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Table of Contents

1. INTRODUCTION 2

1.1 APPLICATION SCENARIOS 2
1.2 METHODOLOGY 2
1.3 OUTLINE OF THIS DELIVERABLE 4

2. USER-CENTRED DESIGN PROCESS 5

2.1 OUTLINE OF THE APPROACH 5
2.2 TARGET USER GROUPS 6
2.3 LESSONS LEARNED FROM GAMIFIED ENERGY CONSERVATION 8
2.4 FEEDBACK FROM THE ONLINE COMMUNITY OF WATER CONSUMERS 11

3. USER STORIES 13

3.1 VISUAL EXPLORATION OF WATER CONSUMPTION INFORMATION (1A) 14
3.2 VISUAL EXPLORATION OF WATER CONSUMPTION AT FIXTURE LEVEL (1B) 15
3.3 EARNING REWARDS BY WATER SAVING AND INFORMATION COLLECTION (2A) 15
3.4 SAVING WATER WITH FAMILY, FRIENDS AND NEIGHBOURS (2B) 16
3.5 LEARNING INTERACTIVELY ABOUT INNOVATIVE PRICING (2C) 16
3.6 SAVING WATER BY PLAYING AUGMENTED CARD GAMES (2D) 16
3.7 MONITORING CONSUMPTION BEHAVIOUR AND HOUSEHOLD CHARACTERISTICS (3) 17
3.8 PREDICTING WATER CONSUMPTION BEHAVIOUR BY CUSTOMER SEGMENT (4A) 18
3.9 PREDICTING CUSTOMER RESPONSE TO SPECIFIC REWARDS SCHEMES (4B) 18
3.10 PREDICTING PRICING MODELS FOR SPECIFIC CUSTOMER SEGMENTS (4C) 18

4. MOCK-UPS 19

4.1 VISUALIZATION MODEL FOR RAISING WATER SAVING AWARENESS 20
4.1.1 Approach 20
4.1.2 Visualization mockups 24
4.2 BASIC CUSTOMER PORTAL: VISUAL WATER METER 29
4.3 ADVANCED CUSTOMER PORTAL: GAMIFIED & SOCIAL WATER METER 31
4.4 GAMES PLATFORM 35
4.4.1 Drop! card game 36
4.4.2 Mobile game app 36
4.5 BUSINESS DASHBOARD: CUSTOMER CONSUMPTION MONITOR 38
4.6 AGENT-BASED CONSUMPTION SIMULATOR 41

5. DATA MODEL 42

6. USER MODEL 50

7. USE CASES OVERVIEW 52

8. BASIC CUSTOMER PORTAL: VISUAL WATER METER 58

8.1 USE CASE: COLLECTING CONSUMPTION DATA WITH SMART METERS 60
8.2 USE CASE: MANUALLY COLLECTING CONSUMPTION DATA 61
8.3 USE CASE: VISUAL EXPLORATION OF WATER CONSUMPTION INFORMATION 62
8.4 USE CASE: VISUAL EXPLORATION OF WATER CONSUMPTION AT FIXTURE/APPLIANCE LEVEL 64
8.5 USE CASE: PROVIDING FEEDBACK ON DISAGGREGATED CONSUMPTION DATA 65
8.6 USE CASE: GETTING WATER CONSUMPTION ALERTS 65
8.7 USE CASE: GETTING WATER CONSUMPTION TIPS 66

8.8 USE CASE: GETTING SYSTEM NOTIFICATIONS 67
8.9 USE CASE: LEARNING INTERACTIVELY ABOUT INNOVATIVE PRICING SCHEMES 68

9. ADVANCED CUSTOMER PORTAL: GAMIFIED WATER METER 70

9.1 USE CASE: MAKING GAMIFICATION ACTIONS AND EXPLORING RESULTS 72
9.2 USE CASE: SELF SETTING CONSUMPTION GOALS 73
9.3 USE CASE: FULFILLING CONSUMPTION GOALS 74
9.4 USE CASE: RECOMMENDING WATER SAVING ACTIONS 75
9.5 USE CASE: DECLARING WATER SAVING ACTIONS 76
9.6 USE CASE: CONTRIBUTING HOUSEHOLD AND USER PROFILING INFORMATION 77
9.7 USE CASE: DECLARING WATER END-USE EVENTS 77
9.8 USE CASE: VERIFYING MANUALLY INSERTED CONSUMPTION INFORMATION 78
9.9 USE CASE: MAKING ACTIONS AND EARNING DIGITAL CREDITS WITH THE GAMES PLATFORM 79

10. ADVANCED CUSTOMER PORTAL: SOCIAL WATER METER 81

10.1 USE CASE: COMPARING ACHIEVEMENTS WITH OTHER HOUSEHOLDS 82
10.2 USE CASE: INVITING ANOTHER USER TO JOIN A TEAM 83
10.3 USE CASE: ACHIEVING GOALS COLLABORATIVELY AS A TEAM 84
10.4 USE CASE: INVITING FRIENDS ON SOCIAL NETWORKS 85
10.5 USE CASE: SHARING ACHIEVEMENTS ON SOCIAL NETWORKS 86

11. CUSTOMER PORTAL USER ACCOUNT MANAGEMENT 87

11.1 USE CASE: CUSTOMER PORTAL SIGN-UP 88
11.2 GAMIFICATION ENGINE SIGN-UP 89
11.3 USE CASE: MODIFYING USER SETTINGS 90
11.4 USE CASE: UPGRADING TO THE ADVANCED GAMIFIED VERSION / DOWNGRADING TO THE BASIC VERSION OF CUSTOMER PORTAL 91
11.5 USE CASE: LEADERBOARD OPT-IN / OPT-OUT 92
11.6 USE CASE: GEOLOCATION OPT-IN / OPT-OUT 92
11.7 USE CASE: CUSTOMER PORTAL UNSUBSCRIPTION 93

12. CUSTOMER PORTAL ADMIN 95

12.1 USE CASE: SETTING WATER CONSUMPTION TIPS 96
12.2 USE CASE: SETTING ACTIONS, BADGES AND REWARDS 96
12.3 USE CASE: CONVERTING GAME ACTIONS INTO REWARDS 97

13. GAMES PLATFORM 99

13.1 USE CASE: GAMES PLATFORM SIGN-UP 100
13.2 USE CASE: PLAYING A STANDARD MOBILE GAME 101
13.3 USE CASE: PLAYING THE CARD GAME AND ITS DIGITAL GAME EXTENSION 102
13.4 USE CASE: GAINING POWER-UPS BASED ON THE GAMIFICATION ENGINE CREDITS 102
13.5 USE CASE: CONNECTING PLAYER PROFILE TO THE GAMIFICATION ENGINE 103
13.6 USE CASE: SETTING CONTENT OF GAME QUESTIONS 104

14. BUSINESS DASHBOARD: CUSTOMER CONSUMPTION MONITOR 105

14.1 USE CASE: VISUALIZING AGGREGATE HOUSEHOLD CONSUMPTION INFORMATION BY GEO-LOCATION 106
14.2 USE CASE: QUERYING AND DISPLAYING CUSTOMER ATTRIBUTES 108
14.3 USE CASE: IDENTIFYING CUSTOMER GROUPS 109

14.4 USE CASE: SETTING CONSUMPTION GOALS AND REWARDS FOR SPECIFIC CUSTOMER GROUPS 109
14.5 USE CASE: SETTING RECOMMENDED WATER SAVING ACTIONS FOR SPECIFIC CUSTOMER GROUPS 110
14.6 USE CASE: SETTING WATER CONSUMPTION ALERTS 111

15. AGENT-BASED CUSTOMER CONSUMPTION SIMULATOR 113

15.1 USE CASE: MODELLING BEHAVIOUR BASED ON CONSUMPTION 114
15.2 USE CASE: PREDICTING CUSTOMER SEGMENT CONSUMPTION BEHAVIOUR 115
15.3 USE CASE: PREDICTING BEHAVIOUR BASED ON INCENTIVE RESPONSE 116
15.4 USE CASE: PREDICTING CUSTOMER SEGMENT RESPONSE TO PRICING SCHEMES 116

16. SUCCESS CRITERIA 118

16.1 MEETING PROJECT OBJECTIVES 119
16.1.1 Setting target water consumption goals 119
16.1.2 Key Performance Indicators 122
16.2 BASIC CUSTOMER PORTAL: VISUAL WATER METER 123
16.2.1 Technology acceptance criteria 123
16.2.2 User-based performance indicators 123
16.2.3 Technical success criteria 124
16.3 ADVANCED CUSTOMER PORTAL: GAMIFIED & SOCIAL WATER METER 125
16.3.1 Technology acceptance criteria 125
16.3.2 User-based performance indicators 126
16.3.3 Technical success criteria 127
16.4 GAMES PLATFORM 129
16.4.1 Technology acceptance criteria 129
16.4.2 User-based performance indicators 129
16.4.3 Technical success criteria 130
16.5 BUSINESS DASHBOARD AND AGENT-BASED CUSTOMER CONSUMPTION SIMULATOR 130
16.5.1 Technology acceptance criteria 130
16.5.2 User-based performance indicators 131
16.5.3 Technical success criteria 132

17. SOFTWARE INTEGRATION REQUIREMENTS 133

17.1 PREAMBLE 133
17.2 INTEGRATION BETWEEN PLATFORM COMPONENTS 137
17.3 INTEGRATION WITH EXTERNAL DATA PROVIDERS 138
17.4 EXAMPLE OF SMART COUNTER DATA FILE PROCESSING FLOW 140

18. CONCLUSIONS 142

19. REFERENCES 143

20. APPENDIX A: USER GROUPS SPECIFICATION 146

21. APPENDIX B: STATE-OF-THE-ART OVERVIEW OF WATER AND ENERGY CONSUMPTION VISUALIZATION MODELS 154

Executive Summary

This deliverable D2.2 contains the final requirements for the SmartH2O applications.

In this document, use cases, user-centred functional and non-functional requirements, and success criteria have been identified and refined according to the two main application scenarios of the project:

- Saving water by social awareness.
- Saving water by innovative pricing schemes.

In the preceding deliverable D2.1, we identified target user groups and consumer needs through the review of relevant studies and reports, and exploratory interviews with water supplier representatives in the UK and Switzerland. Following this initial analysis, preliminary user stories and mock-ups had been developed. To elicit more specific user-centred requirements, they were evaluated with end-users during workshops involving water consumers and water utility employees. Feedback on the technical scope and feasibility was also collected in an additional workshop with the technical partners. Based on this, a preliminary user model, the early use cases and user-centred requirements were formulated.

In this document, we present the final outcomes of a second iteration of the requirements analysis, which consisted of additional literature studies and target user group analysis, updates from recent studies on water consumption reduction, lessons learnt from gamified energy conservation systems, and additional feedback from water consumers and the wider innovation community of the SmartH2O project.

Based on this, the user stories and mockups were refined. As part of the mock-ups, we have also developed a water consumption visualization model to raise users' awareness of their own water consumption.

In accordance with the revised user stories and mock-ups, a refined data and user model, the use cases were also revised, both by refining existing and introducing additional use cases.

They describe the following SmartH2O applications:

- Basic customer portal: Visual water meter
- Advanced customer portal: Gamified and social water meter
- Games Platform
- Business dashboard: Consumption monitor
- Agent-based customer consumption simulator

For each identified application, the high-level functional and non-functional requirements have been refined. Finally, success criteria have been specified as operationalized non-functional requirements. They include overall Key Performance Indicators to measure the main project objectives, and, defined by application, technology acceptance indicators, user-based performance indicators and technical success criteria.

The deliverable concludes with software integration requirements that have been identified, focusing on the critical issues of integration and communication of the SmartH2O system with the existing infrastructure of the water utilities involved in the project.

1. Introduction

In this chapter we describe the overall approach that was used to formulate the use cases and final requirements for the SmartH2O applications.

1.1 Application scenarios

The use cases and final requirements consider both application scenarios and their goals in the context of SmartH2O:

- Saving water by raising social awareness
- Saving water by innovative pricing schemes

The first scenario is related to saving water by raising social awareness. The main goal is to promote water conservation behaviours and achieve quantifiable water savings using social awareness incentives. The objective is to encourage a rational use of water, possibly changing users behaviour. Social networks and smart metering can be exploited to provide feedback to the users about their consumption and tips to consume water more efficiently.

The goal of the first part of the scenario is to allow consumers to monitor their water usage online leveraging social gamification mechanisms, increasing individual and collective awareness. By connecting consumers in a network, they will be able to see good and bad practices of others and exchange tips on how to improve consumption. The goal of the second part of the scenario is to test different water demand management strategies, aiming at more sustainable consumer behaviour, and identify which of these strategies were most effective. The social gamified platform will be used to collect insights into customers' consumption behaviour.

The second application scenario is related to saving water by innovative pricing schemes. The ultimate goal will be to encourage discretionary consumption during off-peak times (e.g. washing machine outside of peak showering times) and during wetter seasons (e.g. filling the pool during rainy periods in summer for later use). It will consider how innovative pricing schemes could be published in a transparent and rapid way and integrated into social media communication with and by consumers. The goal of the first part of the scenario is the exploration of individual water consumption by users in relation to different pricing schemes (i.e. tariff schemes) such as blocking rates to raise awareness of water consumption and pricing schemes and stimulate water saving. The goal of the second part of the scenario is the prediction of customer water consumption response to specific pricing schemes such as blocking rates to maximize water savings.

1.2 Methodology

The aim of this deliverable is to define the final user-centred requirements for each of the two SmartH2O application scenarios, both from the perspective of water consumers and water suppliers. These requirements are based on user needs, which are narrated in user stories, visualized in mock-ups and broken down into formalized user-centred use cases. To describe the use cases, we followed a common format, which was slightly simplified [Cock2000]. The requirements also comprise success criteria for each of the main applications. Sequence diagrams have been specified on a technical component level, and are therefore described in D6.2. The functional system specifications will be described in D2.3.

The requirements analysis has been planned as an iterative human-centred design process as defined in ISO 13407 [ISO1999]. To understand user needs following this process, first the target group and context of use are defined, followed by the specifications of user requirements, the development of design solutions and the evaluation of these solutions with users and stakeholders (see Figure 1). The results feed into the next iteration cycle, in which the activities are repeated until the solution is considered mature enough.

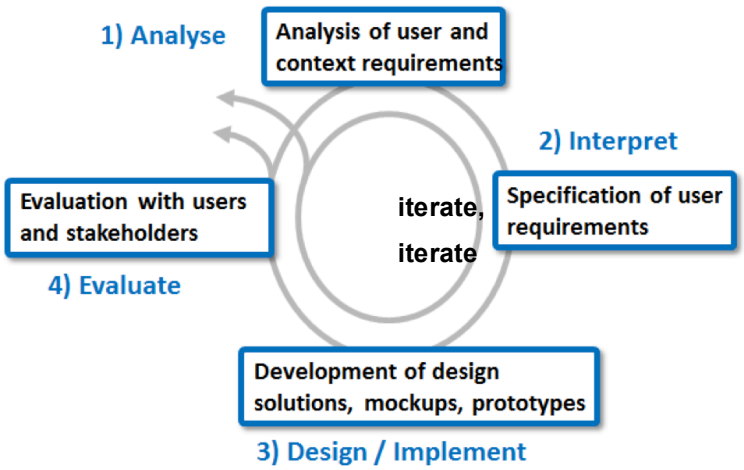

Figure 1. Human-centred design process according to [ISO 13407].

The requirements were elicited in an iterative manner, where end-user feedback of water consumers and suppliers (User pull) is alternated with technical innovation and feedback (Technology push). This cycle aims to construct requirements that are both technically feasible and grounded in user-needs (see e.g. [Nova2013]; [Nova2014]. The cycle is displayed in Figure 1.

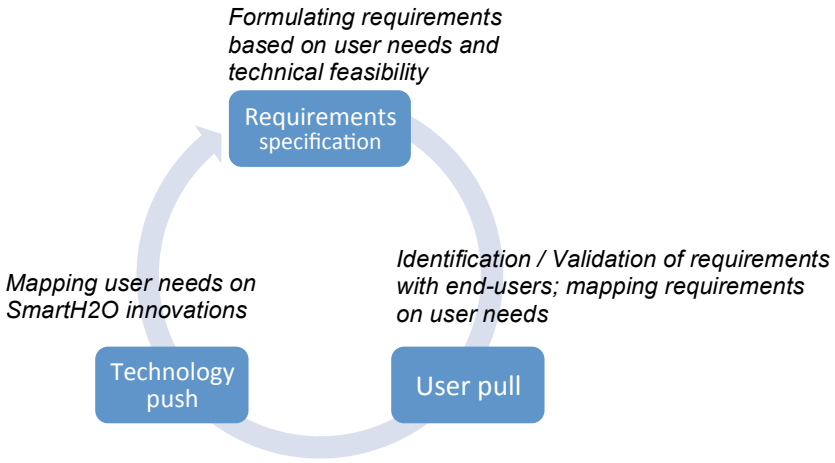

Figure 2. Requirements cycle driven by user pull and technology push.

As the requirements focus on user needs, use scenarios, i.e. narrative descriptions of what people do and experience as they try to make use of a computer system [Carr1995], have been the primary point of reference. However, to avoid ambiguous terminology we use the term scenario to refer to the two SmartH2O application scenarios (Scenario I: Saving water by raising social awareness; Scenario II: Saving water by innovative pricing schemes). Specific combinations of users, contexts, and computer-supported tasks – which can be seen as sub-scenarios – are referred to as user stories.

The user stories, mock-ups, use cases and requirements are rooted in the user-centred requirements studies and workshops, which have taken place in the first months of the project and are described at length in D2.1. For this deliverable we have refined these early outcomes into the final requirements, based on further analysis and additional interactions with target users and technical partners (see Figure 3 for the roadmap of the requirements finalization).

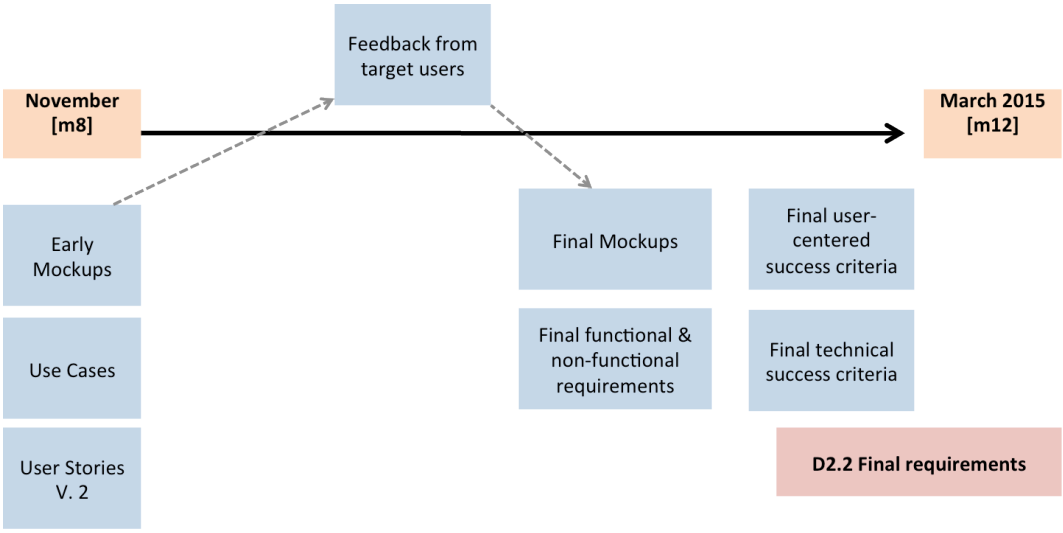

Figure 3. Roadmap of requirements finalization from D2.1 to this deliverable.

1.3 Outline of this deliverable

The details of the approach that led to the elicitation of the final requirements and use cases are described in chapter 2, including a thorough analysis of target user groups, a state-of-the-art review of gamified energy conservation applications and the elicitation of additional feedback from water consumers through an online discussion. In chapter 3, we present the refined personas and user stories as the basis for the requirements. The updated mock-ups that visualize the foreseen application functionalities are shown in chapter 4, including a water consumption visualization model for raising users' awareness of their own water consumption and stimulating environmental behaviour change. The visualization model has been developed by considering a literature review of state-of-the-art consumption visualizations (T4.1) and based on requirements elicited in the workshops with end users as described in D2.1 and in the additional online discussion with water consumers.

Chapter 5 presents the updated data model, followed by the final user model in Chapter 6. Chapter 7 gives an overview of all the use cases, which are organized in use case groups and presented in detail in Chapters 8 – 15 following a common, slightly simplified format (see [Cock2000]).

In chapter 16, the success criteria are listed for each of the main applications, divided into key performance indicators that address the project objectives, user technology acceptance criteria, user-based performance indicators and technical success criteria.

Finally the software integration requirements are described in Chapter 17. The detailed functional system specification of the SmartH2O platform will be described in D2.3. Chapter 18 presents the conclusions of this deliverable.

2. User-centred design process

2.1 Outline of the approach

In the preceding deliverable D2.1, we have described how we defined the early requirements and use cases. Based on an initial analysis of studies of domestic water consumption in both case study areas and exploratory interviews with utility representatives, we had formulated preliminary user stories and early mock-ups. Those were evaluated in individual workshops with technical partners on the one hand and with water utility staff and domestic water consumers on the other. With the feedback obtained, the user stories and mock-ups were refined, based on which a first set of use cases with early non-functional and functional requirements was developed see D2.1).

In this deliverable D2.2, we describe the final outcome of the iterative, user-centred requirements analysis process (see Figure 4). Building on the exploratory analysis of user needs, interviews, and the user study results described in D2.1, we have further analysed the target user groups in this second iteration. We have also reviewed recent work on gamified energy conservation systems to apply and compare some of the key lessons learnt to the SmartH2O customer portal requirements. We also reviewed more recent studies of domestic water consumption behaviour and benchmarks to formulate key performance indicator for water consumption (see Section 16). Finally, to elicit additional feedback from water consumers and the wider innovation community of the SmartH2O project, we have initiated an online discussion based on the current SmartH2O concept and mockups.

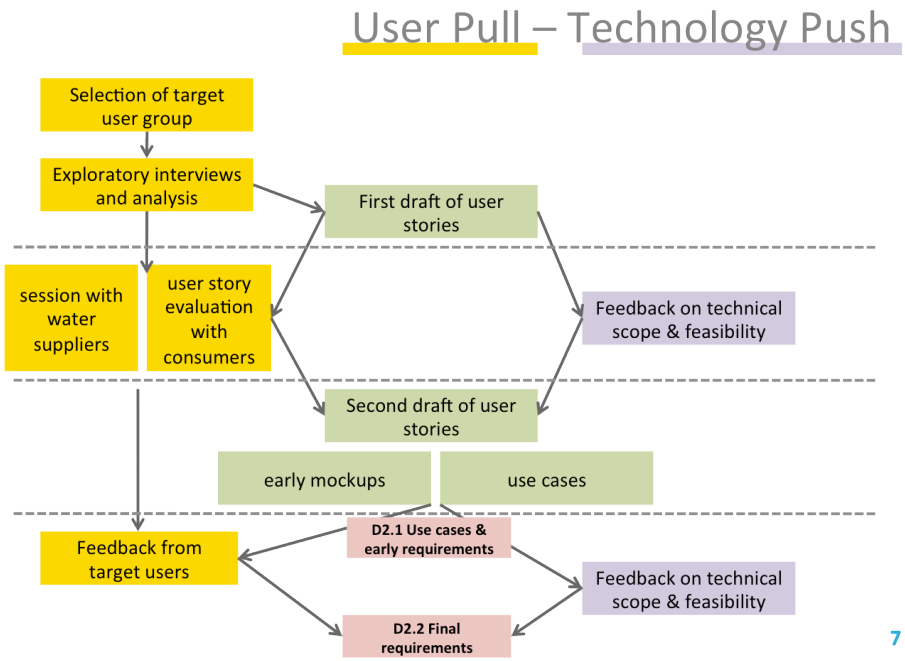

Figure 4. User-centred design approach summary.

As the result, we further refined the user stories and visual mock-ups. The mock-ups have also been extended with a visualization model for displaying water consumption information to end-users. Based on these, we have revised the data model, user model, early use cases and requirements and present the updated data and user model as well as the final use cases and requirements including user-centred and technical success criteria.

2.2 Target user groups

The target users of the smartH2O platform can be divided into different groups and are considered separately for the two case studies in the UK and Switzerland.

UK case study user groups:

- Water consumers in domestic households in Greater London, with a focus on the smart meter rollout sites in Reading (155'300 inhabitants)
- Water utility staff in Greater London (Thames Water).

Swiss case study user groups:

- Water consumers in domestic households in Southern Switzerland in the Locarno region (Canton of Ticino), with a focus on the smart meter rollout sites in Tegna (800 inhabitants)
- Electric utility staff in Southern Switzerland (SES).
- Municipal administrators in Southern Switzerland.

Consumers in domestic households are further sub-categorized in the following way:

- Family households with younger children.
- Family households with older children (teenagers).
- Households without children

From meeting with consumers in the workshops in the two case study areas, we can derive additional characteristics that are likely to play an important role in the adoption of the individual elements of the SmartH2O portal:

Technology affinity

It will be more difficult to involve consumers who are not so familiar with using technology. For this, the application should be as intuitive and easy to use as possible. Different campaigns should be organized to engage users of different affinity levels.

Data affinity

Not all users are equally interested in detailed water consumption data. While the application should also be able to cater to the needs of those who want to know everything about their consumption, it should especially consider those who want to know less about the actual consumption data and more about e.g. concrete tips on how they can improve, and whether they are actually saving or wasting water and/ or money.

Environmental concern

The level of environmental concern varies strongly in consumers, which was already visible during the workshop with the consumers. Thus, environmental concern should be only one of multiple incentives in the system, to motivate different kinds of users. Also, the actual water saving potential will most likely vary accordingly, and features like tips to reduce consumption should be customized to the type of household.

Playfulness

The application should be attractive to users who are more playful and those who are not. While most likely the presence of children in a household positively impacts this attribute, children are not the only aspect to be considered. During the workshops, we were able to clearly identify users that see little to no benefit in playful applications while others were very interested in these aspects. Both should be considered in the application design.

For those users that are more playful, different player types can be distinguished, e.g. Competitors (focused on competition, winning and rank), Socializers (focused on socializing and developing networks), Achievers (focused on status, goals and completion) and Explorers (focused on exploring and discovering) (see e.g. [Ferr2013a]; [Ferr2013b]; [Full2008]).

The following table lists the type of users that are most likely to adopt each of the customer applications and their main features.

Table 1. Main target groups for SmartH2O applications.

Application	Application features	Household types	Characteristics
Basic customer portal: visual water meter	Consumption visualization, water saving tips, alerts	All households	All levels of technology affinity, higher data affinity, higher environmental concern, low playfulness
Advanced customer portal: gamified water meter	Gamification of all actions, consumption goals, water saving actions, credits & reputation points, badges & rewards	All households	Higher technology affinity, lower data affinity, all levels of environmental concern, high playfulness (achievers, explorers)
Advanced customer portal: social water meter	Leaderboard, water saving teams, team goals, sharing achievements on social networks	All households	Higher technology affinity, lower data affinity, all levels of environmental concern, high playfulness (competitors, socializers)
Games platform: standard mobile game	Fun mini games with water saving tips	Family households with older children (teenagers)	All levels of technology affinity, lower data affinity, all levels of environmental concern, high playfulness
Games platform: card game & its digital extension	Card game with water saving trivia, water saving tips	Family households with younger children	All levels of technology affinity, lower data affinity, all levels of environmental concern, high playfulness

Additionally, the target households can be equipped with a smart water meter per household, a smart meter per building (bi-familiar or multi-familiar bulk metering), an easily accessible or a non-accessible standard meter.

For the consideration of innovative pricing schemes, target groups include policy makers such as water utilities and regulators at national and EU level and consumers at local/regional and national level. Table 2 below summarizes the benefits on each user analysis from saving water by innovative pricing schemes like dynamic pricing.

Table 2. Benefits of target user groups regarding innovative pricing schemes.

Target users	Benefits
Water utilities and regulators	- Reduction of water consumption - Monitor of water usage - Improvement of business operations - Improvement of resource efficiency - Increase in efficiency in communication
Domestic consumers	- Reduction of water consumption - Monitor of water usage - Education and change of behaviour

2.3 Lessons learned from gamified energy conservation

Sustainable energy use, an issue as important as sustainable water management, has inspired much research and development that follows a gamified approach using visualized consumption feedback and social interactions in order to motivate people to adopt more energy-efficient lifestyles. An overview of state of the art in this area is therefore helpful for verifying and informing the conceptual design of the SmartH2O customer water portal.

EcoGator [Peha2014] is an efficiency advisor smartphone application designed within an IEE (Intelligent Energy Europe) funded project. It differentiates itself by putting focus on the purchase of energy-efficient products along with stimulating energy-efficient lifestyle. To motivate users the game employs points, advances in different levels, informative tips, questions and quizzes to test the gained knowledge and challenges. The user can collect tips as favourites or rate their usefulness, as well as points through social media actions, by scanning energy labels of appliances and by using the comparison or calculation function of the application. If a defined level is reached, the user is rewarded with an entry to a prize contest. Their application evaluation in real life indicated that EcoGator was perceived as a good shopping assistant but less powerful as a tool for fostering awareness. The authors evaluated the application only in terms of user acceptance.

Social Power Game [DeLu2014] is a mobile game application that aims at tackling the challenge of fostering environmentally friendlier and better uses of energy. What is interesting and different in this work, is that here the social interaction is meant and perceived more in terms of collaboration, considering that there are also other social dynamics in addition to badges and rankings. The application has not been evaluated.

Makahiki [Lee2012] is an open source game engine to motivate people's awareness of energy conservation. It was introduced at an energy challenge during the 2011 Kukui Cup[1] in Hawaii: Smart meters were installed in 4 student residence hall towers and floors competed to minimize energy use. In order to earn points, players should perform certain tasks, like watching informative videos and making public commitments to adopt more sustainable behaviour. Points were also aggregated to a get the floor's overall performance. The game included elements like the smart grid game (organizing tasks and commitments), the daily energy goal, the raffle game, where people could earn a ticket to win a variety of prizes, two-person collaborative tasks plus an additional layer for top players. Among the lessons learned, the importance of incentivizing key participants was highlighted and it is worth mentioning that the raffle game was stated as the most interesting part. Their evaluation concerned only the user acceptance and feedback for the game.

Power House [Reev2012] is an online multiplayer game prototype that connects real world home energy data to a social game, to which players can also connect and invite friends through Facebook. Players' consumption is tracked and affects the user's abilities, options, rewards and reputation. The game employs several game mechanics, such as achievements, points, leaderboards and inviting and challenging friends in real-life energy competitions. The game concept is based on the player helping a virtual family to perform daily household activities, which require switching on and off appliances, thus learning through the game about the energy requirements of different devices. Periodically the play is interrupted to offer opportunities to learn more about energy or challenge other players to save energy. The authors revealed later [Reev2013] the results of two experiments they carried out, one laboratory and one field experiment. The laboratory experiment revealed a positive effect of the behaviour towards energy efficiency after 30 min of playing. In the filed test there was a significant decrease in energy consumption during the game compared with the period before and after. Therefore, the authors emphasized as well the need for game solutions that can bring better long-term results.

[1] Kukui cup project: http://www.ics.hawaii.edu/research/research-profiles/research-profile-the-kukui-cup-project/

LEY (Less energy Empowers You) [Made2011; Made2012] is a pervasive serious game to make household energy usage comprehensive and to stimulate a more positive energy consumption behaviour. It employs real-time consumption information and adopts a collaborative-competitive approach, including scoring of energy consumption, quiz responses, competition results and invitations to other people. In the competition mode players can challenge each other in an environmental sustainability quiz. The work is a presentation of the game design and doesn't include any evaluation process.

Wattsup [Fost2010] is a Facebook application that displays energy consumption and CO2 emission data, giving the users the ability to compare household data. It includes different user interfaces such as the Friends interface showing consumption comparisons with selected Facebook friends and the Rankings interface displaying the highest and lowest energy users. A small-scale evaluation with participants engaged in two scenarios (one where participants could only monitor their own consumption and one that involved social interaction) showed that the energy consumption was significantly lower when social interaction was enabled (in total a difference of 130Kw units of energy saved between the two conditions). Furthermore, while visiting the Facebook application, users spent most time in the Rankings interface, viewing and commenting on the rankings table. Accordingly, the study highlighted the social context and the competitive element of the game, which offered a more enjoyable user experience.

Power Explorer [Gust2009a] is a mobile phone game for teenagers aiming at stimulating a long-term sustained behaviour change in power consumption. The real-time sensing provides instant feedback and, thus, users can directly see the effect of turning on and off an appliance. The authors hypothesize that this option can stimulate a stronger post-game effect on the player's behaviour, as it will build strong associations with the energy consumption of specific appliances. The game contains different multi-player environments including competitive and explorative aspects. The objective is to learn the needs of each appliance for electricity in operation and stand-by mode. The game was evaluated in real use and a 14% reduction was measured during the entire period monitored after the end of the game. This was considered to represent a tentative indication of a post-game effect on consumption. Compared to their previous implementation (Power Agent [Bang2007; Gust2009b]), they concluded that a casual game with small investments by players and fast rewards is more efficient than a highly immersive game with a slow reward mechanism, when long-term effects are in scope.

EnergyLife [Giul2009] is an application adapted for touch-screen mobile phones, built upon the two main pillars of consumption feedback and awareness tools. The extensive literature research provided by the authors suggests that consumption feedback should also be provided per appliance and be sensitive to small saving changes. Furthermore, they find that historical feedback is more effective than comparative one, as users who perform well may lose motivation for further improvement. Awareness and energy saving are expressed in scores, goals are divided and distributed to different levels, knowledge is tested through quizzes and improves through contextualized tips, all contributing to the overall awareness score. The application was tested [Gamb2011] in terms of usability and acceptance and was redesigned to a system more simplified and tailored to the player's actions in terms of considering the user's gradual increase of awareness. In the this model, the player starts from the level of consumption feedback, moves gradually to the level including awareness tips and knowledge testing and eventually to the last level with social interaction and comparison. The application also employs contextualized tips, the content of which is customized based on the collected sensor data.

Summarizing, gamification has been applied to different energy conservation applications with overall success in terms of user acceptance and with some success in consumption reduction (in those cases where that was evaluated). As there are many similar issues in the two fields, we can take advice and inspiration for applying some of the most relevant aspects from this on-going research to the context of water saving. The most important points and lessons learned that apply and/or are interesting in the context of a SmartH2O gamified application are the following:

- Even though a small controversy appears whether social comparisons or historical comparisons of own performance through time have a greater effect on the user, it becomes apparent that it is important and a challenge to retain the users' interest and motivation also once they have achieved high performances.
- The need for consumption information on appliance-level is highlighted in several cases and it is suggested that the association of consumption to specific appliances makes it easier for people to adopt long-term sustainable behaviour.
- Consumption tips and advice are a common strategy, often provided in a contextualized manner.
- Social interaction can also be based on a cooperative approach in addition to the competitive one.
- Rewards in the form of a real prize contest have seemed to work as a good incentive.

The SmartH2O customer portal addresses the abovementioned points. It employs social comparison and competition in the gamified customer portal (see Mock-ups Figure 26), and provides historical comparison of consumption averages for users to see their water saving progress (see Mock-ups Figure 13). The portal also employs social cooperation with collaborative tasks: users can form teams to reach a goal together and compete on a team-level (see Mock-ups Figure 26, Figure 27). Consumption tips are offered to users, in order to enhance their awareness. For smart-meter users or users who manually provide consumption information, tips can also be personalized. In terms of consumption feedback and monitoring, SmartH2O not only provides the overall consumption but also the possibility to monitor the water consumption per appliance (see Figure 10, Figure 11), for users equipped with a smart meter. Finally, the SmartH2O gamified customer portal offers real prize-like rewards to users in exchange for credits that they collect through their actions. Rewards are set by the water utility, and thus depend on their practice, ability and willingness to provide them.

All of these aspects are described in more detail in sections 3 – User stories, 4.2 and 4.3 – Mock-ups, as well as in 8 and 9 – Use case descriptions of the customer portal.

2.4 Feedback from the online community of water consumers

To gain additional feedback from domestic water consumers on our concept, we initiated a discussion about the customer portal concept and mockups on the SmartH2O Innovation Community on LinkedIn[2] (see D9.2 for more details). To provide a fruitful discussion context, a short introduction to the user stories and mockups was presented in a novel visual discussion space that is connected with the LinkedIn group (see Figure 5). In the discussion space, a visual tool enables participants to reference specific mock-up excerpts in their discussion posts and comments (see Figure 5, right).

Figure 5. Introduction to concept and mock-ups in visual discussion space (left) and visual discussion space post referring to mock-up excerpt (right).

Overall, discussion participants showed a high interested in the SmartH2O customer portal concept and innovations. Some more general comments on the existing concept were e.g.

"I like the concept of team water saving. This gives a stronger gamification approach that may have greater impact on the total savings."

"For me, receiving some practical suggestions about how to reduce water would be helpful."

"I think, the most attractive feature to me is the leaderboard and the possibility to compare with friends in general and have such a funny little competition."

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[2] SmartH2O Innovation Community on LinkedIn with visual discussion space. Available at https://www.linkedin.com/groups/SmartH2O-INNOVATION-COMMUNITY-6531529

Table 3 lists example feedback from the discussion that contains interesting aspects to be pursued further in the SmartH2O applications. For each comment, we have derived a requirement for the SmartH2O customer portal.

Table 3. Example feedback on the SmartH2O concept and mockups from the LinkedIn discussion, with derived requirements for the customer portal.

LinkedIn comment	Derived SH2O requirement
*You could try using **analogies** like how many olympic-sized **pools can you fill with the water consumed**. I believe that you can provide a "productive" shock to the consumers this way.* *[…] in my opinion **the bigger the number you present the bigger impact** it has. Therefore, I would vote for total consumption. You can use it in both cases [saving and consuming], maybe with different units. The unit used in each case should be adjusted according to the data. 700 bathtubs is more impressive than 0.3 pools.*	**Use case 8.3:** Analogies should be visualized for consumed and saved water.
*I would suggest something more "basic" [for the home page, with less information] with an option to **switch to more detail/ or advanced mode for the geek ones**.*	**Use case 8.3:** Consumption visualization should be presented at different levels of detail and abstraction according to user preference.
*A future application even includes the option of participants receiving a **mobile phone text message stating rain conditions**, allowing residents to change their water-usage behaviors accordingly. Does this makes sense for SH2O?*	**Use case 8.6:** Weather data can be included in an alert and linked to specific action-oriented recommendations, e.g. “There is a high chance for rain tomorrow. Don’t water the garden.”
*To fight the water problem in developing countries, a possible mean would be to **connect the awards with social projects** (i.e 100 points water saving with smart water = 1L of water in an area with less or where no water is available)*	**Use case 9.1:** Rewards should be customizable and the list of rewards extendable, e.g. to be adapted to the PR and CSR strategies of water utilities and other stakeholders. Rewards needn’t be tangible objects (can e.g. be donations).
*Instead of playing for myself, could I play for an institution in my neighborhood? So that the **rewards** (e.g. the water saving shower-head) **are donated** for example to a local football club.*	**Use case 9.1:** Same as above. There could e.g. be two different reward “tokens”: “Redeem showerhead for yourself” “Redeem showerhead for organization X”.
***Personalizing the incentives** (drawing on both intrinsic and extrinsic motivations) would be helpful.*	**Use case 9.1:** Both intrinsic and extrinsic incentive and reward types should be available to motivate different types of users.

