MOBISTYLE

MOtivating end-users Behavioral change by combined ICT based modular Information on energy use, indoor environment, health and lifeSTYLE

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1 Executive Summary

This deliverable reports the work of task T5.3 related to the development of the Open Users Platform, a web-based application that will give access to public MOBISTYLE data to externals.

The data collected in MOBISTYLE are specifically described in D4.1 and D6.1. The IT solutions accessible to MOBISTYLE users are described in D4.3 (final version M42, 31 of March). The Open data made available in the MOUP are defined by experts through a Learning Engine Task Force which have involved researchers working on aspects related to energy, health and Indoor Environmental Quality (IEQ).

The goal of the Open Users Platform is to allow third parties, external users, to have autonomous access to groups of data collected by the MOBISTYLE platform. They will be accessible via web, through Open APIs (Application Programming Interface).

The present deliverable D5.3 describes the MOBISTYLE Open Users Platform (MOUP hereon), addressing the challenges, functionalities and the IT implementation. This document is meant to be a technical description of the MOUP, at high level enough to be sharable with external public, but it addresses potential third party developers. More technical details can be made available through future documentation but it is relevant to consider that the MOUP is self explaining thanks to its catalogue and based on state of the art technologies and languages.

A first version of the solution was released in April 2019, M31 of MOBISTYLE project. The intermediate version declared the functionalities and challenges that had been then addressed through the developments. It had been useful mainly to approach the exploitation tasks and to verify the effectiveness of the solution proposed with large public.

Final version is released in M40, 29 February 2020 and consists of a definitive list of Open Data available from the current working MOBISTYLE platform.

Testing activities will be done by external developers and reported into D6.4 Evaluation of the effectiveness of the deployed tools, apps and combined information services at the end of the project (after Amendment, 30 June 2020).

Deliverable D5.3 is of type “Other”, which means that it describes a solution which is available online. The availability of the online solution was expected till March 2020, according to the project planning. The Open software adopted and here described, Tyk, approved the availability of the solution till March 2020, and availability afterward is not automatically approved. All relevant screenshots will be reported in this document.

2 Table of content

1 Introduction

Task T5.3 deals with the establishment of the MOBISTYLE Open Users Platform (MOUP) with an open architecture for developer engagements and for further deployment of the developed tools, modular information services, data storage and management, compatible for integration with existing modular services based on the same data storage and exchange principles (See MOBISTYLE DOA). Data will be available through Open Interfaces which allows externals to access aggregated data coming from all MOBISTYLE cases and users.

An open user platform, by definition, should be based on open standards and documented APIs that can allow employment of the existing modular information services in other ways than originally intended:

''In computing, an open platform describes a software system which is based on open standards, such as published and fully documented external application programming interfaces (API) that allow using the software to function in other ways than the original programmer intended, without requiring modification of the source code. Using these interfaces, a third party could integrate with the platform to add functionality.''[1]

In order to achieve this objective, the MOUP is an IT platform that should make its backend services and the Internet of Things (IoT) Data repository **accessible to new services** that might be developed and used also **outside** the MOBISTYLE consortium. From a technical point of view, the accessibility to the platform and/or to its components can be achieved by providing and publishing standardised APIs.

Facing such an objective includes an analysis of the platform design, architecture and functionality from diverse perspectives as the platform scalability, sustainability and, most importantly, trust and privacy should be addressed. Enabling accessibility to the backend services and data repositories necessitates balancing between certain technical requirements and several legal and non-technical aspects. In this respect, the definition, design and implementation of the Open users platform closely relates to the activities conducted in T4.2 (ICT platform, databases and interfaces), T5.2 (Trust and privacy) and T5.4. (Exploitation and business plan for the MOBISTYLE Open Users Platform). This cross-sectional approach includes the analysis of the ICT infrastructure and standards, the legal requirements on the data privacy and confidentiality as well as potential exploitation plan.

This document addresses the Open Users Platform requirements, explicates the choices on the Open platform architecture and functionality and presents the scheduling for activities necessary for the implementation, testing and validation of the architectural solutions.

[1] *Eisenmann, Thomas R. & Parker, Geoffrey & Van Alstyne, Marshall (August 31, 2008). "Opening Platforms: How, When and Why?" (PDF). Harvard Business School Entrepreneurial Management Working Paper No. 09-030. Harvard Business School. p. 2. doi:10.2139/ssrn.1264012. Retrieved 2015-06-30.*

2 Open Users Platform: functionality and challenges

The main objective of MOUP is to provide an open access to the backend services and databases. The MOBISTYLE databases are distributed and consist of local databases (see demonstration case repositories, and D4.1), the user management repositories (containing information about users register to access the MOBISTYLE tools) and the sensor-data repository where data collected from the sensors is stored and managed. The MOBISTYLE tools are software applications that, via dedicated APIs and Users Interfaces (UI), provide services to the end users who can visualise specific data and interact with the UIs of the particular applications (Dashboard, Game, Expert tool, Office app). The APIs enabling access to the sensor data repository provide the applications with the data coming from the sensors that monitor the energy consumption and environmental conditions, e.g. IEQ, that may also impact individual health and wellbeing.

Regarding the GDPR requirements, no personal data can be collected, processed or disclosed without an explicit consent of a user who is, in legal terms, the data subject and owner of her/his own personal data (see D5.2). In addition, a transparent Privacy Policy (see D5.2 and D5.6) should provide the users an unambiguous specification of the scope for which personal data is collected and used. All possible parties involved in personal data collection and processing should be declared.

2.1 MOUP and GDPR compliancy

The GDPR requirements pose certain limitations to the Open Users Platform scope and functionality. In particular, *Open Platform* by the definition refers to ''(*API*) that *allow using the software to function in other ways than the original programmer intended*'' thus leaving the application scope open, while *the GDPR requires to declare specifically the scope for which personal data is used and will be used*. Thus, providing an Open Platform that contains personal data and, at the same time, meets the GDPR requirements is logically impossible, unless the users agree with a Privacy Policy permitting use of their data for any possible purpose. Compliance with the GDPR requires specifying the intended use of personal that that would be accessed or processed by the backend services. However, whenever a Privacy Policy has to deal with unintended use, a paradox emerges from the fact that as soon as an unintended use is specified, it gains the status of an intended use and stops being an unintended use. On the other hand, leaving open possibility for some unintended use of personal data, the scope for which the personal data would be used would stay unspecified. As a consequence, the Privacy Policy and provided services would fail to meet the GDPR requirements.

In order to overcome the limitations posed by the GDPR requirements, the Open Users Platform functionality should exclude and/or minimise employment of personal data. The alternative solution that we have explored is the creation and employment of a dedicated module within the MOBISTYLE platform, i.e. the Open Platform module that could allow access to only **anonymous aggregated data**. The access to the Open Users Platform module could be provided via standardised APIs published to support external parties to develop and use the MOBISTYLE backend services, operating with the aggregated data.

2.2 MOUP maintenance

Maintenance of the platform is another aspect that affects the Open Users Platform functionality. Providing access to external users to a selected fraction of the MOBISTYLE database (e.g. aggregated data within the Open Platform module) requires a continuous engagement of the service providers (database maintenance and management) and the Open Users Platform could be operational overtime only if an appropriate business model supports the Open Users Platform maintenance. Therefore, exploration of the 3rd parties who could have interest in accessing and using the MOBISTYLE data, interest of data owners to share these data, models for making business out of the data and plans to ensure sustainability of the platform should be considered as part of T5.4 activities and T5.3 should be aligned with the exploitations plan.

2.3 MOUP third parties

Possible 3rd parties who are willing to share and use the data (ideally, aggregated data) via the Open Users Platform may include, e.g. energy providers, appliances producers, and facility managers. Preliminary insights indicate that some end-users who have no direct interest in providing their data to others, while some other stakeholders such as hotel managers might be interested in sharing their data with public in order to increase their visibility and appreciation of the implemented approach towards the environmentally friendly solutions. Universities and research institutes could also have interest in accessing and using the Open Platform data as benchmark values developing energy performance or IEQ analysis on buildings with different uses (both residential and non-residential).

3 Open Users Platform: developments and implementation plan

In order to proceed with the developments and implementation that can provide access to the Open Users Platform, while respecting the privacy, exploitation, and maintenance requirements, three phases are defined:

1. definition of Open Users Platform components (aggregated data, Open APIs, Private APIs, Proxy, authorisation module);
2. Implementation of the components; definition of access management policies, to allow defined third parties to receive the aggregated data through the APIs structure;
3. internal testing and final release.

In the first version of D5.3 deadlines had been proposed for the MOUP development and testing. Meanwhile the final deadline of the project had moved to M45 together with validation activities. Table 1 defines the steps related to the development activities, with the new temporal distribution in Months and the deliverables in which the results will be presented

Previous deadline	Step	Ref. deliverable
1 (M24) - done	Creation of infrastructure of private APIs to connect to MOBISTYLE databases	D5.3 first version

2 (M30)	Identification of Single Domain Key Performance Indicators (KPIs) and metadata made accessible through the Open APIs (aggregated data)	D5.3 first version
3 (M40)	Public API structure definition and mapping into Private APIs; implementation of the private APIs for aggregated data	D5.3 final version
4 (M40)	Final version of KPIs and metadata made accessible through the Open APIs: aggregated data of multi-domain KPIs (Key Performance Indicators)	D5.3 final version
5 (M42)	3rd party developers registration to the system	D6.4
6 (M45)	Internal testing completed and final release of the MOUP	D6.4

Table 1 Open Users Platform development steps and deliverables

4 Open Users Platform Architecture

Fig. 1 depicts a basic architecture of the MOBISTYLE solution with the specifications of the Open Users Platform module.

