ECOFLEX

With the support of the Energy Transition Fund

D2.2 Data system architecture for interoperable system solutions

Version number and Date: Version 1; 01/2024

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Abstract for dissemination (PU)

This deliverable contains the result of task 2.2 (“Data System Architecture”) that produces the guidelines for a data architecture easing the exchange of information between the Universal Flexibility Platform (UFP) and other systems of ECOFLEX scope.

Starting from the flexibility valorization potentials of task 2.3 and inputs of other tasks and WPs, the result of task 2.2 is a proposed system architecture focused on the UFP and interacting systems such as on-site gateways and external systems that will interact with on-site EMS through the UFP. This generic architecture has been designed to support the ECOFLEX objectives.

Also, to satisfy interoperability, this deliverable also documents the interfaces between the UFP and every other system. This documentation lists exchanged messages and specifies the exchanges with the proposed communication protocols.

Contents

1. Generic introduction

1.1. Scope of the document

This document contains the deliverable 2.2 ‘Data System Architecture’ as a result of Task 2.2 ‘Data system architecture for interoperable system solutions’. This document aims at describing the high-level architecture of the ECOFLEX project, centered on the Universal Flexibility Platform (UFP) and with a special focus on the way systems interact with the UFP.
Concretely, this document describes the interfaces between each system and the UFP by specifying the proposed communication protocol and listing possible exchanged messages.

Section 1 describes the scope of the UFP and a general overview of the software architecture in which the UFP will be implemented.
Section 2 describes the generic high-level architecture, with Section 2.1 focusing on the different blocks surrounding the UFP and Section 2.2 giving an overview of each interface by listing exchanged messages format guidelines and suggested communication protocols. Section 3 gives additional requirements that were not mentioned in the rest of the document.

1.2. Scope of the Universal Flexibility Platform

The scope of the Universal Flexibility Platform (UFP) is to facilitate any asset with flexibility potentials to value its flexibility among the different stakeholders involved in energy flexibility valorization. This by providing a generic way of offering, requesting and activating flexibility in various forms, e.g. electrical vehicle (EV) charging, BESS and domesting heating systems.

2. Generic architecture

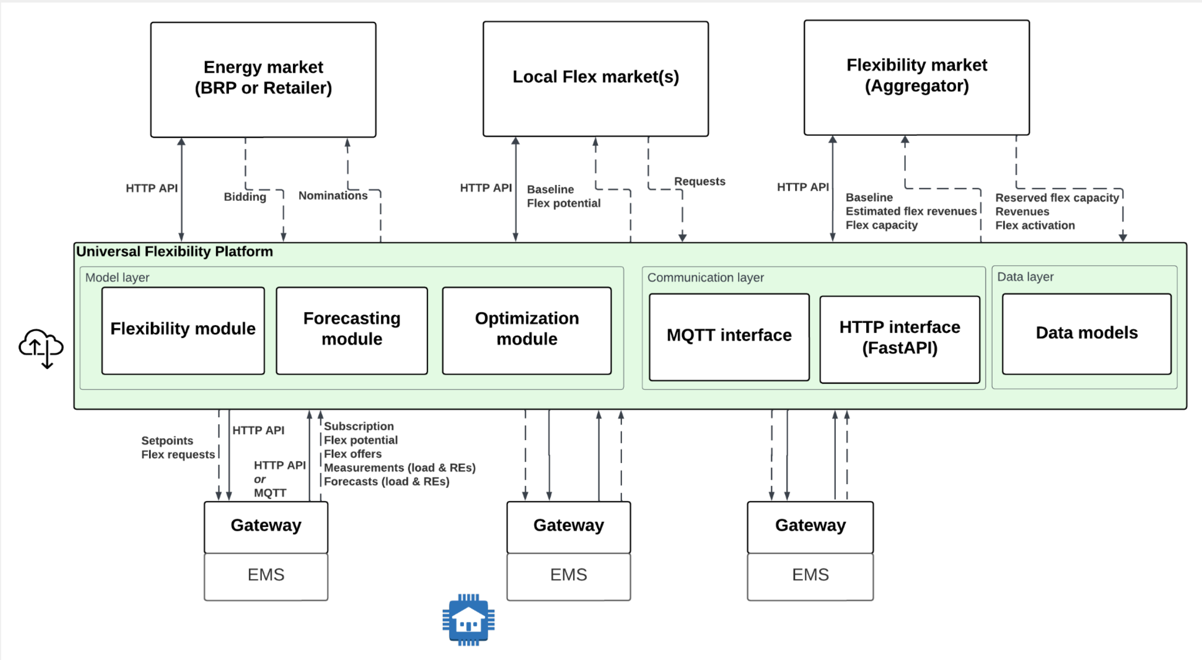

Figure 1 - UFP interfaces with other systems

Figure 1 presents the overall generic system architecture supporting ECOFLEX objectives. In particular, the Universal Flexibility Platform is the cornerstone of this architecture developed within WP3. The figure summarizes the system interactions, the exchanged messages and the selected protocols.