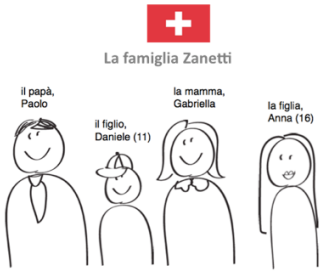
3. User stories

The following sections present the refined personas and user stories:

1A	Visual exploration of water consumption data (consumer)
1B	Visual exploration of water consumption at fixture/appliance level (consumer)
2A	Earning rewards by water saving and information collection (consumer)
2B	Saving water with family, friends and neighbours (consumer)
2C	Saving water by playing augmented card games (consumer)
3	Monitoring customer consumption behaviour and household characteristics (utility)
4A	Predicting water consumption behaviour by customer segment (utility)
4B	Predicting appropriate customer response to specific rewards schemes (utility)

For end users to better relate with the user stories, personas for main end-user groups among consumers were developed for each case study. A persona can be described as "a fictitious, specific and concrete representation of target users" [Coop1999]. It is a "collection of realistic representative information which can include fictitious details for a more accurate characterization" [Coop2003], e.g. to help developers better understand user needs. In our case, the concept of personas is especially valuable to introduce the narrative user stories, which describe how the created personas interact with the system that we envision for SmartH2O. The preliminary personas described in D2.1 have been further refined based on the now more specific target groups presented above.

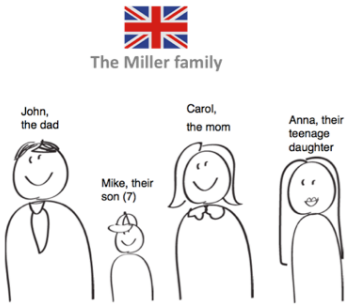
Swiss case study consumer personas



The Zanettis are a family of four living in their own four-bedroom house in a picturesque village in Switzerland. Mr Zanetti is the manager of a local supermarket; Mrs Zanetti works in the local tourist information. Their daughter Anna is 16 and goes to school in the next larger town. She likes to meet her friends in their favourite café and go swimming in the lakes in the summertime. Her younger brother Daniele is 11 years old and loves to spend time in their garden.

After installing a smart meter in their house, the municipality has informed Mr Zanetti via a brochure that they are providing a new online service for residents to monitor their water consumption and to benefit from water saving actions: the gamified water meter application.

UK case study consumer personas



The Millers are a family of four living in their own four-bedroom house in a suburban neighbourhood. Both parents work at the same insurance company and commute to work. They have a 15-year-old daughter, Anna. Anna likes to meet her friends in the city centre and is always looking for the latest gadgets and apps. Mike has a lot of friends who he plays with frequently after school. The local water utility just installed a smart meter at their house and sent out a brochure about a new application available for PC and smartphone with which they could easily access the meter information themselves.

Water utility personas

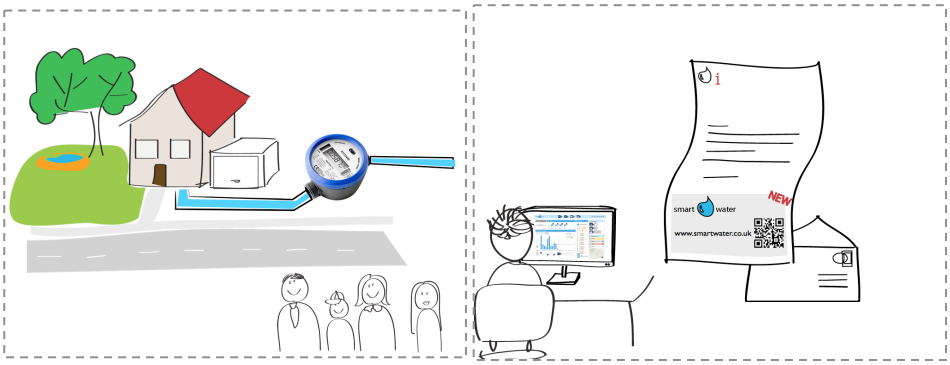
Sarah is the customer service manager at a large water utility in London. She is often planning large awareness campaigns to promote water saving but is looking for more effective solutions that can target different customer types with different kind of water saving incentives. She is open to experiment with different approaches, like providing vouchers for active savers. She is curious towards more innovative pricing schemes but would like to know more on customers' attitudes and likely behaviour towards such an approach.

Steve also works for the water utility. His main job is to manage the water supply for private household customers. He would like to know more on consumption patterns of different household types and neighbourhood areas, to better coordinate pumping and related activities. One of his major concerns is also the detection and quick fixing of leaks. He is very aware of the upcoming supply challenges arising from a growing water demand in 5-10 years from now and is looking for the most efficient ways to distribute the available water.

3.1 Visual exploration of water consumption information (1A)

Goal: Raising individual water consumption awareness by visualizing metered consumption data and providing water saving tips.

Using his desktop computer, John Miller (Paolo Zanetti) opens the **visual water meter** app. He signs in with his name and customer reference number and sees how much water his family has consumed during the past day, week, and month and how much they would pay if their household was billed according to the metered consumption. Their consumption information is presented in a fun and interactive visual widget where he can also see different metrics, e.g. the peaks and lows of their water use over time. He can compare their water use with the average consumption data of his neighbourhood, of similar households and of his town. Looking at the consumption from the last month, he is shocked to see a strong peak marked as a very bad performance, especially in comparison to his neighbours. Then he remembers guiltily that it was the days following their son's birthday, where it had for once been very hot, which led them to water the garden twice as often. The app also shows some water saving tips and alerts John in case of emergency, like low water quality, leaks or water shortage.



3.2 Visual exploration of water consumption at fixture level (1B)

Goals:

- Raising end use water consumption awareness by visualizing end use consumption
- Providing personalized feedback for water saving.

The app provides John a detailed report on the end use water consumption in his house, which allows understanding the fraction of water consumed by each appliance/fixture in a given period of time (e.g., how much water has been used for gardening, dish washing, clothes washing, or showers). Looking at the disaggregate end use water consumption, John realizes that the water used for showers is almost double then the consumption by his neighbours. Therefore, he decides to have shorter showers, and he plans to substitute the showerhead with a water-saving one. The app also informs John that his family is using an old low-efficient washing machine, and it quantifies the water saving that he might have by replacing his washing machine with a new high efficiency one.

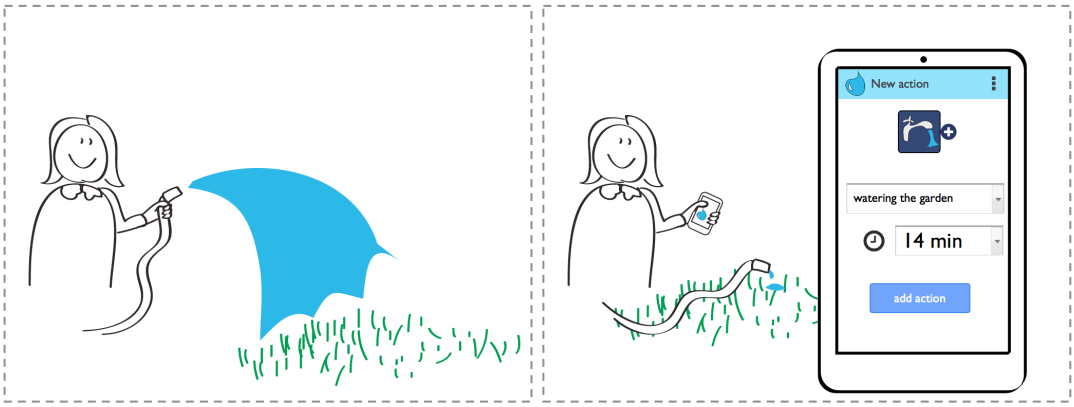
3.3 Earning rewards by water saving and information collection (2A)

Goal: Gamification of individual water consumption and household data provision through points, goals and rewards to raise individual awareness of water consumption and stimulate water saving

In addition to the visual water meter, customers can activate the **gamified water meter**. There, the water utility company challenges them with a water-saving goal each month to be achieved, e.g. staying under a certain consumption average or taking specific water saving actions.

When activating the gamified water meter, John also sees his current status as a beginner saver based on his water saving efforts. He also sees his current credit score and the badges he achieved on the platform. For every action on the platform, he can get more credits and earn new badges. He can e.g. complete his customer profile (how many family members there are, what kind of appliances they have), watch an informational video about water saving and enter a new water use event in his water diary (e.g. “watering the garden for 15 min”).

For now, Mr Miller decides to watch a short presentation about the latest water saving tips, which earns him 10 points. He is surprised how serious the water stress situation has been in the London area in the past. When Mr Miller checks his score again he sees that he only needs 150 more points to redeem a “10% off at the cinema” voucher as a reward and 1350 more points to receive a high quality water saving showerhead.



3.4 Saving water with family, friends and neighbours (2B)

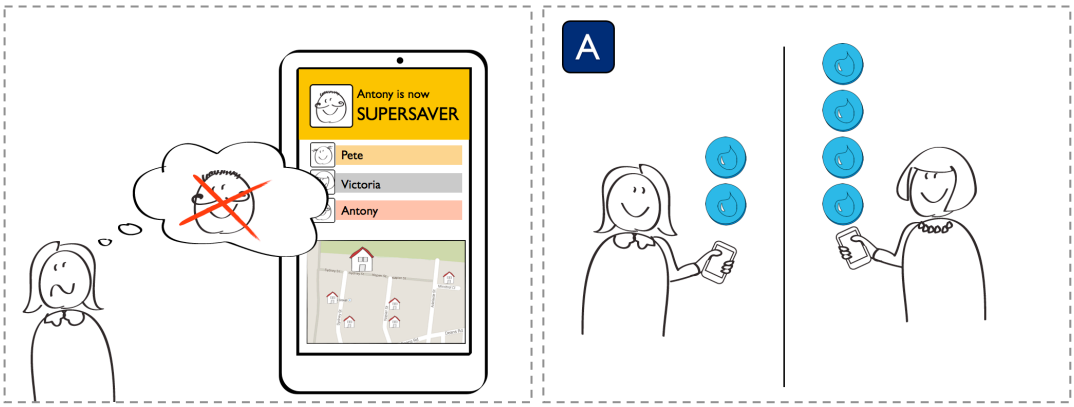
Goal: Raising water consumption awareness collectively by saving water with others

Instead of saving water by himself, John can save water collaboratively with friends, family and neighbours.

Since John knows that he will not always have time to login and participate in the water saving activities His wife and teenage daughter also sign up. Especially the daughter really likes the smartphone app and challenges her friends to sign up on behalf of their families.

After signing up, John's wife Carol opts in to share her score with other users. Now she sees where the other users who have also opted for this feature live on the neighbourhood's map and who out of their circle of friends is participating. She sees that Anthony from down the road is in the lead! To increase her chances, she forms a water saving team with Valeria from next door. This means that from now on, they benefit from each other's water saving actions. They have soon caught up with Anthony because each time one of them performs a water saving action, the other also gets some points. They are also ranked in a team leaderboard where they can compare their team efforts to others,

Each team can also set a common water saving goal for themselves. If they hit their target combined consumption average, they get additional points.



3.5 Learning interactively about innovative pricing (2C)

Goal: Gamification of individual water consumption and pricing schemes (i.e. tariff schemes) such as blocking rates and seasonal tariffs to raise awareness of water consumption and pricing schemes and stimulate water saving

John Miller can gain knowledge on the estimated cost of the amount of water they consume. If they are charged through a flat water tariff, Mr Miller will be soon aware of the unresponsiveness of the bill to his family's achievement in terms of water saving. At this stage, however, he has the chance to compare the cost of water consumption among different pricing schemes. In this way, he will discover that if they were charged through an increasing block rate scheme, the prospective bill would have been 10% less costly.

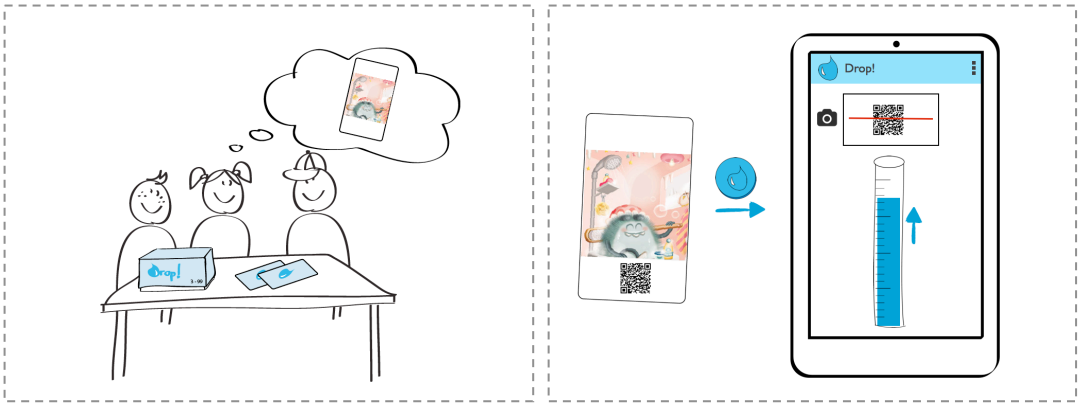
3.6 Saving water by playing augmented card games (2D)

Goal: Raising water consumption awareness of younger children to motivate the family as a whole to save water

As a thank you for signing up, the utility sends out the "push your luck" card game **Drop!** that can be played by the whole family. It's all about avoiding the water waster monster with his bad habits! **Drop!** can also be played in combination with a mobile app, where the users can teach the monster how to improve his bad habits and provide additional household information for the utility. When successful,

they earn points. Family members can log in with their **gamified water meter** account to redeem the **points** earned in the mobile game.

The Millers' son loves the **Drop!** monsters and shows the game to his friends at school. Together, they form an even bigger water saving alliance than John and Valeria – the whole class is the alliance – and they are playing to achieve a common goal to earn a reward for their whole class.



3.7 Monitoring consumption behaviour and household characteristics (3)

Goals:

- Identifying e.g. leakage or consumption metrics of customers to take action (e.g. adjust pumping, fix leaks, adapt pricing schemes)
- Identifying specific customer segments to provide more appropriate and targeted incentives

Steve, the water supply manager at a large water utility, logs onto the smart water **business dashboard**. He can choose between two modes, the monitoring and the simulation mode. In the monitoring mode, he is presented with statistics of their actual customer base and the actual water consumption in the areas they are supplying, as well as their current fixed supply and metering parameters that are e.g. determined by the specific kind of supply method used (e.g. pumping vs. natural reservoirs) or where and which type of meters are currently in use.

An interactive timeline and city map are enriched with contextual information about weather data, local and general incentive campaigns by the company and reports by the media on selected topics, e.g. droughts and other water-related events.

Navigating through the city map, he can select individual districts and households to see their characteristics, billing data, utilities and actions linked to their water consumption. He can identify peak hours of water consumption in a respective area as well as consumption lows. Based on this information, the company can adjust the pumping intensity to maintain a constant pressure level and save energy costs.

In real-time, he can monitor if there are any irregularities in consumption and react accordingly on a daily basis. For large irregularities, the system can also predict the likeliness of leakage in a certain area and whether it is on the customer side or somewhere else in the system. Thus leakages can be discovered and fixed quickly.

Based on the data collected by the smart meters, as well as by the recently introduced **customer portal**, Steve sees what kinds of customers there are and how much water they are consuming at what time. This helps him to plan better in the long term, e.g. the utility's pumping and similar actions. The consumption habits are also interesting for Sarah, the customer service manager. For specific neighbourhoods, she can e.g. view statistics on the types of households (socio-economic information) that dominate and their typical consumption patterns. She can also identify specific customer segments and define tailored reward schemes for them.

3.8 Predicting water consumption behaviour by customer segment (4A)

Goal: water consumption prediction by customer segment based on past information and customer segment def. from information available in the app

In the simulation mode, Steve can influence the otherwise fixed parameters (e.g., weather data, increased demographics, increased usage of low-flow and high-efficiency plumbing fixtures). Based on behavioural models from customers' past behaviour on the customer portal, e.g. undertaken actions and consumption behaviour, the system can predict likely consumption behaviour for individual customer segments. Furthermore, Steve can also see the aggregate short- and long-term water demand forecast at a district scale. Based on the predicted water consumption, Steve can compare the current water supply and the future water demand. Thus, he can plan corrective actions to bridge the gap between supply and demand, such as time-of-day tariffs to incentivize customers to differ the usage of some water appliances to peak-off hours.

3.9 Predicting customer response to specific rewards schemes (4B)

Goal: prediction of customer water consumption response to specific reward scheme / incentive

Based on behavioural models from customers' past behaviour on the gamified water meter system, e.g. undertaken actions and consumption behaviour, the system can predict likely consumption behaviour for individual customer segments based on different incentive schemes that Sarah has in mind and "tests" before actually applying them in the real world, e.g. different kinds of rewards mechanisms or personalized social awareness campaigns.

Based on the past and predicted water consumption based on a specific incentive scheme for a given customer segment, Sarah can gain knowledge about current water supply and future water demand. In this way, she can more easily plan corrective actions for saving water and explore the different reward schemes e.g. discount on a customer's bill when water savings are achieved.

3.10 Predicting pricing models for specific customer segments (4C)

Goal: Prediction of customer water consumption response to specific pricing schemes such as blocking rates and seasonal tariffs.

Based on pricing models from customers' past behaviour on the gamified water meter system, the system can predict likely consumption behaviour for individual customer segments based on different pricing schemes, e.g. blocking rates.

Accordingly, in the simulation mode Sarah can choose the pricing policy on which she wants to run the simulation and get the predicted water consumption. In addition, she can apply different pricing policies to different customer segments. This will allow her to target pricing policies in order to maximize water savings.

4. Mock-ups

The next sections present and explain the mock-ups, which are based on the refined user stories and visualize the functionalities of the main five SmartH2O applications (see Figure 6). For domestic water consumers, we will develop a **basic customer portal (visual water meter)** for customers to access their water meter information, as well as an **advanced customer portal (gamified water meter),** which in addition to basic functionalities will provide different interactive means to encourage water saving based on the customers' meter readings and additional household and consumption information that they provide and can share with others. In addition, a **games platform** will feature a mobile game with two modes. The first mode augments a physical card game that should encourage water saving for younger children and families. The second mode will feature a solitaire game that can be played as a standalone game and may also attract older children. Points collected in the mobile game are connected and transferred to the gamified platform. A **business dashboard** will be developed for water utilities to monitor their customers' consumption behaviour and as a means to design different reward and incentive schemes to target and stimulate specific customer groups to save water. An **agent-based customer consumption simulator** provides utilities with the means to simulate customer behaviour, e.g. according to their household characteristics (based on provided psychographic variables), or based on their past response to different kinds of incentives.

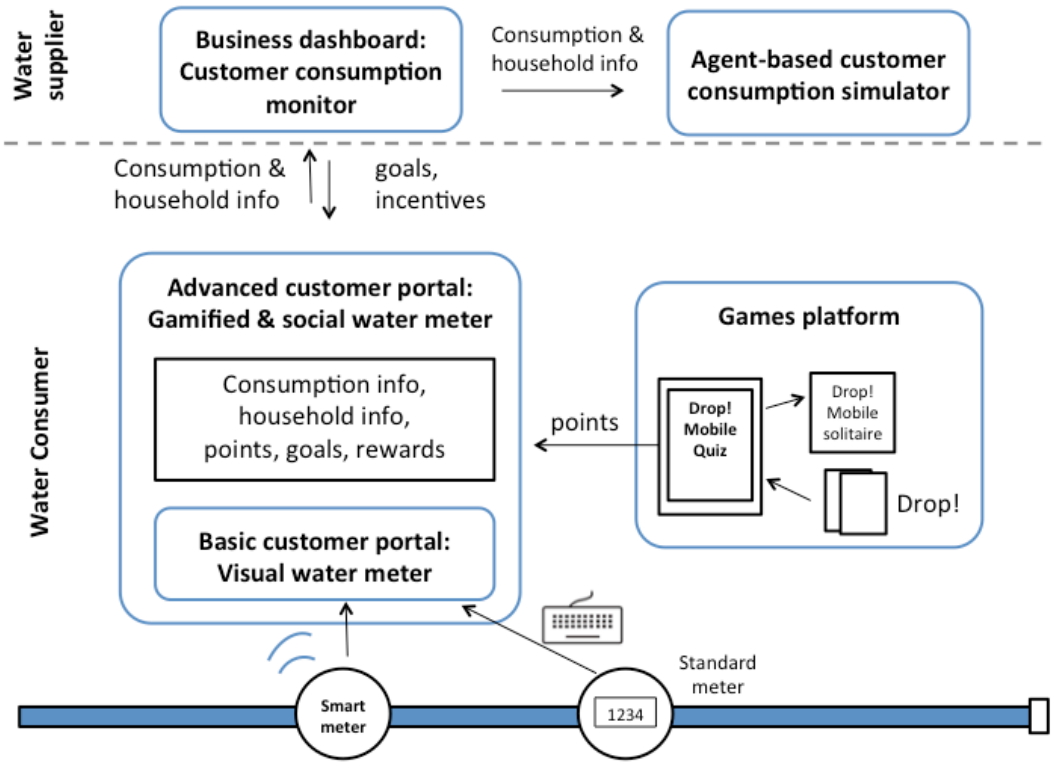


Figure 6. Main applications overview.

First, we present the water consumption visualization model for mapping abstract metering information into a semantically understandable format that raises water saving awareness among different types of users. The model will be the basis for both customer portal versions.

4.1 Visualization model for raising water saving awareness

The visualization model model for mapping abstract metering information into a semantically understandable format and raising water saving awareness is based on the user needs identified in the consumer workshops described in D2.1, as well as a literature review of related work (including [Froe2012]; [Gust2009]; [Lasc2011]). For a visual State of the Art overview, see Appendix B.

4.1.1 Approach

The most relevant study evaluated eco-feedback displays for fixture-level water usage data [Froe2012]. The study examined both specific isolated elements of such displays (e.g. data and time granularity) "to identify and uncover elements of interest to users", as well as integrated design probes "to elicit reactions about competition, privacy, and integration into domestic space" [Froe2012].

[Froe2012] identified four eco-feedback design dimensions that should inform visual displays and similar visualizations of water consumption: *data* and *time* granularity, *comparison* (including goal-setting) and *measurement unit* (see Table 4).

Table 4. Eco-feedback design dimensions [Froe2012].

Design dimension	Parameters
Data granularity	• At each individual fixture • At each fixture category or type of fixture • By activity (e.g. cooking and dishes, lawn watering)
Time granularity	• By month • By week • By day (Observe small, immediate updates versus general usage patterns.)
Comparison	• Self-comparison (daily average next to current usage of each fixture type) • Goal-comparison (self-set or externally set) • Social-comparison (comparing usage to other households such as geographic vs. demographic neighbours and comfort levels with sharing water data anonymously to enable these comparisons.)
Measurement Unit	• Volume-based measures, like CCFs, gallons, or liters • Flow-rate measures such as gallons- or liters-per-minute • Cost, e.g. per day, week or month • Equivalence or metaphorical measurement unit, e.g. 1-gallon milk jug or a 5-gallon water bottle (Used to measure and present usage)

Participants in the study preferred data granularity at individual fixture followed by granularity at fixture category. However, displaying information for individual fixtures requires per-device metering, while disaggregation algorithms can only determine consumption for fixture types. Participants also liked to compare hot water vs. cold water consumption when such information is available as hot water strongly impacts electricity costs.

Regarding time granularity, participants preferred to be able to switch between all three options to display consumption by day, week and month [Froe2012]. Similar observations

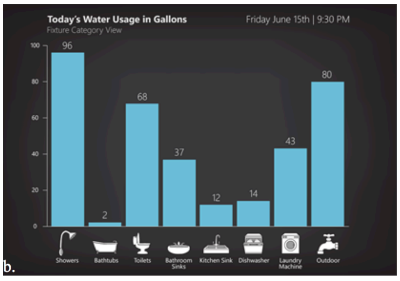
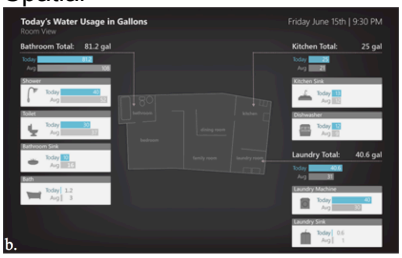
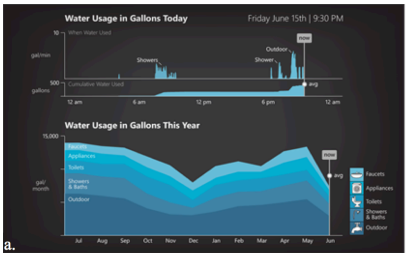
were made for the kind of measurement unit used, where participants preferred to switch between different units such as volume and cost [Froe2012]. Metaphorical units were also considered important ("some found them "shocking" in how much water usage they seemed to reveal") but needn't to be displayed permanently according to participants [Froe2012]. For participants' attitudes towards self-, goal comparison and social comparison, see Table 5.

Table 5. Study participants' attitudes towards self-, goal comparison and social comparison [Froe2012].

Comparison	Participant preference (%)
Self-Comparison	91
Goal-Comparison	68,2
Set manually	58,1
Set by display system	44,1
Set to efficient neighbours	37,4
Set by supplier	21,8
Set by local government	16,9
Social-Comparison	67,7
Demographically similar	**73**
Geographic neighbours	52,4
Households in other cities	35,6
Households in other countries	32,4
Select Family/Friends	35,2

The provided design probes were rated as follows by participants:

Table 6. Participants' attitudes towards design probes [Froe2012].

Design probe	Participant preference (%)	Participant comments
Bar chart 	64	*Simplest and most glanceable*
Spatial 	14	*Makes information easier to read and understand: breakdown between rooms and appliances is clear and gives an intuitive sense of where water is being used*
Time Series 	12	*++ longer term temporal patterns and the effect of reduction efforts in the graph*
Per-occupant 	10	*Notions of accountability (pinpointing who is using water)*
Aquatic ecosystem 	N/a	*++ turning consumption on its head and rewarding saving,* *good for children, more ambient, more like a screensaver*

[Froe2012] also offer the following additional design guidelines for eco-displays:

Competition & Cooperation:

"Make those elements or displays that specifically encode competition optional. Another [solution] is to make the comparative elements stress collaboration rather than competition (e.g., by making the comparison target other households)."

Accountability & Blame:

"There is a thin line between enabling accountability and introducing elements that could be perceived as blame inducing. As with competition, there is clearly a contingent of people attracted to the idea of knowing who uses water. However, any eco-feedback system that tries to encode accountability explicitly should realize that 'accountability' can be perceived as 'blame.'"

Playfulness & Functionality:

"Playful and fun designs can be good at creating engagement and interest as well as serve an educational tool but the actionability of the visual representation is of paramount importance. In addition, designs that are more ambient need to take care not to look more visually interesting with increased consumption."

Privacy:

"Privacy is an important aspect of future eco-feedback displays in the home, particularly as sensing systems become more granular. Designers need to take care to offer different levels of abstraction to make particular events in the home less visible in some views. Privacy and eco-feedback is an important area for future work."

In conclusion, we have tried to incorporate many of the main findings, enabling consumption visualization at an aggregated and, when this information is available, also at a fixture- level, and by offering different levels of time granularity and measurement units. We have also particularly focused on incorporating different aspects of self-, goal-, and social comparison. In addition, we consider conceptualize a playful, more ambient visualization similar to the fish tank proposed by [Froe2012] (for more similar approaches, see Appendix B).

Furthermore, to address the needs of different types of users (see Section 2.3), consumption should be visualized in different levels of detail and information to be adapted and explored based on individual user preferences.

4.1.2 Visualization mockups

The following subsections describe the visualization model we have conceptualized.

Overview visualizations

The overview visualizations provide users with very simple messages regarding their water consumption. One widget shows the average water consumption of the users' household in comparison to others (similar households, your neighbourhood, households in your town), addressing the social comparison aspects pointed out by [Froe2012]. A more ambient widget can address especially environmentally conscious users, showing for example, which nature reserves are positively (directly and indirectly) affected by the user's water saving efforts. A third widget extrapolates current savings to a year's worth of water saving, visualized in more metaphorical way so that the user can get an impression of the impact of their water saving if carried out over a longer period of time (see Figure 7). This is especially important, since the amount of water saved in a single day or week is likely to have a small volume and a related very small monetary or other impact. This may seem insignificant at first for the consumer, but when added up over a longer period of time even small savings when repeated can accumulate to significant effects. Visualizing a projection of these cumulated savings in advance, based on current user behaviour is thus an important means of raising consumer awareness about the effect of their actions and stimulating water saving.

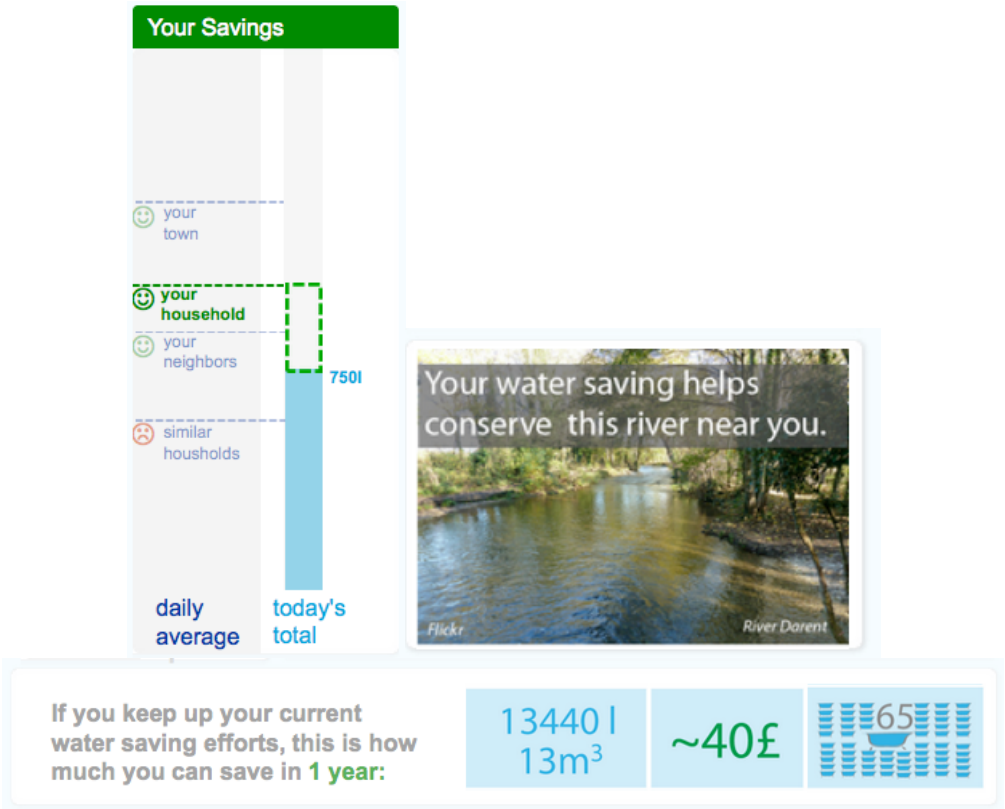


Figure 7. Overview visualizations.

Simple aggregated consumption visualization

To visualize consumption in more detail, a water pipe metaphor is used. It displays the monthly total consumption, as well as the total for a specific day and week. The total is compared to the average consumption (self-comparison), and monthly goals are also indicated (goal-comparison). Goals can be set by users themselves or their water utility.

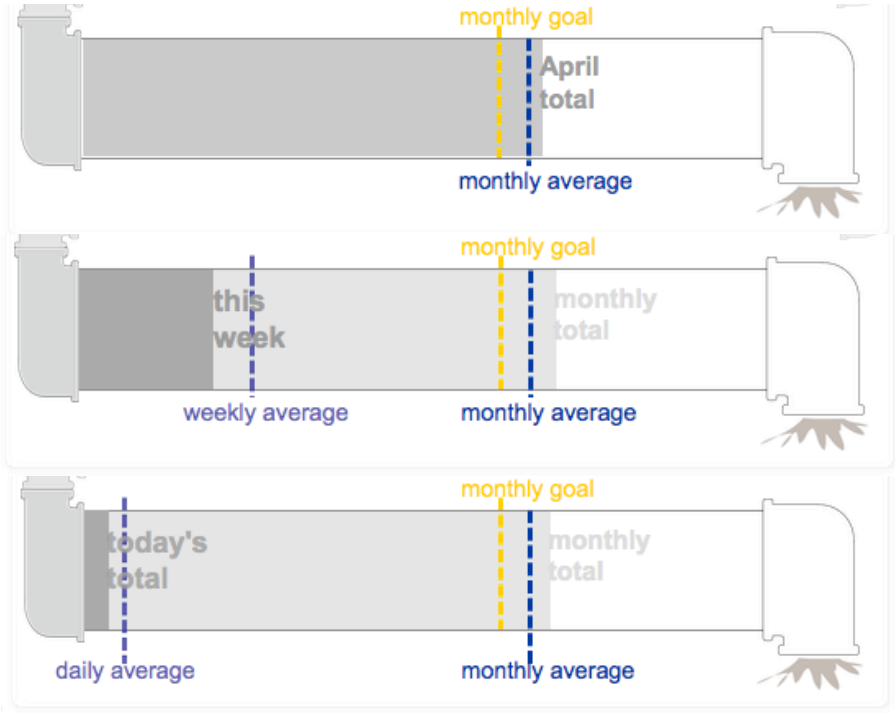


Figure 8. Aggregate consumption visualization.

Goals are also visualized in a separate widget, and can be daily, weekly and monthly goals. Goals are considered to be consumption badges, self-set goals and goals set by the utility (see Figure 9).

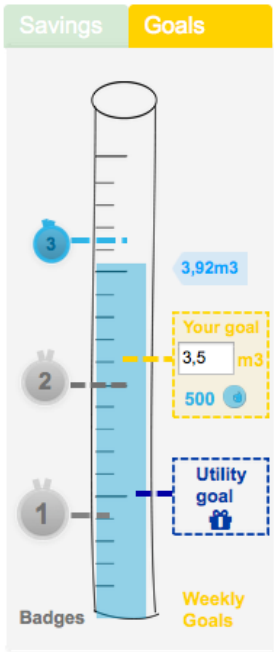


Figure 9. Fulfilling consumption goals based on consumption average.

Disaggregated consumption visualization

When available, consumption information can also be shown by appliance (see Figure 8 and Figure 11). Users can view the consumption percentage for each device type. Secondly, consumption (end-use) events can also be shown. Such events (e.g. watering the garden at 11:05 for 15 min.) are detected automatically but can also be edited manually to correct errors, add missing events etc. They are visualized as device icons of different sizes, i.e. the bigger the icon the more water has been consumed.

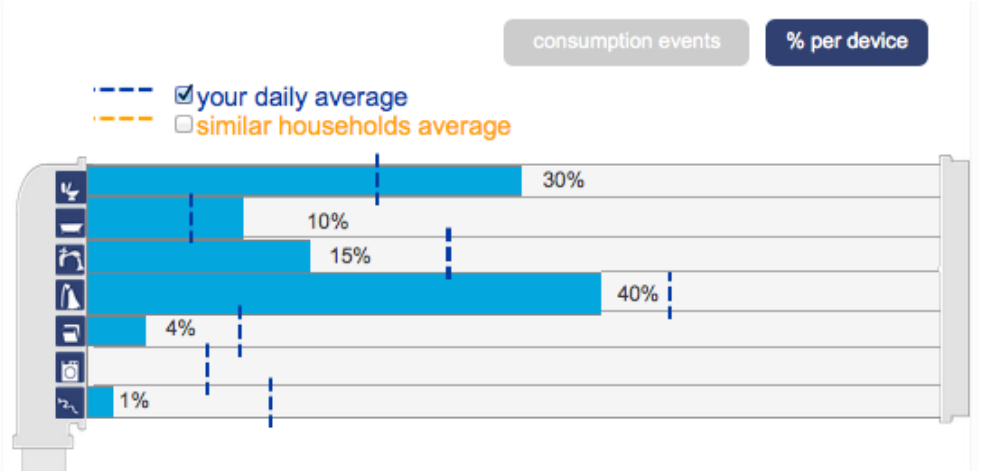


Figure 10. Consumption visualization at fixture level: displaying consumption percentage per device.

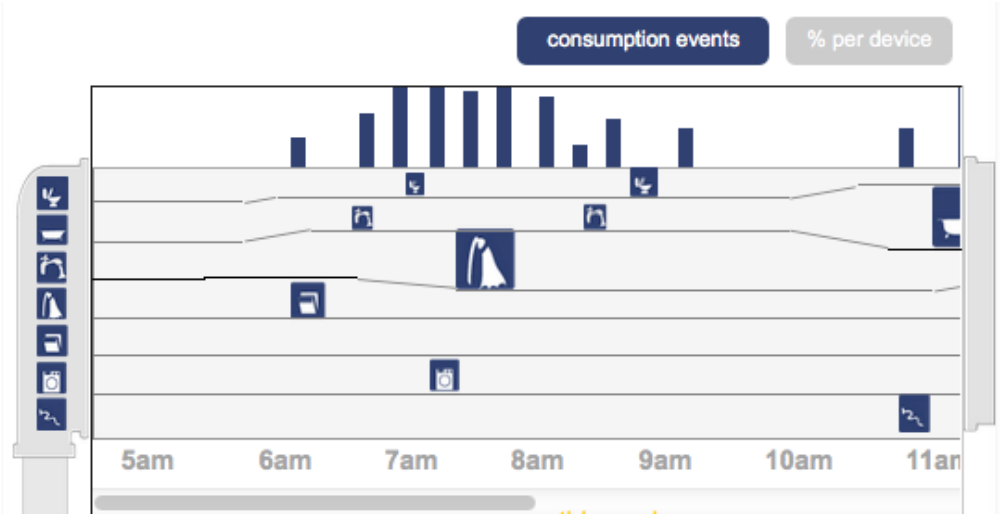


Figure 11. Consumption visualization at fixture level: displaying end-use events per device.

Detailed consumption visualization

The household consumption can also be visualized in more detail with a bar graph (see Figure 12). The bar graph can display metrics like consumption peak hours, and be viewed at a daily, weekly and monthly level.

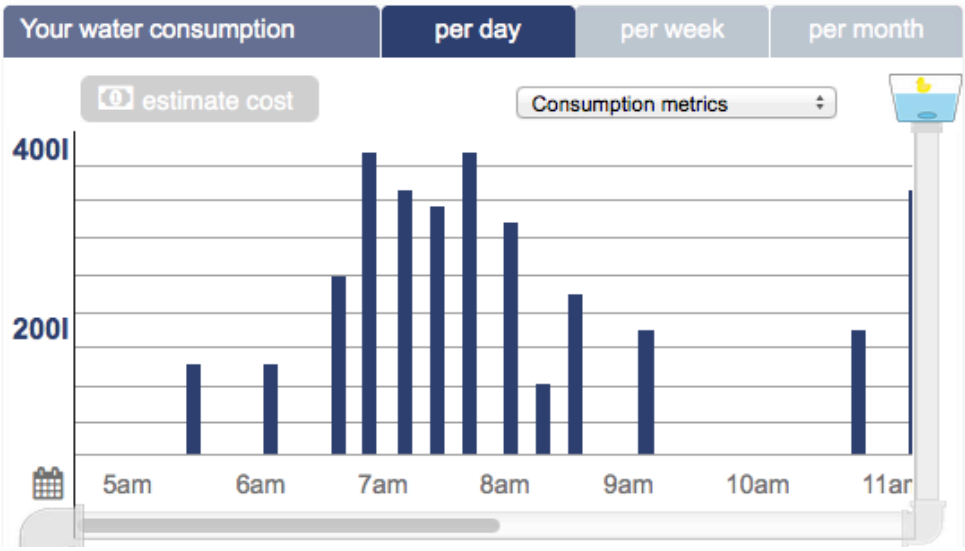


Figure 12. Detailed bar graph visualization of daily water consumption.

