Exploratory research
BTO 2021.066| December 2021

Outcomes - SMART Water Conservation

Bedrijfstakonderzoek

KWR

Bridging Science to Practice

Rapport

Outcomes Water SMART Conservation

BTO 2021.066| April 2021

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Opdrachtnummer
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Projectmanager
Geertje Pronk

Opdrachtgever
BTO - Verkennend onderzoek

Auteur(s)
Dr. Koop, S.H.A.; Hillebrand, B. MSc; Clevers, S.H.P. MSc; Pan, Q. MSc; Dr. Blokker, E.J.M.; Dr. Brouwer, S.

Kwaliteitsborger(s)
Prof. Van Leeuwen K.

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Meer informatie
..
T +31 6 54294476
E stef.koop@kwrwater.nl

PO Box 1072
3430 BB Nieuwegein
The Netherlands

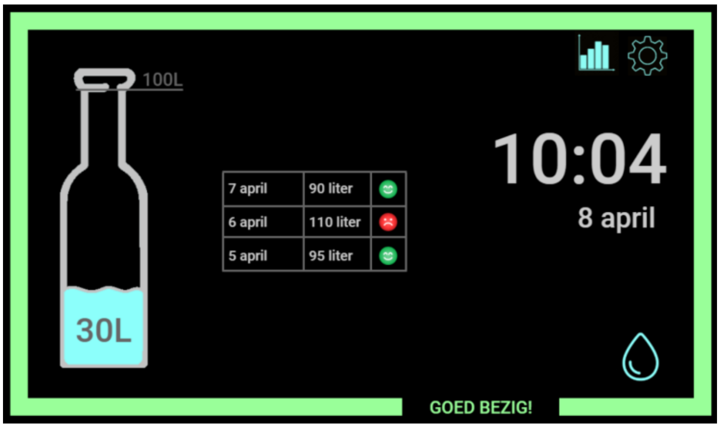
T +31 (0)30 60 69 511
F +31 (0)30 60 61 165
E info@kwrwater.nl
I www.kwrwater.nl

Managementsamenvatting

WaterInzichtPakket maakt klantgerichte slimme waterbesparing mogelijk

Auteur(s) Stef Koop, Bram Hillebrand, Sharon Clevers, Quan Pan, Mirjam Blokker en Stijn Brouwer.

Huishoudelijke (drink)waterbesparing kan een belangrijke bijdrage leveren in de omgang met droogte, een stijgende watervraag en toenemende druk op drinkwaterbronnen. De inzet van digitale meters is hiervoor veelbelovend, maar alleen als ze meer bieden dan enkel het terugkoppelen van het waterverbruik. Op basis van gegevens uit 50 huishoudens met een volumestroom datalogger is een methode ontwikkeld om waterverbruik van douche, toilet, of wasmachine te onderscheiden. Hiermee kunnen automatisch feedback en tips worden gegeven die volledig aansluiten bij iemands thuissituatie, waterverbruikspatroon en drinkwaterperspectief. Dit WaterInzichtPakket (WIP) is een softwareapplicatie gekoppeld aan een digitale watermeter en een datalogger, en biedt een gebruikersmenu waarvan de boodschappen slim inspelen op de wensen en behoeften van verschillende klanttypen. De koppeling met de digitale watermeter en logger is nog niet gerealiseerd, maar een proof-of-principle is wel geleverd. Aangezien uit onze enquête blijkt dat 78% van de 1037 ondervraagden een aanbod van een digitale watermeter direct zou accepteren, lijkt het veelbelovend om de WIP verder te ontwikkelen en toe te passen.



Water Inzichtpakket (WIP) bestaat uit een digitale watermeter, datalogger, gebruikersscherm en een software-applicatie waarin feedback slim inspeelt op verschillende klanttypen.

Belang: Huishoudelijke waterbesparing essentieel voor droogtemitigatie
De recente droogteperiodes zijn een duidelijke 'wake-up call' geweest voor (drink)waterbesparing. Naast lagere consumptie door zakelijke klanten, is ook huishoudelijke waterbesparing nodig om voorbereid te zijn op droogte, een stijgende watervraag en toenemende druk op waterbronnen. Mensen zijn echter niet zomaar overtuigd dat zij water moeten besparen. Gelukkig laten internationale studies zien dat een slimme toepassing van digitale watermeters gecombineerd met gedragswetenschappelijke inzichten veel mogelijkheden biedt. Tot nu toe was toepassing van digitale meters meestal beperkt tot enkel het terugkoppelen van verbruiksgegevens met vaak een beperkt effect op besparing. Een reden daarvoor is dat huidige toepassingen geen rekening houden met het feit dat tips, aansporingen en herinneringen alleen helpen bij het veranderen van gedrag als zij inspelen op iemands i) bestaande gedragspatronen en ii) houding ten aanzien van drinkwater.