In the foreseen system architecture, the UFP aims at letting any EMS communicate with different energy and flexibility markets, as well as aggregators to valorize their flexibility. Based on the analysis of the role and responsibilities of each system, exchanged messages (data format and frequency) between all systems have been identified. Each system is described below in this section.
Further, based on the data type and frequency, the most adequate protocols have been selected to be compliant with technical (e.g. Flexcity's API requirements) and functional requirements (described in systems' sections) while being generic to ensure interoperability of any system that would like to interact with UFP.

In terms of impact, the EMS interface (API) serves as a standardized, abstracted, and interoperable bridge between software components. Its genericity can facilitate the integration of energy communities and e-mobility by interacting with valorization markets through the UFP. In that scope, the effort of identifying exchanged messages in each interface and suggesting a generic yet relevant protocol ensures interoperability.

2.1. Software blocks

2.1.1. Universal Flexibility Platform

Scope

Within its scope (universal platform for flexibility valorization) the UFP needs to be able to handle all kinds of flexibility that are provided by the EMSs, which implies that the UFP should be able to receive and send flexibility capacities (i.e. the EMS' capabilities) or requests (i.e. the EMS' actions) using relevant flexibility signatures to support ECOFLEX goals.

In addition to flexibility, EMSs will also provide metering data (measured and forecasted) of their demand profile. This implies that the UFP can collect data with several relevant time resolutions (e.g. 4 seconds, 15 minutes, …) depending on the use cases. In order to provide appropriate flexibility requests to the EMSs that do not support setpoints, but will receive recommendation signals (i.e. the ones who don't control the load but are taken into account by the EMS in its active management), the UFP should be able to anticipate their reaction by forecasting the resulting demand. This implies that the UFP should indeed collect measurements as soon as they are available (e.g. near real-time) in order to: (i) score the assessment that has been made and (ii) use adjusted forecasts to compute the reaction on the most recent expected demand (disregarding any potential flexibility activation).

The universality of the UFP requires to rely on common communication protocol(s) [1] in order to let any system communicate with the UFP. Therefore, only well-known and widely used communication protocols (TCP/IP, HTTP, FTP, ...) [1] will be adopted between the UFP and any other system, including markets for flexibility valorizations or intermediaries of these markets.

Architecture

UFP developments will take place in the AMEO [2] (**A**dvanced **M**anagement of **E**nergy **O**perations) software platform (developed by Haulogy since 2019), a cloud-based and feature-rich software solution developed by Haulogy to build applications exploiting data and artificial intelligence in order to help energy actors in the energy transition. Mainly, developed applications are:

- forsourcing and hedging management including risk assessment,
- for energy traceability from energy sources to the final consumption including invoicing and metering split,
- for energy sharing such as community-like mechanisms, and
- for active energy management.

AMEO also already includes data and AI features that are relevant for ECOFLEX goals such as:

- headpoint management to model EMS,
- time series management (in/out and handling) to handle time series data exchanges and computations,
- support of forecasting models to integrate demand-side response forecast models, and
- data models to organize energy and flexibility data.

AMEO uses a microservices based approach where each microservice defines (i) a set of event handlers listening on specific commands and events from message queues, (ii) an HTTP API interfaces exposed to other services and/or external applications, (iii) its own database schema and, (iv) a python client which defines accessible routes, commands and events for other services. All microservices respect the CQRS (Command and Query Responsibility Segregation) paradigm and follow the Domain-Driven Design principles [3]. The segregation of commands, events and event handlers allows a good segregation of responsibilities in between the different microservices. A new microservice linked to specific functional needs of ECOFLEX can be added to support ECOFLEX goals while benefiting from AMEO existing features. Therefore, exploiting AMEO existing features will accelerate the development of the UFP solution.

Haulogy ecosystem

AMEO is part of the Haulogy software ecosystem and is made of three platforms, namely the (i) energy platform for DSOs, (ii) the platform for energy retailers and (iii) the platform for new energy markets. These platforms include software such as SANO (**S**mart **A**ctive **N**etwork **O**perations) for smart active network management of electrical distribution systems, and HAUGAZEL [4] for retailers' customer information and billing.

Microservices based approach

Microservices based approach consists in developing small and independent services that communicate over well-defined APIs. The goal of this organizational and architectural approach[1] is appropriate for scalable and versatile applications. Each microservice can be independently developed as well as ran, updated, deployed and scaled.

CQRS paradigm

The Command Query Responsibility Segregation (CQRS) aims at separating the data mutation (i.e. *what modifies the data*) part of the system to the part that only does data queries (i.e. *what only reads the data*). Data mutation consists of commands that handle the creation, the update, and the deletion of data. Figure 2[2] illustrates the CQRS paradigm where the user interacts with the application through APIs. If the user action creates, updates or deletes data, then the API emits a command with the user action that will be handled, validated and then executed, and the operation will be persisted in the database. After the command is executed, an event describing the operation is triggered. If database replicas exist, they process the event to apply the same operation. If the user action reads data, then a query interrogates the database or one of its replicas.