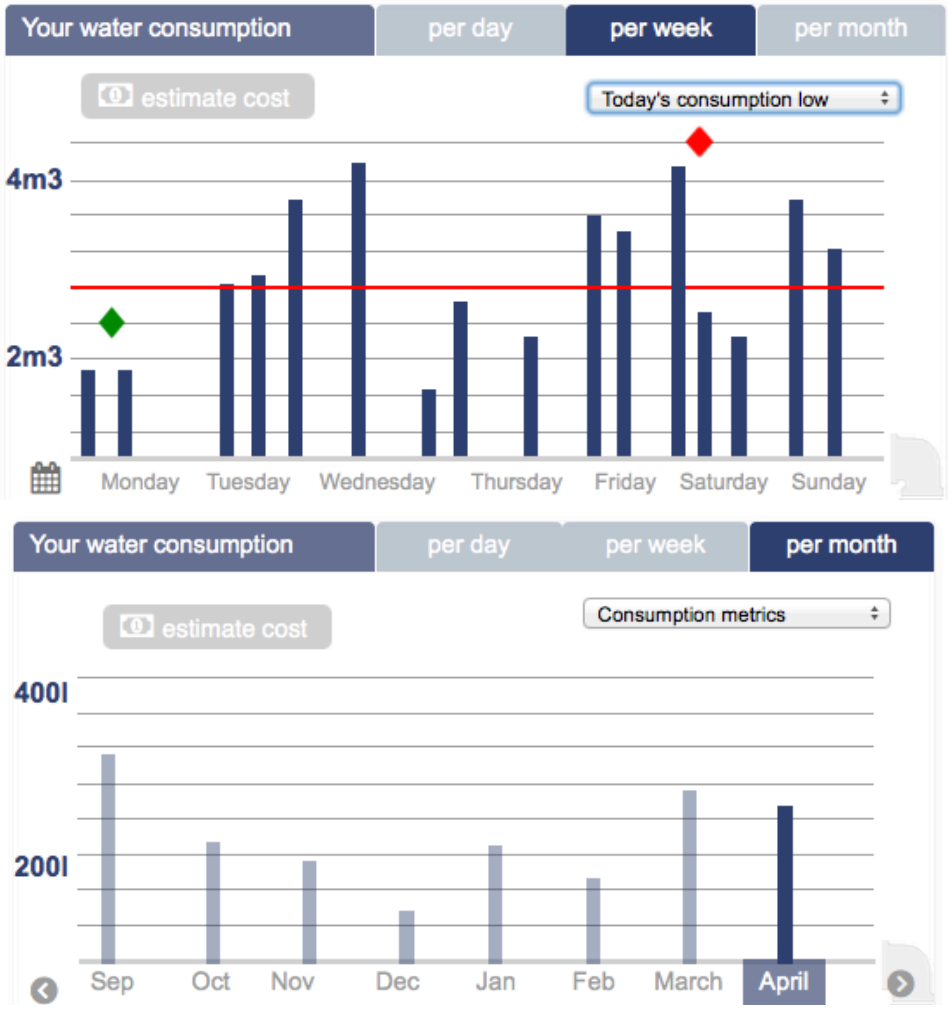


Figure 13. Detailed bar graph visualization of weekly / monthly water consumption.

Ambient & playful consumption visualization

A more ambient and playful visualization shows a yellow rubber duck in a bathtub with water levels varying according to the amount of the overall consumption. The more water is consumed over the course of a day, the lower the water level becomes. A small icon shows this visualization as a simple indicator in the other visualizations as well, but users more interested in this kind of approach can interact with it in detail (see Figure 14). The amount of water in the tub at the beginning of each day is just a bit more than the total amount that is recommended to be used daily depending on household size. The goal is to keep the duck from swirling down the drain at the end of the day as a result of high consumption. The duck could e.g. be saved by implementing water saving actions and thus keep the tub from becoming empty. Additionally, users can unlock bonuses using points they collect in the gamified platform. E.g. a bonus could enlarge the duck or equip it with balloons to escape the drain (see Figure 16). This visualization is aimed especially at younger children who have been recognized as an important target group for raising awareness on environmentally friendly practices, both for themselves and through their implicit influence on family dynamics (see [Froe2012]; [Owen2013]; [Owen2014]).

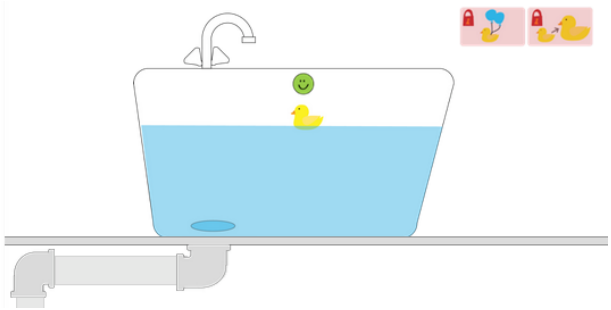


Figure 14. Bathtub and duck ambient visualization: high water level gives a happy duck.

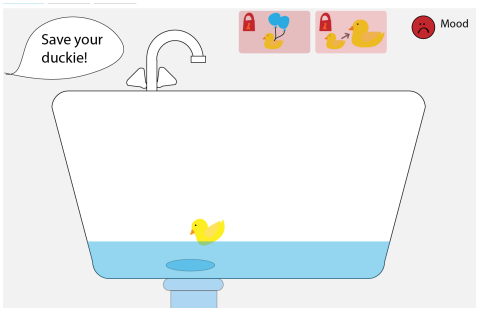


Figure 15. Bathtub and duck ambient visualization: low water level threatens the duck.

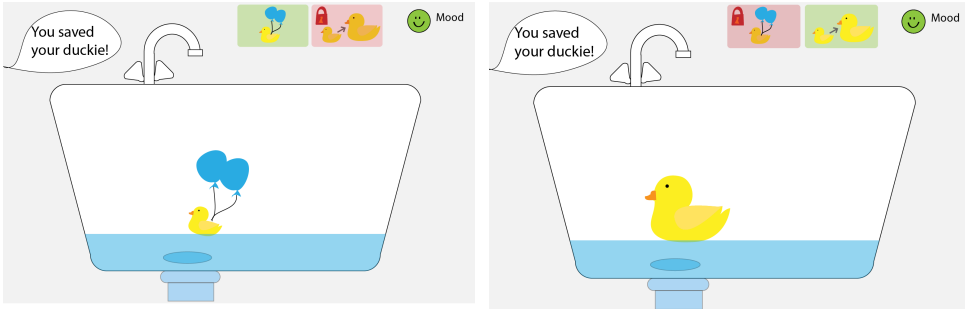


Figure 16. Duck can be saved from drain by unlocking bonuses with points from the gamified water meter, e.g. by equipping duck with balloons (l) or by enlarging (r).

4.2 Basic customer portal: Visual water meter

User stories: 1A, 1B

The smartH2O customer portal provides customers access to their water consumption information. It will be available as a basic version that focuses on the basic water meter access, and an advanced version (see joint signup page in Figure 17).

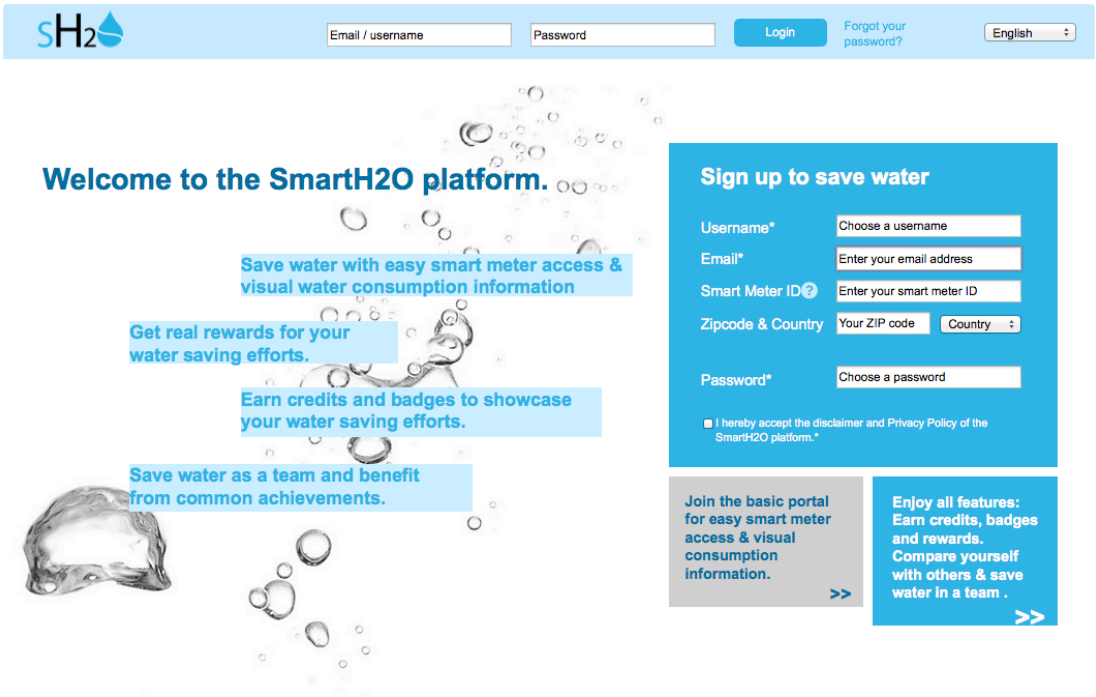


Figure 17. Customer portal sign-up page mock-up.

The visual water meter provides customers with the most basic access to their consumption information. It connects to the meter data that is either collected automatically via smart meters, or provided manually by customers who have easily accessible standard meters and want to use the application as well.

A visual widget displays the consumption over time and calculates the average consumption of the user's household (see Figure 18). It can also calculate other important metrics like peak hours. These average can also be compared to other aggregated consumption information, e.g. to the neighbourhood's or town's consumption average. Based on the consumption information, the application can calculate a "virtual bill" that shows how much a household would have to pay approximately if it was billed based on the smart meter information.

Secondly, the basic application can also provide alerts, e.g. warning the user about possible leaks or bad water quality. As found out in the requirements workshops, these alerts are more important for the Swiss case study. Additionally, the application can also display water saving tips and info material like videos providing information about topics related to water saving.

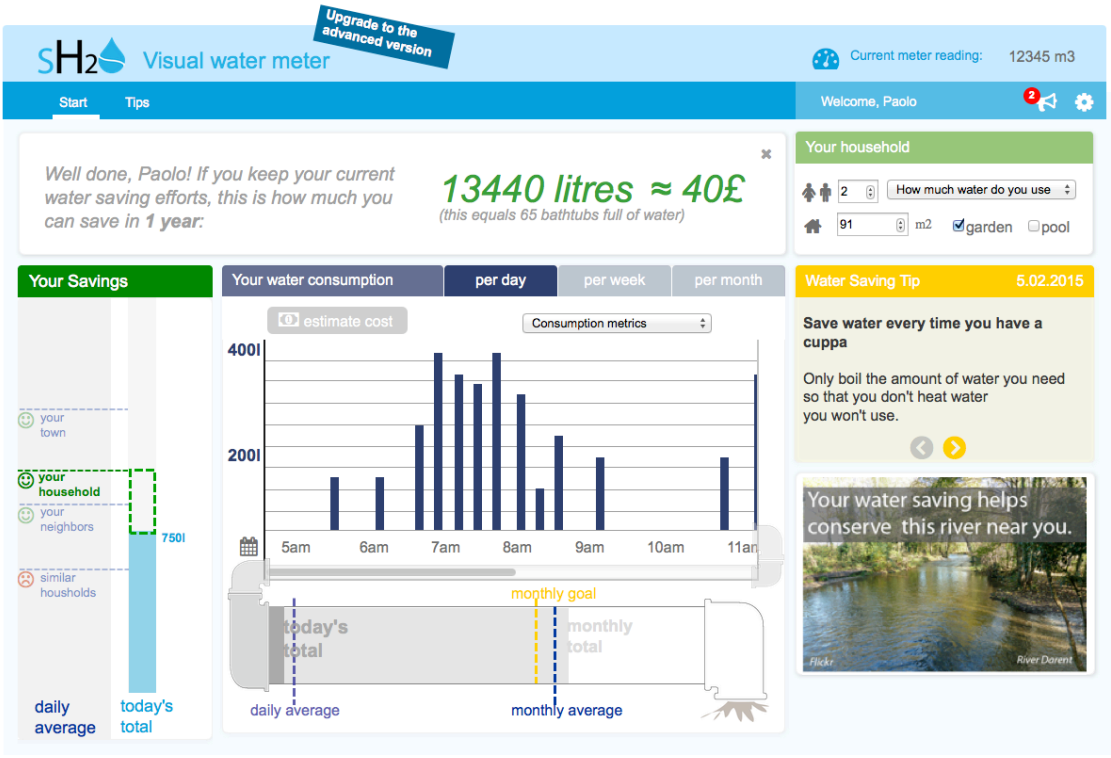


Figure 18. Mock-up of visual water meter.

In both versions of the application, users can also estimate their consumption cost and learn about innovative pricing models by simulating different tariff types based on their current consumption (e.g. blocks rates) in the visual widget. Thus, customers can understand the potential impact of innovative pricing models if they were to be applied to their current consumption (see Figure 19).

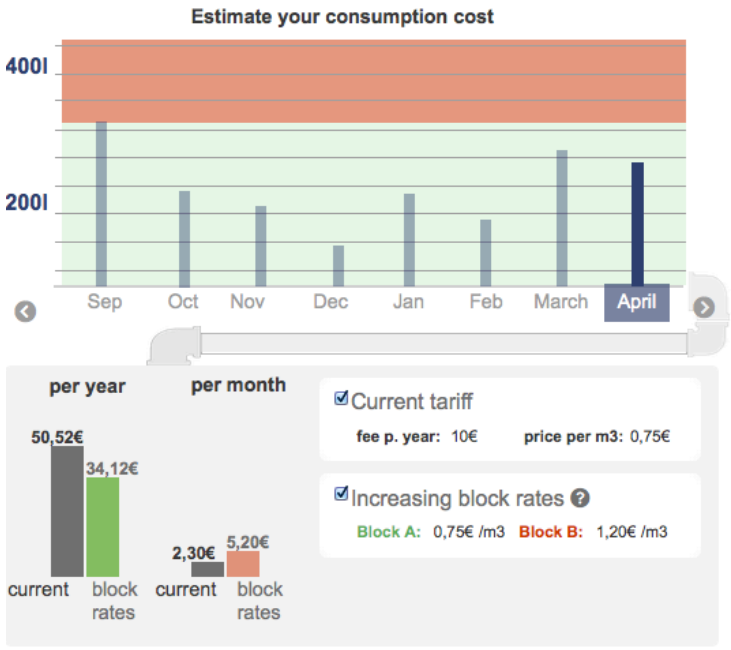


Figure 19. Innovative pricing simulated customer portal (here: block rates).

4.3 Advanced customer portal: Gamified & social water meter

User stories: 1A, 1B, 2A, 2B, 2C

The gamified water meter provides interactive and "gamified" means for customers to learn about water saving and contribute and benefit from additional information. Besides the functionalities that are available in the basic visual water meter, the advanced customer portal will incorporate many gamification and social features (see for an overview of the application). The application will be available as a web version and a mobile application, each providing the same functionalities.

Figure 20. Mock-up of the gamified water meter web application.

Gamifying such an application means that besides learning about their consumption, customers can earn credit points for each action they perform in the application. With these points they can reach different levels and earn badges, and based on their status, they can eventually redeem the points for different kinds of rewards, e.g. water saving gadgets (see Figure 21).

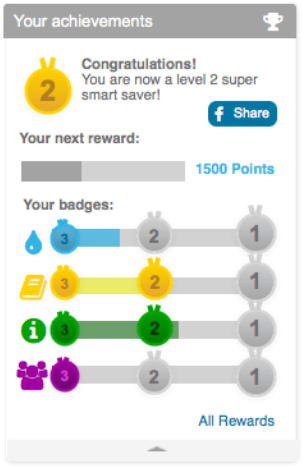


Figure 21. Visualization of collected credits and badges.

Possible user actions as envisioned for the gamified water meter application are described below.

User action: Fulfilling consumption goals that were set either by the utility or the customers themselves (see Figure 22).

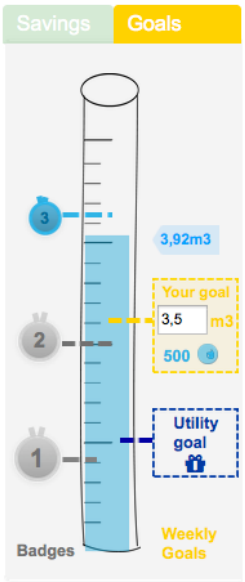


Figure 22. Fulfilling consumption goals based on consumption average – goals can be consumption badges, self-set goals and goals set by the utility.

User action: Providing household and personal information like number and demographics of household members, number and kinds of appliances (see Figure 23) or general information like number of rooms, size of garden (see data model in section 5 for the full list of customer attributes that could be considered).

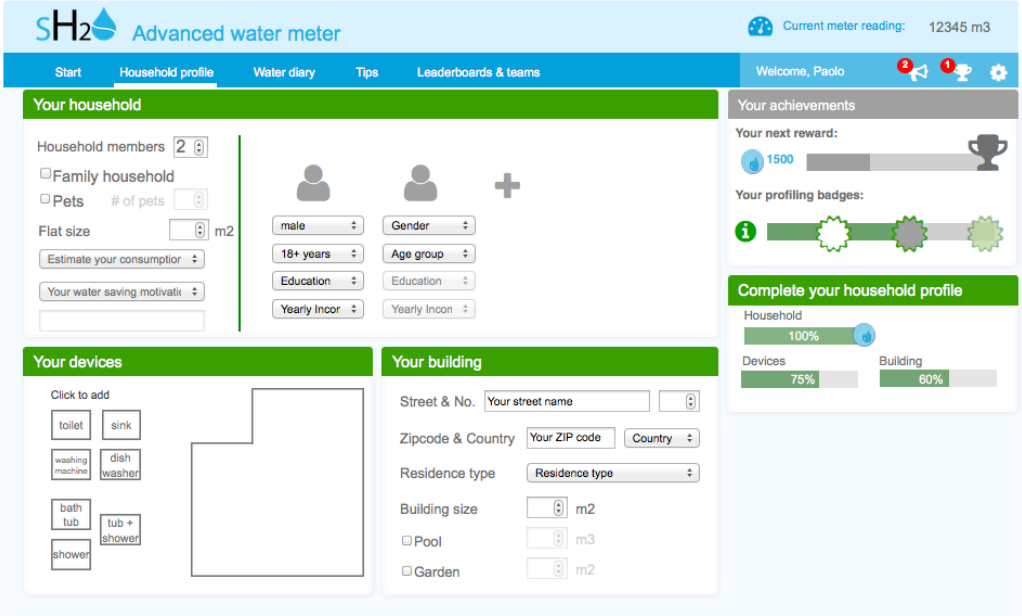


Figure 23. Providing household and personal information.

User action: Providing consumption information of specific end-use events in a kind of water diary, e.g. “10 min. shower at 7am” or “14 min. watering the garden”.

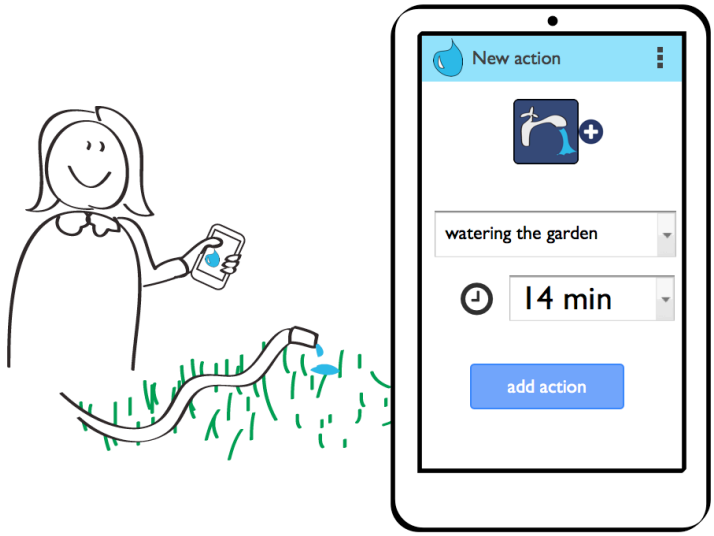


Figure 24. Providing consumption information on end-use events in a water diary.

User action: Reporting water saving actions like the instalment of new water saving devices and the adoption of new habits. Reading and watching water saving tips in a separate section

that provides info material like videos or slide shows on water saving and sustainable consumption. Getting information about Drop! board and mobile game. (see Figure 25).

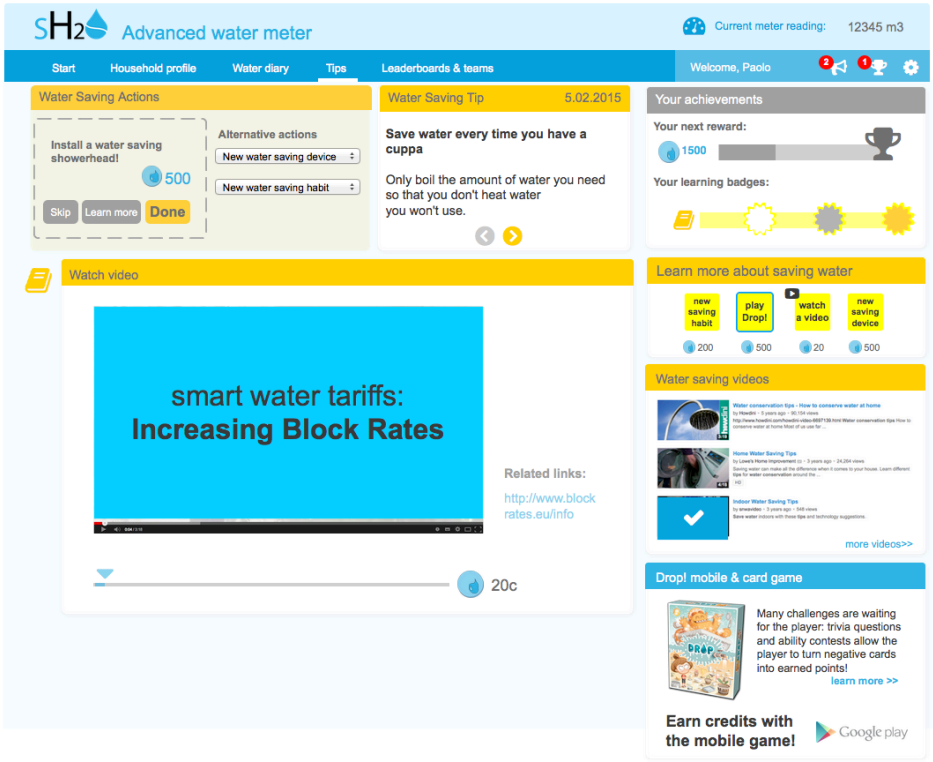


Figure 25. Consuming information materials like videos and other water saving tips, playing Drop! The card game, or implementing water saving actions.

User action: Comparing own achievements with others and joining water saving teams. In addition to considering ones own actions, users can compare themselves directly with family, friends and neighbours by allowing the application to show them in the leaderboard or even on a neighbourhood map. There, each user is listed with his badges and total of points (see Figure 26).

Users can also team up with others to benefit from each others' points, and work towards achieving common water saving goals as a larger group of users, e.g. a circle of friends, all households in a building or all inhabitants of a participating town.

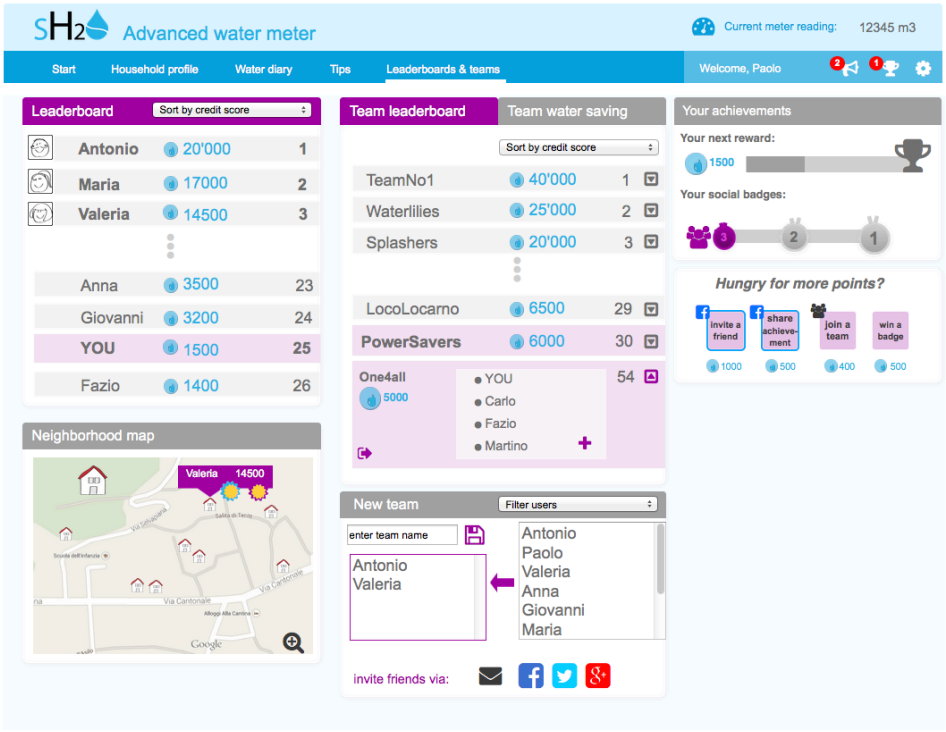


Figure 26. Left: Leaderboard & neighbourhood map to compare own achievements with other users. Center: Water saving teams on team leaderboards.

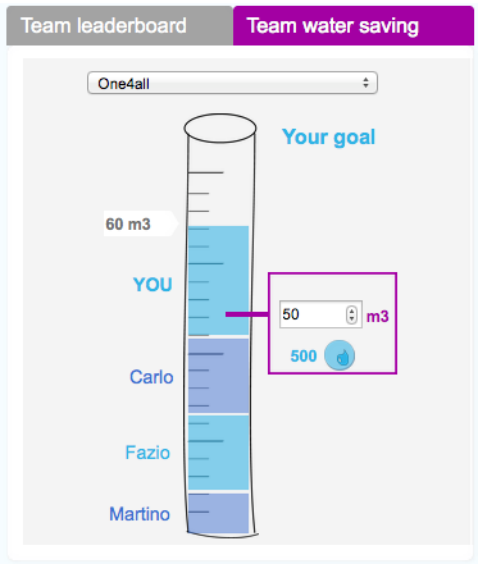


Figure 27. Team water saving goal.

4.4 Games Platform

User stories: 2D

The games platform connects a physical card game called “Drop!” with a digital mobile app. Points earned in the mobile game can also be used in the gamified water meter applications, if the accounts are connected.

The goals of the games platform are to leverage game techniques of a card game and augment them with a digital mobile app to:

- Raise awareness of water saving and of how to prevent wasteful water consumption among younger children
- Engage all members of a family household
- Gather useful data for the specific utility to be used to base marketing and commercial decisions upon.

The overall concept of the game is about the story of a kid and his monster. The two are always together playing and messing around. When playing, they encounter many different water-related activities and while the kid, remembering his parents' teachings, adopts water saving behaviour, the monster is always so clumsy that he wastes a lot of water. Therefore, the kid tries to teach the monster not to waste water and along the way the player will be in charge of this teaching as well. With the playful graphics, we want to leverage on the juvenile adventure nostalgia of grown ups and engage young players.

4.4.1 Drop! card game

The card game Drop! is based on a system known as "push your luck": Technically speaking, this is a game where you get points only if you stop at the right time, before hitting a penalty that makes you lose everything. The mechanism has been adapted to the type of audience and introduces the possibility of winning thanks to his fortune or at the misfortune of others. It consists of regular playing cards, which have different numeric values, and "bad" cards showing the water wasting monster and a unique QR code (see Figure 28). The monster cards count as -10 points at the end of a match. The negative score can be turned in positive points by using the app and scanning the QR code on the card; trivia questions will be given to the players as a challenge in order to convert the points. See D2.1 and D4.1 for more details on the concept and game rules.

Figure 28. Drop! card game prototype.

4.4.2 Mobile game app

The accompanying mobile app will deliver different features aiming at engaging the user, which are all accessible via the start screen see Figure 29). The main goals of the app are:

- Getting the user on board.
- Get information about users' behaviours and habits.
- Teach good behaviours by Baby Step techniques [Fogg2011].
- Deliver a single player game experience.
- Enhanced card game experience.

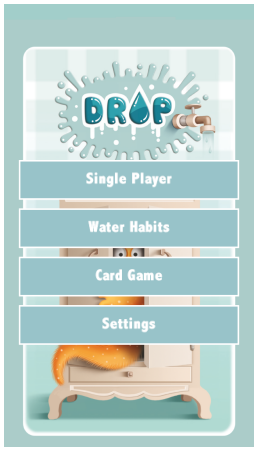


Figure 29. Start screen mock-up of mobile game app.

The card game concept requires a connection with the app as follows:

As soon as the board game finishes, all players that ended up with monster cards can try to convert them into points.

The process requires that with the app, the player scans the card she wants to convert with the smartphone camera. The app reads the QR code and launches a mini-game (see Figure 30, left screen).

The mini-game will be composed of two parts.

Part 1) Skill game: The monster was not a great water saving buddy and now his fur is full of water. In order to recover the water and save it, the player will need to tap as fast as he can on the monster. At each tap some water from the monster's fur will be squeezed into a tank. Saving at least 80% of the water will earn the player 5 points.

Part 2) Trivia: As soon as the skill game ends, the trivia will pop up and a question will be asked with 3-4 answers (see Figure 30, centre screen). Providing the correct answers will grant the user 5 more points.

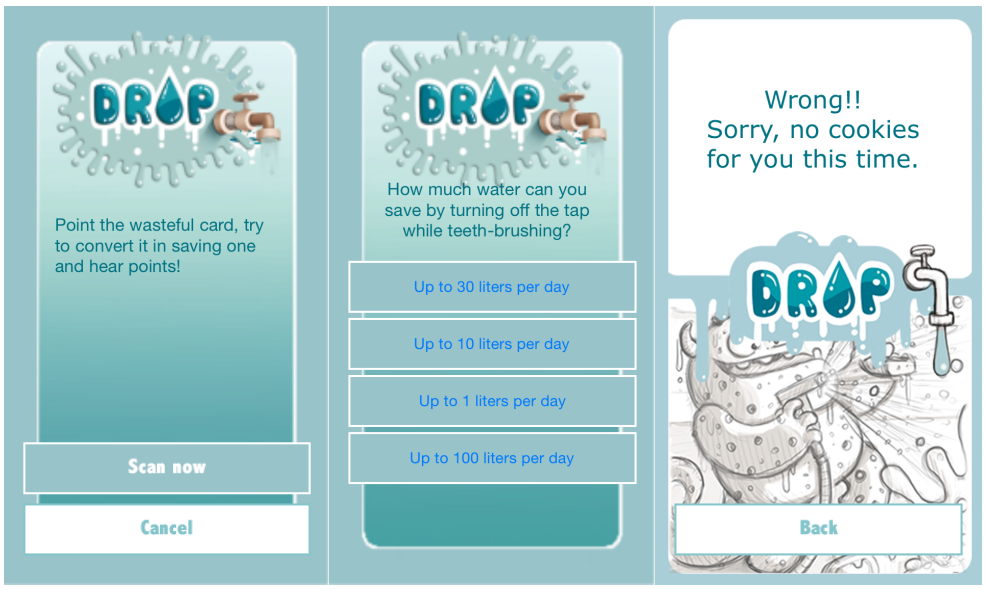


Figure 30. Mobile app mini-game mock-up: It connects with the card game. The user scans the water monster card (left) and answers trivia question to earn extra points (centre). Wrong answers result in no points (right).

The single player game will be a “Pipe” game (see Figure 31, left). The player will be guided through 35 levels of increasing difficulties (see Figure 31, right). Each level represents a drop of water on its journey through a labyrinth of pipes, undertaken by the user and the monster. Every complete level will earn the user a “drop” to be used as a reward on the gamified water meter. The levels will not be stand-alone levels but have to be completed in a path-like style.

Figure 31. Single Player mobile game mockup: journey of the drop of water through the pipes in a level (left) and level selection (right).

Game Play of single player game: At the start of the level the board of unordered and messy pipes will be laid down. Water will start to flow from the top pipe and as soon as it will start to leak because the pipe is not connected to another one, the level ends. The player needs to rotate the pipes, some will be turns and others will be straight pipes, in order to guide the water from the tank to the recycler. The higher the level, the higher will be the number of rotated pieces and the number of rotation of each.

4.5 Business dashboard: Customer consumption monitor

The Business Dashboard for water utilities monitors customers’ water consumption, as well as customer profiling information and activity that is elicited through the Customer Portal.

User story: 3

The Customer Consumption Monitor aggregates and visualizes the data that is collected via the smart meters and the customer portal. With the Monitor, utility staff can easily access and explore this information (see Figure 32 for an overview of the application mock-up).

Figure 32. Mockup Customer consumption monitor.

Based on a selected geo-location, the utility user can view consumption data on different resolutions, e.g. aggregated information for a whole city or district (borough), or even per household level (see Figure 33). The can compare different consumption metrics, including the amount of water consumed vs. the amount of water pumped into a certain area. Exogenous information like weather data can also be displayed.

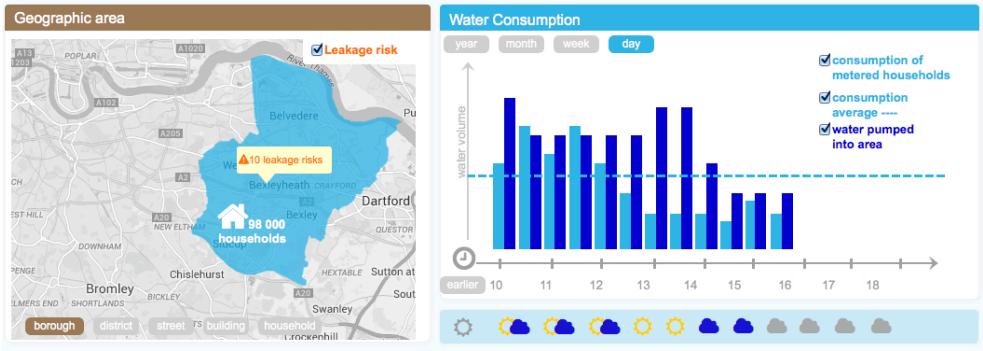


Figure 33. Visualizing consumption information based on geo-location.

The Monitor furthermore provides information about customer activity on the Gamified Water Meter (see Figure 34). E.g. utilities can identify most active users (“super savers”. They can also see which kind of attributes these users share, allowing them to identify more specific customer segments based on their activity on the portal.

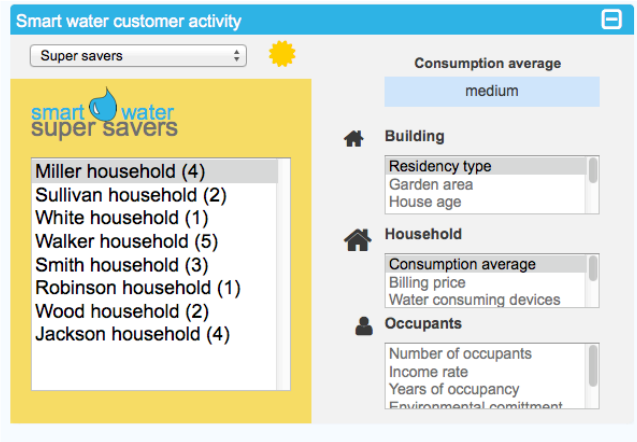


Figure 34. Monitoring user actions on the Gamified Water Meter.

Utilities can also identify and specifically monitor customer segments or customers groups by selecting shared average household data from customers in the selected geo-location, e.g. all customers who have a low environmental commitment, a medium shower consumption and no garden (see Figure 35). The household data is collected both by smart meters and by the Gamified Water Meter application. The possible attributes are those specified in the Data Model (see Section 5). Each of the configured customer segments can be saved and thus monitored continuously. Utilities can also assign specific consumption goals for a defined customer group (see Figure 36).

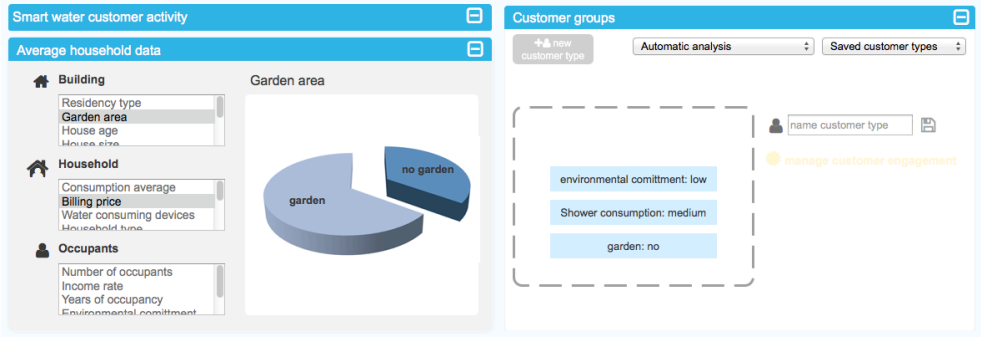


Figure 35. Identifying customer groups by selecting common household attributes.

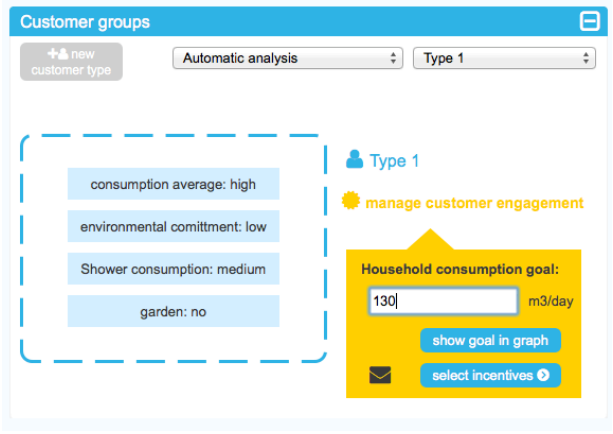


Figure 36. Assigning consumption goals for specified customer groups.