Aanpak: Hoogfrequente digitale watermeter, klantperspectieven en algoritme in één WIP
In deze studie zijn technische mogelijkheden en publieke perceptie rond drinkwater en digitale meters gecombineerd voor de ontwikkeling van een

concreet WaterInzichtPakket (WIP) dat huishoudens maximaal kan helpen water te besparen. Het pakket omvat onder meer een hoogfrequente digitale watermeter die waterverbruikspatronen nauwkeuriger kan monitoren en ze met een algoritme classificeert om feedback te geven die volledig aansluit op iemands dagelijkse handelingen. Op basis van data van 50 huishoudens waarbij het waterverbruik per 0,1 L per seconde is gemeten, is een methode ontwikkeld om specifiek waterverbruik zoals douche, toilet, of wasmachine te onderscheiden. Ook is een CO_2-calculator ontwikkeld voor het verwarmen van drinkwater in de douche en wasmachine. Omdat iedereen anders is, is het essentieel slim in te spelen op persoonlijke wensen en behoeften. Werken vanuit vier (eerder ontwikkelde) klantperspectieven biedt een snelle en duidelijke manier om dat te doen. Zo kunnen de boodschappen die individuele klanten krijgen goed inspelen op precies datgene wat deze klant overtuigend vinden. Een raamwerk van boodschappen is ontwikkeld, toegespitst op de vier klantperspectieven, type waterverbruik en/of de waterbesparingsdoelstelling gehaald is of niet. Deze boodschappen zijn getest in focusgroepen. Tot slot is met een uitgebreide vragenlijst onder 1037 klanten onderzocht in hoeverre mensen openstaan voor de installatie van digitale watermeters.

Resultaten: Slimme toepassing digitale watermeters veelbelovend voor waterbesparing

Het WaterInzichtPakket is als proof-of-principle ontwikkeld en bestaat uit een digitale watermeter met een hoge resolutie, een datalogger met een hoge frequentie, een gebruikersmenu en een softwareapplicatie. In het prototype worden achterliggende rekenmethoden en een raamwerk van boodschappen gecombineerd om geautomatiseerd en gericht feedback en tips te geven die volledig aansluiten bij de thuissituatie, waterverbruikspatronen en het drinkwater-perspectief van de individuele klant. Ook bevatten de boodschappen tal van gedragsnudges. Nudges zijn duwtjes in de goede richting door de goed keuze makkelijker en aantrekkelijker te maken. Door de gedragsnudges wordt de effectiviteit verhoogd. De koppeling met de digitale watermeter en logger moet nog worden gerealiseerd. De enquête over de publieke perceptie van digitale watermeters laat zien dat 93% van de ondervraagden geen bezwaar heeft tegen investering van het waterbedrijf in digitale watermeters en dat 78% een aangeboden digitale watermeter direct zou accepteren. Tot slot blijkt het klantperspectief een goede voorspeller van iemands besparingsbereidheid. Dit biedt mogelijkheden om het WaterInzichtPakket of andere software-applicaties bij digitale meters gerichter aan te bieden en zo het waterbesparingspotentieel te verhogen.

Toepassing: Experimenteer nú met slimme toepassingen van digitale meters

Het ontwikkelde WaterInzichtPakket is een veelbelovend proof-of-concept omdat het gebruikmaakt van de technische mogelijkheden én optimaal rekening houdt met het gedrag, wensen en behoeften van klanten. Het mock-up scherm combineert i) het ontwikkelde algoritme dat waterverbruikspatronen onderscheidt, ii) de klantperspectieven die het type feedback bepalen en iii) gedragswetenschappelijke inzichten die helpen boodschappen effectiever over te brengen. Deze componenten zijn zorgvuldig samengebracht om de klant optimaal te helpen bij het besparen van drinkwater. Het WaterInzichtPakket moet verder worden ontwikkeld om de effectiviteit op langere termijn aan te tonen. Andere (internationale) experimenten met digitale watermeters maken geen onderscheid tussen klantperspectieven, exact gebruik (douche, toilet of wasmachine), sluiten niet aan op de Nederlandse en Vlaamse context en koppelen in veel gevallen alleen watergebruik terug, zonder gedragsprincipes toe te passen. Met het oog op de toekomst is het daarom essentieel experimenten te starten met deze ‘slimme’ vorm van digitale watermeters.

Rapport

Dit onderzoek is beschreven in het rapport *Follow-up plan Water SMART Conservation* (BTO 2021.066).