[1] Interested readers can for example read AWS documentation [5].
[2] Figure inspired from [6]

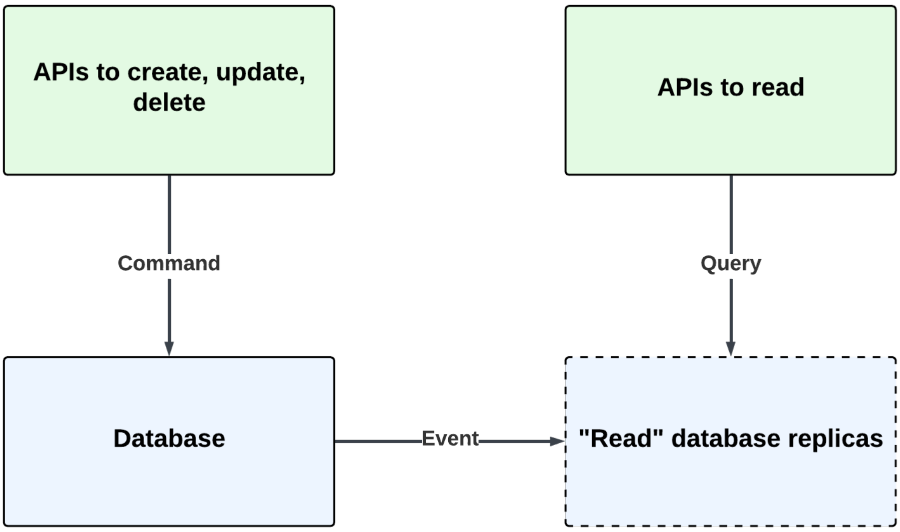

Figure 2 - CQRS paradigm (based on [6])

Domain-Driven Design principles

Domain-Driven design principles (DDD) [3] are typically advised when the business domain is highly complex. The main principle is to start building a domain that is the main part of the software and which models the implemented business logic and then additional layers that will interact with the domain. Figure 3 illustrates that principle where the application does not interact directly with the domain but rather, as seen in the CQRS paradigm, through commands/events that are handled by services.

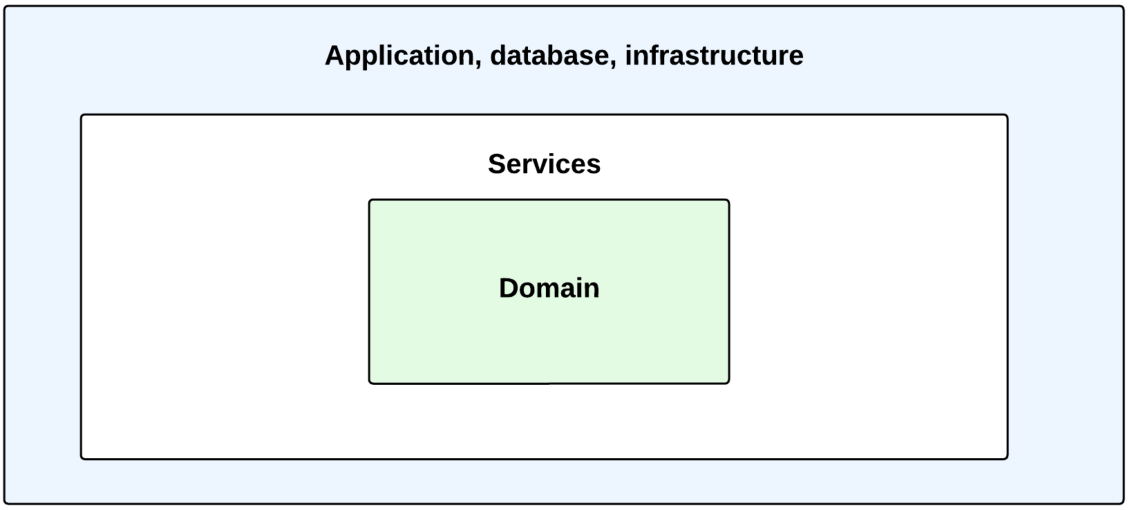

Figure 3 - Data Driven Designs (DDD) schema example

2.1.2. EMS gateway

An Energy Management System (EMS) is a tool that allows the user to monitor, control and optimize the managed system that offers some flexibility (i.e. able to modulate the energy demand in some way). For example, an EMS can be used to monitor a consumption site that has an battery energy storage system (BESS). The EMS can then charge/discharge the BESS depending on external factors such as market prices and forecasts (e.g. when (i) the battery is empty, (ii) there is local production, or (iii) market prices are expected to be very high in the next hours, then the battery is charged to cover energy needs in expensive market price hours). An EMS is therefore par excellence a tool able to exploit the flexibility of a system.

In the ECOFLEX project, an EMS, controlling a site offering some flexibility, should be able to send (e.g. the available flexibility) and receive information (e.g. the setpoints) to and from the UFP. This communication layer added on top of the EMS is referred to as the EMS gateway.

As its name indicates, the Universal Flexibility Platform should be compatible with every kind of EMS's gateway, therefore the EMS gateway is seen as a generic gateway able to use standard and typical communication protocol(s) such as HTTP and MQTT over TCP/IP.