4.6 Agent-based consumption simulator

User stories: 4A, 4B, 4C

An agent-based simulator enables utilities to not only monitor actual water consumption, but to simulate consumption based on changed parameters. E.g. they could change exogenous data like weather conditions and simulate possible consumption patterns for a specific geo-location and customer group under these new conditions. They could also change reward schemes, e.g. by setting consumption goals, or by applying different tariffs as a kind of monetary incentive, to see how this may affect the behaviour of specific customer groups.

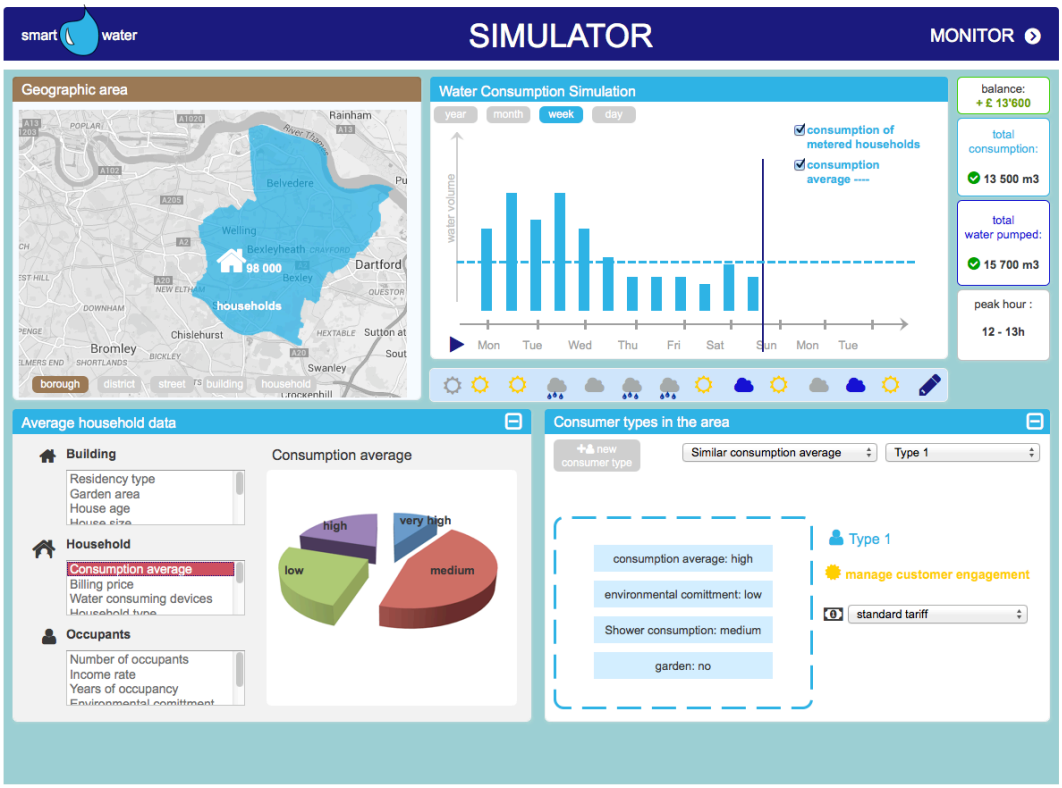


Figure 37. Mock-up agent-based consumption simulator.

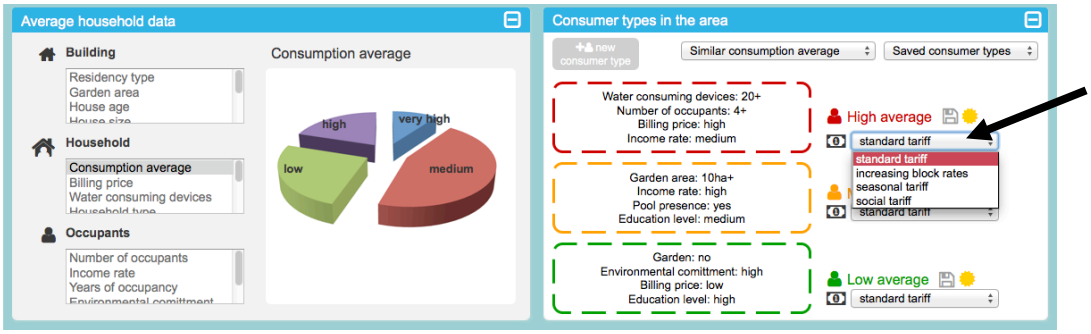


Figure 38. Simulating innovative pricing by applying different tariffs in the customer consumption simulator.

5. Data model

The SmartH2O data model comprises the set of entities and relationships that express knowledge about user data made available by the water utilities (smart metered or billed). This knowledge, which is used for analysis purpose, can be automatically produced by smart meters, obtained from on-line bills, or manually produced by users that interact with the gamified water meter system. We describe the main entities of the data model here in the context of the requirements and use cases, as it has strongly informed the process of eliciting them (information desired from customers, and for the monitoring and simulation of customer consumption behaviour and incentive response). In this section we describe the updated version of the SmartH2O data model, previously defined in deliverable *D3.1 Database of User Information*. Such updates stem from the progress in the specification of the user's requirements and of the system architecture, which prompted for the refinement of aspects mostly related to the user's profile data.

Customer Data Model

In essence, the Customer Data Model of SmartH2O, whose data are organized into a database represented in Figure 39, contains entities for:

Household: it identifies the concept of household (a.k.a. "family"). Each household has an identification [Oid], an [UtilityID] linking the house to the water utility, the size [Household Size], a flag stating if the Head of household is either a tenant or an owner [Ownership], the number of occupants [Number Occupants], the presence of pets, if any, [Number Pets], the area of the garden (if any) [Household Garden Area], the volume of the pool (if any) [Household Pool Volume], a flag stating if the house is used only for holidays or weekends [Second], a flag stating if the household discloses the geo-location to other users [Visible], a flag stating if the household discloses household information to other users [Public].

Each Household could have up to *n* Devices (Device Class). Each **Device Class** device has an identification [Oid], the name of the device [Name] and the number of pieces of that device present in the considered house [Number].

Device Consumption: it identifies the consumption data, *disaggregated by Device*, result of models computation. Each Device Consumption has an identification [Oid], a given interval [Start Date][End Date] ant the consumption value [Device Consumption].

Bill: each bill is identified by the account number [Account Number], the date [Bill Date] and the company [Company] which invoiced the bill. Moreover, for each bill we store the charge for water supply [Volume Charge], the charge for service supply [Service Charge] and the currency of that bill [Currency]. Each bill is in association with the Household the bill is referring to and has some Billing Price composition.

Billing Price: for each month [Month], year [Year] and company [Company], it stores the monthly service charge [Monthly Service Charge] and volume charge [Monthly Volume Charge].

Household Consumption: identifies the consumption data, *disaggregated by Household*. If no disaggregation is computed, it will store the original consumption data coming from smart meter readings. Each Household Consumption has an identification [Oid], the given interval [Start Date][End Date], and the computed consumption value [Consumption].

Each Household could have *n* Neutral User (a.k.a. "family members"). Each Neutral User inherits an identification [Oid] from the **User** entity, the authentication information [Username] and [Password], the email [Email], the firstname [Firstname] and lastname [Lastname] and the birthdate [Birthdate]. Moreover, for each **Neutral User** we store the registration date [Registration Date], the name of his/her role in the family [Family Role], his/her educational level [Educational Level], the economic level [Income Rate], the money system adopted by

the user [Currency], a flag stating if the user discloses personal information to other users [Public], the user language [Language], the temperature unit [Temperature Unit] and the length unit adopted by the user.

The data model implements the Role Based Access Control (RBAC): Users are clustered in Groups, which represent the various classes of users. Each **Group** has an identification [Oid] and a name [GroupName]. Groups are connected to Modules, which represent the interfaces to the SmartH2O resources that the class of users is entitled to access. Each **Module** has an identification [Oid], a name [ModuleName] and the name of the module domain [ModuleDomainName].

In order to provide more appropriate and targeted incentives, Neutral Users are grouped into consumer segments. Each **Consumer Segment** is identified by a unique id [Oid], a name [Name] and a description [Description]. A segment of users is characterized by a set of features. Each **Feature** is identified by a unique id [Oid], a type [Type] and a level [Level] (e.g. Consumption Average: medium, Environmental Commitment: high).

Media Asset: each media object provided to users is identified by a unique id [Oid], a title [Tile], a description [Description], the author [Author], the duration of the video [Duration] and the URL of the media object [Media].

Some Tips are provided to users. Each **Tip** is identified by a unique id [Oid], a name [Name] and the text content divided into a header [Header] and a body [Body].

Users can be notified about possible leaks or bad water quality through alerts. Each **Alert** is identified by a unique id [Oid], a type [Type] (e.g. Water Quality Alert, Leakage Alert, Shortage alert), a level [Level] (e.g. low, medium, high). When a new alert is inserted, the current date [Date] is stored in order to keep track of the progress of a particular type of alert and to record past critical situations.

An Alert can be associated to a Mail, in order to directly notify the user. Each **Mail** is identified by a unique id [Oid], a description [Description], the subject of the email [Subject], the body of the email [Body]and the language [Language].

Building: it identifies the physical building, containing one or more Households. Each building has an identification [Oid], an address [Address], the area of the garden (if any) [Building Garden Area], a description of the type of residence [Residence Type], the size [Building Size], the number of years since the house was built [Age], the volume of the pool (if any) [Building Pool Volume].

Each building could be metered by one smart meter. **Meter Reading** stores the readings and each of them has an identification [Oid], the smart meter number [Meter Id], the timestamp [Reading Date Time], the company [Company] and the actual reading [Total Consumption].

Each building is also associated to the District where it is located. Each **District** has an identification [Oid], a Zip code [Zip Code], the name of the country [Country] and the city it belongs to [City] and the name of the district [Name].

Weather Condition: the entity stores, for a given interval [Start Date][End Date], the quantity of rain [Rain Fall] and the Average Temperature [Average Temperature] in a certain District.

Unit Of Measurement: stores the information needed to perform conversions. Each conversion is applied to a given physical quantity [Physical Quantity] and is characterized by a unique id [Oid], the primary [Primary Unit] and secondary [Secondary Unit] unit of measure and the coefficient to be applied in order to perform the conversion.

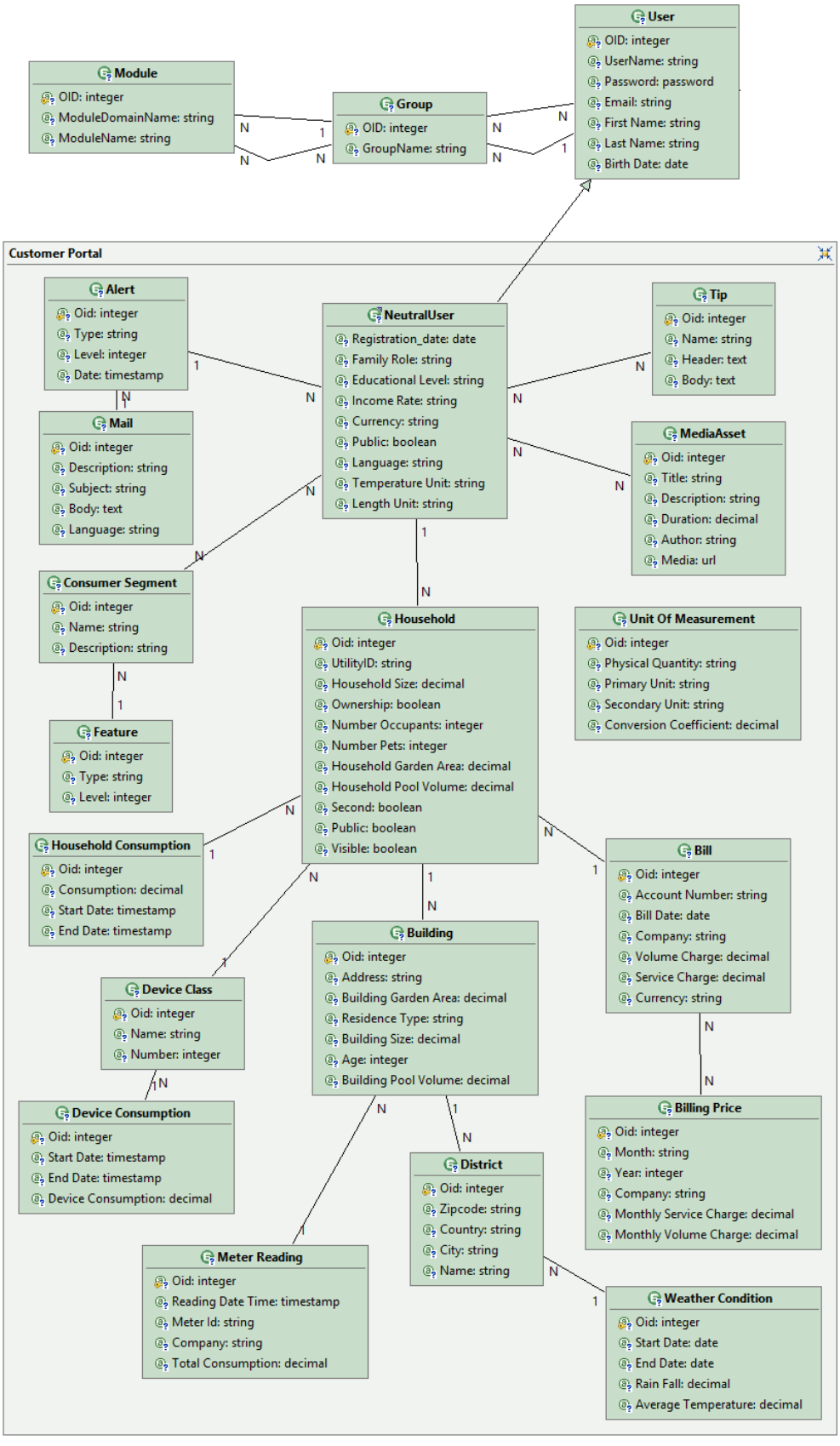


Figure 39. Customer Data Model.

Gamification Data Model

The Gamification Data Model comprises the set of entities and relationships that express knowledge about user data made available by the Advanced gamified Customer portal.

The schema in Figure 40 shows the implemented gamification engine database. The following entities have been considered:

Community Users: the entity is a specialization of **User** and contains all the attributes that identify the user as a member of a community (like credits, bio information, …).

Gamified Application: this table contains information about applications that call the gamification engine.

Action Type: the entity contains the dictionary of the actions of the gamification engine. The attribute values of an action are the specific features of the considered action.

Action Instance: the entity stores all the action instances performed by a user.

Badge Type: the entity contains the dictionary of the badges that a user can acquire.

Badge Instance: the entity contains all the badge instances acquired by the user.

Reward Type: the entity contains the dictionary of the rewards.

Reward Instance: the entity contains the instances of the rewards acquired by the users.

Text Mail: the entity contains information about the notification to send to users after a particular event in the gamification engine (e.g. a user gains a badge).

Notification*:* this entity contains the notification sent to users.

Thematic Area: this entity contains the thematic areas to organize actions and badges according to topics. Each thematic area is identified by a unique id and a name.

Game Result: this entity contains the possible outcomes of games, that need to be converted into credits. Each game result is identified by a unique identifier, a title (e.g. New level reached) and optionally by a score, a level and the current available lives. Each game result is mapped to an Action Type and, according to the game results attributes (score, level, lives) the game result is converted into credits.

Game Points Converter: each conversion is identified by a unique id, the game to which the conversion rule is applied, and the customizable formula which will take the attributes as inputs (score, level, lives) and will produce credits amount as output.

Alliance: this entity contains the coalitions created among competitor users. Each Alliance is identified by a unique id, a start date and an end date.

Goal: this entity contains the consumption goals assigned to users. Each goal is identified by a unique id, a title, a consumption value, and optionally the completion date. A goal can be assigned to a given user or to an alliance of users. Goal can be associated to a Badge Type, obtained by the user when the consumption goal is achieved.

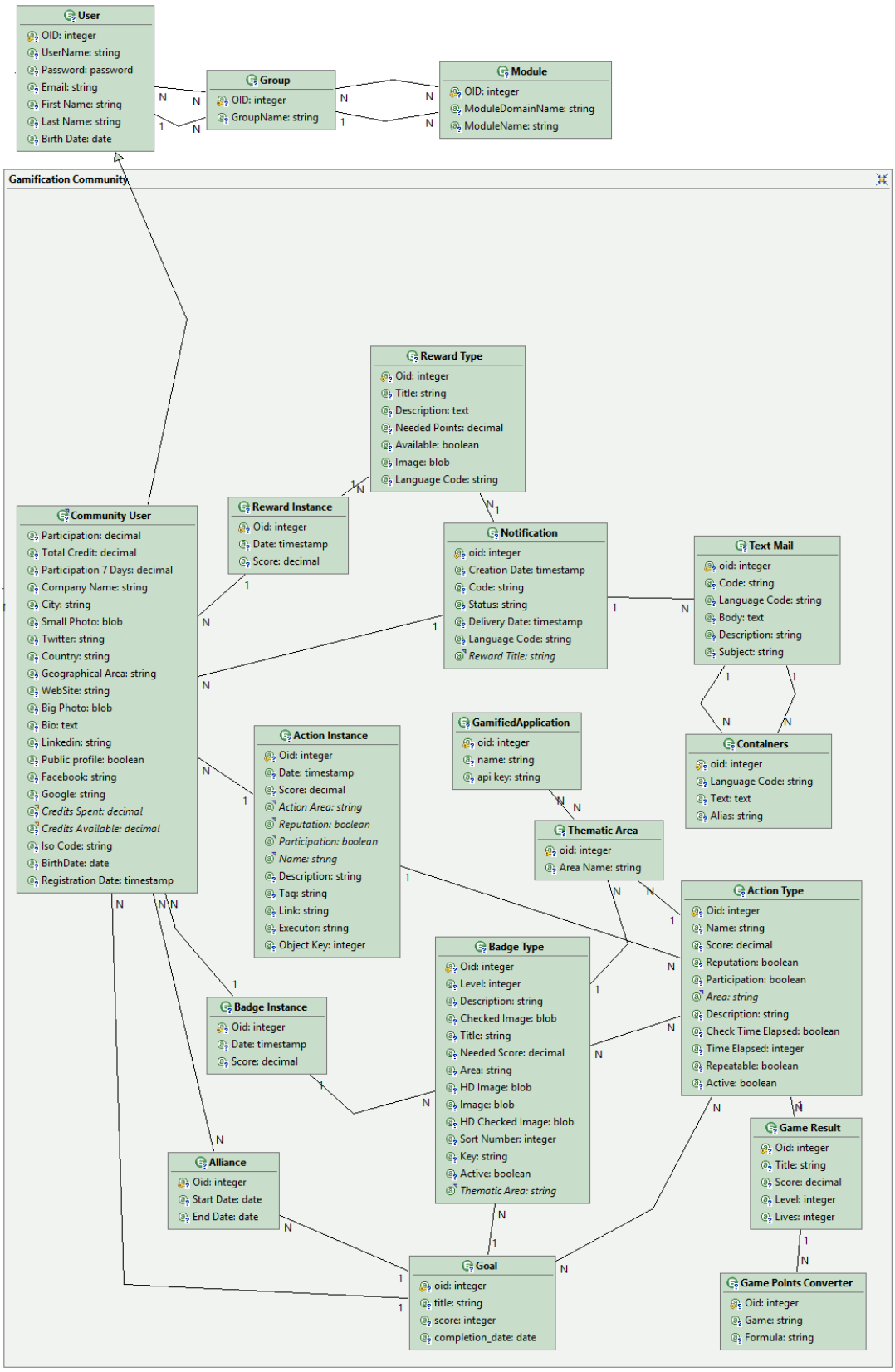


Figure 40. Gamification Data Model.

Games Platform Data Model

Figure 41 illustrates the schema of the database supporting game data persistence.

Game is the core entity: the *Mode* attribute represents the gameplay modes (e.g. Single Player, Multi Player, Cooperative), while the *Genre* attribute identifies its genre (e.g. Puzzle, Educational). Each game is also characterized by a *Title*, a *Theme* and the *Minimum/Maximum number of players*.

An **Achievement** has an *Icon*, which describes it in a visual way, a *Category* that specifies the task (Instructor, Grinder), an attribute *PointsGiven*, which contains the amount of points to be granted, and a Boolean attribute *OfTheDay* defining whether the achievement has to be completed on a specific day in order to obtain virtual goods, more points, or increased levels.

The **Player** entity accommodates game-specific personal and social features. *Avatar* and *Nickname* allow the user to be recognizable by using a custom image or a unique fictional name, while *Player Type*, *Player Level* and *Experience Points* convey player progress. *Reputation* in online gaming communities is fundamental and distinctive feature of any player; being able to recognize wheter a player is bad mannered, prone to cheating, unpleasant to play with is of utterly importance to assure a satisfying gaming experience for the user of an entertainment platform; it is usually measured as an integer number ranging from 0 to 5.

The model describes also the game-relevant statistics (**GameStats**): the proficiency and the experience of a player in a given game are represented by aggregating in a compact way such indicators as points gathered and hours spent playing.

GameBadges represent the achievements that have been unlocked by a player. The *CompletionPercentage* field shows how much the player has already achieved in a specific task. *StartDate* and *EndDate* record the dates in which the player has started to work on the achievement's goals and the date in which he has obtained it. The *TrialsN* attribute tracks how many times the user tried to fulfill the achievement.

A **GamePlayAction** of a player, associated with a specific **Gameplay**, records the *StartDate* and *EndDate* of the gaming session and the actual actions performed by the player on that specific time frame and the *Role* defines which are the allowed actions in the game for the role associated to a player.

In order to store questions and answers required by the Drop!TheQuestion trivia game, **Question** and **Answer** entities have been provided. **QuestionInstance** keeps track of players game play information related to the specific quiz game.

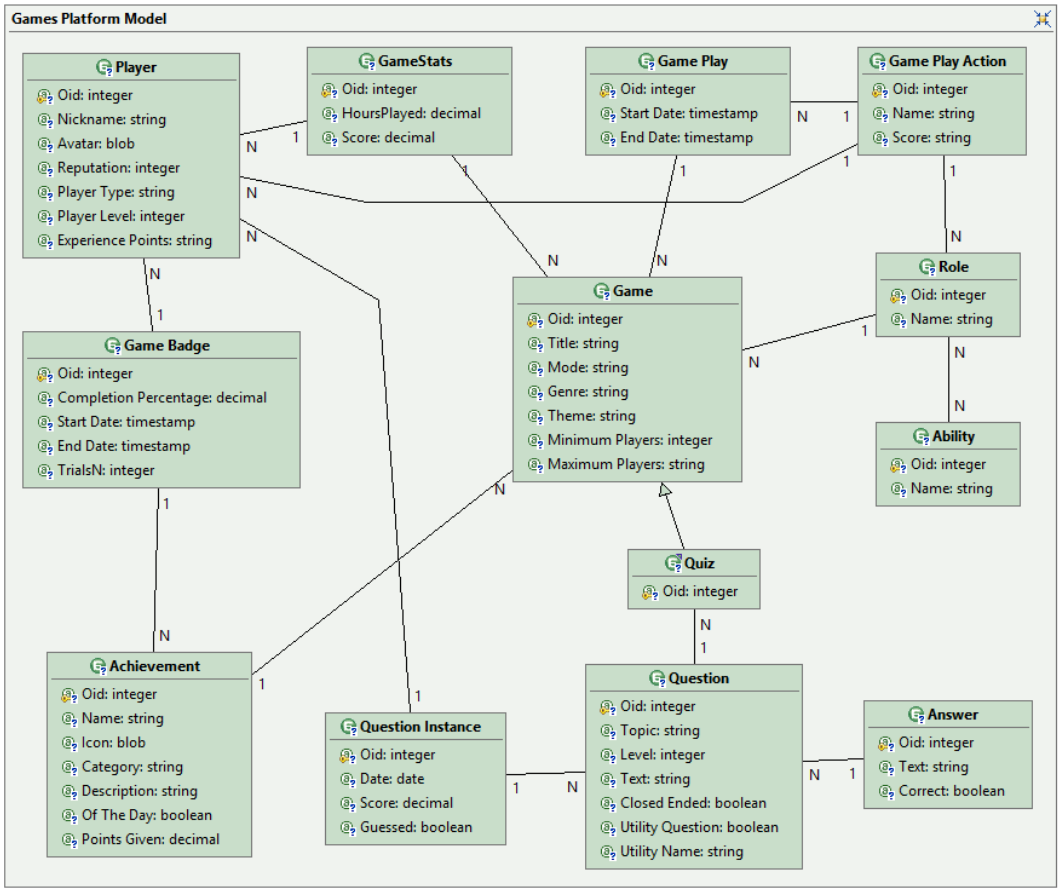


Figure 41. Games Platform Data Model.

Data requirements for modelling responses to innovative pricing schemes

Data needed for modelling innovative pricing is based on the Data Model described above and on data related to policy (non-pricing) and price data. Policy (non-pricing) data are presented in the table below and are related to water restriction use policies, incentives policies and information policies. The price (i.e. billing price in Figure 14) data are presented in more detail as well.

Policy data

NAME	DESCRIPTION	UNIT
Water restriction use policies	Presence, thresholds and period in which water use restriction policies were active, if some were adopted	[L/day usage threshold]
Incentives policies	Presence, type and period in which incentives for water efficient devices were active	[day incentives were active], [amount of £ for incentives]
Information policies - 1	Consumption history of the bill	{same period in the previous year; all periods of the previous year; other; any}
Information policies – 2	Conservation message (type and	{on the bill; through other

	communication media)	media in the observed period; other; any}

Price data

NAME	DESCRIPTION	UNIT
Number of blocks	Number of price blocks	[-]
Water quantity at kink	Water quantity beyond which users switch to the following price block, only if IBPs or DBPs	[L/month]
Block 1, 2, … rate	Price charged for one liter in each block, only if IBPs or DBPs	[£/L]
Number of periods	Number of time periods only if Time-of-Use	[-]
Time period 1,2,… rate	Price charged for one liter in each period	[£/L]

From a methodological point of view, the provision of the above data and data from the previous section will allow us to estimate a water demand model to assess the impact of prices and other exogenous factors on the water consumption. The estimated price elasticity of residential water demand, i.e. the responsiveness of water consumption to changes in prices could potentially allow us to design and implement innovative pricing schemes such as blocking rates and seasonal tariffs. Alternatively, if the acquisition of the above data is not feasible, a meta-regression analysis will be employed to explain the variations in the price, income and household size elasticities in the residential water demand based on existing studies from selected EU studies.

6. User Model

The following section describes the user model as visualized in Figure 42. For the detailed specification, see Appendix A.

A first distinction among user groups is between **Consumer** and **Admin**: the former is the generic user who can access the services provided by the SmartH2O system; the latter is instead in charge of managing the services provided by the SmartH2O system.

Consumers are partitioned into sub-groups based on which services they access.

- **Player** users are the ones who play the games provided by the system. They can be:
  - **Casual Player**s: they are not registered visitors interested in playing a game.
  - **Registered Player**s: they are registered to the Games Platform.
- **Customer** are users registered to the Costumer Portal, who access in order to monitor their water consumption and make use of the other services provided by the application. They can be:
  - **Smart metered** users: they are customers having smart meters system installed in their house. The water meter measures the customer's water consumption automatically.
  - **Standard metered** users: they are customers not having smart meters system installed in their house. They need to manually input consumption data into the gamification engine.

    - **Competitor** users: they are the ones who accepted to participate to the gamification mechanisms, including execution of actions, acquisition of badges and redemption of rewards.

CustomerPlayers are users who are registered both to the Gamified Customer Portal and the Games Platform. They have the possibility to collect points either by performing actions provided in the Gamified Customer Portal or by playing the available games.

Admin users are partitioned into sub-groups based on which services they manage.

- **Content Editors** are administrators in charge of creating the content of the applications composing the system.
  - **Gamification Engine Content and Rules Editors**: they are in charge of creating the content related to the Gamified Customer Portal (the one used by Competitor users) such as actions, rewards and goals. They are also in charge of defining the rules to assign the suitable amount of points to each action.
  - **Customer Portal Content Editors**: they are in charge of creating the content related to the Customer Portal (used by Customer users), such as tips to improve water saving or teaching videos.
  - **Games Platform Content Editors**: they are in charge of creating the content related to games, such as the questions provided in a quiz game related to generic water consumption topics.
    - **Utility Games Platform Content Editors**: they are a specialization of the Games Content Editor users, related to a specific utility. For example they could manage the specific questions provided in a quiz game with subjects of interest to the utility.

- **Utility Admins:** they are administrators in charge of monitoring consumption data, also profiling users in customer segments, and simulating user consumption based on some parameters.

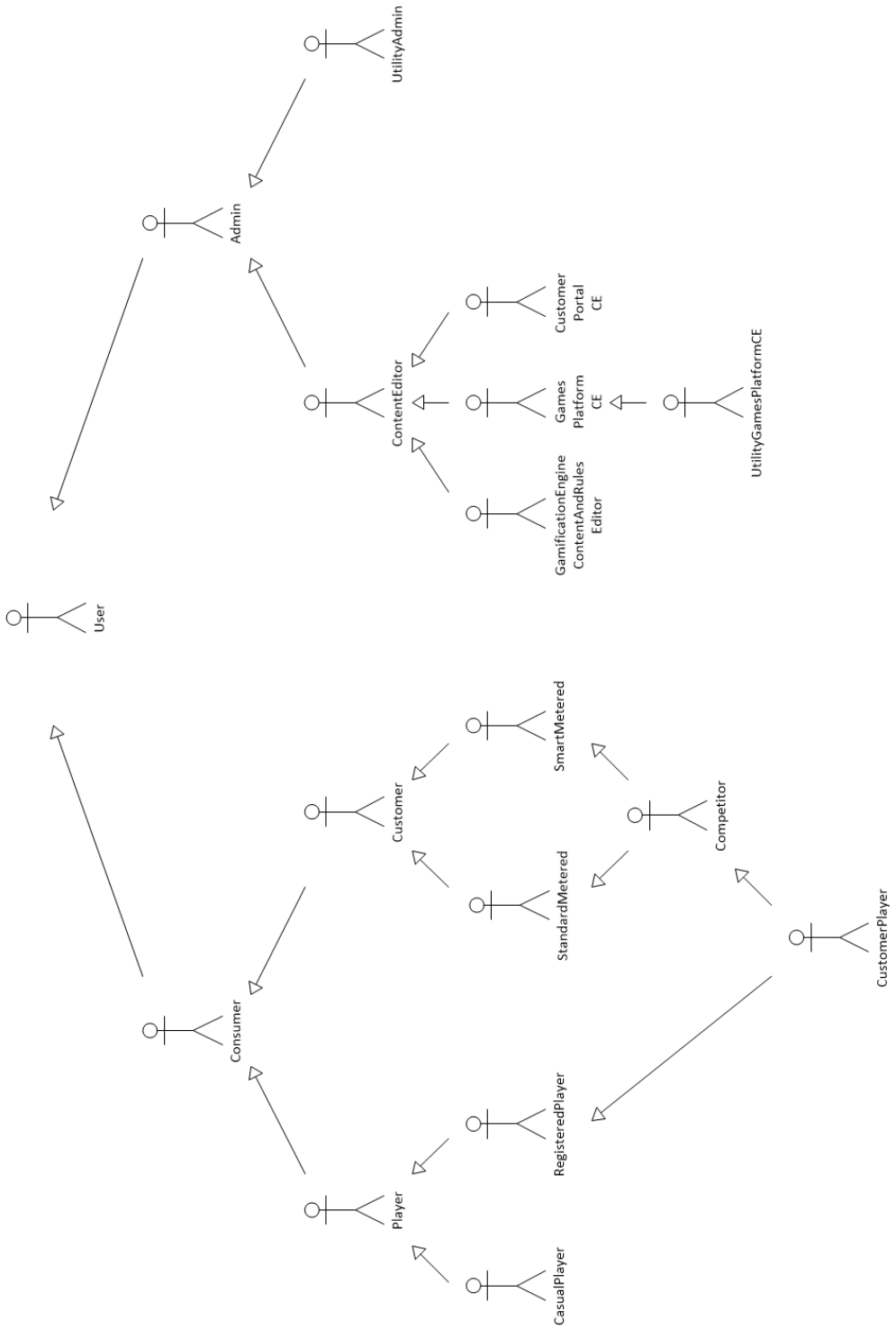


Figure 42. User model.

7. Use cases overview

By formalizing use cases, the following sections bridge the gap between the high-level user needs, which we have described both narratively (user stories) and visually (mockups) in the previous sections, and the detailed component specifications. The use cases are specified to the extent that they impact the end users. The underlying components have been specified in detail, but for reasons of readability, are not part of this deliverable. These detailed specifications are included in the updated version of D6.2 Platform architecture and design.

To describe the use cases, we have followed a common format (see e.g. [Cock2000], which was slightly simplified, resulting in the following use case template:

	Use case: *<the name should be the goal as a short active verb phrase>*	
Goal in Context	<a longer statement of the goal, if needed, its normal occurrence conditions>	
Preconditions	<what we expect is already the state of the world>	
Success End Cond.	<the state of the world if goal succeeds>	
Failed End Condition	<the state of the world if goal fails>	
Primary, Secondary Actors	<a role name for the primary [and secondary] actor, or description>	
Trigger	<what starts the use case, may be time event>	
DESCRIPTION	**Step**	**Action**
	1	<put here the steps of the scenario from trigger to goal delivery, and any cleanup after>

The following table lists all use cases. They are described in detail in the following sections.

They are grouped as follows:

- Basic Customer Portal: Visual water meter
  - User stories 1A,1B, 2C
- Advanced Customer Portal: Gamified water meter
  - User stories 1A, 1B, 2A, 2C
- Advanced Customer Portal: Social water meter
  - User stories 1A,1B, 2B, 2D
- Customer Portal user account management
- Customer Portal admin
- Games Platform
  - User story 2B
- Business Dashboard: Consumption monitor
  - User story 3
- Agent-based customer consumption simulator
  - User stories 4A, 4B, 4C

Table 7. List of use cases.

#	USE CASES
8	**Use cases of basic customer portal: Visual water meter**
8.1	Use case: Collecting consumption data with smart meters
8.2	Use case: Manually collecting consumption data
8.3	Use case: Visual exploration of water consumption information
8.4	Use case: Visual exploration of water consumption at fixture/appliance level
8.5	Use case: Providing feedback on disaggregated consumption data
8.6	Use case: Getting water consumption alerts
8.7	Use case: Getting water consumption tips
8.8	Use case: Getting system notifications
8.9	Use case: Learning interactively about innovative pricing schemes
9	**Use cases of advanced customer portal: Gamified water meter**
9.1	Use case: Making gamification actions and exploring results
9.2	Use case: Self setting consumption goals
9.3	Use case: Fulfilling consumption goals
9.4	Use case: Recommending water saving actions
9.5	Use case: Declaring water saving actions
9.6	Use case: Contributing household and user profiling information
9.7	Use case: Declaring water end-use events
9.8	Use case: Verifying manually inserted consumption
9.9	Use case: Making actions and earning digital credits with the Games Platform
10	**Advanced Customer Portal: Social water meter**
10.1	Use case: Comparing achievements with other households
10.2	Use case: Inviting another user to join a team
10.3	Use case: Achieving goals collaboratively as a team
10.4	Use case: Inviting friends on social networks
10.5	Use case: Sharing achievements on social networks

11	**Customer portal user account management**
11.1	Use case: Customer Portal Sign-up
11.2	Use case: Gamification Engine Sign-up
11.3	Use case: Modifying User Settings
11.4	Use case: Upgrading to the advanced gamified version / downgrading to the basic version of Customer Portal
11.5	Use case: Leaderboard opt-in / opt-out
11.6	Use case: Geolocation opt-in / opt-out
11.7	Use case: Customer Portal Unsubscription
12	**Customer Portal Admin**
12.1	Use case: Setting water consumption tips
12.2	Use case: Setting actions, badges and rewards
12.3	Use case: Converting game actions into rewards
13	**Use cases of Games Platform**
13.1	Use case: Games Platform Sign-up
13.2	Use case: Playing a standard mobile game
13.3	Use case: Playing the card game and its digital game extension
13.4	Use case: Gaining power-ups based on the Gamification Engine credits
13.5	Use case: Connecting player profile to the Gamification Engine
13.6	Use case: Setting content of game questions
14	**Use cases of business dashboard: Customer consumption monitor**
14.1	Use case: Visualizing aggregate household consumption information by geo-location
14.2	Use case: Querying and displaying customer attributes
14.3	Use case: Identifying customer groups
14.4	Use case: Setting consumption goals and rewards for specific customer groups
14.5	Use case: Setting recommended water saving actions for specific customer groups
14.6	Use case: Setting water consumption alerts
15	**Use cases of agent-based customer consumption simulator**
15.1	Use case: Modelling behaviour based on consumption

15.2	Use case: Predicting customer segment consumption behaviour
15.3	Use case: Predicting behaviour based on incentive response
15.4	Use case: Predicting customer segment response to pricing schemes

The following table lists the use cases by user group.

Table 8. Use cases by user group.

USER	USE CASES
Consumer	8.1 Collecting consumption data with smart meters 11.1 Customer Portal Sign-up 13.1 Games Platform Sign-up
Customer *(extends Consumer)*	8.3 Visual exploration of water consumption information 8.6 Getting water consumption alerts 8.7 Getting water consumption tips 8.8 Getting system notifications 8.9 Learning interactively about innovative pricing schemes 9.6 Contributing household and user profiling information 9.7 Declaring water end-use events 11.2 Gamification Engine Sign-up 11.3 Modifying User Settings 11.4 Upgrading to the advanced gamified version / downgrading to the basic version of Customer Portal 15.2 Predicting customer segment consumption behaviour *Inherited Uses Cases:* • *8.1, 11.1, 13.1 from Consumer*
StandardMetered *(extends Customer)*	8.2 Manually collecting consumption data *Inherited Uses Cases:* • *8.3, 8.6, 8.7, 8.8, 8.9, 9.6, 9.7, 11.2, 11.3, 11.4, 15.2 from Customer* • *8.1, 11.1, 13.1 from Consumer*
SmartMetered *(extends Customer)*	8.1 Collecting consumption data with smart meters 8.4 Visual exploration of water consumption at fixture/appliance level 8.5 Providing feedback on disaggregated consumption data *Inherited Uses Cases:* • *8.3, 8.6, 8.7, 8.8, 8.9, 9.6, 9.7, 11.2, 11.3, 11.4, 15.2 from Customer* • *8.1, 11.1, 13.from Consumer*
Competitor	9.1 Making gamification actions and exploring results

(extends SmartMetered, StandardMetered)	9.2 Self setting consumption goals 9.3 Fulfilling consumption goals 9.4 Recommending water saving actions 9.5 Declaring water saving actions 10.1 Comparing achievements with other households 10.2 Inviting another user to join a team 10.3 Achieving goals collaboratively as a team 10.4 Inviting friends on social networks 10.5 Sharing achievements on social networks 11.5 Leaderboard opt-in / opt-out 11.6 Geolocation opt-in / opt-out 11.7 Customer Portal Unsubscription *Inherited Uses Cases:* • *8.2 from StandardMetered* • *8.1, 8.4 from SmartMetered* • *8.3, 8.6, 8.7, 8.8, 8.9, 9.6, 9.7, 11.2, 11.3, 11.4, 15.2 from Customer* • *8.1, 11.1, 13.1 from Consumer*
Player *(extends Consumer)*	13.2 Playing a standard mobile game 13.3 Playing the card game and its digital game extension *Inherited Uses Cases:* • *8.1, 11.1, 13.1 from Consumer*
CasualPlayer *(extends Player)*	*Inherited Uses Cases:* • *13.2, 13.3 from Player* • *8.1, 11.1, 13.1 from Consumer*
RegisteredPlayer *(extends Player)*	13.5 Connecting player profile to the Gamification Engine *Inherited Uses Cases:* • *13.2, 13.3 from Player* • *8.1, 11.1, 13.1 from Consumer*
CustomerPlayer *(extends RegisteredPlayer, Competitor)*	9.9 Making actions and earning digital points with the Games Platform 13.4 Gaining power-ups based on the Gamification Engine credits *Inherited Uses Cases:* • *9.1, 9.2, 9.3, 9.4, 9.5, 10.1, 10.2, 10.3, 10.4, 10.5, 11.5, 11.6, 11.7 from Competitor* • *8.2 from StandardMetered* • *8.1, 8.4, 8.5 from SmartMetered* • *8.3, 8.6, 8.7, 8.8, 8.9, 9.6, 9.7, 11.2, 11.3, 11.4, 15.2 from Customer* • *13.5 from RegisteredPlayer* • *13.2, 13.3 from Player* • *8.1, 11.1, 13.1 from Consumer*
GamificationEngine ContentAndRules Editor	12.3 Converting game actions into rewards

GamesPlatformCE	13.6 Setting content of game questions
UtilityGamesPlatform CE *(extends GamesPlatformCE)*	*Inherited Uses Cases:* • *13.6 from GamesPlatformCE*
ConsumerPortalCE	12.1 Setting water consumption tips
UtilityAdmin	14.1 Visualizing aggregate household consumption information by geo-location 14.3 Identifying customer groups 14.4 Setting consumption goals and rewards for specific customer groups 14.5 Setting recommended water saving actions for specific customer groups 14.6 Setting water consumption alerts 15.2 Predicting customer segment consumption behaviour 15.3 Predicting behaviour based on incentive response 15.4 Predicting customer segment response to pricing schemes

8. Basic Customer Portal: Visual water meter

This set of use cases describes the basic interaction of the customer with the consumption visualisation functionalities of the visual water meter, including the input process options and the verification of inserted or aggregated data.