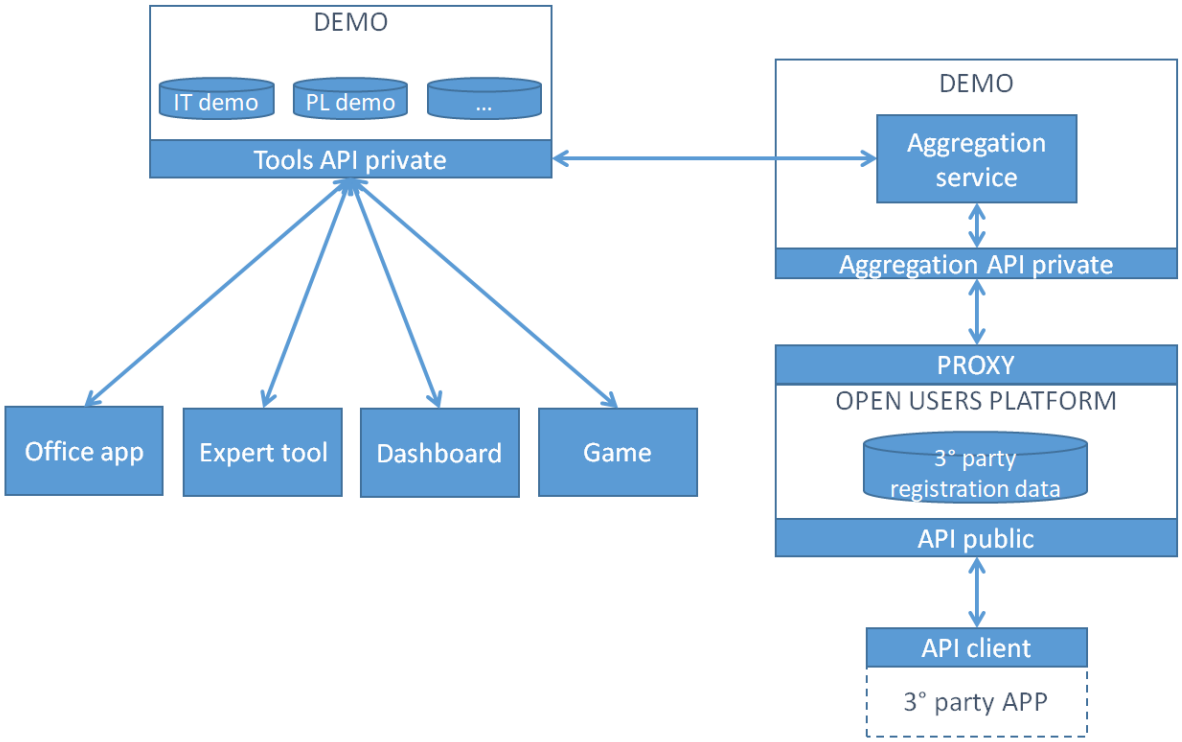

Fig. 1 Open Users Platform module in the MOBISTYLE architecture

The Open Users Platform is integrated into the MOBISTYLE infrastructure and communicates with its persistence layer to gather aggregated data coming from the sensors. For this purpose, a dedicated private API is developed and configured to anonymize data of the user's rooms. The aggregation module calculates the aggregated KPIs using the data feed from the sensor-database of the MOBISTYLE platform. The data from the sensor-database pass through the data aggregation layer that calculates the aggregated KPIs. The final list of KPIs is explicated in chapter 5.

4.1. The Aggregation Service

The Aggregation service translates private data into anonymous aggregated data according to the Open Users Platform KPIs defined in WP3. Input is the data living in the MOBISTYLE platform, often private and requiring explicit consent before disclosure. Output is anonymous and adheres to GDPR regulations. This strict separation between input and output safeguards the private data from 3rd party access and bridges the gap involved in adherence to both Privacy Policies and the GDPR.

4.2. The aggregated data repository

The aggregated data repository is a database module of the MOBISTYLE platform that stores the most relevant anonymous aggregated data on e.g. energy consumption, indoor environmental quality and users' behaviours. It is populated by the aggregation service. This repository is the only one accessible by 3rd parties after passing through the proxy layer.

4.3. The proxy

In order to process the requests coming from external third party users, a proxy is set up to forward them to the MOBISTYLE private API using M2M authentication. The authentication process is the same as the regular MOBISTYLE interaction of the Dashboard with the DEMO's APIs, with dedicated credentials for the task. The requests are not modified in their content, but processed by the Open Users Platform to ensure that are authenticated and authorized. This communication adds a security layer and hides the private APIs from the external world.

4.4. The Open Users Platform users registry

For authentication and authorization purposes, the Open Users Platform requires a repository (user registry) to store necessary information on users willing to access the aggregated data of MOBISTYLE.

During the initial phase registration to the Open platform is done semi-automatically: users send via email an approval request to the database administrator who gives permission, credentials and API keys to the OP users.

The final phase may employ a persistence layer to automatically store credentials and applications keys used by third party companies and developers to connect to the Open Users Platform and make calls to the Open API.

The users registry allows the Open Users Platform to track when and who is requesting a specific resource and for which purposes.

4.5. Open API

The Open Users Platform exposes a public open RESTful API to the external world. This APIs are used to query the aggregated data of the private APIs of DEMO and are protected by an API key/secret mechanism. The keys are used to authenticate and authorize the third party application who is requesting a specific resource and are stored in the MUOP repository. If the application making the requests is not registered or not authorized (e.g bad/expired key), the request is not forwarded to the proxy and consequently not forwarded to the private APIs of MOBISTYLE. A dedicated unique set of keys is generated for each user registered in the MUOP, which are identified by a *name* and *email.*

The Open APIs are practically a mirror of the dedicated private APIs for aggregated data of DEMO. Having this layer of APIs allows exposing a certain subset of private APIs to external users, if needed (e.g. if a private API resource has been deprecated or is for internal use only, it can be hidden to external users).

4.6. Application flow

Suppose there's a third party developer in a third party company who wants to use the aggregated data of MOBISTYLE to give to its users added value for its field, for example an electricity-provider company who wants to share the average electrical consumption of MOBISTYLE users. Imagine the company wants to develop a mobile app with a dashboard showing both MOBISTYLE aggregated data and its own. To reach this goal the company can use the MUOP, following these steps:

1. The company developer asks to the system administrator to register itself on the MOUP e.g. via email. In case of dedicated GUI this step can be done automatically.
2. The MUOP generates an API key/secret pair for the application to be used to make calls to the Open API.
3. The developer creates its proprietary app (outside of the context of MOBISTYLE) and configures an http client with the given API keys to query the Open API of the MUOP.
4. Whenever the third party application makes a request to the Open API, the MUOP checks if the application is registered and authorized using the API keys, identifying the company/user that is making the request.
5. If the application is authorized, the MUOP forwards the request to its internal proxy as is, with no further modifications.
6. The proxy adds the M2M authentication to the request and forwards it to the private APIs of DEMO.
7. When the data is received, the proxy returns it to the Open API which will get it back to the application.
8. The application can now show the data to its user.

5 Open Data to be shown: KPIs definition

In T5.3, POLITO was involved in the process for the definition of new KPIs to be Open to Third Parties. The workflow was the following:

1. Definition of a first proposal of "nice to have" KPIs, which where single-domain KPIs (M30);
2. Check on possible technical criticalities (M31);
3. Check on relevance and consistency with MOUP value proposition (M36);
4. Definition of multi-domain KPIs with the related algorithms (M39).

Initially, KPIs were proposed in WP3. They are single-domain KPIs that were treated within MOBISTYLE for different purposes (evaluation, visualization in ICT tools, expert tool, etc.) at each pilot level. In T5.3 they were partially reviewed and redefined further in terms of their time-step and spatial dimensions (e.g. definition of clusters of rooms/buildings).
Starting from those KPIs, a process of checking on technical criticalities of their implementation and on their relevance and consistency with the MOUP value proposition, as defined within the exploitation view development, was put in place. In particular, the second need brought to the choice of establishing a dedicated Task Force, leaded by POLITO. In accordance with the MOUP value proposition, the reasoning of the Task Force was to go beyond the single-domain and more traditional KPIs to offer multi-domain ones, elaborated on data coming from the energy, IEQ and well-being domains, keeping in mind the two questions:

- **Value**: Which is the derived knowledge from the multi-domain KPIs?
- **Relevance**: Who would be interested in the multi-domain KPIs (and for which purpose)?

5.1 Single-Domain KPIs

The single-domain KPIs, proposed in WP3 by POLITO, were treated within MOBISTYLE for different purposes (evaluation, visualization in ICT tools, expert tool, etc.) at each pilot level. Those KPIs were defined in terms of time-step and spatial dimensions (e.g. definition of clusters of apartments), focusing on the parameters gathered in the different MOBISTYLE case studies. The gathered parameters cover three areas:

1. Indoor environmental conditions;
2. System-user interactions;
3. Energy/water consumptions.

No health-related parameters are collected in the MOBISTYLE central database.
However, even if it was the case, health-related data are considered sensitive data, thus they should be treated carefully.

The set of single-domain KPIs for the different three areas is exemplified in the followings. Starting from the indoor environmental conditions, single-domain KPIs are mean monthly values for temperature (T), relative humidity (RH) and CO_2 concentration, and hourly profiles for one day for T, RH and CO_2. Daily profiles are also differentiated for weekdays and weekends.
Coming to system-user interactions, number of interactions with windows and thermostats can be calculated on a monthly-basis, since they are affected by seasonality. All data can be

also normalized over the number of expected occupants to give an idea about the density of the interactions, as long as this information is available.
Single-domain KPIs related to energy/water consumptions includes annual, monthly and hourly indicators referred to energy and water final uses. Also, energy costs can be relevant, as long as information on energy tariffs are available, and can be expressed on an annual basis.

Some of the single-domain KPIs were aggregated in order to translate them in anonymous data. For example, in residential case studies (Danish and Polish) consumptions aggregation can be performed per clusters of households based on their sizes. In all demo cases, indoor parameters could be aggregated, for example, based on type of occupancy, as long as this information is available.

Starting from the single-domain KPIs, a process of checking on technical issues of their implementation and their relevance and the consistency with the MOUP value proposition was put in place.

5.1.1 Checking on technical criticalities

Starting from the list of single-domain KPIs, a first check on possible technical issues of their implementation was carry out by POLITO in collaboration with Holonix and Demo. The main challenges encountered in MOBISTYLE are listed in the followings:

- Some data required for the computation of the preliminary list of KPIs are not gathered from the local databases at demo cases side to the central MOBISTYLE database (developed by Demo). Their integration would require further development in the database, with extra efforts and capacity.
- Moreover, also some metadata are not collected, preventing the system from recognizing some differences (e.g. difference between weekdays and weekends). To overcome this challenge, the integration with additional databases would be required. The latter would be also the only possible technical solution to the need of collecting data from external sources about e.g. weather data, energy tariff, square meters, etc.
- In addition, some of this data would not be available at pilots' side.
- Finally, a significant amount of complexity is brought by the definition of different time-steps of the KPIs (year, month, day, hour).

5.1.2 Checking on relevance and consistency with MOUP value proposition

The second check consisted in thinking about KPIs relevance for the MOUP users and their consistency with the MOUP value proposition, to be clarified. Indeed, the definition of the KPIs for the MOUP opened an important discussion about the scope it should support and, accordingly, the trade-off between offering widely pre-processed data or rawer data. Indeed, the level of processing of data uses to be strictly connected with the scope of the MOUP itself. From one side, the MOUP would offer to an external developer aggregated information, limiting the possible interrogations, trying to forecast which could be the needs of a potential final user of the MOUP, but generating value by the pre-processing activity performed on data. On the other side, the MOUP would deliver a service which permits more complex and versatile interrogations, but without any guidance about the relevance of the data gathered. This trade-off is depicted in the following figure.

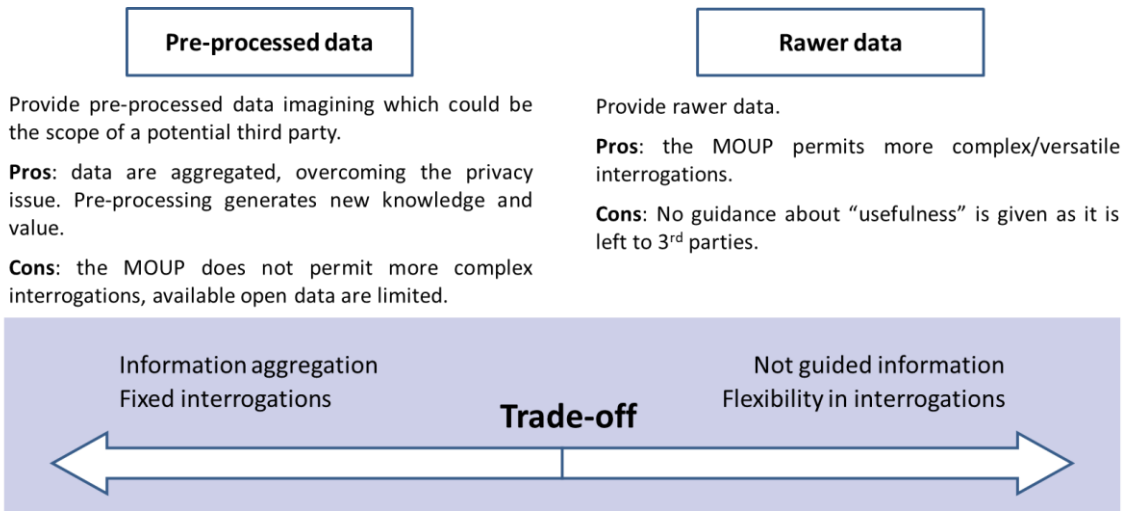

Fig.2 – The difficult trade-off in defining aggregation criteria for the MOUP.