2.1.3. Flexibility market (Aggregator)

The Transmission System Operator (TSO), responsible for maintaining the balance on a particular grid (e.g. Elia for the Belgian grid), is in charge of the flexibility market in the same area. The system balance is traditionally maintained by steering the generation to the uncertain consumption. However, another option is that the delivery points (e.g. individuals, companies or communities) with flexibility[3] capabilities can agree to adapt their use of electricity to the demand on the network, in exchange for financial compensation. They can, for instance, offer the energy of a charged BESS if they do not plan to use it at a given time, or they can temporarily stop certain energy-intensive processes if it is needed to balance the network and are rewarded for this service. Therefore, a flexibility market is a means of maintaining the balance between consumption (plus losses) and production in the electricity network by exploiting the available flexibility and monetizing it. Automatic Frequency Restoration Reserve (aFRR[4]) is an example of such flexibility market.

However, these flexibility markets are typically not directly addressed by delivery points but through an intermediary that can modulate flexibility offers to optimize their value. An aggregator is an energy market actor responsible for aggregating flexibility with core business to build up (aggregate) a portfolio of customers who have agreed to provide this flexibility service. It can be the intermediary between delivery points with flexibility offers and Elia (i.e. the flexibility market) as Balancing Service Providers (BSP). In other words, the goal of an aggregator is to consolidate and optimize the flexibility offered by a diverse set of energy assets, such as renewable energy sources, (battery) energy storage systems, and electric vehicles, and present this aggregated flexibility as a unified and valuable resource.

Based on the ECOFLEX scope, flexibility is valorized on flexibility markets only via aggregators, and therefore the flexibility market system is actually an interface with the aggregators' systems.

2.1.4. Energy market (BRP/Retailer)

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[3] Flexibility involves the capacity for these adjustments of energy supply and demand to accommodate consumption and production fluctuations.

[4] https://www.elia.be/en/electricity-market-and-system/system-services/keeping-the-balance/afrr.

An energy market serves as a dynamic platform where the buying and selling of electricity and related services take place. It functions as a marketplace where various stakeholders, including generators, distributors, consumers, and traders, interact to establish prices, allocate resources, and ensure the reliable and efficient supply of energy. In the systematic process of an energy market, generators submit offers, and customers submit bids, leading to the identification of a market-clearing price.

The Day-Ahead (DA) market, this is the energy market where offers / bids are settled one day ahead of the delivery period, is an example of an energy market compatible with flexibility valorization. For example, a flexible delivery point that is expected to consume a given amount of energy in a fixed period of time can modulate its energy demand (on day-ahead market) in order to minimize the total cost of the required energy. In this context, the flexibility does not generate extra revenues but allows to minimize sourcing costs.

With energy markets, two stakeholders are relevant, namely the balance responsible party and the retailer.

A Balance Responsible Party [7] (BRP) is a producer, major customer, energy supplier or trader responsible for developing and taking measures tmaintain the balance on the network. More specifically, a BRP is responsible for a portfolio of network access points, and must maintain the balance between injections, offtakes and commercial power trades in its portfolio. In their role, BRPs can also purchase the energy on behalf of members of its portfolio (eg, a BRP buying energy for a supplier/retailer) on energy markets. BRPs are also exposed to energy demand uncertainty and exploiting flexibility may allow them to reduce the expected imbalance and therefore imbalance costs (that are typically more penalizing than energy market costs).

A retailer (also referred to as an energy supplier) refers to an entity that directly engages with end-users or consumers by supplying electricity and related services. These retailers act as intermediaries between the energy market and individual customers, offering a range of energy plans, pricing structures, and services tailored to meet the diverse needs of consumers. Retailers provide consumers with energy purchase choices such as fixed or variable-rate plans and other options such as green sourcing of energy. Beyond electricity supply, they often offer services such as smart home solutions, education and energy efficiency consultations. To supply the energy demand of its portfolio, a retailer must source the energy demand of its portfolio on energy markets (unless delegated to a BRP). Similarly, to a BRP, retailers can exploit flexibility to reduce the expected imbalance.

In their intermediary roles for energy markets, BRPs and retailers' systems are therefore the relevant systems to which the UFP should communicate with to interact with energy markets.

2.1.5. Local flexibility / congestion market (DSO)

The Distribution System Operator (DSO) is responsible for ensuring a reliable supply of electricity to customers connected to its network. It must therefore ensure that congestion is avoided on this network. Nowadays, this is mainly done by local grid reinforcement but in the future this can be addressednotably by taking advantage of the local electricity flexibility available. Establishment of a local flexibility market (LFM) facilitates the exchange of flexibility offered by both generation and consumption units at the distribution level. This creates market opportunities for flexibility service providers such as Distributed Energy Resources (DERs), and serves as a valuable tool for DSOs. The LFM aims to enable the trading of flexibility from various sources, granting market access to flexibility providers and offering DSOs a support mechanism for addressing technical challenges [8].

Local flexibility markets can fulfill the following objectives [9]

- Balancing local demand to align with fluctuating renewable supply during congestion.
- Managing constraints within transmission and distribution networks.
- Optimizing portfolios for market agents by considering network requirements at specific times and locations in the grid.
- Postponing grid investments if flexibility proves to be an effective component in the Distribution System Operator's (DSO) grid planning strategy.

2.2. Interfaces

In this section, the interfaces between the Universal Flexibility Platform and the other systems are described, with a focus on the messages exchanged between them and the communication protocols used. Detailed specifications of APIs will be part of deliverables of task 3.1.

