

# Water saving tips, peer pressure, and gamification: long-term behavior change and rebound effects from a long experimental trial

Andrea Cominola<sup>1</sup>, Matteo Giuliani<sup>2</sup>, Andrea Castelletti<sup>2</sup>, Piero Fraternali<sup>2</sup>, Andrea Emilio Rizzoli<sup>3</sup>, and Joan Guardiola<sup>4</sup>

<sup>1</sup>Technische Universität Berlin - Einstein Center Digital Future

<sup>2</sup>Politecnico di Milano

<sup>3</sup>Scuola universitaria professionale della Svizzera italiana

<sup>4</sup>Global Omnium

November 24, 2022

## Abstract

Demand-side management strategies based on customized feedback have proved their worth in supporting water conservation efforts and behavior change programs. Several studies in both the water and energy sectors report of observed short-term savings deriving from feedback-based programs and awareness campaigns, often based on smart metered data and high levels of customization in presenting information on resource usage to users in the form of past consumption, real-time information, peer comparison, analogies, and resource saving tips. Yet, feedback-based programs are often run as part of experimental trials with a limited duration, and their effectiveness is therefore only evaluated for a short time span, potentially overlooking rebound effects. Assessing the long-term effect of feedback information on behavior change is still an open research question. In this work, we analyze the long-term impacts of a smart-meter fed gamified ICT platform providing customized feedback to water users, which was deployed starting in 2014 in a long experiment trial with over 200 users of the Global Omnium utility in Valencia (Spain). The platform core is a data-driven demand management pipeline that enables water utilities to foster consumer engagement and promote water conservation via customized feedbacks. It includes customized water saving tips, peer-comparison of water usage, and a reward program based on gamification tools and mechanisms. After three years of development and testing from 2014 to 2017, the platform has proven to be very effective in the short-term, when a user is engaged. A 5.7% volumetric water use reduction among Global Omnium users was achieved after the first year of full implementation, along with a 20% approximate water consumption difference with respect to non-platform users. Here, we analyze the smart meter data of the platform users, respectively after one and two years from the end of the funded platform trial period, to assess long-term behavior changes and rebound effects on different groups of platform adopters.



# Water saving tips, peer pressure, and gamification: long-term behavior change and rebound effects from a long experimental trial

H43P-2293

Andrea Cominola<sup>1,2</sup>, Matteo Giuliani<sup>3</sup>, Andrea Castelletti<sup>3</sup>, Piero Fraternali<sup>3</sup>, Andrea Rizzoli<sup>4</sup>, Joan Carles Guardiola Herrero<sup>5</sup>

1. Chair of Smart Water Networks | Technische Universität Berlin | Berlin (DE), 2. Einstein Center Digital Future | Berlin (DE), 3. Department of Electronics, Information and Bioengineering | Politecnico di Milano | Milano (IT), 4. Dalle Molle Institute for Artificial Intelligence Research, SUPSI | Manno (CH), 5. Global Omnium | Valencia (ES)

