D4.6 FIWARE4Water Demonstrations: Performance, Insights and Lessons Learned – a technical brief and recommendations

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Executive Summary

This document contains the assessment of performance and suitability of services and solutions developed in the framework of Fiware4Water (F4W) project for the four demonstration cases (Greece, France, Netherlands, United Kingdom). The four demo cases cover a wide range of challenges from different water domains: raw water supply, water distribution networks, wastewater treatment, and citizen engagement and water use.

The document reports for each demo case the end-user experience, as gained during the development, implementation and use of FIWARE-enabled solutions, with respect to two key aspects:

- the services developed (i.e., scientific models, platforms, tools, algorithms), from the end-user perspective (i.e., staff of water utilities and customers)
- the FIWARE technology itself, from those (i.e., developers and IT personnel) who have been involved in the development and deployment of "Powered by FIWARE" services.

The assessment of the two aspects above was conducted on the basis of relevant metrics, known as Key Performance Indicators (KPIs), by asking direct feedback from the end-users. In order to collect feedback in a standardised way, two questionnaires were compiled and distributed to the relevant stakeholders. The first questionnaire intended to assess the services developed themselves and the second questionnaire was related to FIWARE technology. Each questionnaire contains qualitative questions to study specific traits of each aspect, i.e., indicators of excellence in a specific function or performance field, such as component integrity, configuration, ease of installation, usefulness and usability, potential of integration with third-party systems, and data model integration. Further to the predefined questions, the recipients were asked to provide open feedback, aiming to gather information about advantages and disadvantages of the technology assessed as well as suggestions for their further development and improvement.

This document reports the results of the above assessment procedure for the services and FIWARE technology deployed at each demo case, providing also overall scores and insights at project scale. Furthermore, it presents the general comments, insights and lessons learned from the deployment of FIWARE-enabled solutions, along with their potential impacts, as well as suggestions for progress beyond F4W project. Particularly for FIWARE technology, the open feedback, which was provided directly by the developers involved in the deployment procedures at each demo case, delivers a valuable list of recommendations and suggestions for further development and improvement.

Related Deliverables

D3.1, D3.2, D3.3, D3.4, D3.5 – Describing the development of smart applications for the 4 demo cases.

D4.1, D4.2, D4.3, D4.4, D4.5 – Describing the deployment and implementation of FIWARE-enabled solutions at 4 demo cases.

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Final V2	21/07/2022		Revision after reviwers' comments

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List of Acronyms/Glossary

CB Context Broker

EAV European Added Value

F4W Fiware4Water project

F4W-AV Added-value of F4W services as a whole

IG Integrity

IT Information technology

KPIs Key Performance Indicators

NGI Next Generation Internet
The Next Generation Internet (NGI) initiative, launched by the European Commission in the autumn of 2016, aims to shape the future internet as an interoperable platform ecosystem that embodies the values that Europe holds dear: openness, inclusivity, transparency, privacy, cooperation, and protection of data.

TF Technical Functionality

TRL Technology Readiness Level

UB Usability

UI User Interface

UF Usefulness

UL User learning and support

WPL Work Packages Leaders

WP Work Package

Introduction

In the framework of Fiware4Water (F4W) project, different services and analytics have been developed to address specific water-related challenges and operational needs of water utilities at four demo cases. The services were integrated with the legacy systems, as well as new sensors installed in the framework of the project, of the four water utilities using FIWARE technology.

In this context, the assessment of both services and FIWARE technology is of paramount importance to draw inference on the performance and suitability of solutions developed, as well as to obtain insights, lessons and recommendations for the further upgrade of the solutions developed or similar developments in other cases. To allow this, we developed an assessment protocol, targeting directly the experience of end-users after their interaction with the services and FIWARE. Specifically, the assessment of serviced was conducted from the perspective of the staff of water utilities and customers (in the case of UK demo case), while the assessment of FIWARE was carried out by those involved in the deployment of FIWARE components, so as to integrate the different data sources and services (i.e., scientific models, platforms, tools, algorithms) into a common operation figure. Two questionnaires, one for the services developed and one for FIWARE technology, were compiled and distributed to the relevant stakeholders, to collect feedback.

The assessment procedure is described in Section I, while Sections II, III, IV, V provide the results of assessment for Greece, France, Netherlands, United Kingdom demo case, respectively, along with a summary of developed solutions, general comments and lessons learned, potential impacts, and suggestions for progress beyond F4W project. The findings from the assessment of the overall added-value of F4W services are described in Section VI. The assessment of the different components of FIWARE ecosystem, deployed at the four demo cases, is presented in Section VII. Section VIII provides a list of recommendations for further improvement of FIWARE. Section IX concludes the report, while Section X describes aspects of EU-added value and further upscaling. The questionnaires to allow the collection of feedback from the end-users are given in Annex A and B, for the services and FIWARE technology, respectively.

I. Assessment protocol of Fiware4Water services

I.1. Overview of the methodology

Task 4.5 in WP4 has the objective of defining the assessment process, i.e., the methodology that sets the parameters to validate the FIWARE-enabled services developed in the framework of F4W project. To perform this evaluation, building on experience from past European research on the evaluation of tools and services [1], the methodology focuses on the end-user experience, which is gained during the implementation of the project. The evaluation process covers two key aspects of F4W project:

- the services developed for each demo case (i.e., scientific models, platforms, tools, algorithms), from the end-user perspective (i.e., water utilities and customers)
- the FIWARE technology itself, from those (e.g., developers and IT personnel) who have been involved in the development and deployment of “Powered by FIWARE” services at four demo cases.

To assess the two aforementioned aspects, metrics and protocols are developed using direct feedback from end-users of services and FIWARE. This feedback is graded based on relevant metrics, or otherwise known as Key Performance Indicators (KPIs). The relevant KPIs are included as part of the

validation plan come in the form of tool and technology traits, i.e., indicators of excellence in a specific function or performance field, such as component integrity, configuration, ease of installation, usefulness and usability, potential of integration with third-party systems, and data model integration. These traits characterize the performance, as seen by the end-user, and hence allow them to evaluate performance based on qualitative (graded) questions linked to these traits. Seven main trait categories are identified for the evaluation of services and nine categories are identified for the evaluation of FIWARE technology. To collect feedback from the stakeholders, relevant questionnaires addressing these traits were formulated, with qualitative performance questions based on a 5-degree Likert scale [2], that ranges from very weak (1) to very strong (5) performance in a particular trait. A F4W application (or the whole technology, for the higher-level questionnaires) can thus have performance scores for each of the considered traits, which can be then either presented separately or combined together to have a single performance score.

While a linear combination of these scores yields a single metric for the tool or system, it is generally good practice to also display the performance of the tool and platform at the level of individual attributes [3], in order to reveal strong and weak aspects of the product character that provide useful feedback for design improvements. This type of display at an individual attribute level can be facilitated with the use of spider diagrams (Figure 1).

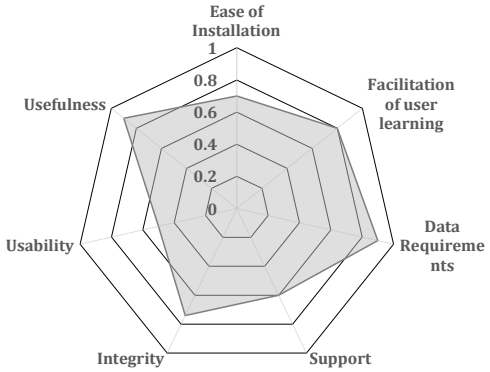


Figure 1: Example of validation results at an individual category (trait) level from a past project [1].

Besides this lower-level display, the performance scores for different questions and, consecutively, categories, can be aggregated to provide a scalar quality metric for the whole F4W tool or technology by calculating the weighted mean score for all end users, categories (traits) or different tools:

$$S_t = \frac{1}{k}\sum_{i=1}^{k} w_i X_i^{(t)}$$

where $S^{(t)}$ is the aggregate score value of the tool t , k is the number of traits, $X_i^{(t)}$ is the individual score of the trait i for the tool t and $\boldsymbol{w} = \{w_1, w_2, \dots, w_k\}$ is an appropriate weight vector with its elements having the sum of 1.0. Unless there is reason to use uneven weights, weights are assumed equal across all levels, as this uniform weight distribution leads to maximum entropy in the weight space of [0,1]. This gives the chance for all questions to be represented equiprobably as a measure of performance for each category and tool. Based on the 5-grade Likert scale, a score of 3.0/5.0 and above equals a 'pass' for that particular category, tool, or technology, while scores less than 3.0 indicate areas of improvement, according to end user experience.

I.2. Assessment of services

Following the above methodology, questionnaires have been complied to assess the performance and suitability of services (e.g., algorithms, tools, platforms) from the perspective of end-user of the service. In all four demo cases, the end-users of services are the water utilities involved. In addition, in UK demo case, an alternative questionnaire was compiled and distributed to assess the performance of smart application for customers. The questionnaires that have been distributed to the demo cases are provided in Annex A.

To assess the services for water utilities, we identified seven main trait categories, which include specific partial characteristics that elaborate on the general train concepts. These traits are:

- The **usefulness (UF)** and performance of a service, which gives insight on how useful the service is with respect to the addressed needs and challenges, and includes the following partial characteristics/questions:
    - Do you consider this service as a useful addition to the needs and challenges of your water service?
    - Based on your experience from the interaction with the service, how well do you think the service performs the specific function that it was designed/supposed to do?
    - Based on your experience from the interaction with the service, is the tool able to provide accurate outcomes or outcomes which improve the current operation?
- The **integrity (IG)** of a service, which gives insight on the integrity of the service (i.e. the speed, stability and reliability of its structural functions), and includes the following partial characteristics:
    - The executing speed of the function
    - The stability of executing its functions
- The **usability (UB)** of a service, which gives insight on how easy, straightforward and intuitive is to use the service (thus exploring its structural simplicity, aesthetic and functional aspects of its interface and intuitiveness), and includes the following partial characteristics/questions:
    - Whether the service has a graphical interface
    - The time it took you to get acquainted with the interface
    - User interface functionality
    - The design of the user interface
    - The overall intuitiveness of the user-service interaction
    - The functionality of the tool in general
- The facilitation of **user learning and support (UL)**, which gives insights on whether the learning material and/or support provided to the end-users for the service was satisfactory or not, and includes the following partial characteristic:
    - Whether the support and learning material provided is sufficient.

Further to the above main trait categories, which aim to assess the individual services developed for each utility, there is a series of additional questions targeting the assessment of “F4W developments as a whole”. To provide such an overall assessment, we employed the following two trait categories:

- **Added-value of F4W services as a whole (F4W-AV)** trait, that gives insight on the added value that F4W services, as a whole, has provided at each utility/demo case, and includes the following partial characteristics/questions:
    - Do you consider the F4W services as a whole, a useful addition to the needs and challenges of your water services?

- How much do you think F4W contributes to the improvement of the interoperable profile of your water utility?
- How much do you think F4W contributes to the seamless integration of different data sources (e.g., SCADA, sensors, proprietary databases) in your water utility?
- How much do you think F4W contributes in the integration of different services (e.g., models, decision support systems, analytics, platforms) in your water utility?
- Would you suggest the adoption of standardization protocols in the development of new services (tools, applications, decision support systems) and deployment of new data sources (Scada, meters, sensors) for the water utility in the future?
- Usefulness of F4W services, which gives insights on how useful the F4W services, as a whole, are in respect to the challenges at the case study. This trait includes case specific questions, tailored to the services developed in each demo case.

For the assessment of smart application developed in UK demo case for customers, a separate questionnaire was compiled. The following main trait categories included:

- The **usefulness (UF)** and performance of a service, which gives insights on how useful the Smart Meter Mobile Application is with respect to the addressed needs and challenges, and includes the following partial characteristics/questions:
  - Do you consider this application as a useful addition towards the improvement of water efficiency of your household?
  - Based on your experience from the interaction with the application, how well do you think the application performs the specific function that it was designed/supposed to do?
  - Is the service efficient at raising your awareness on drinking water use efficiency?
- The **integrity (IG)** of a service, which gives insight on the integrity of the Smart Meter Mobile Application, i.e. the speed, stability and reliability of its structural functions, and includes the following partial characteristics:
  - The executing speed of the function
  - The stability of executing its functions
- The **usability (UB)** of a service, which gives insight on how easy, straightforward and intuitive is to use the Smart Meter Mobile Application, and includes the following partial characteristics/questions:
  - How would you rate this user interface in terms of the time it took you to get acquainted with the interface
  - How would you rate this user interface in terms of user interface functionality
  - the design of the user interface
  - the overall intuitiveness of the user-application interaction
  - the functionality of the application in general
- The facilitation of **user learning and support (UL)**, which gives insights on whether the learning material and/or support provided to the end-users for the service was satisfactory or not, and includes the following partial characteristic:
  - Whether the support and learning material provided is sufficient.

I.3. Assessment of FIWARE technology

The second aspect that is evaluated is the FIWARE technology, from the perspective of those (developers and IT personnel) who have been involved in the development and deployment of FIWARE

components and the integration of sources and services at each demo case. Specifically, the procedure covers the following key aspects:

- Installation of FIWARE components (such as Context Brokers and other Generic Enablers)
- Configuration of FIWARE components (e.g., add Context data into the Context Broker or define dataflows in FIWARE-Draco GE)
- Use of Smart Data models to describe Context data and information
- Creation of new Smart Data models (e.g., data model for EPANET)
- The overall integration procedure of third-party systems (e.g., legacy systems, sensors, applications, third-party software and algorithms etc.) with FIWARE

The questionnaire for FIWARE, distributed to the end-users is given in Annex B.

To assess the above aspects, nine main trait categories. Specifically, the assessment of FIWARE components was conducted on the basis of 4 traits:

- The **ease of installation**, that gives insights on the effort required to install a FIWARE component, and has the following partial characteristics/questions:
  - Installation time needed:
  - Installation process simplicity/complexity:
  - Integration with the current system:
  - Dependence on third-party software/hardware:
  - Installation guidance and support
- The **ease of configuration**, that gives insights on aspects of the effort required to configure a FIWARE component to specific needs, and has the following partial characteristics/questions:
  - Configuration time needed
  - Configuration process simplicity/complexity
  - The time it took you to get acquainted with the component
  - The overall intuitiveness of the component interaction
  - Informativeness of errors
  - Configuration options
  - Configuration guidance and support
  - Clarity in the Available Documentation
- The **integrity**, that gives insight on the integrity of FIWARE components, i.e. the speed, stability and reliability of its structural functions, and includes the following partial characteristics:
  - The speed of executing their function
  - The stability of their functionality
  - The security of the component
  - The time it took you to get acquainted with the interface
  - The user interface functionality
  - The design of the user interface:
  - The overall intuitiveness of the user-service interaction:
- The **usefulness**, gives insight on how useful the FIWARE component is in the Context of FIWARE reference system architecture, and how easy is to use it, and includes the following partial characteristics/questions:
  - Based on your experience, how well do you think the component performs the specific function that it was designed/supposed to do?
  - How do you view the use of the specific component as part of the FIWARE-enabled reference system architecture for your case?

- Based on your experience, how do you view the functionality of the component in general.

As an additional key trait category, we assess the experience of using the **ETSI NGSI-LD standard** via the following questions:

- The experience in terms of the time it took you to get acquainted with the standard
- The experience in terms of standard simplicity/complexity
- The experience in terms of Usefulness and efficiency of the standard
- The experience in terms of Guidance and support to understand and utilize the standard
- The experience in terms of Documentation to facilitate the use of standard

With respect to the **use and creation of smart data models**, the following characteristics/questions were assessed:

- The experience in terms of the time it took you to get acquainted with the structure of data models
- Data models simplicity/complexity
- Guidance and support to understand and utilize or create data models
- Documentation of entities, properties and relationships of data models:
- Usefulness of data models
- The amount of information required to create a new data model

The final key trait category aims to give insights on the overall effort required to integrate third-party systems (such as devices, applications, sensors etc.) with FIWARE, developing connectors. The following questions were examined:

- Integration time needed (including the time needed to adapt a system to make it work with FIWARE)
- Integration process simplicity/complexity
- Integration guidance and support

An indicative example of the questions aiming to gather insights from the end-users is given in Figure 2.

