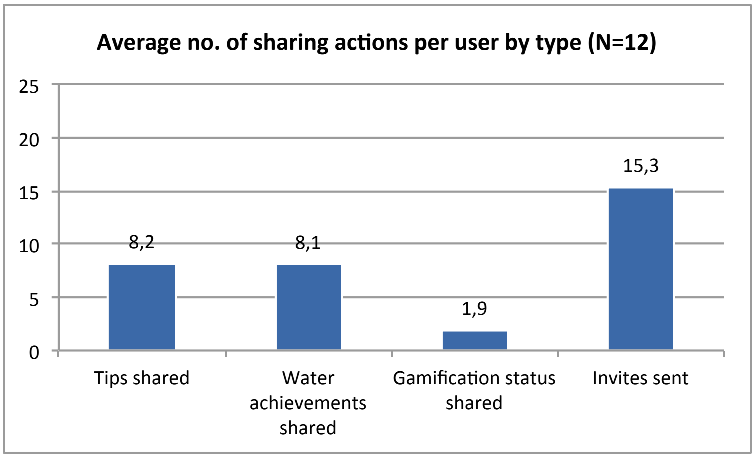


Figure 63. Spanish case study: Average no. of social sharing actions per user.

On average, each of the 12 users shared tips 8.2 times (s.d.=7.1), water saving achievements 8.1 times (s.d. =8.2), their gamification status 1.9 times (s.d.=1.7) and sent out invitations 15.2 times (s.d.=15.0) (see Figure 63). These first results tentatively indicate that water-related achievements and content (water saving achievements and tips) were shared more frequently than the gamification status. Thus, outside the SmartH2O portal, users seem to define themselves through their water saving actions and want to engage others from their social circle to engage in topics related to water saving rather than “bragging” with their gamification achievements.

One reason why the gamification status hasn’t been shared as often as tips or the water saving achievements could be that it carries little meaning outside the SmartH2O portal and is only information worth sharing with other SmartH2O users. E.g., the high acceptance of the neighbourhood map indicates that within the portal, users do want to compare their gamification status (see also section 4.4.2). Information and achievements related to real-world issues (water saving) on the other hand are meaningful also outside the portal and may therefore be more popular for sharing actions.

Secondly, sharing the gamification status is only rewarded once per week per channel since the status in unlikely to change frequently, while the other actions are rewarded once per day. This probably encourages the sharing of the tips and water saving achievements rather than sharing the gamification status. Still, these first findings can only be tentative indicators and further investigation is needed to confirm these assumptions.

Out of the 12 analysed users, 7 used the social sharing features actively (see Figure 64).

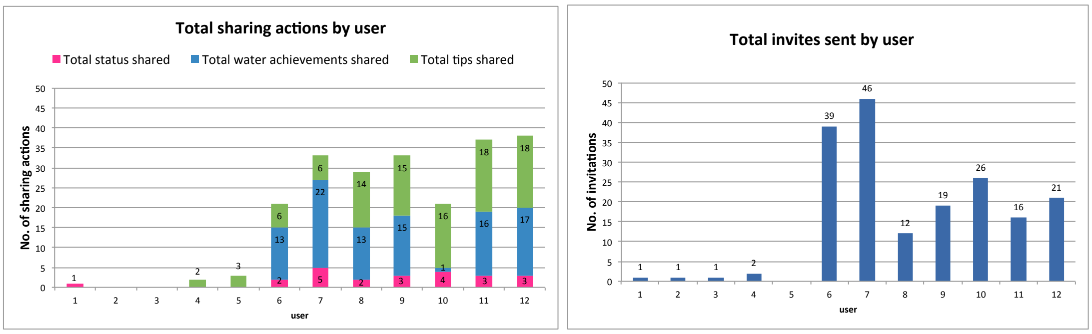


Figure 64. Spanish case study: Total sharing actions (l) and sent invitations (r) by user.

Again, water saving achievements and water saving tips dominate the sharing, likely due to the reasons explained above. Figure 64 also underlines that for active users, the ratio of sharing information and inviting others to join is similar. However, because the monitoring period was only one month, it still needs to be investigated if either of those two types of actions, and especially sending the invitations, will subside after a certain time because users may not continually invite their friends if they don't join after the first invitation.

In addition, it was analysed which type of channels were the most popular among users (Figure 65).

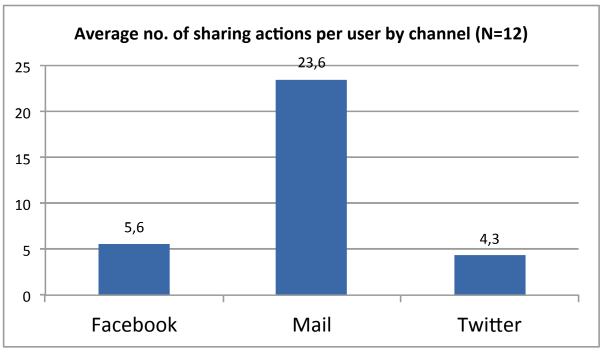


Figure 65. Spanish case study: Average no. of sharing actions per user by channel.

From the three available social channels, e-mail was by far the most popular when one considers the single action (Figure 65).

However, while e-mail is a typical one-to-one communication channel, the reach of social media channels like Facebook and Twitter is much higher. If a user makes between 4 and 6 posts on these social media channels, he could easily reach and thus influence several hundred users, depending on the number of Twitter followers and Facebook friends. To analyse the long-term impact of the social sharing features (e.g. increase in sign-ups), more time is needed to observe user behaviour. Also, invitations are currently only being sent out and the tracking of users who sign up in response to an invitation is not yet possible. Further research is needed to investigate social sharing behaviour and the impact of the individual channels.

4.5 Impact of portal usage on water consumption

In Section 4.1 we have demonstrated the overall effect of SmartH2O by comparing the water consumption of SmartH2O users against a control group. Results have demonstrated a reduction difference of 21.5% compared to the water consumption of the control group (3.8% absolute consumption reduction of SmartH2O users vs. 17.7% increase in the control group). In this section we inspect the results more closely, by relating the observed consumption difference to the usage of SmartH2O portal features. Such correlational analyses can demonstrate that the observed effects can indeed be attributed to the use of the platform.

For the 253 users for whom their consumption difference between baseline and trial period could be reliably computed (after data cleaning and removing outliers), we computed partial correlations between the consumption difference and the total and average number with which features were used, while controlling for their baseline consumption level, and how long users are member of the platform.

The results are summarized in Table 19. The consumption delta is the percentage with which the consumption has changed, compared to the baseline, with negative values meaning reductions, and positive values meaning an increase. Consequently, negative correlations denote that higher levels of usage are related to larger consumption reductions.

Table 19. Correlation between use of SmartH2O features and consumption delta.

Feature	R	Significance level
Total no. of logins	-.13	*
Total no. of water saving tips read	n.s.	
Total no. of water saving infographics inspected	n.s.	
Total no. of consumption chart inspections	-.13	*
Total no. of pipe overview inspections	-.18	**
Total no. of leaderboard inspections.	-.13	*
Total no. of self-set monthly goals	-.17	**
Total no. of self-set weekly goals	-.17	**

* $p < .05$; ** $p<.01$ *** $p< .001$

The results demonstrate that the more the key features of the SmartH2O portal are used, the larger the reduction of water consumption. This applies to logging in in general, but also to inspecting the water consumption pipe overview, inspecting the leaderboard, and setting water saving goals. Such results bear testimony to the effectiveness of the holistic SmartH2O incentive model, which seeks to foster engagement with water saving by appealing to generic basic desires (e.g. the leaderboard that seeks to appeal to the need for competition; Reiss, 2014), as well as to intrinsic motivations to save water (e.g. encouraging monitoring of water consumption, creating commitment by setting goals). The significant correlations found provide evidence for the potential of these incentive model elements to induce water saving behaviour.

Impact of using SmartH2O mobile apps

Even though the cross section of mobile app users and users for whom the difference in consumption is available is relatively small, computing the difference in consumption difference before and after the trial can provide a first indication of the potential of the app for inducing a change in water consumption behaviour. The results are displayed in Table 20.

Table 20. Average consumption delta for app users on and portal-only users

SmartH2O applications	n	Consumption delta (%)	S.d.
Web portal only	30	-3.90	19.46
Web portal only + app	15	- 5,94	13.37

At first glance, mobile app users seem to have a stronger reduction in consumption than users who only use the web portal. However, a univariate analysis of variance with the applications used (web portal only vs. web portal + app), and baseline consumption, and days of platform membership as covariates revealed that this difference was not significant ($F(1, 249)=.092$; n.s.). This could be due to the high standard deviations in both groups, and the difference in sample size. Furthermore, the mobile app has only been launched later in the trial. A longer duration of the trial and a larger share of the users installing the app could extend the tendency observed towards statistical significance.

4.6 Conclusion

In this section, the Spanish case study results have been presented. During the pilot, 508 users have signed up for the SmartH2O portal. Over the trial of almost a full year, water consumption has been monitored and compared against a historic baseline. Results have shown a 21.7% consumption reduction for SmartH2O users relative to the control group. This is quite a significant result, considering that Summer 2016 in Spain was recorded among the hottest, and the driest of the last decades. Moreover, the result is also relevant in comparison to scientific literature on similar experiences: most benchmark studies from the state of the art have shown behavioral change interventions leading to reductions of overall water consumption between 3 and 10% [WaterSmart, 2014]; [Davies et al., 2014]; [Inman and Jeffrey, 2006]; [Anda et al., 2013]; [Willis et al., 2010]. Only in exceptional cases reductions between 15 and 27% have been reported [Willis et al., 2010]; [Mayer et al., 2004]; [Ampt and Ashton-Graham, 2013], mainly due to technological interventions on specific end-uses and increased efficiency of water consuming devices. Apart from the result obtained as a response of SmartH2O users in terms of water conservation, the results presented in the previous sections are also interesting from a methodological point of view. Our single- and agent-based behavioural models have shown to be able to characterize and reproduce water consumers' behaviour with high accuracy, as well as to capture heterogeneity in behaviours, which contributes key information to utilities in view of a transition towards customized water demand management.

The user population has also managed to increase their awareness level on most measures, albeit less clear-cut as a result of the already high reported initial awareness. More specifically, increased awareness has been found on the beliefs on the necessity to save water, and the perceived behavioural control (i.e. the user's confidence in his/her ability to save water). Such beliefs and perceived behavioural control are important predictors for water consumption behaviour (e.g. [Gilg & Bar, 2006]; [O'Keefe, 2005]).

These results are corroborated by the user feedback from the questionnaire on specific features of the portal. More than 75% of the respondents stated that the consumption chart and overview, the tips, self-setting goals, and the water consumption alerts increased their motivation to save water and think about water consumption. Moreover, these results were also strongly correlated to the respective awareness measures, suggesting that the incentive model elements have succeeded in inducing a raise in awareness through an increased motivation of users.

The log analysis results have demonstrated an average level of user activity that exceeds the regular pattern of interaction between a water utility and the customer. Whereas customers commonly receive a water bill once every two months, and, in the case of EMIVASA, only 3% of the users log in to their customer portal every month, in SmartH2O the average number of logins is almost five times a month (though with a large variability between users).

The SmartH2O mobile app has been released to further increase the level of activity. A comparison of the behaviour of the app users before and after installation of the portal has demonstrated a significant increase with respect to the general login frequency, the use of the consumption chart, and the inspection of the gamification overview page. These results suggest that the mobile app is used to quickly check the consumption and the game status.

Finally, the correlation analysis further confirmed the results of SmartH2O impact on consumption reduction, as the results have shown that the frequency of use of all main system features significantly correlates with reduced consumption (e.g. water consumption chart and pipe overview, self-set goals, leaderboard). This can be considered as further evidence of the effectiveness of the SmartH2O incentive model to increase the engagement with water consumption information and subsequently to induce behavioural change in water consumption.

5. Final results of the Swiss case study

The Swiss scale pilot was set up as a testbed for the measurement infrastructure and the iterative deployment and testing of the SmartH2O app. In this section we report the final findings for this case study.

5.1 Water consumption results

5.1.1 Baseline water consumption profiles

Similarly to what we presented for the Spanish case study, we report model validation results also for users from the Swiss case study. We considered data in the baseline period between 1/06/2015 and 31/01/2016 for model calibration and validation. Adopting the same criterion used in the Spanish case study, we used 2/3 of the dataset (i.e., data between 1/06/2015 and 31/10/2015) for model calibration, and the remaining 1/3 for model validation (i.e., data between 1/11/2015 and 31/01/2016). Again, the baseline period is chosen prior to the adoption of the SmartH2O web portal by EMIVASA's user, so that water consumers are not influenced by any demand management intervention and their consumption in a non-intervention period can be evaluated. This period is different than that of the Spanish case study because the SmartH2O platform has been released a few months before in the Swiss case study.

After cleaning, the dataset considered included 1-hour resolution data for 48 users who registered to the SmartH2O portal, and 239 who did not, out of overall 329 metered users. Therefore, in this case we managed to consider data for around 87% of the users, meaning the quality of data for this small, controlled, case study was higher, even though the sample size is lower than that of the Spanish case study. The 239 users who did not register to the SmartH2O portal were used as the control group for comparison of consumption levels, despite it was not planned in principle. However, given that we did not run any questionnaire with these users, we only had information on water consumption for them, not on socio-demographics and preferences.

According to the procedure adopted for the previous case study, we extracted 4 clusters computed on the average daily consumption of the considered users and, then, partitioned each cluster again in two subclasses depending on the day-label, i.e., weekend or weekday depending on when water users usually consume the most. The resulting profiles are illustrated in Figure 66. In this case, the low number of users does not allow for generalization. Still, we can notice that the lowest profile contains more users than the other ones. Also, it is worth noticing that the consumption range (0-4 m^3/day) is larger than the one we found for the Spanish case study, the latter spanning between 0 and 0.8 m^3/day.