The solution to this trade-off is strictly related to the exploitation view for the MOUP. To solve this point, a business model was defined thanks to the work developed in T5.4, running in parallel, where Lean Canvas was developed for the MOUP. What came out from the discussion on the business view is that the MOUP main value proposition lies in giving additional combined information from the MOBISTYLE gathered data to external users. From this the necessity of developing new multi-domains KPIs and the choice of establishing a dedicated Task Force, leaded by POLITO.

5.2 Multi-domain KPIs

The **Learning Engine Task Force**, leaded by POLITO and included AAU, MU and IRI-UL teams, had the aim to improve multi-domains KPIs starting from the single-domain ones that were initially developed in WP3. The reasoning was to go beyond the traditional single-domain KPIs to offer multi-domain KPIs, elaborating on data coming from the energy, IEQ and well-being areas. In face of the data available in MOBISTYLE, the offered KPIs have to be considered as benchmark values computed on MOBISTYLE pilots on combined information about the performance of the buildings in terms of energy, IEQ and well-being. A list of multi-domains KPIs was developed keeping in mind value and relevance of the proposed ones, by answering to the two following questions, mentioned above:

- **Value**: Which is the derived knowledge from the multi-domain KPIs?
- **Relevance**: Who would be interested in the multi-domain KPIs (and for which purpose)?

As already mentioned, a final list of multi-domain KPIs was improved, reflecting the interest of having combined information about energy, IEQ and well-being. The list had to be developed by checking the data availability and keeping in mind the technical constraints already mapped for single-domain KPIs. Aggregation criteria had to be defined in face of the actual availability of data per each demo case to keep the KPI meaningful. The set of defined KPIs is reported in the followings (with description, algorithm, legend and technical details per

each KPI), with some insights about their value and relevance with respect to possible final users of the MOUP (namely different stakeholders connected to the building sector).

5.2.1. Carbon intensity of consumption

Sum of all final energy consumptions weighted on the greenhouse gases (GHG) emission factors of each energy carrier.

Algorithm:

$$\frac{\sum_{d=1}^{n}(district\ heating\ consumptions)_d \cdot\ coeff.emiss_{DH} + \sum_{d=1}^{n}(electicity\ consumptions)_d \cdot coeff.emiss_{el}}{\sum_{d=1}^{n}(district\ heating\ consumptions)_d + \sum_{d=1}^{n}(electicity\ consumptions)_d}$$

$$[\frac{kg_{CO2eq}}{kWh}]$$

Legend:

District heating consumptions: daily consumptions of district heating (including both space heating and domestic hot water production) in kWh.

Electricity consumptions: daily consumptions of electricity (all final uses) in kWh.

Coeff. emiss $_{DH}$: national emission factor of CO_{2eq} for district heating (or defined by local supplier) in $kgCO_{2eq}/kWh$.

Coeff. emiss $_{el}$: national emission factor of CO_{2eq} for electricity in $kgCO_{2eq}/kWh$.

Technical details:

- **Calculation period n:** year;
- **Time-step d:** day;
- **Space dimensions:** single apartment (or cluster of apartments based on size);
- **Involved demo cases:** Danish;
- **Measured parameters:** district heating consumptions; electricity consumptions.

Value and relevance insights:

- ***Value****: Which is the derived knowledge from the new KPI?*
  Carbon intensity of energy consumptions based on the mix of energy carriers.
- ***Relevance****: Who would be interested in the new KPI (and for which purpose)?*
  Policy makers (reference value for the assessment of stock performance with respect to GHG target); building designers (benchmark value in assessing GHG intensity of different mixes of energy carriers); researchers (reference value for the assessment of environmental performance of the building stock); energy suppliers (benchmark value in assessing potential GHG savings due to different supply scenarios).

5.2.2. Energy performance

Energy performance weighed on thermal discomfort with respect to a performance target – daytime. Ratio between the targeted specific consumption and the current one, where the current is weighted on a coefficient (called "POR") which is proportional to the severity of the thermal discomfort, quantified according to how far the indoor air temperature is from the

first class of thermal comfort as defined by EN 15251[2]. Since heating consumptions and indoor air temperature use to be measured at different scale, typically at whole apartment and room level, respectively, heating consumptions are scaled to the room level by multiplying them for the share of square meters of the room over the total heated floor area.

Algorithm:

$$\frac{\left(\frac{district\ heating\ consumption}{m^2}\right)_{target} \cdot m^2_{livingroom}}{\sum_{d=1}^{n} POR(T)_d \cdot (district\ heating\ consumption)_d \cdot \frac{m^2_{livingroom}}{m^2_{apt}}} \quad [\%]$$

Legend:

District heating consumption/m^2, target: yearly consumptions of district heating (only for space heating) in kWh/m^2 representing the target performance. It can be changed by the user.

District heating consumptions: daily consumptions of district heating (only for space heating) in kWh.

POR(T) = severity of discomfort in terms of Temperature (T) computed in the occupied hours (Oh) as:

$$POR(T) = \sum_{i=1}^{Oh} wf_i \qquad [-]$$

where wf_i per each hour i correspond to a number ranging from 0 to 3 according to how far the temperature is from the optimal thermal comfort class as defined by EN 15251 for residential case. wf_i equals 0 for comfort class I, 1 for class II, 2 for class III and 3 for discomfort. It is computed on daytime assuming permanent occupation.

m^2_{apt} = heated square meter of the apartment in m^2.

$m^2_{livingroom}$ = heated square meter of the living room (where temperature is measured) in m^2.

Technical details:

- **Calculation period n:** year;
- **Time-step :** day;
- **Spatial dimensions:** living room of each apartment (or cluster of apartments);
- **Involved demo cases:** Danish;
- **Measured parameters:** district heating consumptions (daytime); indoor air temperature (daytime).

Value and relevance insights:

- ***Value**: Which is the derived knowledge from the new KPI?*

[2] CEN (2007). *Indoor Environmental Input Parameters for Design and Assessment of Energy Performance of Buildings- Addressing Indoor Air Quality, Thermal Environment, Lighting and Acoustics.* EN 15251 Standard. Brussel: European Committee for Standardization.

Distance from targeted energy and IEQ performances.

- ***Relevance**: Who would be interested in the new KPI and for which purpose?*
  Policy makers (dynamin index in assessing the score of a building with respect to a predefined energy performance, considering also guaranteed IEQ); Energy managers (benchmark value in assessing the score of a building with respect to energy and IEQ targets).

5.2.3. Percentage of hours in comfort

Percentage of hours in comfort in terms of temperature, relative humidity and CO_2 and VOC concentration – (daytime/night-time).
Sum of percentage of hours in class II of comfort (as defined according to the EN 15251) according to the four measured parameters over the total hours of the monitoring period. Each parameter has the same weight ($\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$), but by changing them it is possible to assess which parameter is influencing the most the overall percentage of hours in comfort and thus to disclose where the criticalities in terms of IEQ are. Only occupied hours should be considered (alternatively during day or night-time).

Algorithm:

$$\alpha_1 \frac{\sum_{d=1}^{n}(Oh - hOR(T))_d}{N \cdot Oh} + \alpha_2 \frac{\sum_{d=1}^{n}(Oh - hOR(RH))_d}{N \cdot Oh} + \alpha_3 \frac{\sum_{d=1}^{n}(Oh - hOR(CO_2))_d}{N \cdot Oh} + \alpha_4 \frac{\sum_{d=1}^{n}(Oh - hOR(VOC))_d}{N \cdot Oh}$$

[%]

Legend:

$\alpha_1, \alpha_2, \alpha_3, \alpha_4$ = weighting factors equal to 0.25 by default. They can be changed (sum=1).

hOR(x) = number of daily hours where x (varying as Temperature T, Relative Humidity RH, Carbon dioxide concentration CO_2 and Volatile Organic Compounds concentration VOC) is out of class II of comfort. It is computed in the occupied hours (Oh) as:

$$hOR(x) = \sum_{i=1}^{Oh} wf_i \quad [hours]$$

where wf_i per each hour i equals 0 or 1 if the parameter x respects or does not respect the thresholds of comfort class II as defined by EN 15251 and D6.2. wf_i equals 0 for comfort class I, 1 for class II, 2 for class III and 3 for discomfort. Occupied hours are assumed from standards BS ISO 18523-1:2016 based on building use.

N: total number of days in the calculation period n.

Oh: number of occupied hours per day.

Technical details:

- **Calculation period n:** heating period;
- **Time-step d:** day;
- **Spatial dimensions:** single room;
- **Involved demo cases:** Danish, Slovenian, Italian;

- **Measured parameters:** indoor parameters (daytime/night-time).

Value and relevance insights:

- ***Value**: Which is the derived knowledge from the new KPI?*

Overall performance of the indoor environment expressed in an easy to understand unit.

- ***Relevance**: Who would be interested in the new KPI and for which purpose?*

Building occupants (benchmark value to be displayed to the occupants to inform about overall performance of the indoor environment); Building designers (benchmark value in assessing the overall performance of the indoor environment); Building managers (dynamic index to define the parameter which is influencing the most the overall comfort/discomfort).

5.2.4. Severity of discomfort

Severity of discomfort in terms of temperature, relative humidity and CO_2 and VOC concentration – (daytime/night-time)

Sum of occupied hours weighted on the severity of discomfort (quantified through "POR" index) according to the four measured parameters over the occupied hours of the monitoring period. Each parameter has the same weight ($\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$), but by changing them it is possible to assess which parameter is influencing the most the overall severity of the discomfort and thus to disclose where the criticalities in terms of IEQ are. Only occupied hours should be considered (alternatively during day or night-time).

Algorithm:

$$\alpha_1 \frac{\sum_{d=1}^{n}(Oh + POR(T))_d}{N \cdot Oh} + \alpha_2 \frac{\sum_{d=1}^{n}(Oh + POR(RH))_d}{N \cdot Oh} + \alpha_3 \frac{\sum_{d=1}^{n}(Oh + POR(CO_2))_d}{N \cdot Oh} + \alpha_4 \frac{\sum_{d=1}^{n}(Oh + POR(VOC))_d}{N \cdot Oh}$$

[-]

Legend:

$\alpha_1, \alpha_2, \alpha_3, \alpha_4$ = weighting factors equal to 0.25 by default. They can be changed (sum=1).