Conventions

The following unit conventions should be used for the corresponding quantity types:

- Energy volumes in kWh.
- Powers in kW.
- Prices in €/MWh.
- Costs in €.

The following format conventions should be used:

- Numbers are expressed as decimal numbers (eg, *2.1*).
- Dates are expressed in the ISO 8601 format *YYYY-MM-DDTHH:MM:SS,ss-/+FF:ff* (eg, *2023-10-05T10:00:00*+01:00).

For energy volumes, either both *from* and *until* datetimes must be sent, or if only one datetime is sent then it must be the *from* datetime (i.e. at the beginning of the period where the energy volume is measured) when the measurement period is unambiguous (e.g. always 15 minutes). The *from* field is always inclusive while the *to* field is always exclusive, and periods must not overlap.

Communication protocols

To support ECOFLEX goals, used communication protocols should be generic and should not be a limitation for systems to communicate. The API (Application Programming Interface) defines how systems communicate and should be publicly accessible in order to let new systems easily connect and thus an Open API (i.e. where API visibility is expanded to public) is required.

Regarding API protocol, REST (Representational State Transfer) is one of the most widely used [10] forms of API and transmits information in several data formats (most used are JSON and XML) over HTTP/HTTPS protocols. A REST Open API is defined by a set of routes characterized by

- an HTTP method (POST to create, GET to read, PUT/PATCH to update, DELETE to remove) corresponding the API action,
- an endpoint (as a URL) corresponding to the route location (i.e. where information are sent to use this route),
- a header corresponding to information about the route call that is made (e.g. data format used for input data),
- a body that contains the bulk of the transmitted data.

OAuth2 protocol will be used for authentication.

For scalability purposes of real-time data exchanges, Message Queuing Telemetry Transport (MQTT) communication protocol over TCP/IP might be used instead of API calls. MQTT is an open-source publish/subscribe communication protocol that uses a broker to collect published information and transmit them to subscribed systems. MQTT is widely used for IoT communications with cloud applications.

2.2.1. UFP – EMS

Figure 4 focuses on the communication between the UFP and the EMS's gateway.

Each EMS's gateway must be generic enough and be able to send relevant information to the UFP such as measurement data and flexibility-related information, and receive information to react to flexibility requests accordingly. Exchanged messages are described more specifically in the subsections below.

A REST Open API will be used for all data exchanges between the UFP and the EMS gateways. For scalability purposes, real-time data (e.g. measurements and forecasts) can also use MQTT alternatively.

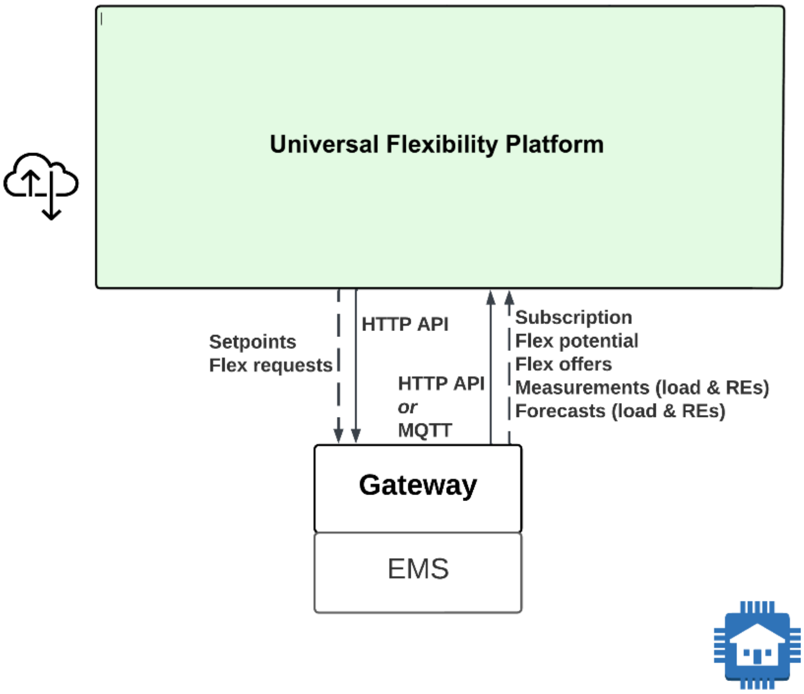

Figure 4 - UFP interface with an EMS's gateway

2.2.1.1. Messages from EMSs to the UFP

Subscription

To participate in UFP, an EMS should register by sending a subscription request to the UFP. This request should contain relevant information in order to allow creation of the corresponding object in UFP, such as identification elements, type of flexibility and eligible markets. It will result in creating a unique identifier for the EMS that should be used when communicating with UFP.

Flexibility potential

Each EMS can inform the UFP about the flexibility it can offer. Each flexibility potential message contains the baseline / nomination (i.e. what the EMS needs) either as a *power value for successive periods of time* (i.e. what the EMS constantly needs during any point of time during the period) or an *energy volume for periods of time* (i.e. what the EMS need to have been supplied at the end of the period) as a list of *value*, *value type* and period (*"from" and "to" time points*).