- Koop SHA, Clevers SHP, Blokker EJM en Brouwer S (2021) *Public Attitudes towards Digital Water Meters for Households*. Sustainability 13, 6440
- Brouwer S, van Aalderen N, Koop S (2020) *Waterbesparing door burgers: welke maatregelen zijn mogelijk en hoe overtuig je mensen?* H_2O

Meer informatie

T +31 6 54294476
E stef.koop@kwrwater.nl

PO Box 1072
3430 BB Nieuwegein
The Netherlands

Inhoud

1 Project outcomes – a readers outline

1.1 Short introduction

Internationally, there are various software developments (e.g. apps of online platforms) that, with the help of digital and remotely readable water meters (sometimes referred to as "smart meters"), are trying to persuade households to use less water. By combining water use feedback with water saving tips and applying various behaviour influencing tactics, households are encouraged to use less water. These types of concepts have proven effective in reducing water consumption in a large number of experiments abroad (click here for an overview). In the Netherlands, there is little experience regarding such experiments, neither are there elaborate experiences with public campaigns for saving water. At the same time, KWR has a lot of knowledge about household water consumption (for example, SIMDEUM). That is why new water-saving software applications that are developed by KWR, can be a major added value both for the Dutch and Flemish drinking water companies as well as for KWR's international research ambitions.

1.2 How does this project integrate different approaches and (scientific) disciplines?

With the SIMDEUM tool the 'normal' water demand can be simulated in order to test and optimize the influence and functioning of a water-saving software application. Although, from the literature's point of view, this seems like a promising way in which drinking water companies can manage water demand in a targeted manner, this, certainly in the Dutch drinking water context, is unexplored territory and therefore its practical application has to be examined. Needless to say, different customers are receptive to different messages. Accordingly, this project differentiates between different user categories based on, amongst other things, insight in modern customer segmentation and demographic data. Tailored messages will be formulated for each of these categories. As such, this project will enable a SMART feedback mechanism, whereby individual customers will receive messages that are Specific (i.e. tailored/personalised), Measurable (as a result of the development of automatic monitoring indicators), Attainable (by means of a combination of behaviour change options and applications), Realistic (based on state-of-the-art data), and Timely (at a moment and interval period preferred by the individual customer). Accordingly, this project aims to provide an integrated architecture that can be applied to persuade households to reduce their water consumption.

1.3 Projects' structure

The exploratory research 'SMART domestic water conservation' is structured around six Work Packages (WPs), as depicted in (Figure 1). The task within WP2 'Perspectives on and from customers' and WP3 'water consumption' provides the basis for WP4 'Mock-up with tailored feedback'. These three task lead to WP5 'strategic follow-up plan'. Finally, the overall project management takes place in WP1 "Coordination" and WP6 "Dissemination", the basis and legitimacy of this study. The projects outcomes are structured in chapter 2 to 6, each representing WPs 2 to 6.