POR(x) = severity of discomfort in terms of x (varying as Temperature T, Relative Humidity RH, Carbon dioxide concentration CO_2 and Volatile Organic Compounds concentration VOC), computed in the occupied hours (Oh) as:

$$POR(x) = \sum_{i=1}^{Oh} wf_i \quad [-]$$

wf_i per each hour i correspond to a number ranging from 0 to 3 according to how far the parameter x is from the optimal comfort class as defined in EN 15251 and in D6.2. wf_i equals 0 for comfort class I, 1 for class II, 2 for class III and 3 for discomfort. Occupied hours are assumed from standards BS ISO 18523-1:2016 based on building use.

N: total number of days in the calculation period n.

Oh: number of occupied hours per day.

Technical details:

- **Calculation period n:** heating period;
- **Time-step d:** day;
- **Spatial dimensions:** single room;
- **Involved demo cases:** Danish, Slovenian, Italian;
- **Measured parameters:** indoor parameters (daytime/night-time).

Value and relevance insights:

- ***Value****: Which is the derived knowledge from the new KPI?*

Overall severity of the discomfort expressed in an easy to understand unit.

- ***Relevance****: Who would be interested in the new KPI and for which purpose?*

Building occupants (benchmark value to be displayed to the occupants to inform about overall performance of the indoor environment); Building designers (benchmark value in assessing the overall performance of the indoor environment); Building managers (dynamic index to define the parameter which is influencing the most the overall comfort/discomfort).

5.2.5. Perceived air quality

Perceived air quality (in terms of percentage of dissatisfied) based on CO_2 concentration – daytime

Percentage of dissatisfied forecasted based on CO_2 concentration according to the model reported by the Commission of the European Communities[3]. Only occupied hours should be considered.

Algorithm:

$$\frac{\sum_{d=1}^{n}(395 \cdot exp(-15.15 \cdot C_{CO_2}^{-0.25}))_d}{N}$$

[%]

Legend:

C_{CO_2}: hourly mean concentration of CO_2 in ppm above outdoor level (equals to 350 ppm) in the occupied hours (Oh) assumed from standards BS ISO 18523-1:2016 based on building use.

N: total number of days in the calculation period n.

Technical details:

- **Calculation period n:** heating period;
- **Time-step d:** day;
- **Spatial dimensions:** single room;
- **Involved demo cases:** Slovenian, Italian (only office space);

[3] Commission of the European Communities (1992). *INDOOR AIR QUALITY & ITS IMPACT ON MAN. Report No. 11 – Guidelines for Ventilation Requirements in Buildings.* Commission of the European Communities. Luxemburg (Luxemburg).

- **Measured parameters:** indoor CO_2 concentration (daytime).

Value and relevance insights:

- ***Value**: Which is the derived knowledge from the new KPI?*

Perceived air quality.

- ***Relevance**: Who would be interested in the new KPI and for which purpose?*

Researchers (benchmark value in assessing the perceived air quality); Building managers (benchmark value in assessing the perceived air quality).

5.2.6. Productivity economic value

Monetized productivity level per employee as forecasted based on indoor air temperature by Seppanen et al. model[4].

Algorithm:

$$\sum_{d=1}^{n}\left(\sum_{i=1}^{Oh}(0.1647524\cdot T_i - 0.0058274\cdot T_i^2 + 0.0000623\cdot T_i^3 + 0.4685328)\cdot L_i\right)_d \quad [€]$$

Legend:

T: hourly mean indoor air temperature in °C in the occupied hours (Oh). Oh are assumed from standards BS ISO 18523-1:2016 based on building use.

L: hourly labour cost of an employee in €.

Technical details:

- **Calculation period n:** heating period;
- **Time-step:** hour (i), day (d);
- **Spatial dimensions:** single room;
- **Involved demo cases:** Slovenian;
- **Measured parameters:** indoor air temperature (daytime).

Value and relevance insights:

- ***Value**: Which is the derived knowledge from the new KPI?*

Economic value of productivity.

- ***Relevance**: Who would be interested in the new KPI and for which purpose?*

Office managers (benchmark value in assessing the economic value of productivity and its balance with respect to costs to keep proper indoor comfort conditions).

[4] Seppanen O., Fisk W. And Lei Q. H. (2006). *Effect of temperature on task performance in office environment*, in Proceedings of Cold Climate HVAC conference, Moscow.

5.2.7. Medium energy consumptions for standby for TVs

Medium energy consumptions for standby computed on a stock of TVs and estimated based on minimum and maximum active power according to Ajay-D-Vimal Raj et al. model[5].

Algorithm:

$$\frac{((\frac{\sum_{d=1}^{n}(Cons_{TV})_d - 24 \cdot N \cdot P_{TV,max}}{P_{TV,min} - P_{TV,max}}) \cdot P_{TV,min})_{,apt1} + ((\frac{\sum_{d=1}^{n}(Cons_{TV})_d - 24 \cdot N \cdot P_{TV,max}}{P_{TV,min} - P_{TV,max}}) \cdot P_{min})_{,apt\dots} + ((\frac{\sum_{d=1}^{n}(Cons_{TV})_d - 24 \cdot N \cdot P_{TV,max}}{P_{TV,min} - P_{TV,max}}) \cdot P_{TV,min})_{,aptm}}{(\sum_{d=1}^{n}(Cons_{TV})_d)_{,apt1} + (\sum_{d=1}^{n}(Cons_{TV})_d)_{,apt\dots} + (\sum_{d=1}^{n}(Cons_{TV})_d)_{,aptm}}$$

[%]

Legend:

$Cons_{TV}$: consumptions for TV.

$P_{TV,min}$: minimum registered power for TV >0.

$P_{TV,\,max}$: maximum registered power for TV.

N: total number of days in the calculation period n.

m: number of apartments composing the stock.

Technical details:

- **Calculation period n:** year;
- **Time-step d:** day;
- **Spatial dimensions:** whole stock;
- **Involved demo cases:** Polish, Italian (only guest rooms);
- **Measured parameters:** active power of TVs, consumption of TVs.

Value and relevance insights:

- ***Value****: Which is the derived knowledge from the new KPI?*

People habits impacts in terms of wasted energy expressed in an easy to understand way.

- ***Relevance****: Who would be interested in the new KPI and for which purpose?*

Appliances producers (benchmark value for product placement); Households (benchmark value to be displayed to the occupants to inform about wasted energy due to their habits).

[5] P. Ajay-D-Vimal Raj, M. Sudhakaran and P. Philomen-D-Anand Raj (2009). Estimation of Standby Power Consumption for Typical Appliances. *Journal of Engineering Science and Technology Review 2* (1), 71-75.

6 Aggregation Service

6.1 Access through Aggregated data API private

DEMO has implemented and published a web service listening for specific endpoints. The Open Users Platform performs as 'man in the middle' in between a 3rd party user and DEMO's back-end. The Open Users Platform simply forwards valid API requests received from end users (once authenticated) to DEMO's 'Aggregated data API private'.
Likewise, results produced for requests are forwarded by the Open Users Platform to the end user without any data modification in between. This API only makes use of anonymised IDs of Objects (Homes/Apartments/Hotel Rooms).

6.2 Calculation of KPIs

The Aggregation service calculates the value of a KPI using the data feed from the sensor-database of the MOBISTYLE platform. This database is accessed by the private tools API. The implementation of the data access and the data aggregation makes use of the technologies Representational state transfer (REST), JavaScript Object Notation (JSON) and BSON (Binary JSON) Serialization.
Because of the fact that an API call can be parameterized by multiple parameters, the KPI value is calculated at the moment the request is done.
The Aggregation service internally maps the internal IDs of Objects (Homes/Apartments/Hotel Rooms) into anonymised IDs, and reversed.

6.3 Security and technology

The webservice make use of specific endpoints. Data security in transit is based on an HTTPS connection (with TLS encryption). Authentication works though Basic Auth that is a pre-shared key between DEMO and the Open Users Platform.
The webservice uses Representational state transfer (REST) for its architecture. Response and (where necessary) request bodies use JavaScript Object Notation (JSON).

6.4 ENDpoints

The following entities are implemented as (parameterized) endpoints:

- List of available Countries
- List of available Objects (Homes/Apartments/Hotel Rooms) of a Country (with anonymised IDs)
- List of available KPI's of a specific Country as a whole
- Calculation of the KPI value of a specific Country as a whole
- List of available KPI's of a specific Object (with anonymised IDs)
- Calculation of the KPI value of a specific Object (with anonymised IDs)

7 Open Users Platform Implementation

The MOBISTYLE Open Users Platform (MOUP) has the mission to facilitate the developers external to the MOBISTYLE project on one hand to interact with applications and data coming from the project and on the other to facilitate the sharing of their own resources to MOBISTYLE's data providers.
One of the issues that could arise is the fact that every single data provider could have its own data exchange strategy, and most of all also its data security approach. For example it can happen that:

- a data provider A could require for its resources a Basic Auth to authenticate the incoming requests,
- data provider B could require a more complex Json Web Token (JWT) to authenticate the incoming requests,
- but we can also have an data provider C that requires some certificate to authenticate incoming requests.

For an external developer the above described scenario is a nightmare to deal with if he has to interface with all three data providers, the ideal way to simplify this nightmare is to have a "single place" where the external developer can deal with but at the same time can reach all three "physical" endpoints without the need of dealing with three different authentication/authorization systems.

To this purpose, the aim of MOUP is to provide a unique place where an external developer can interact with without the need to deal with all the complexity described above and where he can obtain information from all three data sources as in the example above. To accomplish this aim, the open source solution Tyk (https://tyk.io) has been chosen.

The MOUP through Tyk can be divided into two main sections of functionalities: MOUP API catalogue Portal and MOUP dashboard.

- **The MOUP API Catalogue Portal**: accessible to external developers, where Open Data will be made available through subscription by requiring the access privilege (Authentication Auth Token, Basic Auth Token, JWT token, certificates etc) to the interested catalogue.
- **The MOUP Dashboard**: accessible only to the MOBISTYLE developers, necessary to configure the API Catalogues, to manage accesses of external developers to the Open APIs and to translate Open APIs into Private APIs as well as the APIs usage statistics.

7.1 Why Tyk?

The initial plan for the MOUP application was to develop it entirely from scratch. But analysing the requirements that the MOUP had, we understood the need of working on existing **open source software**. As some dashboard for developers already exists in the market, we analysed those available and open source in order to find the most suitable to be customized for MOBISTYLE.
Other dashboard solutions had been evaluated and compared, till the final decision to work with Tyk. Tyk resulted the best as the API proxing solution is the most complete and it is completely free source.

7.2 The working principle of MOUP

As highlighted above, the main purpose of the MOUP is to hide, for developers external to MOBISTYLE project, the complexity of interacting with different service/API providers by interacting only with MOUP and provide the possibility to extract a large amount of data coming from MOBISTYLE ecosystem.