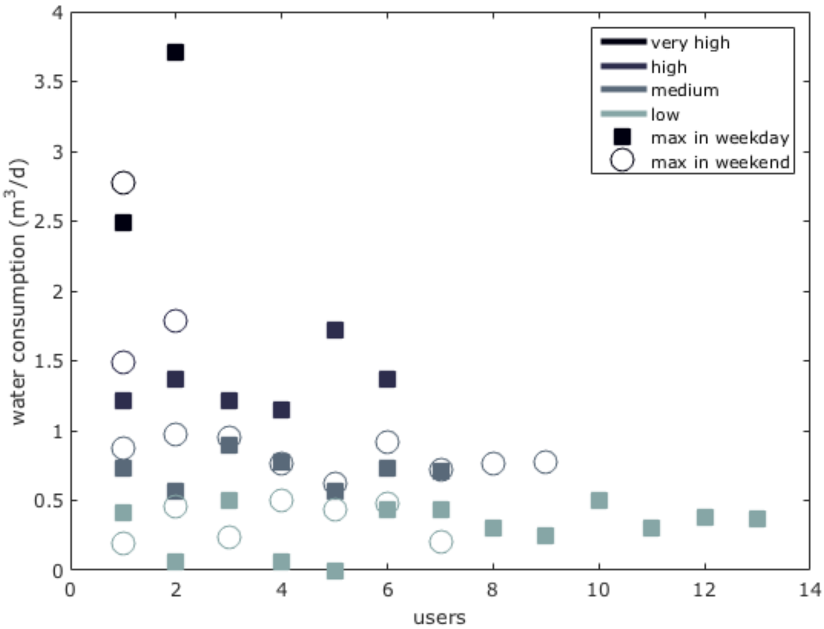


Figure 66: Daily consumption profiles of SES users.

Each profile is then modelled by estimating two probability density functions (assuming a normal distribution), the first for the daily consumption in weekdays and the second for the daily consumption in weekends. The statistics characterising the 8 probability distribution functions are reported in Table 21. According to the previous case study, it is worth noting that the estimated standard deviations are, in most of the cases, larger in weekends than in weekdays due to more regular routines of the users during the week. Moreover, given that only one user with limited data falls in the cluster of very high consumption and maximum consumption in weekend days, average and standard deviation for his/her weekdays are missing.

Table 21: Statistics associated to the identified consumption profiles. All the values are expressed in m3/d.

Profile	M weekday	Std weekday	M weekend	Std weekend
Very high – max in weekday	3.1752	0.8382	2.8948	0.9445
Very high – max in weekend	-	-	2.8349	0.1706
High – max in weekday	1.4157	0.2105	1.1364	0.3074
High – max in weekend	1.5625	0.2892	1.8343	0.0062
Medium – max in weekday	0.7353	0.1350	0.6480	0.0727
Medium – max in weekend	0.7897	0.1163	0.8890	0.1430
Low – max in weekday	0.1754	0.0484	0.2585	0.1856
Low – max in weekend	0.1430	0.0386	0.3932	0.1380

Following the usual procedure, from this statistical characterisation of the 8 consumption profiles, we finally model the single-user consumption behaviours by sampling the corresponding pdfs to generate a trajectory of daily water consumption for each user. Then, the generated trajectory is disaggregated from daily to hourly resolution by using the most typical load-shapes associated to each user. In total, we have identified 26 load-shapes, reported in Figure 67. Given the limited number of users and data, load shapes appear noisier in this case. Yet, most of the commonly adopted ones are characterized by peaks in the morning and evening. Again, high-frequency is obtained also for the load shape characterizing days/houses with no consumption, ranked third in this case.

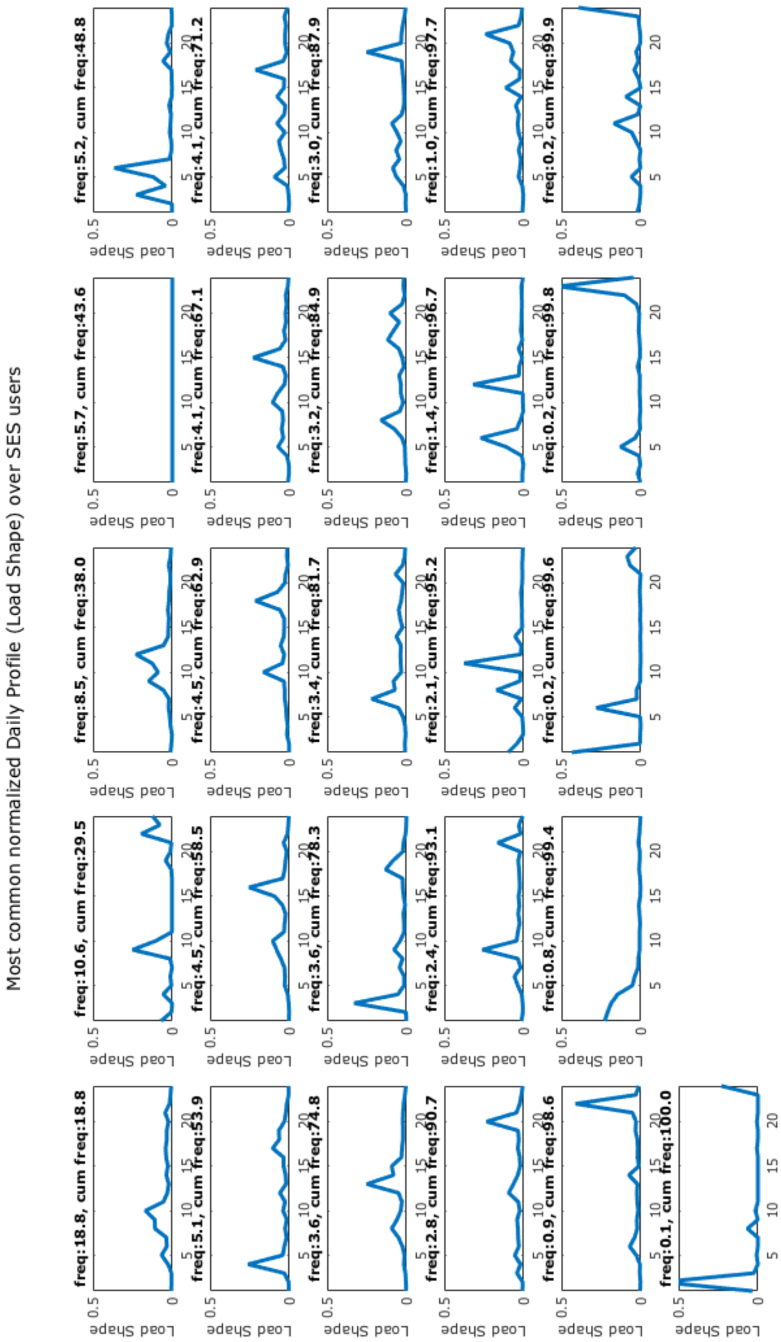


Figure 67: Set of load-shapes representing the typical hourly consumption patterns for SES users.

We evaluated the accuracy of the modelled single-user behaviours by comparing the simulated consumption over the validation period (1/11/2015 - 31/01/2016) against the observed one. Figure 68 shows that the distribution of the simulated daily consumption overestimates the observed one, in this case. The overestimation is probably to be attributed to the fact that the validation period falls in the late Fall - Winter seasons (November – January), while the model is calibrated on data from Summer – early Fall, when usually consumption is higher. Moreover, the low number of users considered does not allow for having an enough representative sample of users for generalization.

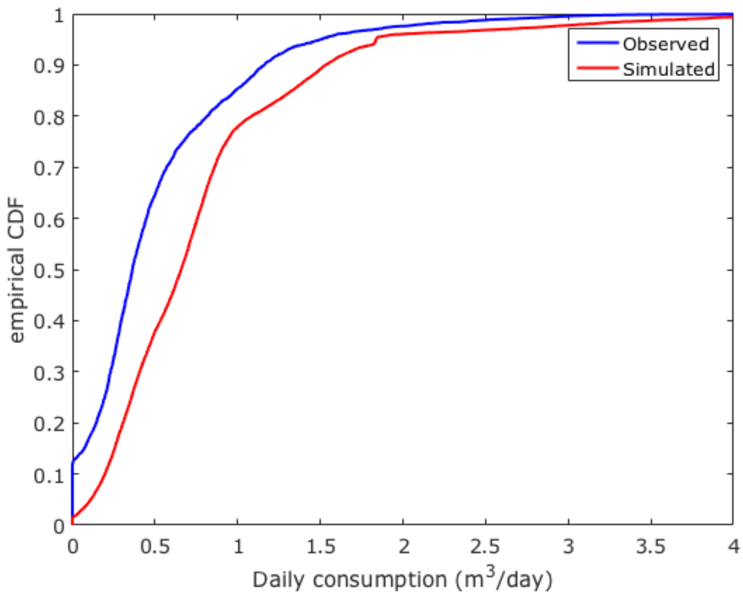


Figure 68: Empirical cumulative density function of daily consumption of SES users.

A more detailed comparison can be performed by comparing the empirical CDFs of simulated and observed consumption separated for weekdays and weekends, see Figure 69. Results are comparable to those commented in the previous figure, with a small systematic overestimation of consumption levels.

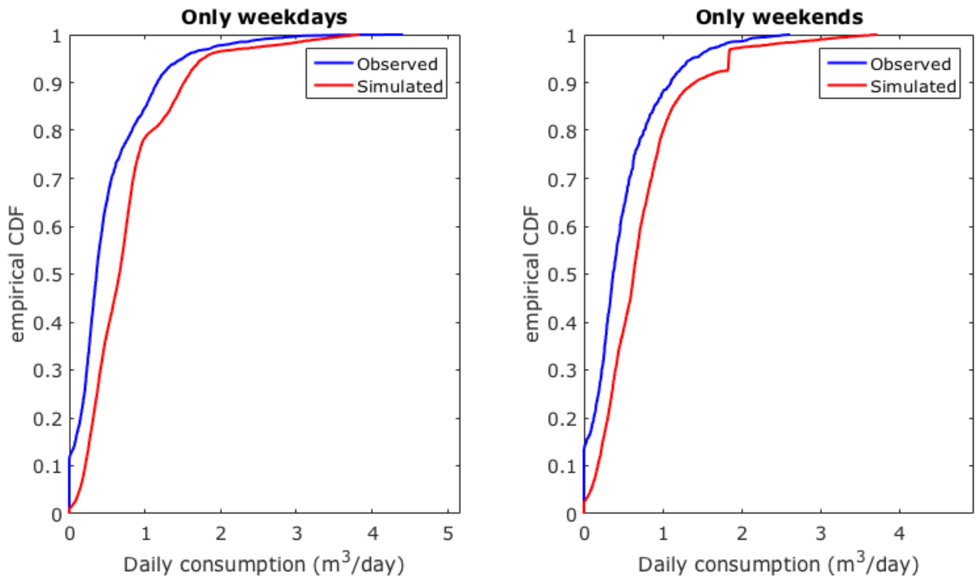


Figure 69: Empirical cumulative density function of daily consumption of SES users, estimated for weekdays (left panel) and weekends (right panel) separately.

Finally, we assessed the quality of our profiles in reproducing the hourly consumption patterns by comparing the empirical CDFs estimated on hourly consumption differentiated depending on different fractions of the days, specifically morning (i.e., from 5 to 9), middle day (i.e., from 10 to 16), evening (i.e., from 17 to 22), and night (i.e., from 23 to 4). In this case, the accuracy is generally high, apart from the overestimation in the morning period, which probably reflects the overestimations found before for the aggregate daily data estimates.

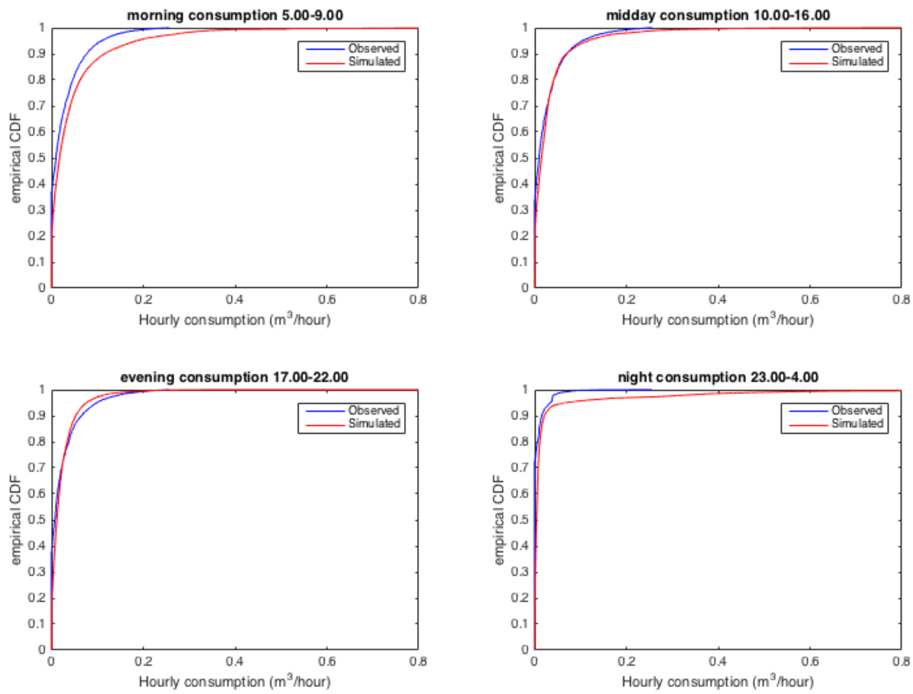


Figure 70: Empirical cumulative density function of hourly consumption of SES users, for different periods of the day.

5.1.2 Water consumption after sH2O platform signup

Despite the Swiss case study is a small pilot used in this project mainly to deploy smart metering systems in the area, we assessed whether SES users involved in the SmartH2O project modified their consumption as a result of adopting the SmartH2O web. As done in the case of EMIVASA users, we compared their distribution among clusters between the baseline period and the observation period, i.e., the period following the introduction of the SmartH2O (1/02/2016 – 17/02/2017). Also in this case, after data were further cleaned by removing those users with unrealistic consumption change via Tukey's test for outlier removal. As a result, we kept data for 44 SmartH2O users and 216 users in the control group.

Results from the above comparison of consumption levels between the two groups and the baseline and observation periods are shows in Figure 71. Again, the comparison is limited to the first level of hierarchical clustering (i.e., clusters of users are based on average consumption levels) to allow for comparison with the results obtained for the Spanish case study.

Results in the figure show that, in general, the distribution of users among consumption clusters is not too different between SmartH2O users and control group users for the baseline period. Later, in the observation period, the distribution of SmartH2O users is strongly shifted towards the lowest consumption cluster, with a decreasing number of users in highest consumption clusters and cluster 4, the one with highest consumption, which becomes empty. The transition among consumption clusters is more evident than in the Spanish case study and this suggests a decrease in overall water consumption. Considering users in the control group, also in that case the highest cluster becomes empty, but there are not as many shifts towards the lowest consumption class as for the SmartH2O users.