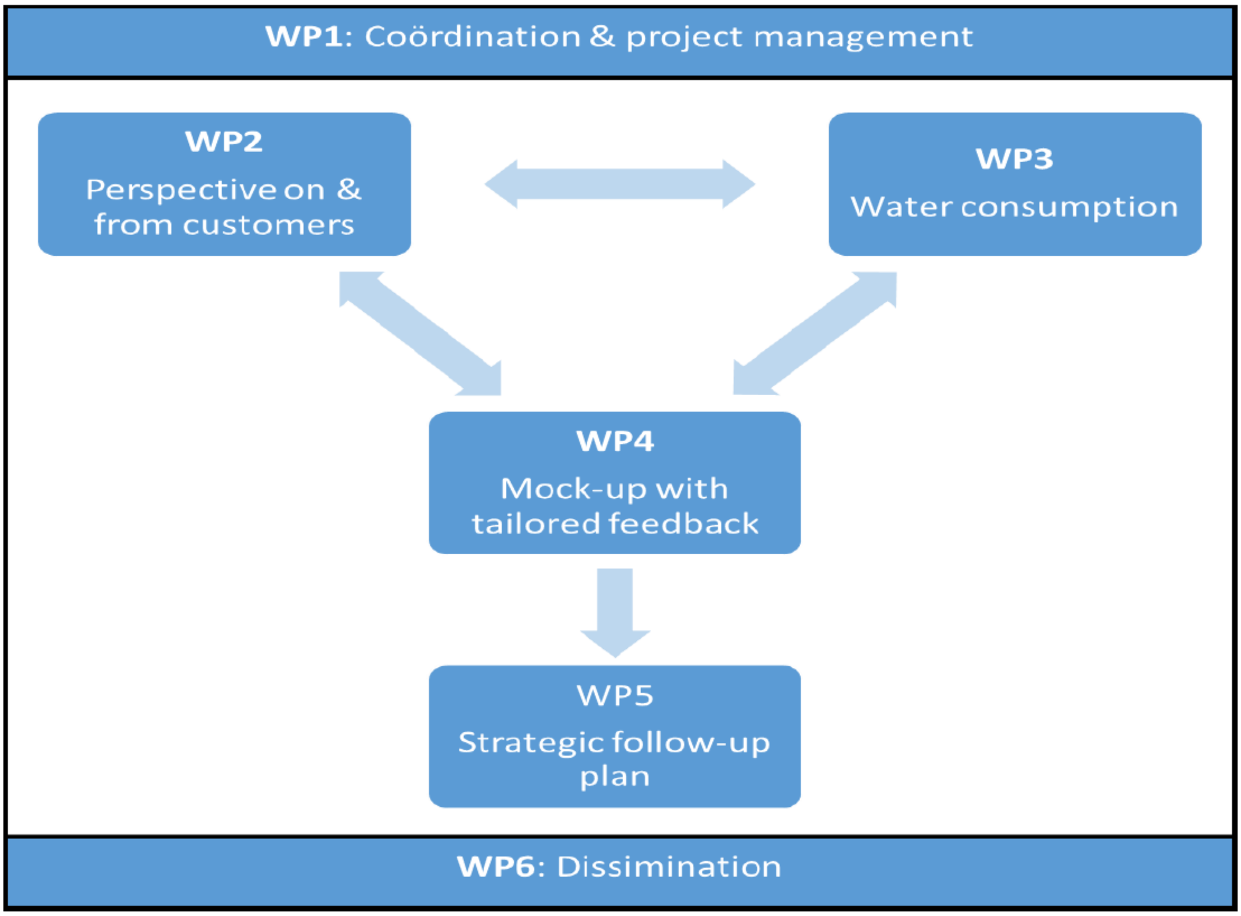


Figure 1 Overview of the project structure in six interconnected Working Packages (WPs). The project outcomes are structured in chapters 2 to 6, each representing WPs 2 to 6.

2 Perspectives on & from customers - WP2

2.1 Large scale survey on customer expectations to smart water metering & targeted messaging

The survey has been conducted amongst 1036 Dutch residents between January and February 2020 which was just before the Covid-19 pandemic affected the Netherlands. The survey can be accessed here.

Results are published in the peer-reviewed journal *Sustainability* as well as the Dutch professional journal *H_2O*

- Koop SHA, Clever SHP, Blokker EJM, Brouwer S (2021) Public attitudes towards Digital Water Meters for households. Sustainability 13 (11), 6440 https://www.mdpi.com/2071-1050/13/11/6440
- Stijn Brouwer, Nicolien van Aalderen, Stef Koop (2020) Waterbesparing door burgers: welke maatregelen zijn mogelijk en hoe overtuig je mensen? H_2O https://www.h2owaternetwerk.nl/vakartikelen/waterbesparing-door-burgers-welke-maatregelen-zijn-mogelijk-en-hoe-overtuig-je-mensen

2.2 Tailored messages & advices

A detailed message tailoring framework has been developed by tailoring messages with respect to:

1. Three situations: I. water use has increased, II. Water use has decreased, and III. Occurrence of a heat wave

2. Household appliances: I. Shower, II. Washing machine and III. Garden hose

3. Four customer profiles: I. Quality & health concerned, II. Aware & committed, III. Egalitarian & solidary and IV Down to earth & confident

4. With and without little children up to eight years old.

Results can be accessed here.

2.3 Testing and fine-tuning messages and advices in customer focus groups

Online focus groups, each representing one of the four customer profiles and consisting of five citizens per focus group, have been conducted to fine-tune messages.
An in-depth presentation of the results can found here (in Dutch).
In-depth transcripts are also available (in Dutch):

- *Quality & health concerned* is available here
- *Aware & committed* is available here
- *Egalitarian & solidary* is available here
- *Down to earth & confident* is available here

3 WP3: Water consumption - WP3

This WP has operationalised micro-level household water distribution patterns of empirical water logger data into actual real-time (seconds, minutes or hours) and water use for different household applications such as toilet, shower and washing machine.

The results have been stored in KWR's private repository GitHub (github.com/KWR-Water/Disaggregation) questionnaire as to elicit: (i) household applications; (ii) SIMDEUM model parameters; and (iii) customer perspectives have been conducted. The questionnaire can be found here.

Simulation of potential water savings (in litres and/or money/CO2) by the acquisition of certain technologies and/or behavioural change has been done (github.com/KWR-Water/SmartWaterConservationTool). This can be observed in the mock-up provided in WP4 (chapter 4).

4 Mock-up with tailored feedback – WP4

A full Mock-up for tailored feedback in a touch screen and water report that can be accessed online has been developed. The mock-ups' name is "Water Insight Package" or WIP.