In particular, these use cases regard:

- The collection of water consumption data, via smart meters or manually for StandardMetered users
- The visualisation of the water consumption, not only in total but also at fixture/appliance level (when smart meters exist)
- The verification of manually inserted data from the system, as well as feedback from the consumer regarding the validity of aggregated data.

The set is extended also in respect to water tips and alerts and the management of the consumer's account to the Customer Portal.

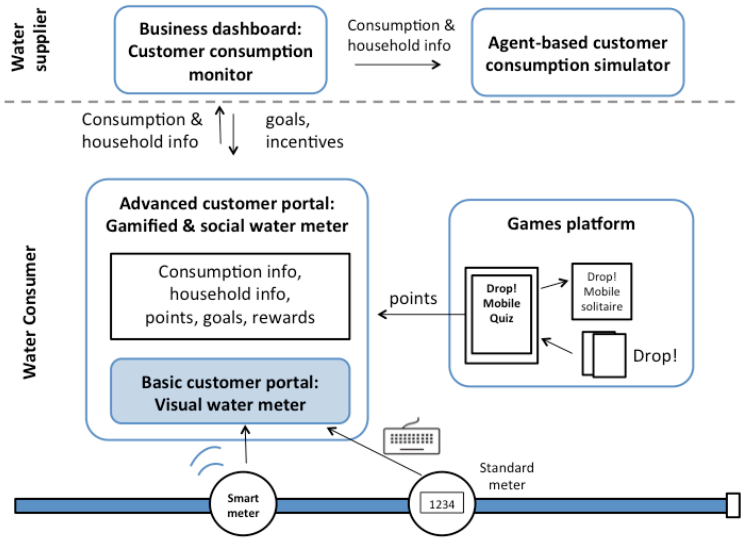


Figure 43. Basic customer portal in application overview.

Table 9 presents the high-level functional requirements that explain the core functionality of the basic customer portal. The requirements will be elaborated in the following sub-sections, which describe the separate use cases. Table 10 lists the high-level non-functional requirements. In addition, measurable technical success criteria that are perceived as operationalized non-functional requirements are formulated in section 16.2. They address e.g. processing and rendering time. From the user point of view, e.g. perception of usefulness and perception of incentive are addressed.

Table 9. High-level functional requirements of the basic customer portal.

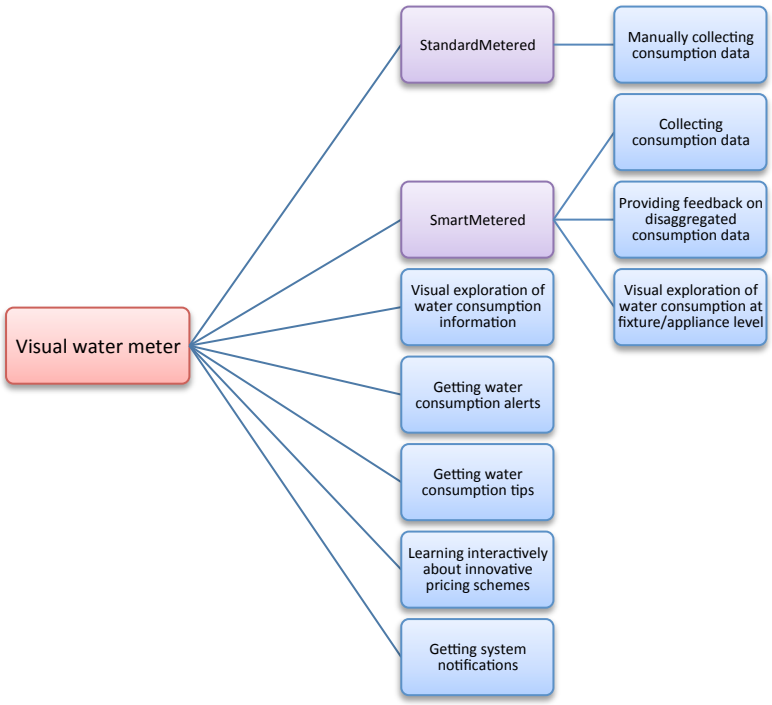
#	High Level functional requirements
VF1	The application should show the consumption data visualized by different periods of time.
VF2	The application should provide some typical consumption metrics, e.g. peak, average of the metered household.

VF3	The application should provide some typical aggregated consumption metrics, e.g. peak and average, of the neighbourhood or municipality to compare to.
VF4	The application should provide disaggregated water consumption information.
VF5	The application should provide the option to insert manually consumption data.
VF6	The application should provide some basic water saving tips.
VF7	The application should be available as a web and mobile app. The mobile apps of the specific portal version should be provided as cross-platform apps for Android and iOS.
VF8	The application should provide means for users to enter a subset of psychographic variables as basic profile information.
VF9	The application should be able to provide alerts in certain cases (leakage, shortage etc.).
VF10	The application should provide the option to simulate pricing schemes or consumption changes and the effect of them on the cost.
VF11	The application should provide notifications.
VF12	The application should be able to store the data provided by the user.
VF13	The application should be available in the national language(s) of the users in each case study area, e.g. in Italian for Swiss case study.

Table 10. High-level non-functional requirements of the basic customer portal.

#	High Level non-functional requirements
VNF1	The application shall be accessible and useable for non-technical audiences.
VNF2	The application shall be well documented and described.
VNF3	The application shall be transparent, allowing users e.g. to understand when displayed information is based on estimates.

Use cases overview



8.1 Use case: Collecting consumption data with smart meters

	Use case: Collecting consumption data with smart meters	
Goal in Context	Collecting consumption data via smart meters	
Preconditions	Water consumption of customer household is metered (smart meters) for the reference interval of time.	
Success End Cond.	The system stores in the SmartH2O platform database the consumption data for a reference interval of time.	
Failed End Condition	The system is not able to store in the SmartH2O platform database the consumption data for a reference interval of time despite the process has been correctly initiated by the Water utility.	
Primary, **Secondary Actors**	SmartMetered user, smart meter and system	
Trigger	The water utility has uploaded to the SmartH2O server via SFTP the file containing the consumption data for a reference interval of time.	
DESCRIPTION	**Step**	**Action**
	1	The smart water meter measures the customer's water consumption. The consumption data is collected by the Water utility automatically (smart meter). The Water utility creates a file with water consumption data in a pre-agreed

Use case: Collecting consumption data with smart meters		
		format.
	2	The water consumption data is transmitted to the SmartH2O platform where it is received, validated, processed and stored.
	3	The result of processing the collected consumption data by the SmartH2O platform is saved in a Log file that can be visualised.
	4	If a smart meter measures consumption for multiple households, the individual household consumption is estimated based on a model, taking into account e.g. number of households per building and number of occupants in household.

Functional requirements

#	*Functional requirement*
1	The application should be able to receive the file containing the water consumption in a pre-agreed format and make a safe copy on the server storage.
2	The application should be able to save a record in the platform database for each water meter reading of the file containing the water consumption.
3	The application should be able to match the water meter reading records against the data records already stored in the database.
4	The application should be able to present a Log file describing the outcome of processing the smart metered consumption data.

8.2 Use case: Manually collecting consumption data

Use case: Manually collecting consumption data		
Goal in Context	Collecting consumption data by manual input	
Preconditions	Water consumption of customer household is metered (easily accessible standard meters) for the reference interval of time.	
Success End Cond.	The system stores in the SmartH2O platform database the consumption data for the current registration time.	
Failed End Condition	The system is not able to store in the SmartH2O platform database the consumption data for current registration time despite he correctly accessed the system and provided the consumption data.	
Primary, Secondary Actors	StandardMetered user, system	
Trigger	User declares a new meter reading.	
DESCRIPTION	**Step**	**Action**

Use case: Manually collecting consumption data		
	1	The user logs in into the Customer Portal.
	2	The user can access a view in the Visual Water Meter front end where s/he can provide the readings of his standard meters for the current registration time.
	3	The user saves the readings into the platform.

Functional requirements

#	*Functional requirement*
1	The application should provide a graphical interface to allow the standard metered user to manually register water consumption at the current registration time.
2	The application should be able to store in the platform database the water consumption provided by the user.
3	The application should be able to allow the user to correct the last registration of the water consumption.

8.3 Use case: Visual exploration of water consumption information

Use case: Visual exploration of water consumption information		
Goal in Context	Raising individual water consumption awareness by visualizing aggregated metered consumption data.	
Preconditions	Option A) Household is smart metered and linked to user account. Option B) Bi-familiar bulk metering: user has provided some basic psychographic variables, e.g. number of occupants, flat size. Option C) Multi-familiar bulk metering: user has provided some basic psychographic variables, e.g. number of occupants, flat size. Option D) Household is not smart metered: user has manually entered meter readings. Option E) Household is not smart metered: user has provided some basic psychographic variables, e.g. number of occupants.	
Success End Cond.	Water consumption is visualized.	
Failed End Condition	Water consumption is not visualized.	
Primary, **Secondary Actors**	Customer user, system	
Trigger	User logs into customer portal.	
DESCRIPTION	**Step**	**Action**
	1A	Accurate high resolution visualization: The system visualizes

Use case: Visual exploration of water consumption information		
		the aggregated, smart metered water consumption information of the household.
	1B,C	Level 1 consumption estimate (simple): User sees a consumption estimate based on entered psychographic variables for households that are similar to his. Level 2 consumption estimate (advanced): A basic model is applied to estimate the metered consumption on household level based on the provided psychographic info and number of households. Level 3 consumption estimate (most complex): An advanced model is applied to estimate the metered consumption on household level based on provided psychographic info AND manually provided water end-use events.
	1D	Low resolution visualization: The system visualizes the aggregated water consumption information of the household according the manual user input.
	1E	Level 1 visualization: User sees a consumption estimate based on entered psychographic variables for households that are similar to his.
	2	The user can interact with the visualization, e.g. by choosing different zoom levels of the data.
	3	The user can compare his own real or estimated consumption metrics to a set of available aggregate metrics (e.g. municipality, similar households).

Functional requirements

#	***Functional requirement***
1	The application should be able to visualize water consumption at different levels of detail, according to the type of household (see precondition and Steps 1A-E).
2	The application should provide the option to adjust the view settings of the visualization to different time intervals and time granularity.
3	Users should be able to view consumption information at different levels of detail and abstraction according to their own preference.
4	The application should provide some typical consumption metrics, e.g. peak and average of end use events.
5	The application should provide users the option to compare their current consumption with their own past and average consumption (self comparison).
6	The application should provide users the option to compare their consumption with the average consumption of the neighbourhood, the municipality and similar households when the information is available (social comparison).
7	The application should provide users the option to compare their consumption with consumption goals set by them, by the application and / or by the utility (goal comparison).

8	The application should show and briefly explain different measurement units, both for consumed and saved water.
9	Analogies should be shown as metaphorical measurement units, both for consumed and saved water.
10	For consumption estimates (e.g. in case of bulk metering or standard metering), the application should clearly state that the displayed consumption is based on an estimate and might not be accurate, and provide information how the estimate was calculated.

8.4 Use case: Visual exploration of water consumption at fixture/appliance level

	Use case: Visual exploration of water consumption at fixture/appliance level	
Goal in Context	Raising individual water consumption awareness by visualizing end use consumption	
Preconditions	Customer household is smart metered (excl. any bulk metering) and linked to user account.	
Success End Cond.	Water consumption is displayed at fixture/appliance level.	
Failed End Condition	Water consumption is not displayed at fixture/appliance level.	
Primary, Secondary Actors	SmartMetered user, system	
Trigger	User opens visual water meter application.	
DESCRIPTION	**Step**	**Action**
	1	The system visualizes the disaggregated water consumption data of the household at a fixture/appliance level. By default the last seven days consumption is shown.
	2	The user can interact with the disaggregated visualization, e.g. by choosing different time slices of the data. The user can select to see the disaggregation for the previous day, for 7 days before, for the past month, for the past season (warm/cold) for the past year.

Functional requirements

#	***Functional requirement***
1	The application should display disaggregated water consumption information when available, e.g. a fixture/appliance level (providing different levels of data granularity).
2	The application should provide the option to adjust the view settings of the visualization to different time intervals and time granularity.
3	The application should provide some typical end-use consumption metrics, e.g. peak and average of end use events.

5	The application should enable the user to manually validate automatically disaggregated end use events (see use case 8.5).

8.5 Use case: Providing feedback on disaggregated consumption data

	Use case: Providing feedback on disaggregated consumption data	
Goal in Context	Validating disaggregated household consumption data through interactive user-provided feedbacks.	
Preconditions	Water consumption of customer household is metered (with smart meters, excl. any bulk metering) for the reference interval of time.	
Success End Cond.	Disaggregated data is validated by the customer.	
Failed End Condition	The customer does not validate disaggregated data.	
Primary, Secondary Actors	SmartMetered user	
Trigger	User receives the results of consumption disaggregation performed by system models.	
DESCRIPTION	**Step**	**Action**
	1	The system provides the user the results of the consumption disaggregation, e.g. as percentages for end use events.
	2	The user provides feedback about the correctness of the disaggregated consumption events.

Functional requirements

#	***Functional requirement***
1	The application should be able to display the results of disaggregated household consumptions.
2	The application should allow the user to confirm the computed disaggregated results (e.g. computed percentages).
3	The application should provide the option to adjust the disaggregated consumption results and save changes.

8.6 Use case: Getting water consumption alerts

	Use case: Getting water consumption alerts
Goal in Context	Warning user about daily consumption and critical exceptional cases related to water consumption and supply.
Preconditions	Data for alerts is available (for household leakage alert: household is

Use case: Getting water consumption alerts		
	smart metered; for water quality alert: quality is measured; other cases: utility provides the information).	
Success End Cond.	Alert is triggered.	
Failed End Condition	Alert is not triggered.	
Primary, **Secondary Actors**	Customer user, system	
Trigger	Measured attributes are below defined thresholds; admin has triggered alert.	
DESCRIPTION	**Step**	**Action**
	1	The system alerts the user in the interface and via notifications in case of water consumption distress. Alert type A - Daily alerts: consumption exceeding own average, consumption exceeding neighbourhood average, consumption exceeding personal goal. Alert type B - Exceptional case alerts: when water leakage is detected in household, when overall water quality is bad, when water shortage occurs.

Functional requirements

#	*Functional requirement*
1	The application should be able to provide daily alerts in case of excessive consumption (compared to own average, own neighbourhood, own goal).
2	The application should be able to provide alerts in case of water shortage.
3	The application should be able to provide alerts in case of leakage.
4	The application should be able to provide alerts relating to the water quality.
5	The application can provide weather-related alerts linked to specific recommendations.
6	The application should be able to send a notification to the user when an alert is triggered.

8.7 Use case: Getting water consumption tips

Use case: Getting water consumption tips	
Goal in Context	Raising individual water consumption awareness.
Preconditions	List of water saving tips is defined.
Success End Cond.	Tip is displayed.
Failed End Condition	Tip is not displayed.

Use case: Getting water consumption tips		
Primary, Secondary Actors	Customer user, system	
Trigger	User opens the visual water meter; user browses tip history.	
DESCRIPTION	**Step**	**Action**
	1	System provides user with different water saving tips (e.g. text snippets, videos, quizzes).

Functional requirements

#	***Functional requirement***
1	An initial saving tips list should be available at the launch of the platform.
2	Customer portal and utility administrators should be able to extend and change the list of saving tips (e.g. with season- or region-specific tips).
3	Water saving tips should either recommend users new habits related to water consumption, or the implementation of water saving devices.
4	The application should provide a 'tip of the day' mode for a random water management tip displayed every day.
5	The application should allow the user to browse through past tips.

8.8 Use case: Getting system notifications

Use case: Getting system notifications		
Goal in Context	Informing users about news, portal activity updates, e.g. new achievements, events, and problems.	
Preconditions	Notifications are enabled.	
Success End Cond.	User can receive a notification from the system.	
Failed End Condition	User can not receive any notification from the system.	
Primary, Secondary Actors	Customer user, system	
Trigger	An event that needs to be notified occurs.	
DESCRIPTION	**Step**	**Action**
	1	An event that needs a notification to inform/warn users occurs.
	2	The system detects the event triggering the notification

Use case: Getting system notifications		
		mechanism.
	3	Everyone involved is notified, receiving a message either in the portal or on the mobile device if available.
	4	The user can view past notifications.

Functional requirements

#	*Functional requirement*
1	The application should be able to detect an event to be notified.
2	The application should be able to select all the users involved by the event.
3	The application should be able to show notifications in the customer portal and send it directly on the mobile device, if available.
4	The application should allow the user to browse through past notifications.
5	The application should mark past notifications as read and highlight new ones.
6	The application should allow the user to turn off/on notifications.

8.9 Use case: Learning interactively about innovative pricing schemes

	Use case: Learning interactively about dynamic pricing schemes	
Goal in Context	Stimulating water saving by raising users awareness of their water consumption and its link to pricing schemes (i.e. tariff schemes) such as blocking	
Preconditions	Customer household is metered, municipality/district of household is known.	
Success End Cond.	Current and alternative tariffs can be estimated and interactively explored by the user.	
Failed End Condition	Current and alternative tariffs cannot be estimated.	
Primary, **Secondary Actors**	Customer user, system	
Trigger	User opens the estimated pricing window.	
DESCRIPTION	**Step**	**Action**
	1	Estimated cost is calculated and visualized for each pricing scheme for the user's real or estimated consumption information.
	2	The user has the option to compare the cost of their water

Use case: Learning interactively about dynamic pricing schemes		
		consumption among pricing schemes.
	3	In controlled experiments, users can commit to a pricing scheme for a defined time period. The virtual savings, e.g. compared to the alternative pricing scheme, are visualized. If users virtually save money in this period they are rewarded.

Functional requirements

#	*Functional requirement*
1	The application should allow users to simulate different pricing schemes according to their real consumption.
2	The application should visualize the estimated cost for each pricing scheme, based on the geo-location of the user (as the parameters differ between utilities and municipalities).
3	Users should be able to virtually manipulate their consumption to understand its effect on the cost.
4	Pricing schemes should only be available to in those areas, where tariff information is available.
5	The application should provide an option that can be activated only for closed, controlled experiments, in which a subgroup of users can commit to a pricing scheme for a defined time period.
6	The application should be able to visualize estimated monetary savings of one pricing scheme to another scheme.

9. Advanced Customer Portal: Gamified water meter

This set of use cases contains the customer interactions with the Gamification Engine. It comprises the basic gamification actions of a registered user, which involve the setting and fulfilling consumption goals, performing water saving actions, learning about innovative pricing schemes as well as his contribution with profiling and consumption information.

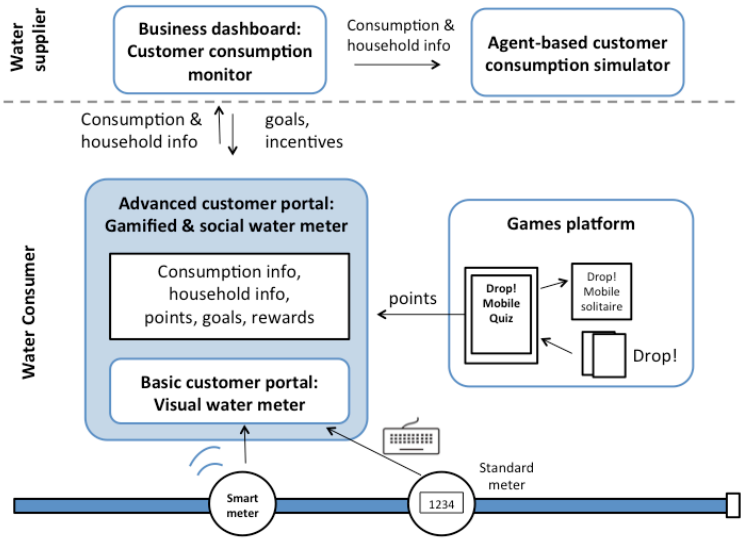


Figure 44. Advanced customer portal in application overview.

Table 11 presents the high-level functional requirements that explain the core gamification functionality of the advanced customer portal. The requirements will be elaborated in the following sub-sections, which describe the separate use cases. Table 12 lists the high-level non-functional requirements. In addition, measurable technical success criteria that are perceived as operationalized non-functional requirements are formulated in section 16.3. They address e.g. processing and rendering time. From the user point of view, e.g. perception of usefulness and perception of incentive are addressed.

Table 11. High-level functional requirements of the advanced customer portal: gamified water meter.

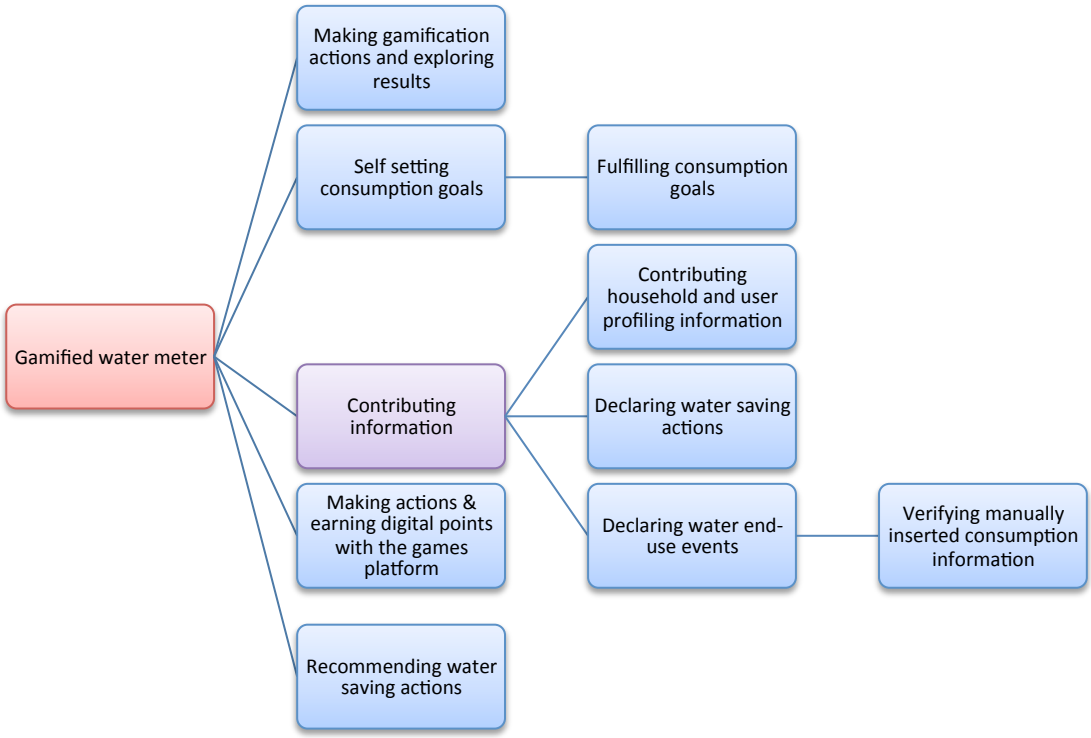
#	***High Level functional requirements***
GF1	The advanced customer portal should provide the functionalities available in the basic version extended with the gamification features.
GF2	The application should enable the user to provide household and user profiling information.
GF3	The application should enable the user to provide information about their water consumption.
GF4	The application should enable the user to record water consumption events.
GF5	The application should incentivize the user to perform actions on the portal by awarding points, badges and rewards.

GF6	The application should enable users to set their own water consumption goals.
GF7	The application should reward users who meet water consumption goals.
GF8	The application should be available as a web and mobile app. The mobile apps of the specific portal version should be provided as cross-platform apps for Android and iOS.
GF9	The application should be able to provide water saving actions.
GF10	The application should be able to verify the declared actions with respect to the metered data.
GF11	The application should be available in the national language(s) of the users in each case study area, e.g. in Italian for Swiss case study.

Table 12. High-level non-functional requirements of the advanced customer portal: gamified water meter.

#	***High Level non-functional requirements***
GNF1	The application shall be accessible and useable for non-technical audiences.
GNF2	The application shall be well documented and described.
GNF3	The application shall be transparent, allowing users e.g. to understand when displayed information is based on estimates.

Use cases overview



9.1 Use case: Making gamification actions and exploring results

	Use case: Making gamification actions and exploring results	
Goal in Context	Stimulating water consumption awareness through gamification	
Preconditions	The user opted for the gamified portal.	
Success End Cond.	User views data related to his past gamification actions.	
Failed End Condition	User can't view data related to gamification actions.	
Primary, **Secondary Actors**	Competitor user, system	
Trigger	User completes action on system or accesses the gamification results area.	
DESCRIPTION	**Step**	**Action**
	1	The user can collect credits and reputation points through his actions on the portal. Actions can be automatically detected or explicitly declared by the user.
	2	User can achieve badges based on reputation points that were collected with different types of actions. **Water saving badges:** meeting water saving goals **Profiling badges:** providing information about the household, water consumption habits and devices, meter readings, … **Water saving insights badges:** reading water saving tips, watching water saving videos, playing drop! trivia game, … **Social badges:** leaderboard opt-in, joining a water saving team, sharing achievement on social networks, inviting friends from social networks, …
	3	User can redeem collected credits for different kinds of rewards (offered e.g. by the utility).
	4	User can also view past actions, badges and rewards.

Functional requirements

#	***Functional requirement***
1	The application should display badges the user can achieve, and the amount of points required.
2	The application should display available rewards and credits required to redeem them.
3	Rewards should be customizable and the list of rewards extendable, to be adapted to the PR and CSR strategies of water utilities and other stakeholders.
4	Rewards needn't be tangible objects (they can also be donations etc.)

5	Both intrinsic and extrinsic incentive and reward types should be available to motivate different types of users
6	The application should display user progress, in terms of badges and credits collected.
7	The application should display the possible actions the user can perform to reach the badges.
8	Earned credits should expire under specified conditions: after specified time period, as a means of sustaining engagement.
9	When rewards are redeemed for a specific amount of credits, the spent credits should be deducted from the overall credit score.
10	The application should notify the user in case of achievements.
11	The application should display the list of past actions performed by the user.

9.2 Use case: Self setting consumption goals

Use case: Self setting consumption goals		
Goal in Context	Stimulating water saving by setting consumption goals	
Preconditions	Customer household is smart metered (excl. multi-familiar bulk-metered households*) and linked to user account. The customer participates in the gamified competition. *) For bi-familiar bulk-metered households, the average consumption can only be estimated, which is clearly indicated in the interface (for multi-familiar bulk-metered households, the estimate is too inaccurate).	
Success End Cond.	Consumption goal was set.	
Failed End Condition	Consumption goal was not set.	
Primary, **Secondary Actors**	SmartMetered competitor user, system	
Trigger	User sets consumption goal.	
DESCRIPTION	**Step**	**Action**
	1	The user can set a consumption goal for himself, to stimulate better consumption. The larger the interval between his current average and the new self-set goal, the more points he can gain when he meets the goal.
	2	For bi-familiar bulk-metered households, the system suggests that they form a team with the other household and define a team goal instead for improved accuracy.

Functional requirements

#	*Functional requirement*
1	The application should specify the lowest (optimal target consumption) and upper (current average consumption) consumption limit.
2	The application should enable the customer to set his own goal within the specified interval.
3	The user should only set one goal at a time.
4	The user should be able to adjust the goal by reducing or increasing it.
5	The user should gain bonus credits for meeting the self-set goal that increase exponentially according to the set interval size.
6	The application should visualize the progress of the household's average consumption with respect to the consumption goal.
7	For bi-familiar bulk-metered users, the system should always indicate that the displayed consumption average is only estimated, and for improved accuracy, users should join a water saving team with their neighbour and define a team goal.

9.3 Use case: Fulfilling consumption goals

Use case: Fulfilling consumption goals		
Goal in Context	Saving water by fulfilling consumption goals and receiving awards	
Preconditions	Customer household is smart metered* and linked to user account. The customer participates in the gamified competition. *) Smart meters: For bulk metered households, the average consumption can only be estimated, which is clearly indicated in the interface.	
Success End Cond.	User is awarded points and achieves the badge related to the completed goal, if provided.	
Failed End Condition	User does not collect points and does not achieve a badge.	
Primary, Secondary Actors	SmartMetered competitor user, system	
Trigger	User has met the defined water consumption average for a specified time interval required for a specific goal.	
DESCRIPTION	**Step**	**Action**
	1	The system logs whether the users achieve their consumption goals (stay below a certain water consumption average within a defined period).
	2	The user is awarded credits when achieving a goal.
	3	If the goal is associated to a badge type, the user achieves

Use case: Fulfilling consumption goals		
		the badge.
	4	If the goal is associated with a specific reward provided by the utility, the user can redeem the reward.

Functional requirements

#	*Functional requirement*
1	The application should be able to monitor and display the progress of a goal.
	The application should be able to log when a goal has been achieved, and notify the user.
3	The application should verify if the goal is associated to a badge, and in that case the system should assign the new badge and notify the user.
4	The application should verify if the goal is associated to a reward, and in that case the system should unlock the new reward and notify the user.

9.4 Use case: Recommending water saving actions

Use case: Recommending water saving actions		
Goal in Context	Raising individual water consumption awareness	
Preconditions	Customer household is metered and linked to user account. The system is able to recommend water saving action for each customer segment based on identified user model.	
Success End Cond.	Recommended action is displayed.	
Failed End Condition	Recommended action is not displayed.	
Primary, **Secondary Actors**	Competitor user, system	
Trigger	A specified time interval has passed (e.g. 1 week).	
DESCRIPTION	**Step**	**Action**
	1	System recommends user a water saving action relating to water saving habits or installing new devices (randomized for users who are not metered and who have not provided information; based on provided household information; based on user model and recommender output).

Functional requirements

#	*Functional requirement*
1	The application should provide water saving actions relating to changing habits or installing devices.

2	The application should allow the user to declare he has implemented a recommended action.
3	The application should allow the user to refuse a recommended action. In this case the application should not reward any credits.
4	For a subset of actions, the application should be able to verify if the user has implemented the proposed water saving actions.

9.5 Use case: Declaring water saving actions

Use case: Declaring water saving actions		
Goal in Context	Stimulating water saving by rewarding water saving actions	
Preconditions	Customer household is metered and linked to user account.	
Success End Cond.	The systems rewards the users based on the implemented water saving action.	
Failed End Condition	The user is not rewarded.	
Primary, **Secondary Actors**	Competitor user, system	
Trigger	User reports a water saving action.	
DESCRIPTION	**Step**	**Action**
	1	The user reports that he implemented one of the recommended water saving actions, e.g. installing more efficient appliances, or one of the available pre-defined actions.
	2	The system verifies that the user has actually implemented the water saving action (if the action can be verified).
	3	The user earns credits for implementing the action.

Functional requirements

#	***Functional requirement***
1	The application should allow the user to declare he had implemented a recommended action.
2	The application should allow the user to refuse a recommended action. In this case the application should not reward any credits.
3	For a subset of actions, the application should be able to verify if the user has implemented the proposed water saving actions.
4	The application should be able to assign credits to users who reported an action.

9.6 Use case: Contributing household and user profiling information

	Use case: Contributing household and user profiling information	
Goal in Context	Gaining insights on customer households and water consumption	
Preconditions	Consensus of customer user to disclose information to utility.	
Success End Cond.	User collects credits for providing information.	
Failed End Condition	User does not contribute information.	
Primary, **Secondary Actors**	Customer user, system	
Trigger	User provides information.	
DESCRIPTION	**Step**	**Action**
	1	The user can provide personal and household information (e.g. number of occupants, types of devices, building information), e.g. to get better consumption estimates, personalized tips etc.
	2	On the gamified portal, the user collects points by providing personal and household information.

Functional requirements

#	***Functional requirement***
1	The application should provide a graphical interface to allow the user to input information about himself and his household.
2	The application should be able to store household and personal information provided by the user in the platform database.
3	The application should assign points when the user provides information.
4	The application should display the progress of completing the household and personal profile.

9.7 Use case: Declaring water end-use events

	Use case: Declaring water end-use events
Goal in Context	Gaining insights on customer consumption and detailed end-use information
Preconditions	Consensus of customer user to disclose information to utility.
Success End Cond.	User collects credits for providing data.
Failed End Condition	User does not collect credits.

Use case: Declaring water end-use events		
Primary, Secondary Actors	Competitor user, system	
Trigger	User provides information .	
DESCRIPTION	**Step**	**Action**
	1	The user can collect points by declaring water consumption events of different end-uses in their water diary (e.g. shower duration, watering the garden).

Functional requirements

#	*Functional requirement*
1	The application should provide a graphical interface to allow the user to input information about water end-use events.
2	To declare a water end-use event, the user should specify the type of event from a pre-defined list, the time-interval it was performed in (e.g. exact time, hour, or day) and the approximate duration.
3	The application should be able to store consumption information provided by the user in the platform database.
4	The application should assign points to the user who contributed water consumption information.
5	The user should be able to view their provided information in a kind of water diary that organizes the events temporally.
6	The system should provide an estimated, averaged amount of water consumed for each event.

9.8 Use case: Verifying manually inserted consumption information

Use case: Verifying manually inserted consumption information	
Goal in Context	Verifying consumption information manually-inserted by users onto the customer portal with respect to the metered data
Preconditions	Water consumption of customer household is smart metered for the reference interval of time.
Success End Cond.	Consumption data are validated.
Failed End Condition	Consumption data are not validated
Primary, Secondary Actors	System

	Use case: Verifying manually inserted consumption information	
Trigger	Reception of the periodical report with the official consumption data.	
DESCRIPTION	**Step**	**Action**
	1	The system periodically verifies manually inserted data stored into the system, according to the consumption data available from the periodical report.

Functional requirements

#	*Functional requirement*
1	The application should be able to receive a periodical report about user consumption.
2	The application should be able to match received data and manually inserted data in order to compare them.
3	The application should be able to validate correct data, the ones matching reported data, and to invalidate incorrect data.

9.9 Use case: Making actions and earning digital credits with the Games Platform

	Use case: Making actions and earning digital credits with the Games Platform	
Goal in Context	Providing water saving participation tools for children	
Preconditions	Smart phone available. User profile on the Games Platform is linked to the one on the Gamification Engine.	
Success End Cond.	User collects credits on the Gamification Engine.	
Failed End Condition	User does not collect credits on the Gamification Engine.	
Primary, Secondary Actors	CustomerPlayer user, system	
Trigger	User reaches an achievement on the Games Platform and the game result is forwarded to the Gamification Engine.	
DESCRIPTION	**Step**	**Action**
	1	User plays physical card games or one of the available mobile games on the platform.
	2	User earns extra credits thanks to the digital game extension of card game (mobile app) or with the standard mobile games.
	3	A game result is reported to the Gamification Engine (e.g.

	Use case: Making actions and earning digital credits with the Games Platform	
		unlocking a new level, achieving a goal).
	4	User redeems credits on the Gamified Customer Portal.

Functional requirements

#	*Functional requirement*
1	The application should be able to report gaming actions from the Games Platform to the Gamification Engine platform.
2	The application should display the actions performed by the user on the Games Platform.
3	The application should be able to convert gaming points into credits valid for the Gamified Customer Platform.
4	The application should assign credits to the user on the Gamified Customer Portal for the performed gaming actions.

10. Advanced Customer Portal: Social water meter

This section describes subgroup of use cases that consider particularly the actions when the user's circle (family, friends, neighbours) gets also involved and enter the Gamification Engine, like collaborative goals and achievements.

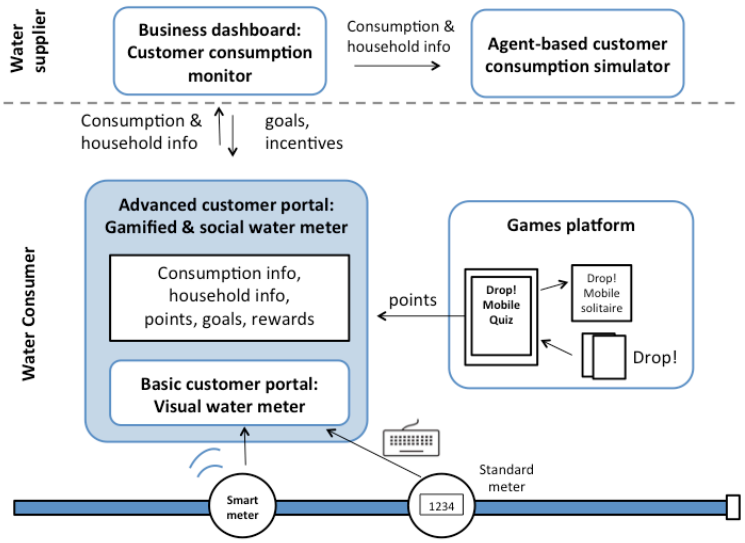


Figure 45. Advanced customer portal in application overview.

Table 13 presents the high-level functional requirements that explain the core functionality of the advanced customer portal, focusing on the social actions. The requirements will be elaborated in the following sub-sections, which describe the separate use cases. Table 14 lists the high-level non-functional requirements. In addition, measurable technical success criteria that are perceived as operationalized non-functional requirements are formulated in section 16.3. They address e.g. processing and rendering time. From the user point of view, e.g. perception of usefulness and perception of incentive are addressed.