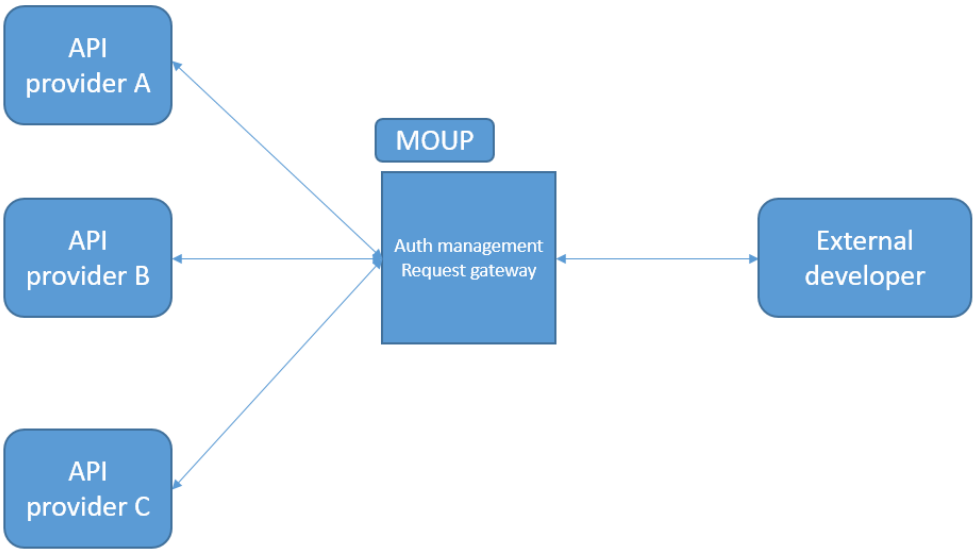

Fig. 3 Schematic representation of MOUP concept, for the workflow please refer to the section 4.6 where the Application flow is described

As shown in the schema above, the core functionalities of MOUP consists of Authorization management and the proxy of API request (request gateway in the schema). Two main functionalities will be described in the sections below.

7.2.1 Authorization management

In the schema above two levels of interaction are highlighted (also mentioned in section 4.6): interaction of External developers with MOUP and the interaction between MOUP and API providers.

1. At the External Developer - MOUP level, the only contact point for the external developer is the MOUP and what the external developer has to do is to provide the authentication token obtained, and described at point 1-5 of section 4.6. The MOUP can setup different kind of authentication mechanism to different catalogues of APIs it provides. To obtain something simple and usable, the MOUP developers decided to establish the authentication mechanism to be Authorization token only.
2. At the data provider-MOUP level, the mechanism is different since at this level, the single data provider's authentication mechanism is preserved: MOUP is, in fact, capable of dealing with different authorization mechanism singularly. Therefore different data providers can preserve their own existing authentication mechanism and can still be easily reachable by external developers through MOUP.

In this configuration there's a point that the MOUP data providers need to be aware of: for the data providers the only entity that is going to require data will be the MOUP and not external developers. This because all the requests to data providers are filtered by MOUP as described at section below.

7.2.2 API Proxy

The second core functionality of the MOUP is the capability to work as a gateway to the API incoming requests from external developers to the correct data provider basing on the requests it receives and once the data provider responds with results to propagate them to the initial require which is external developer.

Following step are executed by the MOUP to accomplish the API proxy functionality:

1. Receive API request from external developer
2. Check the authorization token provided with the request, if not authorized, reject the request
3. Update the request URL to the correct data provider's endpoint
4. Remove the authorization information provided by external developer
5. Add the correct authorization information required by data provider's endpoint
6. Execute the request towards data provider's end point
7. Receive the response from data provider's end point
8. Provide the response to the external developer

Here follows a simple schematic representation of the steps just described:

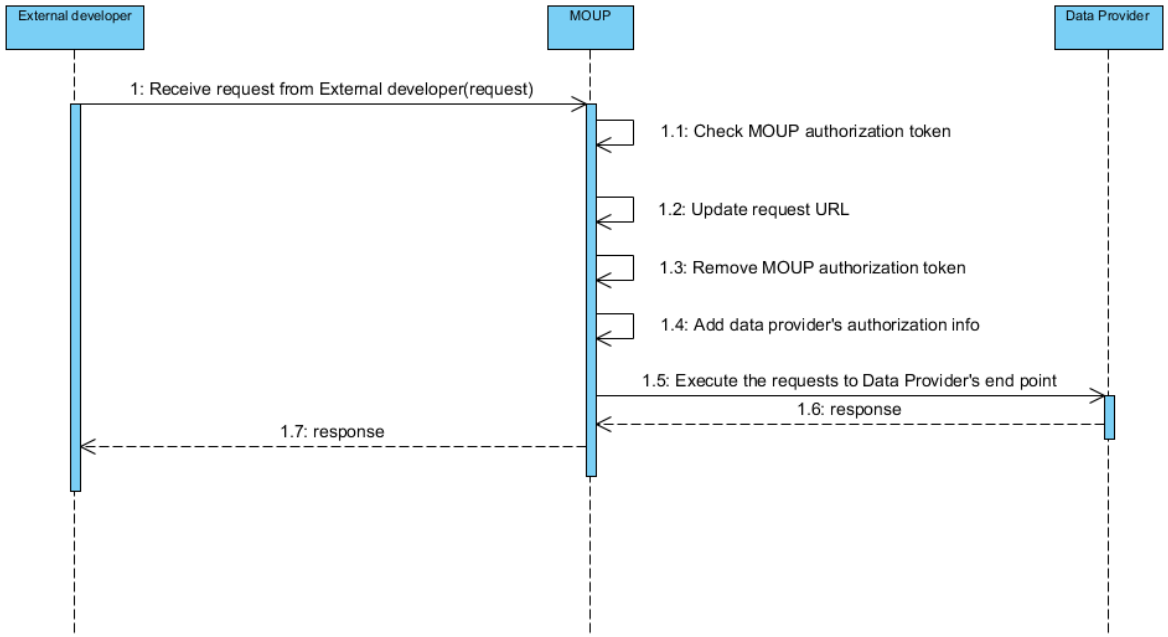

Fig. 4 MOUP proxy flow sequence diagram

With the schema above it is easily notable that with the previous execution flow, steps 2 - 7 are totally transparent to the external developers whilst steps 2 – 5 and 8 are totally transparent to the data providers and as we promised with MOUP, the complexity of dealing with different data providers to the external developers are totally avoided since all the transformation works are carried out by the MOUP.

We can have the same conclusion also for Data providers: also for them it is enough to expose their endpoints through MOUP and the MOUP will carry out all the necessary request transformations before the requests reach the data providers' endpoints.

7.3 MOUP Catalogue Portal

As we mentioned before, in order to utilize the available APIs, the external developer has to subscribe to a set of catalogues in which he is interested.
The API catalogue information is available through a dedicated portal the MOUP provides and from where the external developer can check the availability of the API in the catalogues.

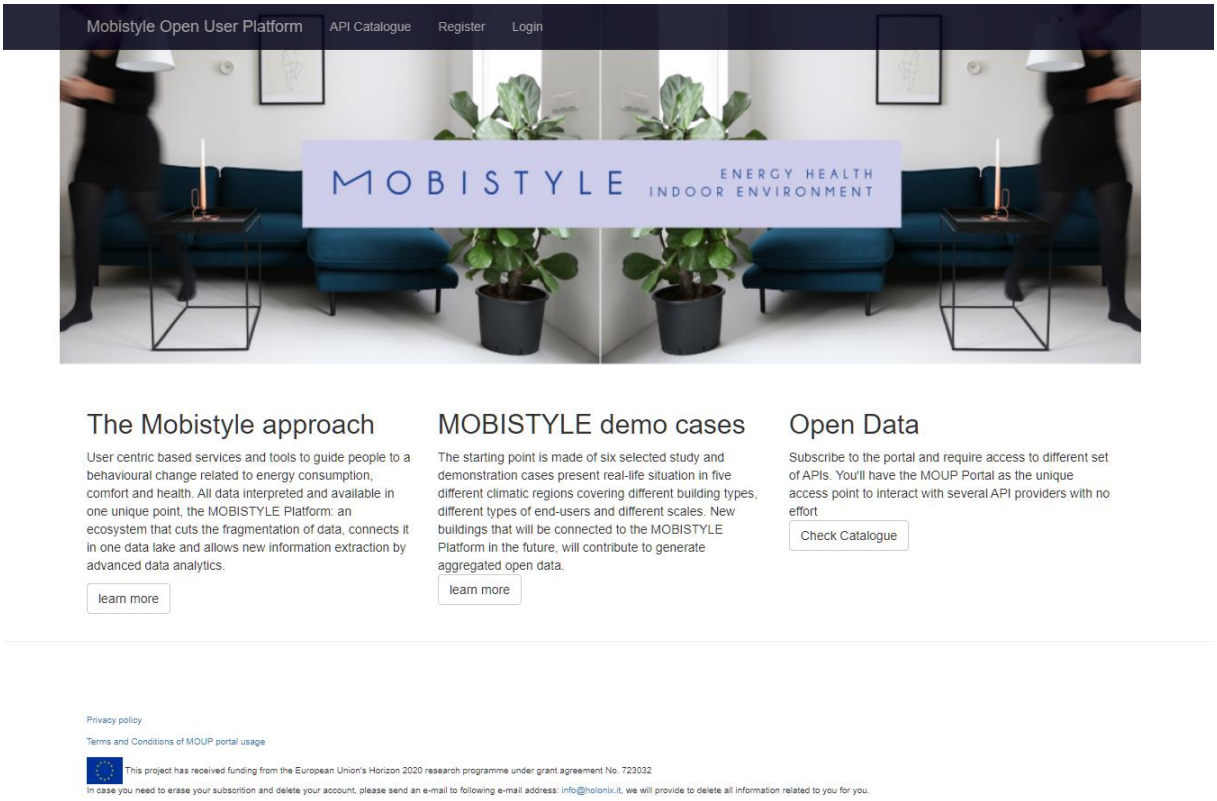

Fig. 5 The index page of the portal containing the catalogue information

As shown in the figure 3 the portal is kept very simple, just the essential functionalities to allow the external developers to browse and require access to available API catalogue: visualization of API catalogue, registration to the portal and login.
The access requirement can't be performed if the user is not registered and logged in.

The MOUP is available at: http://portal.mobistyle.holonix.biz.
Availability is depending on Tyk policies on Open Licences for Funded projects within H2020 framework.