The mock-up consists of the following components:

1. Advice on how to create and select households motivated to use the WIP for reducing their water consumption. This can be accessed through the presentation of the project website: https://www.kwrwater.nl/projecten/smart-waterbesparing-voor-huishoudens/

2. First screen where some basic questions are asked and the two-week baseline measuring period can be initiated. Based on this two-week period's water use pattern, the first water reduction goal can be formulated by the user. This can be accessed via the project website: https://www.kwrwater.nl/projecten/smart-waterbesparing-voor-huishoudens/

3. Mock in-home displays which can be accessed via the project website: https://www.kwrwater.nl/projecten/smart-waterbesparing-voor-huishoudens/

4. Water reports which can also be accessed via the project website: https://www.kwrwater.nl/projecten/smart-waterbesparing-voor-huishoudens/

5 Potential water-saving impact of digital water meters

In the Netherlands 748Mm^3 of surface water and 902Mm^3 of groundwater is being withdrawn annually (Pronk et al. 2020). About 964Mm^3 (58.4%) is being used for domestic drinking consumption and consumption by business. What can the impact of digital water meters be on the total water withdrawn? It is only possible to give very rough estimates of the water-saving potential of digital water meters in the Netherlands, as the basis for the calculations is mainly theoretical, based on studies outside the Netherlands, and there are various uncertainties. Table 2 and
Table 3 provide rough estimates based on three key water-saving impacts of digital water meters:

1. Leakage detection
Digital water meters can enable post meter leakage detection. Particularly in older buildings this can make a significant difference. In this respect, Britton et al. (2013) conducted a study covering 22.000 Australian households that indicated that after communicating a smart meter detected leakage to customers, 89% of leakages were repaired. On a city level this amounted to 5-10% reduction in water consumption. These results are from an Australian context and may differ from the Netherlands. In addition, the initial gain in leakage reductions is relatively high. In the years that follow, this leakage reduction is likely to be significant lower, since the leaks are addressed in the previous years. Another estimate applicable for the Netherlands is based on estimations from Blokker (2008) in Table 1. The water-saving potential is 35.7 Mm^3/year which is 3.2% of drinking water use by households and business. Digital water meters for leakage reductions can be considered a low hanging fruit since it is a one-time decision to repair leaks, does not result is loss of convert and its water-saving impact is relatively high.

Table 1 Potential leakage reduction in the Netherlands. Leakage volumes and share of households with leaks adopted from Blokker (2008). Most conservative estimate for leaking taps is selected since digital water meters detection levels of these low-flow leakages are limited.

	Q (l/h)	Share of households with these leaks	Total for the Netherlands (7,000,000 households)
Leaking tap	1-4	5% 1 tap; 0.7% 2 taps	1.0l/h*24h*365*0.057*7,000,000)/10^6 3.5Mm^3
Leaking toilet	10	2%	10l/h*24h*0.02*7,000,000*2)/10^6 24.5Mm^3
Leaking in-house pipes	4	1%	4l/h*24h*0.01*7,000,000)/10^6 2.5Mm^3
			30.5Mm^3/year

2. Influencing behaviour
Behavioral change through stimulating the purchase of water-efficient equipment and enhancing water conservation behaviour can be realized with the help of digital water meters. We need to extrapolate here from data from controlled experiments with shorter lead times. Moreover, contextual difference are important to account for. For instance, drier climates, larger gardens and circumstances of imminent drought with water-use restrictions may result in higher water-saving potential of such experiments (Koop et al. 2019). However, there are

multiple studies that are long-term and involve more than 10,000 people also show long-term reductions of 2 to 10%. Typically, water-use reductions are achieved with social norms, environmental arguments, increasing self-efficacy of water-saving behaviour and the like. Financial arguments hardly play a role. Some caution is required with translating percentage as water-saving across contexts since it depends on the total water use that tends to be higher in many international field experiments as compared to the Netherlands. Nevertheless these percentages seem applicable to the Netherlands since 2 minutes shorter showers a day can yield about 13% water savings (i.e., (2 minutes*7.5 litres/minute / 120 litres)).

3. Price incentives

The Dutch Behavioral Insights Team is increasingly interested in price incentives. With digital water meters, in theory, it possible that prices can be increased for peak hours, seasons or in extreme cases of drought episodes. The price elasticity is about 0.17 (meaning a 10% price increase results in 1.7% water-use reduction; SEOR 2018). However, how price increases are communicated is essential in this discussion. The communication of real time price graphs could provide a substantial incentive to reduce water use or postponing water consumption (which is likely to mean using less overall). This could lead to a higher price elasticity. Furthermore, the connection with energy use through warming water in washing machines, dish washers and showers may lead to higher price elasticity because energy prices are generally higher and fluctuate substantially more than drinking water prices. If the cost of heating water are well communicated on interactive displays that are tailored to individual water and energy use feedback messages, price elasticity of water-use may increase substantially. Such an approach seems particularly feasible for the developed Water Insights Package conceptualization. The increase in price elasticity due to peak and off-peak tariffs per day, season or drought episode as well as the communication of water and energy costs of heating water is largely unknown and requires further research. For now we make a conservative estimate that the elasticity will increase from 0.17 to 0.37 because of the accumulated elasticity of water (0.17) and energy (0.20). This estimate is based on the assumptions that during peaks the prices are increased by 10%, that off-peaks do not increase and that peaks account about 30% of total consumption.