## THE sH<sub>2</sub> PROJECT

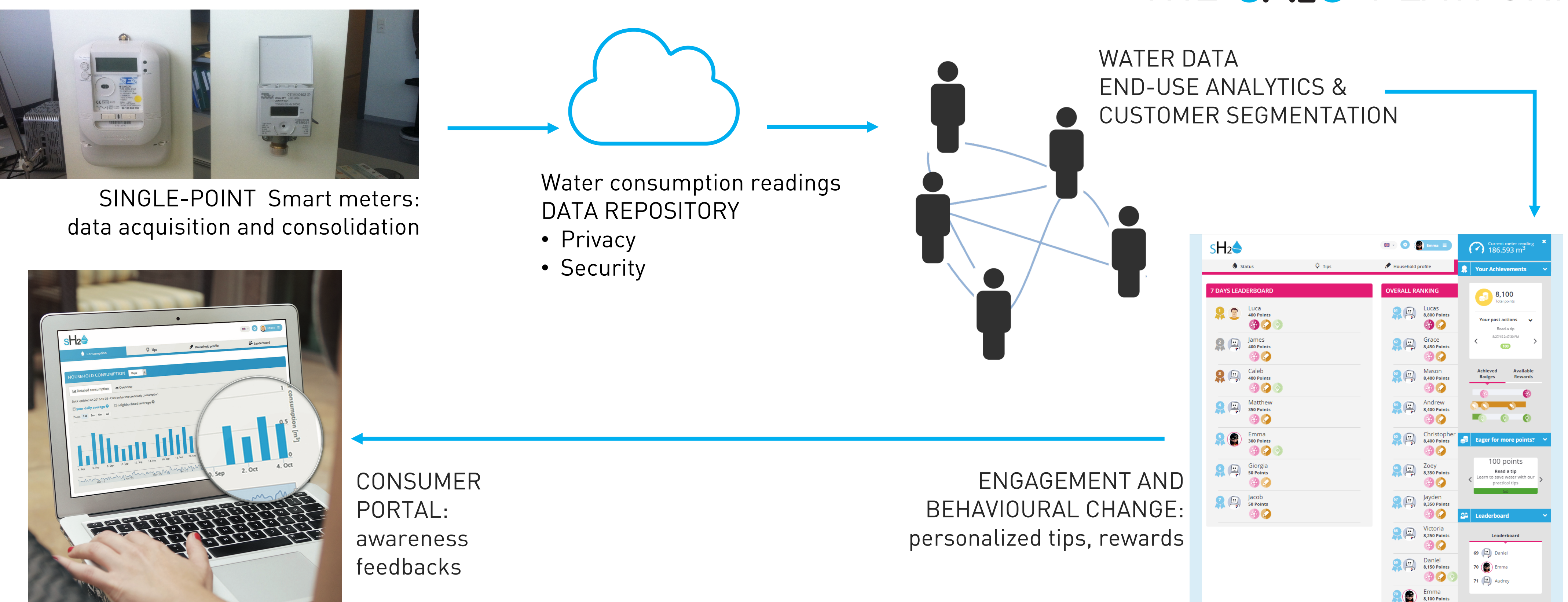
**GOAL** Study, understand and modify consumer behavior to achieve quantifiable water savings by raising consumer awareness and by the design and implementation of customized feedback, peer pressure mechanisms and water saving tips, thus also improving the operational efficiency of water utilities.

**CONCEPT** Developing an ICT platform to improve the management of urban and peri-urban water demand. The SmartH2O ICT platform enables water managers and utilities to close the loop between actual water consumption levels and desired targets, through:

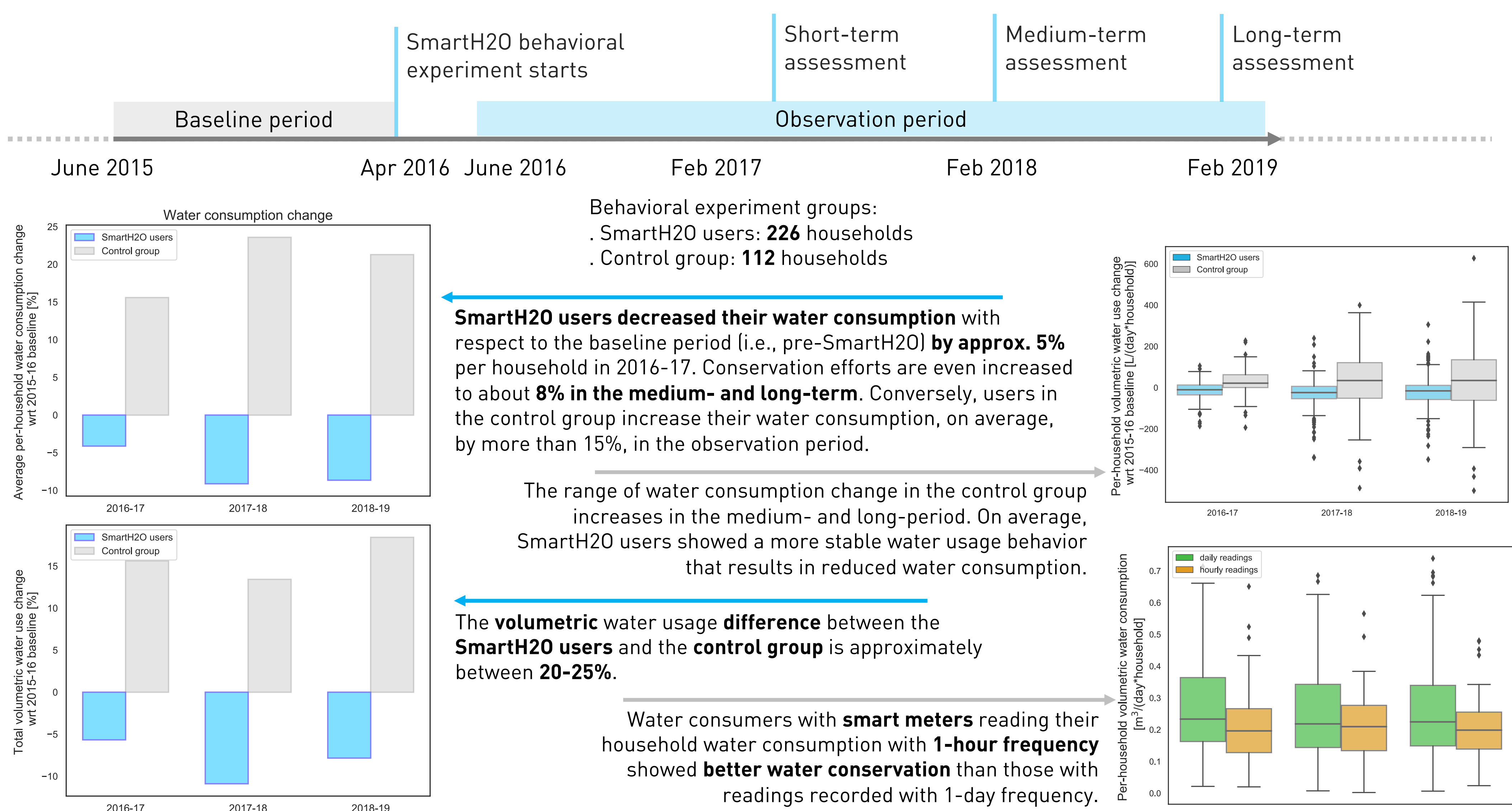
- . understanding and modeling water consumers' behaviour, based on historical and sub-daily water usage data
- . modelling how the consumer behaviour can be influenced by various Water Demand Management Strategies, such as customized feedbacks
- . raising users' awareness to pursue water use efficiency in the residential sector

**CORE ELEMENTS** Sub-daily water consumption readings, interaction with customers for information sharing and socio-psychographic data gathering, data-intensive modelling, gamification.