7.3.1 API Catalogue

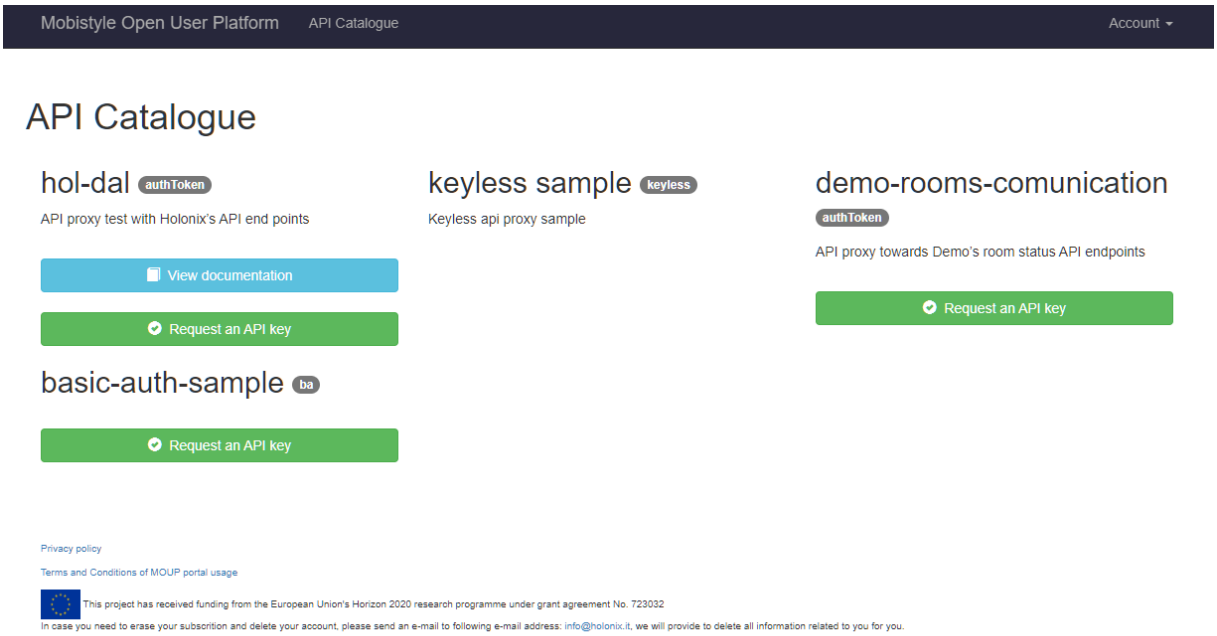

Fig. 6 MOUP API Catalogue page

The Figure 6 is a sample of possible API catalogue page, with preliminary tests taken outside MOBISTYLE. In the figure different aspects of an API catalogue are highlighted and we describe them in the list below:

- Catalogue name: Representative name of the catalogue, usually a set of API endpoints.
- Authentication type: specifies the authentication mechanism that is required to interact with the specific APIs made available through a catalogue. In the sample images there are three kind of authentication mentioned(Several other authentication mechanism are available, we will just mention some of them):
    - authToken: all the catalogues with this kind of authentication mechanism require the presence of a header containing the authorization token provided when a developer requires the access to the catalogue. (MOUP, for default, will enforce this constraint when new APIs are going to be published and made available.)
    - keyless: this means that the catalogues with this kind of constraint is completely open and no authentication information is required
    - ba: Basic Authentication, similar to the authToken authorization mechanism, the difference is that when a developer requires access to this kind of catalogue, two separated values representing username and password will be provided instead of a token. Then the developer will need to encrypt the username and password pair into a single token with a specific algorithm.
    - Other mechanisms: JWT, HMAC, Manual TLS, custom etc
- Brief description of catalogue: a brief description of content of the specified catalogue.
- View Documentation: the MOUP supports the visualization of documentation for catalogues through the importation of Swagger definition written in JSON format. This documentation should be provided by the catalogue provider and its availability is of

very high importance since without an appropriate documentation of APIs it is almost certain that an external developer will not be able to work with.

- Require API key: In this section the registered portal user (external developer) can physically requires access token to a catalogue. Once clicked on the "Request an API key" and after a confirmation check a token string will be provided to the developer who made the request. The API key token need to be carefully preserved by the developer, he will not be able to check it again from portal. It's worthy to mention that depending on the different kind of authorization mechanism a catalogue is set with, the generated token will be of different kind consequently. There will be none if a catalogue is set with keyless as the authorization mechanism.

7.3.2 API Key

We just described the way to obtain an API key to access to API catalogues made available from MOUP's API catalogue portal. It's important to stress out that this is one of essential aspects of whole API proxy process.

When the API key is generated and provided for a catalogue through the API catalogue Portal to an applicant, a rule is added to the MOUP's internal authorization/authentication mechanism, it will allow whatever requests containing the specific API key it receives to be redirected to the data provider's API endpoints and to be executed with possible leakage of data. Hence the applicant must keep the API key token secret and use it only for its own purpose.

Key generated and received once per registration, as follows. Key is blanked as secret.

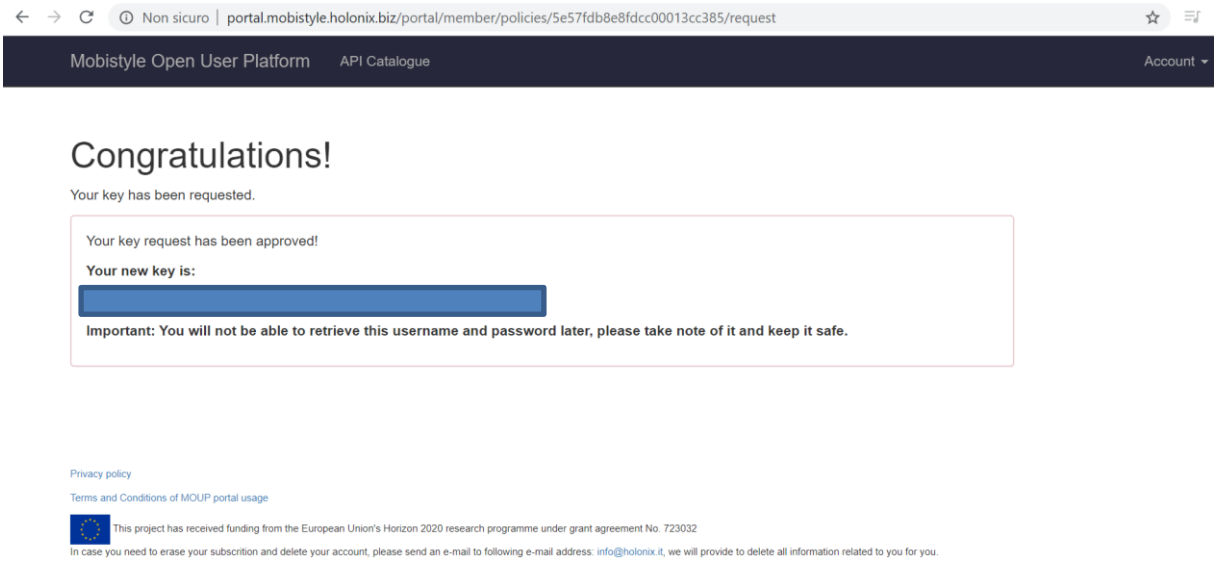

Fig. 7 New API Key

7.3.3 Data removal procedure

If a developer desires to delete his own information from MOUP API catalogue portal, the right process is to send an email to the MOUP API catalogue Portal maintainer, Holonix, asking to delete information related to him. Holonix will manually delete all information related to the

developer who made the request. Automatic procedure will be put in place only when the amount of requests will be hard to support, and this is not expected soon. Holonix account to contact is: info@holonix.it.

7.4 MOUP Dashboard

The MOUP Dashboard is part of the application where all the aspects of MOUP are handled. Following is a list of functionalities of interest for the MOBISTYLE project, and we'll describe them in the following sections:

- User management
  - External developer management
- Catalogue management
  - API management
  - Policy management
  - Catalogue management
- Dashboard functionalities

7.4.1 User management

There are two types of users that need to be distinguished: MOUP application user and MOUP API Catalogue portal user (external developers).
The difference between them is the fact that the MOUP application user can manage the whole MOUP application if is granted with correct permissions, whilst the MOUP API Catalogue Portal user is intended to be used only at MOUP API Catalogue Portal as described at section 7.2.
In this section we will refer only to the MOUP application's user when we refers to users

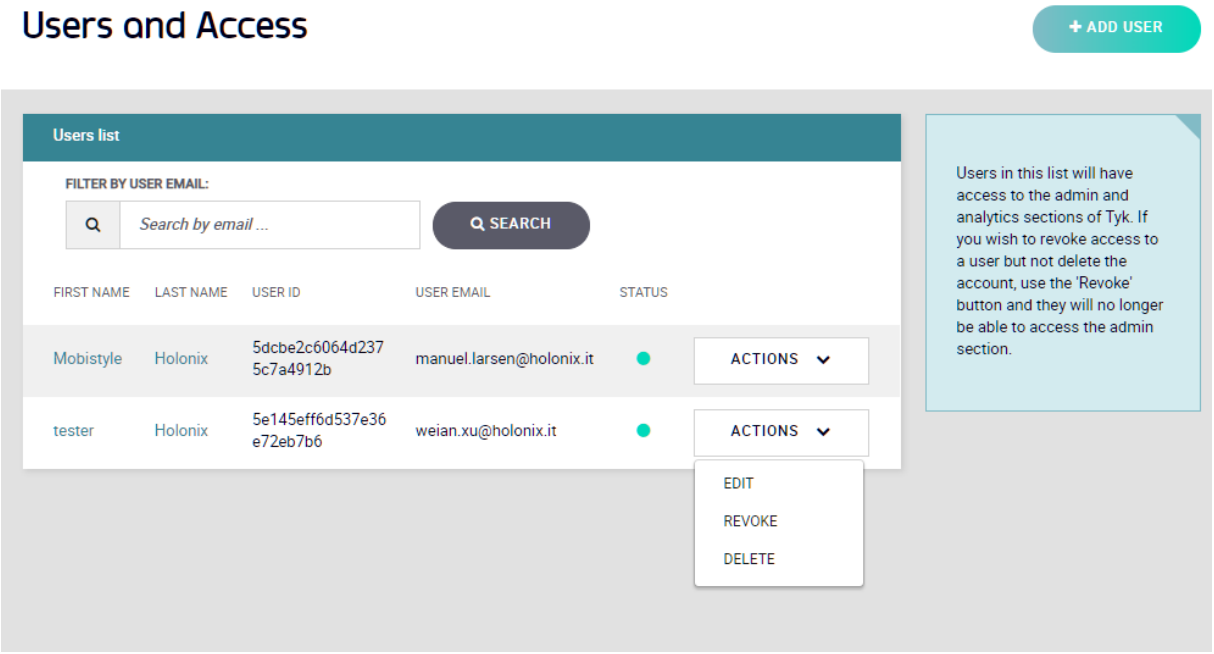

Fig 8 User management interface

The creation of users is straightforward. The only worth mentioning aspect is if the user will be admin user or not.

To an admin user all privileges are granted, also to delete other admin user. In case of the creation of a non admin user, is possible to grant the new user a set of privileges basing on the need.
By default to a normal user all permissions are denied unless specifically granted.
It is also possible the creation of user group to facilitate the user management.
For the time being, it will be only Holonix who is going to manage the MOUP. In this way all the data providers need to do is to provide to Holonix details of their API endpoints. Holonix will take care of the API creation at within MOUP.