II. Installation of FIWARE component

This set of questions gives insights on aspects of the effort required to install a FIWARE component.

Target Group: These questions are directed only to **persons who involved in the installation of a FIWARE component** (e.g., a Context Broker or a Generic Enabler).

How would you rate the ease of use when installing the FIWARE component in terms of:

a.) Installation time needed:

(very long)		(reasonable)		(very fast)
1	2	3	4	5
☐	☐	☐	☐	☐

b.) Installation process simplicity/complexity:

(very complex)		(reasonable)		(simple and concise)
1	2	3	4	5
☐	☐	☐	☐	☐

Very complex: The installation process was lengthy and required special knowledge, e.g. installation of other tools first or technical hardware skills. As such, it had to be done by specialized personnel.
Simple and concise: The installation process was very simple and could be readily performed by me, without extra steps or pre-installation needs.

Figure 2: Indicative example of questions targeting the deployment of FIWARE technology

II. Raw-water supply optimisation (Greece)

II.1. Fiware4Water services for Athens demo case

Athens Demo Case aimed to deploy and demonstrate FIWARE-enabled applications and services in the raw-water external conveyance system that serves the greater metropolitan area of Athens (Greece). The system, composed by more than 495km of aqueducts, is operated by Athens Water Supply and Sewerage Company (EYDAP S.A.), the largest water utility in Greece. The key target within F4W, was to upgrade the real-time operational management of the raw-water supply system by integrating data sources from different sensors and vendors, into a common information system, taking advantage of the data portability and integration functionalities of FIWARE. NTUA and EYDAP designed and implemented a new FIWARE-enabled platform, along with a series of analytics, for the demo part of the aqueduct, Giona to Dafnoula (131 km) integrating data from:

- 5 open channel flowmeters,
- 51 water level meters (46 legacy system and 5 new installed in the context of F4W)
- 6 water quality meters, measuring turbidity, conductivity, and temperature.

Taking advantage of the integrated source of data, a new platform, along with a series of smart applications, has been developed to enable the operational staff of EYDAP to monitor the system on a real-time basis, and get advice on the optimal management of the large conveyance system.

The new services that the platform provides allow EYDAP staff to access in real-time hydraulic and quality measurements, to access process and analyse historical time series, giving also access to 3 new applications customized to EYDAP needs:

- advice provision for optimal sluice-gate (flow regulation structures) operation;
- early warning for high turbidity events and forecast of the level of turbidity at the downstream part of the systems, and
- analysis and forecast of the water volumes conveyed by the system on daily basis.

Detailed descriptions of FIWARE-enabled solution are given in Deliverable 4.1.

II.2. Lessons learnt and future perspectives

The lessons learned during the development and evaluation process can be summarised as follows:

Platform assessment - Dashboard for monitoring of real-time data. The feedback regarding the platform was very positive. The platform was characterized as stable, fast and beautiful. The acquaintance time with the user interface was very reasonable and the integration of the various services and data sources was seamless. The staff welcomed the idea of expanding the use of this platform to the entire external aqueduct of EYDAP to increase the monitoring efficiency. Additionally, the application of a similar toolbox and interphase in the other operational aspects of the company such as the drinking network and sewerage network was suggested.

Sluice gate opening DSS. The staff found the tool fast, reliable, and very intuitive. They reported that it can help substantially with the management of the conveyance system, and it poses a significant improvement to the existing management system. It can assist with the reduction of user errors due to the empirical methodology that is commonly applied for the management of the conveyance system presently. Some staff asked for additional documentational material that facilitates new users with the service. Another request that was reported concerned the expansion of the service to the rest of the conveyance system.

Analysis and forecast tool of total daily demand volumes. The tool was highly appreciated by EYDAP staff. It can assist with the management of the conveyance system during the most demanding periods of the year. No issues were reported.

High-turbidity events and forecast tool of the level of turbidity The tool was straightforward, fast, easy to use and reliable. It can help with dealing with extreme events instantly leading to improved management of the system. No issues were reported.

Through F4W, NTUA and EYDAP developed a fully functional FIWARE-enabled system architecture, which can easily be extended to cover other applications, taking advantage of the connectors developed. The deployment of such interoperable and standardized digital solutions unfolds new perspectives for EYDAP, which is upgrading its supervisory system and digital water strategy and is keen to look and test alternatives to facilitate the integration of different sensors (from different vendors) and applications (from different software providers) into a common system.

II.3. Assessment of F4W services from the end-user perspective

The performance and suitability of services developed for Athens Demo Case were assessed from the perspective of the end-user (i.e., EYDAP staff), on the basis of the qualitative trait categories presented in Section I.1. Specifically, the utility operators provided assessment for the usefulness, integrity, usability as well as the ease of learning of four key services: a) forecast of water supply volumes, b)

warning and forecast of turbidity events, c) optimal sluice gate operation, and d) the new web platform for real-time monitoring. The results of the qualitative evaluation process for each individual service are presented in the left spider diagram of Figure 3, while right spider diagram provides the average performance for all services along with the assessment of the "added-value of F4W developments as a whole" for the utility (indicated as "F4W-AV" in the spider diagram). As it is evident, the feedback for all services is very positive, with the scores being equal or higher than 4 for all trait categories and services. Furthermore, the end-users provided a high score (4.4/5.0) with respect to the overall added-value that services has for EYDAP, while Table 1 shows that the new services contributes positively in the operational efficiency of the utility with respect to specific challenges and targets. It is also worth highlighting that this is the first time EYDAP is empowered with operational analytics for the analysis and forecast of water supply volumes and the level of turbidity in the channel, while the new web platform integrates and gives access to both quality and flow measurements, which were hosted prior to the F4W project into different information systems.

Figure 3: Evaluation results of FIWARE-enabled services developed for Athens Demo Case, in the form of a spider diagram, with scores ranging from 1(lowest) to 5 (highest). The left spider graph depicts the assessment per services, while the right spider graph the average assessment for all services and the "added-value of F4W developments as a whole"(F4W-AV).

Table 1: Evaluation of usefulness of F4W services for Athens Demo case with respect to specific challenges and targets (scores ranging from 1(lowest) to 5 (highest)).

Case-specific questions on the usefulness of F4W services for Athens Demo case	Score
How much do you estimate your preparedness level to be towards unusual turbidity events – compared to the previous state?	3.9 (Modest improvement)
How much do you estimate the operational efficiency of the raw-water conveyance system– compared to the previous state?	3.6 (Modest improvement)
How much do you estimate your preparedness level to be towards high demand events – compared to the previous state?	3.6 (Modest improvement)

Furthermore, the staff of EYDAP provided open feedback and suggestions, which are very useful to inform future developments and further improvements of the services developed in F4W. Overall, the comments are very positive, with some of them proposing the expansion of the area of implementation of services to other parts of, or the entire, conveyance system. Some of their comments (taken directly from the responses) are:

<u>With respect to the web platform:</u>

"*Expand the application points [of the web platform] to the entire conveyance system*."

"*Application of similar toolbox and interphase in the other operational aspects of the company such as the drinking network and sewerage network.*"

"*The graphical interface [of the web platform] is very elegant and straightforward. However, a video demonstration would be very helpful. Also, some information boxes on mouse hover would be helpful to assist the new users.*"

"*No extra material is needed for the dashboard. The service is extremely easy to use.*"

"*Extend the model [for optimal sluice gate settings estimation] to more L structures.*"

III. Water supply system management (France)

III.1. Fiware4Water services for France demo case

The French Demo Case (DC2), of the F4W project, is the drinking water supply system of SICASIL (Syndicat Mixte des Communes Alimentées par les Canaux de la Siagne et du Loup, in English, Mixed Water Union of Municipalities Supplied by the Siagne and Loup Canals). SICASIL has delegated the management of its drinking water supply system in eight municipalities, including Cannes, to SUEZ under a Public Service Delegation contract (from 1993 to 2023).

In the framework of F4W project, four services have been developed and integrated with the FIWARE technology, based on four business issues driving the French Demo Case:

- Forecast water resources availability
- Forecast water demand
- Detect water leaks
- Detect abnormal water quality events

3S, subsidiary of the worldwide SUEZ group, publishes software dedicated to the water sector: Drinking Water, Sewage, Water ways, Assets Management, Smart Metering and Environment in general. AQUADVANCED® Water Networks refers indistinctly to one of the two following software products developed by 3S and used for the French Demo Case: AQUADVANCED® Water Networks "Production and Transport" and AQUADVANCED® Water Networks "Distribution.

The measurements used for the French Demo Case come from the Cannes basin drinking water supply system, they are connected in a classical way: Sensor / RTU / SCADA TOPKAPI / AQUADVANCED® Water Networks. Weather data come from a French national meteorology provider. AQUADVANCED® Water Networks is the data source for the French Demo Case, for which a bidirectional IT connector, FIWARE compliant, has been developed to transmit the measurements to the F4W platform and to receive, in the opposite direction, the calculation results from the 4 scientific models developed by 3S, EGM, EUT and TZW for the 4 above mentioned business issues.

The data sources for the development of the suite of services are shown in Table 2.

Table 2: Overview of data sources for the various F4W services in the France demo case

	Software services			
Data sources	BI01: Forecast water resources availability	BI02: Forecast water demand	BI03: Detect water leaks	BI04: Detect abnormal water quality events
Input data				
Humidity	●	●		
Rainfall	●	●		
Wind speed	●	●		

	Software services			
Data sources	BI01: Forecast water resources availability	BI02: Forecast water demand	BI03: Detect water leaks	BI04: Detect abnormal water quality events
Temperature	●	●	●	●
Water volume	●			
Water demand		●		
Public holidays		●		
Wind direction		●		
Reservoir level			●	
Pressure			●	●
Flow			●	●
Historic of observed leaks dates			●	
Historic of pipe breaks			●	
Historic of customer complaints			●	
Conductivity				●
UV254				●
TOC				●
Free chlorine				●
pH				●
Turbidity				●
Type of used resources				●
Output data				
Water volume	●			
Water demand forecasting		●		
Predicted leaks dates			●	
List of detected events				●

Interoperability of systems based on FIWARE technology is a major theme addressed by the five projects constituting the DigitalWater2020 synergy group (DW2020), through the Task Force 1 "FIWARE and ontology": **F4W**, aqua3S, DigitalWaterCity, NAIADES and SCOREwater. 3S is a partner in the two H2020 projects **F4W** and **aqua3S**.

Seven technical functionalities (TF01 to TF07) have been developed as part of the F4W project and detailed in **deliverable D4.2** "FIWARE4_Leakage Management". In summary, these are:

- TF01: Network Notebook - The users of the AQUADVANCED® Water Networks "Distribution" applications can be local operators at agency level or central operators at region level; they need to exchange information relevant to the management and operation of the network.
- TF02: Evolution of the AMR display - Currently, AQUADVANCED® Water Networks "Distribution" uses AMR data to display several indicators and curves. These indicators and curves are used by the operators to analyse the real consumption of their networks, compare

it with the volume delivered in each DMA (District Metered Area), and calculate water losses. In DMAs where customers are not equipped with AMR meters, water losses are calculated using the night flow or the minimum flow. AQUADVANCED® Water Networks "Distribution" can use two methods (one based on AMR data and the other based on night flow data) to calculate the water losses, but before the new release, it only displayed one of the two.

- TF03: Improvement of the communication between two systems (AQUADVANCED® Water Networks "Distribution" and the intervention system) using a geocoding service - AQUADVANCED® Water Networks "Distribution" has a function that allows users to send intervention requests in the intervention system. This function is very useful for the operators, as it is a way to communicate between the one who analyses the event and those who have to act on the field to repair the leaks. TF03 improves the communication between the user of the AQUADVANCED® Water Networks "Distribution" application and the person in charge of the intervention in the field and makes the intervention area reliable by assigning it a postal address provided automatically by a geocoding service.
- TF04: Generation of events from acoustic loggers - AQUADVANCED® Water Networks "Distribution" retrieves data from several suppliers of acoustic loggers. It displays the noise data, together with the associated thresholds configured by the operators. The application allows the operator to generate the events he wants via a specific configuration, then to allow the system to create events according to the thresholds that the acoustic loggers generate. The interest will be to correlate the events between them (future developments planned for 2022) such as an acoustic logger on alert, an increase in the night-time flow and an increase in the volume of loss.
- TF05: Online integration of scientific models - Scientific models have been developed by 3S, EGM, EUT and TZW for the four French business issues (BI01 to BI04). The functional architecture, designed and implemented for the French Demo Case, is a strong and nice illustration of the theme of systems interoperability in two ways: Online bidirectional data exchanges between AQUADVANCED® Water Networks (software product published by 3S) and the scientific platform, based on the BentoML open-source component, in charge of hosting and executing the scientific models, as a computation server. Data exchanges are carried out through the F4W platform acting as a data gateway between both IT applications. IT connectors have been developed to exchange data in accordance with the FIWARE technology, based on the NGSI-LD standard. A common functional architecture addressing jointly the French Demo Cases of both F4W and aqua3S projects.
- TF06: Big Data models integration - The deployment of the different Machine Learning models (generated by EUT) using the Spark Big Data tool is done using FIWARE components. It consists of showing how fast the predictions of "Forecast water demand" and "Detect water leaks" can be done under heavy data circumstances.
- TF07: Workforce tool integration - This functionality shows the interoperability and deployment of a workforce tool (generated by EUT) that optimally assign and schedule operator's tasks according to maintenance operations to be performed within the water distribution system. It hosts a SAT solver that receives the input from the FIWARE component Orion Context Broker and returns to the user the actions to take out by the operators. The tool is deployed using the same FIWARE environment that is used in TF06, deploying together the Big Data models and the workforce tool within a single platform.

III.2. Lessons learnt and future perspectives

Integration procedures and implementations of FIWARE solutions

The IT connectors developed for data exchanges (online integration; TF05) between AQUADVANCED® Water Networks and scientific platform, through the F4W platform, did not present any particular technical difficulties. The Stellio context broker, the core of the F4W platform, was enhanced by EGM for the French Demo Case for two reasons:

1. Transmit time series whose start or end dates can be in the past, at the current time or in the future
2. Trigger the execution of a model at a fixed period or conditionally to the update of certain input variables required by the model

The deployment of the different Machine Learning models using the Spark Big Data tool is done using FIWARE components (TF06): (i) Orion Context Broker to store the current state of entities, (ii) Cygnus responsible for the historic context.

With the development of the Big Data Machine Learning models, many benefits were obtained:

- Fast large-scale predictions and output visualization
- Data consistency and history
- Scalability and integrability

The workforce tool (TF07) was developed using the OptaPlanner as a solver that is responsible for optimizing plans, schedules and more based on pre-defined constraints.

The developed workforce tool has a focus on being self-manageable, fast, and fully integrated with FIWARE technologies, to keep and store the data entities consistently and to be responsive when new planner requisitions are received through the system. Among its main features some key points can be showcased:

- System interoperability
- Self-management
- Scalability
- Highly customizable

Installation of multiparameter probes

The SUEZ operators and their public client SICASIL expressed their satisfaction with the installation of the 4 nano::stations in the drinking water distribution network and the possible monitoring of the water quality. **Independently but because of the F4W project, SICASIL has asked SUEZ to install, before the end of 2022, 10 other multiparameter probes (probably nano::stations)** in order to have a more exhaustive vision of the water quality of the drinking network.

Development of scientific models

The development of a scientific model for a given area of interest does not guarantee its transposability to other areas of interest in the same territory, and even less so on a national or even international scale. Adapting a model from one area of interest to several others is usually a long, technical and costly exercise, whose conclusion may underline the technical and economic non-viability of a deployment on several areas of interest because the operation would be too long and/or too costly.

The challenge was threefold:

1. Develop scientific models based on Machine Learning (ML) techniques as no physical-chemical model existed for the four French business issues (BI01 to BI04) and it was not planned to build new ones
2. Reduce, or even eliminate, the offline model learning phase, which is long, technical and costly

3. Develop models based on scientific approaches that are sufficiently generic to allow their deployment on several areas of interest in a territory, or even on a national or international scale

The generic character of these four models is based on the fact that their inputs are independent of the number, or even the nature, of the available or exploitable parameters of the area of interest considered. In other words, if the number or even the nature of the parameters is different from one area of interest to another, then there is no need to modify the model code or to redo a study. Adaptability to the existing local metrological context is therefore an intrinsic property of these models. See deliverable D3.2 for further details about points 2 and 3.