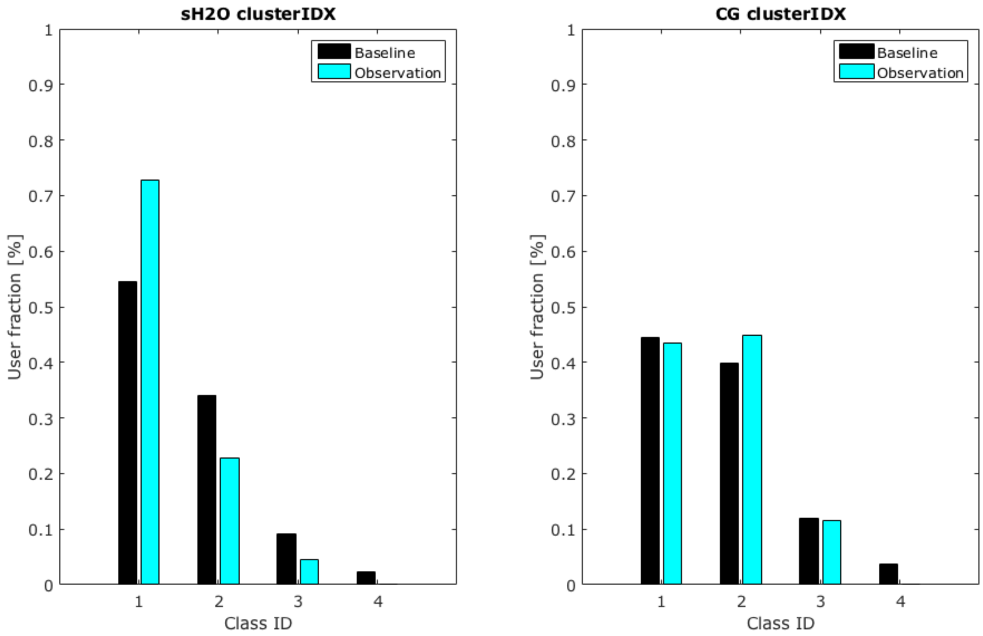


Figure 71. Distribution of users among clusters. SmartH2O users (sH2O) on the left, Control Group users (CG) on the right.

A more detailed overview of transitions among clusters for the SmartH2O users is reported in Table 22, where the percentage of users moving from one cluster to another one is reported. It is clear how, in this case, there is a strong prevalence of shifts towards lowest-consumption clusters, which confirms what commented for the figure above.

Table 22. Matrix of transitions (%) of SmartH2O users among consumption clusters, between the baseline and the observation periods.

		OBSERVATION CLUSTER			
		1	2	3	4
BASELINE CLUSTER	1	56.25	0.00	0.00	0.00
	2	16.67	14.58	0.00	2.08
	3	0.00	6.25	2.08	0.00
	4	0.00	0.00	2.08	0.00

The overall results in terms of behaviour change, i.e., consumption change, are reported in Table 23 and Table 24. In this case, the average per-capita percent of reduction of SmartH2O users is higher than that obtained in the Spanish case study. Indeed, here SmartH2O users reduce their consumption in the observation period by an average of 9.92% if compared to their consumption during the baseline. This implies an overall reduction in volume of water used by over 12%, and over 15 in the Summer period. These values are very relevant, as the average consumption reduction in liters is 94 liters, which corresponds, for instance, to the water used for a 10-minute shower. Overall, if we compare these percentages of reduction with those of the control group, we clearly see that consumption has overall decreased for both groups and it is very similar for both in the Summer period. Yet, the average per-capita percentage change of consumption from the baseline for SmartH2O users is almost two times higher than the the one of the control group. Moreover, such percentages of reduction acquire more value if we consider that the 9.92% consumption reduction for sH2O users refers to a baseline of, on average, 0.76 m3/day, while the 5.83% reduction of the control group refers to a lower baseline of 0.6 m3/day.

Table 23. Consumption change between baseline and observation period.

	Average per-capita % of consumption change from baseline	Total volumetric % of consumption change from baseline
sH2O users	-9.92	-12.43
Control Group	-5.83	-10.48

Table 24. Consumption change between baseline and observation Summer (July - August) periods.

	Average per-capita % of consumption change from baseline	Total volumetric % of consumption change from baseline
sH2O users	-16.80	-15.39
Control Group	-13.08	-18.70

5.1.3 Agent-based model simulation

Analogously to what we have done in Section 4.1.3 for the case study of Valencia, in this section, we apply the agent-based model presented in D3.4 to the Swiss case. First of all, we calibrate and validate the ABM with respect to the baseline water consumption data (between 1/06/2015 and 30/04/2016). Thence, based on the previous step, we calibrate and validate the model with respect to the observed data after sH2O platform signup (between 1/06/2016 and 17/02/2017), and thus try to capture within the model the effect of the SmartH2O platform on water consumption.

***Modelling observed behaviour: the baseline period*.**

The single-user behavioural model described in Section 5.1.1 was run on the dataset collected by SES during the SmartH2O project over the baseline period between 1/06/2015 and 31/01/2016 for model calibration and validation. Adopting the same criterion used in the Spanish case study and for the validation of single-user behavioural models, we used 2/3 of the dataset (i.e., data between 1/06/2015 and 31/10/2015) for model calibration, and the remaining 1/3 for model validation (i.e., data between 1/11/2015 and 31/01/2016). The used dataset included 1-hour resolution data for 48 users who registered to the SmartH2O portal.

The structure of the model, and the procedure for determining the consumption of an agent, are the same as the one described in the Subsection *“Modelling observed behaviour: the baseline period”* of Section 4.1.3.

The calibration of the model has been obtained with the seasonality factors of the ABM validated in D3.4 for the Swiss case study.

Table 25 summarises the obtained results based on 25 simulations. The average value is reported in the first column (standard deviation in the second column). The average daily consumption obtained from the observed data is reported in the third column.

Table 25. Results for the calibration of of the ABM on the baseline period for the Swiss

case study (1/06/2015 - 31/10/2015).

	Mean [m^3/day]	*Standard deviation*	*Average user daily consumption in the Swiss case study [m^3/day]*	*MSE of daily consumption [%]*
June 2015-October 2015	0.8883	0.0300	0.8568	11.57

The % mean square error between daily water consumption as estimated at the district level by the agent-based model, and the observed water consumption during the concerned calibration period corresponds to 11.57%.

The performance of the model has been thence evaluated by considering the validation period ranging from 1/11/2015 to 31/1/2016 against the observed SmartH2O for the same period. For the whole period we have computed the average aggregate daily water consumption. Table 26 summarises the obtained results based on 25 simulations. The average value on the whole considered period is reported in the first column (standard deviation in the second column). This is compared to the average daily consumption obtained from the observed data (third column).

Table 26. Forecasting consumption results of SES users on the baseline period (1/11/2015 - 31/01/2016).

	Mean [m^3/day]	*Standard deviation*	*Average user daily consumption in the Swiss case study [m^3/day]*	*MSE of daily consumption [%]*
November 2015 - January 2016	0.5857	0.0190	0.5150	2.40

From Table 26, we see that the consumption forecast provided by the model is close to the real water usage. This is confirmed by the fact that the % mean square error between daily water consumption as estimated at the district level by the agent-based model, and the observed water consumption during the validation period is small and corresponds to 2.40%.

Modelling observed behaviour: the period after sH2O platform signup.

The model obtained in the previous subsection has then been applied to the period following the introduction of the SmartH2O platform in the Swiss case (1/02/2016 – 17/02/2017). As for the baseline period, the ABM has been calibrated and validated against observed consumption data described in Section 5.1.2.

Analogously to what has been done in the Spanish case study described in Section 4.1.3, in the aim of capturing the influence of the use of the platform, in the ABM we activated the boolean parameter E and the value prob(E) described in Section 4.2.3 of the D3.4. We recall that the parameter E captures the predisposition that a user, once on the platform, will start reducing its daily consumption, whereas the parameter prob(E) captures the probability that an agent will have such a predisposition once on the platform. For the problem of assigning a value to prob(E), we follow the same approach as in D3.4 for the Terre di Pedemonte case study and thus rely on the results of the survey conducted in WP5 on SES users described in Section 4.3.5 of D3.4: symbolic incentives increase of 10.8% the probability of a SES user to reduce its daily water consumption. Based on this observation, we thence assume that with a probability of 10.8% a user born with a predisposition of reducing its water consumption once on the portal, that is prob(E)=0.108.

As done in Section 4.1.3, we then assume that all users are on the platform, and the attitude towards reduction is completely determined by the initial Boolean value of E assigned to the agent with probability prob(E) when the model is initialised. Moreover, based on the finding of Section 5.1.2, we refine the consumption reduction function: instead of applying a simple reduction factor as done in D3.4, we use the transition matrix depicted in Table 25 of Section 5.1.2, and thus we add the following pre-processing step before agent *H* starts the procedure for calculating the consumption described in the previous subsection:

- Assume parameter E of agent *H* is true, and its consumption class is C. Then with probability given by the value in cell (C,K) in the transition matrix of Table 5 (K=1,..4), agent *H* will be in class K during this turn and will calculate its consumption accordingly.

We first study the performance of the model on the calibration period ranging from 1/02/2016 to 9/10/2016 against the observed data for the same period. Table 27 summarises the obtained results based on 25 simulations. The average value is reported in the first column (standard deviation in the second column). This is compared to the average daily consumption obtained from the observed data (third column). It shows that the consumption forecast on the whole period provided by the model is very close to the real water usage on the calibration period after the sH2O platform signup. The % mean square error between daily water consumption as estimated at the district level by the agent-based model, and the observed water consumption during the calibration period is of 10.36%.

Table 27. Results for the calibration of of the ABM on the period after the sH2O platform signup for the Swiss case study (01/02/2016 – 09/10/2016).

	Mean [m^3/day]	*Standard deviation*	*Average user daily consumption in the Swiss case study [m^3/day]*	*MSE of daily consumption [%]*
February 2016 - October 2016	0.7521	0.0391	0.7307	10.36

The performance of the calibrated model for the Swiss case study has then been validated against the observed data in Terre di Pedemonte during the period 19/11/2016-13/02/2016.

Table 28 summarises the obtained results based on 25 simulations and compares them to the average daily consumption obtained from the data coming from the SES database of Terre di Pedemonte (third column). Table 28 shows that, considered the overall complexity of the case study, the consumption forecast over the whole validation period provided by the model is not too far from the real water usage. The % mean square error between daily water consumption as estimated at the considered Swiss district level by the agent-based model, and the observed water consumption during the validation period is of 7.62%.

Table 28. Forecasting consumption results of SES users on the period after the sH2O platform signup (10/10/2016 – 12/02/2017).

	Mean [m^3/day]	*Standard deviation*	*Average user daily consumption in the Swiss case study [m^3/day]*	*MSE of daily consumption [%]*
October 2016 - February 2017	0.5788	0.0267	0.7152	7.62

5.2 User base and questionnaire response

The final user base was comprised of 47 users. From these users, 25 used the basic portal, and 22 the advanced portal. The final questionnaire was sent to both groups of users. For the basic portal, four people responded to the questionnaire (16%), while the advanced portal questionnaire yielded nine responses (41%). Sign-up rates are comparable to the Spanish case study. One of the responses (advanced portal) needed to be discarded because s/he has filled out the questionnaire twice, bringing the final number to eight respondents.

5.3 Water consumption awareness results

This section reports on the awareness results from the final evaluation, reporting on the same measures as were used for the evaluation of the Spanish case study. Even though the small-scale nature of the portal prevents us from drawing conclusions on the impact of the awareness levels, assessment of the awareness with similar instruments as in the Spanish case study can provide a very tentative indication of the impact on awareness.

Data on the TPB measures was collected at sign-up from the release of the advanced portal onwards. For existing users, TPB-measures were collected during the basic portal evaluation. In addition, for all users sign-up questions on the extent to which the water consumption is known and the estimated number of cubic meters per month were available.

In this section we first present the post-trial awareness results, and then compare the results of the two sign-up questions against the final evaluation. For both parts, the results should be interpreted with caution given the small number of responses for both the basic portal (n=4) and the advanced portal (n=8). Rather, the results should not be considered as the small

5.3.1 Beliefs about water consumption

Beliefs about water consumption were assessed using a four-point Likert scale ranging from strongly disagree (1) to strongly agree (4). In Figure 72 the results for the beliefs are displayed.

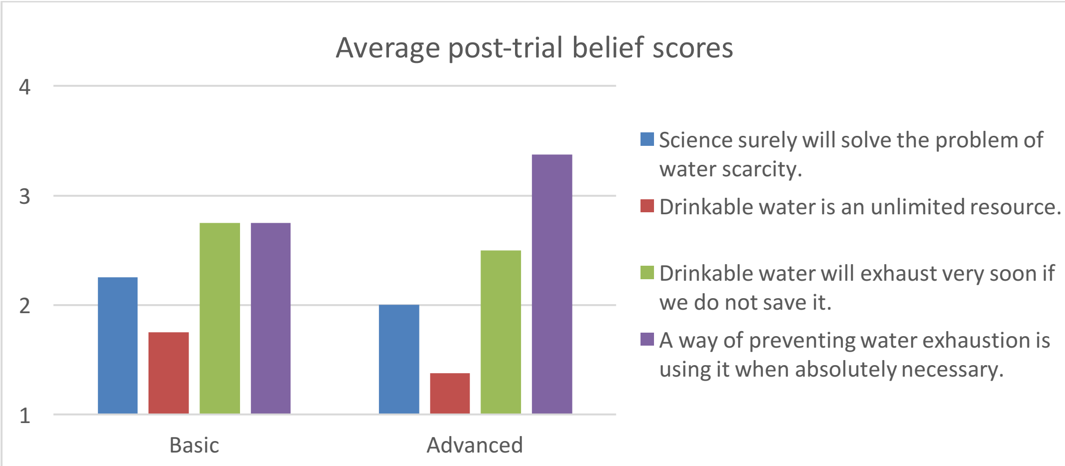


Figure 72. Post-trial belief scores in the Swiss case study.

The results suggest that the belief that preventing water exhaustion through water saving is stronger for advanced portal users than for basic portal users. Advanced portal users also believe to a lesser extent that drinkable water is an unlimited resource. The perceived urgency of saving water to prevent exhaustion is less for the advanced portal users than for the basic users.