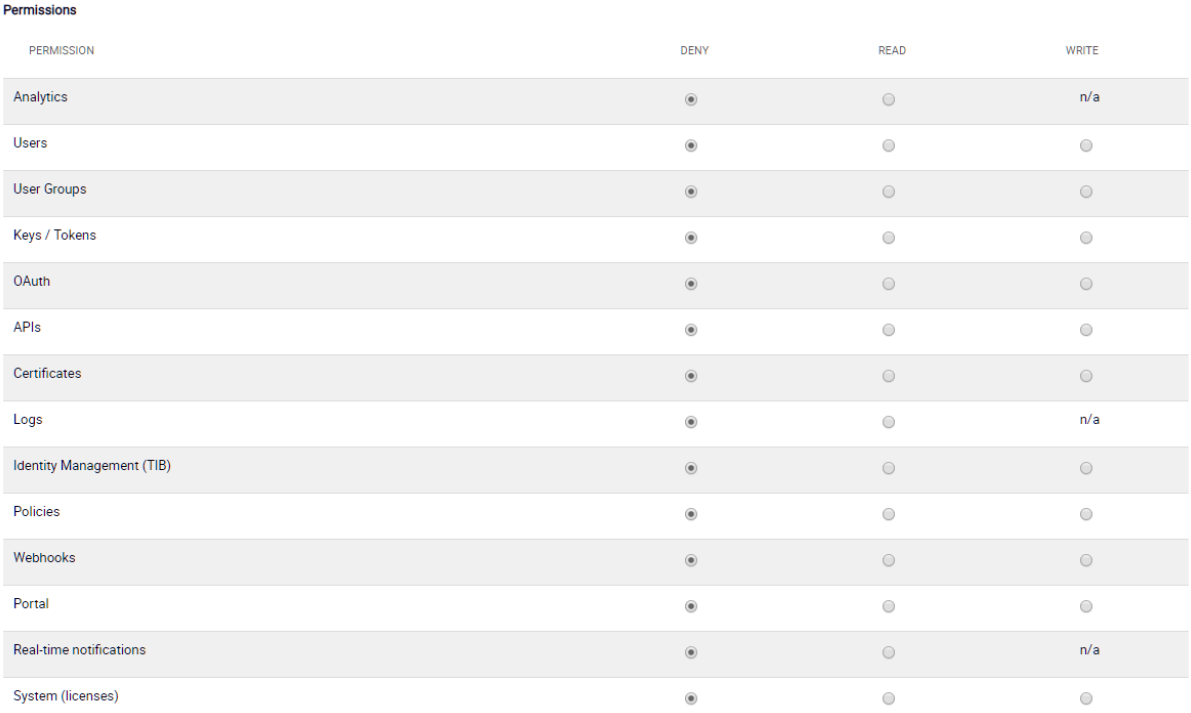

Fig. 9 List of permissions grantable to a user.

7.4.2 Catalogue Management

The catalogue establishes what is available externally to the external developers. It consists of different step the catalogue creation process:

- API Creation
- Policy Creation
- Catalogue creation

7.4.2.1 API Creation

This is core functionality of the MOUP: here is defined the rules to achieve the API proxy. To explain how it is achieved we will going through the most important setting to explain the process:

- API Name: The identification of the API proxy, it has associated also an UUID value generated during the API creation.
- Listen path: usually name of the API, it indicates what PATH to match to establish if an incoming request refers to the current API
- Target URL: The URL of Data provider's API to be "proxied"

- Authentication mode: The authentication mode between external developer's application and MOUP
- Endpoint design: Here is possible to add settings towards Data provider's end points, for example add the necessary authorization token, set necessary headers and so on.

There are several other settings that can be utilised to have more specific proxy functionalities, although, It is not scope of this document to going into technical details of API proxy mechanism, the working flow is already described by the sequence diagram of fig. 4.

7.4.2.2 Policy Creation

Upon the APIs created is possible to add a further set of configurations mainly to configure the accessibility of the APIs by a developer in term of utilization thresholds: number of requests allowed in a given period and so on.
It is possible to relate to a single policy multiple APIs. Main parameters to be set are listed below:

- Policy name: Identifies the policy, to the policy name is associated a generated UUID value also here.
- Rate limits: the combination of two parameters: allow number of requests and Per (seconds), together they establish the maximum number of requests allowed in a pre-established interval.
- Throttling
  - Throttle interval: interval after which attempt request retry
  - Throttle retry limit: maximum number of retries
- Access rights: here can be selected the APIs to be available with this policy

7.4.2.3 Catalogue creation

In order to make a policy available to external developer, it has to be included within a catalogue.
To create a catalogue, the main parameters to be set are:

- Public API name
- Policy to apply: there is a relation of 1 : n between catalogue and policy which means that a policy can be published only once.
- Description: description of related policy, therefor APIs
- Documentation: formal description of APIs published, two formats are supported: Swagger JSON definition and Apiray JSON definition

Once a catalogue is created, the related policies are published to the MOUP API Catalogue Portal where external developers can start to require access hence utilizes APIs underneath.

7.4.3 Dashboard functionalities

Alongside the UI to allow the execution of operations mentioned above, MOUP provides also a section to visually check the API usage data as shown in the chart of figure 10.
It is also possible to visualize the usage data filtering by more specific parameters: by errors (sample in the chart of figure 11), by API and so on.

The dashboard provides also the possibility to configure the general MOUP application management such as management of user group, user or user group permissions, API Key requests management, the partial customization of MOUP API Catalogue Portal interface.

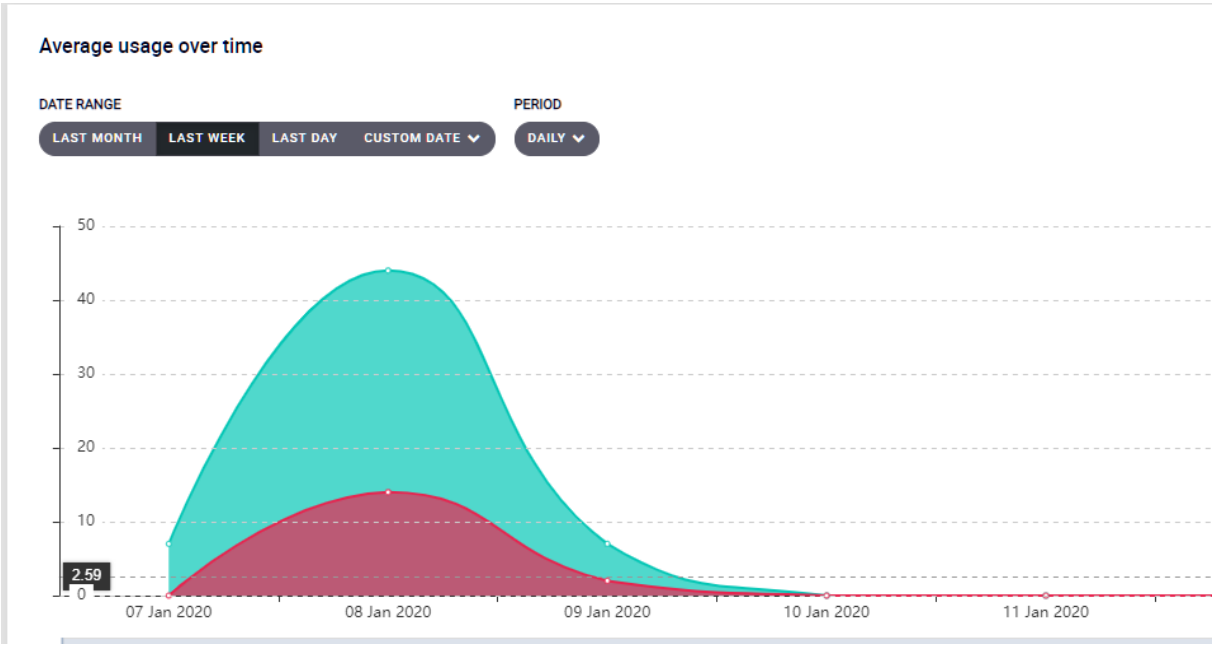

Fig. 10 API usage data visualization sample: green is trend of positive request and red is trend of negative requests during next week

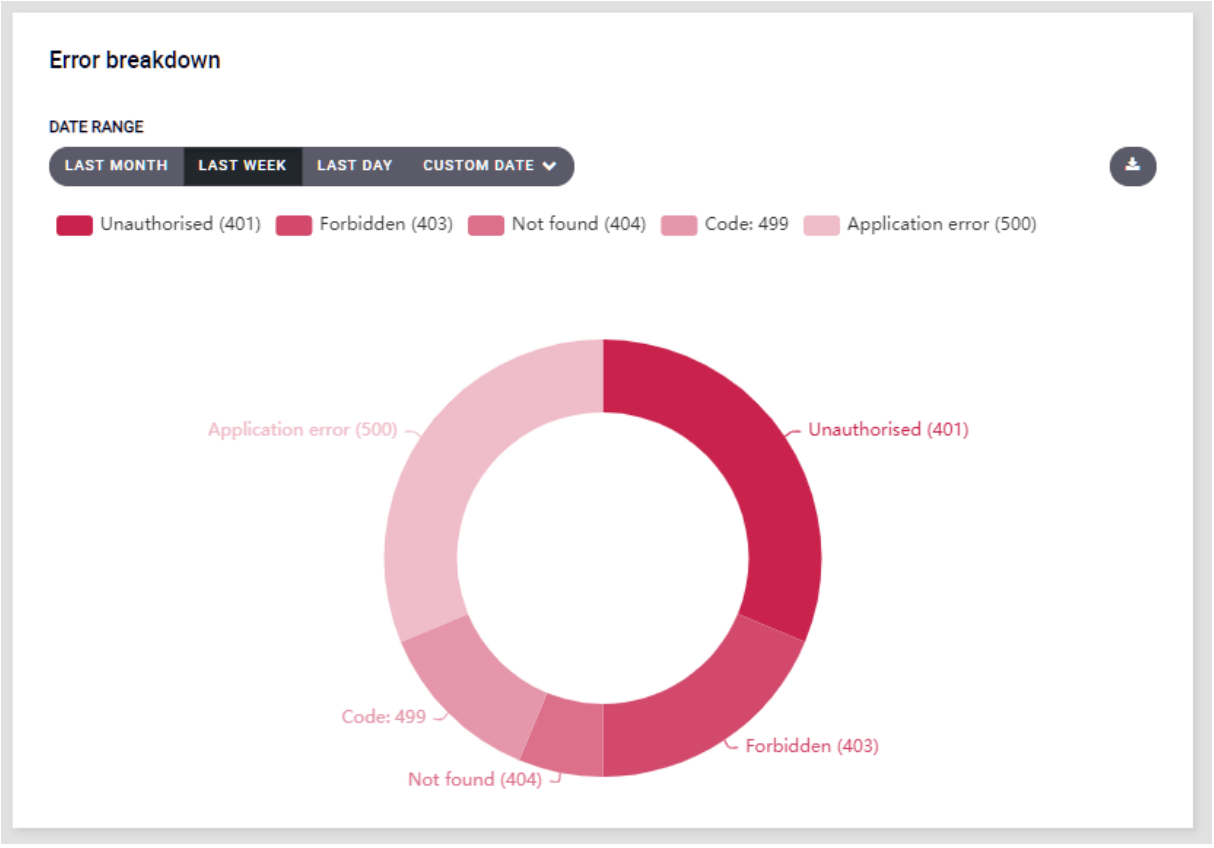

Fig. 11 Details of API request errors occurred during last week

7.4.4 Tyk Documentation

MOUP is a very powerful tool which offers lot of possibilities as an API Proxy gateway. Here we described part of its functionalities strictly related to the task we implemented for the MOBISTYLE project purpose.

To an exhaustive description and documentation of Tyk functionalities please refer to the official documentation provided by Tyk where all the functionalities and possibilities are described: https://tyk.io/docs/

7.5 MOBISTYLE API Catalogue of KPI API

As stressed several times above, the purpose of MOBISTYLE Open User Platform is to provide an "Open place" where at one side it allows the data providers internal to MOBISTYLE consortium (DEMO) to publish their knowledge and at other side it allows users outside of MOBISTYLE consortium to acquire such knowledge to develop dedicated algorithms and applications to better develop the MOBISTYLE environment.