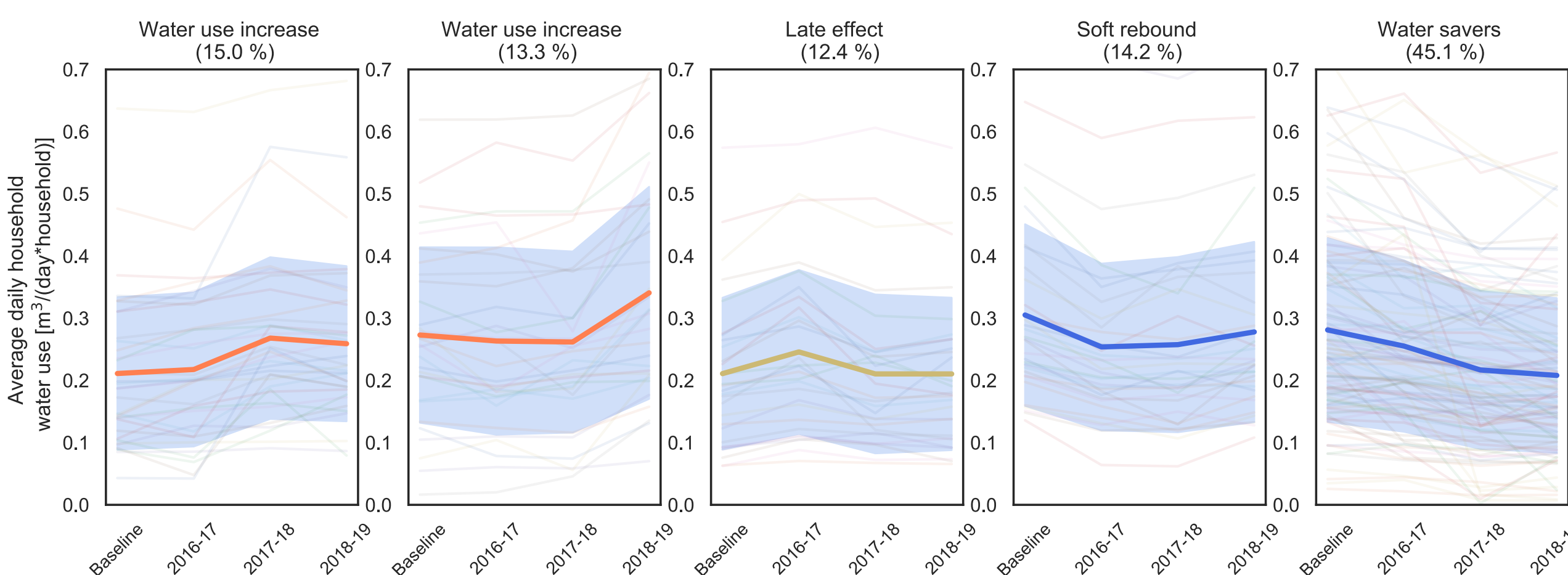
## THE sH<sub>2</sub> PLATFORM



## SHORT- & LONG-TERM BEHAVIOR CHANGE OUTCOMES IN VALENCIA



## CUSTOMER SEGMENTATION ANALYSIS



Among the SmartH2O users, we identified 5 clusters of water users by means of data-driven hierarchical clustering based on correlation distance. From the left, in the figure:

- . **Water use increase** (clusters 1 and 2): no water conservation effects are visible
- . **Late effect** (cluster 3): water conservation slightly starts in the medium-/long-term, but it is not very evident
- . **Soft rebound** (cluster 4): water conservation in the first period, followed by a rebound period with water consumption going back to pre-treatment levels
- . **Water savers** (cluster 5): water conservation starts early in the observation period and even improves in the medium- and long-term. These are the **majority**, approx. **45%** of all users.

## TAKE-HOME CONCLUSIONS

- . SmartH2O has demonstrated to be effective in the short-term: the SmartH2O users conserved more water than the users in the control group and used less water than before the start of the SmartH2O program.
- . Medium- and long-term water conservation effects persist for the majority of users (~45%), while rebound effects are visible for about 14% of the users.