For the same period, the EMS can offer flexibility as a range of admissible power setpoints (*minimal and maximal reachable power*) for periods of times (*"from" and "to" time points*) possibly with another time frequency than for baseline/nomination.

An example for an electrical vehicle can be a request of x MWh to be provided between t_1 and t_2, where the minimal power is zero and the maximal power is limited by the charging station.

If multiple values are submitted for the same period of time, only the most recent submission is considered.

Flexibility offers

Each EMS can inform the UFP about available flexibility it can offer. Each of these messages should contain offers of flexibility for one or several periods of time. In practice, a flexibility offer consists in two lists: one of a *power increase* for a given period (*"from" and "to" time points*) and a *price*, and another one of a *power decrease* for a given period *("from" and "to" time points)* and *a price*. An example of flexibility offer content is given on Table 1.

DIRECTION	FROM	TO	POWER	PRICE
UP	2024-01-01T23:00:00	2024-01-02T11:00:00	5	20
UP	2024-01-02T11:00:00	2024-01-02T23:00:00	7	15
DOWN	2024-01-01T23:00:00	2024-01-02T23:00:00	10	50

Table 1 – Example of flexibility offer

Note that flexibility offers are relative to a baseline/nominated power and are considered as supplementary than the flexibility offered in flexibility potential.

Similar to the flexibility potential, in case multiple values are submitted for the same period of time, only the most recent submission will be considered.

Measurements

Measurements of the actual power consumed / produced by the asset monitored by the EMS must be sent to the UFP. Each message should contain a *value* (power) and timestamp(s) (either "*from*" or "*from/to*"), and the *act* (i.e. offtake or injection).

These measurements will be used by the UFP to compute the actual consumption and injection profiles of the EMS's delivery point and also used for very short-term forecasts. Note also that the frequency of measurements can be down to 4 sec, this to comply with aFRR guidelines [11].

Once again, only the most recent submission is persisted and considered if multiple values are submitted for the same time span.

Forecasts

Similarly to measurements, forecasts are submitted to the UFP for both offtake and injection with the same data format. Note that measurements are used in any case when available but forecasted values are however not overwritten by measurements.

2.2.1.2. Messages from the UFP to EMSs

Although messages are generated by the UFP for the EMS, it is the responsibility of the EMS to fetch the following information (e.g. setpoints, signals, …) from the UFP for scalability and availability purposes.

Setpoints

Given submitted flexibility potentials with technical constraints, UFP can inform the EMS of the setpoints that the EMS should follow, as a constant *power value* for periods of time (*"from" and "to" time points*).

Flexibility requests

Each of these messages contains an activated flexibility offer for one or several periods of time. In practice, and similarly to flexibility offer messages, a flexibility request consists in two lists: one of a *power increase* for a given period (*"from" and "to" time points*) and a *price*, and another one of a *power decrease* for a given period *("from" and "to" time points)* and *a price*. Note that for a given period, only one non-zero flexibility request will be provided to the flexible asset (e.g. if an increase of power is requested, the requested decrease of power will be zero).

Signals

In addition to flexibility-related signals supporting ECOFLEX goals, other information can be sent to EMS such as energy prices (in €/MWh) or abstract signals (no unit) in order to steer indirectly flexibility. In all cases, a signal is a time series and is a list of a *value* (e.g. a price), a period of time ("*from" and "to" time points*) and a quantity type (e.g. from a limited enumeration of types such as "energy_price" or "abstract").

2.2.2. UFP - Flexibility market (Aggregators)

In their roles of intermediary between the UFP and flexibility markets, flexibility market systems (i.e. aggregators' systems) will exchange with UFP information related to flexibility offers and activations (e.g. aFRR activated bids).

The exchanged messages, baseline and estimated flex. revenues among others, are represented in Figure 5 and their contents are described in the following sections.

A REST Open API will be used for all data exchanges between the UFP and the flexibility market systems.

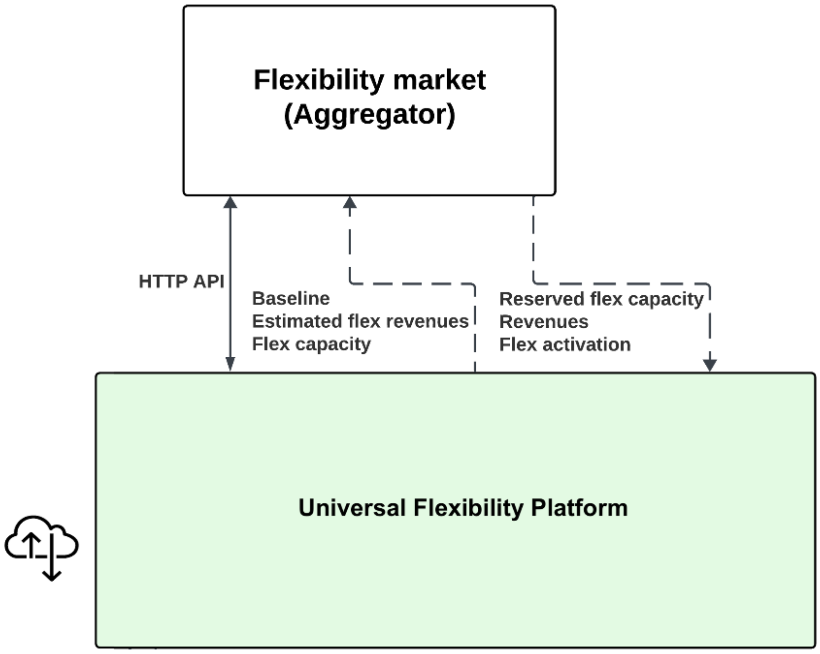

Figure 5 - UFP interface with the flexibility market(s)

