D.T2.7.1 FINAL SELF-EVALUATION REPORT SPLIT

Subtitle

Version 1
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1. Background and objectives

1.1. Challenges and solutions

As the water is natural resource essential for the life on the planet, it is important to promote efficient management of the water that people use. Therefore, real-time water usage metering at three different entry points of public building is dashboard-like presented and analysed. Both current, and already implemented pilot activities are meant for raising the awareness in rational water usage.
Meeting project goals and successfully delivery of pilot concept outcomes, with completed project objectives are listed as follows:

- preliminary measurements of three different state-of-the-art IoT radio technologies used for sensed data delivery were performed with aim to tailor specific needs for on-sight installation of smart water meters. This way, reliable technology for wireless data transmission is used to reduce the implementation risks;
- installation of three smart water meters that meet specific on-sight needs;
- installation of LCD display and application deployment that is used to continuously monitor received data;
- analyse data to bring combined environmental & economic benefit by increasing the awareness in rational water usage, with possible impact on water savings, and decreased exploitation of freshwater resources while implementing modern ICT technologies. This assumed deployment of innovative solution tailored, but replicable by any CE FUA. It included planning, monitoring and implementing cutting-edge engineering through ICT tools, while demonstrating its feasibility. As depicted in Figure 1, these were both tested and verified in the frame of the pilot action, by means of providing cookbook for data analysis for both professional and scientific personnel, raising the awareness through big LCD screen at the entrance of the Faculty to the general population, and doing the exercises with students by using the measurement data.

Further activities are considered to promote it further among citizens while raising the awareness in respect to the deployed concept.

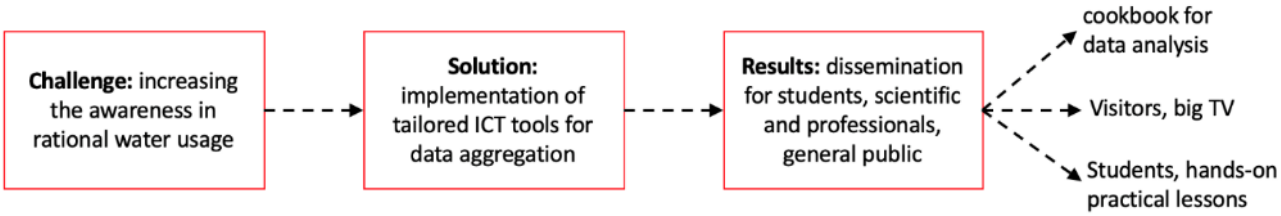


Figure 1 – Challenge, Solution and Results of ViK CWC Pilot project activities

2. Experience of the pilot implementation

In this section, lessons learned during the pilot implementation and monitoring is presented. In short, all the required steps and arising issues were described, while ones overcoming the same to successfully implement the pilot are described. Following the same is important for the sake of replicability by any CE FUA.

2.1. Lessons learned from the planning phase

To successfully implement the pilot, it is required to choose particular IoT wireless technology to deliver the water-metering data, fulfilling specific on-sight needs by ensuring reliable communication between water-meters and dedicated receivers. For this purposes, three different, low-power state-of-the-art IoT radio technologies were considered: Sigfox, LoRaWAN, and NB-IoT. Upon testing the communication reliability, chosen IoT technology should be used for water-meters as a communication module to deliver the metering data. Upon implementation, related dashboard-like software is required to present acquired data in LCD screen located in the Faculty building.
Therefore, given pilot concept at the planning phase is straightforward. It aims at:

1. Defining the measurement campaign and finding the best way to perform the measurements and determine which IoT radio technology is the best option;
2. Procurement and smart water-meters/TV installation phase;
3. Application deployment used to monitor water consumption and data displayed through the web/mobile application. The same system is used to download the data of offline analysis.

Actor that takes the part in the pilot implementation is Faculty of Civil engineering, Architecture and Geodesy, while the beneficiaries are the Faculty needs itself, and students/others interested in data analysis.

2.2. Lesson learned from the procurement phase

Proper resources planning (both equipment and minimum software requirements) ensured smooth procurement phase.

2.3. Lessons learned from the construction/installation phase

Lessons learned from the pilot implementation can be divided into two groups given as technical lessons aiming at determination if the planning process was hiding possible issues, and more unpredictable, practical lessons that come with actual system implementation.