These four models are at least at TRL8 because they have been successfully tested on several areas of interest of the French Demo Case, but they still need to be tested on other territories to reach TRL 9. Nevertheless, the scientific models developed in the F4W project are of industrial quality; indeed, the two models associated with BI01 and BI02 are already integrated in the AQUADVANCED Water Networks "Production and transport" software product. The model associated with BI03 is expected to be integrated into AQUADVANCED Water Networks "Distribution" by the end of 2022 and the model associated with BI04 in 2023.

Independently, but also due to the F4W project, SUEZ ordered from 3S an industrial implementation of two of the four scientific models developed for the French Demo Case:

- BI01: Forecast water resources availability
- BI02: Forecast water demand

This implementation has been completed and SUEZ has expressed its satisfaction.

FIWARE Generic Enablers

The French Demo Case demonstrated the speed and ease of use of Generic Enablers to build smart services:

- **TF05:** online implementation of the functional architecture illustrating systems interoperability using the Stellio Context Broker
- **TF06:** integration of Big Data models where the deployment of Machine Learning models, based on the Big Data tool Spark, uses FIWARE components, Orion Context Broker and Cygnus
- **TF07:** integration of the workforce tool using FIWARE components, Orion Context Broker and Cygnus

AQUADVANCED® Water Networks "Distribution" functionalities

- The four functionalities (TF01 to TF04) developed for AQUADVANCED® Water Networks "Distribution", within the F4W project, are not specific to the French Demo Case **These IT developments are of industrial quality** as they are already integrated in a release candidate (V1.10) submitted to the 3S integration team for testing and final validation. The technical functionality TF03 is even more advanced as it is already integrated in the V1.9 version, which is already deployed in production on some SUEZ sites.
- These four functionalities, which are very useful for the management of a drinking water distribution network, thus enrich the functional scope of the AQUADVANCED® Water Networks "Distribution" software product, which is widely deployed in France but also worldwide. The thousands of current users of this product will benefit from these four new functionalities before the summer of 2022.

Deliverable D4.2 details the deployment and integration of the French Demo Case. The last section "Perspectives" presents some possible perspectives of the functional architecture implemented for the French Demo Case:

- Use of a context broker to ensure data exchanges between the numerous IT applications existing within the IT system of an operator managing a drinking water supply system: SCADA, data historian, hydraulic model, clients complaints, interventions management, GIS, etc.
- Data exchange between a public client (municipality or water union) and its private delegate. For example, the municipality provides open data that its delegate can use; conversely, the operator sends the municipality data related to the operation of the site.
- Data exchange between different stakeholders involved in the functioning and operation of a Smart City IT application: a municipality and its various delegates, a water utility, a street lighting operator and a parking operator.
- Data exchange between a local agency of a water utility and the sites (i.e. the contracts) it manages. Data from the different sites are consolidated at the local agency level.
- Data exchange between a regional agency of a water utility and the local agencies it covers. Data from the different local agencies are consolidated at the regional level.

III.3. Assessment of F4W services from the end-user perspective

The performance and suitability of services developed for French Demo Case were assessed from the perspective of the end-user, on the basis of the qualitative trait categories presented in Section I.1. Specifically, the utility provided assessment for the four key services (business issues) developed: a) forecast water resources availability, b) forecast water demand, c) detect water leaks, and d) detect abnormal water quality events. Figure 4 (left spider diagram) presents the results of the evaluation, with scores ranging from 1 (lowest) to 5 (highest), for the 4 services with respect to their usefulness, integrity, usability as well as the ease of their learning and support. The feedback for all services is very positive, with the scores being equal or higher than 4.5 for all trait categories. It is worth to quote the open feedback taken directly from the responses, with respect the intuitiveness and transparency of the developed services:

“No need for learning material and/or support provided to the end-users as the exchanges between AQUADVANCED® Water Networks and the scientific platform, through the F4W platform, are transparent to the user.

The user only interacts through the graphical interface of AQUADVANCED® Water Networks, which he knows very well.”

As indicated in the right spider diagram of Figure 4, the assessment is very positive for the overall added-value of F4W in the demo case of Cannes (4.1/5). Table 3 indicates the high operational interest of the developed services for the operators of the system, while it is also worth to note that similar services (apart from the detection of water leaks) were not available to the utility before F4W project.

Figure 4: Evaluation results of FIWARE-enabled services developed for French Demo Case, in the form of a spider diagram, with scores ranging from 1 (lowest) to 5 (highest). The left spider graph depicts the assessment per services, while the right spider graph the average assessment for all services and the "added-value of F4W developments as a whole"(F4W-AV).

Table 3: Evaluation of usefulness of F4W services for French Demo case with respect to specific challenges and targets (scores ranging from 1(lowest) to 5 (highest)).

Case-specific questions on the usefulness of F4W services for FR Demo case	Score
How do you evaluate the operational interest of the model dedicated to water resources availability forecasting, developed in the framework of the F4W project?	5.0 (high)
How do you evaluate the operational interest of the model dedicated to water demand forecasting, developed in the framework of the F4W project?	5.0 (high)
How do you evaluate the operational interest of the model dedicated to water leakage detection, developed in the framework of the F4W project?	5.0 (high)
How do you evaluate the operational interest of the model dedicated to abnormal water quality events detection, developed in the framework of the F4W project?	4.0 (fairly high)

As an issue for future investigation for the service that supports the forecast water resources availability, the end-users commented (taken directly from the responses):

"*small fluctuations that appeared in the case of a forecast based on a dry weather scenario (without any precipitation) over the summer period when a decrease in the volume of the resource is expected. No physical significance of this phenomenon has been identified to date; this topic needs to be investigated further.*"

IV. Intelligent control for wastewater (Netherlands)

IV.1. Fiware4Water services for the Amsterdam West WWTP

The wastewater treatment plant (WWTP) Amsterdam West demo case is situated in Amsterdam, the Netherlands. WWTP Amsterdam West consists of 7 treatment lanes. Each treatment lane has its own state and is controlled individually. One of the treatment lanes (lane 2) is dedicated as a full-scale research lane. For this demo case, additional sensors are deployed in the research lane. Furthermore, AI smart applications are developed. The F4W architecture is integrated in the WNT legacy system with AI smart applications and are tested in practice.

Within the Amsterdam West WWTP demo case, a suite of services were developed for the research lane. This smart application suite comprises of:

- Soft sensors for airflow and influent forecasting. The soft sensors make use of AI model predictions, while utilizing a variety of datasets. Specifically, the airflow soft sensor provides a

prediction of the airflow and energy usage for the aeration for each treatment lane in Amsterdam West WWTP. The influent forecast soft sensor provides forecasts for the wastewater influent flow over a prediction horizon while using historical measurements of rainfall data and the influent flow itself.

- An AI-based data validation and reconciliation (DVR) application. The application consists of an anomaly detector that uses statistical methods to assess whether a data point is an anomaly. Additionally, a data reconciliation component utilizes deep learning based autoencoder models to provide a predicted value that can be used for reconciliation.
- The AI soft sensors and the AI-based DVR applications provide input and potentially increase the accuracy of a digital twin model, which has been developed to mimic the wastewater treatment processes.
- An AI-agent-based control engine has been developed to steer the wastewater treatment process such that minimisation of energy consumption and greenhouse gas emissions is achieved while assuring a specific effluent water quality level. The engine is trained offline through Deep Reinforcement Learning techniques. A combination of the digital twin and the soft sensor for input flow forecasting is used as a process simulator for training of the agents.

Detailed descriptions of the smart applications can be found in Deliverable 3.3.

A majority of the above-mentioned smart applications were integrated and deployed within a FIWARE based architecture, thereby demonstrating the possibilities for the use of the FIWARE ecosystem in the (waste)water sector. A culmination of custom-built connectors, which integrated the FIWARE components, the smart applications and the legacy system within the architecture, along with generic smart data models were deployed to showcase the non-intrusive nature of FIWARE. Real-time data of all sensors and actuators from the Amsterdam West WWTP can be accessed for direct use within the F4W architecture and then ingested by the smart applications. Due to the interoperable nature of FIWARE, the methodologies which are implemented in the F4W architecture, could potentially lead to its adoption for other (waste)water treatment systems to enable real-time advanced analytics of available data. Further details of the F4W architecture deployed for the demo case can be found in Deliverable 4.4.

A large selection of sensors and actuator devices serve as data sources for the suite of services and is shown in Table 4. Integration of the legacy services with FIWARE has been completed for the AI-based DVR.

Table 4: Overview of data sources for the various F4W services in the WWTP demo case

	Software services				
Data sources	Influent soft sensor	Airflow soft sensor	AI-based DVR	Digital Twin	Control agent
Input data					
Rainfall data	●				
Nitrate and ammonium			●	●	
Oxygen level, including setpoint				●	
Air valves and pressure		●			
Energy consumption of blowers		●			
Influent, internal, recirculation and effluent flows	●				

Out nitrous oxide volume				●	
Dry solids				●	
Temperature				●	
Output data (: used as an input for the control agent)*					
Volumetric flow of influent	●			●	●*
Oxygen level				●	●*
Oxygen setpoint					●
Pressure				●	●*
Air flow estimation		●		●	●*
Energy		●		●	●*
Estimation of nitrate and ammonium			●	●	●*
Estimation of dry solids, dry solids surplus drain, recirculation flows				●	●*
Out nitrous oxide volume				●	●*
Temperature				●	●*

To obtain fine-grained control and monitoring of the wastewater treatment process, several additional sensors were placed at different locations within the process. On-site electrical data infrastructure had to be engineered and built before operation of the sensor devices. Data of all sensors and analyzers were made available in the legacy Data Historian process information management system (PIMS). The WNT legacy Data Historian PIMS is also integrated with FIWARE components, thereby enabling interoperability within a true F4W architecture. The F4W architecture itself runs continuously in a WNT virtual machine (VM) processing the latest data of multiple sensors and actuators while running the F4W AI smart applications. The coupling of all sensor (existing and new), actuator and setpoint data sources of the WNT legacy system with the F4W architecture provide infrastructure and code that can be reused. Consequently, future development time can be decreased and upscaling potential increased.

IV.2. Lessons learnt and future perspectives

During the development, implementation and integration of smart applications within the F4W architecture, WNT, KWR and EUT collaborated extensively. Due to the nature and challenges of the demo case, the project activities led to a multi-disciplinary approach in identifying solutions, where knowledge on wastewater treatment, sensoring, AI and ICT synergistically led to solutions with a relatively high TRL. Furthermore, the use of AI in the water sector, which is still in its infancy, has been significantly boosted through the development in this demo case, considering a WWTP is of large-scale and complex in nature. The experiences and developed methodology provide the sector adequate information to further adopt and deploy such technologies to enable optimal operation of (waste)water systems. Furthermore, pertinent climate change related challenges, such as the reduction of greenhouse gas emissions and energy security, have been addressed. As a result, various topics that are significant to the EU, from adoption of cutting edge technology to sustainability, have been pursued.

Similarly, the use of FIWARE, as being recommended by the EU to all sectors to adopt within various smart cities initiative, was also showcased. In general, it was learned that the FIWARE ecosystem catalogue is vast, providing the end-user a great deal of choices and options to incorporate to their

specific needs. However, based on the experiences within the demo case, a great deal of time is needed for prospective users to familiarize themselves with the FIWARE components and conduct the configuration. Furthermore, the limited amount of documentation that provide simplistic examples, leads one to rely on trial and error, thereby costing significant time for development. Lastly, for the purpose of wastewater treatment, given the complex and non-linear processes could lead to the need of developing advanced solutions that are trained on historical data (such as the use of deep learning models, e.g., recurrent neural networks). Subsequently, the integration of such applications to a platform such as FIWARE, leads to the requirement of technical capabilities that can in real-time support the smooth functioning of the application. It was concluded that the FIWARE components, in its current stage, are very well suited in the integration of simpler applications and require further upgrades, which can cater to multi-input (with respect to time) based applications. A concise list of lessons learned can be found in Deliverable 3.6, Section III.

The F4W Amsterdam demo case demonstrates the possibilities for the use of FIWARE in practice, with the introduction of AI smart applications and the integration in legacy systems in the (waste)water sector. A number of F4W AI smart applications are introduced in the F4W architecture using F4W wastewater treatment data models this enlarges the possibilities for the use of FIWARE in the water sector. The interoperable properties of the FIWARE-enabled F4W architecture together with the developed F4W data models, enable replication and upscaling. The methodologies, approaches, and developed technologies in the Amsterdam demo case present a successful baseline to guide other water utilities for future digitalization processes.

IV.3. Assessment of F4W services from the end-user perspective

The performance and suitability of services developed for Netherlands Demo Case were assessed on the basis of the qualitative trait categories presented in Section I.1. Specifically, the end-users provided assessment for the usefulness, integrity, usability as well as the ease of learning of four AI-related services: a) the AI soft sensor for airflow forecasting, b) the AI-agent-based control, c) the AI soft sensor for influent prediction, and d) the AI real-time data validation tool. The results of the qualitative evaluation process of each individual service are presented in the left spider diagram of Figure 5, while right spider diagram provides the average performance for all services, along with the assessment of the "added-value of F4W developments as a whole" for the utility (indicated as "F4W-AV" in the spider diagram). The feedback was very positive of the usefulness, integrity and usability of services, with the scores surpassing the base of agreement (3.0/5.0). Exception is the score for the usefulness of AI-agent-based control (2.8/5.0), that is associated with the currently hidden value of this services with respect to the improvement of current operation practices. As explained in the relevant open feedback by the end-user (taken directly from the responses):

"At the moment of the assessment the tests with the final control agent needs to be done so it is unknown for the practice situation at this time. However, since the control agent is very well capable of mimicking the current legacy control, which I have tested in practice, and seen the preliminary results of the final control agent in off-line tests, the expectations are that it will be able to improve the current operation."

Regarding the facilitation of learning trait, the end-users found the support satisfactory (3.0/5.0), but they mentioned that "*No extra material needed*".

Furthermore, positive feedback (3.5/5.0) was provided with respect to the overall added-value of F4W for the water utility Waternet, while Table 1 shows that the new services improve the operational

efficiency of the utility with respect to specific challenges and targets. It is worth to note that a similar service was available to the utility for the forecasting of airflow per lane, but the operators reported that the new service improves substantially the already existing one. The other three services consist new additions, developed in the framework of F4W.

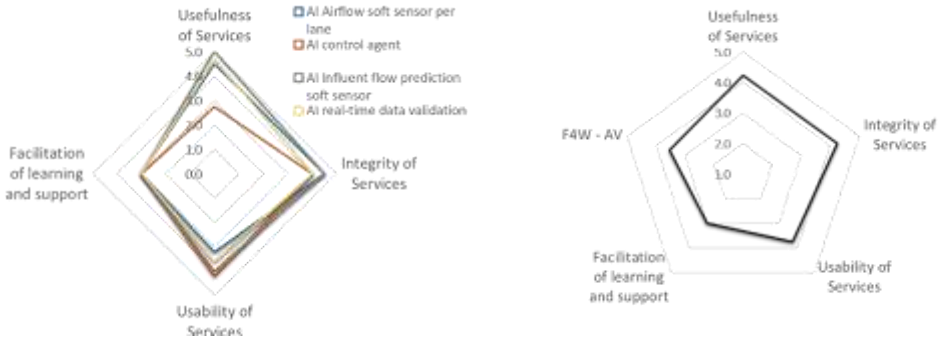


Figure 5: Evaluation results of FIWARE-enabled services developed for Amsterdam Demo Case, in the form of a spider diagram, with scores ranging from 1(lowest) to 5 (highest). The left spider graph depicts the assessment per services, while the right spider graph the average assessment for all services and the "added-value of F4W developments as a whole"(F4W-AV).

Table 5: Evaluation of usefulness of F4W services for Amsterdam Demo case with respect to specific challenges and targets (scores ranging from 1(lowest) to 5 (highest)).