2.2.2.1. Messages from aggregators to the UFP

Reserved flexibility capacity

Aggregators can let the UFP know that a given amount of flexibility should be preserved. Exchanged messages for reserved flexibility capacity is made of two lists of increase (resp., decrease) of power (i.e. a *value*) during a period of times (*"from" and "to" time points*) for a given flexible asset, and a price rewarding the reservation (a *value in €/MW/h*) such that if 1MW is reserved for 4 hours with a price of 100€/MW/h, the reservation revenue is 100 [€/MW/h] * 1 [MW] * 4 [h] = 400€.

Flexibility activation

Aggregators can let the UFP know that a given amount of (reserved or not) flexibility is activated (i.e. the flexible asset should execute). Exchanged messages for activated flexibility is made of two lists of increase (resp., decrease) of power (i.e. a *value*) during a period of times (*"from" and "to" time points*) for a given flexible asset, and a price rewarding the activation (a *value in €/MW/h*). Note that a power value (increase or decrease) given for a period is assumed to be constant for the whole period. Note also that if a non-zero value is given for a direction (e.g. increase) for a period of time, there should be a zero value in the other direction.

Revenues

The aggregator must communicate to the UFP the revenues that were generated by reserving and activating the flexibility of a given EMS as a time series of revenues (*list of values per reference period of times*, i.e. 15 minutes, and per *types* of revenues, i.e. reservation or activation).

2.2.2.2. Messages from the UFP to aggregators

Baseline

Aggregators can access information about what will be required for each flexible asset without any non-validated flexibility activations. Baseline messages are made of *power values* for successive periods of time (*"from" and "to" time points*).

Estimated flexibility revenues

Aggregators can access information about what are the expected revenues from other markets estimated by the UFP as a time series of revenues (*list of values per reference period of times*, i.e. 15 minutes).

Flexibility capacity

Each of these messages should contain offers of flexibility for one or several periods of time. In practice, a flexibility offer consists in two lists: one of a *power increase* for a given period (*"from" and "to" time points*) and a *price*, and another one of a *power decrease* for a given period *("from" and "to" time points)* and *a price*. If the price was not provided by the flexibility sources (i.e. flexible assets), the UFP may fill that price based on estimated flexibility revenues on other markets.

2.2.3. UFP - Energy market (BRP or Retailer)

Regarding energy markets, interactions will mainly be about nominations (i.e. requirements) and required modifications on these requirements. The exchanged messages can be seen in Figure 6 and their contents are described in the following sections. A REST Open API will be used for all data exchanges between the UFP and the energy market systems.

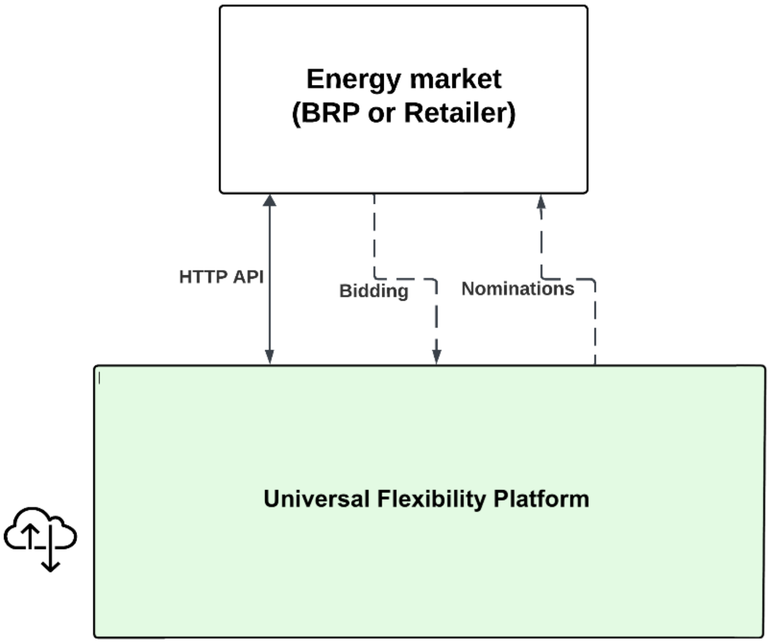

Figure 6 - UFP interface with the energy market(s)

2.2.3.1. Messages from the energy market to the UFP

Bidding

Actors within the energy market (i.e. BRPs and retailers) can request flexible assets to deviate from their nominations in order to provide a service to these actors.
Each of these messages contains a requested flexibility for one or several periods of time. In practice, and similarly to flexibility offer messages, a flexibility request consists in two lists: one of a *power increase* for a given period (*"from" and "to" time points*) and a *price*, and another one of a *power decrease* for a given period *("from" and "to" time points)* and *a price*. Note that for a given period, only one non-zero flexibility request will be provided to the EMS (e.g. if an increase of power is requested, the requested decrease of power will be zero). UFP can acknowledge the flexibility by updating the relevant nomination.