- Technical lessons learned were just as planned. Used equipment was enough to determine the needs and follow-up with the implementation phase;
- Practical lessons include a list of notable details that needs to be properly followed-out, which were noticed during the implementation phase:
    - tight schedules in the project implementation required procurement of branded/verified water meter manufacturers to minimise the risk of delays in the product delivery, especially in COVID-19 circumstances. Normal

delivery time for the water-meters is 4-6 weeks and this should be properly planned;
- positions of the water-meters given the particular location (block C) was not easy due to the other underground installations next to the pipe location; as a consequence, since the planned manhole size did not match, finding similar tiles was necessary to put it back as it looked before;
- implementation should be made during the night time, when the building is empty, since placing the water meters is intrusive and time-consuming activity as the pipes were not initially ready for the water-meter implementation; pipe quality is an important factor when it comes to its installation.
- Modern SmartTVs (big LCD screens) have WiFi connectivity; however, if cable connection was not planned, given TV location should have WiFi connection. This is required as SmartTV connectivity is required to connect to the *IoT Wallet* system where water-metering data is stored.

2.4. Lessons learned from operation

Deployed *IoT Wallet* system, with the functionalities given in Figure 2, was used for continuous data monitoring, and later data analysis. In short, basic *IoT Wallet* system functionalities are:

- Integrating random sensors to the system by using the admin interface – ViK pilot action assumes these are LoRaWAN water meters. For LoRaWAN, The Things Network (TTN) cloud service as third-party service was used, and its APIs for data delivery to the *IoT Wallet* Influx database.
- Users can view data in dashboard-like system, set notifications and add sub-users that can only view data. Role of only-viewing data is for students, as changing sensor data for this role is restricted.

During the operation phase several important details were announced and to continue *IoT Wallet* services these were required to be updated. This included major updates:

- TTN V2 to TTN V3 – it involved another LoRaWAN package contents and depreciation of old APIs, while updating *IoT Wallet* accordingly to continue using its functionalities;
- Influx 1.8 to Influx 2.0 – another database query style was required and its updates accordingly;

SmartTV browser functionalities that display *IoT Wallet* in full screen mode logged out of the system in irregular basis, although the system configuration in other web browser showed that this expiration was set to 5 years (*infinite time*). As these should be related to the security defaults of SmartTV, *IoT Wallet* was updated with feature that enables bypassing log-in page and show dashboard data.

At the beginning of July, water-meters stopped transmitting due to the manufacturer bug in water-meters calendar. Manufacturer was urged to send new water meters and send old ones for repair. These were already replaced and monitoring continued.

There were periods when TTN were dropping-out gateways due to the outages in TTN network as third-party service. As a consequence *IoT Wallet* dashboard hangs and was unable to show data. Simple restart of IoT Wallet solves the problem, but now the system is updated to restart automatically if given exception occurs.