Case-specific questions on the usefulness of F4W services for NL Demo case	Score
How much do you estimate the wastewater treatment softsensors attribute to improved operations?	3.0 (modest improvement)
How much do you estimate the AI applications will contribute to the operational insights and efficiency (N2O emission and energy use) of the wastewater treatment processes– compared to the previous state?	3.5 (modest improvement)
How do you estimate the usefulness of the real-time F4W integration with the legacy systems?	4.5 (substantial improvement)

Further evidence on the suitability of the developed AI services is provided by the open feedback of utility operator:

"The soft sensors and data validation smart applications are well developed. At the moment of the assessment the control agent has not been tested for a longer period yet, and our expectation is that we will further develop the environment and control model to incrementally improve the control agent."

V. Smart metering and citizen engagement (United Kingdom)

V.1. Fiware4Water services for UK demo case

South West Water (SWW) installed domestic smart meters and telemetry infrastructure in a region called Great Torrington to collect daily water use consumption from customers. The goal being to drive positive changes to water consumption behaviour, reduce customers water bills and reduce overall demand on resources and treatment requirements. The technology stack includes:

- 1 x Sigfox IoT communication network

- 100 x Domestic Smart Meters (Diehl Altair v4)
- 4 x commercial smart meters ((Diehl Altair v4)
- A data context broker (Stellio)
- A http client built using Django and Flutter

FIWARE enabled data pipelines, IoT agents and data brokers were built to collect, store, and analyse water consumption data and the following micro-services were developed:

- A customer smart phone application allowing customers with a smart meter to view their daily usage, compare their use against others and set consumption reduction targets,
- An automated leakage detection and high consumption utility application which presents SWW with sensor and data driven alarms,
- A machine learning tool to cluster customers into groups of similar water use behaviour to help SWW target customers with water efficiency campaigns. Household level data such as garden size, building size and occupancy were used as features to the clustering model.

Detailed descriptions of the smart applications can be found in Deliverable 3.4., while the implementation of FIWARE-enabled solution is described in Deliverable 4.4.

V.2. Lessons Learned and future perspectives

The customer application was demoed by 7 customers in the Great Torrington Water Forum and their feedback can be summarised below:

- **Data Frequency**: Daily consumption data (i.e. a single reading for each day) is useful but more frequent data (e.g. 15 minute) available near real-time would increase awareness of wasteful water use behaviour. This would significantly reduce the lifetime of the device battery but options where near real-time data is made available via Bluetooth to a customer in-home display may be more efficient.
- **Historic Data**: historic data allows customers to review water use practices over a longer time period and see the impact of any changes they have made. A period of least 1 month should be made available to the customer
- **Reward and recognition**: A points systems whereby a customer earns points for achieving targets or reducing water consumption would help motivate and encourage water saving practices. A symbol of a droplet of water could be used represent a point.
- **Competition**: Competing to be the lowest water user is helpful to provide context but a grade (low, medium or high) should replace the ranking system. Ranking may lead to reinforcement of negative behaviours or disengagement with the service if customers are always at the top (highest water consumption)
- **Environment**: Communication should always link to environmental impact and the benefits of reduced water use on water resources and energy usage associated.
- **Monetary Value**: Statistics and graphs should always include an option to view on monetary value as well was water volume to reinforce the financial benefits of reduced water consumption.
- **Visualisation**: Estimated data (e.g. when a meter fails to send in) should be colored differently than measured data

The utility application was demoed to 5 members in SWW Operations responsible for water efficiency, leakage and water resources. Their feedback can be summarised as follows:

- **Historic consumption data**: Historic consumption data covering 5+ years from manual meter reads should be presented against the daily consumption data. This will help determine whether a customer is generally a high water user or whether a time-boxed activity (such as a leak or filling up a swimming pool) has generated the high consumption alarms.
- **Repair data**: Repair data should be presented against the alarms to quickly check whether interventions (e.g. pipe repairs, home efficiency audits) are in progress or need further action to fully resolve.

The customer smart phone application and utility application have proven the potential of smart meter data for helping customer reduce water use and quickly finding customer-side leaks. The challenge with the technology will always be the operational costs of maintaining a large smart meter estate powered by batteries. Further work is needed to understand whether it is cost-beneficial to increase the frequency at which the data is made available to the customer, i.e., 15-minute data near real time vs daily data currently available.

V.3. Assessment of F4W services from the end-user perspective

As discussed above, in the framework of UK Demo Case, services for the water utility and customers have been developed. The performance and suitability of the services were assessed from the perspective of the end-user (both water utility and customers in this case), on the basis of the qualitative trait categories presented in Section I.1. Specifically, the utility provided assessment for the 2 key services developed: a) automated leakage detection and b) identification and clustering of customers into groups of similar water use. The results of the assessment of two services from utility's perspective are given in Figure 6, with scores ranging from 1 (lowest) to 5 (highest). The utility staff provided very positive feedback with respect to the integrity, usability and ease of learning of the services, with the scores approximately equal to 4.0 (out of 5.0) for all trait categories. Regarding the usefulness trait, the score also surpasses the base of agreement (3.35/5.0), with end-users considering the services a useful addition to the needs and challenges of the utility. At the same time, some of end-users indicated that more time is required to reveal the value of the services with respect to the improvement of current operation practices.

As indicated in the right spider diagram of Figure 4, the assessment is very positive for the overall added-value of F4W (4.1/5). Table 6 indicates the high operational interest of the services developed for the operators of the system.

It is worth to note that the utility had already service for the detection of leakages, but the operators reported that the new service improves substantially the existing one. The service for customer identification and clustering is a new addition, developed in the framework of F4W.

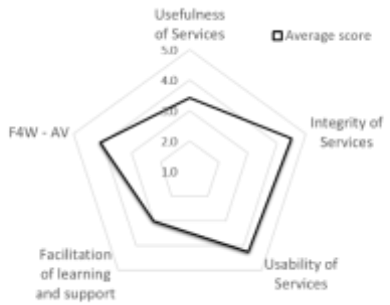


Figure 6: Evaluation results of FIWARE-enabled services developed for UK Demo Case, in the form of a spider diagram, with scores ranging from 1(lowest) to 5 (highest). The left spider graph depicts the assessment per services, while the right spider graph the average assessment for all services and the "added-value of F4W developments as a whole"(F4W-AV).

Table 6: Evaluation of usefulness of F4W services for UK Demo case with respect to specific challenges and targets (scores ranging from 1(lowest) to 5 (highest)).

Case-specific questions on the usefulness of F4W services for UK Demo case	Score
How quickly can you gain meaningful insights into regional consumption patterns compared to previous systems?	4.0 (substantial improvement)
How confident are you that the high consumption and leak alarms from smart meters are relevant and require SWW intervention compared to previous systems?	4.3 (very confident)
Are you better enabled to effectively manage interventions to address high consumption and leaks (promotion and monitoring of remedial actions) compared to previous systems?	4.0 (substantial improvement)
Are you better enabled to evidence and quantify the benefit of interventions (e.g. reduced consumption or customer satisfaction) compared to previous systems?	4.3 (substantial improvement)

Further to the services for water utility, in the framework of UK Demo Case, a smart phone application was developed to allow customers with a smart meter to view their daily usage, compare their use against others and set consumption reduction targets. The assessment of the application was conducted by the customers on the basis of the qualitative trait categories presented in Section I.1. Specifically, the evaluation was conducted in the framework of 1-hour online workshop of Great Torrington Water Forum, which took place on the 18th of May 2022. The collective feedback provided by the 7 people attending the workshop is given in the spider diagram of Figure 7. The feedback of the customers with respect to the usefulness, integrity, usability and facilitation of learning is positive, with scores for all trait categories being higher than 3.0. According to customers view, the application is a very useful addition towards the improvement of water efficiency of their household, performing its functionalities with high speed and stability. As a development for further improvement, the customers proposed the access to tabulated daily water use data, further to graphs.

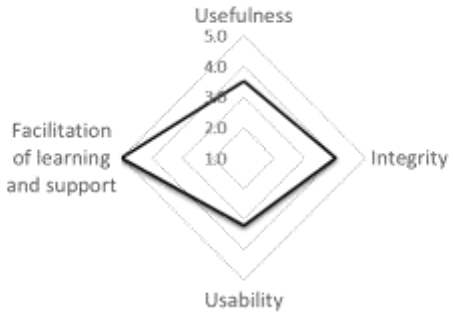


Figure 7: Evaluation results of smart applications developed for customers, in the form of a spider diagram, with scores ranging from 1(lowest) to 5 (highest).

VI. Overall assessment of the added-value of F4W services

This section gives insights on the overall added-value of FIWARE-enabled developments at the four demo cases, focusing on interoperability and standardization, which are key concepts and targets

throughout the F4W project. To provide a qualitative assessment of these aspects, we followed the approach presented in Section I.2. The results of the evaluation, as obtained from the staff of water utilities, are summarised in tabular form in Table 7, while a graphical representation in the form of spider diagram is given in Figure 8.

All four demo cases provided a very high score (≥ 4.0 out of 5.0) for the usefulness of services (F4W - AV_2) developed in F4W, considering them as very useful additions for their needs and challenges. According to the feedback collected, F4W contributes to the improvement (scores higher than 2.0 for F4W - AV_3) of the interoperable profile of all four utilities. Specifically, two utilities (GR and UK demo case) considered this improvement as "*substantial*" (with scores ≥ 4.0/5.0), while the other two (GR and UK demo case) reported a "*partial improvement*". Improvement (scores higher than 2 for F4W - AV_4 and F4W - AV_5) also reported from all demo cases with respect to the seamless integration of data sources (e.g., Scada, sensors, proprietary databases) and services (e.g., models, decision support systems, analytics, platforms), considering that F4W contributes toward this direction. Finally, all four water utilities are very positive (scores ≥ 4.0 out of 5.0)) to adopt standardization protocols, such as FIWARE, for the development and deployment of new services and data sources in the future.

Table 7: Evaluation results of the added-value of F4W services, as a whole, for the 4 demo cases (scores ranging from 1(lowest) to 5 (highest)).

Added-value of F4W services as a whole		**GR DC**	**FR DC**	**NL DC**	**UK DC**
F4W - AV_1	Did your water utility utilize **other standardisation protocols** (e.g., OGC, Saref4water, Other national standards) for data sources and services interoperability?	I don't know	No	Yes	I don't know
F4W - AV_2	Do you consider the F4W services as a whole, as a **useful addition to the needs and challenges of your water services**?	4.5	4.0	4.0	4.0
F4W - AV_3	How much do you think F4W contributes to the improvement of the **interoperable profile of** your water utility?	4.0	3.0	3.0	4.5
F4W - AV_4	How much do you think F4W contributes to the seamless **integration of different data sources** (e.g., Scada, sensors, proprietary databases) in your water utility?	5.0	3.0	3.0	4.0
F4W - AV_5	How much do you think F4W contributes in the **integration of different services** (e.g., models, decision support systems, analytics, platforms) in your water utility?	4.5	3.0	3.0	4.0
F4W - AV_6	Would you **suggest the adoption of standardization protocols in the development of new services** (tools, applications, decision support systems) and deployment of new data sources (Scada, meters, sensors) for the water utility in the future?	4.5	4.0	4.0	4.0

Figure 8: Evaluation results of the added-value of F4W services, as a whole, for the 4 demo cases, with scores ranging from 1(lowest) to 5 (highest).

VII. Assessment of FIWARE

This section presents a qualitative assessment of FIWARE technology, based on the experience and feedback collected from those (i.e., developers and IT personnel) who have been involved in the development and deployment of FIWARE-enabled services at the four demo cases. As described in Section I.3, the assessment of FIWARE technology focuses on 6 key aspects: i) the installation of FIWARE components; ii) the configuration of FIWARE components; iii) the use of ETSI NGSI-LD standard, iv) the use of smart data models, v) the creation of new smart data models, and vi) the overall experience from the integration of third-party systems (e.g., legacy systems, sensors, applications, third-party software and algorithms etc.) with FIWARE.

At each demo case, different components of FIWARE ecosystem have been employed and customized to support the deployment of a FIWARE-enabled architecture that integrates in a standardized way the new smart applications developed, the new sensors installed and the existing data sources from the legacy systems. Detailed descriptions of the FIWARE solutions deployed at each demo case are given in the relevant deliverables of WP3 and WP4. Table 8 summarizes the FIWARE components used at each demo case and the relevant services integrated.

Table 8: Summary of FIWARE components deployed at each demo case and the relevant services integrated.

	FIWARE components	**Services Integrated**
GR DC	Orion-LD CB, DRACO GE, IoT Agent for JSON	NESSIE platform, new smart applications, EYDAP's legacy system
FR DC	Stellio CB, Cygnus	AI and ML models, databases and data visualizing tools, AQUADVANCED® Water Networks "Production and transport" and AQUADVANCED® Water Networks "Distribution"
NL DC	Orion-LD, Cygnus, IoT Agent for JSON	AI smart applications, Waternet Smart Legacy Connector
UK DC	IoT Agent for Sigfox, Stellio CB, Cygnus	Smart Meters, New software applications

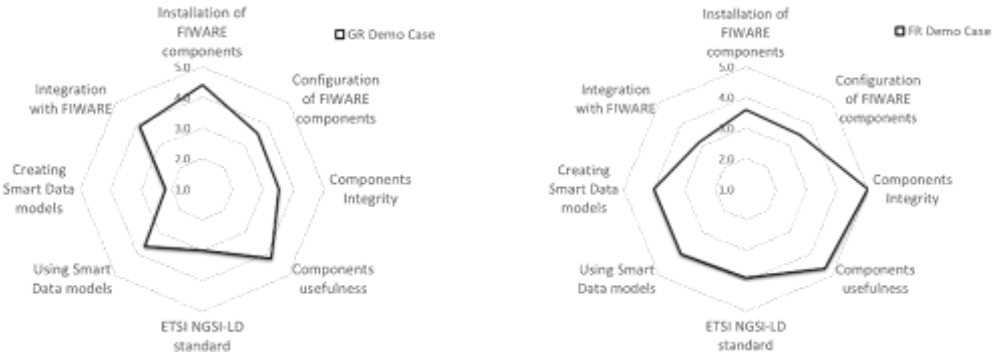
The results of the qualitative evaluation process, as provided by the developers for the corresponding FIWARE components and services (presented at Table 8) per demo case, are given in the spider diagrams of Figure 9. A direct comparison of the results for all cases is given in Figure 10 (left spider diagram), along with the average scores over all demo cases (right spider diagram). Regarding the qualitative traits that concern the installation and configuration of FIWARE components, as well as the

integrity and usefulness of the components, the scores overall surpass the base of agreement (3.0/5.0), indicating in general positive feedback from the developers for FIWARE technology. The lower scores appearing for the FIWARE configuration trait are mainly attributed to the excessive time that was reported from some of the developers, so as to get acquainted with the structure and options of the component, having as a consequence longer time for the configuration of the component. Furthermore, some of the developers reported that generated errors, obtained during component configuration, do not provide adequate information to allow the user to make corrections easily. It is worth mentioning that all developers reported that FIWARE components provide enough configuration options to cover the requirements of the solutions developed, with some of them suggesting the enrichment of the available supporting material with more real-world examples and cases for further guidance. Furthermore, the feedback from developers does not report any major problem with respect to the installation and configuration of FIWARE components. Particularly for the installation of FIWARE technology all developers followed a "Docker compose" deployment technology, and most of them reported that the time required for the installation and the complexity of the procedure is reasonable. In all demo cases, the integrity trait received a high score, indicating that FIWARE components perform their functionalities in a fast and stable way.

Further to FIWARE components themselves, Figure 9 provides the feedback of developers from their experience with the interaction with ETSI NGSI-LD standard. In all cases, the overall score for this aspect is higher than 3.0 out of 5.0, and in the case of French and UK demo case higher than 4.0, which is associated with the longer previous experience of the responders with this standard. It is worth to mention that even the less-experienced developers provided positive feedback regarding the time required to get acquainted with the standard, the usefulness and efficiency of the standard with respect to the services developed, as well as the existing learning material and documentation.