5.3.2 Attitudes about water saving

Attitudes were assessed using four seven-point semantic differentials, with 1 representing the negative anchor (e.g. bad), and 7 representing the positive anchor (e.g. good). Results are displayed in Figure 73.

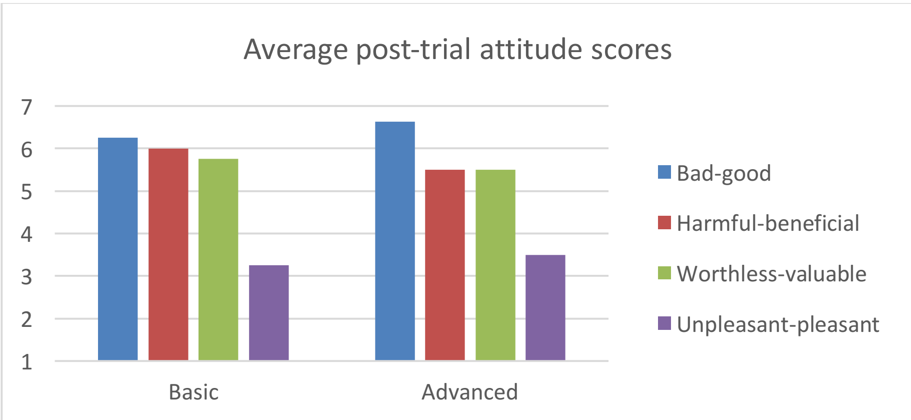


Figure 73. Post-trial attitude scores in the Swiss case study.

The results demonstrate comparable attitude levels for the basic and advanced portal users. Small differences can be observed on the bad-good item, which is rated more positively by the advanced portal users, whereas the harmful-beneficial item is slightly higher for the basic portal users. For both groups of users, the unpleasant-pleasant item is lower than the other attitudes, suggesting a trade-off between hedonic and ecological values (e.g. [Lindenberg & Steg, 2013]).

5.3.3 Perceived behavioural control over water consumption behaviour

Perceived behavioural control was measured using a single seven-point Likert scale, ranging from completely disagree (1) to completely agree (7): *"I am confident that I could save water."*

The result is displayed in Figure 74.

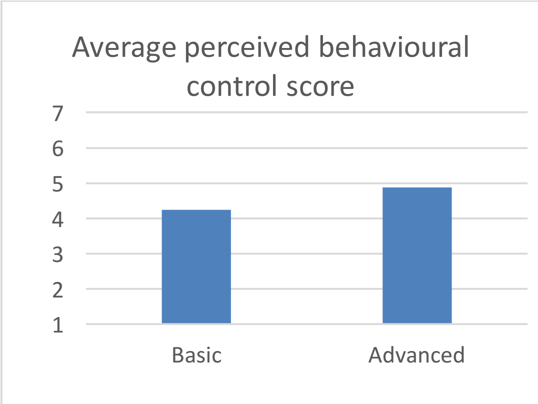


Figure 74. Post-trial perceived behavioural control score in the Swiss case study.

The results indicate that advanced portal users are more confident in their ability to save water than basic portal users. The moderate levels about one point above the neutral point of the scale suggest that there is room for improvement and for additional incentives to attract the attention of the users to the water saving tips.

5.3.4 Subjective norm

Subjective norm was assessed by means of three seven-point scale Likert items. In Figure 75 the results are shown.

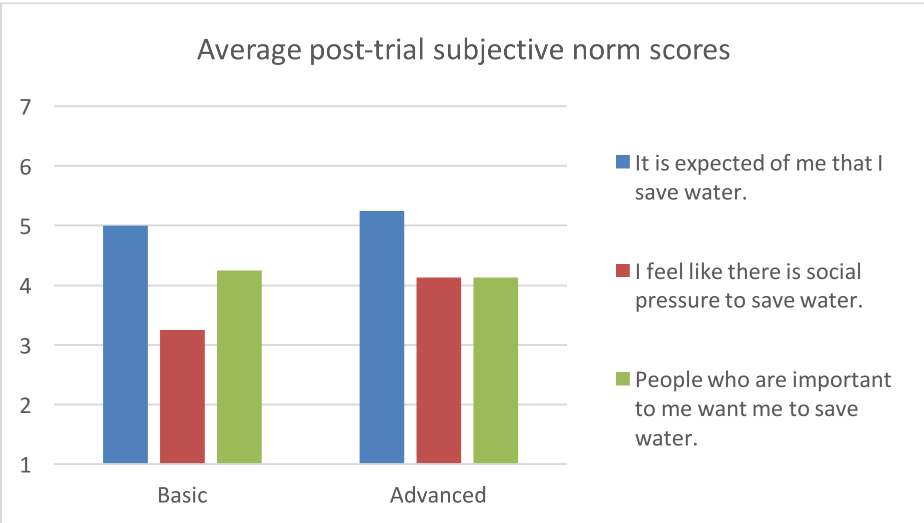


Figure 75. Post-trial subjective norm scores in the Swiss case study.

For the first two items, the advanced portal users have provided higher scores than the basic portal users, suggesting they are more susceptible to social incentives than the basic portal. In contrast, the basic portal users seem to have more important people in their environment who want the user to save water.

5.3.5 Behavioural intention

Behavioural intention was assessed using three seven-point Likert-scale items. Figure 76 depicts the results.

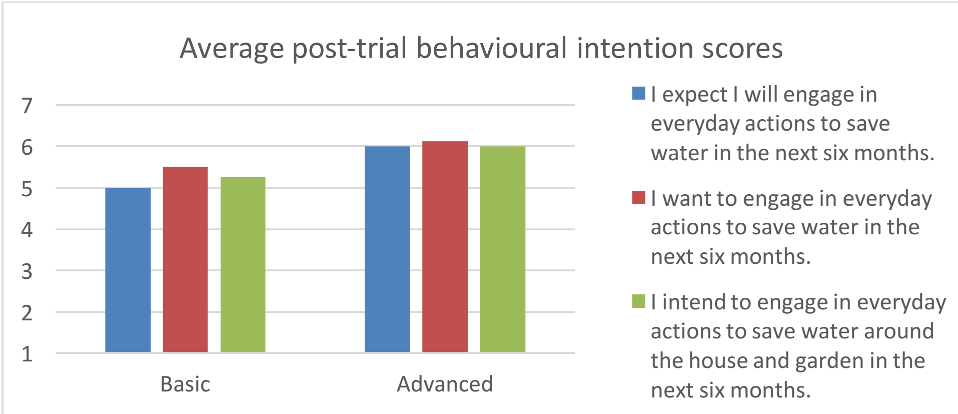


Figure 76. Post-trial behavioural intention scores in the Swiss case study.

Results suggest that the behavioural intention to save water is higher for the advanced portal than for the basic portal, with little variation between the three items. This result is positive since the full incentive model employed in the advanced portal seemed to have contributed to a more positive intention to save water (with average scores around 6), while for the basic portal users the average was slightly above 5. However, considering the sample size, this result should be interpreted with caution.

5.3.6 Comparing the baseline against post-trial measurements

In this section we compare the answers users have provided to the two awareness questions at sign-up with the answers to the same questions that were introduced in the final evaluation questionnaire. A Likert item was used to assess the perceived awareness of the consumption level, while an open question was used to ask for an estimation of how many cubic meters per month the user's household is consuming.

Given the small numbers and the distribution of users over the basic and advanced portal, no statistical analyses could be performed. However, visual inspection of the results provides an indication of the effect of the portal on awareness.

For the self-reported awareness item, the results are displayed in Figure 77.

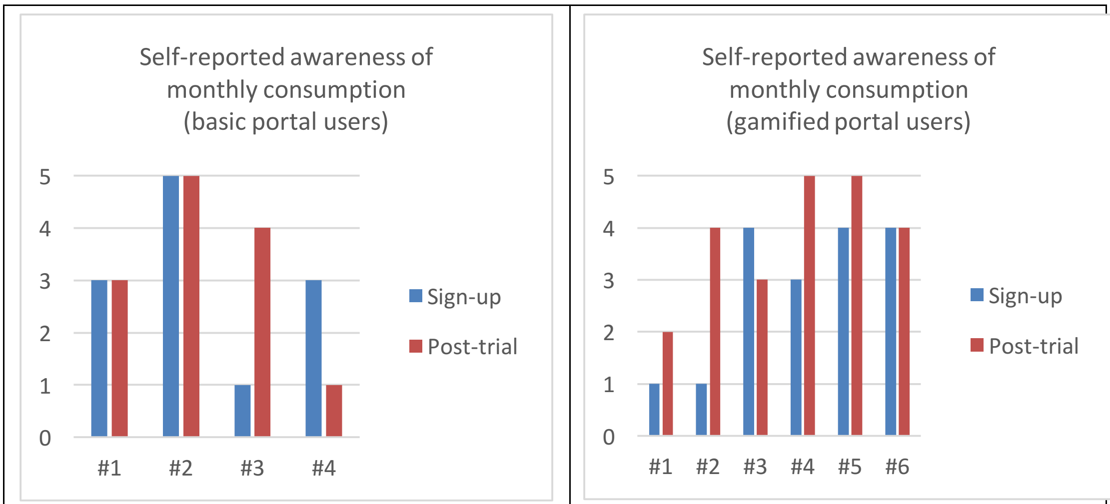


Figure 77. Self-reported awareness of monthly consumption for basic and advanced portal users.

Results show that for four of the six advanced portal users and for one of the basic portal users the self-perceived awareness has increased. In contrast, for one user in each portal version the awareness has decreased, while for the other users the awareness has remained at the same level.

The second question concerned the estimated number of cubic meters of water the household has consumed. We computed the difference between the actual consumption and the estimated consumption, and compared the deviation between sign-up and post-trial. For the basic portal, to avoid the graph becoming unreadable one user was left out of the graph whose estimated error was 1000 m3 at the baseline, and 19.52 post-trial.

The results are displayed in Figure 78.

Basic portal	Advanced portal

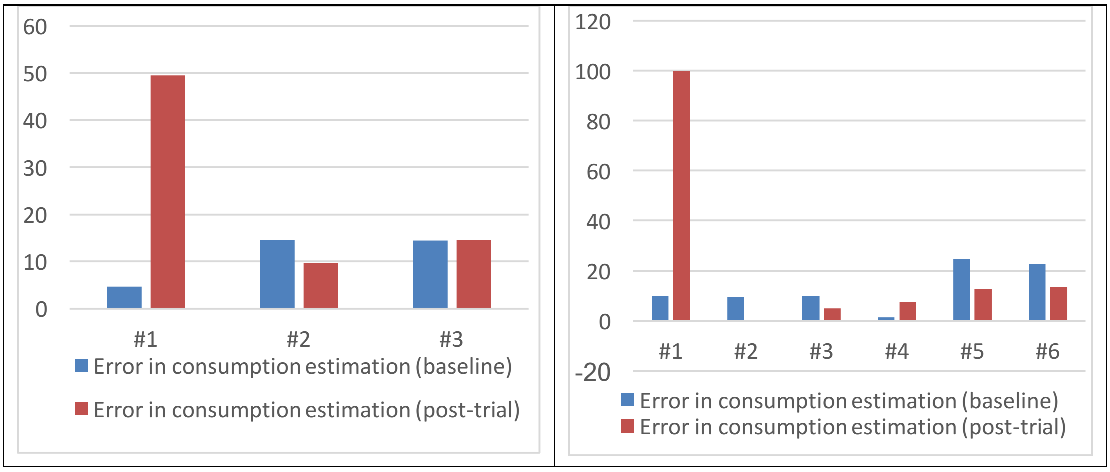


Figure 78. Error in user's estimation of household consumption (in m3)

With the with a 1000 m^3 error at baseline user included, for two users the error in estimation has reduced, for one user it has remained almost the same, and for one user it has increased. From the six users in the advanced portal, for two user the error in estimation has increased, and for four users it has decreased.

Given the number of users no generalizations can be made concerning the effect on awareness. However, results suggest a small tendency towards the advanced portal with all incentive model elements reducing the error in estimation more than the basic portal.

5.4 Technology acceptance results

Both advanced and basic portal users were considered in the final evaluation of the Swiss case study. The total of 12 respondents subdivides into 8 advanced and 4 basic portal users. They are presented separately in the following two subsections.

Technology acceptance at the application level was measured using the established UTAUT framework [Venkatesh et al., 2003]. In this final evaluation, performance expectancy and attitude toward using the technology were assessed to be able to account for temporal influences since the intermediate evaluation reported in D4.4. Effort expectancy (usability) and Hedonic quality stimulation vs. pragmatic quality [Hassenzahl, 2004] have already been reported in D4.4 and were omitted in the final questionnaire since no temporal effect is expected to occur.

5.4.1 Technology acceptance of the Advanced portal

Overall, Swiss users express a positive attitude towards the advanced portal (Figure 79).

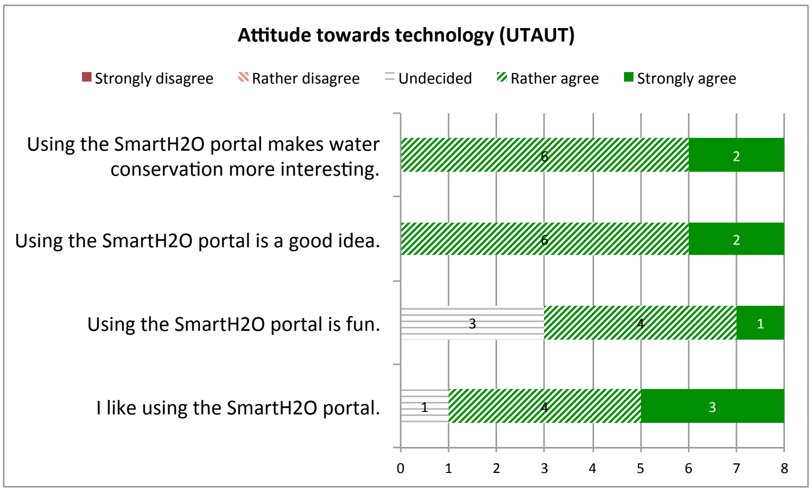
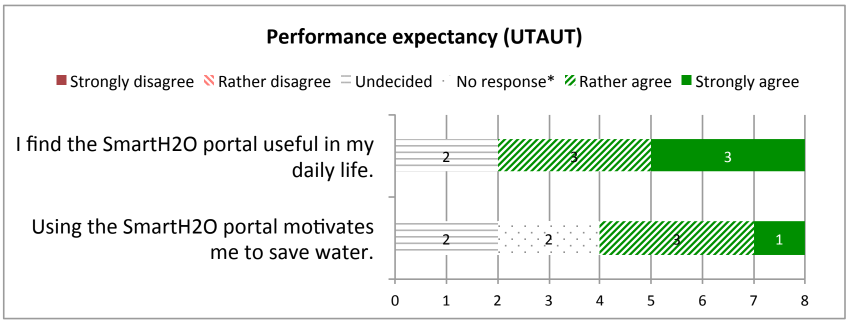


Figure 79. Swiss advanced portal (N=8) : Attitude towards technology (UTAUT).