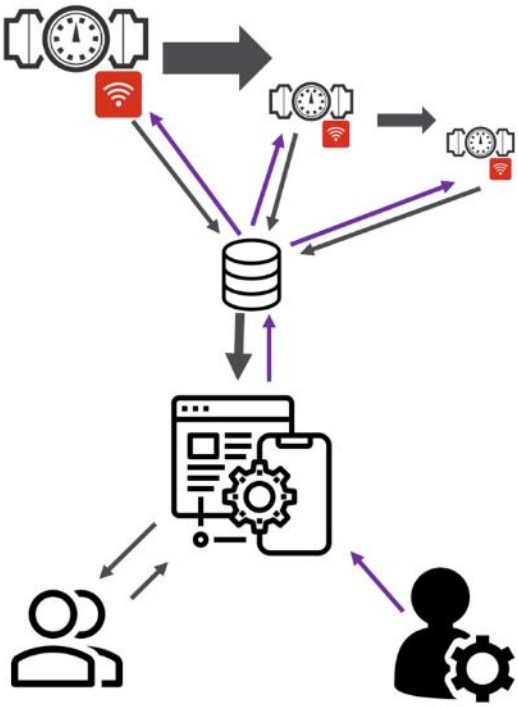


Figure 2 – Application architecture

3. Timeline and responsibilities

Activity	*Planned Start Date*	*Planned End date*	*Status*	*Responsible (person/dept. or org.)*	*Involved people / stakeholder*	*Comment*
1. Revisiting the problem	30.10. 2020.	15.11. 2020.	COMPLETED	Waveform j.d.o.o. (Petar Solic), ViK Split (Boris Bulovic)	Faculty of Civil engineering, Architecture and Geodesy	
2. On-sight measurements, water-meter purchase	15.11. 2020.	15.12. 2020.	COMPLETED	Waveform j.d.o.o. (Petar Solic), ViK Split (Boris Bulovic)	Faculty of Civil engineering, Architecture and Geodesy	
3. Pilot implementation (water-meters, LCD, Application installation)	15.12. 2020.	28.02. 2020.	COMPLETED	Waveform j.d.o.o. (Petar Solic), ViK Split (Boris Bulovic)	Faculty of Civil engineering, Architecture and Geodesy	
4. Continuous monitoring, application updates (web/mobile version), debugging, and usage instructions	28.02. 2020.		IN-PROGRESS	Waveform j.d.o.o. (Petar Solic), ViK Split (Boris Bulovic)	Faculty of Civil engineering, Architecture and Geodesy	

5. Data analysis and dissemination among professionals, scientific personnel, students and general public	28.02. 2020.		IN-PROGRESS	Waveform j.d.o.o. (Petar Solic), ViK Split (Boris Bulovic), Faculty of Civil engineering, Architecture and Geodesy (Ivo Andrić, Adrijana Vrsalović)	Faculty of Civil engineering, Architecture and Geodesy	Current achievements are given in Results /Monitoring section

4. Costs

The budget is within the plan, with activities of 5000 EUR for equipment.

5. Results

The results of the pilot implementation are summarized in Figures 3, 4 and 5.
Figure 3 shows the pilot location building, i.e. Faculty of Civil engineering, Architecture and Geodesy. Left side shows building blocks, while right side shows the locations of implemented smart water-meters.
Figure 4 shows the photos of the implementation location, performed measurement to retrieve which IoT technology is the best choice, installation details and final state.
Figure 5 shows SmartTV installation location and preview of *IoT Wallet* dashboard system.

Figure 3 – Faculty building - pilot site (left side of Figure); water-meter installation locations for A, B and C block of the Faculty building, namely 1, 3 and 2 locations (right side of Figure)

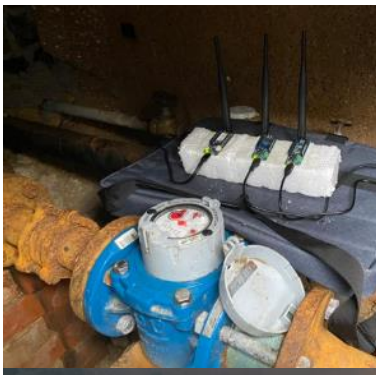
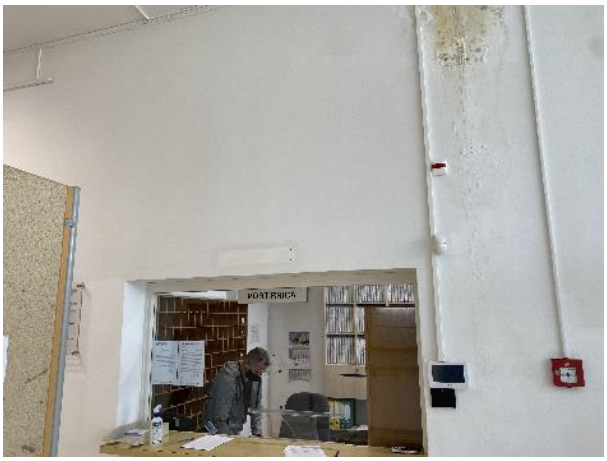
	Position A (DN50)	Position B (DN40)	Position C (DN40)
Initial state			
On-sight measurements (planning)			
Water meters installed (implementation)			
Final state			

Figure 4 – Locations for smart water-meters installation



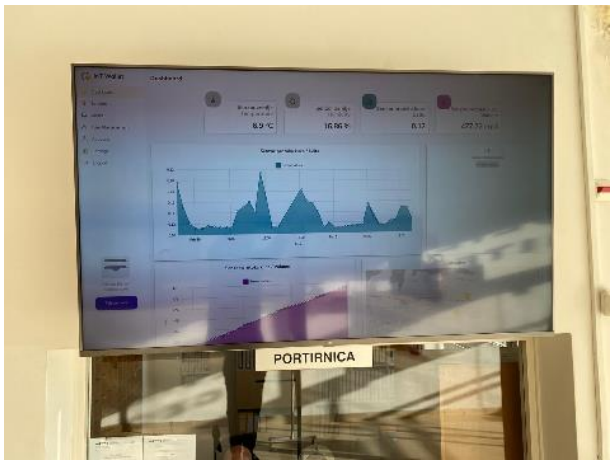


Figure 5 – Installation location: before (left), and after implementation with IoT Wallet display (right)