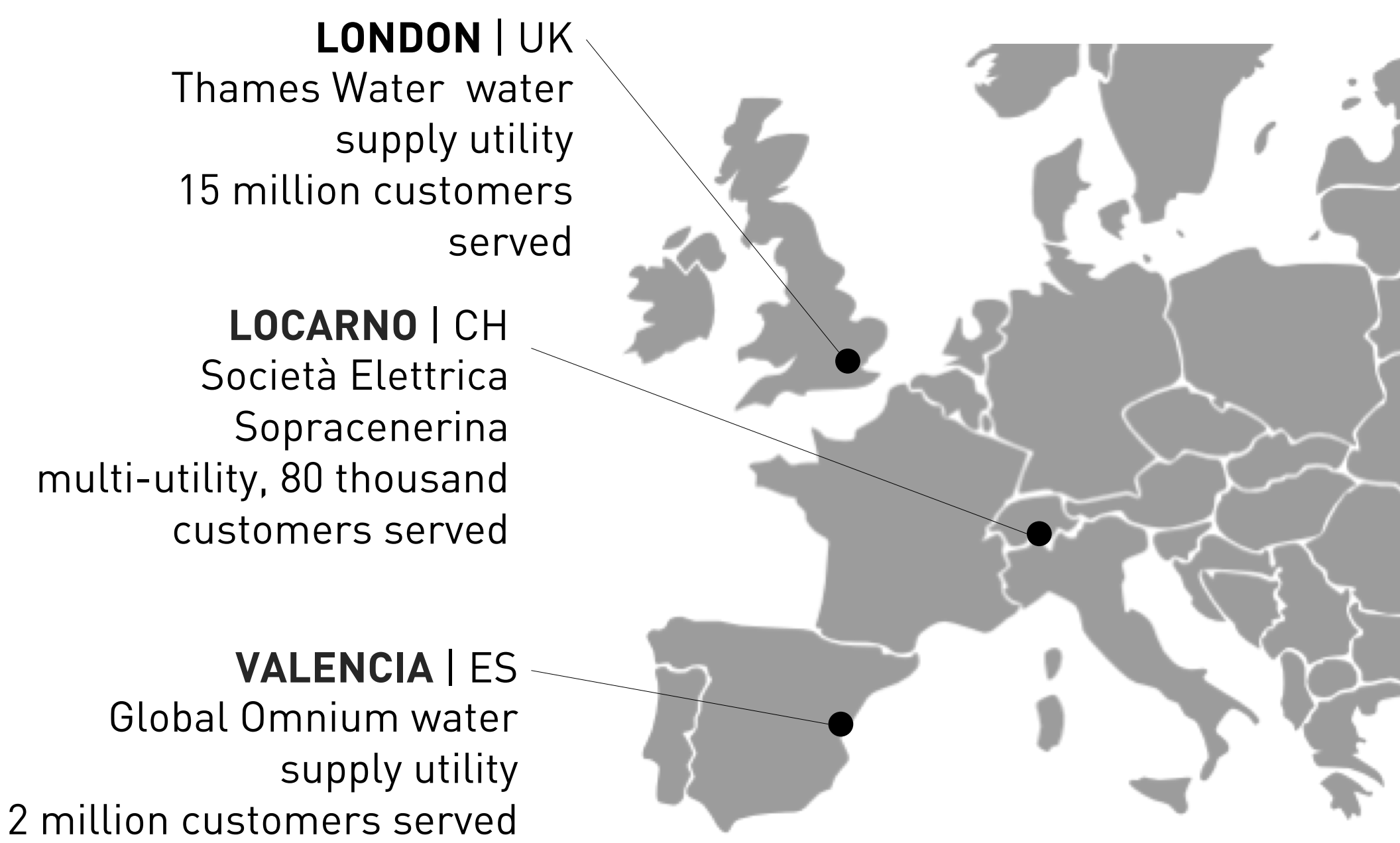
## Related literature

Cominola, A., Nguyen, K., Giuliani, M., Stewart, R. A., Maier, H. R., & Castelletti, A. (2019). Data mining to uncover heterogeneous water use behaviors from smart meter data. *Water Resources Research*, *in press*.