While respondents all agree that the portal makes water conservation more interesting, that using it is a good idea and that they like using it (except for one undecided user), 3 out of 8 users are undecided on whether it is also fun to use. One reason for this could be that the main goal of saving water is rather utilitarian and outweighs to some extent the more game-like aspects for a subset of the users.

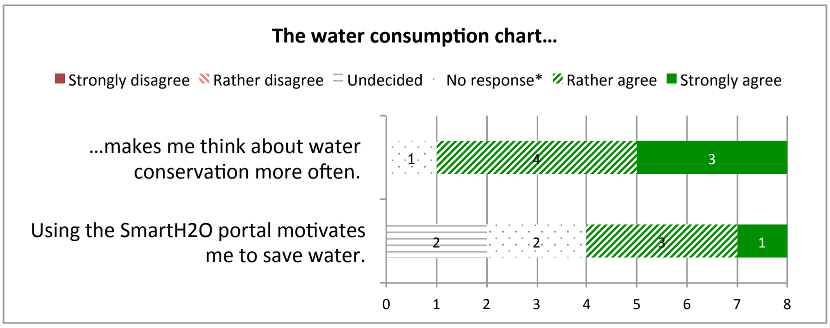


due to a technical error, some questions were not prompted to all users

Figure 80. Swiss advanced portal (N=8/6) : Performance expectancy (UTAUT).

Furthermore, 6 of 8 respondents find the SmartH2O portal useful in their daily live, and 4 of 6 respondents find that using the SmartH2O portal motivates them to save water (Figure 80). These are positive indicators towards the perceived usefulness of SmartH2O.

In addition to the overall perception of the portal, feedback on individual features was collected.



due to a technical error, some questions were not prompted to all users

Figure 81. Swiss advanced portal (N=7/6): Water consumption chart.

All responding users find that the water consumption chart makes them think about water conservation more often and only two are undecided whether the portal motivates them to save water or not (Figure 81).

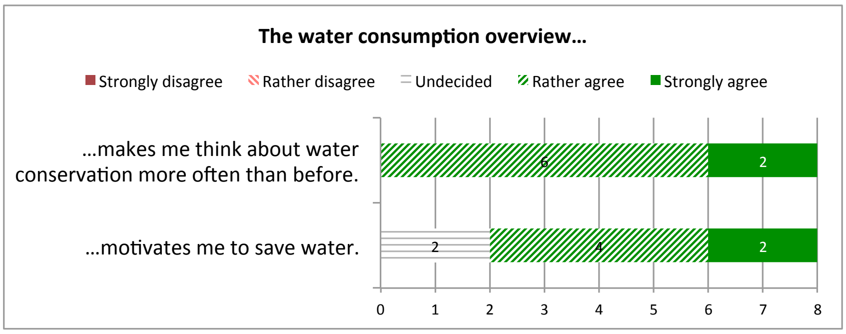


Figure 82. Swiss advanced portal (N=8): Water consumption overview.

All users think that the water consumption overview makes them think about water conservation more often than before and, similarly to the consumption chart, only two users are undecided whether the consumption overview motivates them to actually save water while the rest agree to strongly agree (Figure 82).

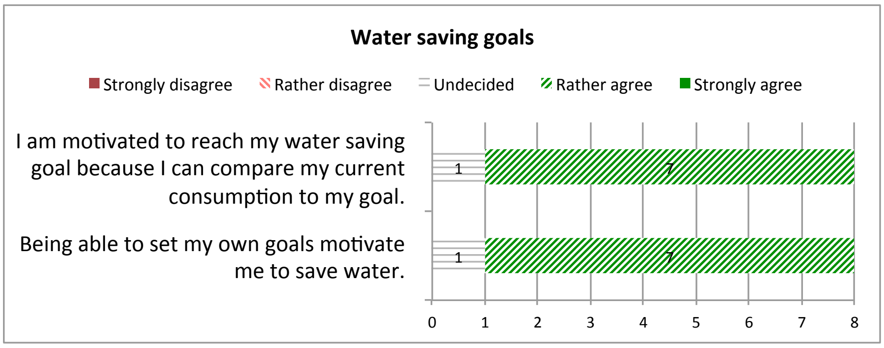


Figure 83. Swiss advanced portal (N=8): Water saving goals.

All but one user rather agree that being able to set their own goals motivate them to save water and that they are motivated to reach their water saving goal because they can compare their current consumption to their goal (Figure 83).

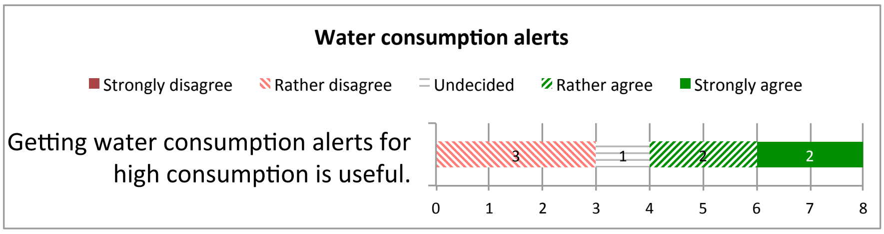
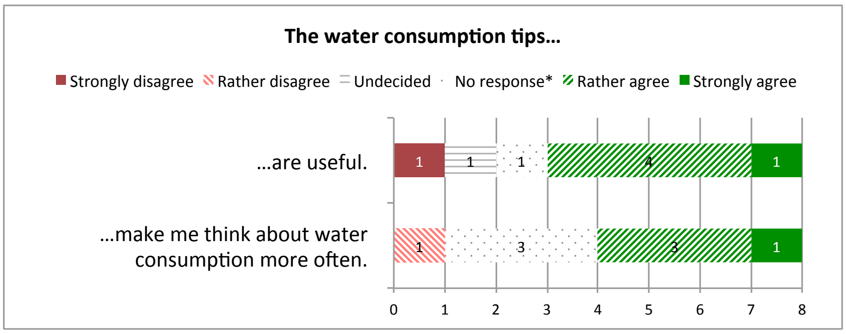


Figure 84. Swiss advanced portal (N=8) : Water consumption alerts.

Attitude towards the usefulness of the consumption alerts varies (Figure 84). 3 users rather disagree that getting water consumption alerts for high consumption is useful in contrast to 4 users who rather to strongly agree. Further information and a larger sample would need to be collected to investigate why some users don't find this feature useful. The perceived usefulness of the water consumption alerts may be related to the type of alerts users have received. Need achievement theory (Atkinson, 1960) states that users feel the need to demonstrate high rather than low ability. When confronted with negative alerts that contradict one's self-image, users may become more negative about the respective feature. To validate this claim, the perceived usefulness must be correlated to the type of consumption alerts the users have received. However, the currently available data do not allow for such an analysis.



*due to a technical error, some questions were not prompted to all users

Figure 85. Swiss advanced portal (N=7/5) : Water consumption tips.

All but one of the respondents agree that the water consumption tips are useful and make them think about water consumption more often (Figure 85). The specific user who disagrees may not find them applicable to their own situation since tips are not personalized at this point. As a direction of future research, personalisation of water saving tips could be investigated as a strategy to influence their (perceived) usefulness.

5.4.2 Technology acceptance of the Basic portal

In addition to the advanced portal users, the basic portal users were also asked for feedback.

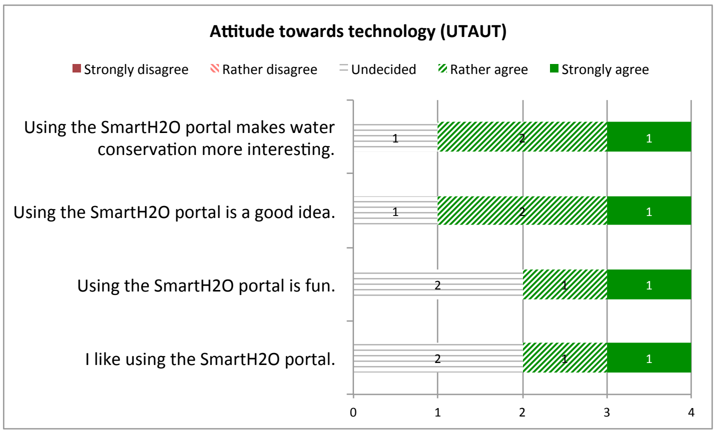


Figure 86. Swiss basic portal (N=4): Attitude towards technology (UTAUT).

They overall express a positive attitude towards the portal, but similar to the advanced users there is some indecisiveness about whether using the portal is fun and they like using it (Figure 86). This is still a very positive result for a system that visualizes ones water consumption.

To judge this result, the use of the SmartH2O portal must be compared against the regular interaction between a utility and their customers, which is focused on the water bills. Looking at the such water bills is unlikely to be considered fun by most customers.

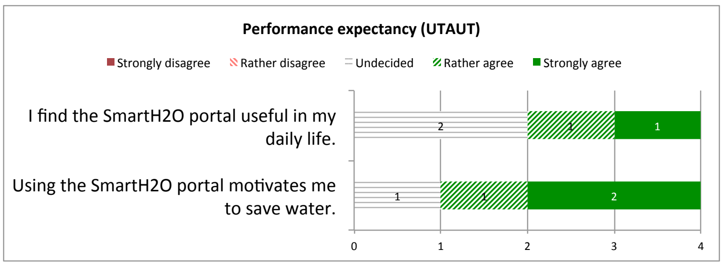


Figure 87. Swiss basic portal (N=4): Performance expectancy (UTAUT).

The basic portal users who responded either agree that the SmartH2O portal is useful in their daily life or are undecided while none disagree (Figure 87). Users don't usually login into the portal on a daily basis, nor are they expected to, which may have influenced responses. Instead, using it once a week to several times a month already ensures an engagement with water saving that cannot be reached with standard means such as paper water bills or even standard digital billing systems. Two users strongly agree and one rather agrees that using the SmartH2O portal motivates them to save water. Since they are using the basic rather than the advanced portal, saving water is likely the main goal they have when using the portal and the indication that this is indeed the case for three out of the four users is a positive result.

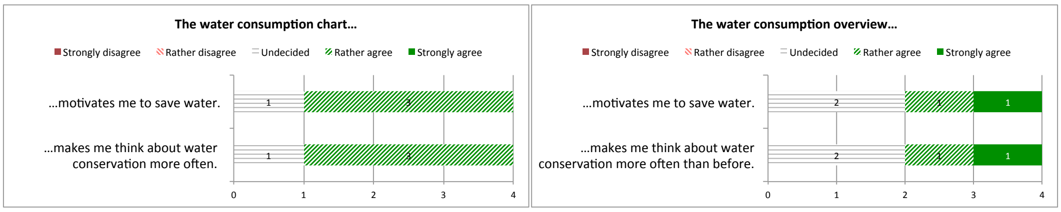


Figure 88. Swiss basic portal (N=4): Water consumption chart (l) and overview (r).

The water consumption chart motivates three of four users and makes them think about water consumption more often (Figure 88). Two of the users are undecided whether the water consumption overview has the same effect, while the other two rather and strongly agree. But since the basic portal users are assumed to not value gamification and playful features as much as advanced portal users, it is only logical if the basic bar chart appeals the most to them.

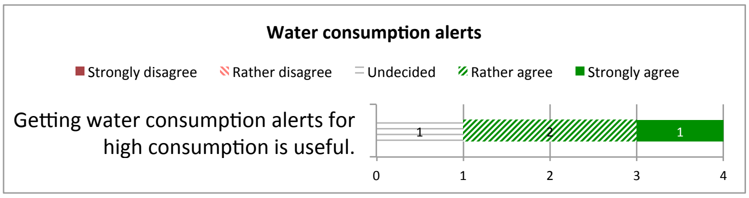


Figure 89. Swiss basic portal (N=4): Water consumption alerts.

Three of the four users find the water consumption alerts useful (Figure 89). This indicates that basic portal users are interested in their consumption and value being informed about any irregularities, even if they indicate that they might be using too much water with their current behaviour (in contrast to some of the advanced users, who don't find the alerts useful).

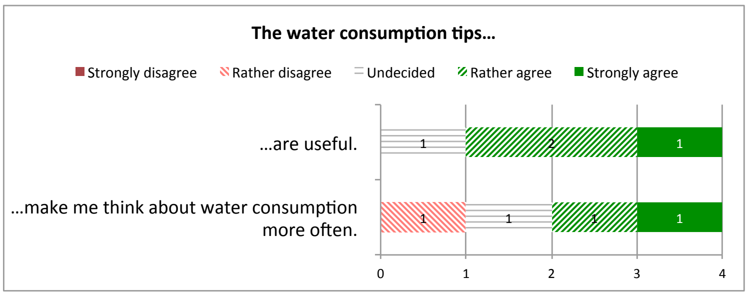


Figure 90. Swiss basic portal (N=4): Water consumption tips.

Finally, consumption tips are found useful by three of four users. Whether they also make them think about water consumption more often is slightly less clear from their mixed responses (Figure 90). Users may have read the tips only once since they are not encouraged to read through them with points like the advanced portal users, thus not viewing them as a trigger to think about water consumption as opposed to a chart of their actual consumption.

5.5 User activity analysis results

The log analysis in the Swiss case study assessed the behavior that occurred on the portal. As the full incentive model is only available in the advanced portal, our analyses focus on this complete release. To test whether the full incentive model yields different usage patterns than the basic portal, differences in login frequency between the advanced and basic portal are also assessed. In that sense, the basic portal can be compared to traditional feedback systems often found in the literature. The user activity analysis presented in this section updates the findings presented in *D4.4 Final social game and implicit user information techniques*.

5.5.1 User Activity Summary

In the advanced portal, 22 users registered to use the portal between October 26, 2015 and June 15, 2016.