6. Mentoring visit

During ViK pilot monitoring period, mentoring visit was performed by Erwin Nolde and Norma Khoury-Nolde. The visit was successfully hold in a virtual form on 11.06.2021. Petar Šolić, Boris Bulović, Ivo Andrić and Božidar Čapalija presented the Mentoring visit pilot site during the meeting which lasted for approx. 80 min. The Meeting involved walkthrough pilot site. At first, campus location and Faculty building as a pilot location was presented, which was followed by showing the location of smart water-metering and *IoT Wallet* implementation in SmartTV, with explanation on how the IoT radio technologies were used to determine which one is the best fit for the particular metering purpose. At the end of the meeting, functionalities of the *IoT Wallet* system were explained both in terms of current and future upscaling plans.
Before the mentoring visit, Split sent ahead a PowerPoint Presentation describing the pilot action which initially raised a few questions that were answered in advance in order to clear-out possible misunderstandings and prepare the presentation/other mentoring material to be easily cross-understand and prepare further material for wider public understanding and upcoming peer-review visits.
Meeting was recorded for further editing/documentation purposes and can be found in CWC project google drive. The transmission and recording technology worked very well. Only a few minutes were cut out of the video for documentation and reporting.
Details of the visit can be found in in the report of the Mentoring visit prepared by FBR.

7. Monitoring activites and results

Monitoring activities performed from 01.03.2021. can be divided into several groups:

1. Technical maintenance of the system which involved:
    a. updates of the software – involved major updates of *IoT Wallet* system where TTN V2 to moved V3, and Influx 1.8 to 2.0;
    b. continuous monitoring of the system functions including hardware performances which due to the bug in water-meters required needful replacements.

2. Dissemination activities for purposes of raising the awareness:
    a. Data was analysed by scientific personnel and the contributions were peer-reviewed and accepted as a scientific paper in the 6th International Conference on Smart and Sustainable Technologies (SpliTech 2021), September 08-11, 2021, which is technically co-sponsored by IEEE and IEEE ComSoc (Communication Society) that ensures the quality and accepts only $\leq 49\%$ of submitted contributions.

       IoT Deployment for Smart Building: Water Consumption Analysis
       Adrijana Vrsalović and Ivo Andrić (University of Split, Croatia); Toni Perković (University of Split, FESB, Croatia); Marin Aglić (University of Split, Croatia); Petar Šolić (University of Split, FESB, Waveform j.d.o.o, Croatia)
       Which according to the Preliminary program should be presented in:
       S11: IoT - Software and Systems from Thu, September 9, 2021 14:30 until 16:00 (3rd paper) in HVAR (18.0 min.)
       Accepted paper should be published in most influential databases such as SCOPUS and Web of Science (WoS). Further on, after the conference there is a possibility to extend the paper for journal publication.

       Given paper contribution is tutorial/cookbook hands-on like contribution explaining main findings of ViK Split pilot action and instructions to replicate the setup. Figures 6 and 7 presents the preview from given paper showing the water consumption pattern and average hourly consumption respectively. Preliminary analysis gave indications on peak hours of water consumption, as well as leaking in every building block. It was shown that building blocks B and C have smaller losses due to newer installed pipes with better quality.

    b. During the spring semester at the Faculty of Civil engineering, Architecture and Geodesy 20 graduate students enrolled at “Hydrotechnical Systems” course took data for its analysis. In next, fall semester 60-70 students enrolled at undergraduate study course “Water Supply and Sewerage Systems” will have the same opportunity. The flyer for graduate course (in Croatian) is given as Figure 8.