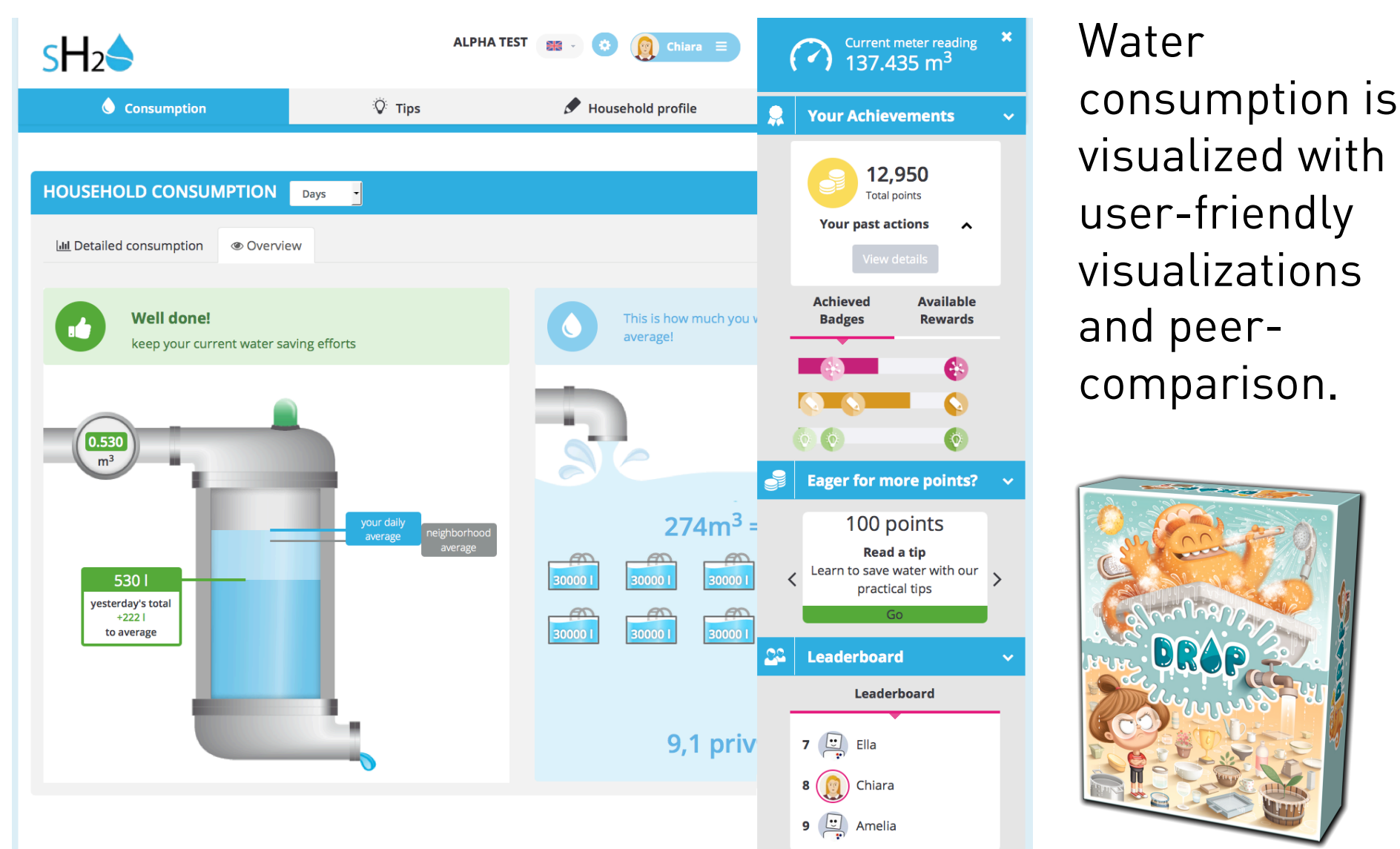
Cominola, A., Giuliani, M., Piga, D., Castelletti, A., & Rizzoli, A. E. (2015). Benefits and challenges of using smart meters for advancing residential water demand modeling and management: A review. *Environmental Modelling & Software*, 72, 198–214.

Stewart, R. A., Nguyen, K., Beal, C., Zhang, H., Sahin, O., Bertone, E., Vieira, A. S., Castelletti, A., Cominola, A., Giuliani, M., Giurco, D., Blumenstein, M., Turner, A., Liu, A., Kenway, S., Savić, D. A., Makropoulos, C., & Kossieris, P. (2018). Integrated intelligent water-energy metering systems and informatics: Visioning a digital multi-utility service provider. *Environmental Modelling & Software*, 105, 94–117.

## USE CASES



## GAMIFICATION



The SmartH2O user awareness portal includes a smartphone app and gamification mechanisms to promote water conservation behaviors.