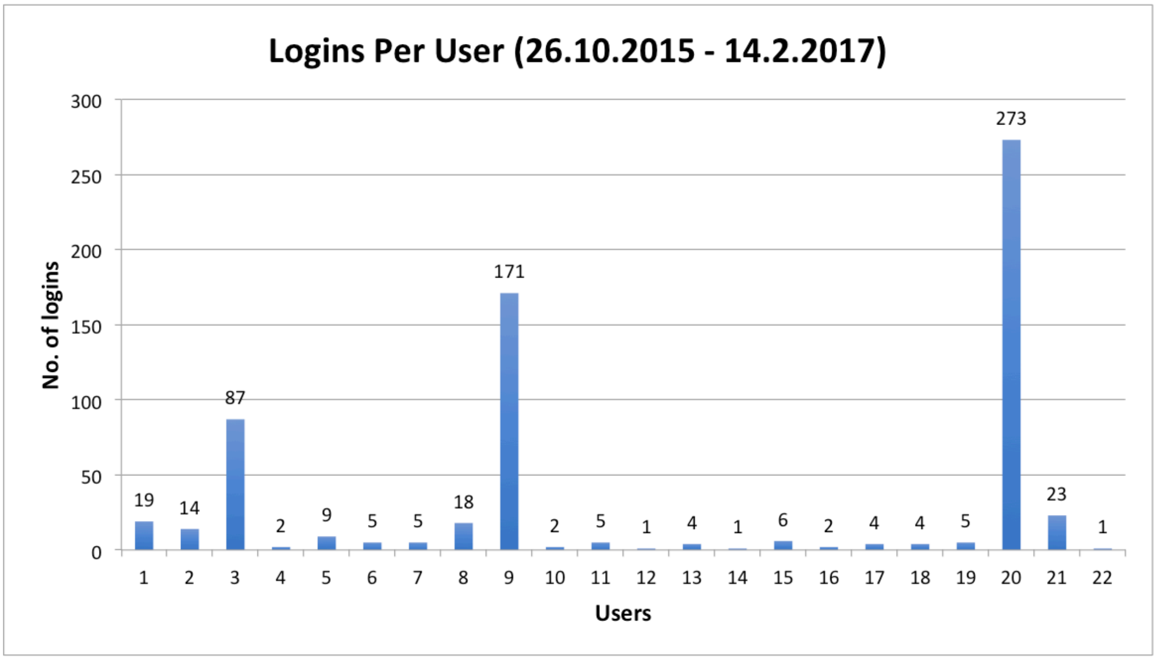


Figure 91: Total number of logins per user (Swiss Case Study)

From Figure 91 we can identify three lead users who dwarfed the login activity of the other users (compare also D4.3 for a detailed analysis of Swiss lead user activity). If users get disinterested during the activation process, they may not be motivated enough to come back later.

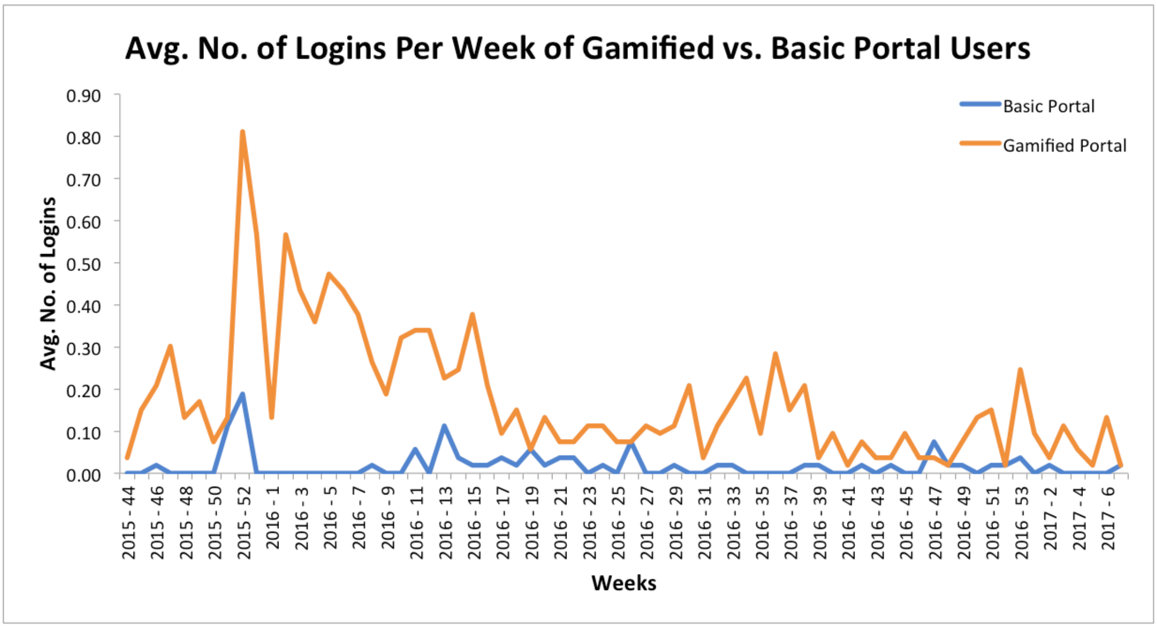


Figure 92: Average no. of logins per week of gamified vs. basic portal users (Swiss Case Study)

In comparison to basic portal users, gamified portal users logged in more frequently as seen in Figure 92; this shows that the gamified incentive model does stimulate portal usage to the extent that it becomes visible even in such a small-scale case study. The login patterns follow the same shape with the gamified version leading the basic portal in terms of usage.

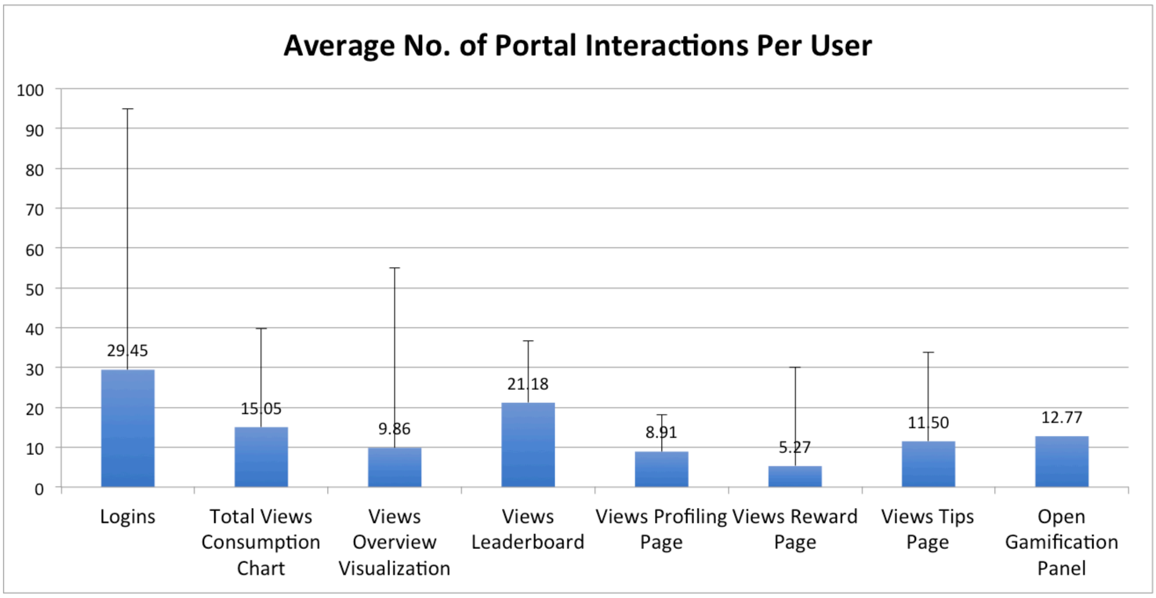


Figure 93: Average number of portal vIsulatizations per user (Swiss Case Study)

Figure 93 shows that besides the login actions, the leaderboard was the next most interacted portal action. Both the login and leaderboard view actions have a fairly high standard deviation, which is likely to be the result of the 3 lead users who were substantially more active than the other users. Interactions with the gamification panel and the consumption chart would also suggest that there is merit to the incentivized approach to encourage water consumption awareness. The relatively low activity on the rewards page could be open to different interpretations, in terms of the relevance of the rewards for the users and the degree to which they want to receive them. However, this cannot be validated with the currently available data.

5.5.2 Interaction with water consumption visualizations and goals

In addition to the gamification actions, users' interactions with the consumption visualization were also analyzed. The average number of interactions with the different water consumption charts and visualizations is shown in Figure 94.

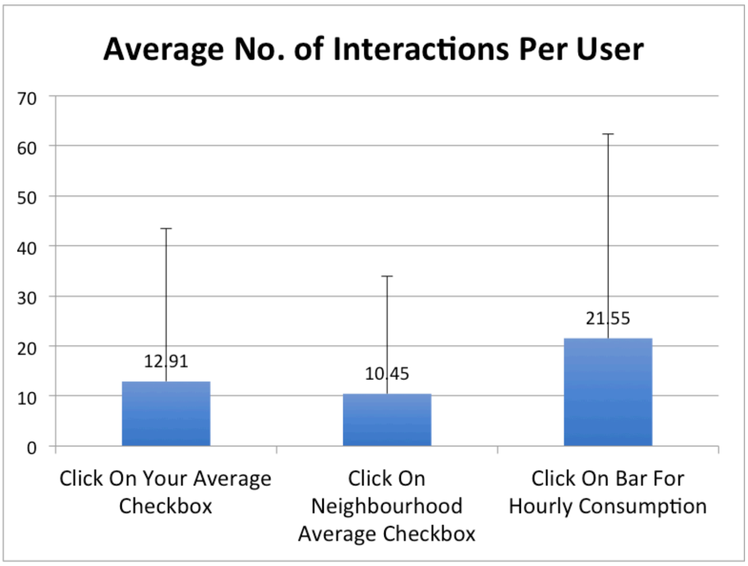


Figure 94. Average no. of interactions per user (Swiss Case Study).

The average number of interactions per user was quite high, while the high standard deviations also reflect larger variations among users. The 3 lead users in the study could have skewed this result. Users seem to be very interested in their own hourly consumption and also in their own average consumption. They seemed almost equally interested in how they were compared to their neighbourhood. This shows that the neighbourhood average feature could actually be exploited further to boost portal engagement through gamification.

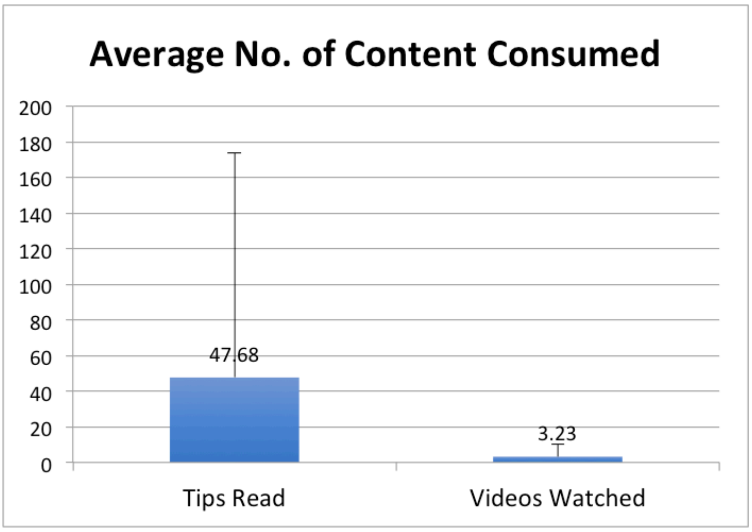


Figure 95. Average no. of content consumed on tips page (Swiss Case Study).

Figure 95 above shows that tips about water consumption were fairly actively consumed but the high standard deviation means that there was a large skew between the users. Videos however showed much less interaction amongst users but with more reliable standard deviation. This could suggest preliminarily that users are more open to receiving tips and suggestions to reduce their water consumption through the portal than sit and consume content in the form of videos. On the other hand, much fewer videos in comparison to textual tips were available on the portal. Overall, more data is needed to substantiate this hypothesis.

Finally, we have analysed the use of the goal setting features. In total, users have set 14 goals. Seven of these goals were to achieve a 15% reduction, four goals aimed at a 10% reduction, and three at a 5% reduction. Of these 14 goals two goals were reached, one for the 5% and one for a 10% reduction. The goals were set by two users. These results suggest that users rely more on the system's default saving level settings rather than setting goals themselves. A possible way to increase self-goal setting would be to offer this option during the onboarding process, E.g. showing users the average weekly savings in the neighbourhood and then offering them a choice to set their own. The default would still be preset.

5.6 Conclusions

The small-scale Swiss case study has recruited 47 utility customers to use the portal (22 used the advanced gamified portal and 25 users the basic portal version). Although this pilot had a limited focus and objectives which concerned the iterative testing of the application and the water consumption measurement and processing, it has also yielded overall positive results on user behaviour, even though the small-scale nature requires a cautious interpretation.

Water consumption measurements have shown that compared to non-SmartH2O households the users have reduced their consumption with 9.9%. Also in this case the result appears meaningful. Despite the small number of consumers considered in this case study, and the fact that the focus on this small case study was primarily on testing metering and analytics technologies, overall results in terms of water conservation confirm the potential of awareness tool to influence positively the water consuming behaviour of those users who get engaged in the awareness program. Moreover, again, despite the small size of the consumption dataset in this pilot, our models showed capabilities of reproducing with acceptable accuracy the behaviour of different segments of water users, at multiple aggregation scaled.

Even though a reliable assessment of the portal on water consumption awareness requires a substantially larger number of users, the results provide an initial indication that for the advanced portal users the self-reported awareness the household has increased for most of the users, while the error in the estimated water consumption has decreased. The number of responses was not sufficient to report on the change in the Theory of Planned Behaviour [Ajzen1991]-measures.

Feedback of the users on the SmartH2O application is rather positive, with users demonstrating a very positive attitude towards the application, and, on feature level, expressing the impact of the water consumption chart and pipe overview as well as the self-set goals on the motivation to save water and think about water consumption.

Log analysis has shown that three lead users of the advanced portal continue their high level of activity, whereas the other users remain active on a basic level. In contrast, the activity level in the basic portal has dropped significantly, providing preliminary evidence for the suitability of the SmartH2O gamified incentive model in comparison to a model where only consumption feedback and water saving tips are provided.