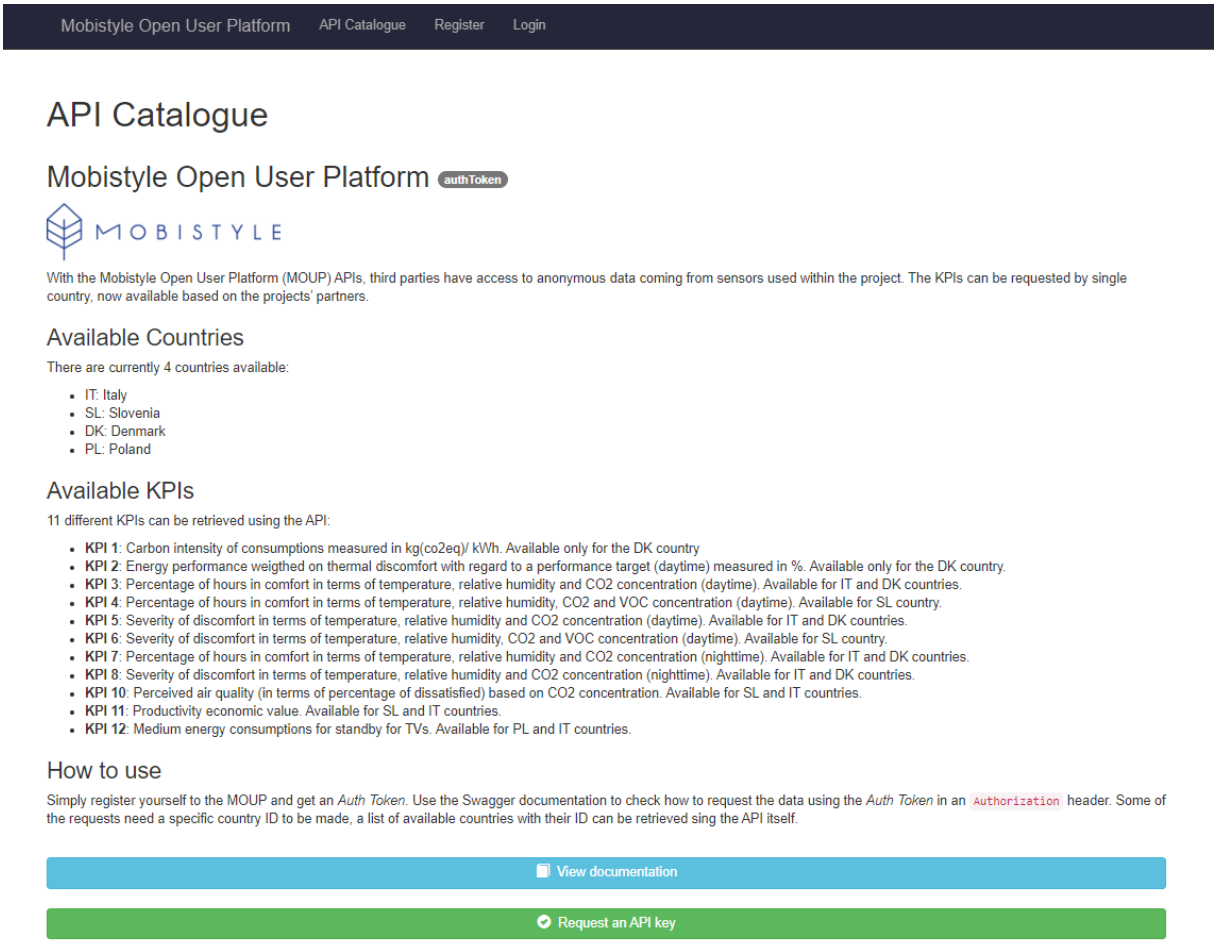

Fig. 12 API catalogue created basing on DEMO's KPI endpoints

The fig 12 shows the API catalogue created for the DEMO's KPI API's endpoints.

7.5.1 API Documentation

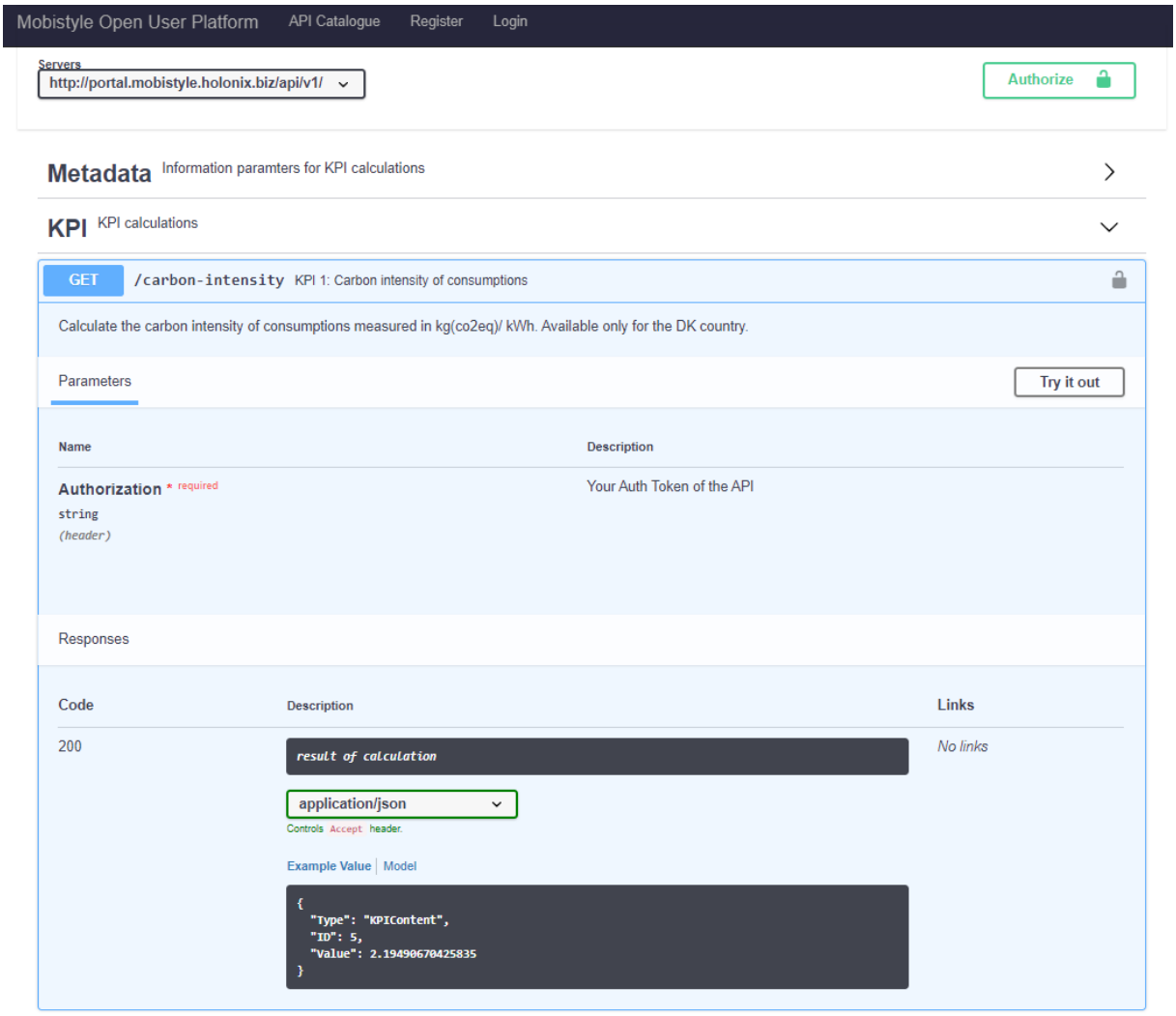

Fig. 13 MOUP API Documentation

As mentioned above, the documentation is a key aspect for the MOUP catalogue. The documentation provides to the external developer all the information needed to query the MOUP endpoints, specifying which parameters are available, the type and format of the request and of the response of each endpoint. The documentation is written using Swagger.

7.5.2 API Test

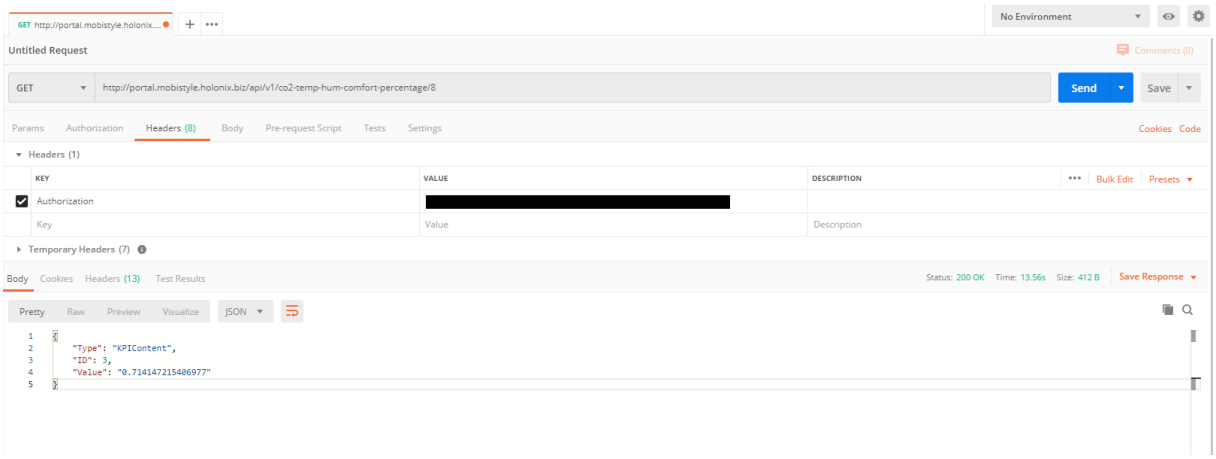

Fig. 14 Postman testing of the APIs

Using the documentation or with an HTTP client of choice, you can test each of the endpoints documented in the catalogue. In the figure above, we tried one of the endpoints, using the *Authorization* header as explained (here blacked out to keep it secret). As it can seen, the whole flow worked as intended and the response we receive is the same as we had requested the result directly from the DEMO private APIs.

8 Conclusion

The access to Open Data allows third party developers to collect aggregated available information and to have specific analytics on them. Anonym aggregation, segmentation and analysis of big data are coming from different kind of information devices and consist of energy consumption, Indoor Environmental Quality, Behaviour and Health data. The information is coming from the monitoring which is in place at MOBISTYLE customers.

The whole developing process offered the possibility to map the challenges that can occur while developing a service whose aim, by definition, is going beyond the initial scope of the platform itself. To overcome some of these challenges a Learning Engine Task Force was established with the aim to go beyond the more traditional single-domain KPIs offering multi-domain KPIs, that combine data from energy, IEQ and well-being areas. In face of the data available in MOBISTYLE, the offered KPIs have to be considered as benchmark values computed on MOBISTYLE pilots.

MOUP development had been completed successfully as they are reported in this deliverable. Internal validation had been completed for all KPIs. External validation at third party developers is conducted and reported in D6.4 at the end of the project.

According to T5.4 the Open Users Platform is one of the Key Exploitable Assets of MOBISTYLE. Exploitation task (T5.4), which runs in parallel, defines the potential market adoption of the solution.