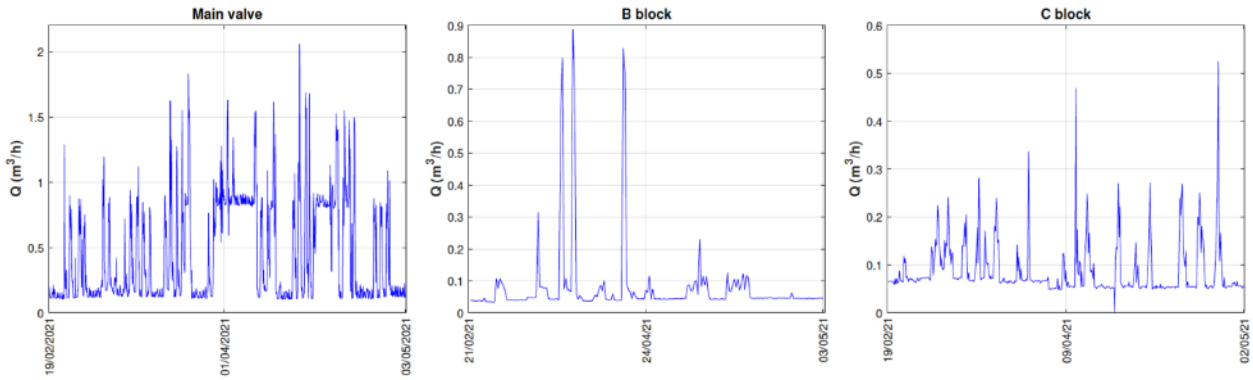


Figure 6 – Water consumption data pattern

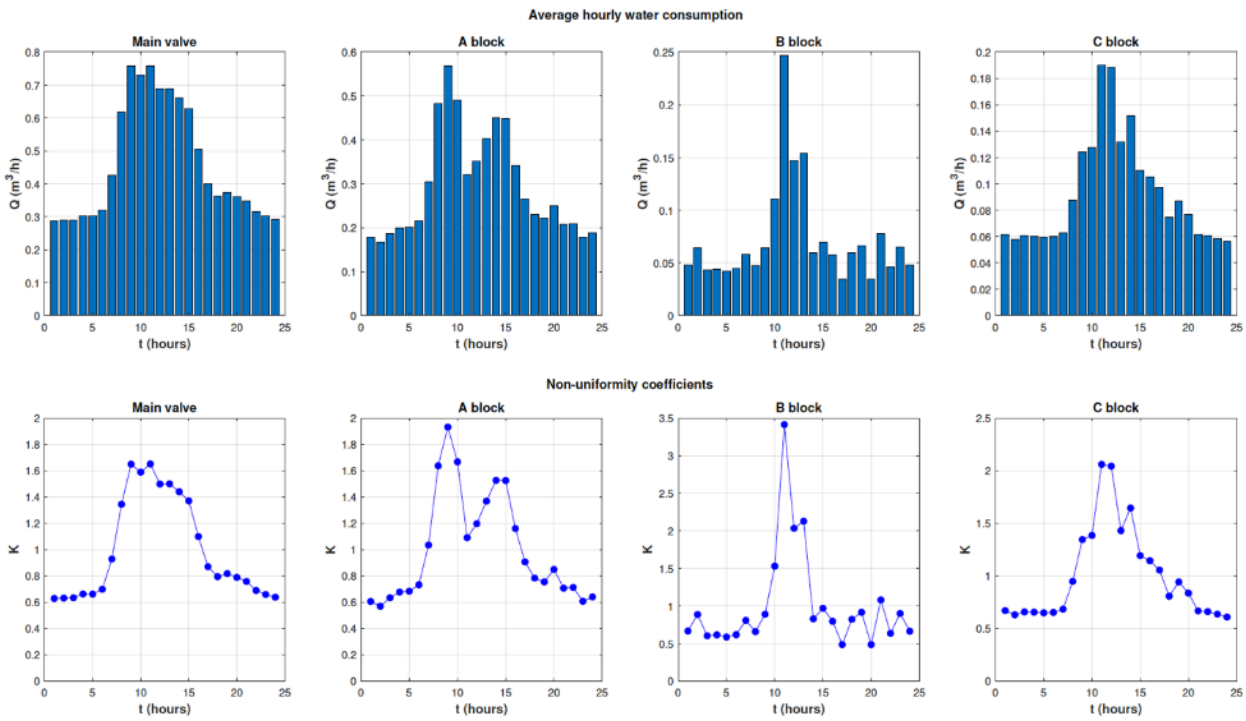


Figure 7 –Overview of the average hourly water consumption and non-uniformity coefficients in the entire building and for blocks A, B and C individually.