6. Impact analysis

6.1 Overall KPI assessment

SmartH2O declared four major objectives at the project start, as described in Annex I to the project contract and which were further detailed in D7.1. Here, we review the objectives and the value of the KPI which we measured during the project experiments.

6.1.1 Understanding consumer behaviour

A major objective of the SmartH2O project is to analyse smart meter data at medium and high resolution in order to understand and possibly predict consumer behaviour.

KPI_1: Average error between the expected and measured water consumption. More specifically the Mean Square Error (MSE) has been computed to assess the accuracy, with no distinction between under- and over-estimation of the user consumption attitude. The indicator has been computed at the household level.

- Target value for the KPI: a MSE not greater than 20% per day in the case of a single household.
- Achieved value: numerical values for KPI_1 are represented in Table 25 for both case studies and both baseline and intervention period. Indeed, results in the table are evaluated as the median of daily % MSE (i.e., mean square error between daily water consumption as estimated at the single household level by the agent-based model, and the observed water consumption) across all houses because the mean would be strongly influenced by a few high values of MSE obtained for those users with a very low consumption (see Figure 96). Indeed, for those users our model generally overestimates water consumption, given the non-zero value of the centroid of the lowest consumption cluster, and small overestimations result in high % MSE when compared to a very low reference value. Overall, results in the table show that in 3 cases out of four we do not exceed the 20% MSE target threshold for this KPI. The performance is valuable, considering that for the Spanish case study of EMIVASA, which is bigger and more significant, we do not exceed the threshold for both the baseline and the intervention period. This also confirms the influence of data availability on model performance, as already commented in sections 4 and 5 with a detailed analysis of our model outputs.

Table 29. Median MSE assessment on EMIVASA and SES case studies (both baseline and intervention period) for KPI_1.

	EMIVASA	SES
Baseline period	19.86%	19.55%
Intervention period	17.42%	28.18%

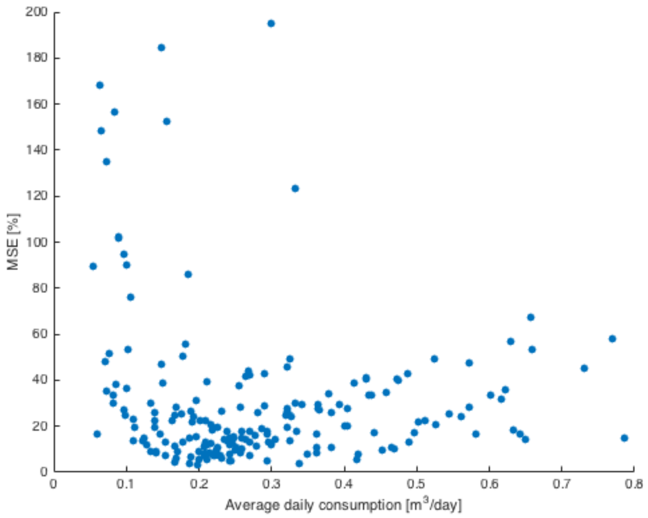


Figure 96. Household-level % MSE vs Average daily consumption for EMIVASA users.

KPI_2: Average error between expected and measured consumption. The indicator has been computed at the district level to evaluate the model performance, when the behaviour of multiple users is used to predict the aggregate consumption.

- Target value for the KPI: a MSE not greater than 10% in the case of a district composed by at least 50 households.
- Achieved value: We evaluated the error on both the Valencian case study and the Swiss case study. Numerical values for KPI_2 are represented in Table 25 for both baseline and intervention period (in the intervention period for the Valencian district we took the mean of the obtained values for each scenario). Indeed, results in the table are evaluated as the daily % MSE (i.e., mean square error between daily water consumption as estimated at the district level by the agent-based model, and the observed water consumption). Overall, results in the table show that in all cases we do not exceed the 10% MSE target threshold for this KPI, even in the Swiss case, where the considered number of users was below 50 households. The performance is thence very good. As before, this also confirms the influence of data availability on model performance, as already commented in sections 4 and 5 with a detailed analysis of our model outputs.

Table 30. MSE assessment on EMIVASA and SES case studies (both baseline and intervention period) for KPI_2.

	EMIVASA	SES
Baseline period	1.51%	2.40%
Intervention period	1.27%	7.62%

6.1.2 Conserving water by raising awareness

SmartH2O leverages on increasing consumer awareness to stimulate a more responsible use of water. This objective is achieved by introducing persuasive technology principles in order to modify users' behaviour.

KPI_3: Water saved per capita per period: we have measured/obtained the past water consumption over a meaningful long period in order to consider seasonal variations. This amount of water has been contrasted with the amount used over a similar (in terms of season and extreme events) period after the introduction of SmartH2O. The period was long enough to include enough time for potential *rebound effects* to set in. We identified a control group of consumers at the district level and we measured the effective consumption after the actual introduction of the proposed policies.

- Target value for the KPI: it is expected to depend heavily on typology of the sample households. We expect a smaller saving for environmentally friendly households, who have already a high level of awareness. We assume that a 5% overall saving would be a success, but we expect a greater saving in drought periods (if they will occur during the testing phase), where we aim to a reduction of 20%.
- Achieved value: 21.7% for Spanish case study w.r.t. control group (4% per capita reduction w.r.t. baseline, corresponding to 5.7% volumetric reduction w.r.t. baseline) 4% for Swiss case study w.r.t. control group (9.9% per capita reduction w.r.t. baseline, corresponding to 12.4% volumetric reduction w.r.t. baseline). Results show that in Spain the intervention group reduced their consumption, whereas the control group considerably increased its consumption during the intervention period. Conversely, in the Swiss case study both intervention and control groups managed to save water during the intervention period, but the savings achieved by the intervention group were more consistent.

6.1.3 Saving water by dynamic pricing schemes

Smart metering enables new approaches for European water utilities to interact with their customers and charge them for services. Dynamic prices, i.e. prices that change over time, could potentially better reflect the real financial and environmental cost of public water supply. It also presents an opportunity to change how water users view water consumption in relation to those around them (other consumers) and the environment.

KPI_4: Percentage of customers expressing intention to voluntarily adopt a dynamic pricing scheme if available. The goal is to measure and understand changes in attitudes towards smart-meter enabled dynamic pricing. A customer fairness/acceptability index for smart-meter based pricing was designed and informed from a range of questions, exercises, and games delivered in a workshop setting. Some of these involved observed interaction of customers using the app and data stored on it. Others involved more traditional questions and tests. The index change was measured with customers that had or did not have access to the SmartH2O platform or with the same customers at initial and late stages of its use. We also estimated the combined impacts of dynamic water pricing and user awareness, to verify if the interactions of these two signals can be cooperative or competitive.

- Target value for the KPI: we hope for a statistically significant rise in the positive perception of dynamic pricing schemes and the intention to voluntarily adopt such a pricing scheme if available. A successful target would be a 5% increase in customer’s stated intention to adopt this scheme. This would be related to customer’s estimation that they would be able to adapt their consumption and get pay less for water whilst reducing their carbon/energy footprint.
- Achieved value: SmartH2O platform users’ response to dynamic pricing has been tested by using a stated-preferences approach. They have been exposed to a price increase triggered by a water scarcity scenario, and their reactions in terms of water saving actions has been measured. Ticino users have been found to reduce their shower-time by 18.2% (on average, a 0.94 minute reduction from an average starting shower-time of 5.17 minutes) after the water price was increased by approximately 30%. In Valencia, the same estimation procedure led to 7.6% reduction in shower-time. Conversely, no statistically significant effect has been found when considering other water saving actions, such as irrigation time reduction, and more parsimonious

plants watering (SMARTH2O, D5.4 - Experimental economics-based tests of pricing policies).

6.1.4 Improve the efficiency of water utilities

We expect the SmartH2O platform to bring not only benefits to the end users, but also to the water utilities.

KPI_5: Peak-period reduction of water consumption: this indicator was measured by comparing the historical data of peak water consumption in the two case studies with the data monitored after the introduction of SmartH2O.

- Target value for the KPI: 10 to 20% water consumption reduction for the customers actively participating in the SmartH2O platform.
- Achieved value: 24.5% for Spanish case study w.r.t. control group (+0.5% per capita reduction w.r.t. baseline, corresponding to 4.7% volumetric reduction w.r.t. baseline) 4,8% for Swiss case study w.r.t. control group (16.8% per capita reduction w.r.t. baseline, corresponding to 15.4% volumetric reduction w.r.t. baseline). Results show that in Spain, though the intervention group slightly increased its consumption during the peak period, the increment in water consumption of control group is considerably higher. Therefore, the savings achieved by the intervention group w.r.t. the control group are still significant. Conversely, in the Swiss case study both intervention and control groups managed to save water during the peak period, but the savings achieved by the intervention group were more consistent.

6.2 SWOT-analysis

In order to better assess relevance and impact of the SmartH2O project we present a typical strengths, weaknesses, opportunities and threats analysis of the SmartH2O project.

6.2.1 Strengths

The SmartH2O approach has proven to be very effective when a user is engaged. The water savings are meaningful and long-lasting, the level of awareness on water conservation is effectively increased.

The SmartH2O platform is easy to install and deploy, and it can be integrated with existing smart metering infrastructures, as demonstrated in the Valencia case.

The water utilities can learn more about the habits and water use patterns of their customers thanks to the user profiling features of SmartH2O and can therefor plan awareness campaigns, also using the agent based modelling simulation platform.

6.2.2 Weaknesses

The major weakness of SmartH2O is shared among this type of interventions that try to engage customers. While the gamification approach has proven effective to engage users who join the platform, it is not sufficient on its own for attracting very large groups of users to join the platform in the first place. More widespread propagation requires continuous additional large-scale marketing campaigns that accompany digital channels with traditional advertising media. Contrary to popular intuition and early “only digital” approaches, current practices move to hybrid campaigns for reaching large scale user groups. This has been shown in a range of cases with all major online platforms heavily investing in mass media advertisement to support the acquisition of large user bases for their digital platforms and/or apps (ranging from general to specialized domains such as fashion, transport or energy).

6.2.3 Opportunities

As the gamification approach has proven effective in engaging registered users, we think that an approach which is based on a background analysis of consumption pattern and an engagement strategy aimed at those users who are more susceptible to make a great progress in water saving can be a winning solution. SmartH2O provided an infrastructure that allows such an approach, and this is an opportunity that is already being explored by some partners.

6.2.4 Threats

We do not see major threats on the horizon, at least from the exploitation of the project results by the larger scientific community. In this context we are not discussing the exploitation of the individual partners, who could be subject to threats by other organizations that are working on similar topics. In general, the threat that we can identify against this approach to water demand management could be given by an increasing mistrust by the users in giving access to personal data to water utilities. Here the water utilities should work in collaboration with water authorities to gain the trust of the users.

6.3 Exploitation opportunities in future applications

Given the outcomes obtained from the assessment of the main project KPIs, as well as the number of strengths and opportunities identified through the SWOT analysis in the previous section, SmartH2O has high potential for following up with future applications, after the official end of the project.

The most valuable and exploitable asset of the project is the integrated SmartH2O platform. Yet, both the platform itself and its component taken individually, i.e., data analytic tools, social awareness and engagement tools, digital web platform and app, board and digital games, have shown potential for business and research exploitation.

Indeed, several real opportunities and achievements are already in place with concrete actions by partners of the SmartH2O consortium, in order to follow up with it. A detailed description of the exploitation plan is presented in deliverable D8.6. We can summarize here the most relevant plans for future business applications:

- EMIVASA is going to continue the adoption of the SmartH2O platform, and is proposing it to new customers;
- POLIMI is working with an Italian utility in the metropolitan area of Milan (CAP GROUP) to set up a pilot of the digital SmartH2O platform in Italy;
- SETMOB and POLIMI are setting up a pilot with ANGLIAN WATER in the UK, also interested in a preliminary assessment of Drop! The card and digital game.
- SETMOB and WEBRATIO are exploiting the SmartH2O technology to develop and launch on the market a new product, called “SmarterWater”;
- MOONSUB is planning the commercialization of Drop!The Question together with KALEIDOS GAMES.

In addition to the above points for business exploitation, SmartH2O is also influencing future research and investigation: SUPSI, POLIMI, SETMOB and EIPCM are now collaborating on a new EU funded research project (H2020 enCOMPASS) which draws many ideas and inspiration from SmartH2O.

The diverse nature of the future developments mentioned above is key both for guaranteeing a prosecution of SmartH2O, in all its components, and offers several opportunities to examine those benefits and challenges that could not have been completely or partially assessed within this project, mostly because of time constraints. The long-term adoption of SmartH2O by a number of real-world utilities would allow confirmation/updates on the values obtained from the

KPIs regarding water conservation, as well as a better assessment of the impacts of behavioural changes on water distribution operations and business. On this aspect, understanding better the benefits of having such a platform, in terms of customer relationship, data communication, and user engagement, would give more information supporting future deployment strategies for water utilities and municipalities. This is particularly relevant, also keeping into account differences between public-owned and private utilities, and integration with other sectors through adoption by multi-utilities. A longer-term adoption would also contribute refining and updating SmartH2O features based on utilities' and users' needs, as well as environmental and market conditions.

Finally, results from the SmartH2O also highlighted several challenges in the status quo of customized and smart-metered residential water management at the large – urban - scale. Among them, the most important are (i) technological challenges, in terms of reliability and quality of the data collected through smart meters overtime, and (ii) social/awareness challenges, in terms of increasing users' engagement. The development of follow up projects and pilots addressing all these issues with an integrated approach, as it has been followed across all the SmartH2O project, is going to speed up the refinement of products ready-to-market able to support water utilities and engage water consumers on a daily basis.

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Appendix A Measurement instruments

A.1 Control group script for Spanish pilot (post-trial)

[Introduction]

Hello, my name is _________ and the reason I'm calling you is about water. Universitat Politècnica de València and your water utility, EMIVASA, are conducting an academic study on water consumption for a European research project. In April last year you have answered some questions for our research project. Now, at the end of the project, we would like to ask you some questions about water again. The survey will only take about 5 minutes. If you participate again, you can win an iPad Mini 2.

Did you participate yourself last time?

If yes: continue

If no: do you know who else in your household has participated? If yes: would he or she be available to answer some questions now? If not: when would be a good moment to call back?