Overall positive feedback was reported also for the use of smart data models, with scores surpassing the base of agreement (3.0/5.0). Even less experienced, and less familiar with the structure of data models, developers provided positive feedback, considering the complexity of the models as reasonable or concise, the existing data models as very useful, and the time required to get acquainted with the structure of data models as reasonable or minimal. Similar were the findings from the assessment of creating new data models to cover the needs of the project. A differentiation is noticed in the case of Athens Demo case that is associated with the open feedback received, which is explained further below.

Finally, we asked from the developers to assess the overall effort required to integrate new smart applications, the new sensors as well as the existing data sources from the legacy systems with FIWARE. In general, the feedback was positive with scores higher than 3.0 out of 5.0, with effort and complexity of integration procedure being at reasonable levels.



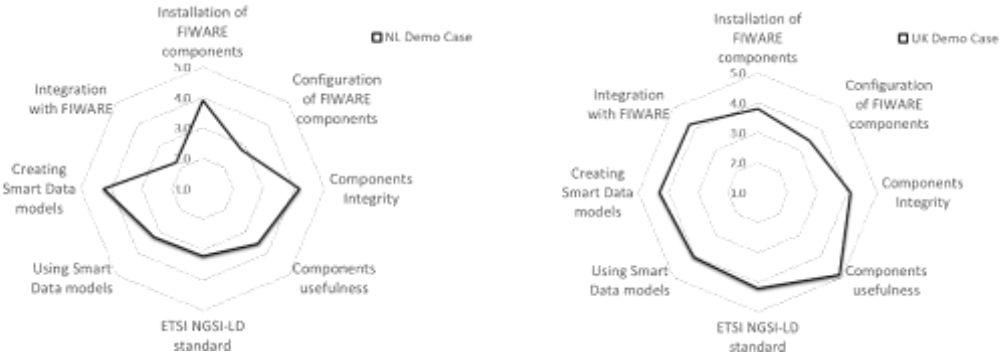


Figure 9: Evaluation results of FIWARE smart solution from the implementation at four demo cases, in the form of spider diagrams, with scores ranging from 1(lowest) to 5 (highest).

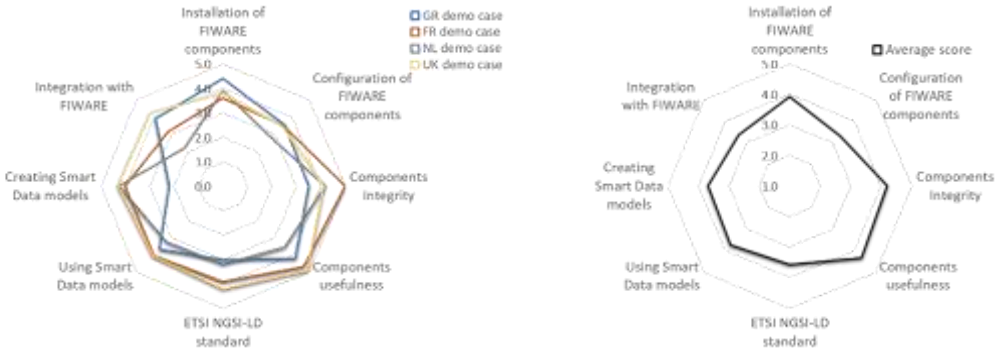


Figure 10: Evaluation results of FIWARE smart solution from the implementation at four demo cases (left spider diagram) and average scores over all 4 demo cases (right spider diagram).

Further to responses to specific questions, developers also provided open feedback and suggestions, which are very useful for the further development and improvement of FIWARE itself. To quote developers directly from their open feedbacks:

<u>With respect to installation and configuration FIWARE components:</u>

"Not easy for Draco inside the Docker container to communicate with PostgreSQL which was outside the container, maybe the database should be included inside the docker image. Docker composed FIWARE Draco is not easy to communicate with PostgreSQL outside the container."

"Orion Docker image from Docker Hub had its CA certificate out of date, which caused all requests to fail.

Had to build the Cygnus-NGSI-LD component ourselves from source, instead of pulling an image from Docker Hub. For other components we used, the versions were available in Docker Hub."

"There are more options possible in a FIWARE configuration, multiple components overlap in functionality. not always clear what is the best choice for a case."

"*With the use of Orion-LD and/or IOT Agent JSON to be able to store data in a database, the component does not recognize the different entity types as it is. It then results in the component declaring each entity to be of type 'thing'. This therefore creates an issue in being able to create entities of different entity types as desired, which then creates issues in working with Cygnus-LD and a database. There is a possibility that a specific configuration was needed to be conducted by us, however it was not*

straightforward to solve and we did not find any documentation to help us with it. We believe, this was a problem related to the context used in the data models."

"Docker-compose / docker-desktop: Stellio will fail silently if insufficient memory is available for docker. Normally throws errors in neo4j, but not explicitly related to memory issues. Stellio will also fail if postrges is being used in another container and default port is in use. Had a lot of problems using Stellio in memory-limited server environment."

With respect to FIWARE component integrity:

"*With the injection of lot of data points at high speed, data points are dropped when sent to the IoT Agent JSON, thereby leading to missing values in other components, which could potentially lead to failures in the applications integrated. Therefore, additional code and effort needs to be considered on different failing scenarios that needs to incorporated into the application itself, to allow the application to continue running in spite of FIWARE related issues.*"

"The Sigfox IoT Agent uses an OAuth2 access token to secure the communication with the Context Broker. For obvious security reasons, this access token has an expiration date, but the renewal process is not automatically handled by the Sigfox IoT Agent, so a cron job had to be set up in order to automatically refresh it once a day."

"We found that Stellio was really http.request rate limited and had a lot of functionality that required all the broker entities (c100) to be queried which ended up taking about 1-2mins to process. This was mitigated by threading requests, it was still slow and suggested that processed data should be stored in the broker. We were unable to store very large entities in the broker."

With respect to ETSI NGSI-LD standard:

"I couldn't find more real-world examples in order to help me with our demo case so we had to improvise."

"As any standard specification, the NGSI-LD specification is a long and exhaustive document that can be difficult to get acquainted to for newcomers. There exists an NGSI-LD Primer which is helpful, it could however be expanded to cover more use-cases.

On the FIWARE ecosystem side, there was not a lot of NGSI-LD related resources (tutorials, getting started guides, …), as the NGSI-LD standard was quite young at the time the F4W project started. However, the FIWARE Foundation has put a lot of effort into NGSI-LD tutorials during the past year and the situation has largely improved."

"I found the NSGI-LD standard generally good to work with, but it had some clear limitations for development and testing (not so much for operations):

1) setting up test cases on the broker requires a lot of patch requests, it would be helpful to send arrays of patches rather than a single patch.

2) Having transaction trails would help debugging

3) Functionality to archive and rebuild brokers

4) Functionality to remove historic temporal data without removing the entire entity

5) Functionality to report the status of the broker, in terms of the tenants and entity types and instances for each tenant."

With respect to the use and creation of smart data models:

"Not so easy or straightforward to describe our demo case. We spent a lot of time discussing and trying to decide on the best possible way to describe things."

"Sometimes it wasn't easy to depict what we had in our minds exactly, and avoid becoming too complex. The minimalism imposed by the standard sometimes leads to complex solutions."

"The existing data models keep some backward compatibility with NGSIv2 (the ancestor of NGSI-LD), which sometimes makes things less easy to understand. Having "pure" NGSI-LD data models would be a nice improvement."

"The 'link' field of the data model was very difficult to work as no-one from FIWARE seemed to know what it did and setting it to the 'wrong' value tended to stop entities from being added to the broker, this was particularly so with 'device' instances.

Brokers tended to have a hit and miss approach with working with short and full property names which caused a lot of frustration and generally defensive programming.

Smart model repositories seemed to be fairly redundant as it wasn't particularly difficult to create smart models from scratch and the generally human-readable nature of the models meant that they are fairly self-explanatory."

"In general, creating smart models was a lot like creating classes in programming, though the link and type fields tended to produce strange results at time. I went through a period of creating devices that resulted in a 204 (success) but no entity stored in the broker. Would have been helpful to have had more information about the required fields in a smart model and their formats, in particular the id field."

<u>With respect to the integration of third-party services:</u>

"Some minor issues regarding the payloads have been emerged because a previous version of the Orion Context broker had some incompatibilities with the NGSI-LD protocol but by installing the latest version all problems were resolved"

"Because of problem in Cygnus, we had to manually create PostgreSQL tables to enable Cygnus to write all device properties to the database. Probably has to do with device which have multiple properties and the observed_at property for each of them."

"Our main issue with integration was that for much of the project we only had access to the live broker on the project and we were unwilling to add test data to the live service. Discovering docker and the broker images was a revelation for us, in terms of being able to build out test cases, though the hefty Stellio broker made it impossible to build brokers on lightweight remote servers.

EGM provided postman resources for getting data from Stellio, but these were not updated to reflected changes in ETSI implementations, in particular adding a cap to the number of entities returned from an entities/type= call to 20 or the resultant approach of querying the number of entities first.

The ETSI document was very helpful, but very detailed. Stellio provided a 'beehive' example as part of its documentation, but this seemed to go missing as its git repo was updated. It would have been very helpful to have documentation between the beehive and ETSI documentation.

It was very difficult to do anything with the Stellio notifications in our use case of a live service and local development, i.e. the remote Stellio server would not be able to 'see' local machines. Using local docker brokers was a solution to this, but by the time we realised it, we were too far into the project and (at the time) we didn't have the 'skill' to be able to archive the current operational broker and recreate it locally or redirect meter updates into our local broker.

Docker diagnostics from Stellio were difficult to follow as there tended to be a lot of output generated for each operation making it difficult to tell what the outcome was and the http.response generally contained little detail."

Additional general feedback:

"Extend FIWARE to insert missing data through Orion and Cygnus into PostgreSQL (knowing that there is missing data is something different to not knowing if there is data at all).

Add subscriptions with conditions that are comprised of multiple sensors at a timestamp / time-window simultaneously.

On a subscription notification, add ability to add historical values of a sensor. To ingest historical data which is sometimes needed with a new data point for AI applications like GRU, LSTM models.

Would be nice to extend the documentation with some tutorials on adding components to an existing FIWARE architecture.

Add features for time-critical responses. For example, timeouts, ordering of events / subscription notifications, et cetera.

Reduce lead time on opened pull requests.

Allow components like Cygnus with a structured database to handle updates if the entity / device changes in the context broker.

Error handling - subscriptions are fire-and-forget, would be nice if there are some error handling features."

"The FIWARE documentation and tutorials on the website could be more detailed with more examples. Furthermore, the examples provided are very simple and basic. It would be beneficial to also have more advanced examples.

Many Smart applications and AI models used for the water sector (and other sectors as well) require the use of historical Data, which is used as input into AI models. It would be beneficial for the subscriptions to be able to handle historical values from a device directly.

When integrating Smart applications, a lot of effort and time is needed to create a proxy to integrate the applications to a FIWARE architecture, particularly due to the use of historical input. However, a majority of the time goes in debugging the Application When using It with FIWARE, as It is not straightforward to test and debug running FIWARE components. It would be worth exploring solutions to ease the integration of applications by developers by considering a easier method to perform the debugging and testing."

"There is a choice in components which overlap in functionality. It is not always clear what is the best option in what case. Would be great if there are more examples of setups.

Examples from other users, specifically docker setup files, tell you what works and what not. Not always clear from the documentation.

Would be nice to extend the documentation with some tutorials on adding components to an existing FIWARE architecture."

"The tutorials available on the FIWARE documentation sometimes have a different repository name on Github, causing some confusion, but overall, the guidance material is very solid."

"In general, I found the FIWARE approach to be incredibly helpful for the project and using Stellio was generally a lot easier than building explicit sql tables and bespoke queries. I would strongly recommend using Stellio but with a couple of caveats:

1) The development team get a good understanding of the ETSI spec

2) The development team get a good understanding of docker

3) http.request performance is addressed, or workarounds are outlined

In terms of ETSI spec and docker, I feel it would help a great deal if FIWARE could put some learning materials in place that go beyond the 'simple' cases of one device and one sensor and look at building out broker installations that follow the typical use cases of out projects and look at the development-testing-operations approach of development.

On another project, we used Orion-LD and Cygnus with no end of problems. However, Orion-LD does support multiple tenants which Stellio does not (or didn't at the time of first using).

Stellio is something of a resource hog and appears to require large amount of memory. It would be helpful to have Stellio functionality but in a smaller package as virtual server costs get expensive quickly."

VIII. Recommendations for further development of FIWARE technology

The lessons learned and reccomendations for further development of FIWARE-enabled services developed in F4W are provided individually for each of the four demo cases in sections II.2 (GR demo case), III.2 (FR demo case), IV.2 (NL demo case) and V.2 (UK demo case), while relevant information for the smart applications developed can be found in Deliverable D3.6. Here, we focus on FIWARE technology itself and we provide a list of recommendations for its further development, based on the comments (see section VII) provided by the developers involved in the four demo cases.

- Creation of a single portal, instead of different websites, to host all technical details, along with documents, best/worst case scenarios, helper tools, examples, data models, best practices, FAQs, etc., for the different aspects of FIWARE technology and expand material with more real-world examples.
- Development of entry-level tutorials for the newcomers, since some of the existing ones are long, detailed and exhaustive, but difficult to be followed by the newcomers. Expansion of existing entry-level tutorials (e.g., *NGSI-LD Primer*) to cover more use cases.
- Enhancement of Context Broker with more subscription rules. For example, to receive notifications only if the measured value is between a certain range, or receive notifications only during the daily hours, or weekdays.
- Extension of Context Broker to handle missing values. For example, the consumer could configure the Context Broker to send a "warning message" when it hasn't received values for a certain device.
- Extension of Context Broker to allow access also to historical data depending on the needs of applications.
- Extension of FIWARE to insert missing data through Orion and Cygnus into databases (e.g., PostgreSQL) (knowing that there is missing data is something different than not knowing if there is data at all).
- Addition of subscriptions with conditions that are comprised of multiple sensors at a timestamp/time-window simultaneously.

- Enhancement of FIWARE Draco with more features: e.g., offer “UPSERTing” functionality by inserting new values and updating existing values depending on certain fields. For example, Draco (or a similar GE) could be configured to update old values or insert new values depending on a certain condition (e.g. if the unique id is the same in both SQL injections)
- Simplification of the communication between modules inside and outside a Docker container. Although dockerization makes it easier to install FIWARE components, it makes configuration of them harder to accomplish. Since most developers use Linux VMs, installation could be achieved in two steps: Adding a FIWARE repository, installing the needed applications from that repository. In our case it took us much time to configure dockerized FIWARE Draco to communicate with non-dockerized PostgreSQL database.
- Enhancement of Sigfox IoT Agent to renew automatically the authentication token of OAuth2 procedure.
- Extension of components like Cygnus with a structured database to handle updates if the entity/device changes in the context broker.
- Update the existing data models so as to be compatible with NGSI-LD. The existing data models keep some backward compatibility with NGSIv2 (the ancestor of NGSI-LD), which sometimes makes things less easy to understand and more complicated to design.
- A simple way to apply SSL certificates in order to encrypt the communication between Context Broker and FIWARE components and Context Broker with 3rd party applications.
- Provide guidance to support the newcomers in the selection of proper FIWARE component/tool (which provides similar functionalities) depending on the peculiarities of the project.

IX. Conclusion and Perspectives

This report presents the assessment of services and FIWARE technology, developed and implemented, as part of WP3 and WP4 activities, for each demo case. Technical details of the FIWARE-enabled solutions can be found in the relevant deliverables of WP3 and WP4, while an overview of the solutions, along with lessons learned and recommendations, is provided in the deliverable D3.5.

The results of the assessment, based on the feedback collected directly from the end-users of services, show that F4W delivers applications are characterised by high usefulness, usability and integrity, and improves the operational efficiency and capacity of water utilities at the four demo cases. Additionally, the end-users reported that FIWARE-enabled solutions proved to be useful additions to the specific needs and challenges studied, while the project as a whole has a positive contribution towards the improvement of the interoperable profile of water utilities. In this direction, it is worth highlighting that the end-users are positive with respect to the adoption of standardisation protocols for future development of services and integration of sources, indicating the importance of the endeavor conducted in Fiware4Water project.