Table 2 Largest water-saving potential of digital water meters (DWM) for households and business. It assumes that DWM are embedded in behaviour influencing tactics and price incentives apply to all Dutch households and business.

	Assumptions	Potential drinking water savings	Share of total water withdrawal
Leakage detection	5% reduction on city level[1,2]	5.0% - 48.2Mm^3	2.9%
Behaviour influencing	2-10% reductions being averaged at 6%[3]	6% - 57.8Mm^3	3.5%
Price incentives	Price elasticity of 0.37 of water and energy use at peaks that account for 30% of total water consumption[4]	1.1% - 10.7Mm^3	0.6%
Most optimistic estimation	No interaction between leakages, behaviour and price incentives	**12.1% - 116.7Mm^3**	**7.07%**

[1] Britton TC, Stewart RA, Kelvin R.O'Halloran KR (2013) Smart metering: enabler for rapid and effective post meter leakage identification and water loss management. Journal of Cleaner Production 54, 166-176

[2] Blokker M (2008) Een gouden standaard van representatieve volumestroomverdelingen. KWR 08.029

[3] Koop SHA, Van Dorssen A, Brouwer S (2019) Enhancing domestic water conservation behaviour: A review of empirical studies on influencing tactics. Journal of Environmental Management 247, 867-876

[4] SEOR (2018) Erasmus School of Economics: Prijselasticiteit van de vraag naar leidingwater in Vlaanderen Finaal onderzoeksrapport. Available online: https://www.seor.nl/Cms_Media/S1208-Prijselasticiteit-van-de-vraag-naar-leidingwater-in-Vlaanderen.pdf [Accessed 2-12-2021].

Table 3 Correction of largest water-saving potential of digital water meters (Table 2) by reduced leakage detection, lower employment of behaviour influencing tactics, no price incentives and limited installment of digital water meters 2035 assuming all other factors equal (demographics, legislation etc.).

<table>
<tr><th colspan="2"></th><th>Potential drinking water savings</th><th>Share of total water withdrawal</th></tr>
<tr><td colspan="2">Projection 2035
(accumulation of correction factors below)</td><td>1.3% - 12.6Mm³</td><td>0.7%</td></tr>
<tr><td rowspan="4">Correction factors</td><td>Post meter leakage detection is lower in Dutch context (i.e., 3.7%)</td><td>3.2% - 30.5Mm³</td><td>2.1%</td></tr>
<tr><td>Behaviour influencing is only applied in 25% of the cases because of limited knowledge and interest</td><td>1.5% - 14.5Mm³</td><td>0.9%</td></tr>
<tr><td>Price incentives are not included</td><td>0.% - 0.0Mm³</td><td>0.0%</td></tr>
<tr><td>Installation digital water meters in 25% of households and business by 2035</td><td>3.7% - 35.2Mm³</td><td>2.1%</td></tr>
</table>

6 Dissemination, follow-up & impact – WP5 & 6

6.1 Publications

Koop SHA, Clever SHP, Blokker EJM, Brouwer S (2021) Public attitudes towards Digital Water Meters for households. Sustainability 13 (11), 6440 https://www.mdpi.com/2071-1050/13/11/6440

Stijn Brouwer, Nicolien van Aalderen, Stef Koop (2020) Waterbesparing door burgers: welke maatregelen zijn mogelijk en hoe overtuig je mensen? H_2O http://api.kwrwater.nl/uploads/2020/08/Brouwer-van-Aalderen-Koop-Waterbesparing-door-burgers-welke-maatregelen-zijn-mogelijk-en-hoe-overtuig-je-mensen-H2O-Online-(2020)30-juli.pdf

Draft peer reviewed article in collaboration university of Nerada about disaggregation of high frequency digital meter flow data

6.2 Presentations

As part of the follow-up planning several dissemination activities have been taken place.

An overview:
1. Video for BTO-CEO meeting – recorded May 25th
2. Presentation at the BTO Theme group client – June 3th
3. Presentation of the mock-up in IoT meeting - June 8th
4. Three interactive sessions with:
   - Brabant water and Waterbedrijf Groningen – June 15th
   - Vitens – June 28th
   - De Watergroep – September 6th
5. Presentation in the European project B-WaterSmart – August 31st
6. Aquatech Data Science meeting – November 4th
7. Presentation Hydroinformatics knowledge exchange session – November 8th
8. Separate follow-up meeting with Vitens – November 25th

1. Video for CEO meeting – recorded May 25th
In order to raise awareness of the exploratory research projects at the BTO-CEO meeting, a short video was recorded highlighting the key objective, deliverables and relevance for the water sector at the strategic level.

2. Presentation at the BTO Theme group client – June 3th
Presentation provided a brief introduction of the mock-up, with particular attention to client profiles, behavioural aspects, and the public attitude towards digital water meters for households. After the Q&A, a follow-up meeting focussed on a more detailed level of application within the utilities was being asked. As a results Brabant Water, Waterbedrijf Groningen, Vitens and De Watergroep have been approached for more detailed interactive sessions.