SVEUČILIŠTE U SPLITU
FAKULTET GRAĐEVINARSTVA,
ARHITEKTURE I GEODEZIJE

UNIVERSITY OF SPLIT
FACULTY OF CIVIL ENGINEERING,
ARCHITECTURE AND GEODESY

Pilot projekt CWC u Splitu

Pilot projekt ugradnje pametnih vodomjera na FGAG

Tehnička komponenta

Korisnička komponenta

Edukativna komponenta

Loading ...

Studenti mogu:

- Analizirati potrošnju na stvarnim podacima,
- Određivati koeficijente neravnomjernosti,
- Analizirati specifičnu potrošnju,
- S dodatnom dogradnjom senzora moguće je analizirati tlačne odnose u vremenskoj i frekvencijskoj domeni
- Razrađivati koncepte ušteda i implementirati mjere održivosti.

Prednosti pametnog praćenja potrošnje vode

Iz perspektive pružitelja usluge

- Redukcija potrošnje energije,
- Detekcija gubitaka,
- Prognoziranje potrošnje,
- Promoviranje tehnologija za smanjenje potrošnje.

Iz perspektive potrošača / korisnika

- Informacije o potrošnji (Gdje i Kada),
- Detekcija gubitaka,
- Usporedba potrošnje s drugim potrošačima (potrošačima sa sličnim socio – demografskim odrednicama),
- Analiza neravnomjernosti potrošnje i mjenjanje obrazaca potrošnje.

Kako do podataka:
Koristeći se računalom ili mobitelom potrebno je otvoriti stranicu:
http://wallet.waveform.hr/login

Email: **student@student.hr**
Password: **student**

Osnovni prikaz vam daje potrošnju po tri mjerne točke koje reprezentiraju ventile u C i B zgradi FGAG, te glavni ventil s kojim je cjelokupna zgrada priključena na mrežu. Ukoliko odaberete glavni izbornik ☰, možete pretraživati senzore (pametne vodomjere i za svaki odabrani senzor preuzeti podatke u csv formatu.

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Figure 8 – Flyer prepared for students enrolled at "Hydrotechnical Systems"

8. Indicators

Indicators	Description	Baseline	Achieved so far	Target value	Measurement/ monitoring method	Regularity of measurement
Output1 Preliminary measurements	Preliminary measurements were performed to better understand the performances of low power IoT radios for purposes of deploying the smart water meter equipment	0	1	1	It was measured by external experts of ViK specialized in low power radio technology.	it was one shot measurement to determine the best option.
Output 2 Water meters installation	Deployed 3 smart water meters based on LoRaWAN radio technologies. 2XDN40 and 1XDN50.	0 (Analog (standard) water meter was available at entry point used to read official water consumption. Other two places were single pipes.)	3	3	It is measured by the implementation of smart water meters to sights that monitor water consumption at given points.	After installation

Output 3 LCD display installation	Deployment of LCD screen to the public building entry point. It should present dashboard like web-based system with water consumption data.	0	1	1	It is measured by implementation of LCD screen in public building entry point.	After installation.
Result 1 Database of acquired measurements	Water consumption measurements from three different locations Interpret data from the database as an informative point for purposes of increasing the awareness in water usage. On the other side data can be analyzed by different stakeholders.	1 (Only single, standard analog measurement point for purposes of total water consumption was used. No real time, remote monitoring was available.)	0	1	Database will include measurement data acquired by receiving water consumption data from smart water-meters stored into the cloud and remote server used to get the data out of for web/mobile software.	at the end of the project

Result 2 Published paper within scientific conference	Cookbook for replicating the installation and measurement analysis presented within scientific paper	0	1	1	Number of participants involved at the scientific conference. So far, more than 100 presentations will be presented September 08-11, 2021.	At the end of the project.
Impact 1 Informed stakeholders	Estimated number of people entering the building; students/stakeholders that can interpret the data for their own purposes. Informed citizens and students about the smart water usage.	0	1	2 (Due to COVID circumstances the numbers are currently reduced.)	Counting the number of students used to analyse the data, and estimated number of people that visit Public building.	At the end of the project.