Especially positive was also the assessment of FIWARE technology from the developers' perspective, with respect to the components' usefulness, usability and integrity. Furthermore, the list of suggestions and recommendations that were compiled, after the implementation of different FIWARE components in different water-related operational contexts, provide valuable feedback towards the further upgrade of FIWARE technology, particularly with respect to integration with other commonly used technologies.

X. EU added value and upscaling

F4W, and specifically WP4, demonstrated the feasibility to implement FIWARE-enabled solutions for water sector, covering a wide range of water challenges, in a variety of demanding situations with respect to the large-scale nature of demo cases, the complexity of legacy systems (large number of sensors, hosted usually at different information systems), the variety of temporal resolutions involved as well as the ad hoc nature of processes and variables. It is important to highlight that the challenges addressed are not artificial, but are challenges that are virtually omnipresent throughout Europe and the world. These solutions were implemented in fully operational context, integrated with the systems used by operational staff of utilities for operational purposes on a daily basis. All systems delivered are fully compliant with the FIWARE technology (a framework initiated and supported by EU), and hence the potential for further uptake of these solutions is enormous and ensured by their interoperable FIWARE-enabled nature. Evidently, utilities can take advantage of these solutions to integrate new sensors and other parts of their legacy systems in a straightforward way, while new FIWARE-enabled services can be customised to consume the integrated data sources with minimum effort.

The European Added Value (EAV) of the present report, evaluating the solutions and providing recommendations for further development, comes from different perspectives. First, it provides the results of the assessment, insights and lessons, directly from the end-users, of a wide range of operational FIWARE-enabled services that were implemented to address different, though typical, challenges of the water cycle in different European countries. Undoubtedly, this information is a valuable source of prior knowledge for the deployment of similar developments in other countries and operational cases. The same also stands for FIWARE technology, since this report summarises the assessment of different components from FIWARE ecosystem, as implemented to integrate services and legacy systems of different characteristics and peculiarities. Furthermore, this report contributes to the further overall upgrade of FIWARE technology, via insights and suggestions directly from the developers. Finally, the questionnaires compiled to support the assessment of services and FIWARE can be extended, or deployed in their current form, to assess similar developments in other projects.

References

[1] STOP-IT T7.2 Report: Validation Plans including KPIs per demo, https://stop-it-project.eu/download/validation-plans-including-the-kpis-per-demo/

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[3] Voas, J. & Agresti, W.W. (2004). Software quality from a behavioral perspective. IT Professional. [Online]. 6 (4). p.pp. 46–50. Available from: http://ieeexplore.ieee.org/document/1324574/.

Annex A: Questionnaire to assess F4W services from end-user perspective

Questionnaire template and Guidelines

The following questions are directed at the end-users of services (e.g., algorithms, tools, platforms) developed within Fiware4Water, as well as at those who are aware of the Fiware4Water services, as a whole.

To fill this questionnaire, please provide:

- your ranking, in case of grading questions. If needed, an explanation of the different grades is provided below each question.
- your feedback, in case of open questions or conditional (Yes/No) answers.

Most questions are based on a grading/ranking evaluation that ranges from 1 (poor performance) to 5 (great performance). Open questions supplement some sections, allowing you to provide feedback back to Fiware4Water consortium.

Introduction

Please fill in the required information.

First Name: ……	Last Name: ……
Demo Case: ……	Role in the Demo Case/Utility: ……
Date of Assessment: __ / __ / ____	

Important Note: In case you are reviewing the **Fiware4Water services as a whole**, and not only a specific tool, please provide your feedback also in **the two last sections**.

Which service, developed within Fiware4Water, have you used and are now reviewing? (e.g., get advice on optimal sluice gate settings, use of a web monitoring platform, tool to forecast demand)

……

……

Have you used a similar service (besides F4W), in the past, that addresses similar needs and challenges?

Yes	No
☐	☐

If you answered Yes to the question above, which was the name and provider of that service?

……

……

……

How would you rate your level of expertise as an end-user of similar services?

Low experience	Moderate experience	Experienced	Highly Experienced
1	3	4	5
☐		☐	

Usefulness and performance

This set of questions gives insight on how useful the service is with respect to the addressed needs and challenges.

F4W develops and demonstrates Smart Applications and Smart Devices across the entire water cycle to serve specific challenges of water domains. Based on your experience, to which of the following domain does **this service** belong to?

(Note: multiple answers are accepted)

Improve management and operation of large **raw water conveyance systems**	Optimise and improve drinking **water distribution network** management	Optimisation of **wastewater treatment plant** operations	**Empower customers** towards drinking **water efficiency**
☐ Please answer questions a.), b.), c.), e.)	☐ Please answer questions a.), b.), c.), e.)	☐ Please answer questions a.), b.), c.), e.)	☐ Please answer questions a.), b.), c.), d.) and e.)

Did you already have a service available to address similar challenges and needs?

Yes	No
☐	☐

In case you answered yes to the previous question, how would you rate the improvements by and/or additional functionalities of the new service compared to the already existing one:

(no difference or worse)		(somewhat better)		(much better)
1	2	3	4	5
	☐			

No difference: the new service performs the same functionalities compared to the already existing one.
Somewhat better: the new service provides some extra functionalities compared to the already existing one.
Much better: the new service improves substantially the already existing one.

a.) Do you consider this service as a useful addition to the needs and challenges of your water service?

(not that useful)		(useful)		(very useful)
1	2	3	4	5

Not that useful: The service is not useful, in its present form, to the needs and challenges of the water services my utility provides.
Useful: The service is a useful addition to the needs and challenges of the water services my utility provides.
Very useful: The service is a highly desirable addition to the needs and challenges of the water services my utility provides.

b.) Based on your experience from the interaction with the service, how well do you think the service performs the specific function that it was designed/supposed to do?

(very limited success)		(partial success)		(success)
1	2	3	4	5

Very limited success: The service's function deviates from what was promised and only a small part of the initially defined objectives and challenges are currently fulfilled.
Partial success: Core functionalities are as promised, even though the service could be further improved to serve its functional requirements.
Success: The service works exactly as it was envisioned and all of its requirements are met.

If the objective of the service is to provide predictions, early warnings and detection of abnormal events:

c.) Based on your experience from the interaction with the service, is the tool able to provide accurate outcomes or outcomes which improve the current operation?

Unknown yet	(inefficient)		(moderately efficient)		(very efficient)
0	1	2	3	4	5

Inefficient: The service did not provide accurate outcomes at all.
Moderately efficient: The service has a certain accuracy, but I find it limited for my operational context.
Very efficient: The service provides highly accurate outcomes useful for my operational context.

d.) Would you like to see some improvements in the functionalities provided by the service?

Yes (major issues)	Yes (minor issues)	No
☐		

In case you answered yes to the previous question, could you please suggest some improvement areas?

……

……

……

Integrity

This set of questions gives insight on the integrity of the service, i.e. the speed, stability and reliability of its structural functions.

How was your experience of the execution of the service in terms of:

a.) The executing speed of its functions:

(very slow)				(very fast)
1	2	3	4	5
		☐		

Very slow: The runtime/operational time of the service as a whole was significant and the user had to wait a considerable amount of time before the results could be presented or before accessing different tools.
Very fast: The runtime/operational time of the platform was very short and the tools were executed fast.

b.) The stability of executing its functions

(very unreliable)		(overall reliable)		(always reliable)
1	2	3	4	5

Very unreliable: There were frequent problems and these problems were structural, e.g. due to the services crashing or freezing.
Reliable: Most of the functions were run without errors. Some issues occurred at some more complex cases or when I did something that the service did not expect.
Very reliable: The analysis was always able to run and the results were displayed with no problems. No crashes were observed.

c.) Did you encounter any problems during the operation of the service to your system?

Yes (major issues, instabilities etc.)	Yes (minor issues, e.g. some bugs)	No
☐		

In case you answered yes to the previous question, please explain the issues encountered:

……

……

……

Usability

This set of questions gives insight on how easy, straightforward and intuitive is to use the service, thus exploring its structural simplicity, aesthetic and functional aspects of its interface and intuitiveness.

You interacted with the service through a web user interface (UI) that includes all buttons, commands, graphics etc. or through a command line, protocol or (hardware) technology that does not have a specific interface.

Did the service have a graphical user-interface?

Yes	No
(proceed to Section 0)	(proceed to Section 0)

Service with a user interface

How would you rate this user interface in terms of:

a.) The time it took you to get acquainted with the interface:

(excessive)		(reasonable)		(minimal)
1	2	3	4	5

Excessive: It took me a long time to get used to the graphics and functions of the service interface and I am still unsure about what many of the options do.
Reasonable: The amount of time needed to get acquainted with the buttons and graphics was reasonable and in par with the service goals. I now know what most options do.
Minimal: I learned how to interact with the service very quickly and got used to it very quickly as well.

b.) User interface functionality:

(cumbersome)		(functional)		(very functional)
1	2	3	4	5

Cumbersome: The user interface is complicated and a considerable amount of time is required to explore the options and functions of the service.
Functional: The user interface offers a decent level of functionality, even though some aspects could be improved (e.g. some options could be simplified).
Very functional: The user interface is simple and functional, on par with the service goals.

c.) The design of the user interface:

(basic)		(good)		(beautiful)
1	2	3	4	5

Basic: The user interface works with a very crude design, i.e., it is a simple command-line, or it is a primitive graphical user interface.
Functional: The user interface is designed to serve the basic functions of the service and facilitate the user experience.
Very functional: The user interface is beautifully designed and offers a pleasurable user experience.

d.) The overall intuitiveness of the user-service interaction:

(not intuitive)		(reasonable)		(very intuitive)
1	2	3	4	5

Not intuitive: During the user-service interaction, required actions from my side frequently do not make sense or are not easy to deduce and I must spend a considerable amount of time to learn them. The sequence of actions needed from me is confusing.
Reasonable: During the user-service interaction, I occasionally have to look out where to find specific options and/or actions. However, the general experience is not cumbersome and I can interact with the service without overall confusion.
Very intuitive: The user-service interaction works in a very intuitive way. I know or can easily guess where I can find the tool options without a lot of learning.

e.) The functionality of the tool in general:

(unnecessarily complex)		(functional)		(very functional)
1	2	3	4	5
		☐		

Unnecessarily complex: The service in general looks very complex and offers a lot of options that I'm not going to or wouldn't like to use.
Functional: The service offers interesting options, even though some aspects could be improved.
Very functional: The service feels 'just right' and it has complexity and functionality in par with the service goals. I find it very functional and would like to use it further.

Open Question
Did you encounter any problems with the graphical interface of the service?

Yes (major issues)	Yes (minor issues)	No
☐		

In case you answered yes to the previous question, please explain the issues encountered:
……

……

……

Service without a user interface

How would you rate your experience with the service in terms of:

The way the service runs in your systems so far and the functionality it offers:

(problematic)		(functional)		(very functional)
1	2	3	4	5
		☐		

Problematic: The protocol or technology is not able to run multiple times and/or I had to uninstall it/operate the system without it.
Functional: The protocol or technology is operational during most times, with slight issues that do not bother me or cause downtime to other services.
Very functional: The protocol or technology has a seamless operation to my working environment and is always working well.

Facilitation of user learning and Support

This set of questions gives insights on whether the learning material and/or support provided to the end-users for the service was satisfactory or not.

Was support (e.g., in the form of live demonstration from the developer) and/or learning material (e.g. tutorial, documentation, examples) provided to you, along with the service?

Yes No

In case you answered yes to the previous question, how would you rate this support?

(not helpful)		(satisfactory)		(very satisfactory)
1	2	3	4	5
		☐		

Not helpful: the support and/or learning material did not make it easier to understand the functionality of the service and I am still confused about many of its aspects.

Satisfactory: the support and/or material covered specific aspects and functions of the service, but not all of them.

Very satisfactory: the provided support and material was very helpful when I ran into any type of problems with the platform and helped me find solutions, as well as understand different functions of the service.

Open Question

What type of additional material do you think would be useful to facilitate the use of service? (e.g., tutorials, documentation, examples/toy models)

……

……

……

Case specific questions on the usefulness of Fiware4Water services (GR demo case)

These questions give insight on how useful the Fiware4Water services, as a whole, are in respect to the challenges at the case study.

Fiware4Water developed services and tools to address specific challenges at each demo case. According to your experience:

How much do you estimate your preparedness level to be towards unusual turbidity events – compared to the previous state?

(No improvement)		(Modest improvement – 50% better)	(Substantial improvement – 100% better)	
1	2	3	4	5
		☐		

How much do you estimate the operational efficiency of the raw-water conveyance system– compared to the previous state?				
(No improvement)		(Modest improvement – 50% better)	(Substantial improvement – 100% better)	
1	2	3	4	5
		☐		

How much do you estimate your preparedness level to be towards high demand events – compared to the previous state?				
(No improvement)		(Modest improvement – 50% better)	(Substantial improvement – 100% better)	
1	2	3	4	5
		☐		

Case specific questions on the usefulness of Fiware4Water services (FR demo case)

These questions give insight on how useful the Fiware4Water services, as a whole, are in respect to the challenges at the case study.

Fiware4Water developed services and tools to address specific challenges at each demo case. According to your experience:

How do you evaluate the operational interest of the model dedicated to water resources availability forecasting, developed in the framework of the Fiware4Water project?			
(low) 1	(fairly low) 2	(fairly high) 3	(high) 4

How do you evaluate the operational interest of the model dedicated to water demand forecasting, developed in the framework of the Fiware4Water project?			
(low) 1	(fairly low) 2	(fairly high) 3	(high) 4

How do you evaluate the operational interest of the model dedicated to water leakage detection, developed in the framework of the Fiware4Water project?			
(low) 1	(fairly low) 2	(fairly high) 3	(high) 4

How do you evaluate the operational interest of the model dedicated to abnormal water quality events detection, developed in the framework of the Fiware4Water project?

(low) 1	(fairly low) 2	(fairly high) 3	(high) 4

Case specific questions on the usefulness of Fiware4Water services (NL demo case)

These questions give insight on how useful the Fiware4Water services, as a whole, are in respect to the challenges at the case study.

Fiware4Water developed services and tools to address specific challenges at each demo case. According to your experience:

How much do you estimate the wastewater treatment softsensors attribute to improved operations?

(No improvement)		(Modest improvement – 50% better)		(Substantial improvement – 100% better)
1	2	3	4	5
		☐		

How much do you estimate the AI applications will contribute to the operational insights and efficiency (N2O emission and energy use) of the wastewater treatment processes– compared to the previous state?

(No improvement)		(Modest improvement – 50% better)		(Substantial improvement – 100% better)
1	2	3	4	5
		☐		

How do you estimate the usefulness of the real-time Fiware4Water integration with the legacy systems?

(No improvement)		(Modest improvement – 50% better)		(Substantial improvement – 100% better)
1	2	3	4	5
		☐		

Case specific questions on the usefulness of Fiware4Water services (UK demo case – for water utility)

These questions give insight on how useful the Fiware4Water services, as a whole, are in respect to the challenges at the case study.

Fiware4Water developed services and tools to address specific challenges at each demo case. According to your experience:

How quickly can you gain meaningful insights into regional consumption patterns compared to previous systems?

(No improvement)		(Modest improvement – 50% better)		(Substantial improvement – 100% better)
1	2	3	4	5
		☐		

How confident are you that the high consumption and leak alarms from smart meters are relevant and require SWW intervention compared to previous systems?

(No confident)		(Somewhat confident)		(Very confident)
1	2	3	4	5
		☐		

Are you better enabled to effectively manage interventions to address high consumption and leaks (promotion and monitoring of remedial actions) compared to previous systems?

(No improvement)		(Modest improvement – 50% better)		(Substantial improvement – 100% better)
1	2	3	4	5
		☐		

Are you better enabled to evidence and quantify the benefit of interventions (e.g. reduced consumption or customer satisfaction) compared to previous systems?

(No improvement)		(Modest improvement – 50% better)		(Substantial improvement – 100% better)
1	2	3	4	5
		☐		

Added-value of Fiware4Water services as a whole

These questions give insight on the added value that Fiware4Water services, as a whole, has provided at each utility/demo case.

Did your water utility utilise other standardisation protocols (e.g., OGC, Saref4water, Other national standards) for data sources and services interoperability?

Yes ☐ No ☐ I don't know ☐

According to your experience and the developments within Fiware4Water project:

a.) Do you consider the Fiware4Water services as a whole, a useful addition to the needs and challenges of your water services?