3. Presentation of the mock-up in IoT meeting - June 8th

Presentation of the client profiles with focus on their implications on the mock-up. Another focus of the presentation was the technical requirements for smart water meters needed to obtain the data "used" by the mock-up.

4. Three interactive sessions

Three interactive online sessions with utilities have been held lasting for about an hour each. The sessions consisted of a short presentation regarding a possible strategy for the recruitment of households for the above explained Water Insight Package (WIP). This was followed by an interactive session guided by three key questions for the utilities:

1. What is the current state of affairs regarding digital meters (for households)? Are there any ideas, plans or experiments?
2. How does your drinking water company think about the future i.r.t. drought and water use? What role is seen for digital water meters?
3. What could be a next step where the utilities' ambitions and the project results align?

A concise summary of the three interactive sessions can be found in appendix 1.

5. *Presentation in the European project B-WaterSmart – August 31st*

   In an expert session on how to make digital water meters more effective, the key findings of this study have been presented to a broad audience of experts across Europe. Presentation was recorded and can be accessed on the project page: https://www.kwrwater.nl/projecten/smart-waterbesparing-voor-huishoudens/

6. *Aquatech Data Science meeting – November 4th*

   A meeting organised by data scientists of Vitens during the Aquatech. The client profiles and the mock-up were presented as a motivation for water use dissagregation (separating the water use to its individual appliances).

7. *Presentation Hydroinformatics knowledge exchange session – November 8th*

   Key insights from this project from a behaviour and client point of view have been presented to key representatives of utilities with respect to digital water meters enrolment.

8. *Separate follow-up meeting with Vitens – November 25th*

   Strategic talks have been held with Jacqualine de Jong (customer innovation manager), Micha van Aken (Business Development Manager Innovatie & Digitale Transformatie), Yvonne Hassink-Mulder (Data scientist) and Marten Hutten (Data scientist), Stef Koop (KWR) and Stijn Brouwer (KWR).
   Goal: information exchange and alignment of long-term agenda's. To this end, both the case Westeinde in Leeuwarden with about 1400 digital meters and ambitions to upscale the installment of digital water meters in the next years to about 25.000 householders was discussed. Particularly, the mutual interest of water conservation purposes through tailoring techniques was identified as a promising avenue for collaboration in existing or new digital water meters. A follow-up meeting was planned to elaborate this initiative in more detail.

6.3 Follow-up planning

This project has provided an integrated concept for the specific application of a digital water meter with volumetric datalogger that is able to tailor water-use feedback information of specific household appliances, and to attune messages to value-based perspectives on drinking water. In addition, a specific recruitment strategy to enhance the water-saving potential of the developed Water Insights Package has been developed. In this way, it provides ample of opportunity to be further developed, tested and applied within the next five to ten years in order to mitigate droughts. Moreover, the knowledge developed in this project can also be applied to more generic types of digital water meters (without volumetric disaggregation of water-use activities). For instance in the development of a recruitment strategy for potential users that accounts for behaviour influencing tactics and attitudes with respect to digital water meters or in the application of message tailoring of non-disaggregated water-use information.

The concept shown presented by the Water Insights Package can be considered as a niche in the rollout of digital water meters in the near future. It is a niche because it requires more sophisticated and expensive equipment. Both the disaggregation method and its effectivity in terms of water-use reductions need to be further developed and explored. Hence, we propose a two-tiered approach in order to strengthen the developed of the Water Insights Package in practice:

1. Develop a generic and standarised volumetric disaggregation methodology
   This will be the subject of a Smart Water Network Pilot in 2022. The goal of the project is to develop and test dissagregation method(s) by analysing synthetic data created by SIMDEUM as well as real smart-meter data. We also aim to answer the question about what data density is required to achieve sufficient dissagregation of the water signal.

2. Rollout of behaviour experiments with digital water meters in order to test the water-saving potential of tailored feedback, social norms (comparison with others) and message framing over longer periods.
   Opportunities are explored how this can be integrated into future Bedrijfsonderzoek related to the BTO-theme group client.

These tiers run in parallel and may be integrated by actually developing an applicable Water Insights Package that can be used by households through a TKI project.

7 Literature

Blokker M (2008) Een gouden standaard van representatieve volumestroomverdelingen. KWR 08.029

Britton TC, Stewart RA, Kelvin R.O'Halloran KR (2013) Smart metering: enabler for rapid and effective post meter leakage identification and water loss management. Journal of Cleaner Production 54, 166-176

Koop SHA, Van Dorssen A, Brouwer S (2019) Enhancing domestic water conservation behaviour: A review of empirical studies on influencing tactics. Journal of Environmental Management 247, 867-876

Pronk G, van Dooren T, Stofberg S, Bartholomeus R (2020) Waterhergebruik en de Zoetwatervoorziening. BTO 2020.011

SEOR (2018) Erasmus School of Economics: Prijselasticiteit van de vraag naar leidingwater in Vlaanderen Finaal onderzoeksrapport. Available online: https://www.seor.nl/Cms_Media/S1208-Prijselasticiteit-van-de-vraag-naar-leidingwater-in-Vlaanderen.pdf [Accessed 2-12-2021].