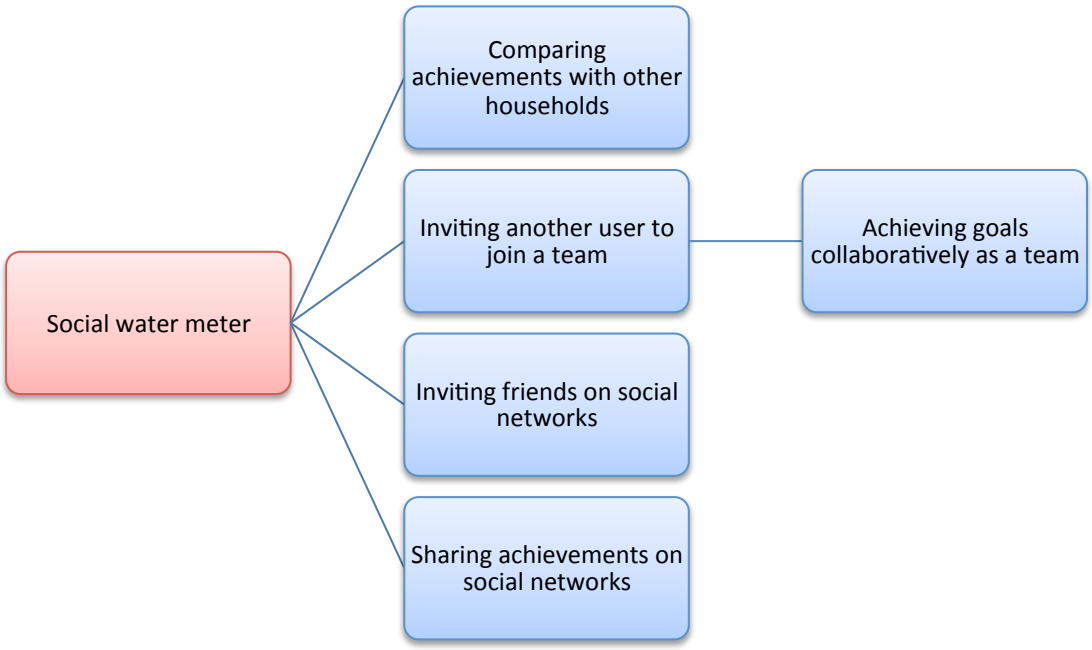
Table 13. High-level functional requirements of the advanced customer portal: social water meter.

#	***High Level functional requirements***
SWM1	The application should enable users to compare their own achievements to other users' achievements.
SWM2	The application should display the leaderboard of the gamified water saving competition.
SWM3	The application should enable users to opt into and out of sharing information and geo-location with other users.
SWM4	The application should enable users to form teams to benefit from each others' water saving.
SWM5	The application should enable teams of users to set and achieve common water saving goals.
SWM6	The applications should reward all team members for achieving a water saving goal with

	credits.
SWM7	The application should enable users to share their achievements on social networks.
SWM8	The application should enable users to invite contacts from social network to join the portal.

Table 14 High-level-non functional requirements of the advanced customer portal: social water meter

#	*High Level non-functional requirements*
GNF1	The application shall be accessible and useable for non-technical audiences.
GNF2	The application shall be well documented and described.
GNF3	The application shall be transparent, allowing users e.g. to understand when displayed information is based on estimates.



10.1 Use case: Comparing achievements with other households

	Use case: Comparing achievements with other households
Goal in Context	Encouraging competition to stimulate water saving
Preconditions	Leaderboard opt-in; optional: geo-location opt-in

Use case: Comparing achievements with other households		
Success End Cond.	User is ranked on leaderboard with other users.	
Failed End Condition	User is not ranked on leaderboard.	
Primary, Secondary Actors	Competitor users, their social environment and system	
Trigger	User opts in to share his achievements with other users.	
DESCRIPTION	**Step**	**Action**
	1	User is ranked on leaderboard with other users based on credits he scores in the system.
	2	User can filter leaderboard (e.g. users in same neighbourhood, similar households, households with the same badges).
	3	In addition to the leaderboard, the user can also view his location on a neighbourhood map together with the position of other users near him (when agreed to geo-location opt-in).

Functional requirements

#	*Functional requirement*
1	The application should ask for user's permission to be ranked on leaderboard (leaderboard opt-in).
2	The application should rank user on leaderboard according to the total credits he collected.
3	The leaderboard should be able to be filtered by different parameters.
4	A neighbourhood map should display households nearby with their associated credit score.
5	Users should be able to opt in/out of appearing on the neighbourhood map based on their geo-location.

10.2 Use case: Inviting another user to join a team

Use case: Inviting another user to join a team	
Goal in Context	Encouraging collective water saving action
Preconditions	Consensus of user to disclose information to other users.
Success End Cond.	The selected user receives an invitation to join a team from the sender user.
Failed End Condition	No invitation is sent.

Use case: Inviting another user to join a team		
Primary, Secondary Actors	Competitor user	
Trigger	The user selects another user he wants to invite into the team.	
DESCRIPTION	**Step**	**Action**
	1	The user views the possible users to invite into teams.
	2	The user selects the user to invite.
	3	The user can add the selected user to an existing team or create a new team.
	4	The selected user receives an invitation to join the team.
	5	The user can also remove himself and others from an existing team.
	6	When a member in a team earns credits on the Gamified Customer Portal, the other team members get a percentage of the earned credits, too.

Functional requirements

#	*Functional requirement*
1	The application should allow the user to select any other user for joining a team.
2	The application should notify the candidate ally selected by the user, inviting him to join the team.
3	A team can consist of multiple users.
4	Team members should benefit from each other's credit earnings.
5	The application should enable users to remove themselves from existing teams.
6	The application should enable the team founder to remove others from the team.

10.3 Use case: Achieving goals collaboratively as a team

Use case: Achieving goals collaboratively as a team	
Goal in Context	Encouraging collective water saving action.
Preconditions	User has joined a water saving team.
Success End Cond.	Users achieved a goal collaboratively.
Failed End Condition	No common goal was achieved.

Use case: Achieving goals collaboratively as a team		
Primary, Secondary Actors	Competitor user, their social environment and system.	
Trigger	Common goal is set.	
DESCRIPTION	**Step**	**Action**
	1	A team founder can set a common water saving goal that is based on the sum of the average consumption of each team member.
	2	When a team meets the self-set water-saving goal, all team members will receive bonus credits.

Functional requirements

#	*Functional requirement*
1	The application should provide a team founder the option to set a common water saving goal.
2	The application should notify all team members when a new goal is set.
3	The application should notify all team members when a goal is met.
4	The application should award credits to all team members when a goal is met.

10.4 Use case: Inviting friends on social networks

Use case: Inviting friends on social networks		
Goal in Context	Increasing participation through social networks	
Preconditions	The customer has a social network profile.	
Success End Cond.	Users sent a request to invite a friend on a social network	
Failed End Condition	No request was sent.	
Primary, Secondary Actors	Competitor user, system, their social environment and social network friends.	
Trigger	User selects the social network where to send invitations.	
DESCRIPTION	**Step**	**Action**
	1	The user selects the social network where to send invitations.
	2	The user can search and select friends to invite.
	3	The system will send a notification to the selected friends in order to invite them to join.

Use case: Inviting friends on social networks		
	4	The user earns credits for inviting friends.

Functional requirements

#	*Functional requirement*
1	The application should allow the user to invite friends on different social network platforms.
2	The system should be able to send an invitation to the friends selected by the user.
3	The application should notify the user when a friend accepts an invitation on the social network.
4	The application should award credits for inviting friends on social networks.

10.5 Use case: Sharing achievements on social networks

Use case: Achieving goals collaboratively as a team		
Goal in Context	Increasing participation through social networks	
Preconditions	The customer has a social network profile.	
Success End Cond.	Users shared an achievement on a social network.	
Failed End Condition	No achievement was shared.	
Primary, **Secondary Actors**	Competitor user, system, their social environment and social network friends.	
Trigger	User clicks to share a given content on social networks.	
DESCRIPTION	**Step**	**Action**
	1	The user selects the content of the Customer Portal he wants to share.
	2	The user selects the social network where to publish this content and optionally posts a comment.
	3	The user can earn credits for sharing content.

Functional requirements

#	*Functional requirement*
1	The application should allow the user to share some content, such as achievements, on the social networks.
2	The user should be able to attach a comment to the achievement he decided to share.
3	The application should award credits for sharing achievements on social networks.

11. Customer portal user account management

This section describes subgroup of use cases that focus on portal sign-up, user profile management and application settings management.

Table 15 presents the high-level functional requirements that explain the core functionality of the customer portal user account management. The requirements will be elaborated in the following sub-sections, which describe the separate use cases. Table 16 lists the non-functional requirements.

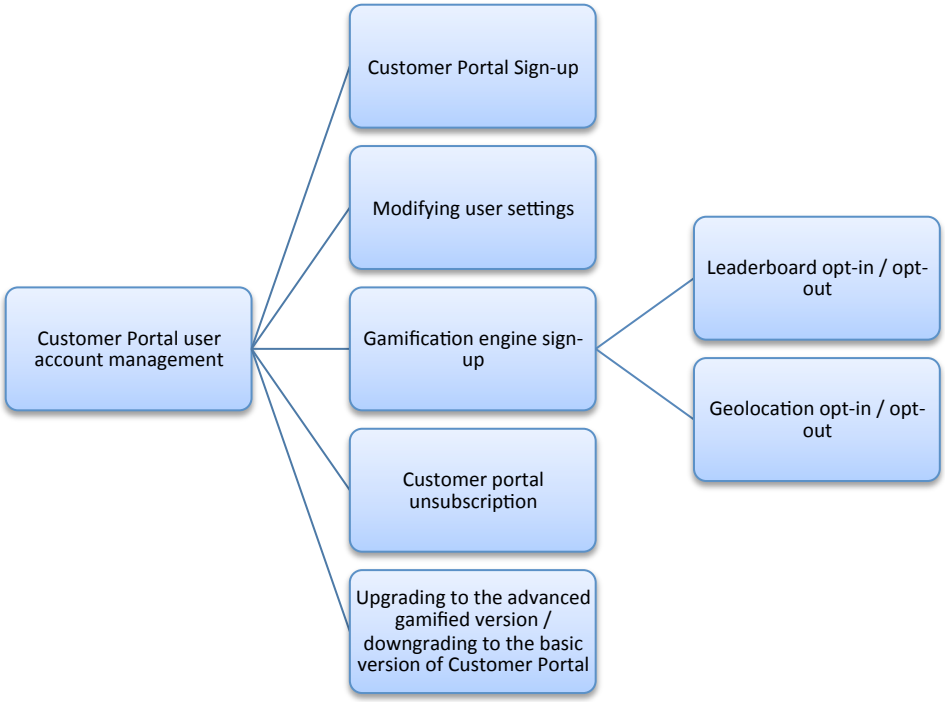
Table 15. High-level functional requirements of the customer portal user account management.

#	*High Level functional requirements*
GF1	The application should provide the user the option to register to both the basic and the advanced version of the Customer Portal.
GF2	The application should allow the user to unsubscribe from the Customer Portal at any moment.
GF3	The application should allow the user to modify application settings.
GF4	The application should allow users who are registered to the basic version of the Customer Portal to upgrade to the advance version.
GF5	The application should allow users who are registered to the advanced gamified version of the Customer Portal to downgrade to the basic version.
GF6	The application should allow users of the gamified portal to opt-in / opt-out the public leaderboard.
GF7	The application should allow users of the gamified portal to opt-in / opt-out their geo-location on the public map.

Table 16. High-level non-functional requirements of the customer portal user account management.

#	*High Level non-functional requirements*
GNF1	The application shall be accessible and useable for non-technical audiences.
GNF2	The application shall be well documented and described.
GNF3	The application shall be transparent, allowing users e.g. to understand which functionalities he has opted in and out of.

Use cases overview



11.1 Use case: Customer Portal Sign-up

Use case: Customer Portal Sign-up		
Goal in Context	Providing the user with an application for registering to the Customer Portal	
Preconditions	None.	
Success End Condition	The user becomes a Customer user, who can access the Customer Portal.	
Failed End Condition	The user does not become a Customer user and cannot access the Customer Portal.	
Primary, **Secondary Actors**	Consumer user	
Trigger	Consumer accesses the Customer Portal registration area.	
DESCRIPTION	**Step**	**Action**
	1	The user accesses the registration area from the public home page.
	2	The user selects the Customer Portal (basic version) as preference during the registration phase.
	3	The user inputs the required basic personal information: username, password, email, and optionally zipcode, country

Use case: Customer Portal Sign-up		
		and unique customer ID.
	4	The system checks the validity of the provided information (e.g. no duplicates of username, correctness of email, correctness of unique customer ID).
	5	The user confirms the registration.

Functional requirements

#	*Functional requirement*
1	The application should provide a graphical interface to allow the consumer to register to the Customer Portal, providing some mandatory data for authentication and optionally some basic personal information about household.
2	The application should be able to verify data provided by customers and alert users in case of errors.
3	The application should be able to store user data in the platform database, creating a new profile for the consumer.
4	The application should be able to identify if the customer shares the smart meter measuring consumption with other households in the same building (bulk metering), starting from the provided unique customer ID.
5	In case of shared smart meters (bulk metering), the application should ask for additional mandatory information during registration (e.g. number of households in building, number of occupants, flat size), in order to be able to estimate single household consumption and allow standard visualization of the platform services.

11.2 Gamification Engine Sign-up

Use case: Gamification Engine Sign-up		
Goal in Context	Stimulating water saving by providing gamification mechanisms to the water utility customer.	
Preconditions	None.	
Success End Cond.	The user becomes a Competitor customer and can exploit the gamification extension of the customer portal.	
Failed End Condition	The user does not become a Competitor user, and cannot exploit the gamification extension of the customer portal.	
Primary, Secondary Actors	Customer user	
Trigger	The customer decides to participate to the gamification mechanism and accesses the Gamification Engine registration area.	
DESCRIPTION	**Step**	**Action**

Use case: Gamification Engine Sign-up		
	1	The user accesses the registration area from the public home page.
	2	The user selects the Gamified version of the portal as preference during the registration phase.
	3	The user inputs the required basic personal information: username, password, email, and optionally zipcode, country and unique customer ID.
	4	The system checks the validity of the provided information (e.g. no duplicates of username, correctness of email, correctness of unique customer ID).
	5	The user confirms the registration.

Functional requirements

#	*Functional requirement*
1	The application should provide a graphical interface to allow the consumer to register to the Gamified Customer Portal, providing some mandatory data for authentication and optionally some basic personal information about household.
2	The application should be able to verify data provided by customers and alert users in case of errors.
3	The application should be able to store user data in the platform database, creating a new profile for the consumer.
3	The application should be able to identify if the customer shares the smart meter measuring consumption with other households in the same building (bulk metering), starting from the provided unique customer ID.
4	In case of shared smart meters (bulk metering), the application should ask for additional mandatory information during registration (e.g. number of households in building, number of occupants, flat size), in order to be able to estimate single household consumption and allow standard visualization of the platform services.

11.3 Use case: Modifying User Settings

Use case: Modifying User Settings	
Goal in Context	Customizing and managing personal profile and application settings.
Preconditions	The user is registered to the system.
Success End Cond.	Changes to user profile or settings are applied.
Failed End Condition	Changes to user profile or settings are not applied.
Primary, Secondary Actors	Customer user

Use case: Modifying User Settings		
Trigger	The user accesses the settings area.	
DESCRIPTION	**Step**	**Action**
	1	The user accesses the settings area.
	2	The user inputs changes to the personal profile (e.g. email, address) or to the general application settings (e.g. notifications, privacy).
	3	The user confirms and changes are applied.

Functional requirements

#	*Functional requirement*
1	The application should provide a graphical interface to allow the user to modify his profile.
2	The application should provide a graphical interface to allow the user to modify settings. User should be able to turn on/off notifications and change the more general settings of the application (e.g. language, privacy).

11.4 Use case: Upgrading to the advanced gamified version / downgrading to the basic version of Customer Portal

Use case: Upgrading to the gamified version / downgrading to the basic version of Customer Portal		
Goal in Context	Managing application settings. Stimulating water saving by providing gamification mechanisms to the water utility customer.	
Preconditions	The user is registered to the basic or advanced Customer Portal version.	
Success End Cond.	Changes to user settings are applied.	
Failed End Condition	Changes to user settings are not applied.	
Primary, **Secondary Actors**	Customer user	
Trigger	The user accesses the settings area.	
DESCRIPTION	**Step**	**Action**
	1	The user accesses the settings area.
	2	The user selects the option to upgrade/downgrade the current version to the advanced/basic one.
	3	The user confirms and changes are applied.

Functional requirements

#	*Functional requirement*
1	The application should provide a graphical interface to allow the user to modify settings.
2	The application should allow basic users (Customers) to upgrade to the gamified version of the portal.
3	The application should allow advanced users (Competitors) to exit the competition and downgrade to the basic version of the portal.

11.5 Use case: Leaderboard opt-in / opt-out

Use case: Leaderboard opt-in / opt-out		
Goal in Context	Stimulating water saving by providing gamification mechanisms to the utility customer	
Preconditions	Customer is registered to the Gamified Customer Portal.	
Success End Cond.	User is visible/ not visible in the public leaderboard.	
Failed End Condition	User is not visible/visiblein the public leaderboard.	
Primary, **Secondary Actors**	Competitor user	
Trigger	User decides to enter/exit the public gamified competition.	
DESCRIPTION	**Step**	**Action**
	1	User consents/does not consent to participate to the public competition and disclose information to other competitor users.
	2	User will be now visible/ not visible in the public leaderboard.

Functional requirements

#	*Functional requirement*
1	The application should ask the user to accept to participate to the public competition and disclose information with other users.
2	The application should allow the user to decline to appear in a public leaderboard and leave the public competition at any time.

11.6 Use case: Geolocation opt-in / opt-out

Use case: Geolocation opt-in / opt-out	
Goal in Context	Encouraging competition to stimulate water saving

Use case: Geolocation opt-in / opt-out		
Preconditions	Customer is registered to the Gamified Customer portal.	
Success End Cond.	User location is visible/not visible to other utility users.	
Failed End Condition	User location is not visible/visible to other utility users.	
Primary, Secondary Actors	Competitor user	
Trigger	User decides to disclose/not disclose information about his house geo-location.	
DESCRIPTION	**Step**	**Action**
	1	User consents to disclose/not disclose information about his house location to other competitor users.
	2	House location will appear/not appear on a map, visible to other users.

Functional requirements

#	*Functional requirement*
1	The application should ask the user to accept to disclose his geo-location, appearing on a map visible to other users.
2	The application should allow the user to decline to disclose his geo-location, not appearing on the map visible to other users.

11.7 Use case: Customer Portal Unsubscription

Use case: Customer Portal Unsubscription		
Goal in Context	Allowing the user to unsubscribe from the system	
Preconditions	The user is registered to the system.	
Success End Cond.	All content related to the user is permanently deleted from the system.	
Failed End Condition	The user is still in the system, deletion of all content related to the user failed.	
Primary, Secondary Actors	Customer user	
Trigger	The user clicks to unsubscribe.	
DESCRIPTION	**Step**	**Action**
	1	The user requests to be deleted from the system.

Use case: Customer Portal Unsubscription		
	2	All data related to the user is permanently deleted from the system.

Functional requirements

#	*Functional requirement*
1	The application should be able to allow the user to unsubscribe from the system.
2	The application should be able to permanently delete all content related to the user from the platform database, including user profile and all consumption data.

12. Customer Portal Admin

This section contains the specification of a set of use cases describing the admin interface of the Customer Portal. They consider particularly the actions needed by the admin editors to create the content of both the basic and the advanced version of the portal.

It comprises the basic actions for providing educational content (e.g. tips, teaching videos) and all the editing actions related to the gamified context (e.g. definition of actions/badges/rewards, definition of rules to assign credits).

Table 17 presents the high-level functional requirements that explain the core functionality of the customer portal admin interface. The requirements are elaborated in the following sub-sections, which describe the use cases. Table 18 lists the non-functional requirements.

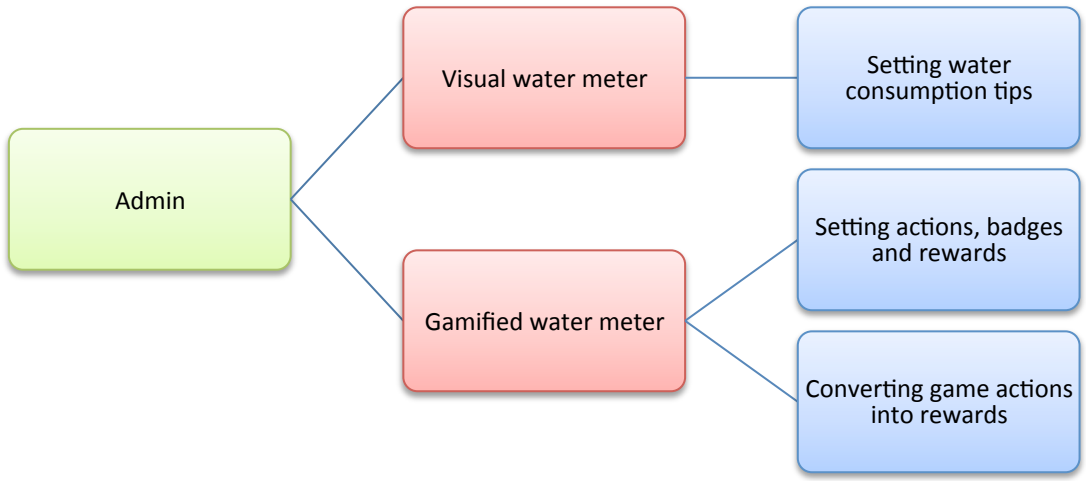
Table 17. High-level functional requirements of the customer portal admin interface.

#	***High Level functional requirements***
AF1	The application should enable the Admin (incl. utilities) to set external water consumption tips.
AF2	The application should allow the Admin to create new actions/badges/rewards for the gamification system.
AF3	The application should allow the Admin to specify the rules to convert gaming results coming from the Games Platform into credits valid for the Gamification Engine.

Table 18. High-level non-functional requirements of the customer portal admin interface.

#	***High Level non-functional requirements***
ANF1	The application shall be well documented and described.

Use cases overview



12.1 Use case: Setting water consumption tips

Use case: Setting water consumption tips		
Goal in Context	Raising individual water consumption awareness by providing water saving tips	
Preconditions	None.	
Success End Cond.	Water saving tip has been inserted into the system.	
Failed End Condition	Water saving tip has not been inserted into the system.	
Primary, **Secondary Actors**	ConsumerPortalCE user, system	
Trigger	User accesses the tips management area in the admin interface.	
DESCRIPTION	**Step**	**Action**
	1	The user accesses the tips area in the admin interface and provides data.
	2	The user can create a new tip or delete/modify an existing one.
	3	The user can assign a tip to a given customer or segment of customers.

Functional requirements

#	*Functional requirement*
1	The application should be able to store in the platform database the tips provided by admin users.
2	The application should provide a graphical interface to allow the Adminto insert, modify or delete water consumption tips.
3	The application should provide different input data formats for the water management tips, including text, images and video files formats.

12.2 Use case: Setting actions, badges and rewards

Use case: Setting actions, badges and rewards	
Goal in Context	Stimulating water consumption awareness through gamification
Preconditions	None.
Success End Cond.	New action,reward or badge type is inserted into the system
Failed End Condition	No action, reward or badge type is inserted into the system.

Use case: Setting actions, badges and rewards		
Primary, Secondary Actors	GEContentAndRulesEditor, system	
Trigger	The user accesses the area for managing actions , badges and rewards and provides data.	
DESCRIPTION	**Step**	**Action**
	1	The user can organize gamification objects (actions, badges) by thematic areas (e.g. Playing area).
	2	The user can create a new action related to a specific thematic area or modify/delete an existing one.
	3	The user can create a new badge related to a given area, and specify which actions could contribute to achieve this badge.
	4	The user can insert a new reward in the system, or modify/delete/mark as not available an existing one.

Functional requirements

#	*Functional requirement*
1	The application should provide a graphical interface to allow the user to create new thematic areas.
2	The application should display the list of the available actions/badges/rewards.
3	The application should allow the user to input new actions related to a given thematic area or to modify/delete existing ones.
4	The application should allow the user to input new badges related to a specific area or to modify/delete existing ones.
5	The application should allow the user to specify which are the actions contributing to a specific badge.
6	The application should allow the user to input new rewards in the system, or modify/delete an existing one.
7	The application should allow the user to mark a reward as not available at the moment, keeping it still in the list of rewards.

12.3 Use case: Converting game actions into rewards

Use case: Converting game actions into rewards	
Goal in Context	Providing means of participation in water saving for younger children
Preconditions	Games Platform possible outcomes have been defined.

Use case: Converting game actions into rewards		
Success End Cond.	Games results converted into gamification engine actions.	
Failed End Condition	Games results are not converted into gamification engine actions.	
Primary, **Secondary Actors**	GamificationEngineContentandRulesEditor user, system	
Trigger	A new Games Platform action is available and it needs to be mapped in the Gamification Engine.	
DESCRIPTION	**Step**	**Action**
	1	User converts games platform achievements into gamification engine actions. User manually inputs formulas to convert inputs (game achievements and points) into outputs (Gamification Engine actions).
	2	User can assign specific badges and rewards for games-related actions.

Functional requirements

#	***Functional requirement***
1	The application should provide a graphical interface to allow the user to define the rules applied to convert gaming actions into Gamification Engine actions.
2	The application should allow the user to manually input formulas to be applied in the conversion phase.
3	The application should allow the user to define the rewards a user can redeem performing gaming actions.

13. Games Platform

The Games Platform set of use cases contains the interaction cases of the consumer with the Games Platform and the possibility to link his/her player also to the Gamification Engine. This set describes the choices of the consumer to get involved in available SmartH2O games (board game, its digital extension and mobile game) and aims to stimulate water consumption awareness.

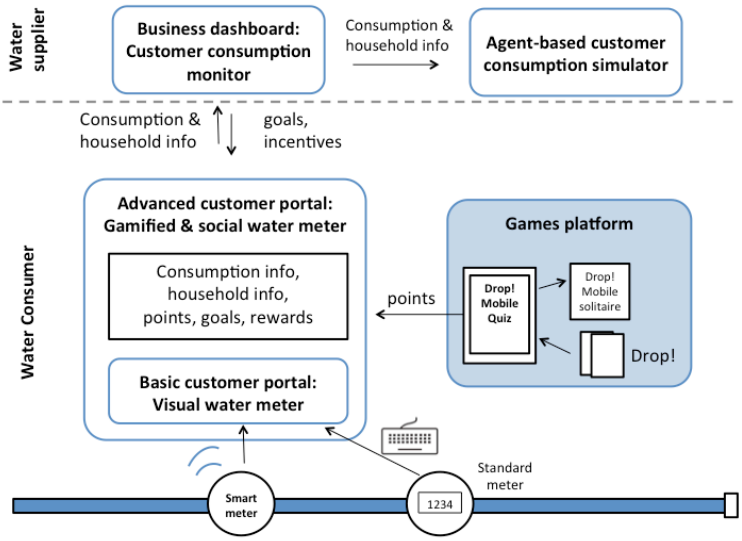


Figure 46. Games platform in application overview.

Table 19 presents the high-level functional requirements that explain the core gamification functionality of the games platform. The requirements will be elaborated in the following sub-sections, which describe the separate use cases.

Table 20 lists the high-level non-functional requirements. In addition, measurable technical success criteria that are perceived as operationalized non-functional requirements are formulated in section 0. They address e.g. processing and rendering time. From the user point of view, e.g. perception of joy and perception of incentive are addressed.

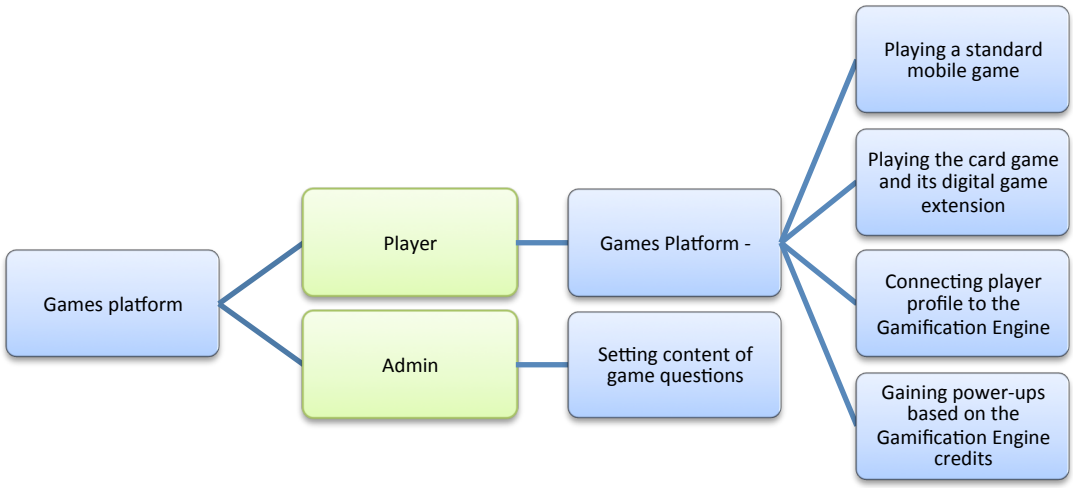
Table 19. High-level functional requirements of the games platform.

#	*High level requirements*
GF1	The application should incentivize the user to play games, awarding points and rewards.
GF2	The application should enable content editors to set games content and questions.
GF3	The application should incentivize the joint use of games and gamification services provided by the utility.
GF4	The application should be able to connect the player profile on the Games platform with the one on the Gamification Engine.

Table 20. High-level non- functional requirements of the games platform.

#	*High Level non-functional requirements*
GNF1	The application shall be accessible and useable for non-technical audiences.
GNF2	The application shall be well documented and described.
GNF3	The application shall be transparent

Use cases overview



13.1 Use case: Games Platform Sign-up

Use case: Games Platform Sign-up		
Goal in Context	Stimulating water consumption awareness through gaming activities	
Preconditions	The player installed the application on a device.	
Success End Cond.	User profile is created in the Games platform system.	
Failed End Condition	The email already exists, the player is notified.	
Primary, Secondary Actors	Consumer user	
Trigger	Player inputs information in order to register.	
DESCRIPTION	**Step**	**Action**
	1	The player asks to register to the platform specifying email and name.

Use case: Games Platform Sign-up		
	2	The system verifies if the email has been used on another registration.
	3	If the email does not exists then the system creates a new profile, otherwise it notifies the error to the player.

Functional requirements

#	*Functional requirement*
1	The application should provide a graphical interface to allow the player to register to the Games Platform, providing authentication data.
2	The application should be able to store user data in the platform database, creating a new profile for the player.

13.2 Use case: Playing a standard mobile game

Use case: Playing a standard mobile game		
Goal in Context	Stimulating water consumption awareness through gaming activities	
Preconditions	Mobile device available	
Success End Cond.	The user plays a game session.	
Failed End Condition	The user does not play a game session.	
Primary, Secondary Actors	Player user	
Trigger	The user accesses the Games Portal and chooses to play one of the available games.	
DESCRIPTION	**Step**	**Action**
	1	The user accesses the Game Portal and selects the game to play.
	2	The user is redirected to the selected game, where a new game session starts.

Functional requirements

#	*Functional requirement*
1	The application should be able to display the available games on the platform.
2	The application should be able to manage new game sessions, started by casual or registered players.
3	The application should store information retrieved during the game sessions.

13.3 Use case: Playing the card game and its digital game extension

	Use case: Playing the card game and its digital game extension	
Goal in Context	Stimulating water consumption awareness through gaming activities	
Preconditions	Mobile device is available.	
Success End Cond.	The user is able to play a game session involving both the physical card game and the digital extension.	
Failed End Condition	The user is not able to play a game session involving both the physical card game and the digital extension.	
Primary, **Secondary Actors**	Player user	
Trigger	During a card game session, the user is required to solve a task using the digital game extension.	
DESCRIPTION	**Step**	**Action**
	1	The user is playing a card game session.
	2	The current card requires the user to solve a particular task, using the digital game extension.
	3	Using the mobile device, the player completes the task.
	4	The user returns the points obtained playing the digital game into the physical card game context, integrating them with his current score.

Functional requirements

#	*Functional requirement*
1	The application should manage game sessions, which are an extension of the physical card game, performed by registered or casual players.
2	The application should manage the difficulty of the tasks provided to the players, according to the information provided by them.

13.4 Use case: Gaining power-ups based on the Gamification Engine credits

	Use case: Gaining power-ups based on the Gamification Engine credits
Goal in Context	Stimulating water consumption awareness through gaming activities
Preconditions	The player is a customer of the utility, registered to the Gamification Engine.

	Use case: Gaining power-ups based on the Gamification Engine credits	
Success End Cond.	The player is able to gain power-ups exploiting Gamification Engine credits.	
Failed End Condition	The player is not able to gain power-ups exploiting Gamification Engine credits.	
Primary, **Secondary Actors**	CustomerPlayer user	
Trigger	Player clicks to “buy” power-ups.	
DESCRIPTION	**Step**	**Action**
	1	The user clicks to buy power-ups, exploiting the credits collected in the Gamification Engine.
	2	If the user has enough credits, the system takes the required credits off the total ones available in the Gamification Engine.
	3	The user gets the power-ups.

Functional requirements

#	***Functional requirement***
1	The application should manage Gamification credits redemption requested in the game context.
2	The application should be able to verify the credits availability in order to suggest the suitable power-ups the user can request.

13.5 Use case: Connecting player profile to the Gamification Engine

	Use case: Connecting my player profile to the Gamification Engine	
Goal in Context	Stimulating water consumption awareness through gaming activities	
Preconditions	The player is a customer of the utility.	
Success End Cond.	The user connects his player profile with his customer profile on the Gamification Engine.	
Failed End Condition	The user does not connect his player profile with his customer profile on the Gamification Engine.	
Primary, **Secondary Actors**	RegisteredPlayer user	
Trigger	Player clicks to connect the player profile to the utility customer profile.	
DESCRIPTION	**Step**	**Action**

	Use case: Connecting my player profile to the Gamification Engine	
	1	The user decides to link his player profile to the gamification engine one, in order to collect points in both platforms.
	2	The user provides the required information to connect his profiles and confirms.

Functional requirements

#	*Functional requirement*
1	The application should be able to match the player profile on the Games platform with the one on the Gamification Engine.
2	The application should manage the collection of points performed using both the platforms.
3	The application should display user progress and ranking in both the Games Platform and the Gamification Engine.

13.6 Use case: Setting content of game questions

	Use case: Setting content of game questions	
Goal in Context	Stimulating water consumption awareness through gaming activities	
Preconditions	None.	
Success End Cond.	A new question is inserted into the system.	
Failed End Condition	No question is inserted into the system.	
Primary, Secondary Actors	GamesPlatformCE user, UtilityGamesPlatformContentEditor	
Trigger	The user accesses the area for managing game questions and provides data.	
DESCRIPTION	**Step**	**Action**
	1	The user inputs a new question and, in case of a closed-ended question, the possible answers.
	2	The user can also modify an existing question.

Functional requirements

#	*Functional requirement*
1	The application should display the questions already in the system.
2	The application should provide a graphical interface to allow the user to input a new question.
3	The application should allow the user to modify an existing question.

14. Business Dashboard: Customer consumption monitor

This set of use cases describes the interaction of utility staff with the customer consumption monitor, one of two Business Dashboard applications. In particular, the following use cases comprise the monitoring of consumption information, the identification and calculation of attributes, the segmentation of customers based on these attributes and the setting and provision of targeted incentives to the different customer groups/segments.

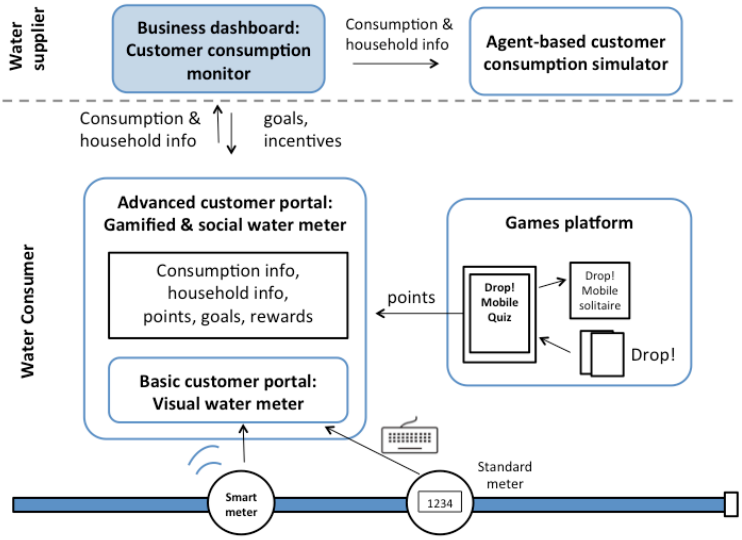


Figure 47. Business dashboard in application overview.

Table 21 presents the high-level functional requirements that explain the core gamification functionality of the business dashboard. The requirements will be elaborated in the following sub-sections, which describe the separate use cases. Table 22 lists the high-level non-functional requirements. In addition, measurable technical success criteria that are perceived as operationalized non-functional requirements are formulated in section 16.5. They address e.g. processing and rendering time. From the user point of view, e.g. perception of usefulness and comprehension are addressed.

Table 21. High-level functional requirements of the business dashboard.

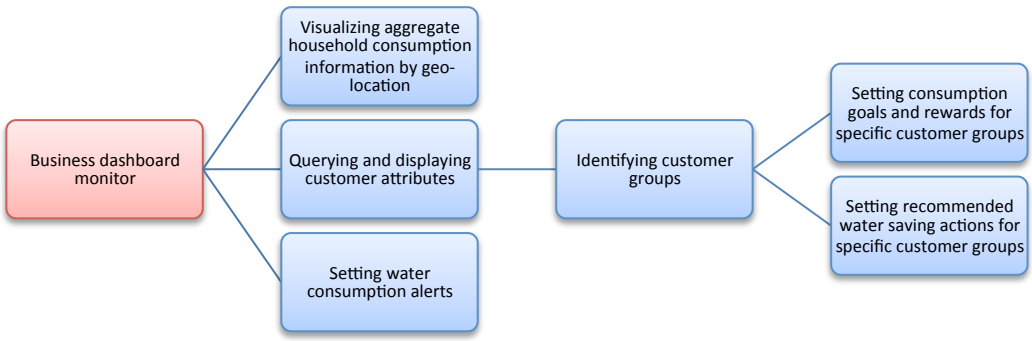
#	***High level requirements***
MF1	The application should display aggregated consumption data by geographical region/district or household.
MF2	The application should display the consumption data visualized by different periods of time.
MF3	The application should provide to the user some typical location-based consumption metrics, e.g. peak and average of the municipality, to compare to.
MF4	The application should have access to the SmartH2O database.
MF5	The application should be able to query and display psychographic information of customers.

MF6	The application should be able to group and display information about customers according to their activity on the gamified customer portal.
MF7	The application should be able to identify customer groups based on their consumption and psychographic variables.
MF8	The application should enable the user to manually specify customer groups
MF9	The application should enable the user to set specific consumption goals linked to specific rewards to individual customer groups.
MF10	The application should enable the user to recommend water saving actions to specific customer groups.
MF11	The application should enable he user to set alerts to specific set of customers.

Table 22. High-level non-functional requirements of the business dashboard.

#	***High Level non-functional requirements***
MNF1	The application shall be accessible and useable for non-technical audiences.
MNF2	The application shall be well documented and described.
MNF3	The application shall be transparent, e.g. by showing how customer groups have been classified.