Impact x	Amount of funds leveraged based on project achievements THIS IS A PROJECT LEVEL INDICATOR, SO PLEASE ADD YOUR SHARE TO THIS.	0		2 900 000 euro	CWC foresees weighty leverage of funds for spin-off projects. Largest investment (at least 1 M EUR) foreseen is a closed-loop recycled water system in Maribor (if recycled water proves to be usable for different purposes e.g. snowmaking, washing of buses). Bydgoszcz intends to introduce decentralized RW utilization for public purposes (e.g. for watering parks, cleaning streets, supplying ponds), Turin aims to roll-out green roofing and Zugló plans to replicate its pilot in other kindergartens.	once, at the end of the project

9. Pilot upscaling plans

During the planning process the system requirements were considered to have the possibility of adding other possible sensors to the system. This involves adding more smart water-meters to the other locations, soil sensors, air sensing (temperature, humidity, irradiation, pressure, CO_2), wind sensors, electricity metering, etc. Admin interface to add given sensors is depicted in Figure 9.
Based on possible requirements these can be easily added through the given system. By using the metering, the project can further evolve into smart building where parts can certainly be automated,

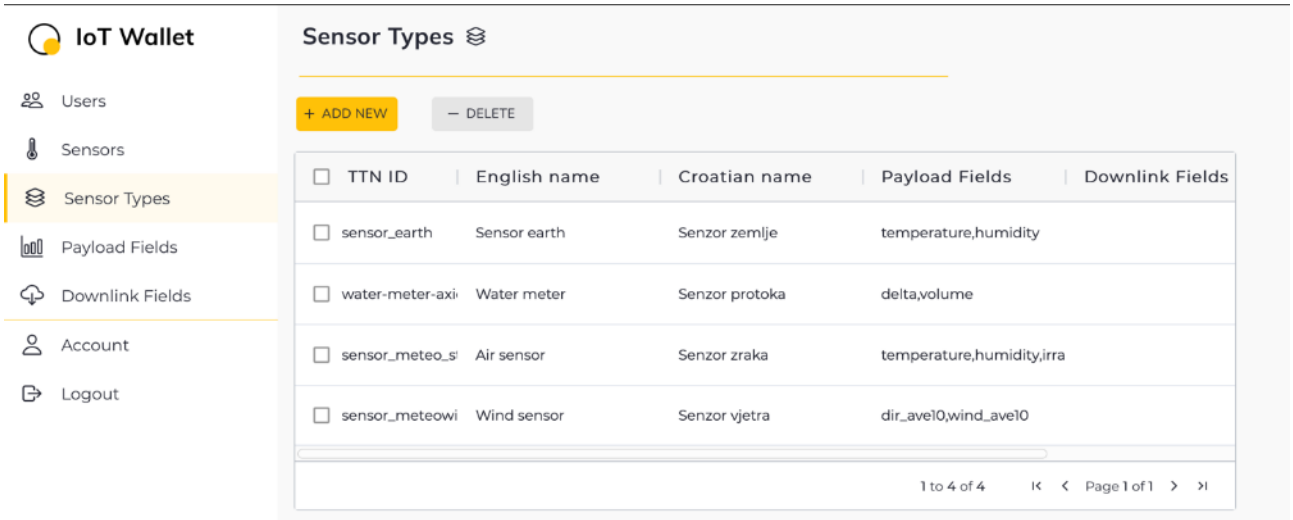

Figure 9 – IoT Wallet admin interface that can add other type of sensors to the system

10. Project follow-up

ViK Split pilot describe steps needed for successful implementation of the smart water meter IoT system while providing use cases on smart water meters implementation and given data analysis. The motivation for implementing such a system is linked with reducing the costs while enabling at the same time more efficient spending by providing users with transparent and real-time data. The pilot included review and testing of different IoT radio technologies for data delivery and analysis, where the best technology option was chosen and analyzed.

As a use case scenario three LoRaWAN-based smart water meters were deployed at the Faculty building aimed at tracking the water consumption of three building blocks.

Monitoring and dissemination activities for purposes of raising the awareness can be summarized as follows:

- Large LCD screen (i.e. SmartTV) at the entrance of the Faculty building is having its own effect on visitors;

- Presentation of the conference paper will have the impact on the audience, while published paper should be available to download from the most influential databases;
- Practical lessons with undergraduate and graduate students are of notable importance due to their current and further professional work;

Using the available data, it is possible to develop savings concepts and implement sustainability measures.