(not that useful)		(useful)		(very useful)
1	2	3	4	5
		☐		

Not that useful: The Fiware4Water services developed is not useful, in its present form, to the needs and challenges of the water services my company provides.
Useful: The Fiware4Water services developed is a useful addition to the needs and challenges of the water services my company provides.
Very useful: The Fiware4Water services developed is a highly desirable addition to the needs and challenges of the water services my company provides.

b.) How much do you think Fiware4Water contributes to the improvement of the interoperable profile of your water utility?

(No improvement)		(Partial improvement)	(Substantial improvement)	
1	2	3	4	5
		☐		

c.) How much do you think Fiware4Water contributes to the seamless integration of different data sources (e.g., SCADA, sensors, proprietary databases) in your water utility?

(No improvement)		(Partial improvement)	(Substantial improvement)	
1	2	3	4	5
		☐		

d.) How much do you think Fiware4Water contributes in the integration of different services (e.g., models, decision support systems, analytics, platforms) in your water utility?

(No improvement)		(Partial improvement)	(Significant improvement)	
1	2	3	4	5
		☐		

e.) Would you suggest the adoption of standardization protocols in the development of new services (tools, applications, decision support systems) and deployment of new data sources (scada, meters, sensors) for the water utility in the future?

(Negative)		(Moderate)	(Positive)	
1	2	3	4	5
		☐		

f.) Would you like to see some improvements in the services provided by Fiware4Water?

Yes (major issues)	Yes (minor issues)	No
		☐

In case you answered yes to the previous question, could you please suggest some improvement areas?

…… …… ……

Please, provide any comment and/or suggestion to support the further improvement and enhancement of interoperability of Fiware4Water services. …… …… …… ……

Questionnaire to assess smart application for customers (UK demo case)

Questionnaire template and Guidelines

The following questions are directed at the end-users of 'Customer Smart Meter Mobile App'.

To fill this questionnaire, please provide:

- your ranking, in case of grading questions. If needed, an explanation of the different grades is provided below each question.
- your feedback, in case of open questions or conditional (Yes/No) answers.

Most questions are based on a grading/ranking evaluation that ranges from 1 (poor performance) to 5 (great performance). Open questions supplement some sections, allowing you to provide feedback back to Fiware4Water consortium for further improvement of the application.

Introduction

Please fill in the required information.

First Name: ……	Last Name: ……
Demo Case: ……	Date of Assessment: __ / __ / ____

Have you used in the past a similar 'Customer Smart Meter Mobile App'?

Yes	No
☐	☐

If you answered Yes to the question above, which was the name and provider of that service?

……

……

……

Usefulness and performance

This set of questions gives insight on how useful the Smart Meter Mobile Application is with respect to the addressed needs and challenges.

c.) Do you consider this application as a useful addition towards the improvement of water efficiency of your household?

(not that useful)		(useful)		(very useful)
1	2	3	4	5

Not that useful: The application is not useful, in its present form.
Useful: The application is a useful addition.
Very useful: The application is a highly desirable addition.

d.) Based on your experience from the interaction with the application, how well do you think the application performs the specific function that it was designed/supposed to do?

(very limited success)		(partial success)		(success)
1	2	3	4	5

Very limited success: The application deviates from what was promised and only a small part of the initially defined objectives and challenges are currently fulfilled.
Partial success: Core functionalities are as promised, even though the service could be further improved to serve its functional requirements.
Success: The application works exactly as it was envisioned and all of its requirements are met.

c.) Is the service efficient at raising your awareness on drinking water use efficiency?

(inefficient)		(moderately efficient)		(very efficient)
1	2	3	4	5

Inefficient: The service did not motivate me to improve the drinking water efficiency.
Moderately efficient: The service managed to raise my awareness on drinking water efficiency.
Very efficient: The service achieved to raise my awareness on drinking water efficiency and I have changed some wasteful water behaviour.

d.) Would you like to see some improvements in the functionalities provided by the service?

Yes (major issues)	Yes (minor issues)	No

In case you answered yes to the previous question, could you please suggest some improvement areas?

……

……

……

Integrity

This set of questions gives insight on the integrity of the Smart Meter Mobile Application, i.e. the speed, stability and reliability of its structural functions.

How was your experience with the application in terms of:

b.) The executing speed of its functions:

(very slow)				(very fast)
1	2	3	4	5
		☐		

Very slow: The user had to wait a considerable amount of time before information could be presented.
Very fast: The runtime time of the application was very short and the functions were executed fast.

c.) The stability of executing its functions

(very unreliable)		(overall reliable)		(always reliable)
1	2	3	4	5

Very unreliable: There were frequent problems and these problems were structural, e.g. due to the services crashing or freezing.
Reliable: Most of the functions were run without errors. Some issues occurred at some more complex cases or when I did something that the application did not expect.
Very reliable: The information were displayed with no problems. No crashes were observed.

d.) Did you encounter any problems during the operation of the application?

Yes (major issues, instabilities etc.)	Yes (minor issues, e.g. some bugs)	No
☐		

In case you answered yes to the previous question, please explain the issues encountered:

……

……

……

Usability

This set of questions gives insight on how easy, straightforward and intuitive is to use the Smart Meter Mobile Application.

You interacted with the service through a user interface (UI) that includes all buttons, commands, graphics etc.

How would you rate this user interface in terms of:

b.) the time it took you to get acquainted with the interface:

(excessive)		(reasonable)		(minimal)
1	2	3	4	5

excessive: It took me a long time to get used to the graphics and functions of the service interface and I am still unsure about what many of the options do.
reasonable: The amount of time needed to get acquainted with the buttons and graphics was reasonable and in par with the service goals. I now know what most options do.
minimal: I learned how to interact with the service very quickly and got used to it very quickly as well.

c.) user interface functionality:

(cumbersome)		(functional)		(very functional)
1	2	3	4	5
☒				

cumbersome: The user interface is complicated and a considerable amount of time is required to explore the options and functions of the service.
functional: The user interface offers a decent level of functionality, even though some aspects could be improved (e.g. some options could be simplified).
very functional: The user interface is simple and functional, on par with the service goals.

d.) the design of the user interface:

(basic)		(good)		(beautiful)
1	2	3	4	5

basic: The user interface works with a very crude design, i.e., it is a simple command-line, or it is a primitive graphical user interface.
functional: The user interface is designed to serve the basic functions of the service and facilitate the user experience.
very functional: The user interface is beautifully designed and offers a pleasurable user experience.

e.) the overall intuitiveness of the user-application interaction:

(not intuitive)		(reasonable)		(very intuitive)
1	2	3	4	5

not intuitive: During the user-application interaction, required actions from my side frequently do not make sense or are not easy to deduce and I must spend a considerable amount of time to learn them. The sequence of actions needed from me is confusing.
reasonable: During the user-application interaction, I occasionally have to look out where to find specific options and/or actions. However, the general experience is not cumbersome and I can interact with the service without overall confusion.
very intuitive: The user-application interaction works in a very intuitive way. I know or can easily guess where I can find the tool options without a lot of learning.

f.) the functionality of the application in general:

(unnecessarily complex)		(functional)		(very functional)
1	2	3	4	5
		☐		

unnecessarily complex: The service in general looks very complex and offers a lot of options that I'm not going to or wouldn't like to use.
functional: The service offers interesting options, even though some aspects could be improved.
very functional: The service feels 'just right' and it has complexity and functionality in par with the service goals. I find it very functional and would like to use it further.

Open Question
Did you encounter any problems with the graphical interface of the application?

Yes (major issues)	Yes (minor issues)	No
☐		

In case you answered yes to the previous question, please explain the issues encountered:
……

……

……

Facilitation of user learning and Support

This set of questions gives insights on whether support provided to the end-users for the use of application was satisfactory or not.

Was support (for example, in the form of live demonstration) and/or learning material (tutorial, documentation, examples) provided to you, along with the application?

Yes	No

In case you answered yes to the previous question, how would you rate this support?

(not helpful)		(satisfactory)		(very satisfactory)
1	2	3	4	5
		☐		

Not helpful: the support and/or learning material did not make it easier to understand the functionality of the application and I am still confused about many of its aspects.
Satisfactory: the support and/or material covered specific aspects and functions of the application, but not all of them.
Very satisfactory: the provided support and material was very helpful when I ran into any type of problems with the application and helped me find solutions, as well as understand different functions of the application.

Open Question
What type of additional material do you think would be useful to facilitate the use of application? (e.g., tutorials, documentation, examples/toy models)
……

……

……

Annex B: Assessment of FIWARE smart solution for the Water Domain

Questionnaire scope and Guidelines

This questionnaire is directed at the developers and IT personnel who were involved in the development and deployment of "Powered by FIWARE" services. Specifically, the questions aim to assess the following key aspects of the procedure:

- Installation of FIWARE components (such as Context Brokers and other Generic Enablers)
- Configuration of FIWARE components (e.g., add Context data into the Context Broker or define dataflows in FIWARE-Draco GE)
- Use of Smart Data models to describe Context data and information
- Creation of new Smart Data models (e.g., data model for EPANET)
- The overall integration procedure of third-party systems (e.g., legacy systems, sensors, applications, third-party software and algorithms etc.) with FIWARE

Important Note: Depending on your role in development and deployment of "Powered by FIWARE" services, please respond to the questions of the relevant section:

- Installation and configuration of FIWARE components (such as Context Brokers and Generic Enablers)
- ETSI NGSI-LD
- Use of Smart Data models to describe Context data and information
- Creation of new Smart Data models (e.g., data model for EPANET)
- Integration of third-party systems (e.g., legacy systems, sensors, applications) with FIWARE
- Any further feedback about FIWARE and FIWARE components

If you had multiple of the aforementioned roles, please answer all corresponding Sections for each role.

To fill this questionnaire, please provide:

- your ranking, in case of grading questions. If needed, an explanation of the different grades is provided below each question.
- your feedback, in case of open questions or conditional (Yes/No) answers.

Most questions are based on a grading/ranking evaluation that ranges from 1 (poor performance) to 5 (great performance). Open questions supplement some sections, allowing you to provide feedback back to Fiware4Water consortium.

Introduction

Please fill in the required information.

First Name: ……	Last Name: ……
Demo Case: ……	Date of assessment: __ / __ / ____

Depending on your role, please indicate which aspect of "developing FIWARE-enabled services" procedure you are reviewing (multiple answers are possible):

- ☐ Installation and configuration of FIWARE components
- ☐ Use of ETSI NGSI-LD
- ☐ Use of Smart Data models
- ☐ Creation of new Smart Data models
- ☐ Integration of third-party systems with FIWARE
- ☐ Any additional feedback

How would you rate your level of expertise on the aspect you are reviewing?

Low experience (less than 6 months)	Moderate experience (6-12 months)	Experienced (1-2 years)	Highly Experienced (more than 2 years)
1	3	4	5
☐		☐	☐

In the case you have used, as part of your development, a specific FIWARE component, please indicate which is this component:

Context Broker components:

- ☐ Orion (NGSI v2)
- ☐ Orion-LD (NGSI-LD)
- ☐ Scorpio
- ☐ Stellio

Generic Enablers:

- ☐ Cygnus
- ☐ Draco
- ☐ STH Comet
- ☐ Cosmos
- ☐ QuantumLeap

Generic Enablers interfacing with the Internet of Things, Robots and Third-party systems

- ☐ IoT Agent for JSON
- ☐ IoT Agent for LWM2M
- ☐ IoT Agent for LoRaWAN
- ☐ IoT Agent for ISOXML
- ☐ Other ……
- ☐ IoT Agent for Sigfox
- ☐ IoT Agent for Ultralight
- ☐ IoT Agent for OPC-UA
- ☐ IoT Agent library

Installation of FIWARE component

This set of questions gives insights on aspects of the effort required to install a FIWARE component.

Target Group: These questions are directed only to **persons who involved in the installation of a FIWARE component** (e.g., a Context Broker or a Generic Enabler).

How would you rate the ease of use when installing the FIWARE component in terms of:

a.) Installation time needed:

(very long)		(reasonable)		(very fast)
1	2	3	4	5

b.) Installation process simplicity/complexity:

(very complex)		(reasonable)		(simple and concise)
1	2	3	4	5

Very complex: The installation process was lengthy and required special knowledge, e.g. installation of other tools first or technical hardware skills. As such, it had to be done by specialized personnel.
Simple and concise: The installation process was very simple and could be readily performed by me, without extra steps or pre-installation needs.

c.) Integration with my current system:

(very limited integration)		(limited integration)		(seamless integration)
1	2	3	4	5

Very limited integration: The component was not able to run with my current system specs or required substantial effort to be installed in my current system.
Limited integration: The component was not able to run with my current system, albeit with some effort and/or after installing some third-party software.
Seamless integration: The component installed easily and integrated fully with my current system, without the need from my side to change parts of my system.

d.) Dependence on third-party software/hardware:

(absolute dependence on commercial software/hardware)		(dependence on open-source software/hardware)		(stand-alone application)
1	2	3	4	5

Absolute dependence on commercial software: The component is fully dependent on software, hardware or libraries that are commercial and require licenses.

Partial dependence: The component is fully dependent on open-source software, which is openly accessible and is free. An example is a tool that is distributed in the form of a Python or R library.
Stand-alone application: The component is a stand-alone application, fully independent from third-party products.

e.) Installation guidance and support

(no resources)		(limited resources)		(ample guidance)
1	2	3	4	5

No resources: The installer/installation process was a hard process, and no means of support were provided, such as tutorial, documentation, examples, tech webinars.
Limited resources: The installer/installation process offered help when needed in the form of simple documentation or very general steps/troubleshooting.
Ample guidance: There is rich supporting material to aid installation of the component, such as troubleshooting guides, tips, clear instructions, a coherent installation manual, a special installer wizard etc.

Deployment technology

a.) Which deployment technology did you use for learning about FIWARE components:

Docker Swarm	Docker Compose	Kubernetes	Helm Charts	Others
☐	☐	☐	☐	☐

In case you answered "Others" to the previous question, please specify which one:
……

……

……

b.) Which deployment technology do you use for development and integration of FIWARE components:

Docker Swarm	Docker Compose	Kubernetes	Helm Charts	Others
☐	☐	☐	☐	☐

In case you answered Others to the previous question, please specify which one:
……

……

……

c.) Which deployment technology do you use for production environments:

Docker Swarm	Docker Compose	Kubernetes	Helm Charts	Others
☐	☐	☐	☐	☐

In case you answered Others to the previous question, please specify which one:

……

……

……

Did you encounter any problems during the installation of the FIWARE component to your system?

Yes (major issues)	Yes (minor issues)	No

In case you answered yes to the previous question, please explain the issues encountered:

……

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Configuration of FIWARE component

This set of questions gives insights on aspects of the effort required to configure a FIWARE component to your specific needs.

Target Group: These questions are directed only to persons **who involved in the configuration of a FIWARE component** (e.g., add Context data into the Context Broker by defining entities).