Use cases overview



14.1 Use case: Visualizing aggregate household consumption information by geo-location

	Use case: Visualizing aggregate household consumption information by geo-location
Goal in Context	Identifying e.g. leakage or consumption metrics of customers to take appropriate action (e.g. adjust pumping, fix leaks, adapt pricing schemes)
Preconditions	Customer households are metered; Household consumption data is available.

	Use case: Visualizing aggregate household consumption information by geo-location	
Success End Cond.	Household consumption data is visualized.	
Failed End Condition	Household consumption data is not visualized.	
Primary, **Secondary Actors**	UtilityAdmin user, system	
Trigger	UtilityAdmin specifies geo-location.	
DESCRIPTION	**Step**	**Action**
	1	User selects specific geographic region / district / household.
	2	The system visualizes the aggregated metered water consumption data of a specific geographic region / district / household .
	3	The user can interact with the visualization by choosing different zoom levels of the information (hourly, daily, monthly).
	4	The user can compare average to a set of available other aggregate averages (e.g. municipality, district).
	5	If data available, the user can compare the consumption with amount of pumped water.

Functional requirements

#	*Functional requirement*
1	The application should enable to user to select a specific geo-location as the basis for the visualization (e.g. district, street, building, household).
2	The application should display a visualization of the aggregated water consumption of a specified geo-location (e.g. district, street, building, household).
3	The application should provide the option to adjust the view settings of the visualization to different time intervals.
4	The application should provide the option to compare the consumption average with the average consumption of other geo-locations / areas.
5	The application should provide a visualized comparison of the current consumption with past measurements.
6	The application should enable the user to compare the consumption of a specific geo-location with the amount of water pumped into the respective area.
7	The application should highlight and visualize unexpected consumption behaviour, e.g. peaks that could relate to leakage.

14.2 Use case: Querying and displaying customer attributes

	Use case: Querying and displaying customer attributes	
Goal in Context	Understanding the most relevant drivers of water consuming at the household level	
Preconditions	Customer households have provided household and consumption information. Households were metered.	
Success End Cond.	The identified behavioural attributes are validated based on observational data.	
Failed End Condition	The identified behavioural attributes are not confirmed by observational data.	
Primary, **Secondary Actors**	System	
Trigger	A sufficient rich set of customers provide household and consumption information.	
DESCRIPTION	**Step**	**Action**
	1	System calculates behavioural attributes from customers' water consumption and interaction patterns on the gamified customer portal (e.g. average consumption, shower duration, overall activity level on platform).
	2	System collects psychographic variables from customer portal household profiles (e.g. number of occupants, garden y/n).
	3	User can query individual attributes/variables of customers.
	4	System displays customer attributes.

Functional requirements

#	***Functional requirement***
1	The system should automatically collect behavioural attributes of customers based on their water consumption behaviour, e.g. top water consumers, top water savers, top water wasters.
2	The system should automatically collect behavioural attributes of customers based on their interaction with the platform, e.g. top credit collectors and top badge collectors [badge type].
2	The system should collect psychographic variables from customer portal household profiles.
3	The system should enable users to query and display these attributes.

14.3 Use case: Identifying customer groups

Use case: Identifying customer groups		
Goal in Context	Identifying specific customer segments to provide targeted incentives and personalized feedback for water saving	
Preconditions	Customer households have provided household and consumption information. Households were metered.	
Success End Cond.	The identified customer segments are validated based on observational data.	
Failed End Condition	The observational data does not confirm the identified customer segments. The identified customer segments are not fine-grained enough.	
Primary, **Secondary Actors**	UtilityAdmin user, system	
Trigger	A sufficient rich set of customers provide household and consumption information.	
DESCRIPTION	**Step**	**Action**
	1	Based on the behavioural, and psychographic attributes, the user can identify and save a specific customer group by selecting a subset of attributes.
	2	System can also classify customer groups automatically.

Functional requirements

#	***Functional requirement***
1	The system should get access to the raw data stored in the SmartH2O database.
2	Users should be able to specify customer groups manually based on a specific subset of customer attributes.
3	The system should be able to classify customer groups automatically.

14.4 Use case: Setting consumption goals and rewards for specific customer groups

Use case: Setting consumption goals and rewards for specific customer groups	
Goal in Context	Stimulating water saving by setting consumption goals and providing personalized incentives based on specific customer groups
Preconditions	User profiles and customer groups are available in the system.
Success End Cond.	Consumption goal linked to a reward was set for a specific customer group.

	Use case: Setting consumption goals and rewards for specific customer groups	
Failed End Condition	Consumption goal was not set.	
Primary, Secondary Actors	UtilityAdmin user, system	
Trigger	User selects a customer group.	
DESCRIPTION	**Step**	**Action**
	1	The user can set a consumption goal for different kind of households (customer groups) to stimulate better consumption.
	2	The user can link a specific reward to a consumption goal.

Functional requirements

#	*Functional requirement*
1	The application should enable the user to set consumption goals for customer groups.
2	The application should provide the option to set different consumption goals for different areas or different household profiles.
3	The application should provide the option to link a specific reward to a consumption goal.
4	The application should notify customers when a new consumption goal is set by the utility.

14.5 Use case: Setting recommended water saving actions for specific customer groups

	Use case: Setting recommended water saving actions for specific customer groups	
Goal in Context	Stimulating water saving by recommending water saving actions	
Preconditions	User profiles and segments are available in the system.	
Success End Cond.	A recommended water saving action is defined for a specific customer group.	
Failed End Condition	A recommended water saving action is not defined.	
Primary, Secondary Actors	UtilityAdmin user, system	
Trigger	User selects a customer group.	
DESCRIPTION	**Step**	**Action**

	Use case: Setting recommended water saving actions for specific customer groups	
	1	The system automatically proposes a recommended water saving action for a customer group based on identified customer user model.
	2	The user can confirm the automatically recommended water saving action, or set an alternative, more suitable water saving action that he selects from a pre-defined list.

Functional requirements

#	*Functional requirement*
1	The system should be able to propose recommended water saving actions for a specific customer group.
2	The user should be able to confirm or override an automatically proposed action.
3	The system should provide a pre-defined list of recommended actions for the user to choose from.

14.6 Use case: Setting water consumption alerts

	Use case: Setting water consumption alerts	
Goal in Context	Warning user about problems related to water supply	
Preconditions	Data for alerts is available, e.g. for household leakage alert: household is smart metered; for water quality alert: quality is measured. Utility wants to provide the information.	
Success End Cond.	Alert is triggered.	
Failed End Condition	Alert is not triggered.	
Primary, **Secondary Actors**	UtilityAdmin user, system	
Trigger	Measured attributes are below defined threshold.	
DESCRIPTION	**Step**	**Action**
	1	The system or the user, via the supervisor portal, detects water consumption distress, e.g. when water leakage is detected in household, when overall water quality is bad, when water shortage occurs.
	2	Alert notifications can be automatically sent to the users when a critical condition has been detected, or the user can select a set of customers involved to be notified.

Functional requirements

#	*Functional requirement*
1	The application should be able to detect water shortage, consumption peak, leakage and water quality problems.
2	The application should allow the user to set alerts for a set of users, according to the consumption data visualization available in the business dashboard.

15. Agent-based customer consumption simulator

The use cases of this set describe the modelling and simulation of user behaviour based on different variables (consumption, incentives and pricing schemes) and the corresponding prediction of the reaction of the customers on these variables in terms of water consumption.

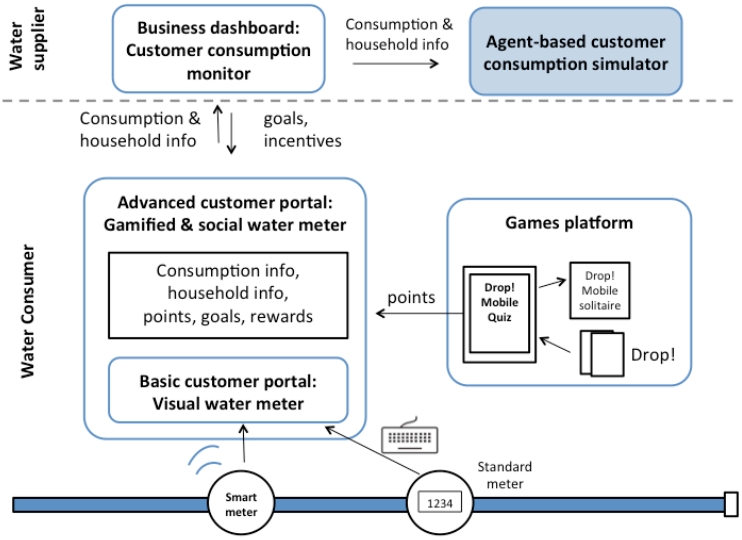


Figure 48. Agent-based customer consumption simulator in application overview.

Table 23 presents the high-level functional requirements that explain the core gamification functionality of the agent-based customer consumption simulator. The requirements will be elaborated in the following sub-sections, which describe the separate use cases. Table 24 lists the high-level non-functional requirements. In addition, measurable technical success criteria that are perceived as operationalized non-functional requirements are formulated in section 16.5. They address e.g. processing and rendering time. From the user point of view, e.g. perception of usefulness and comprehension are addressed.

Table 23. High-level functional requirements of the agent-based customer consumption simulator.

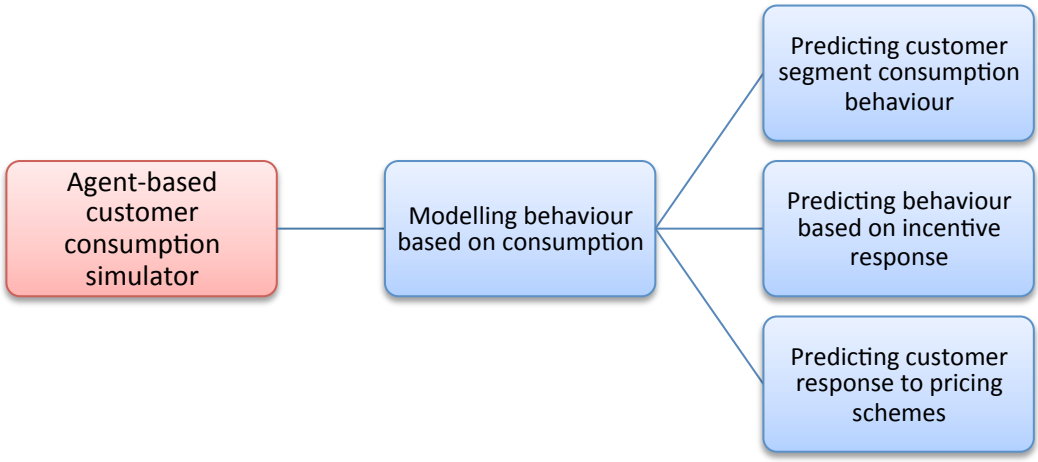
#	*High level requirements*
SF1	The system should have access to the SmartH2O water consumption database.
SF2	The system should be able to produce a behavioural model based on the past consumption data.
SF3	The system should update the model periodically.
SF4	The system should be able to predict future consumption behaviour based on the behavioural model.
SF5	The system should have access to the consumers' water consumption as reaction to applied reward/incentive schemas.
SF6	The system should be able to predict costumer's water consumption as reaction to a reward/incentive schema.

SF7	The system should be able to display the predictions for future water consumption.

Table 24. High-level non-function requirements of the agent-based customer consumption simulator.

#	*High Level non-functional requirements*
SNF1	The application shall be accessible and useable for non-technical audiences.
SNF2	The application shall be well documented and described.
SNF3	The application shall be transparent, e.g. by showing users how the simulation was calculated.

Use cases overview



15.1 Use case: Modelling behaviour based on consumption

	Use case: Modelling behaviour based on consumption
Goal in Context	Understanding and modelling the consumers' current behaviour on the basis of household information and historical and real-time water usage data
Preconditions	Customer households have provided household and consumption information. Households were metered.
Success End Cond.	The model is validated against observational data.
Failed End Condition	Poor matching between the observational data and the output of the model.
Primary, **Secondary Actors**	System
Trigger	Customer provides a sufficient rich set of household and consumption information.

Use case: Modelling behaviour based on consumption		
DESCRIPTION	**Step**	**Action**
	1	A behaviour model is estimated based on previous consumption information provided by smart meters and customer input.
	2	The estimated behaviour model is periodically updated/tested based on new consumption information.

Functional requirements

#	*Functional requirement*
1	The system has access to the water consumption data stored in the SmartH2O database.
2	The system should be able to periodically update the model.

15.2 Use case: Predicting customer segment consumption behaviour

Use case: Predicting customer segment consumption behaviour		
Goal in Context	Predicting water consumption by customer segment based on past information and customer segment defined from information available from the app	
Preconditions	Customer households have provided household and consumption information. Households were metered.	
Success End Cond.	The model is able to accurately predict customer segment consumption behaviour.	
Failed End Condition	The model is not able to accurately predict customer segment consumption behaviour.	
Primary, Secondary Actors	UtilityAdmin user, System, Customer user	
Trigger	User requires a water consumption prediction.	
DESCRIPTION	**Step**	**Action**
	1	Based on behaviour model, system predicts short- and long-term future consumption behaviour.
	2	The water demand forecast is displayed.
	3	Customers and water utilities can foresee possible consumption behaviour scenarios and adjust policy or actions accordingly.

Functional requirements

#	*Functional requirement*
1	The predicted future water consumption should be displayed.

15.3 Use case: Predicting behaviour based on incentive response

	Use case: Predicting behaviour based on incentive response	
Goal in Context	Predicting customer water consumption response to specific reward / incentive scheme based on the estimated model of customer response to rewards/incentive schemes	
Preconditions	Customer households have provided household and consumption information. Households were metered. Relevant and feasible rewards have been identified. Customer response model has been estimated.	
Success End Cond.	The model is able to predict customer consumption response to reward/incentive scheme.	
Failed End Condition	The model is not able to predict customer consumption response to reward/incentive scheme.	
Primary, Secondary Actors	UtilityAdmin user and system	
Trigger	The user requires prediction under given scenarios.	
DESCRIPTION	**Step**	**Action**
	1	Based on the behaviour model on incentive response, the system predicts the likely response in terms of consumption and behaviour change for specific customer segments to different kinds of incentives.
	2	User can adjust incentives targeted to individual customer segments accordingly, e.g. reward schemes.

Functional requirements

#	*Functional requirement*
1	The application should enable the utility user to predict the response of customers' water consumption under different rewards and incentive schemes.

15.4 Use case: Predicting customer segment response to pricing schemes

	Use case: Predicting customer segment response to pricing schemes
Goal in Context	Predicting customer segment water consumption response to specific pricing schemes such as blocking rates

	Use case: Predicting customer segment response to pricing schemes	
Preconditions	Customer households have provided household and consumption information. Households were metered.	
Success End Cond.	The model is able to predict customer segment consumption response to reward/incentive policies.	
Failed End Condition	The model is not able to predict customer segment consumption response to reward/incentive policies.	
Primary, **Secondary Actors**	UtilityAdmin user and System	
Trigger	Utilities user chooses the pricing scheme e.g. blocking rates application	
DESCRIPTION	**Step**	**Action**
	1	Based on the pricing model, the system predicts the likely response in terms of consumption and pricing change for specific customer segments to different kinds of pricing schemes.

Functional requirements

#	Functional requirement
1	Allow utilities users to simulate pricing schemes.
2	Allow utilities users to see customers' consumption and pricing changes for specific customer segments to different kinds of pricing schemes.

16. Success criteria

The following section lists the key performance indicators that address the formulated project objectives, as well as success criteria formulated for each of the main SmartH2O applications. The success criteria are perceived as operationalized non-functional requirements.

In preparation for assessing the technical performance, we have formulated technical success criteria for each use case. The technical success criteria are formulated as [measure] [comparison operator] [value].

Users' technology acceptance is assessed on two levels: the level of an application as a whole and the level of specific application functionalities (human-computer interactions). The general application level needs to be addressed, as the perception of the users of the individual functionalities is influenced by their perception of the application as a whole – and vice versa.

To assess technology acceptance on the level of the main applications, we apply the Unified Theory of Acceptance and Use of technology (UTAUT) [Venk2003] as our starting point. The model is the validated result of integrating eight different user acceptance theories and their measurement instruments. The following indicators that were derived from the UTAUT framework will be used [Venk2003]:

- Performance expectancy: the degree to which an individual believes that using the system will help him or her to attain gains in job performance / the tasks at hand;
- Effort expectancy: the degree of ease associated with the use of the system;
- Attitude towards using technology: an individual's overall affective reaction to using a system.
- Social influence: the degree to which an individual perceives that important others believe he or she should use the new system.

Each indicator is evaluated with a subset of standardized questionnaire items (see Table 25) using a 5-point likert scale. The items will be slightly adapted to fit each application context.

Table 25. Items used in estimating UTAUT.

Performance expectancy	I would find the system useful [in my job]. Using the system enables me to accomplish tasks more quickly. Using the system increases my productivity. If I use the system, I will increase my chances [of getting a raise].
Effort expectancy	My interaction with the system would be clear and understandable. It would be easy for me to become skilful at using the system. I would find the system easy to use. Learning to operate the system is easy for me.
Attitude toward using technology	Using the system is a bad/good idea. The system makes [work] more interesting. Working with the system is fun. I like working with the system.
Social influence	People who influence my behaviour think that I should use the system. People who are important to me think that I should use the system. [The senior management of this business] has been helpful in the use of the system. In general, [the organization] has supported the use of the system.

In addition to the UTAUT indicators, we will assess Hedonic Quality Stimulation (HQS) and Pragmatic Quality (PQ) according to [Hass2004]: HQS measures if a system stimulates users, e.g. by its challenging or novel character, and PQ measures pragmatic aspects of a system, e.g. ease of use. Each indicator will be evaluated with a standardized set of bipolar

verbal anchors: in a questionnaire, users position themselves regarding their impression of a given system on a 7-point bipolar scale. For a detailed description of the evaluation framework, see [Hass2004].

In addition to the main application level, we also assess functionality-specific aspects related to usability, usefulness and the users' perception on the incentive models that are employed.

Both technology acceptance and user-based success indicators do not have a target level, as target levels tend to be arbitrary for user-based success indicators. Therefore, in user-centred design research it is common practice to define what is going to be measured and then analyse the measurement results afterwards, without defining a threshold value a priori.

Furthermore, Likert scales are not analysed with the purpose of providing means and standard deviations, but with the purpose of getting insight in how participants' perceptions are distributed over the scale points.

16.1 Meeting project objectives

The following main project objectives have been formulated for SmartH2O:

PO 1. Understanding consumer behaviour
PO 2. Conserving water by raising social awareness
PO 3. Saving water by dynamic pricing schemes
PO 4. Improve the efficiency and business operations of water companies

In order to measure the success of each project objective, key performance indicators (KPIs) have been defined (see also D7.1 – Validation methodology for more details). They are listed in section 16.1.2.

To better anticipate the amount of water that can potentially be conserved by participating households, we have considered recent studies that may provide indicators and benchmarks relating to water consumption as a result of interventions similar to the SmartH2O project.

16.1.1 Setting target water consumption goals

Recent studies are reporting a positive impact of smart water metering and visual displays on private water consumption. In a study conducted in the Gold Coast, Australia, 44 households were equipped with smart meters and alarming visual display monitors for shower consumption [Will2010]. The installation of the monitor resulted in a significant mean reduction of 15.4 l (27%) in shower event volumes. Using conservative modelling based on these savings, the authors estimate a citywide total of 3% reduction in water consumption [Will2010].

A comprehensive Smart Metering trial in residential homes in a suburb of Sydney conducted in 2009-19 by Sydney Water involved 630 households [Davi2014]. It showed that households with in-home displays were able to reduce their consumption by an average of over 6.8% in comparison to a control group. Comments from study participants also indicate an overall awareness and knowledge increase, e.g. having the display ‘‘will make us more conscious of what we are using and where we are using it’’ and ‘‘I guess I was never aware of how much water I was using, and now I am’’ [Davi2014].

In a 3-year post-trial period without displays, the participant group was able to maintain a saving average of 6.4% compared to their pre-trial consumption, while the control group consumed 1.3% more water per month (see Figure 49). This even shows a long-term value of such a technology [Davi2014].

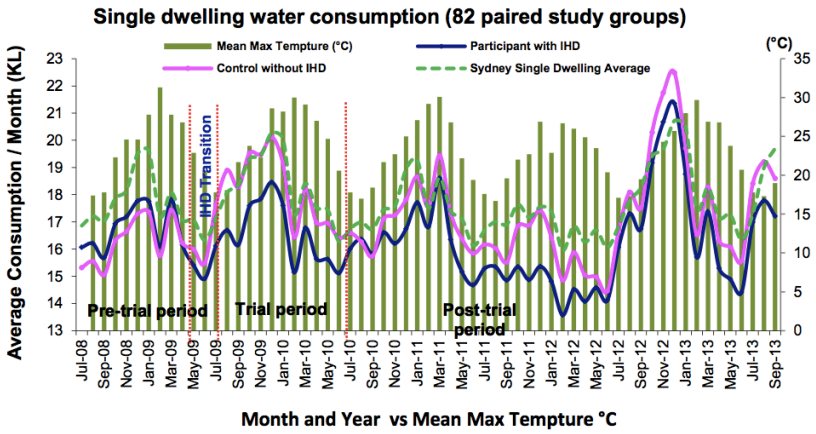


Figure 49. Water consumption trends 2008–2013 (Sydney) showing period of display installation and mean maximum monthly temperature. Source: [Davi2014].

The implementation of water consumption behavioural change and retrofit programmes in the North West of Western Australia resulted in a similar water saving total of 186,625 kL (or 6.9%) during one year [Hens2012].

In the SmartH2O project, we will investigate the impact of smart meters and social applications and campaigns on private households in Switzerland and the UK, and the achieved savings compare to the mainly Australian study findings. Compared to Australian domestic per capita water consumption of 103kL in 2004/05[3] (~283 l/ppd), European domestic water consumption is significantly lower on average. According to Thames Water, the daily domestic per capita water consumption in Greater London is currently 164 l/ppd (UK average: 147 l/ppd; see also D2.1). SVGW has just released the results of a new water consumption study in Switzerland [Frei2015], showing a per capita water consumption compared to the previous study in 1997 from 162 l/ppd l/ppd (0,8% /a) (see Figure 50).

Figure 51 shows the consumption average distribution of households that participated in the most recent study. The study furthermore predicts a minimum possible average consumption of 130 l/ppd by 2030 due to a saturation of water-saving technologies. The study also showed that towns with a higher consumption average were able to decrease their water consumption more significantly over the past years than towns with an already low consumption average (see Figure 52).

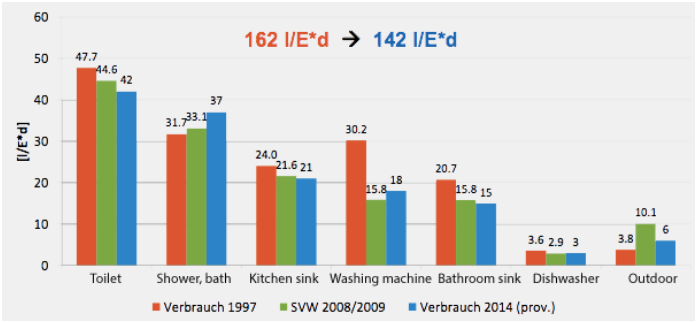


Figure 50. Household water consumption by end-use comparing: SVGW 1997, SVW 2008/09 (multi-family dwellings), SVGW 2014 (preliminary). Source: [Frei2015].

[3] Australian Bureau of Statistics (November 2013). Water consumption per person. Available at http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1370.0~2010~Chapter~Water%20consumption%20per%20person%20(6.3.3), last seen 24/03/2015

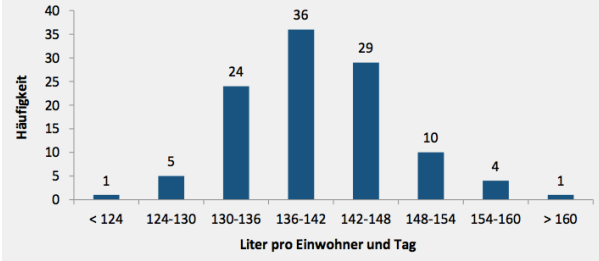


Figure 51. Household consumption distribution (study participants 2014, unit: l/ppd). Source: [Frei2015].

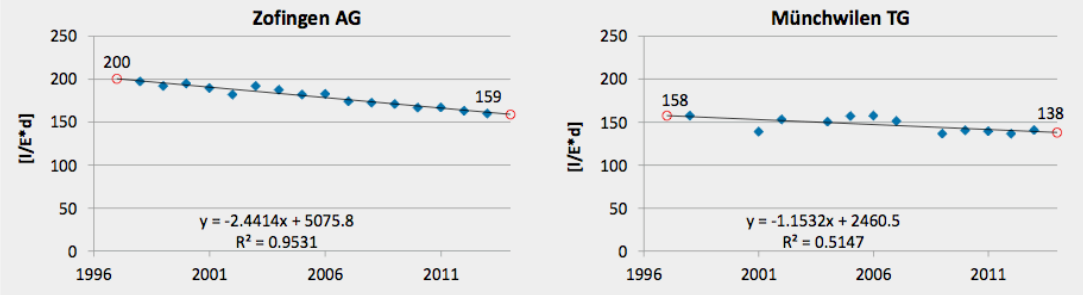


Figure 52. Water consumption series (households and small business) of two Swiss municipalities, one with a higher and the other with lower initial consumption in 1997 (1997 and 2014 extrapolated). Source: [Frei2015].

It will be important to consider these aspects when evaluating the impact of the SmartH2O applications, i.e. a high **impact potential** of interventions and retrofitting vs. the actual **saving potential**, e.g. of already lower consumption averages in the European case study areas compared to the Australian studies. Similarly, the saving potential of individual consumers will vary based on existing habits and household typology. E.g. households with an already environmentally friendly attitude are likely to have a lower saving potential than consumers who are currently wasting a lot of water. Therefore, different consumption targets must be considered for different target user classes / customer segments, and one of the main goals of this project will be to define saving potentials for specific user classes. In the meantime, we define an average saving goal (see KPIs), but there are expected to be significant differences based on the target user class characteristics. We also expect a greater saving in drought periods.

As opposed to water consumption decrease, no real benchmarks have been defined for awareness increase among consumers. Instead, most studies have just quoted selected qualitative statements from individual study participants that may indicate some awareness increase. In the SmartH2O project, we aim to assess an awareness increase by:

- Assessing users' self-perceived awareness of water consumption with a 5-point likert scale, both before and after using H2O customer portal. Awareness is addressed in general with an additional **KPI for PO2,** and in relation to **specific human-computer interactions** (see user based performance indicators). Because a likert scale is discrete, the smallest increase unit to be measured is 1 point. Similar to the water saving potential, the awareness increase potential is expected to vary greatly for different user classes.
- Measuring users' level of activity on the customer portal (e.g. by measuring the number of consumption goals that were set/met)

16.1.2 Key Performance Indicators

All KPIs, which address the main SmartH2O project objectives (PO), are listed in Table 26.

Table 26. Key performance indicators of the SmartH2O project.

PO	KPI	Target level	Remarks
#1	*User behaviour model - MSE predicted vs. measured water consumption*	<= 20% /d	For single household consumption
	Aggr. consumption model - MSE predicted vs. measured water consumption	<= 10% /d	For district composed by at least 50 households
#2	*Water saved per capita per period*	>=5% overall average reduction	Comparison before & after using customer portal; smaller for environmentally friendly households.
	Perception of awareness increase of customer portal users	>=1 likert-scale point (Questionnaire with 5 point likert scale)	Comparison before & after using customer portal; smaller for environmentally friendly households
#3	*Percentage of customer portal users expressing intention to voluntarily adopt a dynamic pricing scheme if available.*	>=5% increase of positive perception of dynamic pricing schemes & intention to voluntarily adopt such a pricing scheme if available.	Comparison of customers that have or not had access to the SmartH2O portal OR with the same customers at initial and late stages of its us
#4	*Peak- period reduction of water consumption of customer portal users*	>= 10 - 20% water consumption reduction	Comparison of historical data of peak water consumption in the two case studies with the data monitored after the introduction of SmartH2O
	Decrease of energy required for pumping water in Swiss case study	>= 2%	Lower target because pumping is not so relevant (hilly location)
	Decrease of energy required for pumping water in UK case study	>= 5%	
	Reduction in CO2 emissions	>= 2% - 5% (see pumping reduction)	Same reduction observed for energy consumption, depends on type of power source used for pumping
	Reduction in Waste Water Treatment	>= 5 – 20%	See KPI for water saved per capita per period; depends on type of household & peak periods.

16.2 Basic customer portal: Visual water meter

16.2.1 Technology acceptance criteria

As explained in the introduction, we use the UTAUT framework [Venk2003] as our frame of reference for the assessment of technology acceptance criteria.

Table 27. Technology Acceptance Criteria of the basic customer portal.

Type of indicator	User	Indicator	Type of measurement
Technology acceptance indicators (UTAUT)	Customer	*Performance expectancy*	Questionnaire (self reported, likert scale)
	Customer	*Effort expectancy (Ease of use)*	Questionnaire (self reported, likert scale)
	Customer	*Attitude toward using technology*	Questionnaire (self reported, likert scale)
	Customer	*Social Influence*	Questionnaire (self reported, likert scale)
AttracDiff [Hass2004]	Customer	*Hedonic quality–stimulation (HQS)*	Questionnaire (self reported, bi-polar scale)
	Customer	*Pragmatic quality (PQ)*	Questionnaire (self reported, bi-polar scale)

16.2.2 User-based performance indicators

In Table 28 the user-based performance indicators for specific human-computer interactions are displayed.

Table 28. User-based performance indicators of the basic customer portal.

Human-computer interaction	Use Case	User	Indicator	Type of measurement
User inputs meter reading manually	8.2	Standard Metered	*Perception of incentive*	Questionnaire (self reported, likert scale)
			Frequency	Analysis of Logs
User explores consumption visualization	8.3, 8.4	Customer	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Comprehension	Questionnaire (self reported, likert scale)
			Perception of awareness increase	Questionnaire (self reported, likert scale)
			Number of views	Analysis of Logs
User provides feedback on disaggregated consumption data	8.5	Smart Metered	*Perception of incentive*	Questionnaire (self reported, likert scale)
User gets a water consumption alert	8.6	Customer	*Perception of usefulness*	Questionnaire (self reported, likert scale)

Human-computer interaction	Use Case	User	Indicator	Type of measurement
User gets a water saving tip	8.7	Customer	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Perception of awareness increase	Questionnaire (self reported, likert scale)
User explores pricing estimates	8.9	Customer	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Comprehension	Questionnaire (self reported, likert scale)
			Perception of awareness increase	Questionnaire (self reported, likert scale)

16.2.3 Technical success criteria

In Table 29 the technical success criteria are displayed.

Table 29. Technical success criteria of the basic customer portal.

Component	Use case #	Indicator	Target level	Remarks
SMMDC (Smart Meter Management Data Component)	*8.1*	*Avg. processing time for daily consumption for 100 smart meters*	<=15 min	
ESB	*8.2* -8.5	*Avg. request processing time in ESB* - *Request take-in* - *Authentication* - *Routing* - *Response delivery* ***Note**: this does not include computing time of publisher services*	<=1 sec	
ESB	*8.2* -8.5	*Uptime for ESB*	>=99.50%	
ESB	*8.2* -8.5	*% of completed requests*	>=99.50%	
Customer Portal (*All pages*)		*Web application availability (Up-time percentage)*	*>=99%*	
Customer Portal (P*ure HTML pages*)	8.6, 8.7, 8.8	*Page response time (time to last byte- TTLB[4])*	*<300ms*	
Customer Portal (*HTML and Javascript pages*)	8.3, 8.4, 8.9	*Page response time (time to last byte- TTLB) + JavaScript event response time*	*<600ms*	
Customer Portal	11.1	*Sign-up response time*	<1s	
Customer Portal	8.3, 8.4	*Consumption chart*	*<1s*	

[4] TTLB indicators are specified with respect to broadband network connection (10bps or more).

Component	Use case #	Indicator	Target level	Remarks
(*Consumption visualization page*)		*rendering time*		
Customer Portal *(Widget interaction)*	8.3, 8.4	*Widget interaction response time*	*<1s*	e.g. Consumption chart zoom-in/zoom-out
Customer Portal *(Submitting form data)*	8.2, 8.5	*Page response time*	*<1s*	
Models of User Behaviour component	8.4	*Precision of classification result*	*- automatic classifier: > 35%* *- automatic classifier with human-in-the-loop (end-user validation input): > 70%*	figures estimated on the basis of energy data for hourly metered consumption

16.3 Advanced customer portal: Gamified & social water meter

16.3.1 Technology acceptance criteria

As explained in the introduction, we use the UTAUT framework [Venk2003] as our frame of reference for the assessment of technology acceptance criteria.

Table 30. Technology Acceptance Criteria of the advanced customer portal.

Type of indicator	User	Indicator	Type of measurement
Technology acceptance indicators	Competitor	*Performance expectancy*	Questionnaire (self reported, likert scale)
	Competitor	*Effort expectancy (Ease of use)*	Questionnaire (self reported, likert scale)
	Competitor	*Attitude toward using technology*	Questionnaire (self reported, likert scale)
	Competitor	*Social Influence*	Questionnaire (self reported, likert scale)
AttracDiff [Hass2004]	Competitor	*Hedonic quality–stimulation (HQS)*	Questionnaire (self reported, bi-polar scale)
	Competitor	*Pragmatic quality (PQ)*	Questionnaire (self reported, bi-polar scale)

16.3.2 User-based performance indicators

Table 31 displays the user-based performance indicators for specific human-computer interactions.

Table 31. User-based performance indicators of the advanced customer portal.

Human-computer interaction	Use case	User	Indicator	Type of measurement
User collects credits and reputation points through his actions on the portal	9.1	Competitor	*Perception of incentive to earn credits through user actions*	Questionnaire (self reported, likert scale)
User achieves a badge with collected reputation points	9.1	Competitor	*Perception of incentive to collect badges*	Questionnaire (self reported, likert scale)
			Frequency	Analysis of logs
User redeems a reward with collected credits	9.1	Competitor	*Perception of incentive to redeem rewards*	Questionnaire (self reported, likert scale)
			Frequency	Analysis of logs
User sets a consumption goal	9.2	SmartMetered competitor	*Perception of incentive to set own goals*	Questionnaire (self reported, likert scale)
User reaches a consumption goal	9.3	SmartMetered competitor	*Perception of incentive to reach a goal*	Questionnaire (self reported, likert scale)
			Perception of awareness increase	Questionnaire (self reported, likert scale)
			Frequency	Analysis of logs
User views recommended water saving action	9.4	Competitor	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Perception of incentive to take action	Questionnaire (self reported, likert scale)
			Perception of awareness increase	Questionnaire (self reported, likert scale)
User provides information (profile information, water saving action, water end-use event)	9.5-9.7	Competitor	*Perception of incentive to provide information*	Questionnaire (self reported, likert scale)
			Frequency of water saving action declarations	Analysis of logs
			Percentage of profile completion	Analysis of logs
			Frequency of	Analysis of logs

			water end-use declarations	
User earns credits and reputation points on the gamified portal by playing on the games platform	9.9	Customer Player	*Perception of joy*	Questionnaire (self reported, likert scale)
User compares himself to others on leaderboard	10.1, 11.4	Competitor	*Perception of competitive incentive*	Questionnaire (self reported, likert scale)
			Frequency of leaderboard opt-in	Analysis of logs
User compares himself to others on neighbourhood map	10.1, 11.5	Competitor	*Perception of competitive incentive*	Questionnaire (self reported, likert scale)
			Frequency of geo-location opt-in	Analysis of logs
User invites another user to join a team	10.2	Competitor	*Perception of incentive*	Questionnaire (self reported, likert scale)
User works towards achieving a joint goal in a water saving team	10.3	Competitor	*Perception of collaborative incentive*	Questionnaire (self reported, likert scale)
			Perception of awareness increase	Questionnaire (self reported, likert scale)
			Frequency of setting / meeting team goals	Analysis of logs
User invites friends on social networks to join the application	10.4	Competitor	*Frequency*	Analysis of logs
User shares an achievement on social networks	10.5	Competitor	*Frequency*	Analysis of logs

16.3.3 Technical success criteria

In Table 32 the technical success criteria are displayed.

Table 32. Technical success criteria of the advanced customer portal.

Component	Use case #	Indicator	Target level	Remarks
ESB	*9.1-9.6, 9.8*	*Avg. request processing time in ESB* - *Request take-in* - *Authentication* - *Routing* - *Response delivery*	<=1 sec	ESB

Component	Use case #	Indicator	Target level	Remarks
		***Note**: this does not include computing time of publisher services*		
ESB	*9.1-9.6, 9.8*	*Up-time for ESB*	>=99.50 %	ESB
ESB	*9.1-9.6, 9.8*	*% of completed requests*	>=99.50 %	ESB
Advanced Customer Portal (*all pages*)		*Web application availability (Up-time percentage)*	*>=99%*	
Advanced Customer Portal (*pure HTML pages*)	9.1, 9.4, 9.9	*Page response time (time to last byte- TTLB)*	*<300ms*	
Advanced Customer Portal (*HTML and Javascript pages*)	9.2, 9.3, 10.3	*Page response time (time to last byte- TTLB) + JavaScript event response time (e.g., widget interaction)*	*<600ms*	
Advanced Customer Portal	11.2	*Sign-up response time*	<1s	
Advanced Customer Portal (*Leaderboard visualization page*)	10.1	*Neighbourhood map rendering time*	*<2s*	
Advanced Customer Portal (*Widget interaction*)	10.1	*Map refreshing time after event*	*<2s*	e.g. Map zoom-in / zoom-out / pan
Advanced Customer Portal *(Submitting form data)*	9.5, 9.7, 10.2	*Actions declaration response time*	*<1s*	
Advanced Customer Portal *(Submitting form data)*	9.6	*User profile updating response time*	<1s	

16.4 Games platform

16.4.1 Technology acceptance criteria

As explained in the introduction, we use the UTAUT framework [Venk2003] as our frame of reference for the assessment of technology acceptance criteria.

Table 33. Technology Acceptance Criteria of the games platform.

Type of indicator	User	Indicator	Type of measurement
Technology acceptance indicators (UTAUT)	Player, CustomerPlayer	*Effort expectancy (Ease of use)*	Questionnaire (self reported, likert scale)
	Player, CustomerPlayer	*Attitude toward using technology*	Questionnaire (self reported, likert scale)
	Player, CustomerPlayer	*Social Influence*	Questionnaire (self reported, likert scale)

16.4.2 User-based performance indicators

In Table 34 the user-based performance indicators for specific human-computer interactions are displayed.

Table 34. User-based performance indicators of the games platform.

Human-computer interaction	Use case #	User	Indicator	Type of measurement
User plays one of the available games (card game, digital game extension, standard game)	13.2, 13.3	Player	*Perception of joy*	Questionnaire (self reported, likert scale)
User scans a QR code on a card	13.3	Player	*Perception of difficulty in scanning under typical lighting condition*	Questionnaire (self reported, likert scale)
User replies to an environmental trivia question	13.3	Player	*Perception of difficulty*	Questionnaire (self reported, likert scale)
User replies to a trivia question related to her household	13.3	Player	*Perception of challenge level*	Questionnaire (self reported, likert scale)
			Perception of incentive to provide information	Questionnaire (self reported, likert scale)
User connects his player profile to	13.5	Customer Player	*Ease of use of linking her*	Questionnaire (self reported, likert scale)

Human-computer interaction	Use case #	User	Indicator	Type of measurement
gamified portal			*customer portal profile to the Games Platform*	
User buys power-ups with credits from the gamified portal	13.4	Customer Player	*Perception of incentive to buy power-ups*	Questionnaire (self reported, likert scale)

16.4.3 Technical success criteria

In Table 35 the technical success criteria are displayed.