Appendix 1 Interactive sessions with utilities

Three interactive online sessions with utilities have been held lasting for about an hour each. The sessions consisted of a short presentation regarding a possible strategy for the recruitment of households for the above explained Water Insight Package (WIP). This was followed by an interactive session guided by three key questions for the utilities:

4 What is the current state of affairs regarding digital meters (for households)? Are there any ideas, plans or experiments?
5 How does your drinking water company think about the future i.r.t. drought and water use? What role is seen for digital water meters?
6 What could be a next step where the utilities' ambitions and the project results align?

Session 1: Brabant water and Waterbedrijf Groningen – June 15th
Attendees: André van Toly (Waterbedrijf Groningen), Tilly Klop (Brabant Water), Johan van Erp (Brabant Water), Stef Koop (KWR), Sharon Clevers (KWR) and Stefanie Salmon (KWR)

Summary position utilities based on three guiding questions:

1. Brabant Water: In the next 5 years, Brabant Water aims to focus on selling DWM to business customers, for a low rate (about €1,- per month). Brabant Water considers an in-home display as being too costly and proposes the provision of information in the form of an email as a less costly alternative.
   Groningen Waterbedrijf*:* At present, the utility owns 2000 digital water meters through a project that is focused on digital energy meters. The water meters are not used at the moment. All large consumers (grootzakelijke klanten) have a digital water meter. Recently a project named "Roadmap smart water network" has started. The key question that this project aims to address is how digital water meters can improve water-demand management to optimise network performances. At present the project is at an early stage.
2. Brabant Water: The provision of additional water-use information and automated meter readings is considered as a service that will be included in the water price. In this respect, installing DWM for households that give feedback and aim for reduced water consumption is not an aim for the next 5 years. the low hanging fruit for reducing water demand is with large customers.
   Groningen Waterbedrijf: They consider the digital water meter as a service that can be sold to customers. Key benefits mainly relate to services that are not necessarily focused on water conservation, but rather automated meter readings and leakage detection. Key benefit for the utility is a more optimized and efficient (financial) administration.
3. Brabant Water & Groningen Waterbedrijf: Not particularly interested in experimentation with Water Insight Package because they rather want to focus on the larger water consumers (i.e.,grootzakelijke verbruikers) and advocate emails or an app instead of an in-home display. Next, they do not immediately see the added value of experimenting for long-term water conservation. They rather want to provide the service of automatic water reading for their business customers within the next 5 years. Nevertheless, they are interested to connect with a potential follow-up research (such as a bedrijfsonderzoek) to anticipate further water conservation beyond their current focus on larger water consumers (grootzakelijke verbruiker). They consider this to be potentially helpful in anticipating more frequent and intensified drought episodes due to climate change and want to be prepared in the long run.

Session 2: Vitens – June 28th
Attendees: Jacqueline de Jong (Vitens), Stef Koop (KWR) and Sharon Clevers (KWR)

Summary position utilities based on three guiding questions:

1. They are already working on DWM in a pilot in Leeuwarden. Their data scientists cannot yet trace it back to equipment level. This is also because the measurement frequency is 5 min of data. There are concerns about implementation. How to apply customer segmentation in practice?
2. Vitens is exploring the role of DWM and water conservation at household level (every drop counts campaign for instance). Vitens is also looking for other sites beyond Leeuwarden since there households get a kind of experiment fatigue.
3. Vitens are interested in experiments with their existing or new digital water meters. Particularly with respect to tailoring strategies for enhanced water conservation.

Session 3: De Watergroep – September 6th
Attendees:: Nele Philips (de Watergroep), Cindy Vanderstraeten (de Watergroep), Stef Koop (KWR), Sharon Clevers (KWR)

1. The utilities has the statutory task to install digital water meters in all households by the year 2030. There have been numerous pilots, particularly in combination with digital energy meters. De Watergroep receives information about the customer's use, whereby the customer can view his own consumption via a customer portal. Customers can choose the frequency with which they view their consumption.
2. The water company is therefore looking positively at the use of smart water meters and is already well underway with their roll-out. However, there still are privacy concerns. In addition, they are curious how to ensure that everyone agrees with the instalment of a digital water meter. Particularly, how can digital water meters be offered in such a way the minimise the number of objections.
3. De Watergroep is interested in how behaviour aspects can enhance the willingness to install digital water meters as well as how it can enhance water conservation efforts.