How would you rate the overall configuration procedure of FIWARE component in terms of:

a.) Configuration time needed:

(very long)		(reasonable)		(very fast)
1	2	3	4	5

b.) Configuration process simplicity/complexity:

(very complex)		(reasonable)		(simple and concise)
1	2	3	4	5

Very complex: The configuration process was lengthy and required special knowledge, e.g. special technical hardware skills. As such, it had to be done by specialized personnel.
Simple and concise: The configuration process was very simple and could be readily performed by me, without extra steps.

c.) The time it took you to get acquainted with the component:

(excessive)		(reasonable)		(minimal)
1	2	3	4	5

excessive: It took me a long time to get acquainted with the structure and options of the component and I am still unsure about what many of the options do.
reasonable: The amount of time needed to get acquainted with the structure and options of the component was reasonable and in par with the service goals. I now know what most options do.
minimal: I learned how to interact with the component very quickly and got used to it very quickly as well.

d.) The overall intuitiveness of the component interaction:

(not intuitive)		(reasonable)		(very intuitive)
1	2	3	4	5

not intuitive: During the interaction with the component, actions from my side frequently do not make sense or are not easy to deduce and I must spend a considerable amount of time to learn them. The sequence of actions needed from me is confusing.
reasonable: During the interaction with the component, I occasionally have to look out where to find specific options and/or actions. However, the general experience is not cumbersome and I can interact with the component without overall confusion.
very intuitive: The interaction with the component works in a very intuitive way. I know or can easily guess where I can find the tool options without a lot of learning.

e.) Informativeness of errors:

(little and/or of poor quality)		(satisfactory)	(ample and/or of high quality)	
1	2	3	4	5

little and/or of poor quality: The errors obtained, during component configuration, do not provide adequate information that will allow the user to easily make corrections and leap back to the correct track in a fast and intuitive manner.
satisfactory: The errors obtained, during component configuration, provide some information, but further details are required to facilitate the user.
ample and/or of high quality: The errors obtained, during component configuration, are very informative and allow the user to leap back to the correct track in a very fast and intuitive manner.

f.) Configuration options:

(limited configuration options)		(reasonable configuration options)		(ample configuration options)
1	2	3	4	5

limited configuration options: The component has some configuration options, but it does not cover all of my needs.
reasonable configuration options: The component has enough configuration options to cover part of my needs, but more options can be given to the user.
ample configuration options: The component is fully customisable covering almost all of the possible requirements and needs.

g.) Configuration guidance and support:

(no resources)		(limited resources)		(ample guidance)
1	2	3	4	5

No resources: The configuration of the component was a hard process and no means of support were provided, such as tutorial, documentation, examples, tech webinars.
Limited resources: The configuration process offered help when needed in the form of simple documentation or very general steps/troubleshooting.
Ample guidance: There is rich supporting material to aid configuration of the component, such as troubleshooting guides, tips, clear instructions, read the docs files, a coherent customisation manual, a special configuration wizard etc.

h.) Clarity in the Available Documentation:

(documentation unclear)		(documentation cover all aspects but not deeply)		(documentation is easy to follow and understand)
1	2	3	4	5

Did you encounter any problems during the configuration of the FIWARE component to your system?

Yes (major issues)	Yes (minor issues)	No

In case you answered yes to the previous question, please explain the issues encountered:

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Component Integrity

This set of questions gives insight on the integrity of FIWARE components, i.e. the speed, stability and reliability of its structural functions.

Target Group: These questions are directed only to **persons who involved directly in the deployment of a FIWARE component** (e.g., a Context Broker or a Generic Enabler).

How would you rate the FIWARE component in terms of:

c.) The speed of executing its functions:

(very slow)				(very fast)
1	2	3	4	5

Very slow: The runtime/operational time of the service as a whole is significant and the user had to wait a considerable amount of time (e.g. a number of minutes).
Very fast: The runtime/operational time of the service is very small and the service were executed quite fast, without waiting times in between (e.g. in a few seconds).

d.) The stability of its functionality:

(not reliable)		(reliable)		(very reliable)
1	2	3	4	5

Not reliable: There were frequent structural problems such as component crashing or freezing.
Reliable: The component runs without critical errors. Some issues occurred at some more complex cases.
Very reliable: No crashes or problems were observed in the component.

e.) The security of the component:

Were you informed of or did you have any knowledge on the security protocols used as part of the FIWARE component, so as to ensure that the handled, processed and generated data cannot be accessed by third users?

Yes	No

In case you answered yes to the previous question, please rate your experience in the tool use in terms of how secure it was:

(not secure)		(secure)		(very secure)
1	2	3	4	5

Not secure: The component, based on my experience, did not employ security protocols such as encryptions to exchange data, and I am concerned about its use as part of my regular water service.
Secure: A reasonable level of security was used by the component and I have basic knowledge on it.
Very secure: The latest security protocols were used whenever needed (e.g. encryption, user-restricted access etc.) and I am well informed of them.

Did you encounter any problems during the operation of the FIWARE component to your system?

Yes (major issues)	Yes (minor issues)	No

In case you answered yes to the previous question, please explain the issues encountered:

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Graphical interface

Did the component have an interface to interact with (e.g., Apache NiFi front-end environment for Draco GE)?

Yes	No
(proceed to the following questions)	(skip the questions of this section)

How would you rate this user interface in terms of:

c.) the time it took you to get acquainted with the interface:

(excessive)		(reasonable)	(minimal)	
1	2	3	4	5

excessive: It took me a long time to get used to the graphics and functions of the service interface and I am still unsure about what many of the options do.
reasonable: The amount of time needed to get acquainted with the buttons and graphics was reasonable and in par with the service goals. I know now what most options do.
minimal: I learned how to interact with the service very quickly and got used to it very quickly as well.

d.) user interface functionality:

(cumbersome)		(functional)	(very functional)	
1	2	3	4	5

cumbersome: The user interface is complicated and a considerable amount of time is required to explore the options and functions of the service.
functional: The user interface offers a decent level of functionality, even though some aspects could be improved (e.g., some options could be simplified).
very functional: The user interface is simple and functional, on par with the service goals.

e.) the design of the user interface:

(basic)		(good)	(beautiful)	
1	2	3	4	5

basic: The user interface works with a very crude design, i.e. is a simple command-line, or is a primitive graphical user interface.

functional: The user interface is designed to serve the basic functions of the service and facilitate the user experience.
very functional: The user interface is beautifully designed and offers a pleasurable user experience.

f.) the overall intuitiveness of the user-service interaction:

(not intuitive)		(reasonable)	(very intuitive)	
1	2	3	4	5

not intuitive: During the user-service interaction, actions from my side frequently do not make sense or are not easy to deduce and I must spend a considerable amount of time to learn them. The sequence of actions needed from me is confusing.
reasonable: During the user-service interaction, I occasionally have to look out where to find specific options and/or actions. However, the general experience is not cumbersome and I can interact with the service without overall confusion.
very intuitive: The user-service interaction works in a very intuitive way. I know or can easily guess where I can find the tool options without a lot of learning.

Component Usefulness

This set of questions gives insight on how useful the FIWARE component is in the Context of FIWARE reference system architecture, and how easy is to use it.

Target Group: These questions are directed only to **persons who involved directly in the deployment of a FIWARE component** (e.g., a Context Broker or a Generic Enabler).

Usefulness

e.) Based on your experience, how well do you think the component performs the specific function that it was designed/supposed to do?

(very limited success)		(partial success)		(success)
1	2	3	4	5

Very limited success: The component deviates from what it was designed/supposed to do and only a small part of the component objectives are currently fulfilled.
Partial success: The component function is as it was envisioned, albeit with a number of limited mishaps during the component operation. Core functionalities are as promised, even though the component could be improved further to cover other cases.
Success: The component performs exactly as it was envisioned and all of its requirements are covered.

b.) How do you view the use of the specific component as part of the FIWARE-enabled reference system architecture for your case?

(a niche/optional part)		(a useful part)		(an integral part)
1	2	3	4	5

A niche/optional part: The component's function has a niche part in FIWARE-enabled reference system architecture and/or does not directly aid/actively contribute to the goals of the system as a whole.
A useful part: The component offers useful functionality that helps/contributes to the general FIWARE-enabled reference system architecture.
An integral part: The component's function is important and can be considered an integral part of the FIWARE-enabled reference system architecture.

c.) Based on your experience, how do you view the functionality of the component in general:

(unnecessarily complex)		(functional)		(very functional)
1	2	3	4	5

unnecessarily complex: The component is in general very complex and offers a lot of options that I'm not going to or wouldn't like to use.
functional: The component offers interesting options, even though some aspects could be improved.
very functional: The component feels 'just right' and it has complexity and functionality in par with the component goals. I find it very functional and would like to use it further.

Using ETSI NGSI-LD standard

This set of questions gives insights on aspects of the effort required to use the ETSI NGSI-LD standard.

Target Group: These questions are directed only to **persons who interacted with ETSI NGSI-LD standard**.

Within Fiware4Water we have adopted the use of the ETSI NGSI-LD standard based on JSON-LD.

How would you rate your level of expertise in JSON-LD?

Low experience (less than 6 months)	Moderate experience (6-12 months)	Experienced (1-2 years)	Highly Experienced (more than 2 years)
1	3	4	5
☐	☐	☐	☐

How would you rate your level of expertise in ETSI NGSI-LD?

Low experience (less than 6 months)	Moderate experience (6-12 months)	Experienced (1-2 years)	Highly Experienced (more than 2 years)
1	3	4	5
☐	☐	☐	☐

How you rate your experience with ETSI NGSI-LD standard in terms of:

a.) the time it took you to get acquainted with the standard:

(excessive)		(reasonable)		(minimal)
1	2	3	4	5
	☐	☐	☐	☐

excessive: It took me a long time to get used to the rational and structure of the standard and I am still unsure about them.
reasonable: The amount of time needed to get acquainted with the rational and structure of the standard was reasonable.
minimal: I learned the rational and structure of the standard very quickly and got used to it very quickly as well.

b.) Standard simplicity/complexity:

(very complex)		(reasonable)		(simple and concise)
1	2	3	4	5
☐	☐	☐	☐	☐

Very complex: The structure of standard is unnecessary complex.
Simple and concise: The structure of standard is very simple and readily understandable by anyone, without extra knowledge on the matter.

c.) Usefulness and efficiency of the standard (how useful and efficient the NGSI-LD standard is with the respect to the smart services you developed?):

(very limited success)		(partial success)		(success)
1	2	3	4	5

☐	☐	☐	☐	☐

Very limited success: The NGSI-LD standard currently covers only a small part of the requirements.
Partial success: The NGSI-LD standard covers several aspects, even though it can further be enhanced with additional features.
Success: The NGSI-LD standard covered adequately all of the requirements.

d.) Guidance and support to understand and utilise the standard:

(no resources)		(limited resources)		(ample guidance)
1	2	3	4	5
☐	☐	☐	☐	☐

No resources: No means of support are provided, such as tutorial, documentation, examples.
Limited resources: There is supporting material (data model documentation, guides, webinars), but more information is needed.
Ample guidance: There is rich supporting material (data model documentation, guides, webinars).

e.) Documentation to facilitate the use of standard:

(too little and/or of poor quality)		(satisfactory)		(ample and/or of high quality)
1	2	3	4	5
☐	☐	☐	☐	☐

Too little and/or of poor quality: the documentation that is available describes inadequately the components of the standard and does not facilitate its use.
Satisfactory: the documentation that is available is of decent quantity and quality.
Ample and/or of high quality: the documentation that is available of good quality and provides a detailed description of the standard.

Please provide any comment, feedback and/or requirement for new features, to support the further improvement of ETSI NGSI-LD standard.

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Using Smart Data models

This set of questions gives insights on aspects of the effort required to use the available smart data models.

Target Group: These questions are directed only to **persons who came across and interacted with data models** to define the structure of Context information (e.g., populate a Context Broker by defining entities and relationships) or consume data from the FIWARE Context Broker.

How would you rate your current level of expertise in data modelling ontologies and semantics?

Low experience (less than 6 months)	Moderate experience (6-12 months)	Experienced (1-2 years)	Highly Experienced (more than 2 years)
1	3	4	5
☐	☐	☐	☐

How you rate your experience with data models in terms of:

a.) the time it took you to get acquainted with the structure of data models:

(excessive)		(reasonable)		(minimal)
1	2	3	4	5

excessive: It took me a long time to get used to the rational and structure of data models and I am still unsure about them.
reasonable: The amount of time needed to get acquainted with the rational and structure of data models was reasonable.
minimal: I learned the rational and structure of data models very quickly and got used to it very quickly as well.

b.) Data models simplicity/complexity:

(very complex)		(reasonable)		(simple and concise)
1	2	3	4	5

Very complex: The structure of data models is unnecessary complex.
Simple and concise: The structure of data models is very simple and readily understandable by anyone, without extra knowledge on the matter.

c.) Guidance and support to understand and utilise data models:

(no resources)		(limited resources)		(ample guidance)
1	2	3	4	5

No resources: No means of support are provided, such as tutorial, documentation, examples.
Limited resources: There is supporting material (data model documentation, guides, webinars), but more information is needed.
Ample guidance: There is rich supporting material (data model documentation, guides, webinars).

d.) Documentation of entities, properties and relationships of data models:

(too little and/or of poor quality)		(satisfactory)		(ample and/or of high quality)
1	2	3	4	5

Too little and/or of poor quality: the documentation that is available describes inadequately the components (entities, properties, relationships) of the data model
Satisfactory: the documentation that is available is of decent quantity and quality.
Ample and/or of high quality: the documentation that is available of good quality and provides a detailed description of the data models.

e.) Usefulness of data models (how well do you think data models captures the related properties and relationships of an entity)?

(very limited success)		(partial success)	(success)	
1	2	3	4	5

Very limited success: The data models capture only a small part of properties and relationships.
Partial success: The data models cover several aspects, even though they can further be enhanced with additional properties and relationships.
Success: The data models cover almost all the information required.

Did you encounter any difficulties during your interaction with data models?

Yes (major issues)	Yes (minor issues)	No

In case you answered yes to the previous question, please explain the issues encountered:

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Creating Smart Data Models

This set of questions gives insights on aspects of the effort required to create new data models.

Target Group: These questions are directed only to **persons who involved in the creation of new data models** to handle Context information for your specific case.

How would you rate your current level of expertise in data modelling ontologies and semantics?

Low experience (less than 6 months)	Moderate experience (6-12 months)	Experienced (1-2 years)	Highly Experienced (more than 2 years)
1	3	4	5
☐	☐	☐	☐

How you rate your experience on creating new data models in terms of:

a.) time needed:

(very long)				(very fast)
1	2	3	4	5

b.) simplicity/complexity:

(very complex)			(reasonable)	(simple and concise)
1	2	3	4	5

Very complex: The procedure of creating new data models is unnecessary complex.
Simple and concise: The procedure of creating new data models is very simple and can be readily done by anyone, without expert knowledge.

c.) The amount of information required to create a new data model

(excessive requirements)		(reasonable)		(minimal requirements)
1	2	3	4	5

Excessive requirements: The creation of a new data model is high demanding, requiring information that can be omitted.
Reasonable requirements: The information that is required is reasonable, but some of them could be optional.
Minimal requirements: The creation of data models requires minimal amount of information.

d.) Guidance and support to create a new data model:

(no resources)		(limited resources)		(ample guidance)
1	2	3	4	5

No resources: No means of support are provided, such as tutorial, documentation, examples.
Limited resources: There is supporting material (data model documentation, guides, webinars), but more information is needed.

Ample guidance: There is rich supporting material (data model documentation, guides, webinars).

Did you encounter any problems during the creation of new data models?

Yes (major issues)	Yes (minor issues)	No

In case you answered yes to the previous question, please explain the issues encountered:

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Integration of third-party systems with FIWARE

This set of questions gives insights on aspects of the effort required to integrate third-party systems (such as devices, applications, sensors etc.) with FIWARE, developing connectors.

Target Group: These questions are directed only to **persons who involved in the development of connectors to allow the integration of third-party systems with FIWARE**.

What type of third-party system did you integrate with FIWARE? (e.g., a database, an AI model or a sensor)

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How would you rate the overall procedure to integrate your third-party system with FIWARE, by:

a.) **Integration time needed (including the time needed to adapt a system to make it work with Fiware):**

(very long)		(reasonable)		(very fast)
1	2	3	4	5

b.) **Integration process simplicity/complexity:**

(very complex)		(reasonable)		(simple and concise)
1	2	3	4	5

Very complex: The integration process was lengthy and required substantial modifications in the third-party system.
Simple and concise: The integration process was very simple and could be readily performed, without substantial modifications/adaptations in the third-party system.

c.) **Integration guidance and support:**

(no resources)		(limited resources)		(ample guidance)
1	2	3	4	5

No resources: The integration process was a hard process and no means of support were provided, such as tutorial, documentation, examples, tech webinars.
Limited resources: The integration process offered help when needed in the form of simple documentation or very general steps/troubleshooting.
Ample guidance: There is rich supporting material to support the integration of a third-party system with FIWARE, such as troubleshooting guides, tips, clear instructions etc.

Did you encounter any problems during the integration of third-party system with FIWARE?

Yes (major issues)	Yes (minor issues)	No

In case you answered yes to the previous question, please explain the issues encountered:

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Additional feedback

Please report here any further comments or feedback you wish to add about FIWARE or FIWARE components in general.

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