Do you want to participate and get a chance to win an iPad Mini 2? [wait for response, only continue with consent]

Please note that all data you provide will be treated confidentially. As this survey is part of an academic research project, the data will only be used for academic, non-commercial purposes.

[Part 1- About you and water]

Please indicate to what extent you agree with the following sentences. For each statement, I would like to know if you:

- completely disagree,
- rather disagree,
- are neutral,
- rather agree, or
- completely agree

[SHORT PAUSE after each statement to note response]

- **It is expected of me that I save water**
- **I feel like there is social pressure to save water**
- **People who are important to me want me to save water.**
- **I am confident that I could save water if I wanted to.**
- **I expect I will engage in everyday actions to save water in the next six months.**
- **I want to engage in everyday actions to save water in the next six months.**

2. ***Next, I would like to know what you think about engaging in everyday actions to save water.***

   Do you find it:

   a) extremely bad, rather bad, neutral, rather good, or extremely good?
   b) extremely harmful, rather harmful, neutral, rather beneficial, or extremely beneficial?
   c) extremely worthless, rather worthless, neutral, rather valuable, or extremely valuable?
   d) extremely pleasant, rather pleasant, neutral, rather unpleasant, or extremely unpleasant

3. ***I'm going to read a few more statements to you.***
   For each statement, I would like to know if you:

- completely disagree,
- rather disagree,
- rather agree, or
- completely agree

[SHORT PAUSE, also after each statement]

- **Science surely will solve the problem of water scarcity**
  To what extent you agree or disagree with this statement?

  [repeat the answer alternatives only if people get stuck]

- **Drinkable water is an unlimited resource**
- **Drinkable water will exhaust very soon if we do not save it**
- **A way of preventing water exhaustion is using it when absolutely necessary**

4. *How much water do you think your household consumes compared to the average consumption of other households in your area? Please pick one of the following options:*

- Much less than average,
- Somewhat less than average,
- Approximately average,
- Somewhat more than average, or
- Much more than average ?
- You don't know

5. *How would you describe your personal attitude towards the environment? I am:*

- Very concerned about the environment
- Rather concerned about the environment
- Not concerned, not unconcerned about the environment
- Rather unconcerned about the environment
- Very unconcerned about the environment

6. *I will list 6 water-consuming activities now. Which activity do you think consumes the most water every month? Is it…*

- Taking a bath,
- Taking a shower,
- Using the washing machine,
- Using the dishwasher,
- Flushing the toilet, or
- Running the tap ? [provide example only if respondent is confused]

7. *Can you name 3 actions that you could perform to reduce your water consumption?* [note answers below]

- …
- …
- …

[If respondents get stuck or indicate that they don't have more ideas, move on to the next question.]

8. *In the last three months, did you hear, read, or see media campaigns on water saving? For example, government messages on the radio, TV, social media, etc. Please pick one of the following options:*

- Very often,
- Often,
- Sometimes,
- Seldom, or
- Never

9. *Have you heard, seen, or read anything about SmartH2O in the last three months?*

- Yes
- No

If yes:

- Where have you heard, seen, or read about SmartH2O?

[name options only when person is unsure, else just write down answer]

- social media
- newspapers or magazines
- personal mail from Emivasa / the water utility
- radio or tv?
- other media? [write down other sources] ______________________

10. *Are you using the SmartH2O portal or mobile app?*

- Yes
- No

[If yes:] When did you start using the SmartH2O portal / mobile app:

[end of questionnaire]

[Outro]

On behalf of Universitat Politècnica de Valéncia and EMIVASA, I thank you so much for participating in today's water survey.

As promised, you can now enter our lottery to win an iPad Mini 2. EMIVASA will draw the lucky winners in XXXX. Would you like to enter the lottery?

[Wait for response].

[If yes to lottery] *How would you like us to contact you if you win the iPad Mini 2? Can we call you or would you like to provide an email address or your home address?*

____

Thank you so much, we will make sure to call you again for our second survey then. Have a nice day.

[End of Outro]

A.2 Questionnaire items for Swiss and Spanish pilot

The following table lists the questionnaire items used in the post-trial evaluation.

Construct	Item no.	Item	Measurement	Source	Spanish web portal	Swiss web portal	Mobile app	Drop! The Question
UTAUT – Performance expectancy	1	I find the Smart H20 portal useful in my daily life.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)	[Venkatesh et al., 2003]	X	B/A	X	
UTAUT – Performance expectancy	2	Using the Smart H20 portal increases my chances of achieving things that are important to me.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)		X	B	X	
UTAUT – Effort expectancy	1	Learning how to use the SmartH2O portal is easy for me.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)	[Venkatesh et al., 2003]	D4.4	D7.2/D4.4	X	X
UTAUT – Effort expectancy	2	My interaction with the Smart H20 portal is clear and understandable.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)		D4.4	D7.2/D4.4	X	X
UTAUT – Effort expectancy	3	I find the Smart H20 portal easy to use.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)		D4.4	D7.2/D4.4	X	X
UTAUT – Effort expectancy	4	It is easy for me to become skilful at using the SmartH2O portal.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)		D4.4	D7.2/D4.4	X	X
UTAUT-Attitude towards technology	1	Using the Smart H2O portal is a bad/good idea	5-point Likert scale (1=Strongly disagree; 7=Strongly agree)	[Venkatesh et al., 2003]	X	B/A	X	X
UTAUT-Attitude towards technology	2	The system makes work more interesting.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)		X	B/A	X	??
UTAUT-Attitude towards	3	Working with the system is fun.	5-point Likert scale (1=Strongly disagree;		X	B/A		X

technology			5=Strongly agree)					
UTAUT-Attitude towards technology	4	I like working with the system.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)		X	B/A	X	X
UTAUT-Social Influence	1	People who influence my behaviour think that I should use the system.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)	[Venkatesh et al., 2003]				X
	2	People who are important to me think that I should use the system.	5-point Likert scale (1=Strongly disagree; 5=Strongly agree)					X
Hedonic quality (stimulation)	1	Typical—original	7-point semantical differential	[Hassenzahl, 2004]	D4.4	D7.2/D4.4	X	
Hedonic quality (stimulation)	2	Standard—creative	7-point semantical differential		D4.4	D7.2/D4.4	X	
Hedonic quality (stimulation)	3	Cautious—courageous	7-point semantical differential		D4.4	D7.2/D4.4	X	
Hedonic quality (stimulation)	4	Conservative—innovative	7-point semantical differential		D4.4	D7.2/D4.4	X	
Hedonic quality (stimulation)	5	Lame—exciting	7-point semantical differential		D4.4	D7.2/D4.4	X	
Hedonic quality (stimulation)	6	Easy—challenging	7-point semantical differential		D4.4	D7.2/D4.4	X	
Hedonic quality (stimulation)	7	Commonplace—new	7-point semantical differential		D4.4	D7.2/D4.4	X	
Pragmatic quality	1	Technical—human	7-point semantical differential	[Hassenzahl, 2004]	D4.4	D7.2/D4.4	X	X
Pragmatic quality	2	Complicated—simple	7-point semantical differential		D4.4	D7.2/D4.4	X	X

Pragmatic quality	3	Impractical—practical	7-point semantical differential		D4.4	D7.2/D4.4	X	X
Pragmatic quality	4	Cumbersome – direct	7-point semantical differential		D4.4	D7.2/D4.4	X	X
Pragmatic quality	5	Unpredictable—predictable	7-point semantical differential		D4.4	D7.2/D4.4	X	X
Pragmatic quality	6	Confusing—clear	7-point semantical differential		D4.4	D7.2/D4.4	X	X
Pragmatic quality	7	Unruly—manageable	7-point semantical differential		D4.4	D7.2/D4.4	X	X
TPB: Attitude towards water saving	 1 2 3 4	Engaging in everyday actions to save water (around the house and garden): extremely bad/extremely good; extremely harmful/extremely beneficial; extremely worthless/extremely valuable; extremely unpleasant/ extremely pleasant	7-point semantical differential	[Fielding et al., 2012]	X	X		
TPB: subjective norm	1	It is expected of me that I save water (around the house and garden)	7-point Likert scale (1=Strongly disagree; 7=Strongly agree)	[Fielding et al., 2012]	X	X		
TPB: subjective norm	2	I feel like there is social pressure to save water (around the house and garden)	7-point Likert scale (1=Strongly disagree; 7=Strongly agree)		X	X		

TPB: subjective norm	3	People who are important to me want me to save water (around the house and garden)	7-point Likert scale (1=Strongly disagree; 7=Strongly agree)		X	X		
TPB: perc. beh. control	1	I am confident that I could save water (around the house and garden) if I wanted to.	7-point Likert scale (1=Strongly disagree; 7=Strongly agree)	[Fielding et al., 2012]	X	X		
TPB: behavioural intention to save water	1	I expect I will engage in everyday actions to save water (around the house and garden)in the next six months	7-point Likert scale (1=Strongly disagree; 7=Strongly agree)	[Fielding et al., 2012]	X	X		
TPB: behavioural intention to save water	2	I intend to engage in everyday actions to save water (around the house and garden) in the next six months,	7-point Likert scale (1=Strongly disagree; 7=Strongly agree)		X	X		
TPB: behavioural intention to save water	3	I want to engage in everyday actions to save water (around the house and garden) in the next six months	7-point Likert scale (1=Strongly disagree; 7=Strongly agree)		X	X		
TPB: behavioural beliefs (utilitarian)	2	Science surely will solve the problem of water scarcity	Four-point Likert scale (1= completely disagree; 4=completely agree)	[Corral-Verdugo et al., 2002]	X	X		
TPB: behavioural beliefs (utilitarian)	3	Drinkable water is an unlimited resource	Four-point Likert scale (1= completely disagree; 4=completely agree)		X	X		
TPB: behavioural	4	Drinkable water will	Four-point Likert scale		X	X		

beliefs (utilitarian)		exhaust very soon if we do not save it	(1= completely disagree; 4=completely agree)					
TPB: beh. Beliefs (ecological)	5	A way of preventing water exhaustion is using it when absolutely necessary	Four-point Likert scale (1= completely disagree; 4=completely agree)		X	X		
Sign-up awareness	–	How much water do you think you are consuming at home per month (in m3)?	Text field		X	X		
Sign-up environmental attitude		How would you describe your personal attitude towards the environment? I am…	Five-point Likert Scale (1 = Very concerned about the environment; 5= Very unconcerned about the environment)		X	X		
Usefulness	-	How useful are the water saving tips for you? Getting water consumption alerts for high consumption is useful.	Five-point Likert scale (1=complete disagree; 5=completely agree) Five-point Likert scale (1=complete disagree; 5=completely agree)	Success criteria	X	X		
Usefulness	-	How useful are the following notifications you receive from the mobile app? A notification… –with a tip of the week –with a reminder to keep using the SmartH2O app –you get when achieving a	Five-point Likert scale (1=Very useless; 5=very useful)				X	

		consumption goal –you get when winning a badge –you get when winning the weekly competition						
Ease of use	-	It is easy to… • scan monster cards with the mobile app • connect my Drop! player profile to my SmartH2O portal account.	Five-point Likert scale (1= strongly disagree; 5= strongly agree)					X
Comprehension	-	How easy or difficult do you find the Drop! questions?	Five-point Likert scale (1=very difficult; 5=very easy)					X
Perception of awareness increase	-	[…] make me think about water consumption more often than before.	Five-point Likert scale (1=strongly disagree; 5= strongly agree)					
		The water consumption chart…			X	B/A		
		The water consumption overview…			X	B/A		
		Being able to set my own goals…			X	A		
		The e-mail summaries..			X			
		Which SmartH2O version is best to understand your water consumption?	Five-point Likert scale (1=Most certainly the web portal; 5= most certainly the mobile app)				X	
Perception of	–	[…] would motivate me to	Five-point Likert scale					

awareness increase		save water	(1=strongly disagree; 5= strongly agree)					
		The water consumption chart…			X	B/A		
		The water consumption overview…			X	B/A		
		Being able to set my own goals…			X	A		
		The water consumption tips (textual, infographics)…*			X	B/A		
		Comparing my achievements against my neighbours' achievements…			X			
		Sharing my water saving achievements on the SmartH2O portal via Facebook or Twitter…			X			
		The smartH2O app notifications…					X	
		Which SmartH2O version is most motivating to save water?	Five-point Likert scale (1=Most certainly the web portal; 5= most certainly the mobile app)				X	
Perception of awareness increase	-	Please indicate for each of the following notifications to what extent they motivate you to think about water. A notification… …with a tip of the week	Five-point Likert scale (1=To a very small extent; 5= to a very large extent)				X	

		…with a reminder to keep using the SmartH2O app …you get when achieving a consumption goal …you get when winning a badge …you get when winning the weekly competition						
Perception of incentive		Comparing my achievements against my neighbours' achievements motivates me to keep using the SmartH2O portal. Sharing my status (badges, points) on the SmartH2O portal via Facebook or Twitter, would motivate me to keep using the SmartH2O portal How much do the e-mail summaries motivate you to keep using the SmartH2O portal?	Five-point Likert scale (1=strongly disagree; 5= strongly agree) Five-point Likert scale (1=strongly disagree; 5= strongly agree) Five-point Likert scale (1=very little; 5= very much)		X			
		I am motivated to reach my water saving goal because I can compare my current consumption to my goal.	Five-point Likert scale (1=strongly disagree; 5= strongly agree)		X	A		

		Which SmartH2O version is most motivating to log in frequently?	Five-point Likert scale (1=Most certainly the web portal; 5= most certainly the mobile app)				X	
-	-	User reference ID (for tracking purposes)			X	X	X	X
-		Below are a number of reasons why you would NOT use the mobile app. Please check the reasons that apply to you. You can select multiple reasons if you want to.	Selection of options: –I don't have an Android smartphone. –I was not aware that a SmartH2O app exists. –I have not thought about downloading and installing it yet. –I do not think the app is useful to me. –Other:…		X			

UTAUT2 Modifications

Discarded items (Performance expectancy):

- Using mobile Internet helps me accomplish things more quickly. (irrelevant)
- Using mobile Internet increases my productivity. (irrelevant)

TPB: behavioural beliefs (modifications)

Adapted from Corral-Verdugo et al. (2003):

- Water is the cheapest natural resource. That is why the government should charge no cost

  Adaptation: excluded; cultural bias towards US
- Humans have the right to use all the water they want because they are the kings of Creation

Adaptation: excluded; cultural bias towards US

- "Water scarcity is a lie produced by politicians”
  Adaptation: excluded; cultural bias towards US