Table 35. Technical success criteria of the games platform.

Component	Use case #	Indicator	Target level	Remarks
Games Platform	13.2	*Start-up time*	*< 4 s*	
Games Platform	13.3	*QR code scanning time*	*< 1s*	
Games Platform	13.4	*Score submission to Gamification Engine*	< 500ms	
Games Platform	13.3	*Question loading time*	< 1s	

16.5 Business dashboard and agent-based customer consumption simulator

16.5.1 Technology acceptance criteria

As explained in the introduction, we use the UTAUT framework [Venk2003] as our frame of reference for the assessment of technology acceptance criteria.

Table 36. Technology Acceptance Criteria of business dashboard and agent-based customer consumption simulator.

Type of indicator	User	Indicator	Type of measurement
Technology acceptance indicators (UTAUT)	UtilityAdmin	*Performance expectancy*	Questionnaire (self reported, likert scale)
	UtilityAdmin	*Effort expectancy (Ease of use)*	Questionnaire (self reported, likert scale)
	UtilityAdmin	*Attitude toward using technology*	Questionnaire (self reported, likert scale)

16.5.2 User-based performance indicators

Table 37 displays user-based performance indicators for spec. human-computer interactions.

Table 37. User-based performance indicators of business dashboard and agent-based customer consumption simulator.

Human-computer interaction	Use case #	User	Indicator	Type of measurement
User views aggregate customer household consumption information visualization	14.1	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Comprehension	Questionnaire (self reported, likert scale)
User queries customer attributes	14.2	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
User identifies a customer group	14.3	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Comprehension	Questionnaire (self reported, likert scale)
User sets a consumption goal for a specific customer group	14.4	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
User links a reward to a consumption goal for a specific customer group	14.4	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
User sets a recommended water saving action for a specific customer group	14.5	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
User sets a water consumption alert	14.6	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
User views the predicted customer segment consumption behaviour	15.2	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Comprehension	Questionnaire (self reported, likert scale)
User views the predicted customer behaviour based on incentive response	15.3	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Comprehension	Questionnaire (self

Human-computer interaction	Use case #	User	Indicator	Type of measurement
				reported, likert scale)
User views predicted customer group response to pricing schemes	15.4	UtilityAdmin	*Perception of usefulness*	Questionnaire (self reported, likert scale)
			Comprehension	Questionnaire (self reported, likert scale)

16.5.3 Technical success criteria

In Table 38 the technical success criteria are displayed.

Table 38. Technical success criteria of business dashboard and agent-based customer consumption simulator.

Component	Use case #	Indicator	Target level	Remarks
ESB	*14.1-14.6*	*Avg service request processing time in ESB* - *Request take-in* - *Authentication* - *Routing* - *Response delivery* ***Note**: this does not include computing time of publisher services*	<=1 sec	
ESB	*14.1-14.6*	*Uptime for ESB*	>=99.50%	
ESB	*14.1-14.6*	*% of completed requests*	>=99.50%	
BI	*14.1*	*Avg computing of aggregated consumption data*	<=1 hour	
Front End	*14.1-14.6*	*Avg page load time*	<=2 sec	
Models of User Behaviour component	*14.3*	*Precision of customer classification*	>= 70%	
Front End	*15.1*	*Processing time*	<=30 mins	
Front End	*15.2-4*	*Processing time*	<=10 mins	

17. Software Integration Requirements

17.1 Preamble

For providing an effective integration approach, the business and technical requirements are investigated as a first step.

The following describes issues considered for determining the requirements of the integrated SmartH2O software platform:

- Defining integration solution and business processes
  - Clarify the scope of the integration solution
  - Dividing the scope into a collection of smaller, discrete units of work
  - Identifying the business processes that are candidates for integration
  - Define the activities for each business process
  - Define the characteristics for each business process or component
    - Sequence or order (in relation to other tasks and activities)
    - Frequency of occurrence
    - Urgency and timeliness
    - Duration or elapsed time
    - Volume range, including average volume, peaks, and lulls
- Defining actors and their roles in business processes
  - Identifying the water user types, game players
  - Identifying the geographical distribution of the actors
  - Defining how the data is transported between actors and system
- Defining business events
- Defining the message format for business events
- Defining business data flows
- Defining quality of service
- Defining the integration solution topology

The functional requirements of Use Cases described in this document generate integration requirements between components of SmartH2O platform. Bellow is depicted the high-level component architecture of the platform:

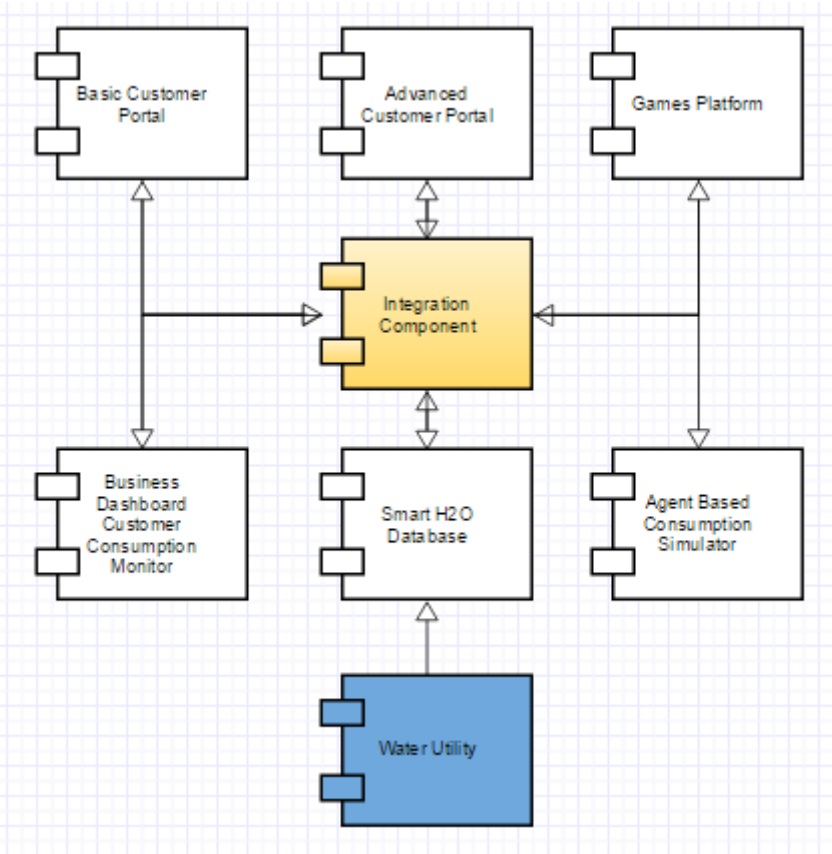


Figure 53. SmartH2O platform General Component Architecture.

The diagram above presents the high-level architecture of the platform based on the components presented in this document. A more detailed architecture of the platform can be found in “D6.2 Platform Architecture and Design” document.

SmartH2O database component will store 2 major types of data:

- Consumer data
  - Consumption data
  - User psychographic data
- Gaming data
  - Rewarding mechanisms
  - User GWAP actions and engagements

A more detailed data model of SmartH2O platform can be found in “D3.1 Databases of User Information” document.

Components that require data exchange needed to accomplish each Use Case are presented in the table below:

Use Case	Integration requirements
Use cases of basic customer portal: Visual water meter	
Use case: Collecting consumption data with smart meters	Water Utility SmartH2O database
Use case: Manually collecting consumption data	Basic customer portal SmartH2O database
Use case: Visual exploration of water consumption information	Basic customer portal SmartH2O database
Use case: Visual exploration of water consumption at fixture/appliance level	Basic customer portal SmartH2O database
Use case: Providing feedback on disaggregated consumption data	Basic customer portal SmartH2O database
Use case: Getting water consumption alerts	Basic customer portal SmartH2O database
Use case: Getting water consumption tips	Basic customer portal SmartH2O database
Use case: Getting system notifications	Basic customer portal SmartH2O database
Use case: Learning interactively about innovative pricing schemes	Basic customer portal SmartH2O database
Use cases of advanced customer portal: Gamified water meter	
Use case: Making gamification actions and exploring results	Advanced Customer Portal SmartH2O database Gamification Engine
Use case: Self setting consumption goals	Advanced Customer Portal SmartH2O database Gamification Engine
Use case: Fulfilling consumption goals	Advanced Customer Portal SmartH2O database Gamification Engine
Use case: Recommending water saving actions	Advanced Customer Portal SmartH2O database Gamification Engine
Use case: Declaring water saving actions	Advanced Customer Portal SmartH2O database Gamification Engine
Use case: Contributing household and user profiling information	Advanced Customer Portal SmartH2O database
Use case: Declaring water end-use events	Advanced Customer Portal SmartH2O database Gamification Engine
Use case: Verifying manually inserted consumption information	Advanced Customer Portal SmartH2O database
Use case: Making actions and earning digital credits with the Games Platform	Advanced Customer Portal SmartH2O database Gamification Engine Games Platform
Advanced Customer Portal: Social water meter	
Use case: Comparing achievements with other households	Advanced Customer Portal SmartH2O database Gamification Engine
Use case: Inviting another user to join a team	Advanced Customer Portal SmartH2O database Gamification Engine
Use case: Achieving goals collaboratively as a team	Advanced Customer Portal

	SmartH2O database Gamification Engine
Use case: Inviting friends on social networks	Advanced Customer Portal Social Network SmartH2O database Gamification Engine
Use case: Sharing achievements on social networks	Advanced Customer Portal Social Network SmartH2O database Gamification Engine
Customer portal user account management	
Use case: Customer Portal Sign-up	Customer portal user account management SmartH2O database Gamification Engine
Gamification Engine Sign-up	Customer portal user account management SmartH2O database Gamification Engine
Use case: Modifying User Settings	Customer portal user account management SmartH2O database Gamification Engine
Use case: Upgrading to the advanced gamified version / downgrading to the basic version of Customer Portal	Customer portal user account management SmartH2O database Gamification Engine
Use case: Leaderboard opt-in / opt-out	Customer portal user account management SmartH2O database Gamification Engine
Use case: Geolocation opt-in / opt-out	Customer portal user account management SmartH2O database Gamification Engine
Use case: Customer Portal Unsubscription	Customer portal user account management SmartH2O database Gamification Engine
Customer Portal Admin	
Use case: Setting water consumption tips	Customer Portal Admin SmartH2O database
Use case: Setting actions, badges and rewards	Customer Portal Admin SmartH2O database Gamification Engine
Use case: Converting game actions into rewards	Customer Portal Admin SmartH2O database Gamification Engine Games Platform
Use cases of Games Platform	
Use case: Games Platform Sign-up	SmartH2O database Games Platform
Use case: Playing a standard mobile game	-
Use case: Playing the card game and its digital game extension	-
Use case: Gaining power-ups based on the Gamification Engine credits	Games Platform SmartH2O database Gamification Engine
Use case: Connecting player profile to the Gamification Engine	SmartH2O database

	Gamification Engine
Use case: Setting content of game questions	Games Platform SmartH2O database
Use cases of business dashboard: Customer consumption monitor	
Use case: Visualizing aggregate household consumption information by geo-location	Business Dashboard SmartH2O database
Use case: Querying and displaying customer attributes	Business Dashboard SmartH2O database
Use case: Identifying customer groups	Business Dashboard SmartH2O database
Use case: Setting consumption goals and rewards for specific customer groups	Business Dashboard SmartH2O database
Use case: Setting recommended water saving actions for specific customer groups	Business Dashboard SmartH2O database
Use case: Setting water consumption alerts	Business Dashboard SmartH2O database
Use cases of agent-based customer consumption simulator	
Use case: Modelling behaviour based on consumption	Models of User Behaviour SmartH2O database
Use case: Predicting customer segment consumption behaviour	Agent Based Simulator Models of User Behaviour SmartH2O database
Use case: Predicting behaviour based on incentive response	Models of User Behaviour SmartH2O database
Use case: Predicting customer segment response to pricing schemes	Agent Based Simulator Models of User Behaviour SmartH2O database

Based on the source and nature of data, two main integration requirements can be identified:

1. Integration between platform components: Customer Portals: Basic and Advanced, Games Platform and Business Dashboard

2. Integration with Water Utility consumption data

17.2 Integration between platform components

Platform components need to exchange data to perform functional requirements described by Use Cases stated in this document. Platform components will be integrated using a dedicated Enterprise Service Bus (ESB) component. To ensure a fast, configurable and reliable integration between platform components, the ESB components need to provide following general functionality:

- Configuration of Publisher and Subscriber Services
- Authentication
- Transformation of messages
- Transaction support
- Logging and auditing
- Performance and scaling
- Asynchronous message delivery and message correlation
- Message signatures and trusted intermediaries
- Complementary development tools

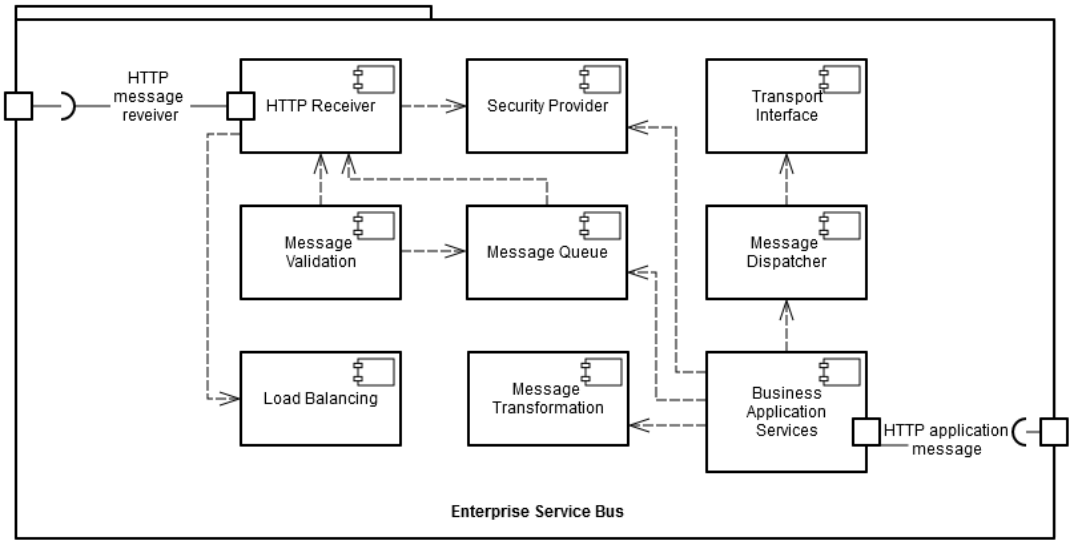


Figure 54. Enterprise Service Bus – High-level Component Architecture.

A more detailed specification of ESB component can be found in "D6.2 Platform Architecture and Design" document.

17.3 Integration with external data providers

Unifying different data sources is an instance of the well-known problem of *heterogeneous data integration,* which addresses the definition of coherent global views on top of multiple data sources, usually heterogeneous. Data integration is an extremely challenging matter, as it requires not only the collection of data from multiple data sources, but also the reconciliation of conflicts and inconsistencies.

Data are important assets for the SmartH2O platform as data are used to identify and understand user behaviour prior to applying models for inducing changes. Data integration is important for providing a unified view of the SmartH2O platform as data assets. The SmartH2O platform requires integrating data from several distributed sources, which are stored using various technologies and provide a unified view of the data. The main sources of data are:

- Smart Metered consumption periodically provided by the water utility in raw data files
- Social data extracted from the Social Media networks
- External databases and services that send data to SmartH2O platform:
  - Existing Customer portals of Water Utility
  - Other portals from the same Project Cluster with Smart H2O

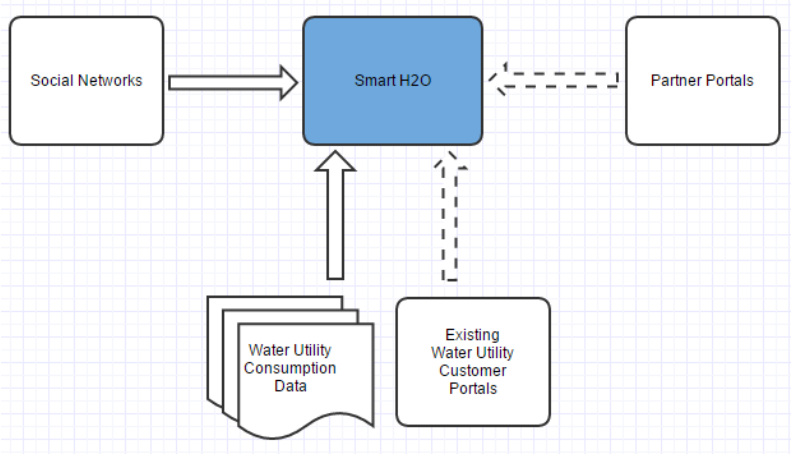


Figure 55. Integration of SmartH2O platform with external data providers.

Integration with Water Utility consumption data. The initial data integration necessity regards obtaining Smart Metered consumption provided by the water utility. This objective is implemented after achieving an agreement with the water utilities regarding the protocol for transferring the data files.

The integration with other Portals may be configured in the integration component (ESB) if those Portals are enabled to support service integration.

Integration of SmartH2O platform with external Portals will most probable need augmentation of current user database model.The scope of the current project is only to provide a flexible platform that allows easy extension of User database structure and configurable data integration via ESB component.

As a data consumer, SmartH2O platform may extend its database with additional geographical or psychographical attributes from external Portals. Such new attributes will be then made available in services layer of SmartH2O platform and will be ready for consuming applications. For example, additional consumer attributes can be made available for Business Dashboard component and will allow Admin user to build more refined user segments and set water saving actions for those segments.

As a data provider, the Smart H2O platform can be configured to expose in a controlled manner its data services to an external Portal. A trust relationship between Smart H2O platform and an external portal can be configured. An integration scenario as the one described above can be done within the project scope because it is based mostly on the flexibility built in Smart H2O platform architecture and design.

More specific and more complex integration scenarios that for example might require a process integration or process orchestration between SmartH2O platform and external Portals is not part of the current project's scope and it can be addressed as a distinct project.

SmartH2O platform also provides an authentication mechanism for external Portals implemented as OAUTH2 protocol. Trusted external Portals can be configured as trusted portals in SmartH2O platform to ensure authentication and authorization flows. A client request that is authenticated in a trusted external portal will be considered as authenticated also in Smart H2O platform. Authorization of different operations for a Client from an external portal will be subject of specific configuration at component level.

Incoming data from external Portal is required to be presented by the external Portal in a format that can be mapped on existing data structure of Smart H2O.

The integration component (ESB) is required to be able to manage the authentication between SmartH2O and external Portals using authentication models like SingleSignOn (SSO).

A more detailed description of integration with external sources can be found in “D6.2 Platform Architecture and Design” document.

17.4 Example of smart counter data file processing flow

The following describes an example flow of transferring, receiving, storing and processing of the smart counter files:

- Step1: The receiving partner (SETMOB) transmits to the providing partner (TWUL, SES) the parameters and credentials for accessing the Secured FTP (SFTP) server. The SFTP server resides in the DMZ of a data center protected by a FortiGate 300C router firewall.
- Step 2: The providing partner connects, authenticates and uploads the archive with files containing smart water counter readings to the SFTP server. After successfully receiving the archive, the SFTP server then moves the archive to the File Storage which resides in the non-DMZ LAN of the data center.
- Step 3: The providing partner will upload the MD5 signature of the uploaded archive. This will be used by the receiving partner for successfully validating the file transfer.
- Step 4: The *Smart Meter Data Management* Component running on the SmartH2O development server process the archive and stores the data from the data files in a local data base protected by a build-in security layer.
- Step 5: After processing, the archive received from the providing partner is automatically encrypted and moved in a dedicated zone on File Storage. A log will be available for the providing partner to acknowledge the outcome of the process.
- Step 6: The data saved in the database is accessed, processed and displayed by user/password authenticated applications according to the business logic.

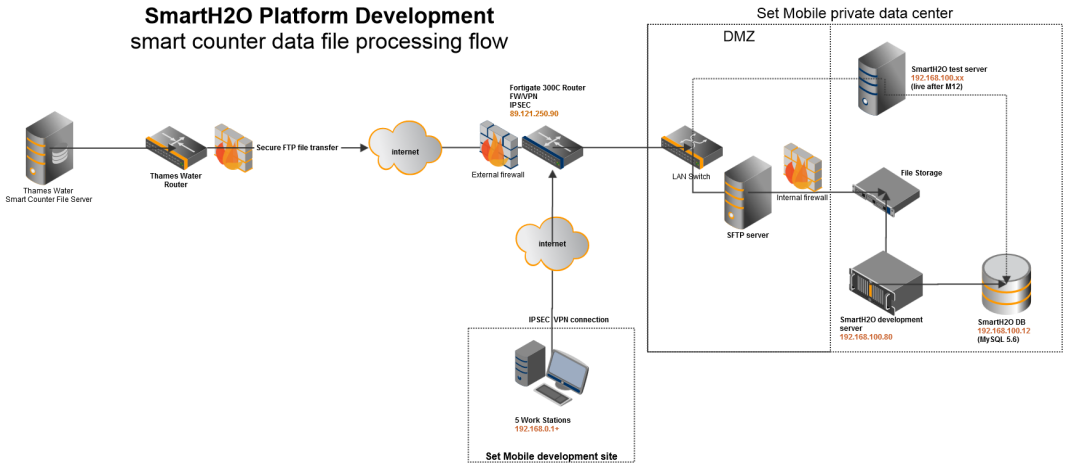


Figure 56. SmartH2O platform development: smart counter data file processing flow.

The data governance policy implemented at the premises of SETMOB - as the partner in charge with the SmartH2O platform development and integration - defines the technical solutions to protect the data files received from the partners during the work flows of the development phase. It regards:

a. Data in transit (data that is transferred between the SmartH2O development server and other network nodes)
   - Firewall FortiGate 300C. No external non-authorized access;
   - IPSEC VPN access for listed IPs. The partners will send their authorized IP addresses. They will receive a ready configured VPN client. The partners will connect through VPN in order to access the platform applications and services;

- *Secured FTP* to upload data files to the SmartH2O development server. The FTP server uses a custom configuration;
- Secured HTTP for application access over the internet;
- User / password authentication for application access over the internet;

b. Data in use (active data under constant change, stored in RAM)
   - Processing data on unique physical server with unique external IP;
   - Setting access rights for data manipulation at application level;
   - Implementing encryption protocols for accessing data via web-services;
   - Application *whitelistening*;

c. Data at rest (inactive data)
   - Private datacenter with limited access (4 IT staff) card based;
   - Unique IT admin for the SmartH2O development server;
   - Policy of No Off-site data backup allowed.

18. Conclusions

In this deliverable we have refined the requirements guiding the development of the SmartH2O applications. We have described a number of different narrative user stories, which are relevant for and have been evaluated with end-users. For this, we considered both application scenarios:

- Saving water by raising social awareness.
- Saving water by innovative pricing schemes.

In particular, this document has specified the final requirements and use cases for the SmartH2O applications applying a human-centred development process. Section 2 has described the process leading up to the final requirements specification based on the early requirements and use cases presented in D2.1. The final user stories are described in Section 3, and the final mock-ups in section 4, identifying the following main applications:

- The Basic Customer Portal “Visual Water Meter”.
- The Advanced Customer Portal “Gamified & Social Water Meter”.
- The Games Platform consisting of the Card Game “Drop!” and its digital mobile game app extension.
- The Business Dashboard with a “Customer Consumption Monitor”
- The Agent-based Customer Consumption Simulator

On the one hand, the envisioned applications aim to engage domestic water consumers of all ages, and of different technology-, data- and game- affinity, and to stimulate water saving by raising social awareness. Means to implement this include the provision of easy meter data access, basic water saving tips and alerts, different complexity and information levels of consumption visualization, and engaging customers in a gamified and social environment: There, users can earn points through their water saving actions, and gain social reputation badges and real rewards through their points. They can also compare their own saving efforts to past and average consumption, to different water saving goals and to others’ water saving efforts, and positively influence their environment by saving water in teams. A specially developed type of a digitally augmented card game, Drop!, will engage even the youngest family members in water saving activities. Utilities will have means to monitor the consumption behaviour of their customers closely, to stimulate them with targeted reward schemes, and to simulate their strategies in advance of implementation.

On the other hand, the applications will also enable the consumers and utilities to gain knowledge on current and new pricing schemes and to predict future water consumption based on new pricing schemes in order to maximize water savings.

From the conceptualized user stories and mock-ups, we have derived a user model, high level functional and non-functional requirements, as well as use cases with functional requirements. In a separate section, we have formulated success criteria based on which the applications will be evaluated: key performance indicators, technology acceptance criteria, user-based performance indicators and technical success criteria. We have also stressed that the user-centred evaluation focuses on the second project objective: Conserving water by raising social awareness. We aim at measuring consumption decrease on the one hand and assessing awareness increase among customers who have used the portal, both on the main applications level as well as by considering specific human-computer interactions.

Finally, software integration requirements have been specified to align the implementation process with integration with the water utilities’ system infrastructure from the start. These will be finalized in D2.3 Functional specification of the SmartH2O platform.

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20. Appendix A: User groups specification

Name	**User**
Description	The user of the SmartH2O system, who can be either a consumer using the services provided or an admin who manages the content or monitors the system.
Profile Data	Username, Password, Email
Super-group	-
Sub-group	Consumer, Admin
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in content management mode	-

Name	**Consumer**
Description	Generic consumer user who may want to exploit the services provided by the SmartH2O system (Customer Portal, Gamified Customer Portal or Games Platform). A Consumer is not yet registered to any service of the system.
Profile Data	No profile required, they are not yet registered.
Super-group	User
Sub-group	Player, Customer
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in content management mode	-

Name	**Player**
Description	User who plays the games provided by the SmartH2O system.

Profile Data	No profile required, they are not yet registered.
Super-group	Consumer
Sub-group	CasualPlayer, RegisteredPlayer
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in content management mode	-

Name	**CasualPlayer**
Description	Not registered visitor interested in playing a game.
Profile Data	No profile required, they are not yet registered.
Super-group	Player
Sub-group	CustomerPlayer
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in content management mode	-

Name	**RegisteredPlayer**
Description	Player registered to the Games Platform.
Profile Data	Username, Password, Email.
Super-group	Player
Sub-group	CustomerPlayer
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in	-

content management mode	

Name	**CustomerPlayer**
Description	User who is registered both to the Gamified Customer Portal and the Games Platform. He has the possibility to collect points either by performing actions provided in the Gamified Customer Portal or by playing the available games.
Profile Data	
Super-group	RegisteredPlayer, Competitor
Sub-group	-
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in content management mode	-

Name	**Customer**
Description	User registered to the Customer Portal, who accesses in order to monitor his water consumption and make use of the other services provided by the application.
Profile Data	Username, Password, Email, First Name, Last Name, Birth Date, Registration Date, Educational Level, Income Rate, Currency.
Super-group	Consumer
Sub-group	StandardMetered, SmartMetered
Use cases	See section 7
Objects accessed in read mode	House, Meter Reading, Bill, Weather Condition, Tip, MediaAsset.
Objects accessed in content management mode	House.

Name	StandardMetered
Description	Customer not having smart meters system installed in his house. The user needs to manually input consumption data into the system.
Profile Data	Username, Password, Email, First Name, Last Name, Birth Date, Registration Date, Educational Level, Income Rate, Currency.
Super-group	Customer
Sub-group	Competitor
Use cases	See section 7
Objects accessed in read mode	House, Meter Reading, Bill, Weather Condition, Tip, MediaAsset.
Objects accessed in content management mode	House, Meter Reading.

Name	SmartMetered
Description	Customer having smart meters system installed in his house. The water meter measures the customer's water consumption automatically.
Profile Data	Username, Password, Email, First Name, Last Name, Birth Date, Registration Date, Educational Level, Income Rate, Currency.
Super-group	Customer
Sub-group	Competitor
Use cases	See section 7
Objects accessed in read mode	House, Meter Reading, Bill, Weather Condition, Tip, MediaAsset.
Objects accessed in content management mode	House.

Name	Competitor
Description	Customer who accepted to participate to the gamification mechanisms, including execution of actions, acquisition of

	badges and redemption of rewards.
Profile Data	Username, Password, Email, First Name, Last Name, Birth Date, Registration Date, Educational Level, Income Rate, Currency, Photo, Bio, Total Credits, Participation Points, Participation 7 days.
Super-group	StandardMetered, SmartMetered.
Sub-group	CustomerPlayer
Use cases	See section 7
Objects accessed in read mode	House, Meter Reading, Device, Device Consumption, Bill, Weather Condition, District, Thematic Area, Action Type, Action Instance, Badge Type, Badge Instance, Reward Type, Reward Instance, Tip, Goal.
Objects accessed in content management mode	House, Device Consumption, Action Instance, Badge Instance, Goal.

Name	**Admin**
Description	Generic administrator of the SmartH2O services.
Profile Data	Username, Password, Email.
Super-group	User
Sub-group	Player, Customer
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in content management mode	-

Name	**Content Editor**
Description	Administrator in charge of creating the content of the applications composing the system.
Profile Data	Username, Password, Email.
Super-group	Admin

Sub-group	GamificationEngineContent&RulesEditor, GamesPlatformCE, ConsumerPortalCE.
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in content management mode	-

Name	**GamificationEngineContent&RulesEditor**
Description	Editor in charge of creating the content related to the Gamified Customer Portal (the one used by Competitor users) such as actions, rewards and goals. The user is also in charge of defining the rules to assign the suitable amount of points to each action.
Profile Data	Username, Password, Email.
Super-group	ContentEditor
Sub-group	-
Use cases	See section 7
Objects accessed in read mode	Goal, Action Type, Badge Type, Reward Type.
Objects accessed in content management mode	Goal, Action Type, Badge Type, Reward Type.

Name	**GamesPlatformCE**
Description	Editor in charge of creating the content related to the games, such as the questions provided in a quiz game related to generic water consumption topics.
Profile Data	Username, Password, Email.
Super-group	ContentEditor
Sub-group	UtilityGamesPortalCE
Use cases	See section 7
Objects accessed in read	Question, Answer

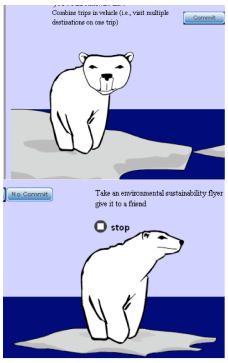
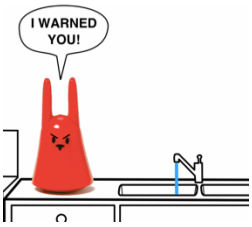
mode	
Objects accessed in content management mode	Question, Answer

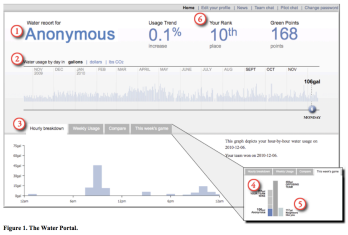
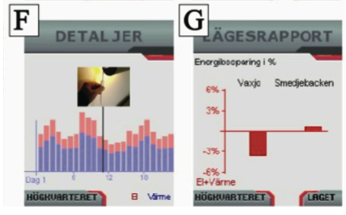
Name	**UtilityGamesPlatformCE**
Description	Editor in charge of creating the content of games related to a specific utility. For example they manage the specific questions provided in a quiz game with subjects of interest to the utility.
Profile Data	Username, Password, Email.
Super-group	GamesPlatformCE
Sub-group	-
Use cases	See section 7
Objects accessed in read mode	UtilityQuestion, UtilityAnswer
Objects accessed in content management mode	UtilityQuestion, UtilityAnswer

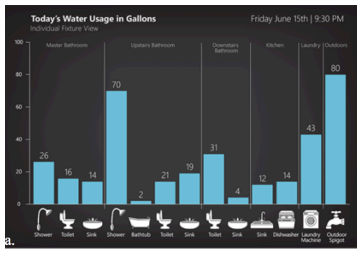
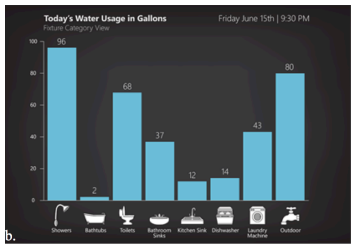
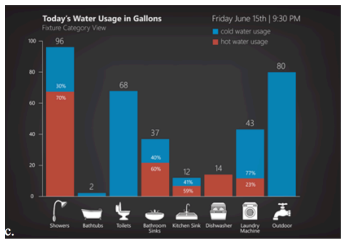
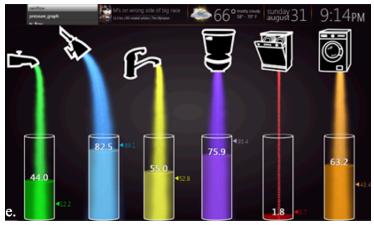
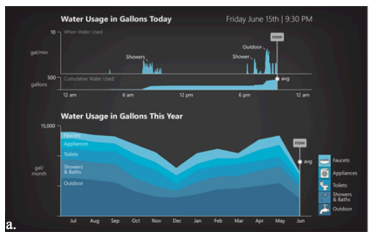
Name	**ConsumerPortalCE**
Description	Editor in charge of creating the content related to the platform used by Customer users, such as tips to improve water saving, teaching videos.
Profile Data	Username, Password, Email.
Super-group	ContentEditor
Sub-group	-
Use cases	See section 7
Objects accessed in read mode	Tip, MediaAsset
Objects accessed in content management mode	Tip, MediaAsset

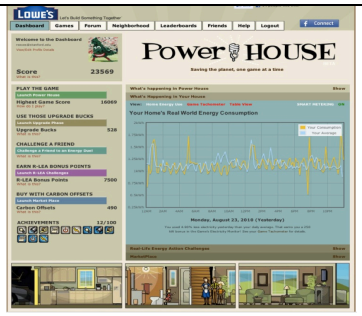
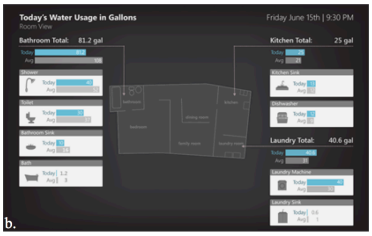
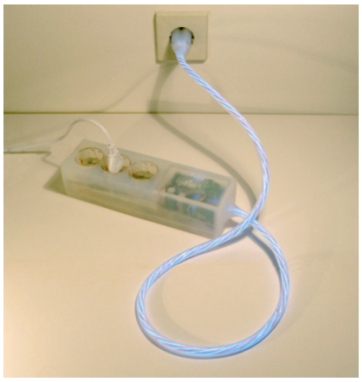
Name	**UtilityAdmin**
Description	Administrator in charge of monitoring consumption data, also profiling users in customer segments, and simulating user consumption based on some parameters.
Profile Data	Username, Password, Email.
Super-group	Admin
Sub-group	-
Use cases	See section 7
Objects accessed in read mode	-
Objects accessed in content management mode	-

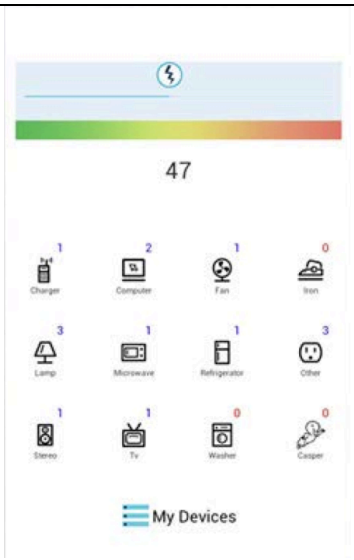
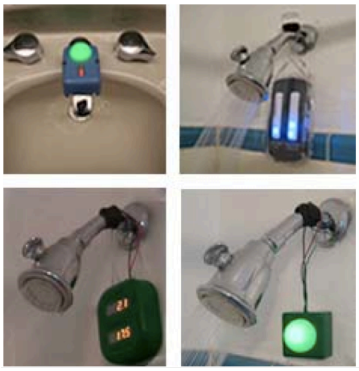
21. Appendix B: State-of-the-art overview of water and energy consumption visualization models

Concept	Visualization	Description	Reference
Animals / creatures	**Polar bear** 	Amphiro shower meter: Ice berg underneath polar bear melts the more energy is consumed	[Amph2014]
		Flash-based virtual polar bear on ice floe melts according to energy consumption	[Dill2008]
	Bunny (Nag-Baztag) 	Physical “personified” smart object that reacts to good/bad energy consumption behavior by color change, audio & ear gesture	[Kirm2010]
	Monster blob habitat 	Virtual climate environment. Goal: keep monster healthy; data for controlling the climate comes from energy usage in the player’s home. Power events such as turning something on -> weed growing up; turning something off -> flowers growing. Plants are good/bad food for monster blob. grey cloud in sky -> levels of CO_2	[Gust2009a]

	Fish tank / aquarium 	Focuses on water savings and reaching water savings goals for different fixtures in the home. When goals are met, the ecosystem evolves in a positive manner, for example, by adding a fish or more vegetation. They did not explore punishment scenarios specifically	[Froe2012]
Per occupant abstract view	**Bubbles** 	Shower calendar shows consumption per shower per occupant based on a bubble that decreases the more water is used; consumption is visible to all family members; raises individual & collective awareness	[Lasc2011]
	Charts (bar & other) 	Per-Occupant view shows water usage broken down by occupant for the current day and past month; shows graph per occupant	[Froe2012]
Graphs	**Bar graph overall usage**  Figure 1. The Water Portal.	Dubuque water portal measures water via smart meters and presents information in online portal as histogram	[Eric2012]
		Power Agent; players are special agents who team up to investigate energy consumption. Visualization of consumption just as bar charts	[Gust2009b]

	Bar graph at fixture level    	At fixture level; alternatively: at individual fixture level, hot/cold water differentiation, by activity rather than fixture	[Froe2012]
	 	"Gamified" bar graphs with colored water flowing into them the more you consume; bars can overflow from too much water being used (e.g. compared to set goal)	[Froe2012]
	Temporal graph  	Shows different time series	[Froe2012]
	Temporal line graph	Power house: shows consumption vs. average	[Reev2012]

			
House	**Floor plan** 	The Spatial view uses a floor plan to show room-level and fixture-level usage	[Froe2012]
Ambient Appliances	**Glowing power cord** 	The power-aware cord gives ambient feedback by visualizing the use of energy through glowing pulses and intensity of light	[Gust2005]
	Ambient lights on shower head 	Show-me: LED bar integrated in shower cabin; more LEDs for increasing consumption	[Kapp2009]
Misc	**(Energy) Ghost detector**	The Ghost Hunter app indicates the strength of an electro-magnetic field (top) using a combination of visual, auditory, and haptic feedback	[Bane2014]

			
	Traffic Signal 	Ambient display at appliance level that uses traffic signal metaphor	[Kuzn2010]
	Quantitative consumption metaphors 	Daily consumption in milk cartons, weekly – bath tubs, monthly – oil truck loads; yearly – water tower	[Froe2012]