2.2.3.2. Messages from the UFP to the energy market

Nominations

Each nomination contains the actual nomination (i.e. what the EMS needs) either as a *power value for successive periods of time* (assumed to be constant during each period) or an *energy volume for periods of time* (same information as in power) as a list of *value*, *value type* and period (*"from" and "to" time points*). For example, for day-ahead market nominations, it will result in sending 96 values (one per 15 minutes) for a day and BRP and/or retailers are intermediaries for the actual day ahead schedules nominations on the markets.

2.2.4. UFP - Local Flexibility Market(s)

Interaction with local flexibility markets will mainly be local adjustments in order to provide a service to local (distribution) networks and avoid congestions. Exchanged messages can be seen in Figure 7 and their contents are described in the following sections. A REST Open API will be used for all data exchanges between the UFP and the local flexibility market systems.

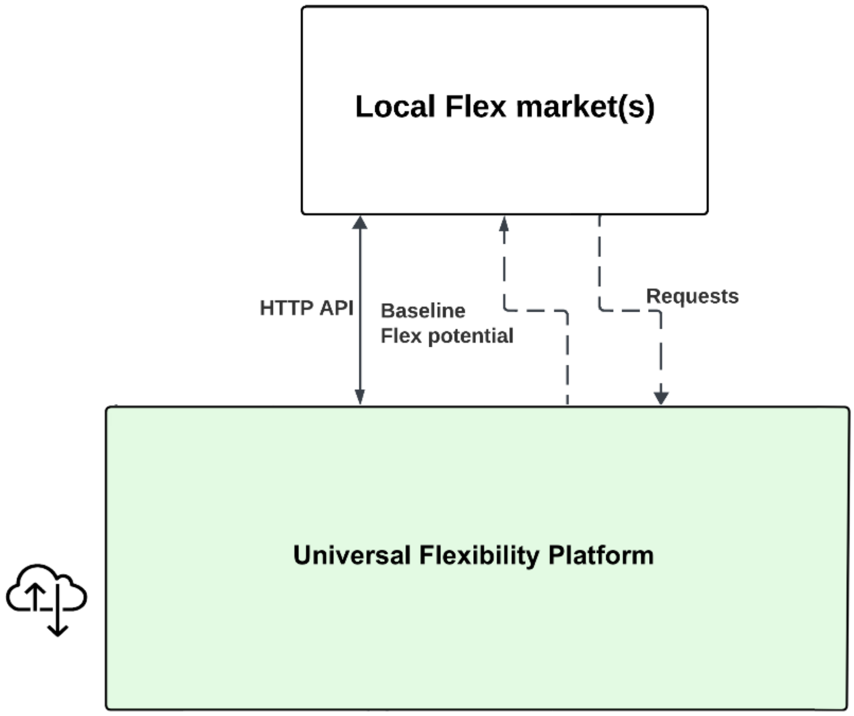

Figure 7 - UFP interface with the local flexibility market(s)

2.2.4.1. From local flexibility market(s) to the UFP

Requests

Local market actors can request flexible assets to deviate from their baseline in order to provide a service to network operators.

Each of these messages contains a requested flexibility for one or several periods of time. In practice, and similarly to flexibility offer messages, a flexibility request consists in two lists: each list is made of several *power quantity* for a given period (*"from" and "to" time points*) and a *price*, *, respectively for power increase and power decrease*.
Note that for a given period, only one non-zero flexibility request will be provided to the flexible asset (e.g. if an increase of power is requested, the requested decrease of power will be zero). Note also that these requests are expected to be followed by the flexible assets because otherwise congestion issues are foreseen.

2.2.4.2. From the UFP to local flexibility market(s)

Baseline

Local market actors can access information about what will be required for each flexible asset without any non-validated flexibility activations. Baseline messages are made of *power values for successive periods of time* (*"from" and "to" time points*).

Flexibility potential

Local market actors can be informed about what flexible assets can offer in terms of flexibility in addition to what they require. Each flexibility potential message contains the baseline / nomination (i.e. what the flexible asset needs) either as a *power value for successive periods of time* (i.e. what the flexible asset constantly needs during any point of time during the period) or an *energy volume for periods of time* (i.e. what the flexible asset needs to have been supplied at the end of the period) as a list of *value*, *value type* and period (*"from" and "to" time points*).

3. Requirements

In addition to exchanged messages, this section aims at listing additional requirements (functional and non-functional) identified that should be fulfilled by the architecture to support ECOFLEX goals.

- Each flexible asset (EMS) will be associated with a unique identifier (generated by the UFP) and all systems should use that identifier to mention this flexible asset. It is not advised for all systems to use their own identification system.
- Additional health statuses of all systems can be exchanged, if required, to ensure that systems are alive (e.g. a value sent every x minutes) and continuous communication required for real-time measurements (e.g. an incremental value sent at each message in order to notice when a message was missed).
- (Pre)qualification tests such as the ones required for aFRR are of the responsibility of the aggregators and are handled as flexibility activation with no rewards.

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